New Zealand End-of-Life Plastic Waste Feedstock Recycling Feasibility Study Proposal

Working Title: *Aranga Kirihou – ka taea te porohita kirihou*; Plastic Resurrection - enabling plastic circularity

(NB Partner companies by segment have not been identified per NDA – will be amended in final document)

June 2022

TABLE OF CONTENTS

1. Purpose

This proposal has been developed in partnership between Partner 1, Partner 2, Partner 3, Partner 4 and Licella to outline the market viability activities needed to be considered when determining the economic feasibility of establishing chemical/feedstock recycling facilities in New Zealand. This proposal leverages a recently completed study for the Geelong-Altona corridor in Victoria, Australia, upon which a full-scale project announcement is imminent, and Mura Technologies[1], the first Cat-HTR^{TM} chemical recycling facility due for commissioning in the UK in Q3, 2022.

2. Introduction

Globally many organisations have picked up the challenge of ending the scourge of plastic pollution and the estimated 8 million tonnes of plastics that end up in our oceans every year[2]. Whilst marine plastic pollution is the more visible challenge that has galvanised consumers, brands, and polymer manufacturers into action, this is just a fraction of the 260 million Tonnes (2016) of plastics produced each year with just 12% of this being recovered currently through mechanical recycling.

[1] https://muratechnology.com/resources/

[2] https://blog.csiro.au/eight-million-tonnes-of-plastic-are-going-into-the-ocean-each-year/

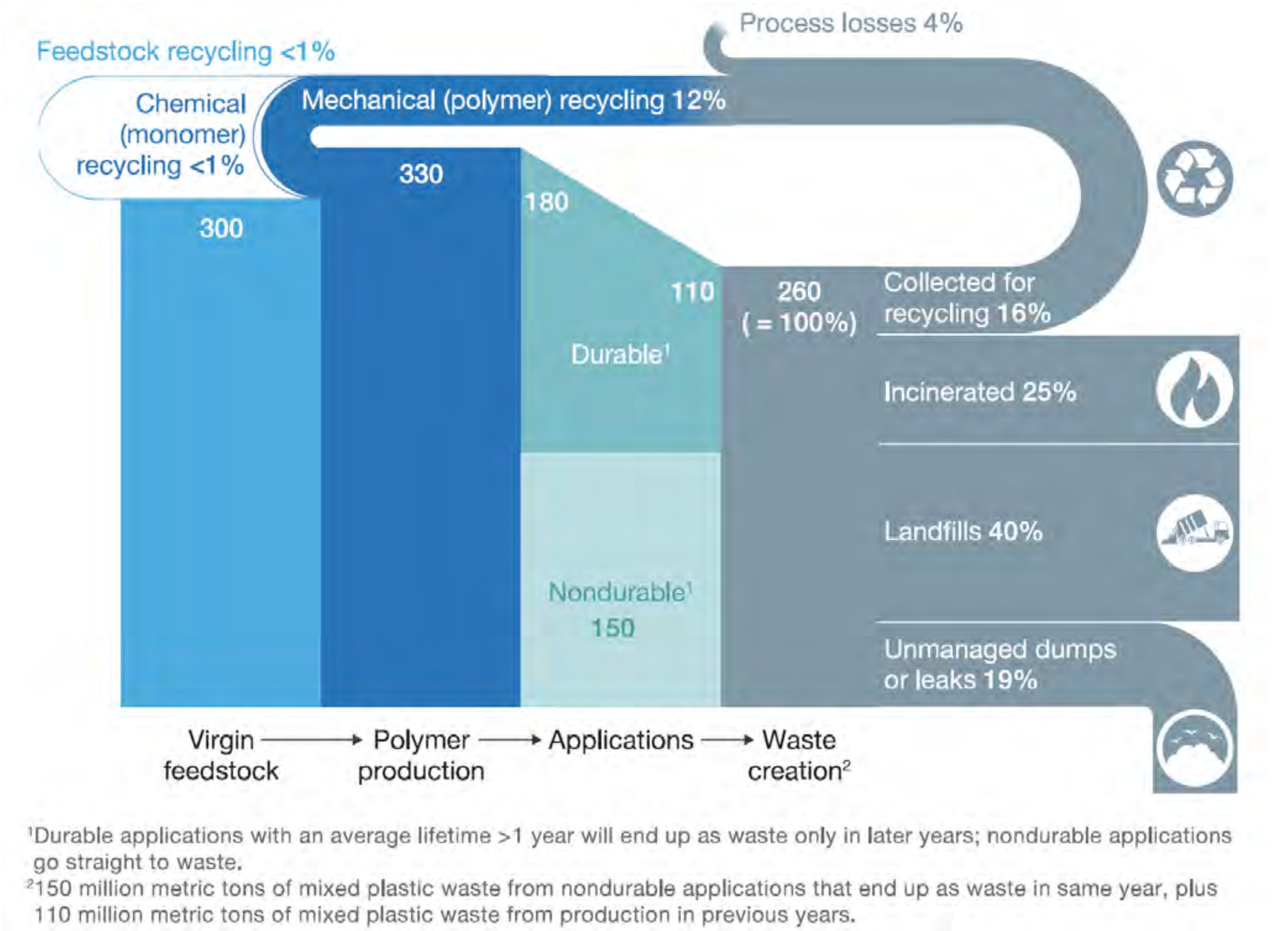
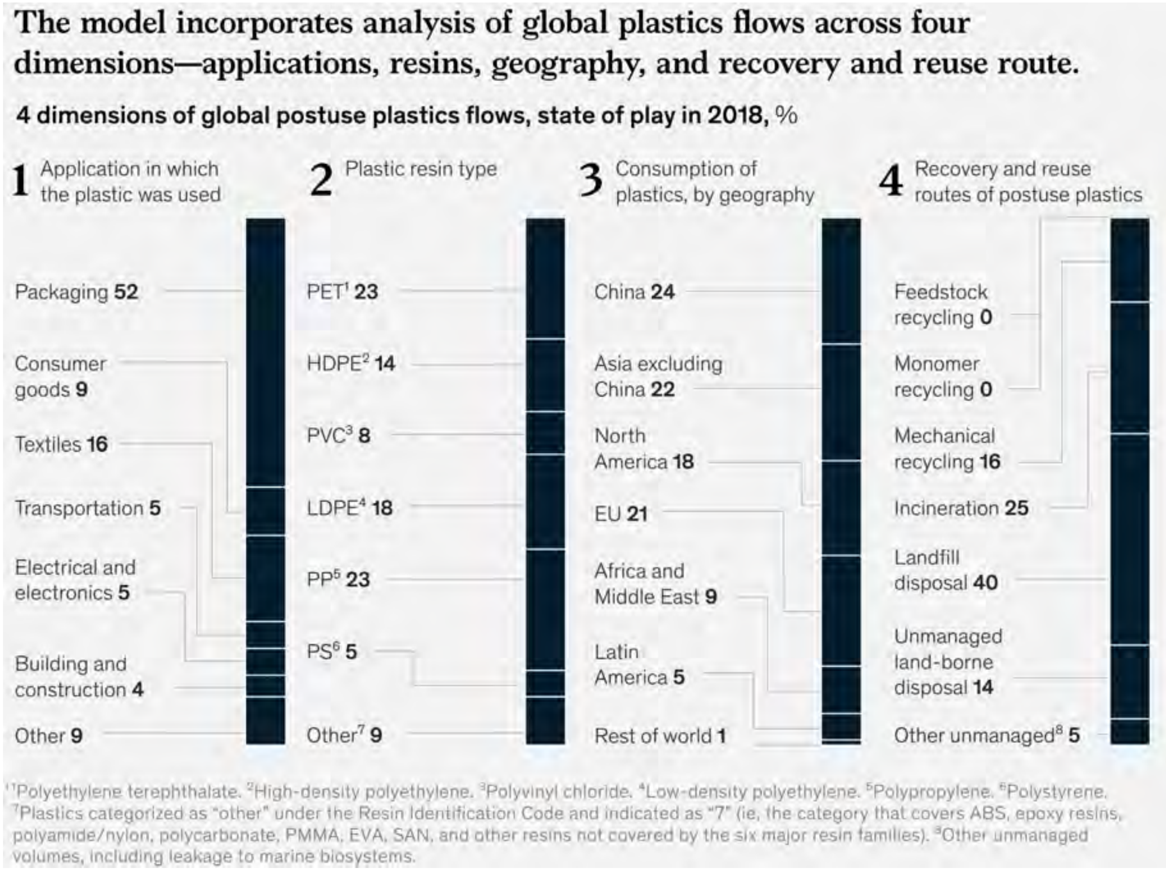


