LANZAJET

Project Pūrākau
Feasibility Study Report

s 9(2)(b)(ii) and s 9(2)(ba)(i)

Client: Air New Zealand

Revision FINAL

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Glossary of Terms

AIAL	Auckland International Airport Limited
ATJ	Alcohol to Jet
BFD	Bulk Flow Diagram
BOD	Biological Oxygen Demand
CAEP	Committee for Aviation Environment Protection
CAPEX	Capital Expenditure
CEF	CORSIA Eligible Fuel
CI	Carbon Intensity
s 9(2)(b)(ii) and s 9(2)(ba)(i)	
COD	Chemical Oxygen Demand
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CV	Calorific Value
FS	Feasibility Study
FSC	Forest Stewardship Council
FTG	Fuels Task Group
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
GTL	Gas to Liquids
ICAO	International Civil Aviation Organisation
IRR	Internal Rate of Return
ISBL	Inside Batter Limit
ISCC	International Sustainability and Carbon Certification
LCA	Life Cycle Assessment
LCOP	Levelised Cost of Production
MBIE	Ministry of Business, Innovation and Employment
MHF	Major Hazard Facility
MSW	Municipal Solid Waste
NES-CF	National Environmental Standards – Commercial Forestry
NGO	Non-Government Organisation
NPV	Net Present Value
ODT	Oven Dry Tonne
OPEX	Operational Expenditure
OSBL	Outside Battery Limit
PEFC	Programme for the Endorsement of Forest Certification
RAP	Ruakaka to Auckland Pipeline
RD	Renewable Diesel
RDF	Refuse Derived Fuel
RMA	Resource Management Act
RO	Reverse Osmosis
RSB	Roundtable on Sustainable Biomaterials
SAF	Sustainable Aviation Fuel
SAFc	Sustainable Aviation Fuel Credit
SBC	Synthetic Blend Component
SRWC	Short Rotation Woody Crops
TIC	Total Installed Cost
VPSA	Vapour Pressure Swing Absorption
WAP	Wiri Airport Pipeline
WOSL	Wiri Oil Services Limited
WTP	Water Treatment Plant
WWTP	Waste Water Treatment Plant

1. Executive Summary

Air travel forms a critical part of Aotearoa New Zealand's transport infrastructure and is vital to its long-term success. It enables trade and connectivity, connects New Zealand communities and businesses both domestically and globally, and brings international tourists to and from the nation. Air travel will remain vital given the country's geographic isolation, dispersed population, and lack of other high-speed transport options. Currently, New Zealand has no domestic jet fuel production and imports all its jet fuel.

To achieve the aviation industry's global goal of net zero emissions by 2050, which the New Zealand government has committed to, it is important airlines reduce their reliance on fossil jet fuel. The International Air Transport Association (IATA) estimates that for this to happen, 65 per cent of the decarbonisation opportunity in 2050 will need to come from Sustainable Aviation Fuel (SAF). As part of achieving this and reducing the aviation industry's contribution to climate change, The International Civil Aviation Organisation (ICAO) established the global Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which places obligations on airlines to reduce or offset the emissions from international flights to achieve carbon neutral growth. Airlines can either meet their CORSIA obligations by using SAF or purchasing offsets.

Additionally, the New Zealand government, via ICAO has committed to support a collective global aspirational vision of a five per cent reduction in emissions by 2030 through the use of SAF and other lower emissions energy sources, in addition to New Zealand's commitment to net zero emissions by 2050 under the Climate Change Response Act.

The most impactful lever to reduce emissions from aviation is SAF. UN scenarios expect it to be approximately 60 to 100 per cent of global jet fuel by 2050 but it is less than 1 per cent of global jet fuel in 2024. Substantive investments and policy support for SAF supply chains and facilities will be key to delivering the ambitious ramp-up necessary to achieve national and global goals. Policy and investment enablers have been critical for setting up and scaling SAF production to date and are expected to continue to be critical in future. Producing SAF in New Zealand therefore has the potential to address both the country's aviation emissions reductions goals and its fuel security goals, whilst also creating hundreds of skilled jobs in regional areas. To seize these opportunities, it is critical to understand the opportunities and role of making SAF from a variety of feedstocks domestically.

Woody biomass from plantation forests is a potential domestic feedstock for making SAF locally, but there will be competition for this resource. All transport modes in New Zealand need a path to net zero emissions by 2050, and woody biomass can be used for clean power generation, heating, and for renewable ground transport fuels. However, the electricity and ground transport sectors have a range of other options to decarbonise, whereas aviation's decarbonisation is primarily reliant on SAF. As such, woody biomass could have a key long-term role to play in New Zealand's mix of domestically produced SAF.

In 2023, Air New Zealand and the Ministry of Business, Innovation, and Employment (MBIE) completed stage one of a joint study into the viability of domestic SAF production. The objective was to evaluate the feasibility and opportunities of operating a commercial-scale SAF plant in Aotearoa, New Zealand. From this process a consortium of partners, led by LanzaJet, were selected to study the feasibility of a production facility to convert forestry residues into 113 million litres of transportation fuels per year, including SAF and renewable diesel (RD), which can be used by a wide range of users outside aviation. CirculAir™, the technology that would be deployed to enable this process, combines the technologies of LanzaTech and LanzaJet to create a seamless process for converting waste carbon into SAF.

It starts with LanzaTech's gas fermentation technology, which converts waste carbon – in this case gasified forestry residues – into ethanol. LanzaJet then converts ethanol into SAF using an advanced alcohol-to-jet (ATJ) technology.

Project Pūrākau is supported by several partners including LanzaTech, LanzaJet, Z Energy, Wood Beca and Scion Research (Scion), each supporting various elements of the Feasibility Study (FS).

Supply Chain

Scion was engaged to assess the characteristics and availability of feedstock, supply chain design, operations and resilience. Key outcomes of their research include:

- Feedstock availability s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] regions were identified as having sufficient feedstock to support the project's annual demand of [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] cubic meters.
- Approximately 30 per cent this demand can be met by residues, while the remaining 70 per cent would need to come from low value export logs (K-grade logs).
- Supply chain partners: The feedstock supply chain will require involvement of various stakeholders, including landowners, forest growers and wood fuel processors.
- Supply chain resilience: There are a variety of risks within and outside of the supply chain that need to be considered and potentially mitigated. These include competition for fibre and feedstock, severe weather events, SAF market pricing and labour shortages.

Downstream supply chain logistics were assessed by Z Energy, who identified several options for the transportation, blending and delivery of SAF to Auckland Airport s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] The preferred design includes transporting SAF via rail to a Z Energy terminal [redacted] for storage and blending with conventional jet fuel. The blended product would be transported via rail to [redacted] where it would then be delivered to Auckland Airport s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] New blending and storage infrastructure would need to be built at Z Energy' [redacted]

Engaging with the Māori Economy

The Māori economy is defined as all known assets owned, wealth generated, and income earned by Māori (more detail in Section 4). Currently, the Māori economy is valued at over NZD $70 billion and expected to grow to NZD $100 billion by 2030, presents significant opportunities. Engaging with Māori entities can drive economic development and foster a diversified, sustainable industry. Discussions with Māori land trusts, forest owners, and Iwi Holding companies have identified opportunities regarding project sites, feedstock supply, and direct investment. This engagement will continue as the project advances.

Project Location

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] The planning and consenting requirements for the project cannot be determined until a project site is chosen, however the pathway and timeline for what is likely to be needed has been mapped for planning purposes.

Process Design and Site Master Plan

The process design integrates gasification and gas fermentation to convert biomass to ethanol, followed by an alcohol-to-jet (ATJ) conversion process. [redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

Wood Beca prepared an Outside Battery Limits (OSBL) design for all the equipment, services and utilities required to operate each process unit, and this was based on inputs provided by LanzaJet, LanzaTech, Z Energy, and Scion. s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] The site layout includes strategically placed feedstock storage, processing units, and product storage areas, to streamline operations and reduce transportation distance and vehicle movements. s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

Environmental Considerations

Scion examined the environmental sustainability of producing SAF from woody biomass in New Zealand. Their study focused on the extraction of biomass from plantation forests, assessing its impact on soil fertility, erosion, water quality, and biodiversity, as well as potential social and economic effects. They found that:

- Extraction of stem wood residues from clear-cut plantations can be environmentally sustainable if best management practices are adhered to, however Scion noted that knowledge gaps exist, which would necessitate further research and field trials;
- Sensitive sites require ongoing research and adaptive management to ensure long-term sustainability;
- Soil fertility, erosion, water quality, and biodiversity are minimally impacted by residue extraction above that of the primary harvesting operation if current best practices are maintained however key knowledge gaps exist in relation to the impact of residue extraction on indigenous biodiversity and soil biology;
- Some residue removal could improve environmental outcomes; and
- Expanding stock of wood in New Zealand's forests supports sustainable harvest levels into the future.
- Given the knowledge gaps identified, Scion's key recommendation was the establishment of a series of long-term site productivity monitoring trials to assess the

on the ground sustainability of residue harvesting. The findings could then be used to inform long term adaptative sustainable management practices.

Sustainability Certification

Scion evaluated leading sustainability certification schemes relevant to Project Pūrākau and their certification requirements, focusing on ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and what would be needed to achieve CORSIA eligible fuel (CEF) certification. These certification schemes cover the full SAF supply chain including forest management, feedstock extraction activities, feedstock processing, SAF production and transport.

Scion examined the alignment of New Zealand's commonly used forest certification schemes (FSC and PEFC) with CORSIA criteria. Both FSC and PEFC have been used in New Zealand's forest industry to certify forest management and there is commonality with CORSIA in terms of the sustainability criteria relevant to feedstock. Beyond CORSIA, other relevant certification frameworks include the Roundtable on Sustainable Biomaterials (RSB) and International Sustainability and Carbon Certification (ISCC). Both have their own certification schemes relevant to biofuel production, and both organizations are also approved CORSIA sustainability certification schemes.

Scion's research also outlined:

- Only about two-thirds of New Zealand's forest area is certified under FSC/PEFC. Additional certification may be needed for more resources.
- For their voluntary certification programs, RSB does not consider roundwood (logs) acceptable feedstock for biofuels while ISCC does not limit the use of low-value logs such as K-grade logs.
- RSB and ISCC also offer CORSIA certification as approved sustainability certification schemes (RSB-CORSIA and ISCC-CORSIA) and neither prevent the use of logs, consistent with the CORSIA sustainability criteria.
- There are several issues related to CORSIA that will require further investigation and engagement with ICAO's relevant technical bodies. These include:
    - There is currently no default LCA value for forestry residues via the ethanol to jet pathway under CORSIA;
    - Low value logs are not included in ICAO's "Positive list of materials classified as co-products, residues, wastes or by-products" last updated in June 2022. *s 9(2)(b)(ii) and s 9(2)(ba)(i)*
    - There is a process through which the ICAO Fuels Task Group (FTG) can recommend additional feedstocks be added to this list, and a case could be made for certain logs that do get discarded and left in the forest as residues. *s 9(2)(b)(ii) and s 9(2)(ba)(i)*

Life Cycle Assessment

A Life Cycle Analysis (LCA) for Project Pūrākau's entire supply chain, from feedstock to fuel combustion, was developed using the ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) methodology and baseline as this is considered the most relevant approach for New Zealand. The Carbon Intensity (CI) of SAF production includes:

- Feedstock cultivation, collection, and transportation;

- Gasification;
- LanzaTech gas fermentation;
- LanzaJet Alcohol-to-Jet (ATJ) process;
- SAF/RD transportation to the final destination; and
- Combustion of SAF/RD.

Relevant emissions factors for New Zealand and feedstock data from Scion were used for the LCA calculations. Under CORSIA, emissions from forest residue cultivation are not included in the LCA, as these materials are classified as residues, wastes, or by-products. For the purposes of the LCA it was assumed that K-grade logs are treated similarly to residues regarding feedstock emissions.

The LCA indicates that the SAF from Pūrākau would have a CI of approximately 20.71 g CO_2/MJ, which represents a 77 per cent reduction compared to conventional jet fuel at 89 g CO2/MJ. This could be reduced by a further 15 g CO_2/MJ through the use of renewable electricty. s 9(2)(b)(ii) and s 9(2)(ba)(i)

Economic Impacts

Scion evaluated the economic impacts of converting woody biomass into SAF at a site in s 9(2)(b)(ii) and s 9(2)(ba)(i) They found that:

- The project is expected to contribute $428 million per year to GDP.
- The plant is projected to create 165 new regional jobs directly at the facility i s 9(2)(b)(ii) and s 9(2)(ba)(i) 88 direct jobs in the feedstock supply chain and a further 386 indirect jobs throughout the entire SAF supply chain; and
- This will represent a 2.4 per cent increase in the annual GDP of the s 9(2)(b)(ii) and s 9(2)(ba)(i) region.

The project could also drive positive social change in s 9(2)(b)(ii) and s 9(2)(ba)(i) by increasing skilled employment opportunities in the local forestry sector, reducing unemployment rates, providing stable future proof income sources for families, and improving overall economic conditions in the community.

Capital and Operating Cost Estimates

Based on the information received, LanzaTech, LanzaJet and Z Energy, and Wood Beca prepared both capital and operating cost estimates for the project. As the project is at an early stage of definition, the accuracy of these estimates is expected to fall in the range of -20 per cent to +50 per cent.

The operating cost estimate includes raw materials, utilities, labour, maintenance, and other operational expenses. The resulting cash cost of production, in the current absence of policy support, is in line with the broader industry consensus that SAF costs two to five times that of conventional jet fuel to produce.

The capital cost estimate of s 9(2)(b)(ii) and s 9(2)(ba)(i) accounts for infrastructure, equipment, and other essential investments necessary for project execution and construction. The accuracy of the estimate is -20 per cent to +50 per cent and includes a contingency allowance of 20 per cent or approximately s 9(2)(b)(ii) and s 9(2)(ba)(i) a sum which accounts for those elements of the scope

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s 9(2)(b)(ii) and s 9(2)(ba)(i)

which are yet to be more fully defined. The estimate does not include the supply chain infrastructure necessary for the blending and distribution of SAF to Auckland Airport.

While this is significant, it should be noted that the accuracy range and contingency value reflect the conceptual nature and hence early stage of definition of the project. It is also in line with recent estimates for projects of a similar nature and magnitude that LanzaJet and LanzaTech have experience with. It will be critical that a value engineering exercise occurs early in the next project phase. This will enable the identification of efficiencies and opportunities to reduce both CAPEX and OPEX and must occur prior to the commencement of any further design or engineering work begins.

Commercial Feasibility Assessment

The Levelised Cost of Production (LCOP) of SAF is in line with the broader industry understanding that currently SAF costs two to five times that of conventional jet fuel in markets without dedicated SAF policy support. Policy support has proven critical for the industry in other parts of the world to establish, and such support can be wound down over time as the industry scales and/or cost of carbon is fully priced into fossil jet fuel. The LCOP and sensitivity analysis demonstrates that reducing general OPEX and CAPEX, rather than feedstock cost specifically, is going to have the largest impact on the Project's returns and financial viability. Feedstock costs are approximately 20 per cent of total operating costs.

An analysis of market and policy incentives for SAF in other regions demonstrates that if similar policy support and market conditions developed in New Zealand and/or Australia as in other countries, the net cost of the SAF produced could be competitive with conventional jet fuel as shown below (USD $/tonne).

s 9(2)(b)(ii) and s 9(2)(ba)(i)

A stable and supportive policy environment for SAF is expected to be critical for a future SAF industry to be created in New Zealand. Without it, there is the risk that SAF produced domestically will be exported to markets with SAF mandates, depriving New Zealand of potential decarbonisation benefits and domestic fuel security.

s 9(2)(b)(ii) and s 9(2)(ba)(i)

To de-risk the project for investors, long term (10+ years) feedstock supply contracts will be needed. Similarly, a long term (10+ years) offtake agreement for the SAF will also be needed. In a scenario where an airline such as Air New Zealand is the anchor offtake customer, it may be desirable to bring in additional offtake customers to reduce the risk portfolio for investors.

Policy Recommendations

Government policy and support has been essential in developing SAF markets and ecosystems to date, much like the successful development of renewable liquid fuels for road transport globally over the past decade. A growing number of countries are also implementing polices to help de-risk and encourage SAF production and uptake in future, including several in Asia Pacific. For example:

- Japan has announced a 10 per cent SAF mandate by 2030, with significant capital grants (up to 50 per cent of project costs) and a production tax credit of ¥30 per litre with legislative approval expected in 2024;
- Singapore has set a target of 1 per cent SAF by 2026, increasing to 3-5 per cent by 2030 for all flights departing from Singapore, funded by a levy on airline tickets; and
- Australia is investing AUD $1.7 billion through the Future Made in Australia Innovation Fund to accelerate SAF projects, consulting on production incentives, and exploring a mandate for low carbon liquid fuels (including SAF).
- At the time of writing, in July 2024, policy is expected to be announced in Malaysia, Indonesia, China, Hong Kong, South Korea, Taiwan and Thailand by the end of 2025.

SAF markets and SAF projects around the world have not been developed without transitional policies in place to support these and help de-risk investment, and such policies are expected to be key for establishing a SAF market in New Zealand. This support often combines both regulated demand measures (such as volumetric mandates or low carbon fuel standards) and production support (like production credits and capital grants). The development of the biofuels industry in the United States illustrates this, whereby RD production has seen significant and consistent growth because of both regulated demand (through a mandate) and supply incentives (tax credits). SAF on the other hand has only benefited from incentives and production of RD continues to outstrip SAF.

To that end, New Zealand Government policy and support is expected to be a critical factor to enable Pūrākau to advance. Considerations for the Government include:

- CORSIA LCA and Certification: Engagement with ICAO to clarify any indirect land use change impact of using K-grade logs;
- Transitional Grants: The potential for capital grants to support the initial development of SAF projects to support the long-term decarbonisation of the economy and improve fuel security through SAF production (similar to Japan and Australia);
- Demand and Supply Measures: The potential to introduce both demand-side measures (like volumetric or carbon intensity mandates) and supply-side measures (like production incentives) to help reduce the cost of SAF and provide long-term investment certainty to establish a credible SAF market.
- Energy subsidies, similar to those used in other industries in New Zealand.

Project Timeline

After "de-risking" activities (as outlined in the next section) have been addressed, the project is expected to be executed according to the following steps:

- Development the Process Design Package;
- Development of a consent strategy
- Planning permission granted
- Front End Engineering and Design (FEED)
- Financing and a Final Investment Decision (FID)

- Engineering, Procurement and Construction (EPC)
- Commissioning and Start Up Operations;
- Full-scale production

The following chart provides an indicative high-level project development and execution schedule, which indicates that full-scale production could begin by 2030.

s 9(2)(b)(ii) and s 9(2)(ba)(i)

Conclusions and Next Steps

Project Pūrākau represents a significant opportunity for New Zealand, potentially one of the largest manufacturing projects in New Zealand's recent history. It offers a significant opportunity to generate economic benefits and develop a domestic SAF industry while advancing the decarbonization of the aviation sector and significantly improving New Zealand's energy security.

This study confirms that a SAF production facility in New Zealand is technically feasible, converting forestry residues into 113 million litres of SAF and RD annually. It would provide significant benefits for the country, by way of:

- Domestic production of 102 million litres per year of unblended SAF each year, equivalent to 5 per cent of New Zealand's 2019 total jet fuel uplift of 1.9 billion litres, or 26 per cent of New Zealand's domestic jet fuel consumption;
- Expected carbon savings from use of this fuel of at least 233,000 tonnes of CO_2 a year, based on the SAF having at least a 70 per cent reduction compared to fossil jet fuel;
- Reduced reliance on imported fuels, enhancing energy security and supply chain resilience;
- Adding $428 million to New Zealand's annual GDP, including a 2.4 per cent increase in the *s 9(2)(b)(ii) and s 9(2)(ba)(i)* region's GDP;
- Domestic production of 11 million litres of RD each year, strengthening diesel supply chain security and resilience (e.g. defence, emergency response and generators);
- Creation of skilled jobs in regional areas, including 165 at the facility, 88 in the feedstock supply chain and a further 386 indirect jobs;
- Opportunities for Māori forest owners, landowners, and holding companies;
- Mitigating environmental and economic impacts during extreme weather events; and

- Positive changes in regional towns like s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] through training, increased skilled employment, reduced unemployment, and improved economic conditions.

To further de-risk the project, there are several next steps Air New Zealand, and the New Zealand Government may consider:

i. Identifying pathways to legislating SAF policy support as soon as possible and begining a public consultative process by government around potential demand and supply side measures for New Zealand. Currently, SAF projects around the world have not been developed without policies in place to support them. Government policy is seen as one of the most important factors to enable Pūrākau to advance.

ii. Incorporate the findings from an additional feasibility study into the use of municipal solid waste (MSW) as feedstock for SAF production due to be completed in 2024. MSW has several potential advantages that could help address some of the challenges identified in this report and the use of both MSW and forestry residues is also a potential outcome.

iii. In parallel with the MSW study, carrying out a value engineering exercise to identify opportunities to the reduce CAPEX and OPEX.

iv. Engage with the Australian Government and its ICAO representatives with respect to the use of K-grade logs and CORSIA.

v. Continue engagement with Maori entities and community stakehodlers regarding the project and the opportunities it presents.

vi. Begin discussions with forest owners regarding feedstock supply.

vii. Identify a project site for either feedstock scenario (woody biomass and MSW). This will be necessary before any further engineering work commences.

