Sustainable Supply Chain Assessment: Lumen Track

Prepared for:

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Executive Summary

This report describes a life cycle assessment (LCA) to validate environmental sustainability within the Lumen Track supply chain, as well as the product itself. The Lumen Track is an outdoor light which uses a polycarbonate material with photo luminescent pigment to absorb light from any source, which is then is released when it becomes dark. The light illuminates for 12+ hours and is made in New Zealand, specifically for New Zealand conditions. Additionally, the Lumen Track is made from environmentally friendly materials, fully recyclable and non-intrusive to animal and plant life.

The Lumen Track is fabricated from an aluminium track which holds the polycarbonate luminescent strip. Lumen is a self-sustaining illumination system, that is, it is a very robust and lights areas without the use of electricity. The Lumen product uses a polycarbonate material with photo luminescent pigment to absorb light from any source, which is then is released when it becomes dark; it illuminates for 12+ hours.

It is recognised that the production of both aluminium and polycarbonate includes impacts such as environmental degradation, including energy consumption, greenhouse gas emissions, and ecosystem disruption. Analysis of the supply chain materials and suppliers has indicated that a range of initiatives and strategies are being adopted to avoid environmental impacts and ensure sustainable business practices. Of note, these materials are both fully recyclable.

The Lumen product has a number of environmental, social and economic mitigating factors. As noted above, aluminium and polycarbonate are both fully recyclable and has a wide range of applications associated with health and safety (e.g., emergency lighting), sites with no or little power and areas where ‘soft’ lighting is preferable and/or reduces environmental impacts (such as those associated with artificial lights in marine areas). The product is essentially a carbon neutral source of light, and so has potentially large implications with respect to reduction of greenhouse gas emissions for the generation of power, especially in remote areas where diesel power generation is the main source of electricity. The product is also very robust and long-lasting, and has the potential to provide a low-cost and long-lasting, sustainable light powered lighting solution for vulnerable communities, especially those residing in regions prone to natural disasters, such as Small Island Developing States (SIDS).

An improvement assessment has found that initiatives such as supporting suppliers to improve on sustainable practices and the development of a sustainability statement will further improve the sustainability of Lumen Track.

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1 Introduction

This assessment considers the supply chain (SC) of MOHNZ's product, the Lumen Track, to verify safe and sustainable practice. In particular, a conceptual product life cycle assessment (LCA) was conducted.

1.1 Summary of Product

The Lumen Track is an outdoor light which uses a polycarbonate material with photo luminescent pigment to absorb light from any source, which is then is released when it becomes dark. The light illuminates for 12+ hours and is made in New Zealand, specifically for New Zealand conditions. Additionally, the Lumen Track is made from environmentally friendly materials, fully recyclable and non-intrusive to animal and plant life (MOHNZ, 2024).

1.2 Summary of Approach

A life cycle assessment provides a framework for measuring environmental impact. Essentially, a traditional life cycle model involves a 'cradle to grave' approach whereby a product is traced from raw materials to processing, distribution, retail, usage and waste disposal – each phase of life. Conducting a life cycle assessment enables a focal company to obtain a transparent view of their supply chain so they can minimise risk and make informed operational decisions. Additionally, measuring enables companies to ensure they are using best practice and confidently communicate their practices to their key stakeholders (Life Cycle Association of New Zealand, 2024).

1.3 Report Outline

The remainder of the report details the approach of a conceptual LCA before identifying the scope and any boundaries. Following this, the supply chain inventory is described in terms of raw materials, suppliers, distributors, manufacturers, retailer and customer. Next, an impact assessment addressing environmental considerations is outlined before an improvement assessment addresses the results and provides recommendations.

2 Approach

A conceptual life cycle assessment has been completed to analyse potential environmental impact of the Lumen Track SC.

2.1 Conceptual Life Cycle Assessment

Generally, a 'conceptual life cycle assessment' is a preliminary basic assessment that enables a focal company to identify boundaries and key environmental concerns prior to conducting an extensive LCA. In this instance, a qualitative analysis was undertaken to form a high level understanding of MOHNZ Lumen Track supply chain.

This report has adopted the Life Cycle Association of New Zealand's (2024) approach, whereby they outline the LCA methodology detailed in ISO standards 14040 and 14044. The methodology involves four steps as outlined below:

1. Goal and Scope:
    - This step involves understanding the 'functional unit' or what is being focused on for the LCA as well as identify any boundaries of the assessment.
2. Inventory Analysis:
    - The inventory step focuses on the collection of data for the LCA such as emissions, energy requirements and material flows.
3. Impact Assessment:
    - This step details the environmental impact of the life cycle inventory discussed in the step prior.
4. Improvement Assessment:
    - The improvement assessment provides an analysis of the results and provides recommendations.

3 Scope

The scope of this assessment is to evaluate the transparency of MOHNZ's Lumen Track supply chain to ensure their suppliers and other key partners are engaging in safe and sustainable practice. A 'cradle to grave' conceptual life cycle assessment has been completed for the Lumen Track, which includes tracing the recycling and reusing of materials to create a closed loop supply chain and promote a circular economy. In particular, this involved ensuring that the raw materials are environmentally friendly and that suppliers are engaged in practices to mitigate environmental impact such as carbon reduction commitments and waste minimisation initiatives. Additionally, an investigation into current and best practice for the end-of-life phase of the product life cycle was also conducted. For the purpose of this assessment, social sustainability aspects have not been addressed. Beyond identifying a general commitment to reducing environmental impact, the analysis based on the key indicators described in the list below:

- The LBC Red List is a tool for building product transformation that documents the "worst in class" materials, chemicals, and elements known to pose serious risks to human health and the environment (International Living Future Institute, 2022).
- International Union for Conservation of Nature red list (IUCN, 2022) is a critical indicators of the health of the world's biodiversity.
- Evidence of monitoring and reporting scope 1, 2, and 3 carbon emissions. Scope 1 emissions are direct emissions owned or controlled by a company, scope 2 are all indirect emissions from operational activities and scope 3 are all other emissions associated with operational activities.
- Evidence of a waste management system to reduce toxic waste entering natural environments and waterways.
- Evidence of commitment or investment towards producing and/or utilising renewable sources.

4 Supply Chain Inventory

Information pertaining to the supply chain inventory analysis was gathered via resources supplied by MOHNZ, academic literature and suppliers publicly available information such as website pages, annual reports and third party news sources. Refer to figure 4.1 below for the MOHNZ Lumen Track supply chain map.

4.1 Aluminium Supply Chain

Aluminium, a widely used raw material in various industries, has significant environmental implications throughout its lifecycle. Research indicates that its extraction, processing, and disposal processes contribute to environmental degradation, including energy consumption, greenhouse gas emissions, and ecosystem disruption. In particular, Research estimates indicate that the aluminium industry contributes between 0.45 to 0.5 gigatons of carbon dioxide (CO2) equivalent emissions annually (Brough & Jouhara, 2020). Aluminium extraction primarily involves bauxite mining, which requires large-scale land clearance and habitat destruction. According to a study by Mudd (2010), bauxite mining contributes to soil erosion, deforestation, and loss of biodiversity, impacting local ecosystems. According to Queensland Alumina Limited (2024), Alumina, also known as aluminium oxide, is extracted from bauxite through the Bayer process, a four-stage chemical procedure:

1. Digestion: Bauxite is finely ground and mixed with hot caustic soda to dissolve the alumina. The resulting solution is cooled in flash tanks.
2. Clarification: Undissolved impurities settle as red mud in thickening tanks. After multiple washing stages to recover caustic soda, the residue is neutralised with sea water and stored in dams. The clear solution moves on to the next stage.
3. Precipitation: Alumina crystals are formed from the caustic solution. In open-top tanks, the solution is stirred and seeded with previously precipitated alumina to aid crystal growth.
4. Calcination: The precipitated material, or hydrate, is washed, filtered, and then heated at temperatures over 1,000°C. This process removes bound water molecules, resulting in a fine white powder known as alumina.