Figure 1: Global polymer flows, millions of metric tons per annum, 2016[1], McKinsey

McKinsey[3] reports that 0% of plastics feedstocks and monomers are recycled. Global leakage or unmanaged dumps of all plastic material flows (both durable and non-durable) is estimated to be around 19 percent, and only 16 percent of all plastic waste is re-processed to make new plastics. Most of the global plastics waste goes into incineration (25%) and landfills (40%), meaning that these materials are lost forever as a resource, despite plastics' potential for reuse and recycling[4].

[3] https://www.mckinsey.com/industries/chemicals/our-insights/plastics-recycling-using-an-economic-feasibility-lens-to-select-the-next-moves

[4] https://www.mckinsey.com/industries/paper-forest-products-and-packaging/our-insights/the-drive-toward-sustainability-in-packaging-beyond-the-quick-wins



With brands such as Nestlé, Unilever, Mars, P&G, Kellogg's etc (See Table 1 below) seeking to source and use high percentages of recycled material as well as legislation now encouraging re-use of packaging, McKinsey see Feedstock, or Chemical Recycling to be a significant growth opportunity for the polymer manufacturers[5].

McKinsey estimate that plastics re-use could rise to as much as 50 percent of plastics production by 2030 but to achieve this level of waste-recovery, capital investment of about $15 billion to $20 billion per year will be required. To put those figures in perspective, the global petrochemical and plastics industry has invested, on average, about $80 billion to $100 billion each year over the past decade. The Polymer manufacturing industry clearly agrees to this need as can be seen by their commitments in Table 1.

[5] https://www.mckinsey.com/~/media/McKinsey/Industries/Chemicals/Our%20Insights/How%20plastics%20waste%20recycling%20could%20transform%20the%20chemical%20industry/How-plastics-waste-recycling-could-transform.pdf

Table 1 – Brand Commitments on use of recyclable content

Brands	Commitment
ALLIANCE TO END PLASTIC WASTE [6]	• 1.5 billion USD funding towards solutions for waste plastic and recover and create value (expected to unlock up to $8 billion USD worth of investment) • Signatories include 47 global polymer producers, refiners, waste companies and brands
Nestlé [7]	• 100% of packaging to be recyclable or reusable by 2025 and elimination of non-recyclable plastics • To create a market for food-grade recycled polymers and allocate more than CHF 1.5 billion to pay a premium between now and 2025 • Source 2 million metric tons of food-grade recycled plastics between now and 2025
MARS [8]	2025 Sustainable Plastic Packaging Plans: • 100% of plastic packaging to be reusable, recyclable or compostable • 25% reduction in virgin plastic use • 10 re-use programs that tests new business models • 30% average recycled content in plastic packaging • Eliminate PVC (2020)
Unilever [9]	By 2025 Reduce virgin plastic packaging by 50%, with one third (more than 100k tonnes coming from an absolute plastic reduction) • Help collect and process more plastic packaging than we sell • Ensure that 100% of our plastic packaging is designed to be fully reusable, recyclable or compostable • increase the recycled plastic content in their packaging to at least 25%
Kellogg's [10]	2025 commitment • Goal of 100% reusable, recyclable or compostable packaging by the end of 2025.
PEPSICO [11]	2025 commitment • Making 100% of their packaging recyclable, compostable or biodegradable by 2025 • Striving to use 25% recycled plastic content in their plastic packaging • Aiming to reduce 35% of virgin plastic use across their beverage portfolio and, driven by SodaStream, avoid an estimated 67 billion single-use plastic bottles by 2025
P&G [12]	2030 Goals • Commitment of reducing the amount of virgin plastic in all packaging by 50% by 2030 • 300 million bottles across P&G's European household cleaning brands will be converted annually to either 100% recycled or partially-recycled plastic.

[6] https://endplasticwaste.org/about/
[7] https://www.nestle.com/ask-nestle/environment/answers/tackling-packaging-waste-plastic-bottles
[8] https://www.mars.com/sustainability-plan/healthy-planet/sustainable-packaging
[9] https://www.unilever.com/sustainable-living/reducing-environmental-impact/waste-and-packaging/rethinking-plastic-packaging/
[10] http://newsroom.kelloggcompany.com/2018-10-25-Kellogg-Announces-New-Global-Sustainable-Packaging-Goal#:~:text=25%2C%202018%20%2FPRNewswire%2F%20%2D%2D,by%20the%20end%20of%202025.
[11] https://www.pepsico.com/sustainability/sustainable-food-system/packaging
[12] https://us.pg.com/environmental-sustainability/

Brands	Commitment
Fonterra [13]	By 2025 • 100% of packaging will be reusable, recyclable or compostable • Have signed NZ's Plastics Packaging Declaration, strengthening our commitment to sustainable packaging
Zespri KIWIFRUIT [14]	By 2025 • Creating a circular economy for our packaging • 100% of packaging will be 100% recyclable, reusable or compostable • Any plastic packaging will be made from at least 25% recycled plastic

[13] https://www.fonterra.com/nz/en/embracing-sustainability/our-commitments/sustainable-packaging.html

[14] https://www.zespri.com/en-NZ/zespri-sustainability

Brand Demand and Shortage in Supply of Recycled Polymers

Company	Total Plastic Packaging (tpa)	Recycled Content Plastic[1] 2019 Progress (%)	2019 Amount (t)	2025 Target (%)	2025 Amount (t)	2030 Target (%)	2030 Amount	Additional Recycled Content Plastic required to meet 2025 demand (t)	Additional Recycled Content Plastic required to meet 2030 demand (t)
Coca-Cola and Resort	2,981,421	9.7%	289,198	25%	745,355	50%	1,490,711	56,157	1,201,513
Colgate-Palmolive	275,440	7.0%	19,281	25%	68,860	50%	137,720	49,579	118,439
Danone S.A.	800,000	10.6%	84,800	50%	400,000	100%	800,000	315,200	715,200
Diageo	31,900	2.5%	798	40%	12,760	100%	31,900	11,963	31,103
Essity	62,300	0.0%	0	25%	15,575	50%	31,150	15,575	31,150
Henkel	361,000	8.5%	30,685	30%	108,300	50%	180,500	77,615	149,815
Kellogg	62,927	0.5%	315	10%	6,293	30%	18,878	5,978	18,563
L'Oreal	137,280	6.9%	9,472	50%	68,640	100%	137,280	59,168	127,808
Mars, Incorporated	191,217	0.0%	-	30%	57,365	50%	95,609	57,365	95,609
Mondelez	187,000	0.3%	561	5%	9,350	25%	46,750	8,789	46,189
Nestlé	1,524,000	2.0%	30,480	30%	457,200	50%	762,000	426,720	731,520
PepsiCo	2,300,000	4.0%	92,000	25%	575,000	50%	1,150,000	483,000	1,058,000
Proctor and Gamble	600,000	5.7%	34,000	30%	180,000	50%	300,000	146,000	266,000
SC Johnson	100,700	14.0%	14,098	15%	15,105	30%	30,210	1,007	16,112
Unilever	700,000	5.0%	35,000	25%	175,000	50%	350,000	140,000	315,000
Total Plastic (t)	**7,333,764**		**351,489**		**2,149,448**		**4,071,997**	**1,797,959**	**3,720,507**

Source: Ellen MacArthur Foundation (2020).