2. Introduction

In 2023, Air New Zealand and the Ministry of Business, Innovation and Employment (MBIE) completed stage one of a joint study into the viability of domestic sustainable aviation fuel (SAF) production. The process invited leaders in innovation to demonstrate the feasibility of operating a SAF plant at a commercial scale in Aotearoa New Zealand. From this process a consortium of partners including LanzaJet, LanzaTech, Z Energy, Wood Beca and Scion Research (Scion) were selected to progress to stage two of the study, which was designed to determine commercial viability and sustainability of domestic SAF production with greater accuracy.

The results of this work are presented in this report, which explores the commercial feasibility of using domestic feedstock to produce SAF, primarily from forestry wastes and residues.

The project name Pūrākau (*poo-rah-co*) was chosen as it appropriately captures the purpose, intent and aims of the study. Pūrākau means story, and there is an important story underpinning this project – continuing to connect people without further damage to Papatūānuku (earth). When broken down, the word Pūrākau refers to the roots or base (*pū*) of the tree (*rākau*). The reference to roots (*pū*) represents a Māori cultural understanding of social relationships and inter-connections between people and between people and the environment. Inter-connectedness is a critical part of this project for project members and for/with stakeholders and communities. While the word rākau references a tree, it is also a word used for weapon and for the challenge baton laid down for a distinguished visitor at a powhiri. The narrative aligns with the challenge that Air New Zealand has set and to find the "secret weapon" to combat the damage fossil fuels are doing to Papatūānuku.

The importance of this challenge is significant and one that is aligned with the New Zealand government's commitment to the ICAO goal of net zero emissions for aviation by 2050. It also aligns with Air New Zealand's own commitment to find a more sustainable way to connect with the world and reach their goal of net zero carbon emissions by the year 2050. Further, Air New Zealand will need substantive volumes of SAF to meet its ambitious 2030 interim science-based target, validated by the Science Based Targets initiative, to reduce carbon intensity by 28.9 per cent, from a 2019 baseline.

Through the development of a domestic SAF supply chain, Pūrākau represents an important initiative of Air New Zealand's climate action plan and one that will be needed to meet their ambitious climate goals.

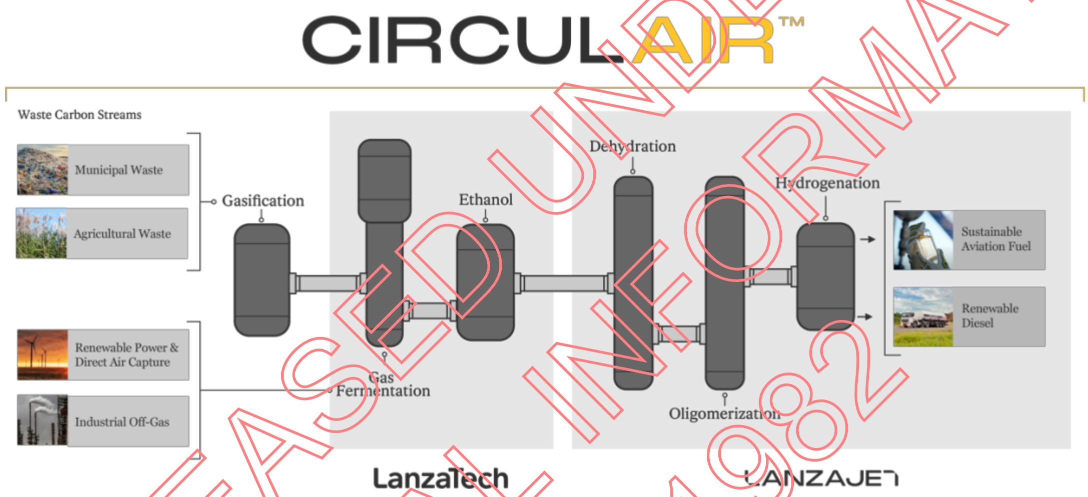
Pūrākau has therefore examined the technical and economic viability, and the sustainability, of a production facility to convert woody waste and residues into 113 million litres of transportation fuels, of which 90 per cent would be SAF and the remaining 10 per cent renewable diesel (RD). In other words, 102 million litres of SAF and 11 million litres of RD each year.

The technology solution that would be deployed to enable this combines the groundbreaking technologies of LanzaJet and LanzaTech to create a seamless process for converting waste carbon into SAF – known as CirculAir™. It starts with LanzaTech's gas fermentation technology, which efficiently converts waste carbon – in this case gasified forestry residues – into ethanol. This process uses microbes to transform carbon monoxide and carbon dioxide into valuable chemicals, like ethanol. LanzaJet then takes this ethanol and converts it into SAF using an advanced alcohol-to-jet (ATJ) technology. By integrating the two technologies, CirculAir™ offers a scalable end-to-end solution, applicable to every country and industry.

The strength of CirculAir™ lies in its flexibility and efficiency. LanzaTech's process can handle a wide range of feedstocks, including municipal solid waste, industrial offgases, renewable power, and direct air capture of CO_2, converting them into ethanol without the need for extensive processing. This flexibility can handle various waste resources available in different regions, ensuring a consistent and reliable supply of feedstock. Once the ethanol is produced, LanzaJet's ATJ technology takes over, transforming it into high-quality SAF. This process retains all the energy in the ethanol molecule, resulting in a higher density in the finished SAF product.

The versatility of this approach means it can use the same feedstocks as those used in other SAF pathways, such as Fischer-Tropsch, Power-to-Liquid, and Waste-to-Fuels, while achieving the same result, but at higher yields.

Figure 1: The CirculAir™ Process



Importantly, each of these integrated technologies has been deployed and proven at commercial scale.

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

Founded in 2005 in New Zealand, the company LanzaTech develops carbon recycling technology which uses bacteria to convert waste carbon into ethanol. Their technology has been deployed all over the world and they now have six commercial plants in operation.

The company LanzaJet deploys ATJ technology developed over 14 years. This technology achieved ASTM certification in 2018, is deployed at the world's first ethanol-to-SAF plant in Georgia, United States, and is now being licensed to projects in over 25 countries, across 5 continents.

Key organisations supporting the delivery of Project Pūrākau via design, research, and advisory services, include:

- Scion, who assessed several key elements of the Pūrākau supply chain including feedstock availability, feedstock operations, supply chain design, certification, risks and environmental, economic and social impacts;

- Z Energy, who provided the design for the downstream supply chain for SAF and RD, as well as valuable advice and guidance regarding the overall scope, execution, and delivery of the feasibility study; and
- Wood Beca, who developed the outside battery limits (OSBL) design and overall master plan and capital cost estimate for the integrated processing facility.

Furthermore, the Māori engagement leads from Air New Zealand, Z Energy and Scion provided invaluable advice and guidance in relation to Iwi engagement and developed the Iwi engagement plan that is outlined in this report.

3. Supply Chain

3.1. Feedstock Characteristics and Availability

Scion was engaged to assess both the characteristics and available supply of biomass feedstock in New Zealand. s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

The purpose of Scion's work was to help inform where in New Zealand a SAF plant could be located based on the availability of biomass now and to 2050. The temporal nature of this work is important as the woody biomass supply varies over time due to fluctuations in the age class distribution of the forest resource. Not all regions have the same degree of fluctuation. Further, it is important to understand the characteristics of the wood biomass available as this may affect the processing operations and the yield of fuel.

3.1.1. Characteristics of the biomass

Most of the woody biomass available in New Zealand is, and to at least 2050 will be, radiata pine. This species accounts for 90 percent of the plantation forest area and a slightly larger proportion of the total volume harvested (34.4 million m^3 total in 2022). There is minimal harvest of native forest in New Zealand (around 10,000 m^3 per annum in 2022) and it is assumed that none of this material will be used in SAF production.

The average calorific value (CV) of radiata pine is in the order of 20.3 GJ per oven dry tonne (ODT) for gross CV and 19.1 GJ per tonne for net CV, although individual samples tested may range from 17 to 25 GJ per ODT.

Ash content varies with source but for clean wood such as chipped logs it should be less than 1 percent by dry weight and for residuals around 3 percent assuming screening to remove fines and dirt /stones. The weighted average ash content at s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] would be around 1.6 percent. This assumes some screening out fines from the material delivered as chipped residues.

Moisture content of the biomass affects the net calorific value, but this can be adjusted within the supply chain and with forced drying at the processing plant prior to gasification to achieve the desired moisture content of <20 percent wet basis. Typically, freshly harvested radiata pine will have a moisture content of 58 to 60 percent on a wet basis, giving a net calorific value of 6.9 to 7.0 GJ per green tonne. The moisture content needs to be reduced from 58 to 60 percent down to less than 20 percent via drying.

The basic composition of wood is around 50 to 51 percent carbon, 42 to 43 precent oxygen and 6 percent hydrogen with traces of other elements (N, K, S, Si, Ca etc.).

The main components found in ash from combusted wood are calcium (~50 percent), potassium, sodium, magnesium, phosphorous and carbon that was not combusted (~4 percent). Silica can also be present, and this can be affected by contamination of the wood fuel resource with soil.

3.1.2. Wood resources

The main resources considered here are in-forest post-harvest residues left at landings (stem to log processing areas) and on cutover (the area felled trees have been extracted from) along with low-grade logs (chip or pulp and K-grades) that have limited domestic market. There are other sources of low-cost wood fibre (shelter belt and orchard turnover), and these are included along with municipal wood waste, but these sources make up only a very small proportion of the possible feedstock available.

To produce 113 million litres of transportation fuels, Pūrākau requires approximately s 9(2)(b)(ii) m^3 per year of feedstock. Scion's analysis looked at two different production scenarios: 1) a single site operation; and 2) a hub and spoke operation with smaller ethanol production spokes feeding a central ethanol-to-SAF hub.

Scion's analysis identified that there is only one region in New Zealand where sufficient feedstock is available to meet this demand for a single-site operation (fully integrated plant); the s 9(2)(b)(ii) and s 9(2)(ba)(i) In this case the feedstock would likely be 28 to 30 per cent from in-forest residuals, 70 per cent from chip / pulp and K-grade logs and 1 to 2 per cent from other sources. This ratio depends on the size of the plant and assumes a plant that is close to the maximum possible based on the resource.

The amount of biomass available varies from region to region. The preferred or most likely candidate region for a woody biomass-based industry is in the s 9(2)(b)(ii) and s 9(2)(ba)(i) possibly drawing on the wider s 9(2)(b)(ii) and s 9(2)(wood supply region to maximise plant size. Other locations with potential for a plant (hub and spoke rather than single site) are s 9(2)(b)(ii) and s 9(2)(ba)(i) (possibly including s 9(2)(b)(ii) and s 9 , as well the combination of s 9(2)(b)(ii) having sufficient biomass to make a hub and spoke type operation possible.

s 9(2)(b)(ii) and s 9(2)(ba)(i)

The supply of biomass from New Zealand plantation forest estate varies over time due to planting rates in the past. Current harvest rates are higher than are likely to be achieved in the period 2035 to 2040 due to very high rates of planting in the late-1990's and early 2000's. This future low supply period needs to be kept in mind when considering the long-term supply and plant size (Table 1). s 9(2)(b)(ii) and s 9(2)(ba)(i) has details of supply over time for the regions. The two recoverability levels represent an aggressive (Level 1) and conservative (Level 2) prediction of the quantity of material recovered, taking into account access to sites and distances from the mills and incumbent use.

Table 1: Low Point in Supply Volume by Recovery Level

s 9(2)(b)(ii) and s 9(2)(ba)(i)

Table 2. s 9(2)(b)(ii) and s 9(2)(ba)(i) Recoverability Level 2 –

s 9(2)(b)(ii) and s 9(2)(ba)(i)

3.1.3. Opportunities for Further Analysis

Further analysis of the impact from changes to New Zealand's National Environmental Standards – Commercial Forestry (NES-CF) for increased removal of residues would be beneficial. These changes may increase the amount of biomass available in certain regions, however these impacts will take some time to become apparent in terms of actual in-forest operations. Analysis of historical data on slash and harvesting operations studies would provide some valuable insights.

It may also be beneficial to look at the Life Cycle Analysis (LCA) in terms of greenhouse gas emissions (GHG) of different uses for K-grades logs and the comparison of using them for SAF production in New Zealand relative to low value uses (e.g. concrete formwork) in export markets such as China.

Scion's analysis is based on existing biomass resources (areas that are already planted) and analysis of the potential to establish new areas of forest was out of scope. This may be a means to increase woody biomass supply in some areas to make a resource large enough to enable a plant, or to provide supply in the 2035 to 2040 period. Analysis of this opportunity including its GHG footprint would be of value.

3.2. Supply Chain and Operations

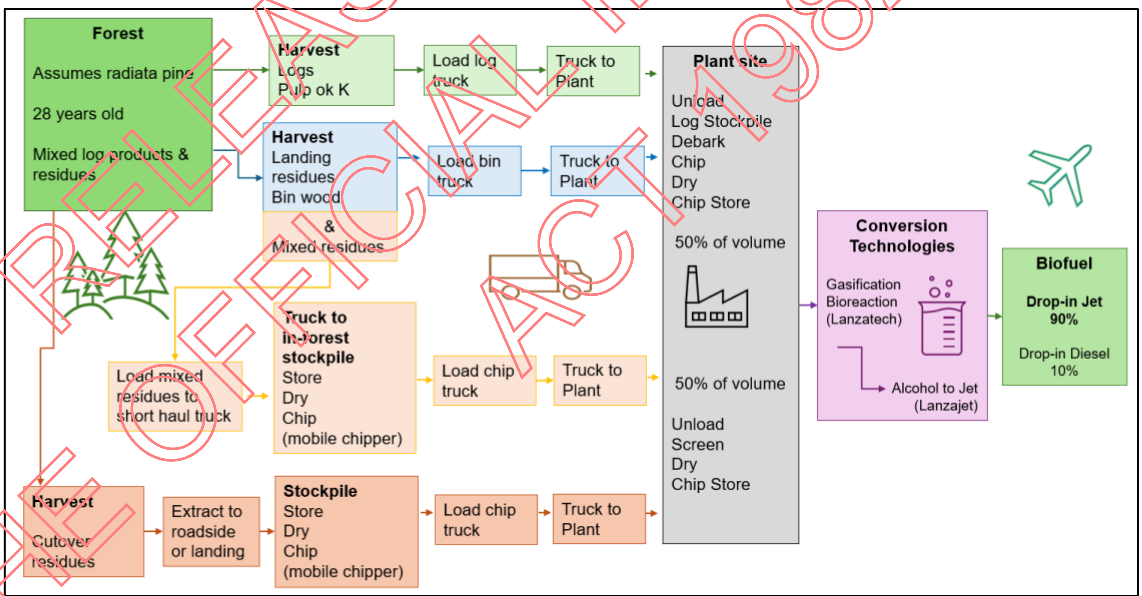
3.2.1. Feedstock Operations

Scion assessed the forestry supply chains for logs and residues, their costs, GHG emissions and levels of employment. The summary of that work is presented in this section and [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] The key objectives of this study were to:

1. Describe the supply chains and their GHG emissions for woody biomass resources available in each of the three short-listed regions:
   i. s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]
   ii. [redacted]
   iii. [redacted]
2. Estimate a cost range for the key biomass resources based on existing residue and log delivery systems and system concepts where required;
3. Estimate the number of employees required to deliver the biomass at the necessary scale; and
4. Identify forest owners and managers, mill owners, and potential fuel wood suppliers in each region.

An outline of the forest to mill supply chain for the various types of woody biomass generated in a forest harvesting operation is shown below in Figure 2.

Figure 2: Forest to Mill Supply Chain



There are four distinct, yet similar, supply chains to consider, each depending on the material being harvested. These include low value logs, bin wood from logging landings, mixed residues from landings, and stem material salvaged from cutovers. Figure 4Figure 3 to Figure 7 provide examples of the various material being harvested and where it is generated during the harvest process.

Figure 3: Standing Tree to Felled Stem, Logs and Residues

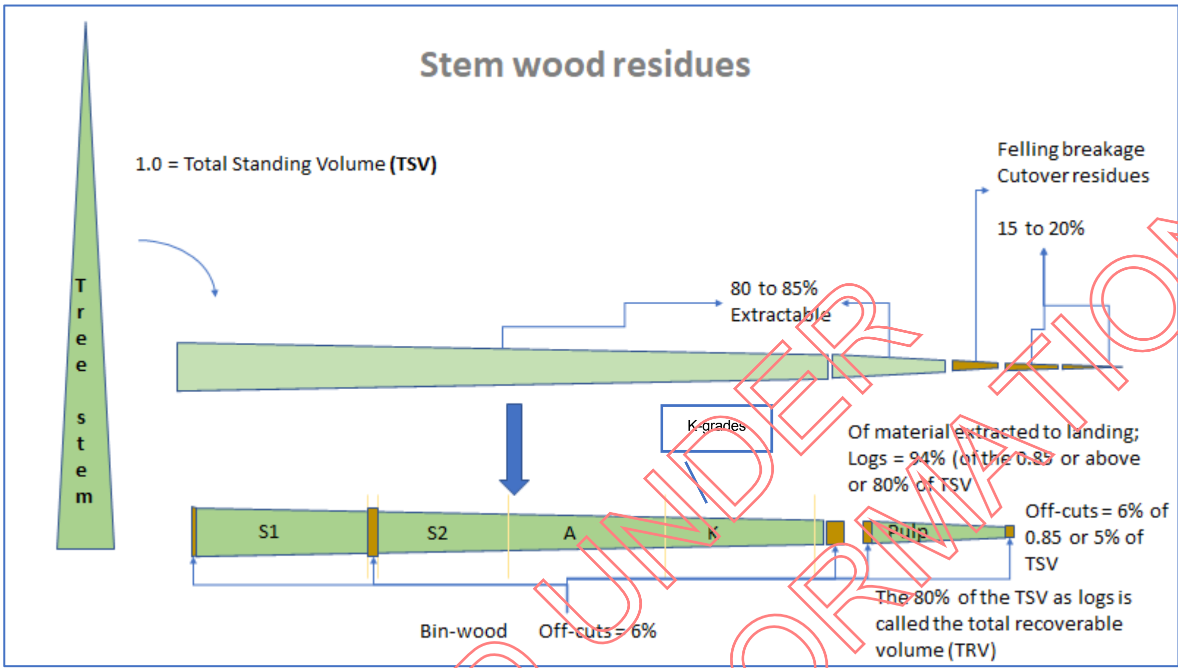


Figure 4: Landing Residues

Figure 5: Cutover Residues (Steep Terrain)

Figure 6: Cutover Residues

Figure 7: Bin Wood

The types of systems used for harvesting the residues are consistent across regions although the proportions of each differs. Transport distances will change by region with [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i) having a significantly longer average haul distance to deliver forest derived biomass to a mill.

The log grades being considered for use will be delivered by a conventional log supply chain and the typical delivered price for these logs is as follows:

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

New Zealand pulp log prices (Figure 8) and K-grade logs (Figure 9) were obtained from published sources. Average prices and are reported for green tonnes delivered to a wharf or mill. The average transport distance for the s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] was estimated at ~90km.

Demand for pulp logs from the existing industry is expected to remain reasonable static in the medium term, with supply of pulp logs expected to be steady, but with a decline estimated around 2035.

Figure 8: NZ Average Prices for Pulp Logs (Delivered)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

The demand for pulp logs is largely driven by

s 9(2)(b)(ii) and s 9(2)(ba)(i)

The price of pulp logs has not kept up with the rate of inflation. In January 2020 pulp logs were *s 9(2)(b)(ii) and* per green tonne, if the price had kept up with inflation these logs would be selling for around *s 9(2)(b)(ii) an* per green tonne.

The prices for the different K-grades (largely going into export markets) are variable compared to pulp log prices (domestic market). The bulk of the K-grade logs are either K or KIS. Prices for K-grades have ranged between *s 9(2)(b)(ii) and s 9(2)(ba)(i)* per green tonne delivered to wharf or mill over the last three years. KIS logs have varied from *s 9(2)(b)(ii) and s 9(2)(ba)(i)* per green tonne.

The trend over the last 3 years is for the price of K-grades to be declining slightly around a highly variable price. The average price for K and KIS over that period have been *s 9(2)(b)(ii) and s 9(2)(ba)(i)* *s 9(2)(b)(ii) ar* respectively. The fluctuations in prices are linked to the volume in demand from China, where they are primarily used for concrete form work and boxing. The price of K-grade logs is not aligned with inflation.

Figure 9: NZ Average K-grade Log Prices (Delivered)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

There are no well-established public information sources on fibre derived from forest residues. Therefore, estimates of these were developed by describing potential harvesting systems and their costs, based on past studies. These values include a stumpage fee of NZD *s 9(2)(b)(ii) and s 9(2)(ba)(i)* *s 9(2)(b)(ii) and s 9(2)(ba)(i)* for the biomass supplied.

