MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Research summary and insights: circular economy and bioeconomy

As part of the first Emissions Reduction Plan, the Ministry of Business, Innovation and Employment (MBIE) undertook a programme of research to determine New Zealand's potential to reduce emissions through resource efficiency and recovery (circular economy) and how to get greater value from New Zealand's biological resources (bioeconomy).

The research was focused on developing evidence and insights relevant to New Zealand's distinctive economy, and related challenges and opportunities.

For the purposes of the research:

a) a circular economy involves designing out waste and pollution, keeping resources in use for as long as possible, then recovering and regenerating products and materials at the end of their lifecycle

b) the bioeconomy encompasses the sustainable use of natural biomass resource and a reduction in waste and pollutants coupled with transitioning away from dependence on fossil fuel resources.

Both have objectives to achieve economic, environmental, cultural and social outcomes.

Research was commissioned from a range of external providers over the period December 2022 to May 2024. Reports from the individual research projects are available on MBIE's Circular Economy and Bioeconomy webpage.

A range of quantitative and qualitative research methods were used in the projects including:

- Material flow analysis: Analysis of mass, energy and carbon emissions data, including presentation in Sankey diagrams, which provide a visual representation of the flows of materials and emissions for New Zealand's economy as a whole, and for waste, food, energy and built environment sectors.

- Market analysis: Analysis of emerging or potential bioeconomy opportunities from a commercial perspective, assessing growth readiness across four dimensions: competitiveness of production for the required biomass; clarity of customers and markets; competitiveness of processing and logistics; and the level of organisation and cooperation in the industry.
- System approaches: Use of system maps and tools, such as the multi-level perspective, to identify patterns of activity and change at sector and whole economy levels and best potential leverage points for actions.
- Literature scan and stakeholder interviews: All projects undertook scans/reviews of relevant international and New Zealand published research. Conversations with stakeholder were used to elicit and test insights and findings during the research.

Some of the key insights we identified from the research as a whole are summarised in the sections below. Each section has drawn on a range of the commissioned research. Links are provided to the research reports for the main source/s at the end of each section.