To respond to the demand, polymer producers globally have announced plans to recycle plastics through traditional mechanical recycling and feedstock/chemical recycling. It is well established that mechanical recycling focuses on rigid plastic (mostly PET & HDPE) and can be done 2-3 times before plastic degrades. Plastic must also be sorted by type.

McKinsey report that for plastic packaging, 'Feedstock Recycling' technologies are globally seen as the method to deliver 'food grade' recycled polymers back through the plastic value chain.

Feedstock recycling (also known as Chemical Recycling) is when the plastics are converted back into a form usable in the same way as virgin fossil feedstock. The benefits of feedstock/chemical recycling are that it enables increased recycling rates by targeting end of life and currently non-recyclable waste plastics.

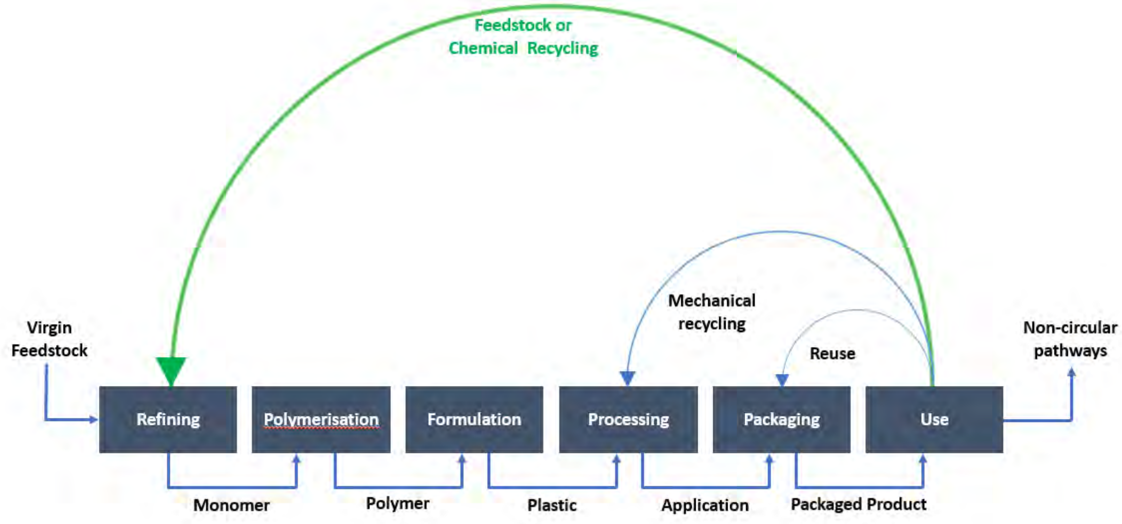


Figure 2: Recycling Pathways

Global Polymer manufacturers continue to respond with a raft of announcements about plans for feedstock recycling to be able to supply the recycled polymers being demanded by these brands. Table 2 contains a few of these announcements and Table 3 summarizes the announced volume targets.

Table 2 - Polymer Producers commitments

Polymer Producers	Commitments
[15,16] lyondellbasell	• Supports the Plastics Europe 2030 voluntary commitment to ensure high rates of re-use and recycling with the ambition to reach 60% for plastic packaging by 2030, and ultimately 100% re-use, recycling or recovery of all plastic packaging in 2040 • Constructing Pilot plant at Ferrera based around *MoReTec developed with* Karlsruhe Institute of Technology • JV with Suez in QCP in Netherlands selling mechanically recycled polymers • Plans to use sustainability criteria to assess a minimum of 70% of its key suppliers globally by 2025.
[17] DOW	• By 2030, enable 1 million metric tons of plastic to be collected, reused or recycled through its direct actions and partnerships • By 2035, will close the loop by enabling 100% of Dow products sold into packaging applications to be reusable or recyclable

[15] https://www.lyondellbasell.com/globalassets/sustainability/lyondellbasells-contribution-to-a-european-circular-economy.pdf?id=24101
[16] https://www.plasticstoday.com/sustainability/lyondellbasell-sets-exacting-sustainability-goals-2030

[17] https://corporate.dow.com/en-us/science-and-sustainability/commits-to-reduce-emissions-and-waste.html

Polymer Producers	Commitments
[18, 19] BASF We create chemistry	• 20 million Euros invested to develop chemical recycling. Feeding recycled plastic feedstock into petrochemical facility to displace fossil feedstock and produce recycled polymers • $1.5 billion over the next five years to develop, deploy and bring to scale solutions that will minimize and manage plastic waste and promote post-use solutions.
bp [20]	• In October 2019, BP announced that it aims to prove its Infinia technology on a continuous basis at a $25 million pilot plant in Naperville, US, which it plans to construct in 2020. BP Infinia is an enhanced recycling technology designed to turn opaque and difficult-to-recycle PET plastic waste into recycled feedstocks that can be used to make new, high-quality PET plastic packaging again and again, with no loss in quality.
[21, 22]	• By 2025 Shell's ambition is to use one million tonnes of plastic waste a year in its global chemical plants by 2025 • Using a liquid feedstock made from plastic waste (via pyrolysis) in it's chemical plant in Norco, Louisiana to make a range of chemicals. • By 2030, amount of recycled plastic in packaging will be 30% and will be reusable or recyclable. • By 2025, one million tonnes of plastic waste per year to be used in global chemicals plants.
[23, 24] NESTE	• Strategic ambition to build-up chemical recycling with speed and at scale • Seeking 400ktpa of plastic waste based liquified feedstocks • From 2030, plan to process over 1 million tons of waste plastic annually • By 2030, want to replace crude oil use with over 2 million tons of alternative renewable and recycled raw materials at our traditional oil refineries

[18] https://www.basf.com/global/en/who-we-are/sustainability/we-drive-sustainable-solutions/circular-economy/mass-balance-approach/chemcycling.html
[19] https://www.basf.com/global/en/who-we-are/sustainability/we-produce-safely-and-efficiently/environmental-protection/resources-and-ecosystems/engagement-against-plastic-waste/Alliance-to-end-plastic-waste.html

[20] https://www.bp.com/en/global/corporate/news-and-insights/reimagining-energy/rita-griffin-coo-petrochemicals-on-bp-infinia.html
[21] https://www.shell.com/business-customers/chemicals/media-releases/2019-media-releases/shell-uses-plastic-waste-to-produce-chemicals.html
[22] https://www.shell.com/sustainability/environment/circular-economy-and-waste.html

[23] https://ir-service.appspot.com/view/ahBzfmlyLXNlcnZpY2UtaHJkchsLEg5GaWxlQXR0YWNobWVudBiAgNDD_evOCQw?language_no=0
[24] https://www.neste.com/products/all-products/raw-materials/future-raw-materials/waste-plastics

Polymer Producers	Commitments
[25, 26] INEOS	• INEOS Styrolution announced a collaboration with Indaver, driving forward chemical recycling for polystyrene in Europe. The collaboration between the two companies aims at taking advantage of the recyclability of polystyrene to convert post-consumer waste into valuable resources. • By 2035, want to incorporate at least 325,000 tonnes of recycled material into its products (this is only 1.5% of chemical production in 2020) • By 2035, wants to have (on average) 30% recycled content in products destined for polystyrene packaging in Europe + offer a range of polyolefin products for packaging applications in Europe containing 50% or more recycled content, and ensure 100% of polymer products can be recycled
سابك sabic [27]	• Long term intention is to rapidly scale up the supply of its certified circular polymers for all global customers • First company to implement a project for the chemical recycling of challenging mixed plastic waste back to polymer
[28] NOVA Chemicals	• 100% of plastic packaging is recyclable or recoverable by 2030 • 100% of plastic packaging is re-used, recycled or recovered by 2040