Aluminium smelting is energy-intensive, with the electrolytic process consuming substantial electricity. Research by Graedel and Reck (2015) highlights the significant energy requirements of aluminium production, contributing to high carbon emissions and air pollution. The smelting process, also known as the Hall-Héroult process, involves dissolving alumina in molten cryolite within an electrolytic cell. Through electrolysis, aluminium ions are reduced at

a carbon-lined cathode, forming molten aluminium metal, while oxygen ions from alumina are oxidised at carbon anodes, producing carbon dioxide. This process is fundamental to the industrial production of aluminium, although it requires substantial energy input due to its reliance on electricity and high operating temperatures.

Aluminium production is a major emitter of greenhouse gases, particularly carbon dioxide (CO2). Studies estimate that primary aluminium production accounts for a significant portion of industrial CO2 emissions globally, exacerbating climate change. The anodising procedure in particular, is a complex multi-stage process which often involves an aluminium extrusion in a number of separate tank immersions in order to clean, etch, sand and seal the material. In this instance, the contents of the tanks include detergent, rinse water, demineralised water, a caustic solution, and other dilute solutions including nitric acid and ferrous sulphates, sulphuric acid, a sulphuric acid and stannous sulphate mix as well as nickel acetate. Some tanks are even heated, therefore, requiring greater energy consumption.

Unlike other materials, aluminium can be recycled indefinitely. Over 75% of all aluminium produced is still in use today (Brough & Jouhara, 2020). Further, according to European Aluminium (2024), aluminium recycling process required only 5% of the energy needed to produce primary metal, leading to significant CO2 savings. While aluminium recycling offers environmental benefits by reducing energy consumption and emissions, challenges remain in optimising recycling processes and increasing material recovery rates. Enhancing aluminium recycling rates is critical for mitigating its environmental footprint. In summary, aluminium's environmental impact is significant, encompassing various stages of its lifecycle, from extraction to production and disposal.

4.2 Poly Carbonate Supply Chain

99% of plastics are produced from a petroleum derivative, expecting to account for approximately 16% of oil consumption and 15% of carbon emissions by 2050 thus contributing to serious environmental harm (Zhou *et al*., 2023). Polycarbonate is synthesised through a multi-step process. Initially, phosgene, generated from the reaction of chlorine obtained from the electrolysis of sodium chloride with carbon monoxide from the pyrolysis of coal, oil, or gas, reacts with bisphenol A. Bisphenol A itself is derived from natural gas, which is cracked to produce cumene. Subsequently, cumene is processed to yield phenol and acetone, which then react to form bisphenol A. This compound finally undergoes a reaction with diphenyl carbonate to produce polycarbonate. In summary, the process can be outlined as follows:

Cumene (Raw Material) → Acetone → Bisphenol A → Polycarbonates (Product)

There are two types of processing methods of polycarbonate, the traditional method and the phosgene free method. The traditional method, using phosgene in the production process, contains chlorine and carbon monoxide. This process poses severe risk to human health and the environment due to the high level of toxic by-products (Altuwair, 2017). In particular, phosgene production methods are associated with high water consumption and large waste water discharges (Zhou *et al*., 2023). Conversely, the phosgene free method, albeit slower, is much less damaging to both humans and the environment due to lower use of toxic materials and energy consumption (Altuwair, 2017). Research suggests that utilising phosgene free methods of product realised a 2.8% to 10% reduction of harmful environmental impacts (Zhou *et al*., 2023). Even though polycarbonate is extremely strong and robust, which makes it long-lasting, it is fully-recyclable through an easy process.

Unlike traditional processing methods, bioplastics do not use phosgene. Bioplastics can originate from primary sources like rice, sorghum, soy, beet, corn, palm, barley, sugar cane, wheat, and potatoes. Additionally, they can be derived from secondary sources such as biowaste, cooking oil residues, and petroleum-based feedstocks. For instance, corn cob biomass waste was processed to produce fermentable sugars, which, through bacterial action, yielded PHA and astaxanthin. This process demonstrates the potential to economically generate PHA and a high-value product like astaxanthin from organic waste, highlighting the importance of utilising organic waste as a cost-effective, renewable resource. Consequently, employing organic waste as raw material is crucial for addressing waste management challenges. Moreover, there is a consensus that adopting a comprehensive waste management approach reduces greenhouse gas (GHG) emissions, as waste prevention and recovery efforts contribute to emission reductions across various economic sectors.

On the other hand, there are several drawbacks linked to bioplastic manufacturing. For instance, composting bioplastics generates methane and other greenhouse gas (GHG) emissions that are significantly more harmful than CO2. Moreover, creating bioplastics from crops such as corn and maize necessitates the repurposing of agricultural land, diverting it from food production to plastic manufacturing. This shift could potentially lead to a substantial increase in food prices, particularly impacting economically disadvantaged communities, as more agricultural land is allocated to biofuels and bioplastics. Additionally, the cultivation of crops for bioplastics involves the use of pesticides and chemical fertilisers, contributing to higher pollution levels, alongside the chemical processing required to convert biomaterials into bioplastic. Interestingly, the production of conventional plastics from fossil fuels has a lesser impact on ozone layer depletion compared to bioplastic production. Finally, the overall cost of production is a significant factor influencing bioplastic manufacturing. In summary, despite

bioplastics having a more positive impact than traditional polycarbonate production, environmental risks remain which require mitigation.

4.3 MOHNZ Suppliers

This section outlines specific processes and measures undertaken by MOHNZ's chosen suppliers.

4.3.1 Aluminium Suppliers

Rio Tinto Alloy

Rio Tinto is an Anglo-Australian multi-national leading mining company that engages in the mining and production of iron ore, aluminium, copper and minerals. In this instance, Queensland Alumina Limited and Yarwun refineries supply alumina to MOHNZ partners. The Queensland site has identified air quality, noise pollution, and water contamination via runoff from rain events as critical environmental impacts. As a result, they have identified several initiatives to mitigate these impacts such as environmental surveys, protecting nearby habitats and ecosystems, further details can be found in Appendix 2 (Queensland Alumina Limited, 2024).

NZ Aluminium Smelters Plant

The NZ Aluminium Smelters (NZAS) Plant is a joint venture owned by Rio Tinto and Japan's Sumitomo chemical company. NZAS is located on Tiwai Peninsula in Southland and the majority of the plant's alumina is supplied from our Yarwun and Queensland Alumina Limited refineries. The NZAS has one of the lowest carbon footprints for an aluminium smelters plant in the world as the plant converts alumina into aluminium using renewable hydroelectricity. NZAS perform a number of environmental initiatives including developing a biodiversity management plan, follow an extensive waste management plan, monitors and reports on coastal erosion, and is working to implements a remediation plan to remove waste and improve environmental performance. Their 2022 environmental scorecard also highlights a recent partnership with Ngāi Tahu, the primary iwi with guardianship responsibility over the South Island of NZ. The partnerships focuses on a joint effort to remove waste, conduct environmental monitoring and remediate NZAS. Further details can be found in Appendix 3.

BASF Chemetall

BASF Chemetall is a global company that is New Zealand's leading suppliers of chemicals specialising in processes for the surface treatment of metals and plastics. In this instance, Chemetall manufactures and supplies their products to Finex Ltd. Globally, BASF released an online report in 2019 detailing their sustainability practices in line with the Global Reporting Initiative standards. Furthermore, BASF have been involved with the United Nations Global Compact since 2000 and pledged a commitment to the Paris Agreement to grow carbon neutrally until 2030. More locally, Chemetall New Zealand have stated their commitment to their Safety, Health and Environment (SHE) policy which stipulates ethical and responsible product stewardship. In particular, the policy focuses on detailing health and environmental protection principles as well as occupational and plant safety. Further details can be found in Appendix 4.