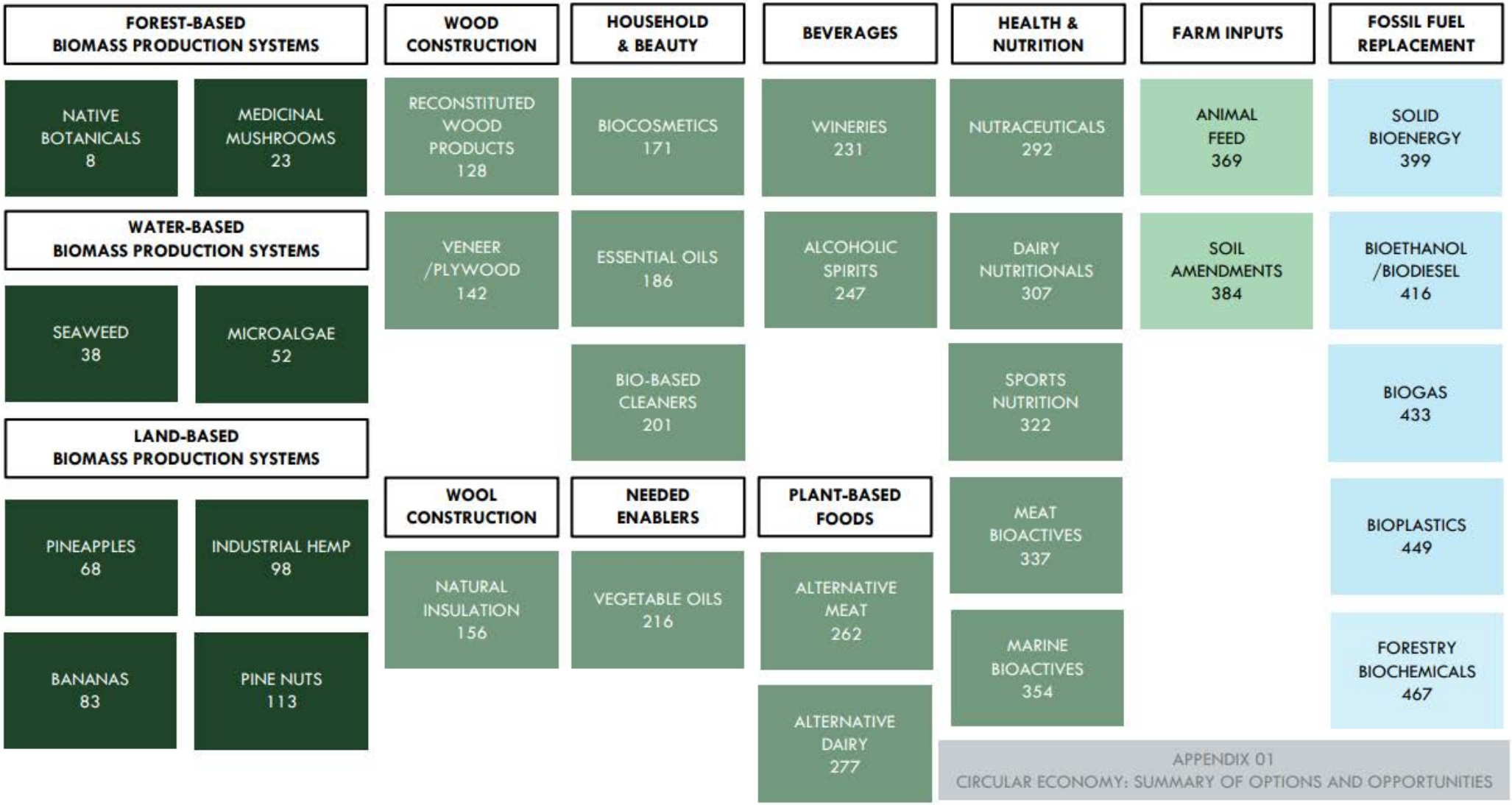
a. Bioeconomy opportunities, near term and future, are key for New Zealand's shift from volume to value

Our research identified emerging or future bioeconomy products/industries that could support the shift to lower emissions and a more productive economy. These use bioresources to their highest value, utilise bio-waste streams, increase circularity in production, and/or reduce emissions and dependency on fossil fuels.

One of our research projects identified commercial opportunities for high-value, sustainable and low-emission use of bioresources. Thirty bioeconomy opportunities were identified, listed in Figure 1 below. In the short-term, the most attractive are complex products aimed at consumer markets in the categories of household and beauty (eg essential oils), and health and nutrition (eg nutraceuticals). In aggregate, added-value bioeconomy exports spanning processed foods, infant formula, nutraceuticals, alcoholic and non-alcoholic beverages, mānuka honey, and petfood were valued at $8.3 billion in 2023, up from $1.5 billion in 2003, a 20-year compound annual growth (CAGR) rate of 9 per cent, above the CAGR required to double in ten years.

Opportunities in biocosmetics, sports nutrition, and marine bio-actives were explored in depth. These are light weight, high-value, knowledge-intensive products aimed at high-growth international markets, and their development may include applications of biotechnology. Importantly, the more value that is created from existing resources through these kinds of products, the more scope there is to achieve greater economic value while limiting or reducing resource depletion and environmental impacts.

Figure 1: Thirty high potential emerging bioeconomy opportunities for New Zealand. (Index page from Coriolis, 2023).



The research finds that our strength in post-farmgate bioprocessing systems (manufacturing) is highly flexible and not directly tied to the land and so it is easily adaptable to the manufacture of high-value products (as distinct from commodities), driving diversification and growth in our export economy. Thus, utilising our existing bioresources – including waste streams – into their highest value applications is found to be easier than developing all new crops and sources of biomaterials.