Table 3: Summary of Estimated Residue Supply Costs

Residue	NZD/green tonne
Bin Wood	*s 9(2)(b)(ii) and s 9(2)(ba)(i)*
Landing Residues	
Cutover Residues (Rolling Terrain)	
Cutover Residues (Steep Terrain)	

The transportation factored into the feedstock costs in Table 3 represent the *s 9(2)(b)(ii) and s 9(2)(ba)(i)* nd an estimated average transport distance of 90km. For *s 9(2)(b)(ii) and s 9(2)(ba)(i)* the average transport distance for logs could be 125 km and for a operation with a hub and spoke arrangement it would be close to 100 km (Table 4).

Table 4: Costs of Biomass Transport by Region; $/t/km and ($/t delivered)

Region	One way Haul distance (km)	Log	Chip	Bin
s 9(2)(b)(ii) and s 9(2)(ba)(i)	90	*s 9(2)(b)(ii) and s 9(2)(ba)(i)*		
	125			
	100			

[2] Excludes the cost of chipping and drying.
[3] Delivered at 35 per cent moisture content by weight.

Scion also estimated the lifecycle GHG emissions associated with the feedstock supply chain. The scope of this analysis includes emissions associated with forest growing, logging and recovery, and transportation to the mill (Table 5). s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

Table 5: Lifecycle GHG Emissions by Residue

Category	kg CO2e/tonne (100km)
Bin wood	s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]
Landing residues	[redacted]
Rolling cutover residues	[redacted]
Steep cutover residues	[redacted]

Employment in the supply chain was also estimated by Scion. There are no effects on employment in forest growing or conventional logging or log transport as these operations would occur otherwise. The direct, indirect, and induced employment numbers were estimated for a single site operation in s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] eceiving s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] m^3 per annum of feedstock (Table 6).

Table 6: New Employment

Work area	No. of Direct Jobs	Indirect multiplier	Induced multiplier	Total
Residue harvesting	59	68	31	158
Chip transport	29	34	15	78
Total	88	102	46	236

3.2.1.1. Opportunities for Further Analysis

An operational study of Shane Hookers cutover log salvage operation in the s 9(2)(b)(ii) and s [redacted] ould be of value. This is a simple small-log from cutover salvage operation targeting residue from flat to rolling terrain using a 20-tonne excavator, with a log grapple, towing a sled with a log bunk. No production or cost data of this operation has been benchmarked for residue recovery efficiency. This operation would potentially be effective at scale with a modified log specification.

Also of value is an analysis of the wood pellet market internationally and its implications for New Zealand, e. g., the emergence of a new and substantial market in Taiwan, which may be a source of fibre competition.

Scion also recommended developing a project with s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] region forest growers to assess the volumes of residues that may become available on steep logging sites, based on the revised NES-CF and the Interpine drone image capture system for slash assessment. This project would require collaboration of multiple parties.

Finally, the potential use of densified sawdust and chipper fines, in the form of pillow briquettes) as a feedstock suitable for feeding into the gasifiers should also be investigated.

3.2.2. Downstream (Products)

3.2.2.1 Overview of SAF Supply Chain

An initial feasibility of a SAF supply chain from s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] to Auckland International Airport Limited (AIAL) has identified three potential supply chains:

s 9(2)(b)(ii) and s 9(2)(ba)(i)

1. [redacted]
2. [redacted]
3. [redacted]

Figure 10: SAF Supply to Auckland Airport

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

The option proposed in the current cost estimate is to rail the manufactured SBC from s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] Then blend the SBC into mineral Jet A1 at s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] to produce SAF. This option necessitates additional infrastructure, as detailed later in this report. In summary, this includes:

- the building of additional tankage on that site (up to s 9(2)(b)(ii) and [redacted] Litres), current design has provisioned s 9(2)(b)(ii) and s 9(2)(ba)([redacted] tanks,
- reconfiguration of the existing Tanker Truck Loading Rack (TTLR) at the site to enable jet fuel delivery; and

- a rail siding with 'gantry' for onload / offload of the railway wagons (includes additional pumps, pipework, and containment bunds) and truck loading arms at s 9(2)(b)(ii) and s 9(2)(ba)(i) and then truck or rail blended SAF to s 9(2)(b)(ii) and s

More detailed engineering assessment of all options – from both fiscal, and feasibility perspective – must occur at the next stage of the project to confirm the optimal supply chain design.

The key constraints in all options of the supply chain relate to product quality requirements (referred to as certification, quality assurance or product quality testing) for blending SBC into the jet supply chain and building sufficient supply chain resilience. Based on current product quality requirements (refer ASTM D7566 (and relevant Annex), DEF STAN 91-091 latest Edition, EI/JIG1530, EI1533), each batch of SBC must be certified as SBC before it is blended with mineral jet fuel. The blended (SAF) product must then be certified to comply with the appropriate jet fuel standard, including any extra tests as detailed in the relevant Annex in ASTM D7566. The current jet supply chain does not have sufficient tankage to enable these additional testing steps. Currently, jet supplied to Auckland is usually recertified at s 9(2)(b)(ii) and s 9(2)(ba)(s 9(2)(b)(ii) and s and then sent via the s 9(2)(b)(ii) and s 9(2)(ba)(i) where it is again recertified as detailed in EI/JIG1530 (only basic testing required) before being sent to the airport. As a result, to enable this new SBC product to be supplied and then blended into the jet supply chain, we will require extra tankage at either s 9(2)(b)(ii) and s 9(2)(ba)(i) The purpose of these tanks is to enable storage and batching of the SBC (recertification test required) and blending with mineral jet, with sufficient residence time prior to testing and (eventual) release.

Consideration must also be given to establishment of more localised testing capability within the local area near s 9(2)(b)(ii) and s 9(2)(ba)(i) Currently all jet fuel testing fo s 9(2)(b)(ii) and s 9(2)(ba)(i) recertification) is completed by IPL located at s 9(2)(b)(ii) and s 9(2)(ba)(i)

To give resiliency to the supply chain, the current cost estimate includes pump back capabilities at s 9(2)(b)(ii) and s 9(2)(ba)(i).

3.2.2.2 Overview of Renewable Diesel (RD) supply chain

Currently, RD can only be sold in NZ after it is blended with fossil diesel to meet the diesel specification (100 per cent RD does not meet fossil diesel fuel specification). It is assumed that the 11 million litres of RD from the plant each year is trucked to s 9(2)(b)(ii) and s 9(2)(ba)(i) where it can be blended with fossil diesel in the existing tankage.

3.2.2.3 Onsite tankage and loading facilities

To facilitate steady operation of the plant and manage the product quality requirements for jet fuel, it is proposed that the plant have s 9(2)(b)(ii) and s 9(2)(b product tanks. Based on the planned product yield (maximizing jet production), four of the tanks are to be in SAF service and two to store RD.

Table 7: SAF and RD Storage

SAF Tankage	RD Tankage
s 9(2)(b)(ii) and s 9(2)(b tanks: 1. Plant product rundown receipt 2. Tank settling and certification testing 3. Loading out tank to rail gantry 4. Spare batch or quarantine	s 9(2)(b)(ii) and s 9(2)(tanks: 1. Plant product rundown receipt 2. Settling, certification testing and truck loading

While a typical fuel supply chain would use larger tanks which may provide some capital efficiencies, a minimum of s 9(2)(b)(ii) a anks is recommended to provide the necessary flexibility to mitigate operational issues.

Onsite certification of the products is important so that product quality issues can be corrected by the plant or by blending. It also enables a title transfer to occur in case the product changes title when it is loaded out (as may be the case if the supply chain is owned by a different entity to the plant).

Based on the current location of the plant, it is recommended that a rail supply chain be contemplated in the initial plant design. Both the current plant location, s 9(2)(b)(ii) and s 9(2)(ba)(i) s 9(2)(b)(ii) and s 9(2)(ba)(i) are proximate to connected rail infrastructure so this may be an optimal supply chain design. This would need to be confirmed with a more detailed assessment at the next stage of the project (and high-level agreement with the owner(s) of the existing infrastructure). For now, a rail loading gantry capable of loading at least 300kL/day is included in the design.

It is recommended that a truck loading gantry be part of the plant design that is sufficient to at least manage the RD production. Regardless of where the plant is located in New Zealand, this recommendation would hold. To provide flexibility and supply chain resiliency, even if the base supply chain for the SBC does not involve trucking, it is still recommended that the gantry and associated piping be built to enable the SBC to be loaded onto trucks.

Figure 11: Product Tankage and Gantries on Proposed Plot Plan

s 9(2)(b)(ii) and s 9(2)(ba)(i)

3.2.2.4 Recommendations for next stage

In the next stage of the project, to determine the optimal supply chain design, the following must first occur:

1. Plant location must be determined.
2. Product quality requirements to be reviewed by the industry to determine if there is a way to minimise the number of full certifications required.

Once this has been done, more detailed engineering can be done to confirm the supply chain design. In addition, engagement with rail infrastructure owners to determine loading and receipt requirements at each point will be required.

3.3. Supply Chain Risk and Resilience

Due to the nature of the feedstock supply chain for Pūrākau, it is important to have a good understanding how resilient it may be to key risks that could affect it. Scion was engaged to examine this and their work aimed to:

- Determine the risks to, and resilience of, the supply chain including economic sensitivities; and
- Identify the impacts of operating an integrated single site vs. a hub and spoke operation.

s 9(2)(b)(ii) and s 9(2)(ba)(i)

There are a variety of risks within and outside of the supply chain that need to be considered and potentially mitigated. These risks are discussed in the sections below and then summarised in Table 8.

3.3.1. Outside the supply chain

There is likely to be competition for biomass both the near-term and longer-term. There are several other entities looking at wood processing operations based at *s 9(2)(b)(ii) and s 9(2)(ba)(i)* including some using post-harvest residues as feedstock. This competition could have an impact on price and long-term supply agreements can help mitigate against this. Section 9.2.1 also discusses the importance of long-term feedstock supply contracts with respect to de-risking the project for investors.

Competition for fibre could also come from multiple sources, with potential for products destined for both the domestic and export markets being possible developments within the wood supply catchment around *s 9(2)(b)(ii) and s 9(2)(ba)(i)*

The profitability of the plant is also sensitive to the sale price for SAF. As SAF is a nascent market and not a traded commodity (yet), forecasts and forward price curves are not available. Understanding the value of SAF in overseas markets (e.g. California) and what airlines may be prepared to pay could help inform this risk.

While there may be some concerns from NGOs and the public over the sustainability of the use of increased amounts of biomass from a forest, there is significant evidence to suggest that harvesting in-forest residues for SAF production is not going to affect site nutrition and forest productivity. There are also public concerns around the carbon impact of using biomass for energy, however in the New Zealand's context these concerns are unfounded.

Storms and floods can affect short and medium-term wood supply due to damage to transport infrastructure and disruptions to transport operations. Contingency plans are required around medium to long-term disruptions from windthrow and holding of stockpiles of up to a month's supply of feedstock may be required to mitigate against damage to roads and bridges disrupting transport.

There is some reluctance from forest growers to engage as a possible feedstock source due to their existing relationships. This is a risk to obtaining supply of K-grade logs.

There may be reduction in harvest levels due to drop in demand for the products from the primary harvest (sawlogs). As Pūrākau will rely on harvest residues and low-grade proportion of the forest harvest, supply may become constrained. Long-term supply agreements are required. On the other hand, the addition of a domestic market for the low-grade logs may be welcomed by forest growers.

There is a role for government to play in reducing risk through various mechanisms, including fuel standards or mandates, tax incentives, subsidies, and capital grants for domestic SAF use and production. These are further discussed in Section 9.4.

3.3.2. Inside the supply chain

Biomass in chipped form is not inert unless it is stored under cover after some form of heat treatment or drying. Chipped logs or residues have sufficient moisture content, that if left in passive piles, will generate heat due to biological activity and lose biomass content. There is a risk of pile fires in some circumstances This can be reduced by good supply chain management involving passive or active drying, covered storage and minimising storage times for chipped wood. Logs do not have this issue and can be stored for 2 to 5 years.

A long-term view of the forest harvest plan within the wood supply catchment and the terrain types involved will be required and the mix of systems and therefore costs of delivered material is important.

Unstable supply from new operators with some inexperience is a risk that will need monitoring.

Workforce, especially trained workforce availability may be a limiting factor as the new enterprises are established. Co-ordination with local economic development authorities and training providers will be required.

There are a range of risks associated with logistics and transport including; shipping and port disruptions, increased fuel costs and driver shortages. There needs to be contingency plans around both moving feedstock to the plants as well as moving product from the plant.

The opportunity for co-products should not be ignored. Whilst the process has a clear target product (SAF) there is also the co-product renewable diesel. There will also be waste streams that should be examined for their potential value and recovery should not be over-looked. Biochar is a good example, and this is discussed further on in this report as a form of carbon removal and a valuable soil amendment.

The project is most sensitive to changes in product price and capital cost. While Scion performed their own sensitivity analysis regarding SAF pricing and capital cost, which was based on assumptions that had to be made earlier in the project. LanzaJet has also conducted feedstock pricing, SAF pricing and capital cost sensitivity cases based on more complete data and these are discussed in Section 0.

3.3.3. Summary of Risks and Mitigations

Table 8: Supply Chain Risks and Mitigations

Market Competition		
Risk	**Seriousness**	**Mitigations**

Potential for fibre competition from other/emerging domestic markets	Long-term serious challenge due to multiple uses and active developers	- Long-term supply agreements for residuals and K-grade logs - Analyse financial metrics of competitor uses - Develop relationships with forest growers and managers
Fibre competition from export markets	Volatile in price and volume, possible decline in Chinese market	- Seek long-term sales agreements with more stable prices - Obtain long-term supply agreements for low-grade log supply
Reluctance to change	Real risk in obtaining biomass supply from existing markets	- Establish relationships with larger growers and forest consulting groups - Secure supply agreements if possible
Freight rates	High risk due to unpredictable changes	- Monitor international shipping situation including fuel oil price - Develop contingency plans for shipping disruptions
Foreign exchange rates	Significant impact on log prices and export returns	- Monitor forex fluctuations - Plan for the impact of changes in forex rates on log prices and volumes
Fuel price variation	High risk due to substantial price fluctuations	- Sensitivity analysis on feedstock prices + fuel price adjustment clauses - Long-term supply contracts for fuel at a fixed price
Domestic gas supply	Predictable issue with medium-term constraints	- Avoid natural gas as an energy source - Explore alternative energy sources like geothermal and biomass
Public concerns over carbon emissions	Generally low carbon source from NZ plantation forestry	- Communicate the low carbon footprint of biomass clearly
Natural Disasters and Climate		
Risk	**Seriousness**	**Mitigations**
Windthrow	Infrequent but sometimes extensive and serious disruptions to log supply	- Stockpile to cover 2 to 4 weeks of demand - Contingency plan for major storms
Fire	Low risk, NZ has small but frequent fires	- Contingency stockpile for 2 to 4 weeks - Purchase and stockpile larger volume of salvage material for large fires - Monitor fire risk and maintain fire-fighting resources
Floods	Highly variable and unpredictable impact	- Stockpile sufficient to cover at least two weeks of operation

Pests and diseases	High risk due to potential damage to forests and markets	- Implement a monitoring and detection system to identify outbreaks quickly - Develop and maintain a response plan for pest and disease outbreaks - Collaborate with industry and government to manage threats
Impact of climate change on wind, fire, floods, pests and diseases	The exact impacts of climate change are not yet clear but predictions are that storms with severe wind and flood events will become more frequent. The range of insects and diseases and their impacts on tree crops may also become worse if weather becomes warmers and more humid.	These impacts could impact future volumes and their costs. The changes to climate and their impacts on forest growing need to be monitored
	Policy and Regulation	
Risk	**Seriousness**	**Mitigations**
Certification	Serious risk if certification is not possible for K-grade logs	Work through ICAO and RSB for certification. Work with MPI and forest industry to develop a local scheme. Consider short rotation energy/fibre forests Monitor FSC status of major growers
ETS and Carbon Price	Volatile, significant impact on forestry operations	- Hedge against future price rises in NZUs - Assess impact of NZU price scenarios on forestry activity
Biofuels mandates, obligations or fuel standards and incentives	Critical for the development of a domestic SAF industry, potential impact from neighbouring jurisdictions	- Investigate current and potential biofuel mandates, obligations, fuel standards and support mechanisms
Political environment risk	Rare but substantial short and long-term effects	- Ensure compliance with resource consents and NES-CF regulations - Conduct independent audits if necessary
	Supply Chain and Infrastructure	
Risk	**Seriousness**	**Mitigations**
Local processing failures	Low risk of major disruption in s 9(2)(b)(ii) and s 9(2)(ba) [redacted] imminent closures in other regions	- Monitor local mills and anticipate potential changes in log supply - Plan for increased or decreased log supply based on mill closures
Labour shortages	Significant as could affect harvesting, transport, and operations	- Develop a workforce strategy to attract and retain skilled workers - Offer competitive wages - Collaborate with industry and educational institutions to train new workers - Implement measures to improve worker safety and well-being

Infrastructure limitations	High, it can lead to increased costs and operation disruptions	- Assess current infrastructure and identify gaps - Invest in infrastructure improvements and maintenance - Collaborate with local authorities and industry to address limitations
	Long-term Sustainability	
Risk	**Seriousness**	**Mitigations**
Forests are not replanted	Long-term impact, currently unlikely	- Monitor trends and consider tree planting / forest establishment to secure feedstock supply

3.4. Supply Chain Partners

The supply chain needed to support Pūrākau will be extensive, with several key partners and suppliers playing important roles up and down the supply chain.

3.4.1. Feedstock Supply Chain Partners

s 9(2)(b)(ii) and s 9(2)(ba)(i) identified several key suppliers of feedstock that should be considered and ultimately engaged as the project moves forward. Potential suppliers are broken down into three categories:

- Forest growers and managers who have control of the primary biomass resource;
- Wood processing mill owners who produce residues, this includes an estimate of the volume of residues that they may have available after existing use (internal use for process heat and external sales to other processors); and
- Wood fuel suppliers who are currently operating and who could be part of a forest biomass feedstock supply chain. These include those active in the existing wood fuel market as well as those who have equipment that could work in the wood fuel supply chain but are currently working in other markets (mulch, landscaping, land clearing, animal bedding etc).

3.4.1.1. Forest Growers

Over half (52.1 percent) of the total forested area in New Zealand, amounting to 917,061 hectares, is under the ownership or operation of just six organisations. Among these, five control quite large areas, each exceeding 150,000 hectares. Table 9 details the forest growers across the North Island by region, including the top six growers by total hectares controlled.

Table 9: Forest Growers (North Island)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

3.4.1.2. Wood Processing

There is only a minimal amount of wood processing residue in New Zealand that is not utilized in some form, such as boiler fuel, wood pellet feedstock, animal bedding, landscaping, or potting mix. Most mills burn their on-site residues as a source of heat for product drying or process heat. There are only a few mills who do not utilise their residues in this way. Some s 9(2)(b)(ii) and s 9(2)(ba)(i) also generate electricity along with the heat they produce. The use of the residues on site for heat production is the main reason there is little in the way of wood processing residues available for use outside of the wood processing industry. It is worth noting that a lot of the residues produced by sawmills and other processors are in a form that is not suitable for use in the gasifiers as specified in this project. Therefore, wood processors are not likely to play a significant role in the Pūrākau supply chain.

3.4.1.3. Wood Fuel Processors

In New Zealand, various companies specialise in using residues from wood processing operations to produce wood fuels, including hog fuel, wood chips, wood pellets, and briquettes.

Scion identified 41 producers and suppliers s 9(2)(b)(ii) and s 9(2)(ba)(i) This category includes 7 wood recyclers, noted as key players due to the sustainable nature of their business, and 7 animal bedding producers who incorporate wood chips into their product range. Scion also identified an independent contractor who specialises in cutover salvage in the s 9(2)(b)(ii) and s 9(2)(ba)(i)

3.4.2. Downstream Supply Chain Partners

It is assumed the downstream of the Pūrākau production facility the logistics associated with SAF and renewable diesel will be primarily handled by Z Energy. Section 3.2.2 describes Z

Energy's role and what will be required to deliver products to Air New Zealand and other customers.

4. Engaging with the Māori Economy

It has been identified that engagement with the Māori economy will be advantageous in advancing this project. The Māori economy is defined as all known assets owned, wealth generated, and income earned by Māori. Broadly meaning that the Māori economy comprises of people, assets and business:

- Māori people – Māori employed in the labour market as well as Māori employers.
- Māori assets – including assets from Iwi, Collectives, Trusts and Incorporations and business.
- Māori business – including Māori businesses and Māori in business.

The Māori economy is valued at more than NZD $70bn, and estimates suggest this will grow to NZD $100bn by 2030 (NZTE, 2017). Maori represent 32.9 per cent of the population in the s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] region, 39.9 per cent in s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] and 56 per cent in s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] Stats NZ, 2023). Māori trusts and incorporations own $4.3 billion of assets in forestry and have ownership of more than 30 percent of land under plantation forestry and large areas of indigenous forest (Te Uru Rākau, 2022).