4.3.2 Poly Carbonate Suppliers

Lotte Chemicals

Lotte Chemical is a global chemical company who have identified a commitment to aligning their operations with ESG management. They were identified by MOHNZ as their polycarbonate resin supplier. Lotte Chemical states that they manufacture their polycarbonate material using eco-friendly non-phosgene process. As a result, negative environmental and human impact is significantly reduced through the diminished use of harmful substances (Lotte Chemical, 2024). Further details can be found in Appendix 5.

4.3.3 Distributors

APL Direct was identified by Inex Aluminium as their distribution partner. APL Direct's fleet runs on 95% Euro-5 engines or higher, with 40% now running on Euro-6 engines. By complying with Euro-5/6 standards set by the European Union, they adhere to strict reduction targets regarding nitrogen oxide and soot emissions. As a result of their advanced technologies, Euro 5/6 engines have lower emissions and improved fuel efficiency. APL Direct has also transitioned their fleet to use of fully synthetic engine oil therefore, reducing the frequency of oil changes and halving of oil disposal and recycling requirements.

There is no information available regarding MOHNZ's distributor.

4.3.4 Aluminium Manufacturers

Independent Extrusions Ltd (INEX)

INEX is Australasia's leading aluminium extrusions manufacturer. INEX is the only extruder in Australasia to recycle its scrap back to a primary producing smelter to produce aluminium billet. FINEX is INEX's on site anodising plant and is regarded as New Zealand's most modern facilities designed with the latest effluent treatment technology. To minimise environmental impact, FINEX have implemented a number of initiatives including; water management systems, and waste disposal procedures (Independent Extrusions Limited, 2020). Further details can be found in Appendix 6.

4.3.5 Poly Carbonate Manufacturers

IMPI Plastics

IMPI Plastics is a plastic injection moulding service located in Auckland, New Zealand. IMPI shares a brief overview of the polymaize material they use to manufacture their goods (IMPI Plastics, n.d.). As a result, it may be assumed that they use a phosgene free method of production, therefore, reducing their environmental impact. It should be noted that there is limited information regarding IMPI Plastics and their production process. Further details can be found in Appendix 7.

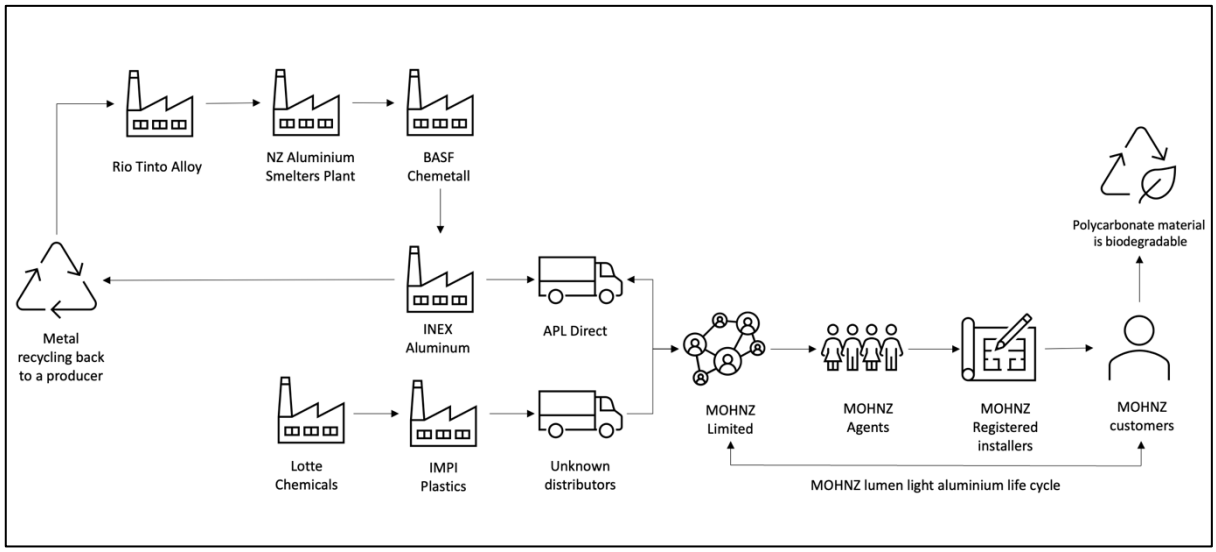

Figure 4.1. MOHNZ Lumen Track Supply Chain Map

4.3.6 Product

Practical Applications and Uses

Lumen is a self-sustaining illumination system, that is, it is a very robust and lights areas without the use of electricity. The Lumen product uses a polycarbonate material with photo luminescent pigment to absorb light from any source, which is then is released when it becomes dark; it illuminates for 12+ hours. The polycarbonate luminant strips can be used indoors and out, as vertical strips on posts, attached to a range of materials via the aluminium track, or along the edge of steps. (Figure 4.2)

Practical applications are diverse, encompassing crucial roles in health and safety protocols, such as emergency lighting in various settings, and cost-effective illumination for waterfront facilities, minimising both energy consumption and adverse impacts on marine life It has a range of applications, including, but not limited to:

- Health and safety emergency lighting inside and outside; since the light is stored photo-luminescence, it does not require a power source and so still operates during a power outage. For example, lighting aisle/pathways and stairwells, exits, etc. and providing light in emergency situations (commercial buildings, apartment blocks, airplanes, large and small vessels, hotels and resorts, convention centres, etc.);
- At outdoor sites that have limited or no power supply (Figure 4.3);
- Areas where ‘soft’ lighting is preferred to reduce light pollution (e.g., marinas, outdoor entertainment areas, swimming pools, etc.) (Figure 4.4 and Figure 4.5);
- Walkways/cycleways;
- Bush and conservation tracks ;
- Conservation huts and toilets;
- Footpaths/Steps;
- Emergency exits interior and exterior;
- Bridges small and large;
- Marina births and pontoons;
- Boat jetties;
- Swimming pools (Lumen also works under water);
- Boat trailers (retrieving boats from the water at night), and;
- Camp sites.

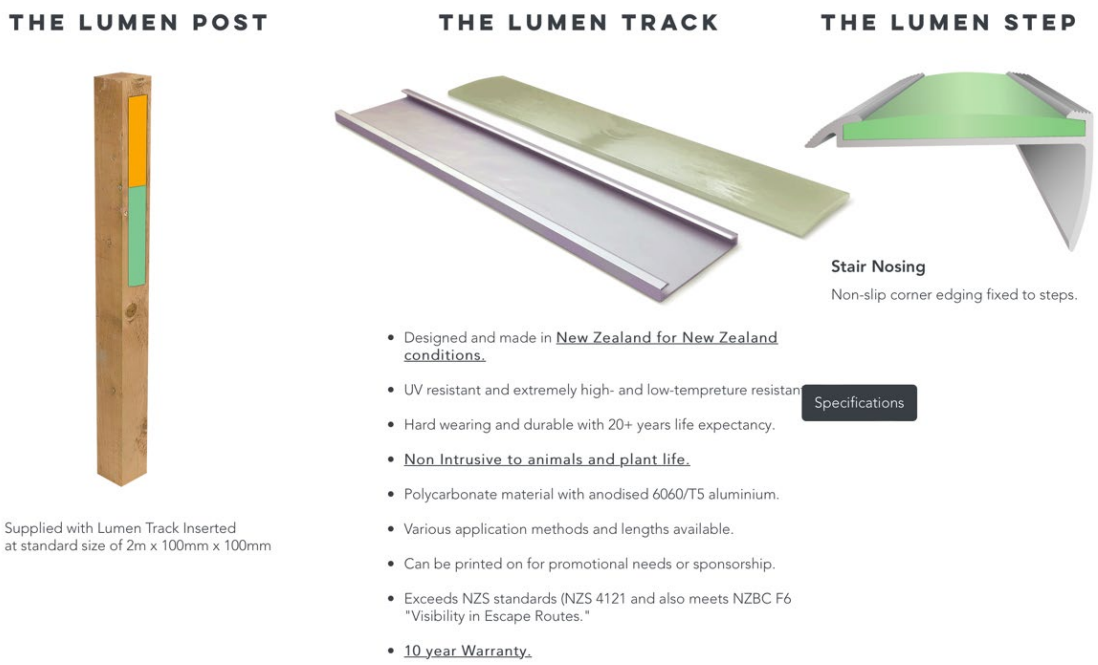

Figure 4.2. MOHNZ Lumen products.