In the longer-term, New Zealand might look to develop new production systems, examples being seaweed, microalgae, industrial hemp, canola, and eucalyptus, most of which are currently being trialled by market players. The key issue with new production systems is whether they can scale quickly and become competitive. Some, like seaweed, will require significant R&D around growing and harvesting systems, to develop efficiency and scale economies. The success of others, like canola, is dependent on whether New Zealand can be internationally competitive with major offshore producers.

Ideally, in the future, New Zealand can utilise its significant forestry resources and potentially new high-rotation crops such as eucalyptus to manufacture biochemicals, bioplastics and bioenergy at a scale to substantially replace similar fossil fuel-derived products. Currently the economics of doing this is challenging. In addition, New Zealand would have to develop a whole value chain around these bio-industries to make them work. This includes funding of innovation infrastructures, such as an open-access pilot-scale biorefinery to enable proof of concept, technical information acquisition and pilot scale production. Work to date on costs of establishing such a facility, including potential revenue streams, indicates that reasonably substantial Government capital investment and ongoing part funding of operations would be required. This is consistent with the experience of similar facilities in other countries.

Māori business are well placed to pioneer and benefit from emerging 'new' bioeconomy products and industries, given existing investment, knowledge, and skills in land-based industries, particularly forestry. For Māori, innovation will be key for: minimising the use of fossil fuels through the development of alternative products; increasing value added by exporting finished and consumer-ready goods rather than raw inputs; and increasing the production of biomass by shifting land-use to higher yielding crops. More generally, our research found that the Māori economy can act as a catalyst for shift to more sustainable and circular use of resources, particularly through land utilisation opportunities and the role of local place-anchored enterprises.

New Zealand needs new skill sets and capabilities in firms and institutions to transition to more value-added and branded export business. New Zealand has highly developed capabilities along the whole value chain as a low-cost commodity food exporter, based on 120 years of public and private investment. Over the last twenty years there has been growing industry investment in developing more complex added-value products, often consumer products, with exports now valued at $8.3 billion as indicated above.

This growth has often been led by start-ups and new entrants (eg Chinese investment in infant formula and petfood) rather than by the large incumbents. A key reason for this is that the commodity business requires skills and capabilities based around scale, efficiency, and quality, while the added-value business requires a whole additional set of skills and capabilities that the commodity players (and New Zealand generally) lack. The additional capabilities include the ability to manage complex value chains, constant product and packaging innovation, access to pilot facilities, new technologies and machinery, market insights, access to capital, and skills in sales and brand development.

Some of the capabilities required have been put in place, such as the New Zealand Food Innovation Network (NZFIN), the Bioresource Processing Alliance (focusing on waste streams), and the Food and Beverage Information Project that ran from 2011 to 2021. Achieving the Government's export target through value rather than volume will likely require scaling and expanding these programmes, in line with the significant investment in food being made by competitor countries Australia, Singapore, Denmark, Ireland. Upgrading of capital equipment to enable the production of added value products is also an important opportunity to embed practices of reducing waste and circularity.

Sources:

Emerging and future platforms in New Zealand's bioeconomy

Barriers, enablers and approaches for a more circular economy

b. Circular practices in buildings and infrastructure, agriculture and food and manufacturing will provide significant emissions savings, over time, and have impacts for productivity, jobs and supply chain resilience

Circular economy practices can reduce resource extraction, loss of resources and waste generation, and through this, lower emissions. Opportunities for emission savings were identified for New Zealand through adoption of circular approaches in building, agriculture and food, and in manufacturing. Approaches include, for example using recycled, reused or renewable materials for buildings, the use of more local and organic alternatives to imported fertiliser, and greater product durability of manufactured goods.