The Māori engagement leads from Scion, Air New Zealand and Z Energy have initiated engagement with Māori on three specific collaborative opportunities:

1. *Mana whenua (Māori with ancestral and territorial rights to an area)* - Establishment of a SAF feedstock processing plant to generate economic development outcomes and create a new, sustainable, diversified industry
2. *Māori forest owners and Māori landowners* - Promotion of bio-feedstock for SAF as a land-use opportunity and an alternative use of wood
3. *Iwi Holding companies* - Direct investment

The approach for this engagement is targeted to specific Māori entities that the Māori engagement leads have identified as being most relevant to the above collaborative opportunities. As such, high-level discussions have been held with a Māori land trust with industrial land that could be a potential site for a SAF processing plant; a Māori forest owner, who is also an Iwi Holdings company, that could supply feedstock and consider direct investment. Both have expressed keen interest in the opportunity. [redacted]
s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] Engagement with mana whenua is at its very early stages.

5. Project Location

5.1. s 9(2)(b)(ii) and s 9(2)(ba)(i)

Based on the outcomes of the feedstock analysis in section 3.1, the s 9(2)(b)(ii) and s 9(2)(ba)(i) emerged as the most logical region for the project given the significant amount of feedstock available now and into the future.

s 9(2)(b)(ii) and s 9(2)(ba)(i)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

Figure 12: Plantation Forests (Light Green) in

s 9(2)(b)(ii) and s 9(2)(ba)(i)

Figure 13: Existing Industry and Infrastructure in [redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

5.2. Utilities Considerations

This section explores available services and utilities in the genera s 9(2)(b)(ii) and s 9(2)(ba)(i) area. Whilst no specific location for the plant has been identified and the study is site agnostic, examples from this area were used to inform design decisions for the processing plant OSBL scope.

Supply of Utilities:

- Electricity - Within the district boundaries of s 9(2)(b)(ii) and s 9(2)(ba)(i) are multiple geothermal power plants and large industrial power consumers. Associated with these are HV substation and associated transmission lines. Detailed network modelling is required to determine what capacity (if any) is available in the area. Other industrial sites in the area do generate a portion of their own electricity where possible (typically in heat recovery boilers and waste material boilers)
- Water – s 9(2)(b)(ii) and s 9(2)(ba)(i) has reticulated water supply, with larger industrial plants and agricultural consumers having their own intakes and do not use the reticulated supply. The area has sources of ground and surface water s 9(2)(b)(ii) and s 9(2)(ba)(i) s 9(2)(b)(ii) and s 9 . Other industrial plants have surface water intakes from the river and their own treatment and reticulation systems, not using the district or municipal systems. It is worth noting that the s 9(2)(b)(ii) and s 9(2)(ba)(i) rea is a geothermal area, and that ground water would likely have a high mineral concentration.
- Gas – Centralised distribution doesn't exist so a special connection would be required for any new consumers. Other industrial sites in the locality have their own connection to the national gas distribution network and hence any new connections would need to be in conjunction with these.

Effluent Streams:

- s 9(2)(b)(ii) and s 9(2)(ba)(i) has a local district council which provides the following:
  - Centralised municipal wastewater system (which treats residential waste)
  - Centralised municipal stormwater system (which treats residential waste)
  - Centralised residential kerbside waste and recycling collection
- Industrial sites in the locality of comparable size have:
  - Onsite wastewater treatment and discharge treated water back to the s 9(2)(b)(ii) and s 9(2)(ba)(i) s 9(2)(b)(ii) and s 9 This includes treated domestic, industrial and stormwater.
  - Have their own landfill facility located approximately 10km from the plant.

Access & Proximity:

- Road access – s 9(2)(b)(ii) and s 9(2)(ba)(i)
- Rail Access – There is an existing spur line to the wood processing industrial area. The existing industrial users primarily use this for export, as opposed to receiving raw materials.
- Air Access – s 9(2)(b)(ii) and s 9(2)(ba)(i)
- Port Access s 9(2)(b)(ii) and s 9(2)(ba)(i)

People and Labour:

- The area has existing heavy industrial facilities with associated and well-established services and utilities providers.
- The locality has a township with existing residential, hoteling and other accommodation options independent to the industrial facilities. s 9(2)(b)(ii) and s 9(2)(ba)(i)
- Emergency Services – within the locality are Fire and Police and Ambulance Stations. s 9(2)(b)(ii) and s 9(2)(ba)(i) Large industrial sites in the area do have their own ERT team (Fire and Ambulance) and part-time medical coverage.

At this time, no capacity modelling or surveying has been completed for the s 9(2)(b)(ii) and s 9(2)(ba)(i) ocality. An assumption of availability and capacity of existing networks to handle additional demands. As a result, this project will require detailed analysis and consultation to be done (e.g. power network modelling with Transpower and local power companies, traffic management plans and capacity with NZTA and KDC, and more).

5.3. Storage and OSBL Considerations

The following requirements should be considered for any potential site for the processing plant. Estimated utility demands:

- Water Supply – A fresh water source with a peak value of approximately s 9(2)(b)(ii) and s 9(2)(ba)(i) This is exclusive of any water recovery or recycling to optimise water usage (assumed for the purpose of the study).
- Power Supply – A peak continuous power demand of around s 9(2)(b)(ii) and s 9(2) (assumed for the purpose of the study).
- Gas supply – A peak operating natural gas demand of s 9(2)(b)(ii) and s 9(2)(ba)(i) for boiler operation, however it has been assumed that this will be offset by the recycle of biogas and tailgas from the process.
- Treated Wastewater Discharge – Estimated daily peak discharge of s 9(2)(b)(ii) and s 9(2)(ba) ignoring stormwater return events which has been estimated as a peak of s 9(2)(b)(ii) and s 9(2)(ba)(i) ased on a 14 day return and nominal catchment areas).

Access and Vehicle/Transport Movements:

- Truck movements will require the facility to be located near a major highway or access road to a major highway:
  - Solid and liquid waste removals. Approximately s 9(2)(b)(ii) and s 9(2) ucks movements per year are expected to handle solid and liquid wastes and by-products from the processing plant.
  - Ingredient shipments (major and minor) is expected to be by truck only and constitutes an additional s 9(2)(b)(ii) and s 9(2)(ba rucks/trailers per annum.
- Train Movements:
  - Finished products shipment is intended to be via train tanker, which would equate to around s 9(2)(b)(ii) and s 9(2) ucks per annum. Therefore, rail would be preferable.
  - Currently the project has not made provision for byproduct or ingredient shipment via rail.

People, Services and Labour:

- Staffing of site – current estimates indicate a peak of approximately 56-57 directly employed staff onsite and a total workforce of around 165 persons to allow for 24 hour operations (excluding contracted labour, such as; cleaning, security, turnaround or major maintenance events) – facilities and transport for these persons need to be considered in the local area(s). The breakdown of the roles is provided below and was developed based on 8hr rosters and estimates by the study team. Consideration could be given to a 12hr roster which would reduce these figures and the balancing between contracted and direct employed services.

Table 10: Personnel levels / breakdown

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

TOTAL	**56.5**	**165**

- Services and utility providers - ideally the site would be local to specialist service, equipment and labour providers outside of the skillset of the onsite workforce for specialist maintenance tasks and the like.
- The proximity of emergency service providers will be an important consideration, as there would otherwise be a need for dedicated ERT facilities onsite and the appropriate sizing of fire protection systems.

5.4. Planning and Consenting Considerations

As a site is yet to be selected the planning and consent considerations in this section are provided as an indication only of what could be expected from a project of this nature and scale. Further work will be required once a site is selected and the local planning requirements and restrictions are identified.

5.4.1. Overview of Planning Considerations

For a project of this scale, it is likely that a suite of resource consents would be required under the Resource Management Act 1991 (RMA), and the relevant National, Regional and District level legislative documents. It is recommended that a Consent Strategy is developed as soon as a site is selected. A Consent Strategy will set the objectives of the project and the requirements under the relevant legislative documents. A Consent Strategy will consider all the planning pathways available for the project and the costs and benefits of each. Additionally, it is recommended that the Consent Strategy also include an engagement strategy for early engagement and communication with the following groups:

- Mana whenua / Iwi – Depending on the actual site identified for the project the appropriate Iwi/Hapu to be identified.
- Surrounding landowners
- Local and regional councils
- The wider community

The following are possible resource consenting pathways for the project that can be assessed further in a Consent Strategy once the site is confirmed. Noting that the preparation of technical reports to form the Assessment of Environmental Effects required to support an application for all consenting pathways are similar and can take approximately 6 to 12 months to prepare. Typically for a project of this scale, resource consent approvals can take between 1- 2 years once lodged with an authority. This means the process could be between 1.5 to 3 years.

5.4.2. Resource Consent Applications

The proposed project will likely trigger multiple resource consent requirements from both the relevant regional council and district council. One pathway is to prepare resource consent applications to both councils, supported by technical reports, following a more traditional pathway under s88 of the RMA. This would likely be considered a notified application, meaning that the council can choose who is considered an affected party or could decide to publicly notify the applications, giving the wider community a chance to submit on the proposal.

This process could result in a council level hearing and can typically take 9-18 months from lodging the application to a decision. If the consent application was publicly notified and submissions were received, it is noted that there are appeal rights to any decision on the application.

5.4.2.1. Private Plan Change Application

Another avenue open to the project is to submit a private plan change application to the relevant councils. This largely follows the format of a resource consent application however requires an additional assessment under s32 of the RMA to ensure the proposal is the most effective and efficient use of the land. The process also includes the council deciding on potentially affected parties and also notifying the community for submissions, including a hearing. The timeframes and technical input would be largely similar to the consenting process. The benefit of a plan change is that it can future proof the site for further expansion or changes to the site that would otherwise require additional resource consents.

It should be noted that depending on the consenting triggers for the project, a decision to carry out a combination of the above two options can be made; a private plan change for one plan (regional or district) and a traditional consenting pathway for the other.

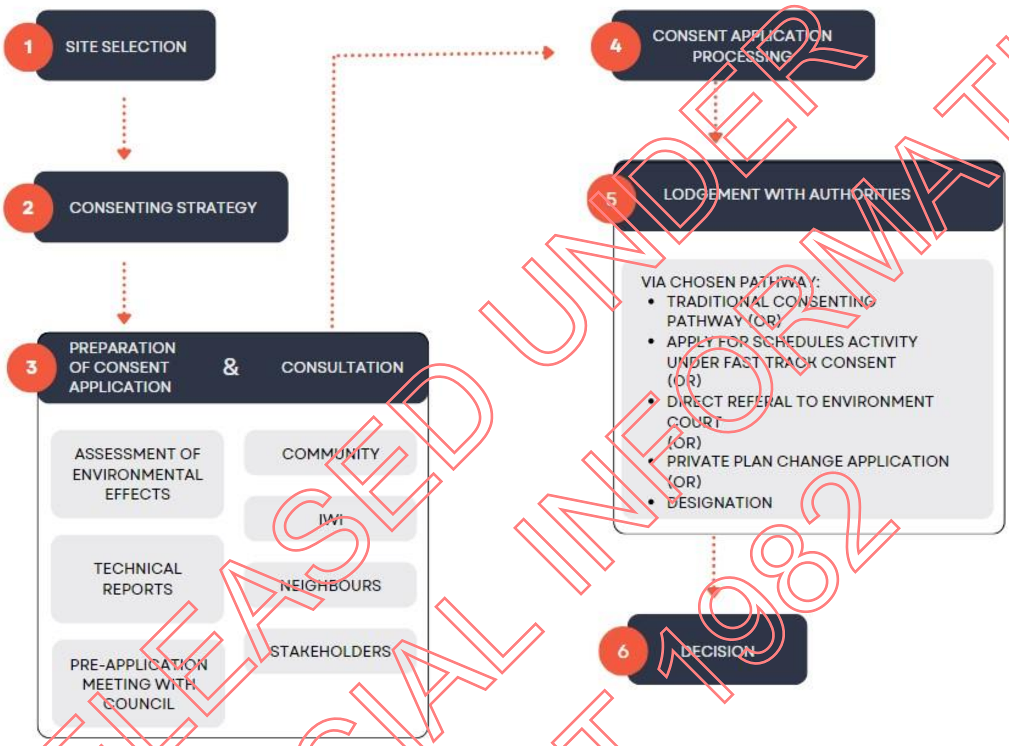
5.4.2.2. Designation

Like the Private Plan Change option above, a Designation creates a change to the district planning map that allows a “Requiring Authority” to operate and maintain a utility. To be able to make an application for a Designation, i.e. to be a “Requiring Authority”, the entity must be listed as such under the RMA. The following entities related to this project are listed as

Requiring Authority and are able to make a Designation on a piece of land; Airways Corporation of New Zealand Limited and Shell New Zealand Limited (now Z Energy Limited), as well as a number of local and regional airports depending on the site that is chosen.

A designation protects the site and allows future growth often without the need for additional consents.

Figure 14: Overview of planning/consenting pathway



5.4.2.3. Fast Track Consenting

Similar to the traditional consenting pathway, the fast-track consenting pathway may be available. This process is currently quite fluid with many ongoing changes by the New Zealand Coalition Government, which has created some uncertainty on timing. In March 2024 the Fast-track Approvals Bill was introduced to Parliament for Select Committee review. At the time of writing this report, the Select Committee has received a large amount of submissions, largely in opposition to the structure of the new Bill, and has not given any indication of the timeframes for referrals and approvals.

This project meets the requirements under the Fast-track Approvals Bill and is therefore a viable option. The intention of this process is to reduce the time taken to approve projects. At the time a consenting strategy is written, the latest fast track consenting framework can be assessed.

5.4.2.4. Direct Referral to the Environment Court

The direct referral process allows applicants to make a request to a council that their notified resource consent or notice of requirement (for a designation) application be decided by the Environment Court, rather than the relevant council. When an application is notified (publicly notified or limited notified), it is open to written submissions from people who may be affected by it, and then usually proceeds to a council hearing for a decision. In the case of direct referral, while the council still notifies the application and receives written submissions, the application is then transferred to the Environment Court for a decision, bypassing the council hearing and decision stage. The direct referral process streamlines decision-making for large scale and/or complex applications that are otherwise likely to end up in the Environment Court on appeal following the council hearing and decision. The direct referral process is intended to save time and costs for both applicants and submitters.

5.4.3. District and Regional Consenting

5.4.3.1. District Plan

The district zoning is important to consider when selecting a site for the project. Generally, the Industrial Zone would be most supportive of the proposed project, followed by the Rural / Rural Lifestyle Zone. It would be more difficult to obtain approval for a site located in a Commercial Zone and very difficult in both the Residential and Reserve Zones.

Under the relevant District Plan the following activities would need to be considered to determine resource consent triggers.

- Vehicle movements to and from a site
- Unanticipated land use, triggering bulk and locational rules such as height, setbacks, gross floor area, coverage etc
- Noise standards
- Use and storage of hazardous substances
- Earthworks during construction
- Provision of services such as water, wastewater, electricity etc

5.4.3.2. Regional Plan

Under the relevant Regional Plans, the following activities would need to be considered to determine resource consent triggers.

- Air discharge – the exact contaminants and level of contaminants emitted will be needed to inform any air discharge application. It is noted that treatment of contaminants in the discharges to air may be required to obtain consent.
- Water take – given the volumes required for the project, it is unlikely sufficient surface water allocation would be available and therefore a groundwater source will be required. Allocations for groundwater are reviewed periodically by Councils and at the time of selecting a site and preparing a consent strategy, the available allocations can be determined.
- Wastewater discharge – discharge to land soakage is preferred over a direct discharge to surface water. However, it is likely that the volumes of wastewater to be discharged from the site will be too high to enable a discharge to land soakage. Any discharge of wastewater to surface water will require a high level of treatment.
- Stormwater discharge – due to higher impermeable surfaces, stormwater will require adequate management and likely some form or treatment and attenuation (e.g. swales) prior to discharge.
- Earthworks during construction.

5.4.4. Site constraints

When choosing a site, the following would prove more difficult to obtain a consent and should be avoided if possible:

- Sites identified as Outstanding Natural Landscapes
- On land in very close proximity to streams/rivers/natural freshwater bodies/wetlands
- In the Coastal Marine Area
- In close proximity to residential areas or reserves
- In close proximity to natural habitats for indigenous species such as long tailed bats, mud fish, etc.
- A site large enough to be able to provide adequate setbacks from the road and other boundaries to allow planting/landscaping. The distance will be based on the underlying zone the site is in and surrounding land uses, can generally range between 5m and 20m.

Ideal locations from a consenting pathway would be, in order of preference, land in the Industrial Zone, land adjacent to the Industrial Zone or the Rural Zone.

5.4.5. Supporting technical information

Any application for resource consents regardless of the consenting pathway discussed above, will require a fulsome Assessment of Environmental Effects, which would, at the minimum, require the following technical assessment reports:

- Urban Design Report
- Water Report – Water Supply and Wastewater
- Stormwater Report
- Geotechnical Assessment
- Landscape and Visual Assessment
- Air Discharge Assessment
- Traffic Impact Assessment
- Hazardous Substances assessment

The following technical assessments are dependent on the site chosen and may also be required:

- Noise Assessment – if close to residential or significant habitat areas
- Lighting Assessment – (same as above)
- Ecological Assessment
- Preliminary Contaminated Land Investigation (PSI or DSI depending on history of the site)
- Economics Assessment (depending on the zoning of the site – especially if accompanying a private plan change)

6. Process Design

6.1. Gasification and Gas Fermentation (Biomass to Ethanol)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

6.1.1. Gasification Technology Considerations

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

Table 11: Comparison of Gasification Technologies

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i)

6.2. Alcohol to Jet

s 9(2)(b)(ii) and s 9(2)(ba)(i)

6.3. OSBL Design, Site Master Plan and Layout

The Outside Battery Limits (OSBL) scope and technical requirements have been derived from inputs provided by all the parties involved in the study (LanzaJet, LanzaTech, Z Energy, Scion and Air New Zealand). Due to the high-level nature of this preliminary study these inputs have not yet been tested or verified and it is assumed this will be undertaken in a subsequent design development stage.

6.3.1. Process Site Design

OSBL refers to all the facilities and infrastructure outside the main process units, which are critical for supporting the operation of the entire plant.

OSBL typically includes:

- Utilities (i.e., power generation, water treatment, steam generation, etc.)
- Storage tanks
- Loading and unloading areas
- Warehouses
- Administrative buildings
- Maintenance workshops
- Roads and access ways
- Security systems
- Fire Protection

These components are essential for the overall functioning of the plant but are not directly involved in the core processing activities that occur within the battery limits of the main process units (ISBL - Inside Battery Limits). Both ISBL and OSBL components must work together for the operation to be efficient and safe.

The primary focus of the design is to attain a level of detail sufficient to establish an accurate order of magnitude for the cost estimate. The key design decisions and information for each of the OSBL sections/units is presented below and how they are related to the ISBL's (where appropriate).

Additionally, the assumptions or impacts of the ISBL units on the OSBL design and layout are explored. Note the approach for the OSBL systems' design has been to include a design factor of 1.2 for the demands of the ISBL packages or supporting infrastructure.

s 9(2)(b)(ii) and s 9(2)(ba)(i)

6.3.1.1. Feedstock Receiving, Handling, Chipping, Drying & Gasification

Feedstock handling and receiving is designed to store a minimum of one week's worth of wet product. A time in motion and supply chain study hasn't been done regarding the loading/ unloading facilities – based on a s 9(2)(b)(ii) and s 9(2)(ba)(i) s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] The resulting unloading time is [redacted] (assuming dayshift only operations) which may prove challenging and needs consideration in further stages.

The layout follows LanzaTech's supplied designs for the chipping, drying and gasification plants.

A single centralized VPSA has been allowed for which could include a centralised liquid oxygen backup system. It also separates the gaseous oxygen equipment from other process areas and the associated risks of oxygen and hydrocarbons.

6.3.1.2. Fermentation & Intermediate Storage

Intermediate storage includes ethanol storage downstream of fermentation, consisting of s 9(2)(b)(ii) a [redacted] s 9(2)(b)(ii) and s 9(2)([redacted] floating roof tanks. This provides a one-week buffer to the ATJ plant. Currently no provision has been made for ethanol importing/unloading and transfer to the intermediate storage tanks except from the fermentation plant, this is something that could be considered in future phases.

The intermediate storage facility also incorporates process disruption buffers from the downstream ATJ plant. Additionally, there is provision for expansion with the addition of two ethanol tanks.

The fermentation plant layout follows LanzaTech's footprint. Electrically it has been assumed there is a single significant high voltage drive associated with the compressor in the plant.

6.3.1.3. SAF Production & Product Storage

The footprint of the refining process area is per LanzaJet's designs. With the OSBL refrigeration building (housing the compressor) included within this footprint.

Final product storage includes bulk storage and truck and train loading facilities and the design is detailed in Section 3.2.2 above. The layout of product storage includes an expansion allowance for three additional bulk tanks.