Figure 4.3. Outdoor sites that have limited or no power supply.

4.6.2. Environmental Implications

As described above, there are a range of actual and potential negative environmental impacts due to the production of aluminium and polycarbonate, which can be mitigated and/or offset. However, both materials are environmentally inert and can be fully recycled. Here the environmental implications of using the Lumen product is considered.

Lumen products store light from any source and illuminates in the dark. This is, the light generates it energy from renewable/sustainable solar energy, or is 're-using/recycling' light that it has stored from a generated source. This means that the product is essentially a carbon neutral source of light, and so has potentially large implications with respect to reduction of greenhouse gas emissions for the generation of power, especially in remote areas where diesel power generation is the main source of electricity.

The Lumen product has been developed specifically for New Zealand's harsh environmental conditions (e.g., extreme temperatures, high UV light levels, etc.), which means its construction is robust and resilient. Comparisons with similar photo luminescent in terms of the type of aluminium track and the material of plastic illuminating strip, indicate that the product is likely the most robust of its class. The product is not a single use plastic, with an expected life of 20 years or more (the product has a 10 year warranty).

As noted above, Lumen provides 'soft' light, which means it is non-intrusive to animal and plant life. For example, there is an increasing body of evidence showing that bright lights due to coastal developments and facilities have a range of negative impacts on marine ecosystems and communities. A recent review of the impacts on artificial light at night on marine ecosystems by Marangoni *et al*. (2022) found it impacts on ecological and biological processes in the marine environment that are guided by natural intensities, moon phase, natural light and dark cycles and daily light spectra alterations. The 'soft' lighting of Lumen can reduce and/or avoid these impacts when used close to marine areas.

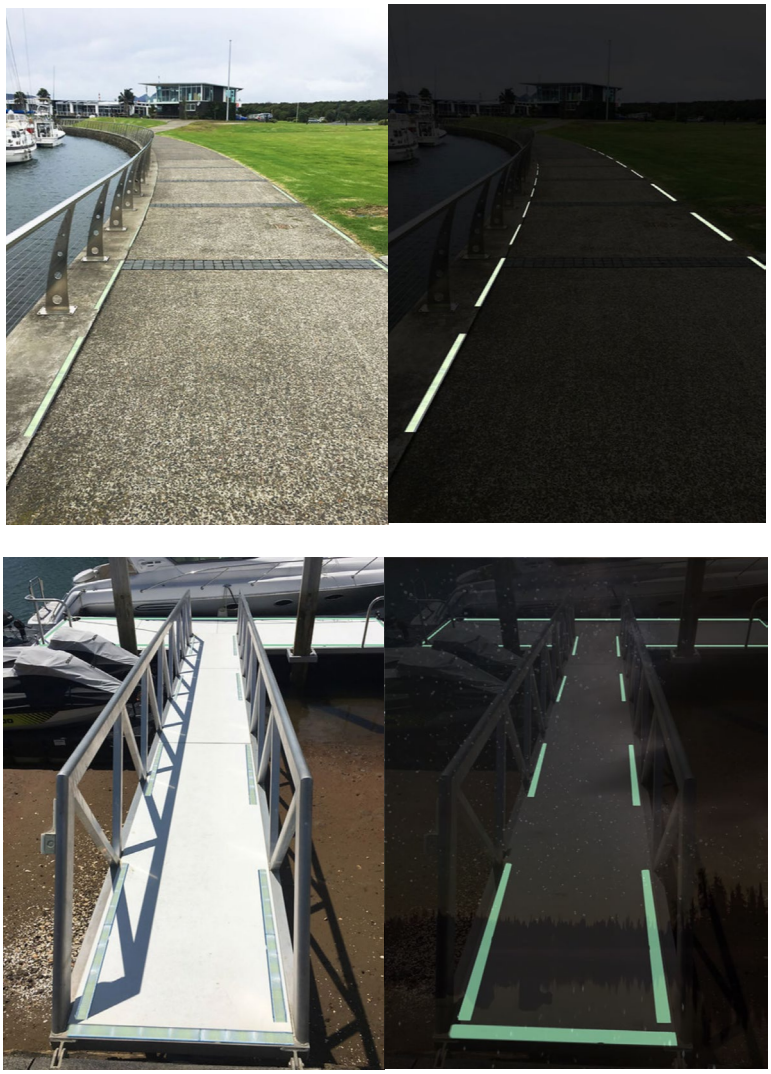

Figure 4.4. ‘Soft’ lighting at a marina to reduce light pollution.

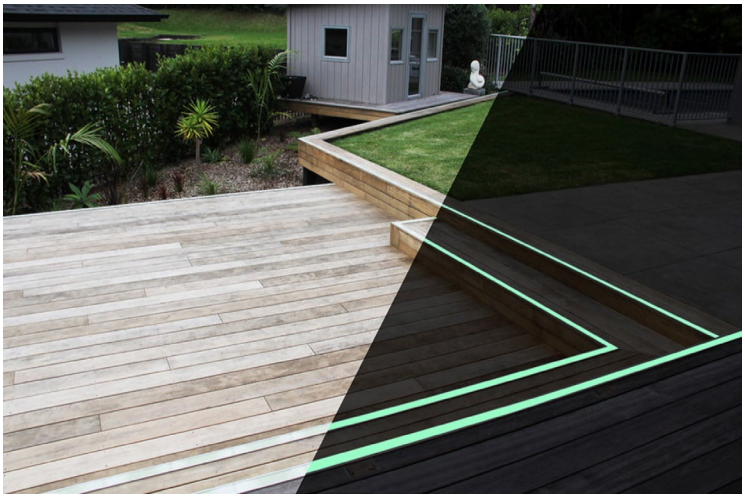

Figure 4.5. ‘Soft’ lighting at the deck and pool area.

4.6.3. Social and Economic Implications

As noted above, the Lumen product has been developed specifically for New Zealand's harsh environmental conditions, which means its construction is robust and resilient and likely the most robust of its class. In combination with the low cost element of the product, it has particular potential to vulnerable communities, especially those residing in regions prone to natural disasters, such as Small Island Developing States (SIDS), many of which depend on the marine environment and tourism (i.e., hotels and resorts, which can also utilise the Lumen product to improve their carbon emissions and sustainability initiatives). It has the potential to provide a low-cost and long-lasting (20+ years), sustainable light powered lighting solution that requires no wiring or maintenance.

5 Impact Assessment

An impact assessment was undertaken to evaluate the environmental impacts associated with MOHNZ's key suppliers. The assessment aimed to identify potential risks, opportunities and areas of improvement within MOHNZ's supply chain practices. Suppliers were identified via information supplied by MOHNZ. To supplement this information, the impact assessment utilised suppliers publicly available resources such as website pages, annual reports and third party news sources. Suppliers were assessed on the disclosure measures identified below and provided a score of Y (disclosed), P (partially disclosed), N (Does not disclose) or N/A (Not applicable). Refer to Appendix 1 for a detailed supplier disclosure analysis.