Table 3: recycled volume commitments from 2025 to 2030 (mechanical + chemical)

Manufacturer	2025 Target (t)	2030 Target (t)
Braskem	300,000	1,500,000
DOW		1,000,000
EASTMAN	250,000	500,000
ExxonMobil Chemical	300,000	3,000,000
INEOS	325,000	325,000*
LyondellBasell		2,000,000
SABIC	200,000	200,000*
Shell	1,000,000	1,000,000*
TOTAL	**2,375,000**	**9,525,000**

*Based on 2025 commitment hence likely to increase

[25] https://www.ineos.com/businesses/ineos-styrolution/news/ineos-styrolution-collaborates-with-indaver-aiming-at-a-chemical-recycling-for-polystyrene/

[26] https://ineosgrenadier.com/en/gb/explore/ineos-group/creating-a-circular-economy-with-ineos

[27] https://www.sabic.com/en/news/21891-sabic-outlines-intentions-for-trucircle-to-close-loop-on-plastic-recycling#:~:text=SABIC's%20commitment%20to%20using%20more,recycled%20plastic%20from%20mechanical%20recycling.&text=Each%20initiative%20aims%20to%20prevent,reaching%20marine%20environments%20and%20ecosystems.

[28] https://www.novachem.com/sustainability/

Although significant, this is the tip of the iceberg. The current global availability of recycled resins is 350,000t with demand predicted to exceed 4M tonnes by 2030.

Licella's Cat-HTR™ Process for End-of-Life (Waste) Plastic Recycling

Licella's patent protected award winning Catalytic Hydrothermal Reactor (Cat-HTR™) eco-technology is the future of the low carbon circular economy. Cat-HTR™ uses supercritical water to affect the depolymerisation of plastics to produce a plasticrude, with a high conversion yield (plasticrude recovery of ~80-85% from feedstock). Cat-HTR™ overcomes many of the issues associated with competitor technologies namely pyrolysis and gasification (low yield, acidic product, char, additional treatment step, corrosivity, etc). The Cat-HTR™ process is plastic agnostic and can accept mixed and even biologically "contaminated" (i.e. biomass contacted) plastics[29]. It should be noted that although processable, PVC is not a preferred feedstock owing to minor chlorine contamination in the plasticrude making it undesirable for refinery upgrading.

The global interest in Licella's unique Cat-HTR™ process is evidenced by a significant project underway in the UK, Mura[1] which is Licella's JV with Armstrong Energy and DOW chemical, and will be operational in Q3 2022. Further projects have been announced with the globally significant chemical companies Mitsubishi (Japan), LG Chem (Korea) and ChevronPhillips Chemical (USA). Furthermore, following the recent completion of a feasibility study for the Geelong-Altona corridor in Victoria NSW[30], an announcement for the first Australian facility is imminent. As a highlight of this project, Licella, along with the Amcor, IQRenew and multinationals Nestlé and LyondellBasell created the first soft plastic food wrapper made with food-grade recycled content[31].

New Zealand's Waste Plastic Situation Analysis and Policy Summary

New Zealand is one of the highest generators of waste per person in the world, (approximately 750 kilograms per person), 49 per cent higher than the OECD average of 538 kilograms per capita[32]. In 2018, 3.7 million tonnes of waste were sent to municipal landfills and the volume is increasing year on year. Additionally, waste plastic can largely no longer be sent overseas for processing. Much more of this resource will need to be recycled, reprocessed or reused, potentially though the implementation of the Cat-HTR™ chemical recycling technology.

---

[29] https://www.licella.com/solutions/plastic/

[30] https://www.licella.com/projects-2/

[31] https://www.licella.com/news/the-kitkat-thats-the-sign-of-a-break-in-australias-waste-challenge/

[32] https://data.oecd.org/waste/municipal-waste.htm

New Zealand's plastic utilisation has been well summarised by PlasticsNZ[33].

	Resin	FGC Tonnes (60% FGC Total)	Total Food & Grocery Tonnes	Adjusted with Industry Information
1	PET	21,483	35,804	36,000
2	HDPE	10,172	16,953	20,000
3	PVC	482	803	800
4	LCPE	9,123	15,205	15,000
5	PP	4,883	8,138	8,000
6	PS	1,594	2,657	3,500
7	Other	6,410	10,683	11,000
Total		54,157	90,245	94,300

Of these volumes PlasticsNZ has suggested that only ~½ of the PET is being captured through existing mechanical recycling due to mixed colours, and, that LDPE via Soft Plastics Recycling Scheme and lids are all underutilised resources.

PlasticsNZ has also identified the following post-consumer waste plastic opportunities;

1. **Building & Construction** – estimated 45,000 tonnes of plastic waste going to landfill p/a (PE, PVC and PP)
2. **Agricultural Plastics** – PP woven bags, HDPE containers and "contaminated" soft plastics eg bale wrap
3. **Fashion – Textile waste** – estimated 45,000 tonnes of synthetic textile waste going to landfill p/a
4. **Other textile waste** – unknown, but understand carpet, curtains, etc are the largest contaminant in our recycling stream
5. **Medical** – plastic and textile waste (esp PP theatre syringes, PPE and sterile wraps)
6. **Automotive** – unknown, and likely to be mixed materials (additives)

The New Zealand government has ambitious plans to reduce waste and improve the recycling of all waste. *Te kawe i te haepapa para Taking responsibility for our waste*[34]: highlights the challenges and the steps being taken to address NZ's waste issue. In Colmar Brunton's Better Futures 2021 survey, issues relating to waste and recycling made up three of the top ten concerns for New Zealanders[35].

33 https://www.plastics.org.nz/

34 https://consult.environment.govt.nz/waste/taking-responsibility-for-our-waste/

35 https://www.colmarbrunton.co.nz/betterfutures-reports-2021/ (10 September 2021)

NZ government policy is being developed to enable a shift from current 'take–make–dispose' system towards a low-waste, more circular economy. Infrastructure has been identified as a key enabler. Currently NZ's domestic resource recovery and waste infrastructure system is limited in the types of materials that can be recovered, as well as the volume of materials that can be processed. The recent Report on Waste Disposal Levy Investment Options estimated Aotearoa has a current waste infrastructure deficit of $2.1–2.6 billion[36]. The report also noted that in the context of the infrastructure needed to support a circular economy, this deficit is likely to be significantly larger.

A number of New Zealand's major manufacturers have adopted challenging targets for plastic packaging. For example, Fonterra will make their packaging 100% reusable, recyclable of compostable by 2025[37]. Zespri's leadership statement "creating a circular economy for our packaging"[38] requires packaging being 100% reusable, recyclable or compostable by 2025, and that any plastic packaging will be made from at least 25% recycled plastic by 2025[39]. The Food and Grocery Council reports that both supermarkets and manufacturers are committed to tackling single use and waste plastic issues head on[40].

It is often argued that NZ's geographic isolation and relatively low population density present challenges to the economic viability of onshore resource recovery infrastructure which generally relies on economies of scale and low logistical costs. Traditional waste export markets now accepting fewer materials and focusing on higher-quality products highlights our need to find viable technology solutions and to consider novel pan-Australasian solutions in order to access key infrastructure and deliver circularity. Such an approach will have the added benefit of limiting NZ's exposure to economically important product pricing swings, which may also be compounded by exchange rate fluctuations.