6.3.1.4. Water Supply & Treatment

Raw water from the borehole system will be used for firewater supply or sent to reverse osmosis (RO) and potable water plants. Borehole implementation is complex, requiring drilling, groundwater testing, and composition analysis which may influence treatment processes:

- Due to being groundwater, a RO plant is included, this is sized at around s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] A large tank is included providing 12hrs of buffer (2,300m^3). To make the water input into the RO plant a conservative estimate, it is assumed maximum brine reject since the exact water supply isn't known.
- Demineralised water is supplied downstream of the RO plant using ion exchange technology for high-quality water for the electrolyser and boiler. The Demin plant is rated at s 9(2)(b)(ii) and s 9(2)(ba [redacted] and the storage/buffer tank estimated at s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] or approximately 1.5 days to allow for maintenance and reagent supply interruptions.
- A potable water treatment facility is included to supply domestic consumers and emergency stations onsite (between 1 - 4 L/s demand typically). A potable water buffer exists for approximately 24hrs supply onsite.

6.3.1.5. Cooling Water

A centralized cooling tower with a single circulating system has been specified for a cooling loop of 10°C (30 to 40°C). It consists of modular 25MW sized cells and a standby cell for maintenance has been included over the common cold-water reservoir.

It is noted that fermentation represents a significant cooling water demand with a low differential temperature (dT), in comparison to requirements by other users. Therefore, future phases may need to consider an optioneering study, which could include but not limited to:

- Additional pump capacity with the existing system
- Dedicated local cooling tower for fermentation

Due to footprint constraints this is currently within the plant, in subsequent phases, prevailing wind direction and interactions with other structures will need further consideration as to its positioning.

6.3.1.6. Waste Water Treatment & Disposal

Pond sizing is based on a 1/10-year event in the [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i) New Zealand, with treatment rates aligned with nominal wastewater production and a 14-day return of the 1/10-year event. Industrial wastewater treatment, detailed in the Effluent section, aims to treat all process waste and rainfall within a bunded process area (as this could be contaminated. Rainfall outside of a process area is directed to the stormwater pond for discharge. Opportunities exist to optimize treatment plant sizing, pending confirmation of the final location and detailed stream data (e.g. BOD, COD. Contaminants, flowrates, etc.).

6.3.1.7. Gaseous By Products

All gaseous by-products and wastes will be flared. Two flare stacks with three tips each are included, along with local stacks and emissions controls. Exclusion zones are based on rules of thumb since flare scenarios are not fully defined, in this case a 61m exclusion zone is provided for assuming a stack height of greater than 23m. The design assumes that fuel gas can be used for boiler operation and hence a multi fuel boiler is considered (however the operating estimates and sizing are based on only using natural gas and no credit is applied)

6.3.1.8. Liquid By Products

A small quantity of light liquid hydrocarbons and fuel oil storage (32m^3 each) is included in the OSBL design along with pumps for transfer on the basis they will be exported or consumed onsite.

The feasibility of onsite consumption or market demand for export has not been reviewed and requires further examination in subsequent phases of the project.

6.3.1.9. Hydrogen Generation

Hydrogen is generated via a [redacted] s 9(2)(b)(ii) and s ! electrolyser, to produce [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i which is fed directly to the ATJ SAF plant or stored as buffer. The current storage is estimated based on a multistage compressor skid and a transportable storage skid of networked bottles at [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i) to provide a 12-hour buffer [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i) in case of production interruption or peak demand.

6.3.1.10. Nitrogen & Compressed Air Supply

A centralized compressor plant will feed instrument air and plant air systems with dried air and includes filtration to ISO standards.

The nitrogen generation plant is sized based on peak flow demand for the intermittent consumers (no compression and storage) and for the lower purity application only via membrane production. It will be fed from the vent stream of the VPSA (used to supply oxygen to enrich the air stream to the gasifiers) whcih is lower in oxygen and requires less treatment to make nitrogen.

As the high purity nitrogen demand is lower, it is assumed to be supplied via industrial bottle from an external vendor.

6.3.1.11. Steam Supply

A new gas-fired boiler is included for steam supply of a peak of approx. s 9(2)(b)(ii) and s 9(2)(ba)(i) supply networks via two letdown stations within the boiler plant footprint.

The boiler is assumed to be multifuel to use high-calorific value waste streams from the primary processing plant. However, these have been assumed as unavailable or not used in the base case, being marked as an opportunity for future, along with other possible waste heat recovery options within the plant. In this scenario gas consumption is estimated at s 9(2)(b)(ii) and s 9(2)(ba)(i)

6.3.1.12. Power Supply

Electrical Power supply is assumed to come on site via overhead transmission lines to a switchyard located within the site boundary. Expected peak power demand is estimated between s 9(2)(b)(ii) and s 9(2)(ba)(i) nstantaneous, with annualised consumption dependent on intermittent loads.

Allowances have been made for a s 9(2)(b)(ii) and s 9(2)(ba)(i) This could be optimized based on site location. The site will use a RMU arrangement with each package or area will have its own MCC and Switchboard. Black Start capacity of 10MVA has been allowed for but requires optimisation in subsequent phases.

6.3.1.13. Solid Wastes

Currently, the design allows for solid wastes to be stored onsite in bulk with buffers for approximately one week before being trucked offsite by others. The one week buffer/stockpile is dependent on assumed material properties where no MSDS or data has been provided.

No provision is made for:

- Landfilling onsite (or own project owned land – as is done elsewhere)
- Saleable by-products packaging or bagging (when this may be necessary for sale.)
- Train loading from the stockpiles, automatic reclaiming or the like

More details on solid waste can be found in subsequent sections.

6.3.1.14. Fire Protection

Fire protection includes mixed foam, hydrant, and deluge systems, the combination of which are to be tailored to specific areas containing flammable materials. Notably:

- Fire water is supplied directly from the borefield to the fire water tanks
- A 30-minute firewater buffer is provided in the form of 2 tanks with a 2,300m^3, adjustable once proximity to the nearest emergency services hub is determined (minimum allowable is 30 minutes)
- Foam is only present for flammable liquids and solids.

Additionally, it is believed that the facility will be a MHF under NZ legislation so an importance level of 5 is assumed for the fire protection system and structures.

6.3.1.15. Site Services

Provisions have been made onsite to include the below onsite (in addition to the process areas discussed above):

- Administration & Office Buildings and Cafeteria, noting it is expected that a peak workforce onsite of approx 57 persons (excluding major shutdowns, turnarounds or construction)
- Warehousing and laydowns (uncovered) for the storage of maintenance spares, minor ingredients/reagents and other items
- Workshop with a crane for maintenance
- Central Control Room
- Laboratory space
- ERT & Security Services
- Sufficient road/traffic access to process and non-process areas including considerations for truck turn arounds and unloading.
- A landscaping buffer around the perimeter of the site – the size of which will be subject to final planning requirements (discussed in previous sections).

6.3.2. Layout / Master Plan

A site layout has been developed and a snapshot is presented below. The current site footprint is estimated as s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] A focus has been made to strategically place feedstock storage, processing units, and product storage areas, to streamline operations and reduce transportation distance and vehicle movements onsite. A precursory consideration of wind and safety distances per relevant codes in New Zealand and industry has been made.

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

Figure 15: Site Master Plan/Layout

s 9(2)(b)(ii) and s 9(2)(ba)(i)

6.3.3. Key Considerations for the Plant

The list below highlights some key risks and considerations for further development of the site layout and design that should be considered in subsequent phases. This list is by no means comprehensive:

- The New Zealand Health and Safety at Work (Hazardous Substances) Regulations of 2017 has been considered but not formalised as complete substance inventory is not established. Further analysis, including scenario and dispersion modelling and assessing the actual prevailing wind direction depending on site location, may necessitate additional clearances and spacings for equipment and tankage onsite. (as will the influence of positions of buildings to cooling towers, and stacks and the like)
- Water quality and source will determine the treatment plant equipment. Identification of suitable bores or rivers and studying of the quality etc. can be a timely exercise
- Proximity to emergency services will influence the sizing of fire systems and the type of ERT services onsite.
- This facility will be classified as an Upper Tier Major Hazard Facility under the New Zealand Health and Safety at Work (Major Hazard Facilities) Regulations of 2016 and prompt additional regulatory requirements.
- A nominal landscaping buffer of 30 meters has been included around the process plant. However, specific planning rules will likely necessitate a larger (or smaller) buffer, especially near State Highways or residential zones.
- Flare sizing and exclusion zones could expand the site footprint and require further consideration in subsequent phases.

- Increasing the feedstock stockpile size to achieve 8 weeks of buffer will necessitate doubling the size of the feedstock handling/laydown area, limited by the current plant layout.
- Water recycling and segregation of process versus stormwater may be possible depending on the final site location and building placement. This could reduce the size of the wastewater treatment plant. Conversely, further information about BOD and COD could increase the required treatment capacity.
- Connection to utilities and critical infrastructure such as roads and rails may impact design.
- Assumed site layout does not consider topographical or soil condition constraints.
- No environmental constraints such as flood levels or conservation areas considered in layout.
- Truck movements are significant and may not be practical or prohibitive (e.g. feedstock unloading) and requires more clarification in future stages

6.4. Product Specifications

6.4.1. Ethanol

The LanzaTech process produces anhydrous ethanol meeting ASTM 4806-21 and other international specifications for ethanol as a fuel blending component (see Table 12) and exceeding the ethanol quality required by LanzaJet (>99.3 wt per cent ethanol).

Table 12: ASTM 4806-21 Fuel Grade Ethanol Specification

Property	Unit	Limits	
		Minimum	Maximum
Ethanol	% (v/v)	92.1	
Methanol content	% (v/v)		0.5
Solvent-washed gum content	mg/100 mL		5
Water content	% (v/v)		1.0
Inorganic chloride content	mg/kg		6.7
Copper content	mg/kg		0.1
Total acidity (expressed as acetic acid)	% (m/m)		0.007
pHe	N/A	6.5	9.0
Sulfur content	mg/kg		30
Existent sulfate	mg/kg		4

6.4.2. Sustainable Aviation Fuel

SAF from the LanzaJet ATJ plant will meet ASTM D7566 Annex A5 specifications (Table 13) and will qualify as SAF that can be blended off with conventional jet fuel to meet ASTM D71655 specifications.

Table 13: ASTM D7566 Annex A5 Specifications

Property	Limit	ASTM D7566 Annex A5
Acidity, mg KOH/g	Max	0.015
Distillation temperature:		
10% recovered, °C (T10)	Max	205
50% recovered, °C (T50)		Report
90% recovered, °C (T90)		Report
Final boiling point, °C	Max	300

Distillation residue, % volume	Max	1.5
Distillation loss, % volume	Max	1.5
T90 – T10, °C	Min	21
Flash point, °C	Min	38
Density @15°C, kg/m^3	Range	730 – 770
Freezing point, °C	Max	-40
Control temperature, °C	Min	325
Filter pressure drop, mmHg	Max	25
Tube deposit rating @325°C	Less than	3
Cycloparaffins, wt.-%	Max	15
Aromatics, wt.-%	Max	0.5
Total paraffins, wt.-%		Report
Carbon plus hydrogen, wt.-%	Min	99.5
Hydrogen, wt.-%	Min	13.4
Nitrogen, mg/kg	Max	2
Water, mg/kg	Max	75
Sulfur, mg/kg	Max	15
Metals, mg/kg	Max	0.1 per metal
Total halogens, mg/kg	Max	1

s 9(2)(b)(ii) and s 9(2)(ba)(i)

LanzaJet's SAF must be blended up to 50:50 by volume with conventional jet fuel for commercial flights. In April 2018, ASTM International published the revision of ASTM D7566[1], which included the approved ethanol based ATJ pathway.

When blended with up to 50 per cent conventional jet fuel, LanzaJet's SAF is considered a "drop-in fuel" and offers the same chemistry of conventional jet fuel. These "drop-in fuels" are used in today's modern aircraft and engines without requiring any modifications and provide the same level of performance and safety as the conventional jet fuel.

Section 3.2.2 outlines the proposed design and approach for blending and product logistics.

6.4.3. Renewable Diesel

The RD produced by LanzaJet's ATJ process meets or exceeds ASTM D975 No. 2-D S15 diesel fuel specifications (Table 14). This fuel is also a good blending component for EN 590 diesel and meets the specifications for synthetic diesel as per EN 15940 paraffinic diesel fuel specification, which governs the next generation of cleaner transport fuel for use in road vehicles.

LanzaJet's RD is free of aromatics, sulphur, and any other contaminants and meets the specifications for paraffinic diesel, offering a clean blending component for fossil diesel or as a stand-alone diesel fuel, helping to achieve Euro 6 diesel standards.

Table 14: ASTM D975 Specifications

ASTM D975 Property	Limit	Grade No. 2-D S15[5]
Flash Point, °C	Min	52
Water and Sediment, % volume	Max	0.05
Distillation Temperature, °C 90% Volume Recovered	Range	282-338
Kinematic Viscosity, mm2/S, at 40°C	Range	1.9-4.1
Ash, wt.-%	Max	0.01
Sulfur, wt.-ppm	Max	15
Copper Strip Corrosion Rating, After 3 hours at 50°C	Max	No. 3
Cetane Number	Min	40
Aromaticity, % volume	Max	35
Cloud Point, °C	Max	Variable
Ramsbottom Carbon Residue, wt.-% on 10% Distillation Residue	Max	0.35
Lubricity, 60°C, HFRR microns[2]	Max	520

s 9(2)(b)(ii) and s 9(2)(ba)(i)

6.5. Scalability

Several factors combine to make the proposed integrated technology solution highly replicable/scalable.

- **Feedstock flexibility.** The integration of s 9(2)(b)(ii) and s 9(2)(ba)(asification technology with the LanzaTech and LanzaJet platforms is a key factor enabling scalability. Gasification unlocks the world's untold quantities of solid waste matter and gives them new life as ethanol (and in turn SAF) feedstock. s 9(2)(b)(ii) and s 9(2)(ba) asification technology can handle a wide range of solid feedstock such as biomass, MSW/RDF and tires. These are large-volume resources that can be converted to gas streams suitable for fermentation.

[5] The fuel grades S15, S500, S5000 refer to the maximum sulfur content allowed in the fuel expressed in ppm by weight (e.g., S15 refers to diesel fuel with a maximum sulfur content of 15 ppm. LanzaJet RD has no sulfur.

Downstream, LanzaTech's gas fermentation process is effective at any H_2:CO ratio, making it very adaptable to fluctuations in syngas composition.

- **Capital intensity will decrease** as gas fermentation and gasification units increase in capacity. Capital costs are expected to scale non-linearly with unit capacity, as is standard for chemical processing and refining processes. This has been validated by LanzaTech with several detailed costing exercises and plant installations.
    - **Scaling up.** While reactors and gasifiers are "numbered up" when increasing capacity, most other equipment can be scaled up, including LanzaJet's ATJ unit, leading to good economies of scale.
    - **Modular design** also leads to reduced capital costs. Both LanzaTech, LanzaJet and s 9(2)(b)(ii) and s 9(will use a modular design approach for their units. Modules are fabricated offsite concurrently with site preparation, shortening duration of engineering and construction phases. Offsite manufacturing also enables standardisation and enhanced quality control. Altogether, by minimizing labor costs, modularization improves cost-effectiveness. Modular design also improves safety by minimizing onsite hazards, risks and potential accidents during construction and commissioning as well as associated costs. Modular packages can easily be added to existing units to expand production capacity.
- **Operating expenses are also expected to decrease**. Fixed costs will decrease as operational learnings are incorporated. Variable costs will decrease with costs of renewable energy, which make up a large proportion (80-85 per cent) of New Zealand's grid. In addition, energy efficiency measures will help further reduce energy consumption.
- **Hydrogen addition.** The addition of hydrogen to the LanzaTech process increases ethanol production rate (at constant syngas feed rate) by converting CO_2 present in the syngas. s 9(2)(b)(ii) and s 9(2)(ba)(i)

7. Environmental

7.1. Waste and Emissions

7.1.1. Solid Waste

The following are the primary sources of solids streams leaving the plant.

Table 15: Primary sources of solid streams leaving the plant

Plant Source	Name	Discharged Via
ATJ	Catalysts and Resins	Landfilled with specialist contractor
Gasification	Biochar	Offtake agreement / sale
Gasification	Ash	Landfilled or sale
Site	Non Process Solid waste	Contracted Landfill

Currently, Wood Beca are not aware of mass production and sale of biochar in New Zealand. Biochar is used for soil enrichment, making it valuable to feedstock providers and other agricultural or horticultural industries, though this would require special agreements. Biochar is also used as a form of carbon removal so the use of it on fields can be used to help organisations meet climate goals. Exact specifications are not available. Depending on its composition and form, biochar could be classified as a hazardous or dangerous good, potentially incurring additional storage costs.

Further analysis on the composition of ash should be undertaken to understand whether it would be suitable for sale and re-use in other industries, such as cement manufacturing.

7.1.2. Liquid Waste

The following are the primary sources of Liquid streams leaving the plant.

Table 16: Primary sources of liquid streams leaving the plant

Plant Source	Name	Discharged Via
WWTP	Oily Sludge	Specialist Contractor
WWTP	Sludge	Landfilled Externally
Fermentation	Fusel Oil	Offtake Agreement
WWTP	Treated Water	Pipeline to Land/River
WWTP	Storm Water	Pipeline to Land/River
Site	Sewage/non process waste	Municipal wastewater system

The current sizing of the wastewater treatment plant (WWTP) is based on a 14-day return period and site footprint. Significant opportunities exist to optimise with first flush systems and adjustments once more catchment knowledge is known. Additionally, COD and BOD levels aren't fully established for the plant, so hydraulic demands are currently driving the WWTP sizing. Changes in BOD or COD levels could necessitate a change in the processing route. Depending on economic viability, the oily sludge fraction in the WWTP could potentially be incinerated to reduce offsite waste and provide a source of waste heat.

Wood Beca is uncertain around the current consumer market for Fusel oil within New Zealand. Existing commercial sites that produce Fusel Oil as a byproduct use it in either bio-digestor processes or for burning as waste heat.

Current discharge rates of treated wastewater would require a prohibitively large soakage field for solely on-land discharge (assuming no recycling of water streams). Thus, discharge would likely be to surface water (a river or lake), requiring additional permitting. This can be reviewed with the final location and catchment areas to determine if consenting limits can be achieved with a split system. Generally, discharges to surface water have stricter quality requirements and necessitate additional public consultation.

7.1.3. Gaseous Emissions

Gaseous emissions are a mix of direct and combusted emissions from the process areas and supporting utilities. The following are the primary sources of gaseous streams leaving the plant.

Table 17: Primary sources of gaseous streams leaving the plant

Plant Source	Name	Discharged Via
ATJ	Cold Flare	Combusted via Flare Stack #2
ATJ	Medium Pressure Flare Gases	Combusted via Flare Stack #2
ATJ	High Pressure Flare Gases	Combusted via Flare Stack #2
Gasification	Start Up Gases	Combusted via Flare Stack #1
Chipping & feed Prep	Chip Drying Off Gas	Local Stacks
Fermentation	Biogas & Tailgas Mix	Utilised in Boiler, balance is combusted via Flare Stack #1
VPSA	VPSA Venting (nitrogen)	Utilised in nitrogen generation, balance released via Exhaust/Stack
Nitrogen Generation	Generator Discharge / Rich Permeate	Local Exhaust/Stack
Boiler	Boiler Combustion Exhaust	Local Exhaust/Stack
Cooling Tower	Water Vapour	Released to atmosphere

The design includes provisioning for flaring a mixture of biogas and tailgas from the fermentation plant. While the flare will combust this gas mixture, significant potential energy exists in this stream. It has been assumed that this steam will be used to fire the boiler system instead of natural gas.

Table 18: Potential biogas/tailgas energy recovery values

Description	Unit	Value
Contained Energy in Stream	MW	*s 9(2)(b)(ii) and s 9(2)(ba)(i)*
Boiler Demand	MW	
Energy avail for export in Gas	MW	
Assumed Electrical Eff of generator	%	
Assumed Heat Recovery Eff of generator	%	
Electrical Load Generated	MWe	
Heat Load Generated	MW	

Concurrent and total flare gas scenarios have not been provided, so stack energy emission profiles remain undetermined. An exclusion zone has been established for each flare stack based on general industry guidelines, but these zones could change (increase or decrease) upon detailed analysis. Further considerations could be ground flares or similar.

7.2. Water Recycling and Reuse

7.2.1. Fresh Water

Assuming the plant is located in *s 9(2)(b)(ii) and s 9(2)(ba)(i)* the water supply will be groundwater since there are no remaining surface water allocations. Due to the geothermal nature, this groundwater will require reverse osmosis (RO) treatment. If surface water were available at the final project location, lower-cost clarification or filtration options might be suitable. For the purpose of this study, the following assumptions have been made:

- Groundwater is assumed as the raw water intake
- Water quality assumed:
    - low hardness <100 g/m³
    - neutral pH and no adjustment required
    - Low iron and manganese
    - No ammonia
    - elevated Silica in a geothermal area. Recovery of 70 per cent through an RO system assumed on this basis. Poses a risk to RO and requires careful assessment in future stages.
    - Low nitrate levels do not require additional treatment
    - Only cartridge filtration, UV and chlorination is required for a supply of between 100 and 500 people.