5.1 Environmental Considerations

Depletion of natural resources, loss of biodiversity, harmful substances to humans and the environment, and carbon emissions of processing and manufacturing were identified as key environmental considerations to MOHNZ's operations and supply chain players. Additionally, sustainability commitment was also assessed to investigate the transparency and traceability of identified players. Refer to the table below for details on the indicators used to define the measures.

Table 5.1. Disclosure Measures.

Disclosure Measures	*Indicators*
Sustainability Commitment	Publicly states general commitment to sustainability
	Publicly releases annual sustainability report
	Shares sustainability performance
	Shares clearly defined sustainability goals
Depletion of Natural resources	Shares commitment to minimise the depletion of natural resources
	Shares activities performed to minimise depletion of non-renewable resources
	Shares production process (as required)
Loss of biodiversity	Shares commitment to minimise loss of biodiversity
	Shares declaration of IUCN red list species which overlap with operating assets
	Shares activities performed to minimise loss of biodiversity
Harmful Substances to humans and the environment	Shares commitment to minimise loss of biodiversity
	Shares declaration of LBC red list substances
	Shares activities performed to reduce harmful substances e.g. waste management system

Carbon emissions of processing and manufacturing	Shares commitment to minimise carbon emissions
	Measures and reports scope 1, 2, and 3 emissions
	Shares clearly defined reduction targets
	Shares activities performed to reduce carbon emissions

5.1.1 Commitment to reducing environmental impact

A commitment to reducing environmental impact was assessed via a suppliers availability of information to the public including a general commitment, an annual sustainability report with clearly defined sustainability related goals and performance metrics. All suppliers were identified to have a general commitment to sustainability. Furthermore, Rio Tinto, NZAS, BASF Chemetall and Lotte Chemical releases sustainability reports which details their sustainability performance and clearly defined goals. In cases where suppliers have not provided a sustainability report, it may suggest the organisation is subject to time and resource constraints which may limit their ability to integrate sustainability measures into their daily operations.

5.1.2 Depletion of non-renewable energy sources

All suppliers publicly share a commitment to minimise the depletion of natural resources including activities performed. Activities include new innovations utilising blockchain technology, external certification and grading systems, supply chain partnerships, stakeholder engagement, and clearly defined strategy. In particular, BASF Chemetall has achieved leadership status in sustainable water management, whereas, Lotte Chemical has implemented Project Loop, a recycling strategy to enhance their ability to create a closed loop supply chain configuration.

5.1.3 Loss of biodiversity

Both Rio Tinto Alloy and the NZAS has shared a declaration of the IUCN red list species and identified species of significance within close proximity to their operating assets. Rio Tinto Alloy utilises a mitigation hierarchy method to address biodiversity risk whereas NZAS works with the Department of Conservation on the ongoing management of their operating area. Additionally, BASF Chemetall identified in their annual report that they have established a farm network in Europe to increase biodiversity across intensively farmed land. INEX, Lotte Chemical and IMPI plastics have not shared their efforts to mitigate loss of biodiversity.

5.1.4 Harmful substances to humans and the environment

All suppliers, excluding IMPI plastics, have publicly shared a commitment to minimise harmful substances to humans and the environment. MOHNZ has ensured that they have partnered with aluminium suppliers/manufacturers (Rio Tinto Alloy, DBASF Chemetall) that do not process any ingredients from 'The Living Building Challenge (LBC) Red List'. To view MOHNZ partner declarations, refer to DBASF Chemetall declaration and Rio Tinto Alloy declaration. Activities performed to minimise harmful substances to humans and the environment include; waste management initiatives, diverting waste materials to recycling programmes, environmental monitoring and auding and external certification.

5.1.5 Carbon emissions of processing and manufacturing

All identified suppliers, excluding IMPI Plastics, has shared their scope 1, 2, and 3 emissions, along with clearly defined reduction targets and activities performed to reduce emissions. Refer to the table below for further details of MOHNZ's supplier's total emissions.

Table 5.2. Supplier total emissions.

Supplier	*Total Emissions*
Rio Tinto Alloy	2022 Scope 1 and 2 emissions were 330.3Mt CO2e (31.0Mt in 2021). 70% of which were from activities related to Aluminium operations.
NZAS	Total calculated carbon dioxide equivalent discharge from NZAS during 2022 was 1.99t CO2-e per tonne of aluminium produced - reports GHG emissions to New Zealand Environmental Protection Agency
BASF Chemetall	GHG emissions - 20.1 million metric tonnes of CO2 equivalents (2019), Carbon Monoxide - 3,530 Mt, Total nitrogen oxide - 10,534 Mt, Nonmethane volatile organic compounds - 4,496 Mt, Total sulphur oxides - 1,982 Mt, Dust - 2,410 Mt, Ammonia and other inorganic substances - 2, 178 Mt.
INEX	INEX NZ has the greenest aluminium extrusion produced in the southern hemisphere with "cradle to grave" at less than 4mt CO2/t Al of extrusion

Lotte Chemical	Lotte Chemical reduced their emissions by 5% from the previous year, emitting 6.21 million tons, which is approximately 350,000 tons less than their target of 6.56 million tonnes. Scope 3 emissions equated to approximately 18 million tonnes

Activities suppliers have undertaken to reduce carbon emissions of processing plants/manufacturing facilities including implementation of renewable energy and regular monitoring of air pollution.

6 Improvement Assessment

The life cycle assessment conducted on the Lumen Track product reveals several areas for improvement in its environmental impact. The supply chain inventory analysis identifies aluminium as a significant raw material, highlighting its extraction and production processes' adverse environmental effects, including carbon emissions, energy consumption, and habitat destruction. Similarly, the polycarbonate supply chain analysis underscores environmental concerns related to the use of phosgene and the associated toxic by-products. Moreover, the assessment identifies challenges associated with bioplastic production, such as methane emissions from composting and land reallocation for crop cultivation, which may increase food prices and impact vulnerable communities.

However, the product's practical applications, such as emergency lighting and its use of renewable solar energy, offer promising solutions to mitigate environmental impacts. To enhance the product's sustainability, measures should focus on optimising material sourcing, reducing energy consumption, and minimising harmful by-products throughout its lifecycle. Additionally, fostering partnerships with environmentally conscious suppliers and adopting eco-friendly manufacturing practices can further improve the product's overall environmental performance.

Chain liability

Chain liability is becoming increasing prevalent within supply chain management. Nowadays, firms must take responsibility for the entirety of their supply chain and ensure they are partnering with suppliers that uphold sustainable and ethical practices (Hartmann & Moeller, 2014). MOHNZ may implement monitoring and evaluating measures such as conducting screenings prior to formalising partnerships followed by audits and site visits to ensure consistency among suppliers. In the case of non-compliance, MOHNZ may invest in supporting the supplier to improve their practices or, in extreme cases, terminate the partnership.

Commitment to safe and sustainable practice

Publicly sharing a commitment to safe and sustainable practice builds trust among stakeholders and legitimises efforts to improve a firms social and environmental impact. Therefore, it is recommended that MOHNZ share a sustainability statement on a public forum such as their website to disclose their commitment along with efforts made to minimise their impact and how the Lumen Track supports sustainable development.

References

Ayres, R. U., & Kneese, A. V. (1969). Production, consumption, and externalities. The American Economic Review, 59(3), 282-297.

Brough, D., & Jouhara, H. (2020). The aluminium industry: A review on state-of-the-art technologies, environmental impacts and possibilities for waste heat recovery. *International Journal of Thermofluids*, *1*, 100007.