Licella's recently completed Advanced Recycling Feasibility Study for the Geelong-Altona corridor offers a number of insights key among them that chemical recycling offers a range of offtake opportunities in addition to producing plastic precursors, (which may also be repurposed as Sustainable Aviation Fuel), can deliver products such as marine fuels and bitumen shown in the following figure, which may be viewed to be in the national

[36] Grant Thornton. 2021. Report on Waste Disposal Levy Investment Options. Wellington: Ministry for the Environment

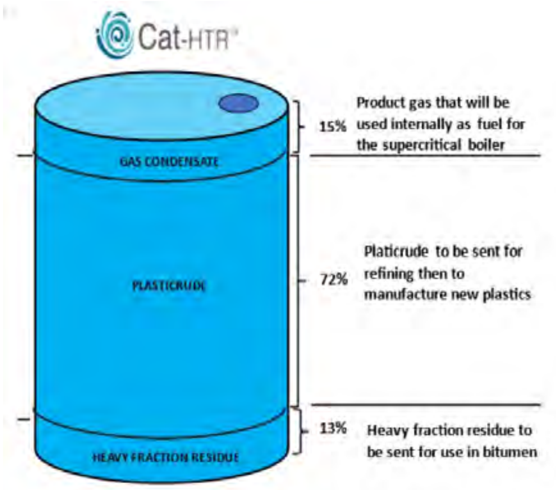
[37] https://www.fonterra.com/nz/en/embracing-sustainability.html

[38] https://www.zespri.com/en-NZ/zespri-sustainability

[39] https://www.zespri.com/content/dam/zespri/nz/sustainability/Zespri-Packaging-Targets.pdf

[40] https://www.fgc.org.nz/industry-tackling-packaging-issues-head-on/

interest[41] particularly given the recent closure of the Marsden Point refinery and repurposing of the site to an import terminal.



42

The NZ Government's early steps to lift the performance of the resource recovery and waste system, and move towards a low-waste, more circular economy are in complete alignment with the goal of the proposed feasibility study. The opportunity to leverage the extensive due diligence already completed on Licella's Cat-HTR™ by major multinational organisations including DOW, Shell, LGChem, Mitsubishi, ChevronPhillips and others minimises both technology adoption risks and plant installation costs thereby enabling any NZ project to benefit as a "fast follower".

A circular economy for Aotearoa New Zealand in 2050 | He ōhanga āmiomio mō Aotearoa hei te tau 2050 is an ambitious undertaking. The essential concept at the heart of the circular economy is to 'ensure we can unmake everything we make'[43]. To achieve a genuinely circular economy within 30 years will require transformational change, and investment in support and infrastructure for innovative resource recovery and recycling facilities like Cat-HTR™. Importantly, the NZ government has also recognised the significant lack of critical core infrastructure across the country in most respects[44]. The

[41] https://www.newshub.co.nz/home/new-zealand/2022/04/waka-kotahi-nz-transport-agency-takes-over-country-s-bitumen-supply-because-it-thinks-it-s-being-ripped-off.html

[42] Establishing Australia's First Advanced Waste Plastics Recycling Facility: Beat Available Techniques and Technologies (BATT), June 2022

[43] https://environment.govt.nz/what-government-is-doing/areas-of-work/waste/ohanga-amiomio-circular-economy/

[44] For the NZ government this term covers large commercial industrial plants though to smaller community facilities for resource recovery of all kinds and collection equipment including trucks and bins – all the equipment and facilities needed to support circular reuse and recycling activities.

recently released Aotearoa New Zealand's first emissions reduction plan will support business to move away from fossil fuels, reduce the amount of waste to landfill, invest in waste infrastructure and lead innovation in some of the most challenging parts of the economy[45]. Given NZ's reliance on Australian infrastructure including refinery and polymer production, a pan-Australasian approach to circularity must be considered for NZ's waste plastic problem.

In addition, the opportunity also exists to make improvements at the bottom of the waste hierarchy which can be addressed through chemical recycling technology. Legacy landfills and residual waste that have no apparent value and will be with us for the foreseeable future can potentially be considered as future feedstock supply. Licella's Cat-HTR™ technology, confirmed through Project MURA, offers better economic and environmental outcomes than landfill disposal of waste plastic.

A further NZ Government priority is to tackle climate change with targets to be set in legislation to achieve net zero emissions for Aotearoa by 2050. The government recognises that the waste system has a significant part to play in reaching these targets. The Ellen MacArthur Foundation has reported that recycling 1 tonne of plastic could reduce emissions by 1.1–3.0 tonnes of CO_2 compared to producing the same tonne of plastics from virgin fossil feedstock[46].

To deliver on the suite of government policies, decisions taken in support of objectives to 2030 will be critical. This proposed Cat-HTR™ New Zealand project feasibility study will assist with addressing, transformational change, supporting resource recovery systems, and reducing emissions from waste. End-of-Life waste plastic chemical recycling projects will contribute to the public good through a transformed waste system, expanded investment in the sector, address material streams and products, strengthen operational and compliance activities and, importantly train the next generation of highly qualified personnel to operate and manage these facilities.

In summary, the proposed End-of-Life waste plastic Cat-HTR™ chemical recycling project will deliver against the following government priorities proposed through to 2030:
1. Te kawe i te haepapa para | Taking responsibility for our waste
2. Stimulate innovation and redesign to encourage long-term change towards circular supply models and reduce waste being generated.
3. Support the establishment of long-term information and education programmes, grounded in connection and responsibility, as the platform for long-term social and cultural change and new behaviours.

---

[45]https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/#:~:text=Aotearoa%20New%20Zealand's%20first%20emissions%20reduction%20plan%20contains%20strategies%2C%20policies,of%20the%20emissions%20reduction%20plan.

[46] Ellen MacArthur Foundation. (2016). The new plastics economy: rethinking the future of plastics.

4. Get the resource recovery and recycling systems working well by: (a) simplifying the material streams flowing through the system (b) investing in the equipment and infrastructure needed to support consistent and widespread collection, sorting and processing at the community and commercial levels (c) developing markets for end products.
5. Reduce emissions from waste by diverting more from landfill.
6. Building best approaches for remediating the damage from past disposal practices.

Finally, it is important to recognise that New Zealand's polymer feedstocks are fully integrated into the Australian plastics supply chain. Taghleef and Amcor, the manufacturers of films, are based in Australia and supply the NZ market. A number of NZ-based plastics product suppliers are headquartered in Australia. The recently completed Feasibility Study for the Geelong-Altona Corridor[24] reported that if Australia is not able to produce its own recycled polymer feedstocks, then they will be imported, further challenging the domestic polymer manufacturers who are already subject to a global over-supply of virgin polymer production and high gas prices. NZ will be similarly affected. Therefore, NZ has a unique opportunity to enhance Australasia's recycled polymer feedstocks, while simultaneously diverting a significant portion of waste plastics from NZ landfills. This will directly support government policy directives for waste minimisation, create plastic circularity and support climate change targets.

The Feasibility Study

This proposal has been written to gain commitment to undertake a Feasibility Study that would be the first step in establishing an End-of-Life waste plastic chemical recycling facility in New Zealand using Cat-HTR™ technology. The intention is to obtain both industry and government support for this Study which will provide the basis to inform subsequent FEL 1-3 detailed engineering studies for construction of the facility.

The costs of the Feasibility Study will be divided equally between the industry participants with the information produced being provided to these participants. Government matching support for the study is being actively sought.

Organisations that choose not to participate financially but allow their manufacturing site/s to be evaluated for construction suitability for a chemical/feedstock recycling facility will be provided with a summary of the findings.

The Feasibility Study will produce a financial model to determine the financial viability of establishing a facility.

No further R&D such as maximising content of plastic precursors, producing any samples or any detailed engineering will be undertaken as part of the Feasibility Study. These are activities that would need to be separately undertaken if the Feasibility Study looks encouraging and the site has been selected.

3. Project Summary

Market viability activities need to be considered in order to determine the feasibility of establishing a facility in New Zealand. In addition, the most advantageous location for such a facility will be decided.

The activities and estimated costs for each task of the Feasibility Study are summarised below, with information being provided to those consortia members who provide their share of the costs.

It is proposed that each financially contributing consortia member will nominate a representative to a steering committee who will meet fortnightly to review progress with the Feasibility Study Project Manager.