7.2.2. Waste Water

Process wastewater and contaminated runoff from plant areas will be transferred to either the buffer tank or the process water pond. This will be treated via a process consisting of the following steps:

1. Oil Water Separation (with recovery of oily sludge)
2. Primary Dissolved Air Flotation (DAF)
3. Moving Bed Biological Reactor (MBBR)
4. Secondary Dissolved Air Flotation (DAF)

Oily sludge from the first step will be collected and stored for disposal. Solids from the other processes will be treated in a centrifuge/press and stockpiled for landfill.

The final water product will be discharged to the rainwater pond and pumped to the consented discharge point for the plant. A smaller-scale domestic waste disposal system will be co-located by the centralised office area and then disposed of through the same process. Water discharged from the plant will be dosed to manage E.Coli levels. Note that altering this to split streams once additional information is available might result in lower costs or a smaller footprint.

7.2.3. Water Recycling/Re-Use

Currently, there is no dedicated water recycling provision in the process plant. However, with the use of RO technology, it will be possible to redirect the treated waste stream back to the RO plant for reuse, with the balance coming from fresh sources.

The need for recycling water is recommended, but the extent of it will be based on allowable withdrawal and discharge provisions for the final location, as well as the type of water (and treatment methodology). For example:

- The current remaining quota available for groundwater in the s 9(2)(b)(ii) and s 9(2)(ba)(i) area is 2.3 million cubic meters per year, which is less than half of what the current process plant uses. Therefore, adding the recycle loop is necessary in that scenario.

- If surface water quota is available then an RO plant may not be necessary to achieve the required process water quality. In this case the quantity of recycle vs waste discharge would have to be considered against the RO plant costs.

7.3. Life Cycle Assessment

This section details the GHG emissions Life Cycle Analysis (LCA) for entire supply chain from feedstock to fuel combustion for Project Pūrākau. This analysis has been done following the LCA methodology from ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). While other LCA methodologies exist (e.g. GREET), CORSIA is the most relevant in the New Zealand context.

The Carbon Intensity (CI) of SAF production is comprised of the following components in the supply chain:

i. Feedstock cultivation, collection and transportation to site;
ii. Gasification;
iii. LanzaTech gas fermentation;
iv. LanzaJet ATJ;
v. SAF/RD transportation to final destination; and
vi. Combustion of SAF/RD

The feedstock for Project Pūrākau is a mixture of clean wood and forest residue. Based on analysis by Scion (section 3.1), the likely mix is 69.7 per cent clean wood (K-grade logs) and 30.3 per cent forest residue on a weight basis. s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

The LCA considers emissions for cultivation, logging/collection, and transportation of the feedstock. Per CORSIA, cultivation emissions for forest residue are not included in the LCA because it is included in CORSIA's positive list of materials classified as co-products, residues, wastes or by-products. [redacted]
s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

The emissions factors for the feedstock were taken from s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] and are summarized below in Table 19.

Table 19: Feedstock Emissions Factors

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

The emissions from the gasification, gas fermentation, and the ATJ are calculated according to the following high-level steps:

i. Determine the quantities of chemical and energy inputs and outputs for each process;

ii. Multiply the quantity of each input by its emission factor, which provides the emissions due to producing and utilizing that input; and

iii. Divide total emissions per unit fuel from all inputs and (non-fuel) outputs by the energy input required (MJ) per unit of fuel produced to determine the GHG emissions per MJ of fuel.

The primary contributor to the carbon intensity of the gasification section is the electricity usage, while the gas fermentation contribution is broken down into three main categories: electricity, steam, and chemicals/WWT/other.

The ATJ process emissions considers natural gas for steam generation, electricity, and hydrogen as inputs to produce SAF and RD from ethanol. The hydrogen used in the process is assumed to be generated via electrolysis.

The emissions from the SAF and RD transportation from site to its destination is also considered in the total CI. Developed by Z Energy, the product logistics assumes a two-step transportation route, both steps via rail. The first step is transporting from [redacted]

s 9(2)(b)(ii) and s 9(2)(ba)(i)

The emission factors used in the CI calculations for the gasification, gas fermentation, ATJ and transportation are summarized below in Table 20.

Table 20: Gasification, Gas Fermentation, ATJ, and Transportation Emissions Factors

Description	Emissions Factor, gCO_2e/MJ[1]	Source
Natural Gas	68.19	GREET 2023, pipeline natural gas used in utility/industrial boiler
Electricity	30.91	GREET 2023, average grid electricity
Hydrogen	51.00	Via electricity EF, assuming electrolyzer efficiency of 55 kWh/kg
Transportation	0.0006	GREET 2023, SAF Transport via Rail

Note 1 – Unit for SAF Transport via Rail emissions factor is gCO2e/MJ/mile

The complete LCA is summarized in Table 21 below.

Table 21: LCA Summary

LCA Step Description	GHG Emissions (gCO_2e/MJ Fuel)
s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]	

s 9(2)(b)(ii) and s 9(2)(ba)(i)	
Overall CI	**20.71**
% Reduction from Fossil Baseline[6]	**76.73%**

Note 1 – Additional details for GHG of Feedstock in Table 19.
Note 2 – CI is reflective of the ISBL in its entirety and OSBL.
Note 3 – Steam is assumed to be generated via combustion of biogas and tail gas generated from LanzaTech's Process in a boiler.
Note 4 – Hydrogen is sourced from an electrolyzer powered from grid electricity.
Note 5 – Biogenic CO_2 emissions from fuel combustion are not included in LCA under CORSIA.
Note 6 – ICAO CORISA Annex 16 Volume IV prescribes the use of a fossil baseline value of 89 gCO_2^e/MJ for jet fuel to calculate CO_2 emissions from aircraft operation under CORSIA.

When renewable/alternative energy sources are used, the overall CI can be lowered significantly. As shown in Table 21, emissions from electricity are the main contributor to the overall CI of the SAF and RD. Using renewable electricity could lead to a further reduction to the overall CI. Table 22 shows variation in the overall CI depending on the source of energy. This clearly illustrates that there is significant potential to reduce the CI further by changing the source of electricity from grid electricity to an alternate/renewable source with a lower emissions factor, such as solar or wind. However, to achieve a reduction in CI via the utilization of renewable electricity, compliance with the CORSIA mandates a direct connection to the facility.

Table 22: Energy Source Sensitivity Analysis

LCA Basis[1]	Renewable H_2[2]	Renewable Electricity and Renewable H_2[3]
20.71 gCO_2e/MJ	18.92 gCO_2e/MJ	5.27 gCO_2e/MJ

Note 1 – Base case. Refer to Table 21 for details.
Note 2 – Hydrogen source for LanzaJet ATJ changed to electrolysis via renewable electricity with an emissions factor of 0 gCO2e/MJ.
Note 3 – Electricity source for LanzaTech and LanzaJet changed to solar or wind powered renewable electricity with an emissions factor of 0 g CO_2/MJ.

7.4. Supply Chain Environmental, Social and Economic Impacts

7.4.1. Environmental Impacts

Scion was engaged to examine the environmental and social sustainability of the production of SAF using woody biomass from New Zealand's plantation forest resources.

The extraction of biomass from plantations for SAF production across New Zealand may include several new forest operations (refer to Section 3.2.1) that require careful analysis and monitoring to meet the criteria for the sustainable production of SAF and ensure sustainable forest management criteria are also achieved.

Scion's key objectives was to review the environmental sustainability of plantation forest management as it relates to post-harvest residue harvesting including the potential impacts on soil fertility, erosion, water quality and biodiversity. In addition, the objectives also included a review of a range of potential social and economic impacts to determine critical knowledge or data gaps across all these aspects of sustainable aviation fuels from forest residues. This work builds on previous Scion investigations into these topics including a review of the latest international literature.

Findings from the review indicate that extraction of stem wood residues post clear-cut harvesting from existing planted forests in the s 9(2)(b)(ii) and s 9(2)(ba)(i) will be environmentally sustainable if best management practices are followed and monitoring is initiated to inform long-term adaptive sustainable management practices.

When looking more broadly across other regions of New Zealand, Scion's review indicates that extraction of forest residue stems from existing planted forests is likely to be environmentally sustainable. However, a limited number of sites will be sensitive to residue removal and on-going research and implementation of adaptive management is required to support residue removal in the long-term.

s 9(2)(b)(ii) and s 9(2)(ba)(i) Scion's analysis of the environmental impacts found that residue and log harvesting would not add to the current level of environmental disruption occurring under current best practice harvesting activities, and in some locations residue removal may improve environmental outcomes. Broadly, these impacts can be summarized as follows:

- *Soil fertility* – The extraction of some of the stem harvest residue will have limited impact on a sites soil fertility. However, sites with lower soil nutrient levels are considered more sensitive to nutrient export and more clay textured soils are more sensitive to soil compaction.
- *Erosion* – The technology and data to model and map erosion susceptibility at within stand spatial resolutions exists and the knowledge just needs to be applied across the National Environmental Standards – Commercial Forestry (NES-CF) regulated locations. Residue harvesting is likely to have limited impact over that generated by the primary roading and harvesting operations.
- *Water quality* – The impact of stem residue harvesting on water quality, nutrient and sediment loss is expected to be no more than existing harvesting operations which already have to comply with resource consent conditions and NES-CF limits.
- *Biodiversity* – The removal of stem woody material for biofuel purposes would have a negligible impact on any threatened or endangered insect species as clear-fell insect communities do not typically contain threatened or endangered insect species. However, details on the impact of residue removal on indigenous biodiversity is a key knowledge gap, and would be needed to confirm sustainable management practices on insect biodiversity.
- *Mitigating Impacts to Soil* - An extensive list of potential solutions for mitigating sensitive sites are listed in the different report sections, such as sediment traps to avoid phosphorus losses, fertiliser treatments to replace nutrient losses and the avoidance of issues through improved soil, water and biodiversity management and monitoring. Some current best practice solutions provide benefits across multiple indicators of sustainability, for example, retention of riparian buffers.

Scion therefore concluded that:

- Up to half the stem wood residues, in the order of 40m^3 per hectare of forest harvest, can be taken from most sites without incurring depletion of site nutrients, which was in line with the assumptions that underpinned Scion's biomass resource assessment (Section 3.1);
- The addition of fertiliser is a viable forest management option for sites that are sensitive to nutrient loss through residue;

- It is unlikely that there will be adverse effects on biodiversity from either plantation forestry or the residue harvesting;
- Harvesting of additional stem wood due to residue harvesting is not likely to significantly impact water, nutrients and sediment levels in catchment streams if best practice forestry management is followed;
- If erosion occurs, then the site is also likely to have reduced sustainable nutrient supplies until recovery of the organic nutrient layers. The required recovery time will be driven by phosphorus weathering rates of the soil minerals; and
- Sound forest management practices that follow the NES-CF regulations and any local resource consent restrictions will be sufficient to ensure that the use of the residues minimises impacts and ensures the environmental sustainability on most sites in New Zealand.

Scion's key recommendation is that demonstrating environmental sustainability can be achieved through establishment of a series of long-term monitoring trials on behalf of forest growers across a range of sites which are sampled on a semi regular basis, such as every five years. s 9(2)(b)(ii) and s 9(2)(ba)(i) predicts harvest areas which will be of high priority based on erosion susceptibility and soil type sensitivity for the s 9(2)(b)(ii) and s 9(2)(ba)(i) region in the next 5-8 years. Environmental sustainability and kaitiakitanga (Māori term for the concept of guardianship of the sky, sea and land) will be best demonstrated by the installation of trial sites at locations that have experienced an extreme weather event after residue collection on sensitive soil types.

Furthermore, the stock of wood in New Zealand's plantation forest estate has been expanding for the last 38 years, from 171M m^3 to 567M m^3. This is the product of increased forest area and increased forest productivity. New Zealand's annual harvest, currently around 33 to 34M m^3 per annum is less than the amount grown in the last year (51.7M m^3) resulting in an increase in total standing wood volume of 18M m^3. The average annual increase in New Zealand's total standing volume has been around 10M m^3 per annum, resulting in a sustainable level of harvest in relationship to the plantation forest estate.

7.4.2. Social Impacts

Scion were also tasked with studying Pūrākau's potential social and cultural impacts in the s 9(2)(b)(ii) and s 9(2)(ba)(i) district. Their work aimed to identify the potential socio-economic and cultural effects of the project using available literature and through communication with a representative of s 9(2)(b)(ii) and s 9(2)(ba)(i)

Among the strengths identified for s 9(2)(b)(ii) and s 9(2)(ba)(i) as a SAF production site are the existing infrastructure (e.g., roads, railway, geothermal energy and nearby ports), the existence of s 9(2)(b)(ii) and s 9(2)(ba)(i) and abundant forest-based resources (including water availability).

Scion found that the proposed SAF production plant would have several favourable socio-economic impacts for s 9(2)(b)(ii) and s 9(2)(ba)(i) districts. Significant increased employment will generally improve a number of key outcomes for the local population (income, housing stress, debt, health), leading to a general improvement in well-being.

There will be a range of social impacts from the development of a SAF production facility in s 9(2)(b)(ii) and s 9(2)(ba)(i) Some of these impacts will be positive, and increased employment opportunities are expected to lead to improved social outcomes. However, Scion also noted that a rapid change in employment could also place stress on local housing supply and other social services such as health and education. It will therefore be important that the local community, Council and providers of social services are engaged as the project proceeds to ensure these impacts can be managed and appropriate planning can be made.

To better understand these impacts, Scion recommended further analysis into the supply of housing in the s 9(2)(b)(ii) and s 9(2)(ba)(i) and surrounding areas s 9(2)(b)(ii) and s 9(2)(ba)(i) may be useful and give some indication of the availability of housing for an influx of new workers. This may also go as far as s 9(2)(b)(ii) and s 9(2)(ba)(i) as the ability to commute is realistic as the distance between them is around s 9(2)(b)(ii) and s Similarly, it may be beneficial to look at the capacity of critical services such as health and primary education to determine their ability to absorb an influx of workers and their families.

Scion also highlighted that properly addressing socioeconomic and environmental aspects can make the production and use of bioenergy even more sustainable. In that context, using tools like the Social Life Cycle Assessment (SLCA) can provide comprehensive social sustainability assessments.

It was also recommended that validating the strengths, opportunities, weaknesses, and threats associated with the project with the members of s 9(2)(b)(ii) and s 9(2)(ba)(i) may provide further insights based on their on-the-ground experience.

Lastly, Scion suggested that consideration be given to the potential for resistance to the SAF plant development from some sections of the community.

7.4.3. Economic Impacts

Scion used a three-step approach to evaluate the economic impacts of transforming woody biomass into SAF at a site based in s 9(2)(b)(ii) and s 9(2)(ba)(i) New Zealand. First, a regional economic profile describes current data from Stats NZ and other published sources. The objective was to present a comprehensive overview of the regional economic landscape, focused on the s 9(2)(b)(ii) and s 9(2)(ba)(i) encompassing key economic indicators, demographic statistics, and relevant industry metrics.

This was followed by a supply chain analysis, examining the entire process from feedstock collection to processing, including sourcing, transportation, and processing stages.

An updated version (2024) of the WoodScape Model was used to measure Pūrākau's impact on regional employment and GDP, quantifying the economic contributions of the project, with a focus on job creation and economic growth.

s 9(2)(b)(ii) and s 9(2)(ba)(i) his analysis found that the economic impacts of Project Pūrākau are expected to be significant in terms of direct, indirect, and induced value added, as well as its significant employment generation. These will have a positive and lasting effect on the regional and national economy, representing a 2.4 per cent increase in the annual GDP of the s 9(2)(b)(ii) and s 9(2)(ba)(i) region.

The plant's total GDP contribution of $428 million per year and its potential to create 165 new jobs at the facility, 88 in the feedstock supply chain and a further 386 indirect jobs, highlights the potential to drive economic growth, create employment opportunities, and promote sustainable development in the s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] region and beyond.

The introduction of the biomass-to-jet fuel project could serve as a catalyst for positive social change in s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] With training, an increase of skilled employment opportunities has the potential to reduce unemployment rates, provide a stable source of income for families and improve overall economic conditions in the community. The jobs created by the plant will have a significant impact on the town, representing a substantial increase in employment opportunities for the local population.

7.5. Sustainability Certification

Scion was engaged to evaluate leading sustainability certification schemes relevant to Pūrākau and the requirements of each in order to achieve certification. s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] and examines the principles used by the International Civil Aviation Organization (ICAO) for the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and other relevant schemes to determine compliance of woody biomass resources in New Zealand and the likelihood of these materials being certified for use to produce SAF and subsequently a CORSIA eligible fuel (CEF).

The woody biomass in question is in part residues that currently left in forests after plantation harvest and low-grade logs (K-grades) that are not desired by domestic wood processors. These are exported unprocessed to overseas markets where they are typically used in low value products such as construction form work.

Certification is an important step in the development, marketing and sale of most consumer products, leading to the wide acceptance of products in global markets. It also enables consumers to have confidence in the sustainability performance and claims being made with respect to certified products. Certification also ensure companies report on steps that they have taken to improve their environmental performance, for example reducing their production of waste and carbon emissions, impact on biodiversity, worker wellbeing, etc. Certification bodies exist for different product classes and often are voluntary in nature and self-regulated.

To achieve the aviation industry's global goal of net zero by 2050, it is important airlines reduce their reliance on fossil jet fuel. The International Air Transport Association (IATA) estimates that for this to happen, 65 per cent of the decarbonisation opportunity in 2050 will need to come from SAF. To achieve this and reduce the aviation industry's contribution to climate change, ICAO established the global CORSIA scheme, which places obligations on airlines to reduce or offset the emissions from international flights to achieve carbon neutral growth. Airlines can either meet their CORSIA obligations by using SAF or purchasing offsets.

It is critical that the production of SAF has lower life cycle emissions compared to conventional jet fuel, and its production does not drive additional deforestation, loss of biodiversity and reduce worker rights and wellbeing. In this context, ICAO established a set of stringent sustainability criteria and an emissions life cycle assessment (LCA) methodology against which SAF must be certified for it to be considered a CEF and used by airlines to meet their CORSIA obligations.

ICAO approved the first edition of the CORSIA Sustainability Criteria for CEFs in June 2019. There have been several revisions to the list of the sustainability criteria for SAF during the pilot phase (2019-2023). These became effective on 1 January 2024 when implementation of CORSIA began (2024-onwards). The criteria include greenhouse gas emissions, impact on water, soil, air, conservation, human rights, local and social development as well as food security, with a focus on protecting areas of high biodiversity and high carbon stock such as found in native forests.

The use of these criteria is intended to ensure that airlines use of the term sustainable aviation fuel can be justified through the use of robust criteria and auditing systems.

s 9(2)(b)(ii) and s 9(2)(ba)(i) also addressed the alignment of commonly used forest certification schemes in New Zealand such as the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) with the CORSIA sustainability criteria. Both FSC and PEFC have been used to certify biomass feedstock for large bioenergy projects such as the Drax power plant in the United Kingdom, which sources woody biomass from all over the world and relies on multiple certification schemes to ensure the sustainability of feedstock. The scale of the Drax project's use of certified woody biomass is a good example of how systems such as FSC and PEFC could be applied alongside CEF certification.

In addition to CORSIA, there are another four sustainability frameworks that are relevant to woody biomass and SAF certification in New Zealand. All of these frameworks are organised around a number of principles and while the language varies somewhat, there is strong commonality in the principles across the five frameworks. Both the Roundtable on Sustainable Biomaterials (RSB) and the International Sustainability and Carbon Certification (ISCC) have their own certification programs for renewable fuel producers (including SAF), however both organisations are also approved sustainability certification schemes under CORSIA, which enables them to certify CEF. As outlined in Table 23, there is a significant amount of commonality across the principals underpinning CORSIA, RSB, ICSS, FSC and PEFC.

Table 23: Summary of Sustainability Principals for Relevant Frameworks

	CORSIA	RSB	ISCC	FSC	PEFC
Certification Focus	Certifies production of SAF	Certifies production of biofuel	Certifies production of biofuel	Certifies forest management	Certifies forest management
Feedstock Coverage	All SAF feedstocks covered	All biofuel crops covered	All biofuel crops covered	Only forest crops	Only forest crops
New Zealand Application	Not currently applied in NZ	Not currently applied in NZ	Not currently applied in NZ	~65% NZ plantations covered	32% NZ plantations covered
Woody Biomass Coverage	All tree components acceptable	Does not allow roundwood (logs)[6] use for bioenergy except in short rotation woody crop (SRWC) systems	All tree components acceptable	All tree components acceptable	All tree components acceptable
Life Cycle Assessment	Includes Life Cycle Emissions assessment – minimum 10% reduction	Includes Life Cycle Emissions assessment –	Includes Life Cycle Emissions assessment –	Moving to inclusion of Life Cycle Emissions assessment globally	Moving to inclusion of Life Cycle Emissions assessment globally

[6] Note there is ambiguity around the definition of harvest residues and roundwood.

		minimum 50% reduction[7]	minimum 50% reduction[8]		
Feedstock Exclusions	No feedstock exclusions	Roundwood (logs) not permitted. New SRWC plantings would be certifiable	All plantings would be certifiable	All plantings would be certifiable	All plantings would be certifiable
GMOs	Use of GMOs not excluded	Use of GMOs not excluded	Use of GMOs not excluded	No use of GMOs	No use of GMOs
High Conservation Land	SAF will not be made from biomass obtained from areas with biodiversity, conservation value, or ecosystem services.	No High Conservation land conversion post 2008.	Biomass cannot be produced on land with high biodiversity value.	No conversion of natural forest to plantation post 1994	No conversion of natural forest to plantation post 1994
High Carbon Stock Land	SAF should not be made from biomass obtained from land/aquatic systems with high biogenic carbon stock	Biomass cannot be produced on land with high carbon stock. Biomass cannot be produced on peatland.	Biomass cannot be produced on land with high carbon stock. Biomass cannot be produced on peatland.	Requires protection and conservation of "high conservation areas"	No specific criteria

Importantly in New Zealand, both FSC and PEFC certification of forest management systems is widespread, and FSC certification has been used in New Zealand for over 20 years. FSC standards for responsible forest management were recognised by RSB in April 2013 and the principles and criteria are considered to be effectively aligned.[9] Both FSC and PEFC have been recognised by ISCC and RSB as compatible with their systems.