European Aluminium (2024). *The Material.* Retrieved from https://european-aluminium.eu/

Graedel, T. & Reck, Barbara. (2015). Six Years of Criticality Assessments: What Have We Learned So Far?. Journal of Industrial Ecology. 20. 10.1111/jiec.12305.

Hartmann, J., & Moeller, S. (2014). Chain liability in multitier supply chains? Responsibility attributions for unsustainable supplier behavior. *Journal of operations management*, *32*(5), 281-294.

IMPI Plastics. (n.d.). *About Us.* Retrieved from http://www.impi.co.nz/about-us/

IMPI Plastics. (n.d.). *Bioplastic Products.* Retrieved from http://www.impi.co.nz/bioplastic-products/

Independent Extrusions Limited. (2020). *Aluminium Extrusion & Sustainability*. [PowerPoint Presentation].

International Living Future Institute. (2022). The Living Building Challenge (LBC) Red List. Retrieved from https://living-future.org/wp-content/uploads/2022/05/The-LBC-Red-List-2022-and-PFAS-Guide-for-Manufacturers.pdf

IUCN. 2022. The IUCN Red List of Threatened Species. Version 2022-2. https://www.iucnredlist.org. Accessed on [23/08/2023].

Kloepffer, W. Life cycle sustainability assessment of products. *Int J Life Cycle Assess* **13**, 89–95 (2008). https://doi.org/10.1065/lca2008.02.376

Life Cycle Association New Zealand. (2024). *Introduction to LCA*. Retrieved from https://lcanz.org.nz/

Lotte Chemical. (2024) *Engineering Plastics.* Retrieved from https://product.lottechem.com/en/advanced_materials/pc.do

Marangoni, L. F. B., T. Davies, T. Smyth, A. Rodríguez, M. Hamann, C. Duarte, K. Pendoley, J. Berge, E. Maggi, and O. Levy, 2022. Impacts of artificial light at night in marine ecosystems—A review. Glob Chang Biol. 2022 Sep; 28(18): 5346–5367.

Mudd, G. M. (2010). The environmental sustainability of mining in Australia: Key megatrends and looming constraints. Resources Policy, 37(2), 130-138.

New Zealand Aluminium Smelters (2024). *Sustainability*. Retrieved From https://nzas.co.nz/sustainability

Norgate, Terry & Haque, Nawshad. (2010). Energy and greenhouse gas impacts of mining and mineral processing operations

Queensland Alumina Limited (2024). *Our Process.* Retrieved from https://qal.au/who-we-are/our-process/

Rio Tinto. (2024). *Sustainability Reporting*. Retrieved from https://www.riotinto.com/en/invest/reports/sustainability-report

Sala, S., Pant, R., Hauschild, M., & Pennington, D. (2012). Research Needs and Challenges from Science to Decision Support. Lesson Learnt from the Development of the International Reference Life Cycle Data System (ILCD) Recommendations for Life Cycle Impact Assessment. *Sustainability*, *4*(7), 1412–1425. MDPI AG. Retrieved from http://dx.doi.org/10.3390/su4071412

Zhou, X., Zhai, Y., Ren, K., Cheng, Z., Shen, X., Zhang, T., Bai, Y., Jia, Y., & Hong, J. (2023). Life cycle assessment of polycarbonate production: Proposed optimization toward sustainability. *Resources, Conservation and Recycling*, *189*, 106765.

Appendix 1. Supply Chain Disclosure Analysis

Disclosure Measures /Indicators	*Rio Tinto Alloy*	*NZAS*	*BASF Chemeta II*	*INEX Ltd*	*Lotte Chemical*	*IMPI Plastics*
Sustainability Commitment						
Publicly states general commitment to sustainability	Y	Y	Y	Y	Y	Y
Publicly releases annual sustainability report	Y	P	P	N	Y	N
Shares sustainability performance	Y	P*	P	P	Y	N*
Shares clearly defined sustainability goals	Y	Y	Y	N	Y	N*
Depletion of Natural resources						
Shares commitment to minimise the depletion of natural resources	Y	Y	Y	Y	Y	Y
Shares activities performed to minimise depletion of non-renewable resources	Y	Y	Y	Y	Y	Y
Shares production process (as required)	Y	Y	N	Y	P	P
Loss of biodiversity						
Shares commitment to minimise loss of biodiversity	Y	Y	P	N	Y	N*
Shares declaration of IUCN red list species which overlap with operating assets	Y	P	N	N	N	N*
Shares activities performed to minimise loss of biodiversity	Y	Y	P	N	N	N*
Harmful Substances to humans and the environment						
Shares commitment to minimise loss of biodiversity	Y	P	Y	Y	Y	N*
Shares declaration of LBC red list substances	Y	Y	Y	Y	N	N*
Shares activities performed to reduce harmful substances e.g. waste management system	Y	Y	Y	Y	Y	N*
Carbon emissions of processing and manufacturing						

Shares commitment to minimise carbon emissions	Y	Y	Y	Y	Y	N*
Measures and reports scope 1, 2, and 3 emissions	Y	P	Y	Y	Y	N*
Shares clearly defined reduction targets	Y	Y	Y	P	Y	N*
Shares activities performed to reduce carbon emissions	Y	Y*	Y	Y	Y	N*

Appendix 2. Rio Tinto Alloy Disclosure Analysis

Disclosure Measures /Indicators	*Results*	*Evidence*
Sustainability Commitment		
Publicly states general commitment to sustainability	Y	"Finding better ways to provide the materials the world needs" - developed a sustainability framework which describes how they manage ESG issues that are important to stakeholders including how they contribute to UNSDGs - also has annual report, sustainability factbook, climate change report and more.
Publicly releases annual sustainability report	Y	Share sustainability activities and performance annually including a sustainability fact book which details non-financial information pertaining to sustainability related activities, performance, methodologies, certifications and policies.
Shares sustainability performance	Y	Publicly discloses sustainability performance relating to health and safety, climate change, environment, communities, human rights, responsible sourcing and transparency.
Shares clearly defined sustainability goals	Y	Shares sustainability targets including supplying low intensity materials, caring for our planet: being a trusted steward of resources, supporting social and economic opportunity, becoming a socially responsible business partner.
Depletion of Natural resources		
Shares commitment to minimise the depletion of natural resources	Y	Aluminium Stewardship Initiative - commitment to maximise the contribution to the development of a sustainable society.
Shares activities performed to minimise depletion of non-renewable resources	Y	Launched SMARTTM in 2021 - first sustainability label for responsible aluminium, delivered to customers using blockchain technology.

Shares production process (as required)	Y	Queensland Alumina Limited share their approach to alumina production via the Bayer process which involves digestion (dissolve and cool), clarification(settling impurities), precipitation (forming crystals) and calcination (wash, filter and heat) to produce a fine white powder known as alumina.
Loss of biodiversity		
Shares commitment to minimise loss of biodiversity	Y	Rio Tinto recognise their responsibility to mitigate the impact of their operations on nature.
Shares declaration of IUCN red list species which overlap with operating assets	Y	Has identified biodiversity species by asset from the IUCN red list in their sustainability fact book.
Shares activities performed to minimise loss of biodiversity	Y	Rio Tinto use the mitigation hierarchy method to address bio-diversity risks - avoidance, minimisation, restoration and offset. Conservation efforts are documented on their website.
Harmful Substances to humans and the environment		
Shares commitment to minimise loss of biodiversity	Y	Part of the ICMM water stewardship statement which requires members to apply strong and transparency water governance, manage water at operations effectively and collaborate to achieve responsible water use and states commitment to minimise impact through careful waste management, including mineral waste such as rock, slag and tailings and non-mineral waste.
Shares declaration of LBC red list substances	Y	Declares that red list substances are not present in the production processes at NZAS.
Shares activities performed to reduce harmful substances e.g. waste management system	Y	Shares waste management initiatives including turning slime into solar panels, diverting waste materials from waste management centre to re-use and recycling programmes, use waste from aluminium processing to grow blueberries and reuse waste from aluminium smelting process to make cement.
Carbon emissions of processing and manufacturing		
Shares commitment to minimise carbon emissions	Y	Shares alignment with Paris agreement and long term commitment of achieving net zero emissions by 2050 - has developed air quality protection standard.
Measures and reports scope 1, 2, and 3 emissions	Y	2022 Scope 1 and 2 emissions were 330.3Mt CO_2e (31.0Mt in 2021). 70% of which were from activities related to Aluminium operations.