Where possible under the terms of pre-existing Non-Disclosure Agreements, this study will where possible leverage key learnings and relevant data from the recently completed Geelong-Altona Feasibility Study[24].

An Expression of Interest has been lodged with Plastic Innovation Fund for 50% of the required funding. Discussion with PIF manager has indicated that this request meets the criteria and will be treated favourably.

Table 4 – Feasibility Study task details:

Feasibility Study Task	Cost(E=estd)	Description	Suggested Resources
Brand Demand Research	$52,000E	Report on the brand demand for recycled packaging and relevant government policy	tbd with assistance from project partners
Feedstock Mapping	$70,000E	Mapping the volumes, availability, type, condition and cost of available waste plastics with associated logistics costs for shipping to sites identified	To be coordinated by with PlasticsNZ
Site Evaluation	$36,000E	Evaluating potential sites for 'Chemical Recycling' plants in NZ	Engineering consultancy tbd tbd in collaboration with project partners
Permitting & Planning	$42,000E	Understanding and mapping permitting pathway for 'Chemical Recycling' technologies in New Zealand	Engineering consultancy tbd in collaboration with project partners
Community Engagement	$25,000E	Deliver engagement plan in support of selected Site(s) and Permitting & Planning requirements	Consultancy tbd tbd in collaboration with project partners

Feasibility Study Task	Cost(E=estd)	Description	Suggested Resources
Product Off-take	$40,000E	Determine value and offtake partners for the products produced	Joe Zingarelli and Azeem Remtulla both veterans of the petrochemical industry[47] have been engaged to revise their Victoria study with assistance from the consortium partners and relevant industry and government bodies
Financial Modelling	$60,000	Financial model development to support business case for 'Chemical Recycling' in New Zealand	Grant Thornton has been engaged to develop model with support from project partners and relevant industry and government bodies
Environmental Benefits	$45,000E	Scoping of LCA to determine boundaries and benefits of 'Chemical Recycling' facility	Thinkstep-anz has been contacted
Product Provenance	$40,000E	Developing requirements on feedstock supply and Chain of Custody to reach product certification	tbd in collaboration with project partners
Project Management Government Liaison	$50,000	Manage steering committee meetings, ensure timely completion of tasks, reporting of the project outcomes, interfacing with the Government Departments for grant funding and policy support, interfacing with industry organizations	Dr Paul Watson, Mick Gaynor
Contingency	$40,000		
Total (excl GST)	**$500,000E**		

The budget is still under development and every effort is being taken to minimize costs without impacting the required outcomes.

4. Feasibility Study Tasks

4.1 Brand Demand Research

This task is a market research study into the demand from brands for recycled plastics. This investigation would involve engaging with all major plastic packaging stakeholders in New Zealand including WasteMinz, Packaging Forum, Packaging Forum, New Zealand Food and Grocery Council Major Brands, Polymer Producers and Converters e.g. Cospak, Pact Group, Talbot Technologies, EPL Group, Woolworths, LyondellBasell, Qenos, Taghleef Industries, Innovia and Amcor.

[47] See Appendix 8.3

The work will cover demand by polymer type, any premium that will be paid to stimulate demand in recycled content and over what period, any planned shifts from plastic to other packaging e.g. paper and cardboard and shifts between polymer types e.g. away from PVDC and PVDF. The period of consideration will be the 2020-2030 timeframe. Also required is information of international packaging trends.
Items to be reported are:

- Overview of packaging types and information on their recyclability, e.g. are soft plastics less recyclable than rigid, multilayer films?
- Current hurdles for generating recycled content in plastic packaging
- Identification of parties in supply chain of plastics in New Zealand. I.e from monomer to polymer resin, manufactured into film, packaging and brands that utilise these materials
- Determine extent to which premiums could be expected on recycled content in packaging, i.e value we could see by chemically recycling plastic
    - Pricing trends for virgin, mixed plastic waste and recycled plastics by polymer type as cost comparison
    - Understanding what percentage, the packaging cost is for an item’s final cost of production and sale price
- Overview of trends with plastic packaging materials
    - packaging moving to paper and cardboard
    - bio-polymers such as PLA
    - moving away from chlorinated plastics, PVDC and PVDF materials

The role central government policy plays in setting industry standards and targets is well established. A review of current government policy and a view on likely future direction is requested.

It is proposed that this work is undertaken by a consultant with extensive connections from the plastics packaging sector through to government.

4.2 Feedstock Mapping

Critical to the viability of an End-of-Life plastic feedstock recycling hub is to ensure that there is an adequate feedstock supply and the condition, cost (gate fee and logistics) and availability of the feedstock is known. The viability of the feedstock supply will help determine:

- The size and configuration of the initial facility and how this can be scaled.
- The best method of aggregating suitable plastics from across the New Zealand

A report will be commissioned to provide quantitative data of End-of-Life Plastic (ELP) waste flows, market research into ELP and expected trends in New Zealand such as the impact of planned Waste-to-Energy plants and increases in the Waste Levy. This task will also look at the current cost of disposal, costs of transport and economic range for transportation to the proposed hub. The objective will be to get an understanding of how at least 80% of waste plastic will “flow” in New Zealand in the 2020–2030 time period.

The task author will also engage with NZ Food and Grocery Council and the retailers who work with them.

The consultant will also review the feasibility study recently completed for the Altona-Geelong Corridor and incorporate the relevant technical findings.

Further information will be collected by consultation with industry stakeholders involved in the management of End-of-Life plastics, from the points of collection through to disposal or recycling. The organisations intended to be contacted include but are not limited to:

- Waste transporters - EnviroWaste and WasteManagment
- MRF operators - OjiFS, EnviroWaste, WasteManagement, Plasback and Agrecovery
- Plastics re-processors - Pact, Cospak, Talbot, EPL Group, Convex
- Waste to energy facilities –
- Others as identified

It is proposed that this work is undertaken by a consultant in close collaboration with PlasticsNZ who currently manage a database of plastic flows.

4.3 Site evaluation

It is anticipated that recommendations for suitable sites will be developed by the project partners. Four sites have been suggested as potential locations for a Cat-HTR^{TM} plant in New Zealand. These will include, but are not restricted to:

1. Mothballed Z-Energy biofuel plant (and associated equipment) at Wiri may be available
2. OjiFS Penrose site Auckland
3. EnviroWaste site tbd
4. Christchurch in support of regional agricultural plastics recovery initiatives

Sites are to be evaluated taking into account:

- Proximity to feedstock supply and product off-take
- Assessment of site; land, infrastructure and utilities
- Potential to leverage existing site infrastructure, operations and staff
- Consideration to existing and future permitting and planning
- Consideration to site logistics and distance from appropriate transport hubs
- Availability of land and proximity to existing operations and residential communities
- Cost and equity interest
- Potential for Grant funding
- Any existing site liabilities e.g. remediation
- Tie-ins to other sites
- Potential to expand

- Potential to integrate other Waste Management capabilities e.g. MRF, Pelletising facility etc

It is proposed that an RFP is prepared and sent to local engineering consultants including Worley Parsons, WSP NZ, Tonkin & Taylor and WoodBeca.

Project partner expertise may be a more cost effective means of determining and prioritizing possible project siting and will be considered prior to the RFP.

4.4 Permitting & Planning

It is important that new and novel technologies that are 'first of their kind' in New Zealand are given careful attention to understand how the planning and permitting requirements will be regulated. The process can then be established to ensure that permitting for the selected site can be expedited.

As these planning and permitting processes can take multiple years to finalise, it is vital to commence these activities as soon as possible to prevent an extended timeframe becoming a critical issue in commercialising the project.