FSC and PEFC certification for forest management and chain of custody cover the woody biomass resource production. Production of SAF must also be certified and the ISCC and RSB systems do this. A combination of RSB or ISCC and either FSC or PEFC systems will cover the entire SAF chain and also meet CORSIA sustainability criteria. However, several aspects need to be considered:

- Only about two thirds of the New Zealand forest resource by area is certified under FSC/PEFC. Additional resource will be available if additional areas of forest are certified. This need will affect the economics of any system.
- RSB does not consider roundwood (e.g. K-grade logs and bin wood) acceptable for use in biofuels for its voluntary certifications (e.g. RSB Global). However, in New Zealand, in some regions, often small logs (roundwood) are left on site as residues due to lack of economic value. Much of the low-grade (K-grade) log resource that is harvested is exported as raw logs as there is no domestic market. These logs go into various low value products / uses in construction in China and are estimated to have

[7] 60% for new production facilities
[8] 60% for new production facilities
[9] https://anz.fsc.org/newsfeed/the-roundtable-on-sustainable-biofuels-recognizes-fsc-certified-forests.

short lifetimes in end products (estimated half-life of 2 to 3 years). In contrast, the ISCC system does not limit the use of low value logs for their voluntary certification programs. Similarly, the CORSIA sustainability criteria does not ban the use of roundwood as feedstock, rather the criteria prevent the use of certain land for their production (e.g. native forests and high carbon stock land).

- While CORSIA prevent the use of K-grade logs, there are several issues associated with their use that require further investigation. These include:
    1. There is currently no default LCA value for forestry residues via the ethanol to jet pathway under CORSIA. This will need to be addressed through the development of a short "working paper" requesting one be calculated by ICAO's Fuels Task Group (FTG);
    2. Forestry residues are included in ICAO's "Positive list of materials classified as co-products, residues, wastes or by-products" as of June 2022, which means they do not present any indirect land use change (ILUC) risk, nor does an ILUC emissions factor apply in the context of an LCA for CEF certification.
    3. There is a process through which FTG can recommend additional feedstocks be added to this list, and a case could be made for certain logs that do get discarded and left in the forest as residues.

s 9(2)(b)(ii) and s 9(2)(ba)(i)

These issues (default LCA value and the use of K-grade logs) would need to be addressed through engagement with New Zealand Government officials and ICAO and its relevant technical bodies (i.e. the Committee on Aviation Environment Protection [CAEP], and FTG.

Furthermore, two certification companies with the ability to certify SAF are active in New Zealand – RSB and ISCC. While these companies certify to their own voluntary standards they are also approved CORSIA sustainability certification schemes. As a result, they can certify fuel producers for compliance with CORSIA sustainability criteria.

In summary:

- The FSC and PEFC forest management certification systems provide a strong underpinning for the certification of the biomass resource supply with either RSB or ISCC providing certification for the production of SAF.

- The RSB system as it currently stands would limit the use of low value (round) logs as part of the feedstock supply. The ISCC system does not limit the use of low value logs as a feedstock and would be preferable.

- Further analysis is needed to be determined when a low value (round) log becomes a waste, residue or by-product to help build a case that they be included on ICAO's "positive list". This will be important with respect to CORSIA certification and a favourable LCA value.

8. Capital and Operating Cost Estimates

8.1. Operating Cost Estimate

8.1.1. Preamble

This section outlines the basis of the operating cost estimate for the project and the estimate details. s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] It should be noted that that the cost estimates provided here are not a statement of absolute cost, rather they have an accuracy range commensurate with various factors such as the extent of relevant information provided, certainty of the data and the level of detail available.

The cost estimate outlined below is based on extrapolation of recent similar project pricing, industry unit rates and practices, indicative cost quotes and Wood Beca's general experience. The estimates are based on incomplete design, inputs and variables provided by others which have not been verified and other information, and hence the estimates are not warranted or guaranteed. For the scope of work described in this document this estimate is not suitable for final CAPEX approval or investment decisions. Further design should be undertaken if a more reliable estimate is required.

8.1.2. Basis

The table below summarises the inclusions and exclusions for the operating cost estimate. This work is based on inputs and outputs provided by third parties. These data points have not been independently verified. Consequently, the results presented in this work are unverified and should be treated as sensitive and subject to change.

Table 24: OPEX Estimate Basis

s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted]

The following assumptions were made to derive an operating cost:

- The Plant operates for s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] per annum
- FOREX rates based on spot at time of pricing received, otherwise the values from the CAPEX were used

- Inflation adjustment per RBNZ Calculator for historic ingredient costs and may not follow market trends. Ingredient pricings may range (in which case a mid-range value has been used) and may vary depending on supply agreements. Hence this work only provides an indication of the order of magnitude of operating costs
- Manning is based on 8-hour shifts
- Utility and minor ingredient consumption assumes intermittent loads operate same as plant
- Estimate values are based on factored values (including factoring from the CAPEX) or unit rates provided by others instances

8.1.3. Estimate

Table 25 below presents the estimated annual OPEX cost for Project Pūrākau.

Table 25: OPEX estimate values

s 9(2)(b)(ii) and s 9(2)(ba)(i)

[redacted]

As highlighted in Section 7, the facility will produce several by-products that have market value and could be sold, providing a credit against OPEX. These include:

- Biochar – a valuable byproduct from gasification that is commonly used as a valuable soil amendment with benefits such as soil enrichment, water retention, carbon sequestration and pollution reduction. Because biochar is a highly porous, stable, and durable form of carbon that can efficiently store carbon for long periods it is also valuable in the voluntary carbon markets. One tonne of biochar can sequester approximately 3 tonnes of carbon dioxide[10]. It's value in New Zealand is uncertain as there is no established market, however anecdotally it has been suggested it could be worth NZD *s 9(2)(b)(ii) and s* [redacted] per tonne.
- Biogas and tailgas – biogas and tail gas are by products from LanzaTech's gas fermentation process. While these will be used for steam production instead of burning natural gas in the boiler, there is still a substantial volume of residual gas that can be sold. To be conservative, it is assumed to be as valuable as natural gas.
- Fusel Oil – a byproduct of ethanol production. The value in New Zealand is unknown and it has therefore not been factored into the modelling.
- Ash – a byproduct from gasification. Ash has potential reuse value in cement manufacturing, however further analysis will be needed to understand if that would be viable in the New Zealand context.

[10] https://www.sciencedirect.com/science/article/pii/S0959652622032383

Table 26: By-product Credit Value

s 9(2)(b)(ii) and s 9(2)(ba)(i)

It is estimated that the sale of these by-products could generate over NZD *s 9(2)(b)(ii) and s 9(2)(ba)(i)* per year (Table 26) providing a valuable offset against the plant OPEX, reducing it to NZD *s 9(2)(b)(ii) and s 9(2)(ba)(i)* per year.

8.2. Capital Cost Estimate

8.2.1. Preamble

This section outlines the basis of the capital estimate for the project and the estimate details. *s 9(2)(b)(ii) and s 9(2)(ba)(i)* It should be noted that that the cost estimates are not a statement of absolute cost, rather they have an accuracy range commensurate with various factors such as the extent of relevant information provided, certainty of the data and the level of detail available.

The cost estimate outlined below is based on extrapolation of recent similar project pricing, industry unit rates and practices, indicative cost quotes and Wood Beca's general experience. The estimates are based on incomplete design, inputs and variables provided by others which have not been verified and other information, and hence the estimates are not warranted or guaranteed. The accuracy of the estimate is not expected to be better than -20 per cent to +50 per cent for the scope of work described in this document and is not suitable for final CAPEX approval or investment decisions. Further design should be undertaken if a more reliable estimate is required.

8.2.2. Basis

For the Capital estimate:

- All estimates are provided in NZD
- Estimate accuracy is a Class 5 per AACE 18R-19 with an expected accuracy of -20 per cent to +50 per cent

The table below outlines the major assumptions, inclusions and exclusions used in the formation of the estimate.

Table 27: Basis of CAPEX Estimate Summary

s 9(2)(b)(ii) and s 9(2)(ba)(i)

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s 9(2)(b)(ii) and s 9(2)(ba)(i)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

8.2.3. Estimate

The table below presents the estimated Total Installed Cost (TIC) or CAPEX cost for Project Pūrākau. It is also worth noting:

- The ratio of direct to indirect:
  - with contingency included in the Indirect is s 9(2)(b)(ii) an
  - without contingency included in the Indirect is s 9(2)(b)(ii) anc
- The ratio of the ISBL to OSBL direct costs are approximately s 9(2)(b)(ii) (for each ISBL dollar spent, s 9(2)(b)(ii) a dollars are spent on OSBL)

The expected capital cost estimate of NZD s 9(2)(b)(ii) and s 9(2)(ba)(i) accounts for all infrastructure, equipment, and other essential investments necessary for project execution and construction. This also includes a contingency of 20 per cent or approximately s 9(2)(b)(ii) and s 9(2)(ba)(i) a sum which accounts for those elements of the scope which are yet to be more fully defined. The estimate does not include the supply chain infrastructure necessary for the blending and distribution of SAF to Auckland Airport s 9(2)(b)(ii) and s 9(2)(ba)(i) For the purposes of modelling the project's economics, LanzaJet has excluded contingency and assumed a capital cost of s 9(2)(b)(ii) and s 9(2)(ba)(i) (Table 28).

s 9(2)(b)(ii) and s 9(2)(ba)(i) it should be noted that the accuracy range and contingency value reflect the conceptual nature and hence early stage of definition of the project. It is also in line with recent estimates for projects of a similar nature and magnitude that LanzaJet and LanzaTech have experience with. It will be critical that a value engineering exercise occurs early in the next project phase. This will enable the identification of efficiencies and opportunities to reduce both CAPEX and OPEX and must occur prior to the commencement of any further design or engineering work begins.

Table 28 - CAPEX estimate breakdown

s 9(2)(b)(ii) and s 9(2)(ba)(i)

8.2.4. Preliminary TIC Opportunities

An initial review of the estimate has identified areas to focus on future value engineering exercises and an approximate opportunity to reduce the TIC. This is approximate as the estimate features factors modifying the base costs of some lines which can have a carry on or compounding effect. A simplification of how factorisation works is applied to estimate the value of these opportunities. This has only been focused on the factors and areas within the OSBL (outside the ISBL) and hence ignores other opportunities as:

- ISBL technology was prescribed by the LanzaTech – no other processes or arrangements were considered which could potentially be more efficient, and cheaper (examples; something smaller and less complicated than the gasification process/technology selected, alternative technologies within the ISBL battery limits)
- Staged expansion / modularisation or hub-and-spoke opportunities to construct a facility

9. Commercial Feasibility Assessment

9.1. Project Economics

To understand the economics of Pūrākau, LanzaJet built a simple economic model using the inputs of volume, OPEX and CAPEX outlined in this report. Due to the early stage of the project, it was assumed that funding would entirely come from equity, with no debt component. The model also assumed a depreciation period of 25 years, a discount rate of 5 per cent, a tax rate of 28 per cent and a USD to NZD exchange rate of 1.63. Excluded from the modelling were:

- the CAPEX and OPEX associated with blending and product logistics by Z Energy;
- Licencing fees;
- The impact of potential SAF policy support; and
- CAPEX and OPEX contingency (20 per cent).

The model was used to understand the fundamental economics of the project and the sensitivity to changes in CAPEX, OPEX and feedstock. It was also used to determine other factors that could be deployed to improve the economics, including different policy measures that could be used to support the development of SAF production in New Zealand. The credit value from the sale of by-products was included in the modelling as an offset against OPEX.

s 9(2)(b)(ii) and s 9(2)(ba)(i)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

While this represents a premium relative to conventional fuel, it is not unexpected for a project of this nature, magnitude and feedstock type. It also represents a scenario in which there is no government policies in place to support the production of SAF in New Zealand.

However, there are several scenarios that could materialize over the coming years that will help improve the economics. The following scenarios (consistent with the policy recommendations in Section 9.4) were modelled to understand their potential value and impact:

- A capital grant of *s 9(2)(b)(ii) and s 9(2)(ba)(i)*
- A production incentive of *s 9(2)(b)(ii) and s 9(2)(ba)(i)*
- A SAF mandate or fuel standard with a compliance obligation (credit/certificate mechanism *s 9(2)(b)* and
- SAFc certificate value for scope 3 emissions reductions for airline and freight corporate customers valued at *s 9(2)(b)(ii) and s 9(2)(ba)(i)* er tonne of carbon, which less than recent reported transactions *s 9(2)(b)(*

s 9(2)(b)(ii) and s 9(2)(ba)(i)

It should be noted that if New Zealand does not implement a SAF mandate, fuel standard, or production incentive, Australia could well do so and has commenced a policy design consultation process for both measures. This would create an alternative and potentially valuable SAF market for Pūrākau meaning that the finished fuel is exported overseas and New Zealand does not receive the decarbonisation benefits.

To further illustrate the potential value under a mandate, the UK have announced a SAF mandate of 10 per cent by 2030, which will include a buy-out option allowing SAF suppliers who do not meet their obligations to pay a price per litre to the government. This has been set at £4.70 per litre (USD $22.75 per gallon). This will essentially act as a price ceiling for SAF in the UK, as a supplier will choose to pay the buy-out price rather than supply eligible fuel or purchase mandate certificates at a higher cost. In this context, Pūrākau would be a competitive supply option for obligated parties under the UK mandate. A mandate in Australia or New Zealand could arguably create similar market conditions.

If we consider the above policy scenarios and their value, the waterfall chart in Figure 16 illustrates the cumulative impact and the net price of SAF. LanzaJet has also factored in OPEX savings, which are considered achievable due to the conservative factors used in the OPEX estimate in this study.

Figure 16: Scenario for Net Cost of SAF (USD$/tonne)

s 9(2)(b)(ii) and s 9(2)(ba)(i)

This demonstrates that if market and policy conditions developed in New Zealand and/or Australia similar to those found in other regions, the net cost of SAF would be competitive with conventional jet fuel.

It will be critical that the project partners be disciplined in identifying opportunities and efficiencies to reduce CAPEX and OPEX as the project advances. The LCOP illustrates that both CAPEX and OPEX are the main drivers regarding cost, as shown in Figure 17 with 45 per cent of the LCOP attributable to OPEX (excluding feedstock) and 35 per cent to CAPEX.

Figure 17: Pūrākau Levelised Cost of Production

s 9(2)(b)(ii) and s 9(2)(ba)(i)

The sensitivity analysis in Figure 18 illustrates that the economics are most sensitive to relative changes in CAPEX and OPEX (excluding feedstock), highlighting the importance of driving down both. Reducing OPEX is going to have the largest impact on the LCOP, while reducing CAPEX will have the largest impact on project returns. It should be noted that Japan is providing capital grants for 50 per cent of the capital cost of ATJ projects.

Figure 18: Economic Sensitivities

s 9(2)(b)(ii) and s 9(2)(ba)(i)

As the project moves forward there are several strategies that will be important for the Project's economics to be optimized, including:

- Value engineering, analytics and automation to identify efficiencies and opportunities to cut OPEX and CAPEX;
- Optimize feedstock costs: Understand the benefit of recovering residues in terms of slash clean-up costs in coastal areas after severe weather events;
- Asses the optimal mix of debt and equity to reduce the cost of capital; and
- Proactively advocate for a supportive policy environment in New Zealand by way of capital grants, a mandate or fuel standard and production incentives or tax rebates for SAF.

9.2. Feedstock and Product Offtake Framework

9.2.1. Feedstock Supply

A critical aspect of any SAF project is securing feedstock. For new technology and first of their kind projects, a long-term feedstock supply contract with an established and credit worthy third party is a needed to help de-risk a project for financial lenders and equity investors. In general, a minimum 10-year supply agreement should be sufficient for most contracts, however in general, the longer the better. Having the vast majority of the project's required feedstock under long term contact would also be an important consideration for financing. Additionally, having a supplemental feedstock supply strategy provides additional risk mitigation and contingency planning in the event the long-term feedstock supply provider is unable to supply. This could equate to a blanket spot purchase arrangement with existing ethanol suppliers or part of a wider global supply contract at other facilities.

In Section 3.4.1 Scion identified all the relevant forest growers and timber processors across the North Island, including the s 9(2)(b)(ii) and s 9(2)(ba)(i) Given the amount of feedstock required for the project it is likely that several feedstock supply contracts with substantially similar terms will be needed. It is proposed that in the next phase of the project, discussions regarding feedstock supply with the forest growers identified by Scion begin.

Furthermore, as highlighted in Section 4 of this report, Māori Trusts and Incorporations own NZD $4.3 billion of assets in forestry and have ownership of more than 30 per cent of land under plantation forestry in New Zealand. As such, the Māori engagement leads from Scion, Air New Zealand and Z Energy have initiated engagement with Māori in this context and high-level discussions have been held with a relevant Māori trust and forest owner.

9.2.2. Product Offtake

SAF will represent 90 per cent of the product produced by Project Pūrākau. The offtake arrangements for this product will therefore be the primary focus as the project advances.

Like feedstock supply, a long-term product offtake with a credit worthy third party will be a key aspect of de-risking a project for financial lenders and equity investors. A minimum 10-year offtake contract should be sufficient, and this will need to be negotiated and executed during the next phase of the project. Price, blending, logistics and delivery location are all key considerations.

A single airline such as Air New Zealand could be the anchor offtake customer for the SAF produced each year. However, to reduce the risk portfolio for the Project and offtaker, it may be desirable to obtain additional offtake customers. LanzaJet can facilitate discussions with other airlines that serve New Zealand as required.

With renewable diesel representing 10 per cent of the product produced by the project, having a long-term offtake contact in place may not be as critical to support the financing of the project. However, further discussion with financial lenders should be held during the next phase of development to ascertain their views.

Given Z Energy's role in the project and New Zealand's largest supplier of diesel, it is assumed for now that Z Energy would be the anchor offtake customer for renewable diesel produced each year. Z Energy would remarket this product to their customers in New Zealand.

9.3. Investors, Owners and Operators

Potential investors, owners and operators of Pūrākau are not yet known as the project is still at an early stage. As the project advances, engagement with interested parties will be important. However, it is recommended that this only begin once the project is further defined. Some suggested groups for future engagement are provided below. These are suggestions and do not represent any formal views or commitments from any of the parties outlined below.

- Lead developer: To take the project forward a project owner and developer will be needed. LanzaJet may be able to play a role either directly, or by bringing in a trusted outside developer to help take the project forward.
- Investors and owners: Section 4 discussed the opportunities associated with engaging with the Māori economy, which is valued at over NZD $70bn, and Iwi Holding companies represent an opportunity for direct investment. Further, some of the partners involved in this study may also have an interest in investment, which should be explored as the project advances. LanzaJet's existing group of investors could also be approached and LanzaJet's development company could potentially also play a role. It would also be worth considering companies active in the forest products manufacturing and supply chain in New Zealand.
- Plant operators: It will ultimately be a decision for the project owner what direction to take with regard to plant operations. The operator role could be kept inhouse if the capability and experience exists. It could otherwise be contracted to an experienced third party. While New Zealand no longer has an operating refinery, some of the large industrial manufacturers that are active especially those in the forest products industry, may be suitable candidates. LanzaJet will also have significant operating experience and learnings from the operation of Freedom Pines as well as other projects by the time Pūrākau could feasibly begin operations.