Shares clearly defined reduction targets	Y	Net Zero by 2050 – Aim to reduce scope 1 and 2 emissions by 15% by 2025 and by 50% in 2030.
Shares activities performed to reduce carbon emissions	Y	Shares efforts to reduce emissions include updating equipment, adding air pollution control equipment and using renewable energy or alternative feed material where possible.

Appendix 3. NZAS Disclosure Analysis

Disclosure Measures /Indicators	*Results*	*Evidence*
Sustainability Commitment		
Publicly states general commitment to sustainability	Y	Transparency commitment, shares priorities of safety, people, growth, partnerships and cash.
Publicly releases annual sustainability report	P	Shares annual sustainable development scorecard which includes NZAS priorities of Safety, People, Growth, Partnerships and Cash.
Shares sustainability performance	P*	NZAS reports environmental performance monthly, quarterly and annually to Environment Southland for discharges to air, land and water.
Shares clearly defined sustainability goals	Y	NZAS share values and commitments, however, sustainability goals are not clearly defined.
Depletion of Natural resources		
Shares commitment to minimise the depletion of natural resources	Y	Known as a responsible supplier producing more than 330,000 tonnes of the lowest-carbon highest-purity aluminium in the world, emitting 2 tonnes of CO2 for every tonne of aluminium - international average is 13 tonnes.
Shares activities performed to minimise depletion of non-renewable resources	Y	Have gained external certification for their RenewAl metal brand - smelting emissions of less than four tonnes of CO2 per tonne of aluminium - guarantees traceability.
Shares production process (as required)	Y	Shares process from mining to manufacturer - 1.5 tonnes of aluminium every 24 hours.
Loss of biodiversity		
Shares commitment to minimise loss of biodiversity	Y	Shared commitment to preserving the biodiversity on the peninsula.
Shares declaration of IUCN red list species which overlap with operating assets	P	Has identified species of significance within close proximity: Asaphodes frivola moth, NZ iris, Euphorbia Glauca, Black fronted tern, Southern NZ dotterel and Australasian bittern.
Shares activities performed to minimise loss of biodiversity	Y	Works with DoC on the ongoing management of the area and undertakes Pest Animal and Plant Control activity.

Harmful Substances to humans and the environment		
Shares commitment to minimise loss of biodiversity	P	Has shared strategy to reduce waste generation and take advantage of reuse, recycling and energy recovery opportunities - no info on human health.
Shares declaration of LBC red list substances	Y	Declares that red list substances are not present in the production processes at NZAS.
Shares activities performed to reduce harmful substances e.g. waste management system	Y	Conducts environmental monitoring at Te Wai Point including assessment of the groundwater site and Spent Cell Lining storage facilities, conducts coastal erosion monitoring, shares waste management strategies to reduce generation and take advantage of reuse, recycling and energy recovery opportunities.
Carbon emissions of processing and manufacturing		
Shares commitment to minimise carbon emissions	Y	NZAS has one of the lowest CO2 footprints in the world and shares NZ's net zero by 2050 vision.
Measures and reports scope 1, 2, and 3 emissions	P	Total calculated carbon dioxide equivalent discharge from NZAS during 2022 was 1.99t CO2-e per tonne of aluminium produced - reports GHG emissions to New Zealand Environmental Protection Agency.
Shares clearly defined reduction targets	Y	Net Zero by 2050.
Shares activities performed to reduce carbon emissions	Y*	NZAS uses hydroelectricity, generated at Lake Manapouri to power the electro chemical reaction that turns alumina into aluminium.

Appendix 4. BASF Chemetall Disclosure Analysis

Disclosure Measures /Indicators	*Results*	*Evidence*
Sustainability Commitment		
Publicly states general commitment to sustainability	Y	BASF shares involvement with the United Nations Global Compact.
Publicly releases annual sustainability report	P	Reports on sustainability in accordance with the Global Reporting Initiative - has not released a report since 2019.
Shares sustainability performance	P	Shares sustainability performance in annual reports - has not released a report since 2019.
Shares clearly defined sustainability goals	Y	Shares sustainability goals in annual report - has not released a report since 2019.
Depletion of Natural resources		

Shares commitment to minimise the depletion of natural resources	Y	Shares commitment to responsible use of water along the SC - water is of fundamental importance in chemical production - target to introduce sustainable water management at all production sires in water stress areas and at all sites.
Shares activities performed to minimise depletion of non-renewable resources	Y	BASF achieved the top grade of A and gained leadership status for sustainable water management - took part in CDP reporting to enhance transparency - total water usage equated to 1,717 million cubic meters in 2019, predominantly used for cooling purposes (86%), after which is recirculated into water supply sources.
Shares production process (as required)	N	General information regarding products, however, there is no information regarding how products are manufactured.
Loss of biodiversity		
Shares commitment to minimise loss of biodiversity	P	State that their innovative products and services help to use natural resources more efficiency and promote biodiversity.
Shares declaration of IUCN red list species which overlap with operating assets	N	No evidence of declaration or acknowledge of the IUCN red list.
Shares activities performed to minimise loss of biodiversity	P	Provides example in annual report that they established a Farm network in Europe to increase biodiversity across intensively farmed land.
Harmful Substances to humans and the environment		
Shares commitment to minimise loss of biodiversity	Y	Implements the Global Product Strategy of the ICCA and has shared SHE Policy which stipulates ethical and responsible product stewardship. In particular, the policy focuses on detailing health and environmental protection principles as well as occupational and plant safety.
Shares declaration of LBC red list substances	Y	Declares that red list substances are not present in the materials manufactured and supplied to INEX Ltd.
Shares activities performed to reduce harmful substances e.g. waste management system	Y	Use of alternative methods for animal testing, implements global chemical regulations (REACH), has robust waste management system - following global directives, if no recovery options are available for waste, it is disposed in a proper and environmentally responsible manner (total waste generated - 2.34 million metric tons, total waste recovered - 0.99 million metric tons, total was disposed - 1.35 million metric tonnes.
Carbon emissions of processing and manufacturing		

Shares commitment to minimise carbon emissions	Y	BASF has pledged a commitment to the Paris Agreement.
Measures and reports scope 1, 2, and 3 emissions	Y	GHG emissions - 20.1 million metric tonnes of CO2 equivalents (2019), Carbon Monoxide - 3,530 Mt, Total nitrogen oxide - 10,534 Mt, Nonmethane volatile organic compounds - 4,496 Mt, Total sulfur oxides - 1,982 Mt, Dust - 2,410 Mt, Ammonia and other inorganic substances - 2, 178 Mt.
Shares clearly defined reduction targets	Y	Stated target to grow their carbon neutrally until 2030.
Shares activities performed to reduce carbon emissions	Y	Regular monitoring of emissions to air, not just greenhouse gas emissions, does not disclose prevention measures.