A specialist consultant will be identified through and RFP. The first stage of this task will be to develop a roadmap for the planning and permitting process of 'Chemical Recycling' in New Zealand. The specialist consultant will need to address:

- Key regulatory groups to be engaged for any future submission
- Determining the state policies or guidelines that could regulate chemical recycling technologies like Cat-HTR™
- Determining the scheduled activities applicable to these technologies
- Determining any particular requirements that have to be met as part of pilot testing

It is proposed that an RFP is developed and forwarded to NZ-based consultants including Worley Parsons, WSP NZ, Tonkin & Taylor and WoodBeca. Once engaged we will then supplement this work as appropriate with other consultants as required

However, project partner in-house expertise may be a more cost effective means of assessing permitting and planning requirements.

4.5 Community Engagement

It is also important that appropriate community engagement is developed to ensure the relevant Iwi, community and councils are brought along. The potential for new employment should also be of appeal to all. Ensuring that local Iwi, Councils and the community are appropriately included in discussions will be a key part of this project.

It is suggested that WSP NZ is contacted to discuss this activity as they have reportedly completed similar projects

4.6 Product Off-take Strategy

Establishing the first of its kind facility will be of higher cost than subsequent facilities however any NZ facility will form an integral part of the Australasian polymer supply chain. Maximising the value from the products produced and confirming both the carbon benefits and novel Australasian circular economy for plastic will ensure that the maximum government grant funding can be leveraged in order to secure equity investment for the study.

Delivering chemically recycled polymers to the polymer supply chain remains a key objective and understanding the demand and premiums that can be achieved is included in the activities covered in Task 3.1. Also important is understanding how recycled plastic feedstocks can be integrated with and delivered to New Zealand polymer manufacturers, as well as requirements for the optimal recycled markets for other hydrocarbons produced.

Feedstock/Chemical recycling technologies such as Cat-HTR™ depolymerise the waste plastics producing a “plasticrude” product and gases. To determine the optimal economics the relative value of these components needs to be established.
The Cat-HTR™ process also produces gases that contain a mix of light olefins. Some of these olefins can be used as feedstocks for food contact compliant grade plastic manufacture. Additional hydrocarbons also produced by the Cat-HTR™ process can be used as a feedstock for steam crackers to produce more olefins.

The Cat-HTR™ liquid product when fractionated produces:

- Naphtha
- Diesel
- Gas Oil
- Waxes
- Bitumen products

Higher proportions of each fraction can be targeted depending on the Cat-HTR™ processing conditions.

The Naphtha, Diesel and Gas Oil products are widely traded commodities that can be used as steam cracker feedstocks as well as fuels. In addition, specialist markets exist for waxes that can be used in a variety of applications including in bituminous products to modify the characteristics of bitumen binders e.g. reduce viscosity. These products are known as Polymer Modified Bitumens or PMB’s. Like plastics, the wax and bitumen markets are keen for products that can be used in Circular Economy type applications.

Understanding the suitability, value and potential offtake of these products will be important to ensuring the overall optimal economics of the feedstock/chemical process. It is proposed to engage specialist oil-process off-take consultants Joseph Zingarelli &

Azeem Remtulla, who previously consulted for the Victoria study, for this task. (See Appendix 8.3)

4.7 Financial Modelling

Understanding the overall economics of the process is critical to all the stakeholders. For this reason, we believe it is worthwhile engaging an external Financial Advisory company to produce a model that will give confidence to the project partners of the value that can be delivered by Feedstock/Chemical Recycling. The model will also articulate the investment requirement which will help substantiate any grant applications under any State or Federal scheme as well as potential industry investment.

Accounting and consulting firm Grant Thornton Australia has been asked to review and update the financial modelling previously completed for the Victoria Feasibility Study. Information about them is provided in Appendix 8.4.

4.8 Environmental Benefits

Demonstrating environmental benefits in the Feasibility Study that a Feedstock/Chemical Recycling facility delivers in terms of volume of recycled materials consumed, the products produced, the associated reduction in the use of virgin fossil products and the reduction in greenhouse gasses (GHGs) are important in determining the "green" credentials of the facility.

For these reasons it is important to commission a Life Cycle Analysis (LCA) report that will be able to quantify the environmental benefits.

Defining the project boundaries is necessary for any LCA undertaken. This will involve understanding the inputs and outputs of the chosen technology. As these are understood for the Cat-HTR™ process, it is proposed to use this data as a reference.

Thinkstep-anz, an LCA accredited foundation member of the Life Cycle Association of NZ in Victoria has been identified as having suitable expertise to deliver this Environmental Benefits report and has been contacted. Information on Thinkstep-anz is given in Appendix 8.5.

4.9 Product Provenance and Chain of Custody

The value of Chemically Recycled products to the polymer supply chain and brands is dependent on the ability of having these polymers certified as being from recycled feedstocks.

After consultation with industry stakeholders and certifying bodies, in May 2019, a white paper was published by the Ellen Macarthur Foundation titled 'Enabling a Circular Economy for chemicals with the Mass Balance approach'. This introduced the methods to determine traceability of chemically recycled product and is now being implemented by certification bodies such as RSB, RedCert and ISCC.

These methodologies are already gaining traction with Industry leaders

- LyondellBasell launched in 2019 the Circulen and Circulen Plus range of bio-based polypropylene (PP) and polyethylene (PE). These products manufactured in Europe, are produced according to the requirements of the certification scheme REDcert[2]

- SABIC in February 2019 became pioneers of the first production of certified circular polymers

- Borealis in March 2020 started producing polypropylene based on Neste's produced renewable feedstock, gaining ISCC certification for its renewable PP, replacing fossil fuel-based feedstock

- Braskem since 2012 has been producing green PE processed from sugar cane and is ISCC certified

Licella has, in consultation with LyondellBasell, reviewed the methodologies used by these organisations for the certification of feedstocks, processes, products and the supply chain and are recommending we adopt the ISCC Plus certification pathway due to ISCC's widespread use and acceptance.

Licella propose outlining a roadmap of how to determine traceability and establish chain of custody through the supply chain by applying a mass balance approach and in so doing enable value to be attributable to the recycled molecules.

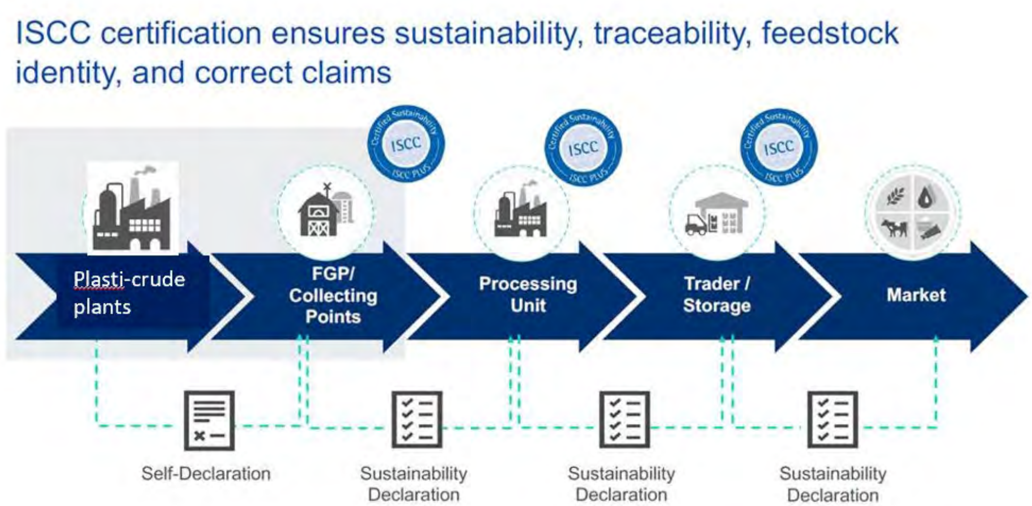


Figure 3: ISCC certification process across the supply chain

LicellaNZ will approach SGS and other consultancies as recommended by the project partners.

5. Project Management & Governance

It is proposed that each organisation who elects to participate in the Feasibility Study will nominate a representative to be engaged in project meetings and co-ordinate resources within their organisation to ensure timely provision of information required. It is also proposed that funding be allocated to pay for an overall project manager to ensure the project is delivered in a timely manner.