9.4. Government Policy Recommendations

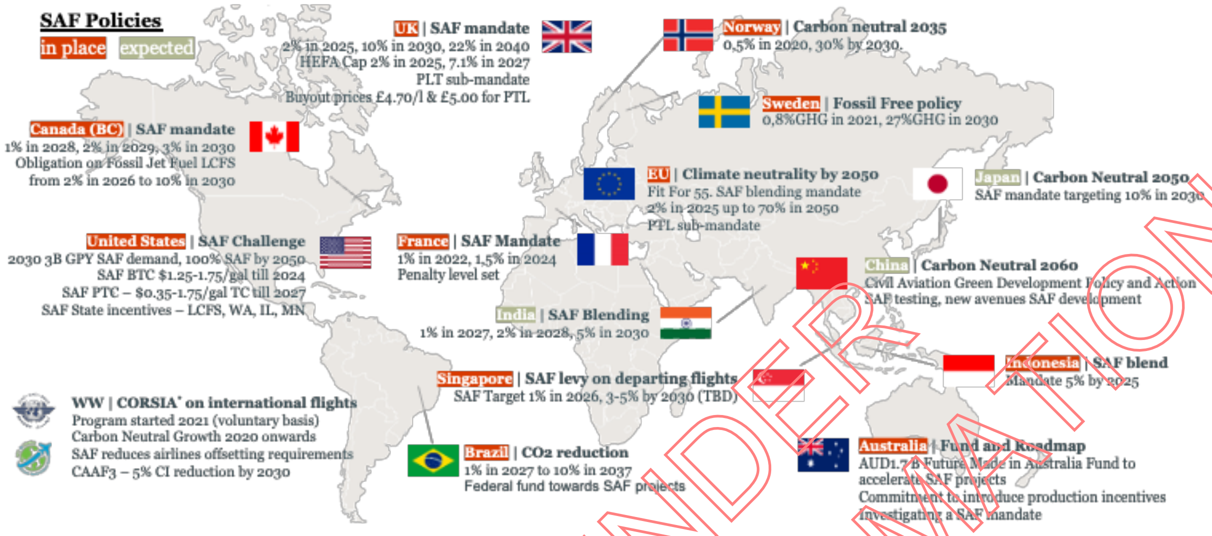
9.4.1. Global SAF Policy

As is the case in other regions around the world that are developing SAF ecosystems, government policy plays a vital role. This has also been the case for the development of renewable fuels for road transport. Where policy has been most effective, it has involved both regulated demand measures (such as mandates or low carbon fuel standards) as well as production support (such as production tax credits and capital grants).

Gradually more countries are implementing polices specifically targeted at SAF to meet 2050 net zero goals for the aviation industry. While this has traditionally been led governments in North America, the United Kingdom and Europe, countries in Asia Pacific are increasingly coming forward with their own supportive policies (Figure 19). For example:

- Japan has announced a 10 per cent by 2030 SAF mandate coupled with significant capital grants (up to 50 per cent of the cost of a new project) and production tax credit of ¥30 per litre.
- Singapore has announced a SAF target of one per cent in 2026, rising to 3-5 per cent by 2030 for all flights departing Singapore. To meet this, a levy will be placed on airline tickets to fund the purchase of SAF.
- Australia has announced that it will invest AUD $1.7 billion through the Future Made in Australia Innovation Fund to accelerate SAF projects, begin consultation with industry regarding the introduction of production incentives, and start investigating the costs and benefits of introducing a mandate for low carbon liquid fuels, including SAF.

Figure 19: Global SAF Policies (2024)



* Carbon Offsetting And Reduction Scheme for International Aviation

9.4.2. SAF Policy Design Principals

LanzaJet is fortunate to be active with projects in over 25 countries across 5 continents, which has provided unique insight into effective design elements for SAF policy. These include:

- Technology and Feedstock Neutral (no positive or negative lists)
  - For example: SAF Blenders Tax Credit and California Low Carbon Fuels Standard
- Performance-Based Standards
  - "Let the Lifecycle Analysis Do the Work"
  - Minimum thresholds, if used, should not preclude fuels that can deliver significant savings (e.g. The United States' SAF Grand Challenge threshold of 50 per cent achieves a good balance of significant GHG reductions with fuel inclusivity)
  - Clear, consistent LCA criteria that are the same for all transport modes
- Long-Term (10+ years) investment signal
- SAF should be prioritized within existing biofuel/biomass complex: Encourage long-term pivot of existing biofuel to aviation
- A holistic and complimentary approach is needed: Neither a mandate nor incentive-approach is sufficient on its own
- Break new ground: Recognise and provide additional value for non-CO_2 and air quality benefits from using SAF

Furthermore, it is essential to implement both supply and demand-side policies, and to do so in tandem, rather than in sequence. Relying on supply side policy alone concentrates high and visible costs on the Government and taxpayers.

Combining incentives with strong regulated demand spreads costs between the government and industry. Demand-side policies require obligated parties in industry (e.g. fuel suppliers) to either purchase SAF or pay compliance costs, so domestically produced SAF doesn't compete directly with inexpensive, polluting fossil fuels. With a levelled playing field, the cost gap between SAF and fossil jet that remains is smaller and can be more affordably covered by government production incentives. Such cost sharing is fair. While the benefits of using SAF accrue mainly to airlines, in the form of emissions reductions, they also accrue to society as a whole: improved air quality, economic development, job creation, and energy security.

Stacked supply-side and demand-side policy also spread and hedge against regulatory risk. In an incentive-only environment, producers and investors need certainty that incentives will be generous and durable enough to reliably bridge the entire cost gap between SAF and fossil jet fuel as long as it persists. This is a risky condition for investment decisions. Spreading support across policies ensure that producers aren't dependent on the functioning and political durability of a single policy.

For these reasons, production support alone is unlikely to build a domestic SAF industry. So far, history bears this out – the box below contrasts how the United States' policies for biomass-based diesel and SAF have played out over the last 20 years, highlighting that incentives alone are insufficient, but when combined with regulated demand can lead to rapid growth of new, innovative industries.

The best contemporary example of layered supply and demand-side policy for SAF is in the United Kingdom. The UK is introducing a suite of policies[17], including grants through the Advanced Fuels Fund and other programs, a revenue certainty mechanism akin to contracts for difference[18], and robust demand-side mandates for low carbon road and aviation fuels[19]. These policies are aimed squarely at building a leading SAF industry. While still too recent to show results, LanzaJet believes this approach offers immense potential for industry building and a strong example for New Zealand.

It is understood that the Sustainable Aviation Aotearoa SAF Working Group is considering policy options to support the development of a domestic SAF production industry. In this context, the above principals should be considered as part of that work. New Zealand has a opportunity to look at what has been done elsewhere around the world and adopt those policies that have been most effective in supporting the creation of SAF ecosystems.

Box 1: History of US Biofuels Policy

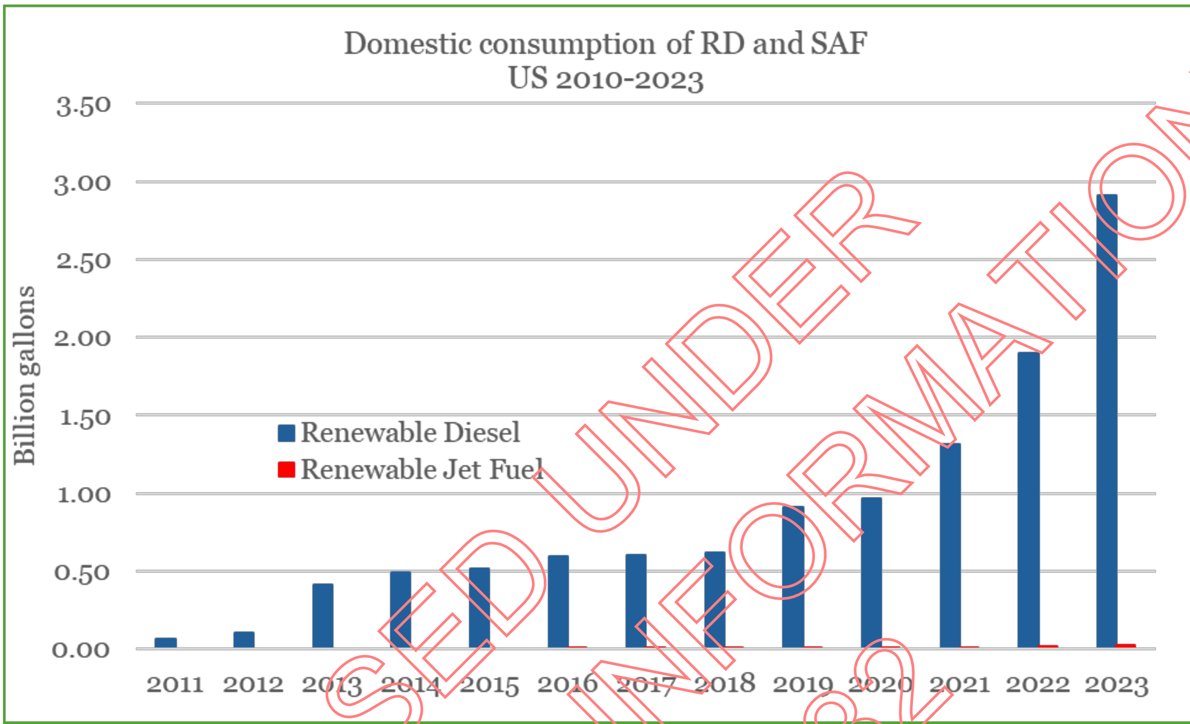
History of Biofuels Policy in the U.S.

Since 2005, U.S. policy has created two different regimes for renewable diesel and SAF. Because both fuels are made with virtually the same technology and producers can effectively choose which of the two to produce, the two regimes form a sort of natural experiment: holding equal the producers, technology, and the political and macroeconomic context, how does each policy approach perform?

The key difference between renewable diesel and SAF policy in the U.S. is that jet fuel is exempted from every demand side policy that covers road fuels. Under both the EPA Renewable Fuels Standard (RFS), which mandates biofuel use, and the state Low Carbon Fuels Standards, which mandate emissions reductions in three states, both renewable diesel and SAF can generate credits, however, while fossil diesel generates deficits, jet fuel does not. Exemptions for jet fuel were embedded at the inception of each program, before the first SAF pathways were certified as drop-in fuels under ASTM and viable as an alternative.

[17] UK Department for Transport. Advanced Fuels Fund competition winners. The UK AFF has already awarded 14 grants to 13 SAF projects.
[18] UK Department for Transport, April 2024. Sustainable aviation fuels revenue certainty mechanism: revenue certainty options.
[19] UK Department for Transport, April 2024. Supporting the transition to Jet Zero: Creating the UK SAF Mandate. *See also* The Renewable Transport Fuel Obligation- an essential guide.

The implication of these exemptions for jet fuel is that, while both renewable fuels get a revenue bump, compliance costs increase the cost of fossil diesel while fossil jet fuel remains inexpensive and plentiful. For producers, the economically rational choice has been clear and is illustrated in the figure below: produce renewable diesel, not SAF.



Source: U.S. EPA RIN Generation Data

Over time, policy has shifted to provide greater supply-side support to SAF, with little effect. The EPA RFS, which set the first mandates on diesel beginning in 2007, allowed opt-in crediting for SAF beginning in 2010. The California Low Carbon Fuel Standard (upon which all other state LCFS programs are based) began in 2009 and allowed opt-in crediting for SAF starting in 2018. The 2022 Inflation Reduction Act added a Blender's Tax Credit for SAF ($1.25-1.75 per gallon) to match the existing (since 2005) Blender's Tax Credit for biomass-based diesel ($1.00 per gallon). In 2025, both Blender's Tax Credits will be replaced with the Clean Fuels Production Tax Credit, which will cover both fuels but favor SAF ($1/gal for renewable diesel; $1.75 for SAF).

Nevertheless, despite increasingly generous supply-side incentives for SAF, the lack of firm, SAF-specific demand has led renewable diesel to continue outstripping SAF by two orders of magnitude. Fortunately, there are indications that this dynamic may be shifting. In the first months of 2024, we have begun to see early evidence of a boost in SAF production—in part a result of the tax credits. Meanwhile, California has proposed removing the exemption for jet fuel used on intrastate flights and has signaled publicly that this proposal is likely to be approved. When that happens, other states are likely to follow.

9.4.3. Pūrākau Policy Recommendations

This report has identified several areas where policy could be impactful regarding the further development and viability of Project Pūrākau. These include:

- CORSIA LCA and Certification: As discussed in Section 7.5, the use of round wood (K-grade logs and bin wood) creates some uncertainty with respect to the LCA and certification of the SAF under CORSIA. While the CORSIA sustainability criteria do not prevent the use of round wood from plantation forests as a feedstock, it would likely be considered a product or co-product with an existing market/s. An indirect land use change (ILUC) emissions factor would therefore apply to the LCA. In contrast, forestry residues are already included on the CORSIA "positive list of materials classified as co-products, residues, wastes or by-products" and therefore have no ILUC emissions factor applicable.

  A case could be made to classify round wood which remains in the forest as a residue, whereas this classification for K-grade logs would be more challenging. Despite this, there is a view that keeping K-grade logs in New Zealand for SAF production would not result in ILUC risk. If such a case can be made and supported with strong data, then it is plausible that K-grade logs could be included on ICAO's positive list. [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] Further engagement by the New Zealand Government with ICAO's relevant technical groups will be needed. It is understood that New Zealand is not represented on either CAEP or FTG; however the Australian Government does have a representative on both bodies and typically represents the interests of Pacific nations. Coordination with Australia in this regard would be recommended.

- Capital grants: As discussed in Section 8.2, [redacted] s 9(2)(b)(ii) and s 9(2)(ba)(i) [redacted] While it is not out of step with other SAF projects of this nature and magnitude, it will be important to identify opportunities to reduce CAPEX with a "value engineering" exercise during the next phase of the project.

  Nonetheless, new technologies and first of their kind projects rely on government grants to get them constructed. The Japanese Government for example is providing grants for up to 50 per cent of the capital cost of alcohol to jet projects, while the Australian Government's AUD $1.7 billion Future Made in Australia Innovation Fund will also provide significant grant funding to help advance SAF projects. Support of this magnitude not only help get projects financed, but also reduces debt service and lowers the cash cost of production.

- Demand side and supply side measures: It is well understood that in general SAF is two to five times the price of conventional jet fuel in markets without dedicated SAF policy subsidies or incentives. As highlighted in Section 8.1, the estimated cost of production for Pūrākau is in this range. There are several avenues that could be pursued to reduce this. A capital grant will help to some extent. Other forms of production incentives, such as production tax credits or contracts for difference, are also effective tools to reduce production costs. Australia and the United Kingdom for instance are both conducting consultations with industry on these specific measures for SAF. It is expected that as the production of SAF scales up the cost of production will reduce and therefore the need for subsidies or incentives will reduce over time.

  A regulated demand measure, such as a mandate or low carbon fuel standard, has the benefit of spreading this additional cost across the entire jet fuel market. In doing so, it also addresses competitive distortions where airlines may be disincentivised to purchase SAF because they do not want to lock in a cost disadvantage relative to competitors who may not be purchasing similar volumes of SAF. The credit or compliance mechanisms that typically support mandates also create significant value for SAF.

It's important that both incentives and mandates are durable and signal long term investment certainty, providing support for at least 10-years. As outlined earlier in this section, it's also important that production incentives are coupled with demand measures and not implemented in isolation. If implemented in isolation, a production incentive will need to be globally competitive as producers will be incentivised to send their SAF to markets where it generates the greatest returns. A mandate helps overcome this.

Such an approach has proven effective in other markets and for renewable ground transport fuels. The Australian Government has also recognised the importance of combining both mandates and incentives in their 2024 consultation paper: *A Future Made in Australia: Unlocking Australia's low carbon liquid fuel opportunit*y, which represents the start of a process to provide the necessary support to establish a SAF industry in Australia. This presents an immediate opportunity to collaborate with Australia and align policies to support the production of SAF on both sides of the Tasman.

10. Conclusions and Next Steps

Project Pūrākau represents a very significant project for New Zealand and would arguably be one of the largest manufacturing projects to be developed in recent memory. It also represents an important opportunity for New Zealand to achieve economic benefits, develop a domestic SAF industry and set in motion the decarbonisation of the aviation sector.

This study has demonstrated that a SAF production facility in New Zealand, converting forestry residues into 113 million litres of SAF and RD per year, is technically feasible using CirculAir™ - LanzaJet and LanzaTech integrated technology offering that can convert just about any waste feedstock into ethanol and then SAF.

Pūrākau would require approximately s 9(2)(b)(ii) and s 9(2)(ba)(i) cubic meters of feedstock each year, which can be satisfied by additional recovery of residues and the use of low-value export logs (K-grade logs), particularly in the s 9(2)(b)(ii) and s 9(2)(ba)(i) and the s 9(2)(b)(ii) and s 9(2)(ba)(i) The use of this feedstock for SAF production would result in significant economic and employment benefits and would be environmentally sustainable using best practice forestry management.

The Project would provide several important benefits for New Zealand, including:

- Domestic production of 102 million litres per year of unblended SAF each year, equivalent to 5 per cent of New Zealand's 2019 total jet fuel uplift of 1.9 billion litres, or 26 per cent of New Zealand's domestic jet fuel consumption;
- Expected carbon savings from use of this fuel of at least 233,000 tonnes of CO_2 a year, based on the SAF having at least a 70 per cent reduction compared to fossil jet fuel;
- Reduced reliance on imported fuels, enhancing energy security and supply chain resilience;
- Adding $428 million to New Zealand's annual GDP, including a 2.4 per cent increase in the s 9(2)(b)(ii) and s 9(2)(ba)(i) region's GDP;
- Domestic production of 11 million litres of RD each year, strengthening diesel supply chain security and resilience (e.g. defence, emergency response and generators);
- Creation of skilled jobs in regional areas, including 165 at the facility, 88 in the feedstock supply chain and a further 386 indirect jobs;
- Opportunities for Māori forest owners, landowners, and holding companies;
- Mitigating environmental and economic impacts during extreme weather events; and
- Positive changes in regional towns s 9(2)(b)(ii) and s 9(2)(ba)(i) through training, increased skilled employment, reduced unemployment, and improved economic conditions.

Scion's analysis found that across the s 9(2)(b)(ii) and s 9(2)(ba)(i) there are theoretically enough forestry residues to supply s 9(2)(b)(ii) and s 9(2)(ba)(i) cubic meters of feedstock each year for Pūrākau. However, due to limitations with recovery and transportation there is no single location in New Zealand that can feasibly supply enough feedstock for Pūrākau to operate with residues alone. s 9(2)(b)(ii) and s 9(2)(ba)(i) was chosen as the best location for the project as it has more potential feedstock than any other region. However, even in s 9(2)(b)(ii) and s 9(2)(ba)(i) the use of low value export logs (K-grade logs) in addition to residues is needed to ensure the project has sufficient feedstock. The use of roundwood (logs) creates some challenges with respect to CORSIA certification and the LCA for the project. Addressing this issue will require the support of the New Zealand Government and coordination with Australia's representatives at ICAO's technical committees (CAEP and FTG).

LCOP of SAF is in line with the broader industry understanding that SAF costs two to five times that of conventional jet fuel. The LCOP and sensitivity analysis demonstrates that reducing OPEX and CAPEX, rather than feedstock cost, is going to have the largest impact on the Project's returns and financial viability.

While the estimated capital cost for Pūrākau of NZD *s 9(2)(b)(ii) and s 9(2)(ba)(i)* it is in line with recent estimates for projects of a similar nature and magnitude that LanzaJet and LanzaTech have experience with. The CAPEX and OPEX estimates are considered conservative, as the project is in its early stage of definition, and it will be important to undertake value engineering exercise to identify efficiencies and opportunities to reduce CAPEX and OPEX. This will be a necessary next step before any further design or engineering work begins. Capital cost will also be an important consideration when selecting a site and those with suitable infrastructure, utilities and not requiring any demolition or remediation works will be highly favourable.

An analysis of market and policy incentives for SAF in other regions demonstrates that if similar market conditions developed in New Zealand and/or Australia, the net cost of the SAF produced would be competitive with conventional jet fuel.

It needs to be recognised that a SAF industry will not be created in New Zealand without the policy environment to support it. In this context, it will be important that New Zealand begin a process to consider the role of regulated demand measures, such as mandates, combined with production incentives. The combination of the two is important and has proven effective in other countries and regions. Australia is going down a similar path and this also presents a good opportunity for both countries to coordinate and align policies where it makes sense to do so.

Project Pūrākau offers significant opportunity for New Zealand with widespread environmental and economic benefits. To further define and de-risk the project, there are several important next steps for Air New Zealand and the New Zealand Government to consider:

i. Identifying pathways to legislating SAF policy support in 2024-2025 and begin a public consultative process by government around the right demand side and supply side measures for New Zealand. SAF projects around the world have not been developed without policies in place to support them. Government policy is arguably one of the most important factors to enable Pūrākau to advance.
ii. Incorporate the findings from an additional feasibility study into the use of municipal solid waste (MSW) as feedstock for SAF production due to be completed in 2024. MSW has several potential advantages that could help address some of the challenges identified in this report and the use of both MSW and forestry residues is also a potential outcome.
iii. In parallel with the MSW study, carrying out a value engineering exercise to identify opportunities to the reduce CAPEX and OPEX.
iv. Immediately beginning a process of engagement with the Australian Government and its ICAO representatives with respect to the use of K-grade logs and CORSIA.
v. Continue engagement with Maori entities and community stakeholders regarding the project and the opportunities it presents.
vi. Begin discussions with forest owners regarding feedstock supply.
vii. Identify a project site for either feedstock scenario (woody biomass and MSW). This will be necessary before any further engineering work commences.

11. Appendix

11.1. List of Attachments

s 9(2)(b)(ii) and s 9(2)(ba)(i)