Appendix 5. INEX Disclosure Analysis

Disclosure Measures /Indicators	*Results*	*Evidence*
Sustainability Commitment		
Publicly states general commitment to sustainability	Y	INEX share commitment to a sustainable world on their website.
Publicly releases annual sustainability report	N	No sustainability report released to the public and limited information regarding sustainability on website - shares sustainability presentation with supply chain partners.
Shares sustainability performance	P	Shares brief qualitative information regarding performance.
Shares clearly defined sustainability goals	N	Does not identify clearly defined SMART goals.
Depletion of Natural resources		
Shares commitment to minimise the depletion of natural resources	Y	Has shared commitment to the circular economy of aluminium.
Shares activities performed to minimise depletion of non-renewable resources	Y	Has demonstrated the recyclable nature of aluminium - ensuring this is being practiced throughout SC through various initiatives and SC partnerships.
Shares production process (as required)	Y	"Due to reciprocal biller/scrap arrangements with NZAS, INEX has eliminated the need for an aluminium re-melt plant that adds additional CO2 emissions to the original metals." - shares details of strategic partnerships with supply chain partners and closed loop SC design in presentation.
Loss of biodiversity		

Shares commitment to minimise loss of biodiversity	N	Does not identify commitment to reduce loss of biodiversity.
Shares declaration of IUCN red list species which overlap with operating assets	N	Does not release an IUCN red list declaration.
Shares activities performed to minimise loss of biodiversity	N	Does not identify actions taken to reduce loss of biodiversity.
Harmful Substances to humans and the environment		
Shares commitment to minimise loss of biodiversity	Y	Shares commitment for continuous improvement to reduce environmental impact.
Shares declaration of LBC red list substances	Y	Declares that red list substances are not present in the materials manufactured and supplied to FINEX Ltd (INEX's plant).
Shares activities performed to reduce harmful substances e.g. waste management system	Y	Shares investments/SC activities for reducing environmental impact - regularly conducts energy audits, timber dunnage for packaging is collected and after grading the dunnage is fully recycled, all steel straps are separated for metal recycling, timber cases for packaging are repaired and recycled, all die steel is separated and recycled.
Carbon emissions of processing and manufacturing		
Shares commitment to minimise carbon emissions	Y	Shares commitment for continuous improvement.
Measures and reports scope 1, 2, and 3 emissions	Y	INEX NZ has the greenest aluminium extrusion produced in the southern hemisphere with "cradle to grave" at less than 4mt CO2/t Al of extrusion.
Shares clearly defined reduction targets	P	Has targets to reduce energy requirements, however, these are not shared.
Shares activities performed to reduce carbon emissions	Y	Induction billet heating on all presses (not gas), eliminates any CO2 emissions.

Appendix 6. Lotte Chemical Disclosure Analysis

Disclosure Measures /Indicators	*Results*	*Evidence*
Sustainability Commitment		
Publicly states general commitment to sustainability	Y	"Lotte Chemical creates a better world and sustainable future through chemistry" - company commitment.
Publicly releases annual sustainability report	Y	Releases a sustainability report annually

Shares sustainability performance	Y	Shares ESG Data in ESG Data Book 2022 detailing environmental (GHG, water, waste responsible production, other air emissions and energy consumption).
Shares clearly defined sustainability goals	Y	Share "Green Promise 2030" (Sustainability Management Strategy) which outlines efforts to achieve net carbon zero, circulation and coexistence and green innovation.
Depletion of Natural resources		
Shares commitment to minimise the depletion of natural resources	Y	"Lotte Chemical, as a company primarily engaged in plastic production, aims to enhance the establishment of a recycling ecosystem for sustainable business operations and growth".
Shares activities performed to minimise depletion of non-renewable resources	Y	Shares recycling plastics project strategy and roadmap for resource circulation including disposal processes, reduction targets, education and stakeholder engagement - Project Loop (LOOP Social, Loop Cluster, Loop Lotte and Loop Alliance).
Shares production process (as required)	P	Provides product data sheets, however, production process information is difficult to locate - Lotte Chemical has released life cycle assessment data in 2022.
Loss of biodiversity		
Shares commitment to minimise loss of biodiversity	Y	Shares commitment to minimise loss of biodiversity in environmental policy.
Shares declaration of IUCN red list species which overlap with operating assets	N	Does not release an IUCN red list declaration.
Shares activities performed to minimise loss of biodiversity	N	Does not identify actions taken to reduce loss of biodiversity.
Harmful Substances to humans and the environment		
Shares commitment to minimise loss of biodiversity	Y	Shares target to reduce environmentally hazardous substance by 50% by 2030 and 100% recycling of utility by 2050.
Shares declaration of LBC red list substances	N	Does not release LBC red list declaration.
Shares activities performed to reduce harmful substances e.g. waste management system	Y	Shares efforts to reduce harm to humans and the environment - Lotte Chemical LICORN system, Lotte Innovation Network Project, Mechanical Recycling Process, Recycling Collected Marine Plastic process, Chemical recycling process, Bio-PET Production. Lotte Chemical Meets ISO 45001 requirements fir H&S management system.
Carbon emissions of processing and manufacturing		

Shares commitment to minimise carbon emissions	Y	Shares commitment for achieving carbon neutrality and eco-management.
Measures and reports scope 1, 2, and 3 emissions	Y	Lotte Chemical reduced their emissions by 5% from the previous year, emitting 6.21 million tons, which is approximately 350,000 tons less than their target of 6.56 million tonnes. Scope 3 emissions equated to approximately 18 million tonnes.
Shares clearly defined reduction targets	Y	2050 net zero target and reduce carbon by 25% of peak in 2019 by 2030.
Shares activities performed to reduce carbon emissions	Y	2022 reduction achieved due to implementation of energy-saving activities at existing plants and partial reduction in utilisation rates. Joined RE100 initiative in 2023, a global effort to encourage companies to transition to 100% renewable energy for power generation.

Appendix 7. IMPI Plastics Disclosure Analysis

Disclosure Measures /Indicators	*Results*	*Evidence*
Sustainability Commitment		
Publicly states general commitment to sustainability	Y	Shares concern for environmental issues and commitment to provide solutions to current problems and ensure long-term benefits for future generations.
Publicly releases annual sustainability report	N	Does no publicly release a sustainability report.
Shares sustainability performance	N*	Does not share sustainability performance.
Shares clearly defined sustainability goals	N*	Does not identify clearly defined SMART goals.
Depletion of Natural resources		
Shares commitment to minimise the depletion of natural resources	Y	Shares commitment to invest in research and development that focuses on the use of renewable resources.
Shares activities performed to minimise depletion of non-renewable resources	Y	Shares use of bioplastic in product development.
Shares production process (as required)	P	Shares brief overview of polymaize material - does not share the entire production process.
Loss of biodiversity		

Shares commitment to minimise loss of biodiversity	N*	Does not identify commitment to reduce loss of biodiversity.
Shares declaration of IUCN red list species which overlap with operating assets	N*	Does not release an IUCN red list declaration.
Shares activities performed to minimise loss of biodiversity	N*	Does not identify actions taken to reduce loss of biodiversity.
Harmful Substances to humans and the environment		
Shares commitment to minimise loss of biodiversity	N*	Does not share commitment to minimise harmful substances to humans and the environment.
Shares declaration of LBC red list substances	N*	Does not release LBC red list declaration.
Shares activities performed to reduce harmful substances e.g. waste management system	N*	Does not share activities performed to minimise harmful substances.
Carbon emissions of processing and manufacturing		
Shares commitment to minimise carbon emissions	N*	Does not share commitment to reducing carbon emissions of processing and manufacturing.
Measures and reports scope 1, 2, and 3 emissions	N*	Does not measure and report carbon emissions.
Shares clearly defined reduction targets	N*	Does not share clear and transparent reduction targets.
Shares activities performed to reduce carbon emissions	N*	Does not share activities performed to reduce carbon emissions.