The project management role will also incorporate liaison with appropriate Government Departments (with a view to providing potential grant/funding opportunities) as well as industry organisations e.g. PlasticsNZ, The Packaging Forum, PacNZ and NZ Food & Grocery Council. It is proposed for the Dr Paul Watson will assume the position of Project Manager in close collaboration with Mr Mick Gayner, project manager for the recently completed Victoria study. Details are in Appendix 8.6.

The costs of the project will be split between the participants and the information within the report distributed to those participants who make a financial contribution.
A summary public dissemination report will also be prepared containing non-confidential or sensitive material.

6. Timeframe and Government Engagement

It is envisaged that the study could be completed in a 4-month timeframe from now. However, with the challenge of securing matching government funding in a suitable timeframe, an 8-month project is proposed. The key drivers are to get the project initiated and to conclude current engagements with the MBIE, MPI, MfE and Waka Kotahi.

The Gantt chart in Appendix 8.7 outlines a schedule.

7. Next Steps

Companies with input into this project need to agree:

- Review and execute the HOA
- Nominate one steering committee participant
- Receive and approve quotations from proposed consultants and issue PO's
- Issue review meeting invitations
- Issue invoices for first tranche of funding
- Provide working capital to ensure first tranche payments can be made to consultants
- Review submission to Plastic Innovation Fund, including soliciting letters of support from non-study participants eg EPL Group

8. APPENDICIES

APPENDIX 8.1 – Feedstock demand and supply consultant

APPENDIX 8.2 – Planning Consultant

APPENDIX 8.3 - Offtake Consultants

Offtake Consultant – Gases & Liquid Fuels

Joseph Zingarelli, C.Eng FIChemE MAIE

Summary of Experience

Technical areas

Forty plus years experience across a range of Petrochemical industries and companies including liquid natural gas, alternative fuels, petroleum refining, natural gas processing, gas purification, adsorption technologies, power generation, energy conservation and energy integration, process safety, risk assessments, new technology development,.

Roles

Process design, project management, operations technical support, troubleshooting, R&D execution, R&D management, front end development, greenhouse gas life cycle assessment and management, HAZOP leader.

Relevant Experience

Joseph A. Zingarelli & Associates, Engineers and Consultants, Principal, (November 2017 –) Private consultant on energy, fuels, power, oil, gas and petrochemical issues .

Shell Australia Pty Ltd, Project Advisor, Special Projects, May-October 2017

Shell Global Solutions International B.V. Program Unit Manager – Enhanced LNG, Expertise and Deployment Department, Projects and Technology Upstream, Integrated Gas, October 2011 to April 2017

Shell Refining Australia Pty Ltd, Senior Technologist – Major Projects/ Project Development Technologist, Clyde Refinery, March 2008 to October 2011

Joseph A. Zingarelli & Associates, Engineers and Consultants, Principal, (July 2001 to Feb 2008) Private consultant on energy, power, oil, gas and petrochemical issues to the resource industries.

Hatch Associates Pty Ltd (formerly BHP Engineering Pty Ltd), Principal Consultant - Hydrocarbon Processing (1988-2001).

Seamgas Enterprises Pty Ltd, Manager (1992 to 1994). Responsible for the overall management of Seamgas Enterprises, a company jointly owned by BHP Engineering Pty Ltd and USX Engineers and Consultants Inc. Seamgas Enterprises provided technology for the extraction of methane from coal seams.

Crooks Michell Peacock Stewart Pty Ltd, Manager Chemical and Related Industries (1986- 1988). Responsible to the Manager, NSW Division for the operation of the Division in the areas of fine and heavy chemicals, petrochemicals and petroleum refining.

Southern Pacific Petroleum NL, Senior Process Engineer (1983-1986)

Shedden Pacific Pty Ltd, Senior Chemical Engineer and Manager Adelaide (1982-1983). Responsible for business development and engineering work in Adelaide and for process design throughout Australia

Environmental Products Pty Ltd, Applications Engineer, (1981-1982). Responsible for marketing, design and commissioning of plants for the control of hydrocarbon and odour emissions. Major activities included troubleshooting an acetone/toluene solvent recovery system.

Union Carbide Australia Ltd, Process Engineer, Chemicals and Plastic Division (1977-1981). Responsible for the marketing, design, technical support and project management of high technology products, processes and plants for the oil, gas and chemical industries.

Education

Bachelor of Engineering in Chemical and Fuel Engineering - University of New South Wales (First Class Honours and University Medal)

Professional Affiliations

Institution of Chemical Engineers (Fellow)

Australian Institute of Energy (Member)

Bitumen Consultant

Azeem Remtulla
Principal Consultant – Bitumen Solutions
37 years working in the bitumen and road construction industry, in various technical, operational, and commercial roles with responsibilities in research and product development, plant and process design, facilities construction, manufacturing operations and logistics. Recently retired from SAMI, where he was the Executive Director and General Manager of the SAMI Group of companies which included the specialties manufacturing arm SAMI Bitumen Technologies and series of SAMI Bitumen import companies located in various states across Australia.
During his time at SAMI he was responsible for setting up national manufacture of modified bitumen, bitumen processing and import terminals. These included Fremantle WA, Corio in Geelong VIC, Fisherman Island in Port of Brisbane QLD and Port Botany in Sydney NSW. Azeem was also involved in scoping a new build bitumen storage terminal in Kwinana WA in partnership with Puma Energy.

APPENDIX 8.4 - Financial Modelling

Grant Thornton Australia
Grant Thornton International is one of the world's leading organisations of independently owned and managed accounting and consulting firms, with 45,000+ staff globally. In Australia, Grant Thornton is a single nationally integrated firm with 150+ partners and 1,200+ staff operating in the 5 major State capital cities as well as in Canberra and other locations.
Grant Thornton holds close relationships at the all levels of public and private sectors, providing a range of advisory, assurance and taxation services. We have delivered a number of infrastructure procurement projects within the public and corporate sectors. Our core expertise within Australia includes:

- Viability/Feasibility studies
- Valuations
- Due diligence reviews
- Financial modelling
- Infrastructure advisory
- Mergers and acquisitions
- Project development
- Strategic consulting
- Benchmarking
- Research and publishing
- Tax
- Audit and assurance
- Recovery and reorganisation.

With respect to major capital projects, Grant Thornton Australia has a wealth of experience across a range of financing, advisory and economic services available for major infrastructure projects, and hence has an extensive appreciation of their relative costs and benefits. Grant Thornton has established itself as a premier provider of financial, economic and consulting services, together with strong capabilities in project evaluation, financial modelling and financial and economic advice.
Recent examples of renewables projects include

<u>CDP Waste2Energy, QLD Australia</u>
CDP Waste2Energy was established to commercialise the Catalytic Depolymerisation Process (CDP) technology it had developed to efficiently convert a variety of feedstock's such as municipal, construction and industry waste or coal, to high quality diesel. Grant Thornton undertook a development of a detailed CDP project financial model with sufficient level of details and robustness for potential investor. Grant Thornton also provided associated tax and accounting advice.

<u>SJR Holdings Limited Co No, New Zealand</u>
Grant Thornton undertook an assignment to build an upgraded model for the bio-diesel production project in New Zealand and provide the evaluation of the company for internal purposes. The new model had to be built on top of the existing internal to satisfy the sophisticated requirements for the capital raise.

<u>Pacific Hydro</u>
Grant Thornton undertook an independent review of a financial model underpinning IFM Investors' existing investment in Pacific Hydro's renewable energy portfolio comprising of wind, hydro, solar and geothermal assets located across Australia, Brazil and Chile. Project size A$5.5 billion.

APPENDIX 8.5 – Environmental Benefits

APPENDIX 8.6 – Project Management

APPENDIX 8.7: Project Gantt Chart

`