In these areas, emission savings were able to be quantified for eight interventions with a total savings of 1.5-1.9 Mt CO2e on the annual emission level. Opportunities related to more resource-efficient building accounted for most of these quantified savings. This analysis was supported by material flow analysis, displayed in Sankey diagrams, eg as illustrated in Figure 2. For reference, the savings quantified are equivalent to about three per cent reduction on New Zealand's 2021 net emissions.

Further emissions savings are possible over time, for example, a saving of 1.5 Mt CO2e per annum was estimated to be achievable in 50 years' time if residential buildings are designed to last 100 years, rather than 50 years.

Many other opportunities for emissions savings through circularity approaches exist that were not identified or quantified in this research. These include those from emerging or long-term change such as designing buildings for reuse, reducing consumption of resources, and agricultural and manufacturing practices that enable storage or sequestration of carbon. These savings would be in New Zealand domestic emissions production, as well as global emissions in products that we import and consume.

Other impacts of circular approaches identified in the research though not quantified were:

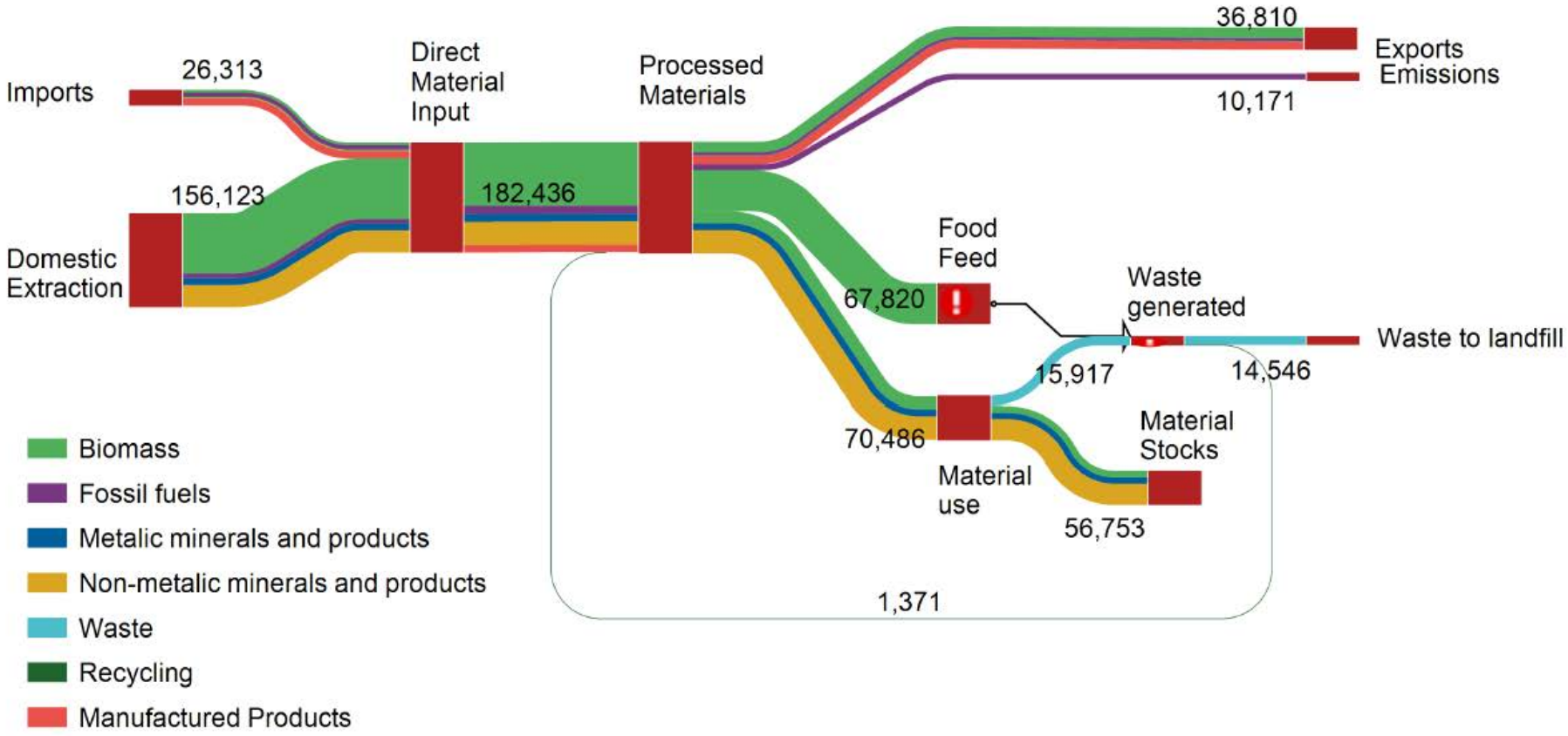
- greater productivity through more efficient use of physical resource inputs for manufacturing
- maintaining trade and export competitiveness
- opportunities to mitigate supply chain risk and increase economic resilience, for example through enabling durability, reuse, repair, recovery and local sourcing of critical materials
- new and changed jobs, for example job gains in repair and remanufacturing and job losses in packaging and waste management
- protection of natural capital.

These impacts have particular relevance to manufacturing and point to opportunities for circular approaches to strengthen the performance of New Zealand manufacturing and its contribution to GDP and exports. Our research identified that industry is wanting to shift to more resource efficient circular practices, and are open to collaborating across industry and with government, but need access to better data to support decision-making.

International experience shows that transitioning to a more circular economy is both rewarding and challenging, requiring comprehensive approaches and sustained action over decades. Sustained action is particularly important for buildings and infrastructure, where the benefits of greater durability manifest not at the point of construction, but at the time when these assets would otherwise have been replaced.

Figure 2: High level material flows in the New Zealand economy, used to identify impacts of circular approaches (Sankey diagram)

Data is mass in kt (thousand tonnes) for 2019. Source: Impacts of circular approaches on emissions, jobs, and other factors, page 27.



Sources:

Impacts of circular approaches on emissions, jobs, and other factors

Barriers, enablers and approaches for a more circular economy

c. Internationally, many policies and regulations are aimed at circular practices and have implications for New Zealand exporters

There are approximately 40 national or trans-national level circular economy strategies worldwide and more than 180 international legislative instruments. Governments have adopted circular approaches to address limited raw material availability and supply chain shocks, increase productivity and jobs, and address climate change and degenerating natural capital.

A wide range of measures are used including bans, levies, taxes, minimum prices, standards, requirements for information on products, extended producer responsibility, procurement, grants and other regulatory and fiscal incentives.

Policies focussed on upstream waste prevention and resource recovery are of growing interest and include incentives for circular design, repairability, and use of digital product passports and other measures to provide consumers with information about the origin, footprint, recyclability and life cycle of products. New Zealand is also among 175 countries that have agreed to develop a legally binding Global Plastics Treaty, including circular economy approaches to address plastic pollution.

Most attention on emissions and climate change mitigation to date focus on the role of energy (largely scope 1 and 2 emissions). However, increasing attention globally is being paid to material and wider supply chain-related emissions (scope 3). A shift to a circular economy is a key part of reducing scope 3 emissions in material production and supply chains.

Our trading partners' circular economy transitions will likely have implications for some New Zealand exporters and our place in wider global trade flows. Circular economy objectives are reflected in the trade and economic policies of New Zealand's top four trade partners: China, Australia, US and Japan, as well as in the UK, EU, and indications towards this in India. There are explicit circular economy provisions in New Zealand's recent Free Trade Agreements with the EU, UK, and the updated Closer Economic Relations (CER) Sustainable and Inclusive Trade Declaration with Australia. Shared interest in working together on circular economy is part of the joint statement on California-New Zealand Climate Cooperation signed in July 2024.

New Zealand will require ongoing awareness of international circular economy developments to make timely responses to opportunities and risks, including where regulatory interventions may be needed. Failure to comply with international standards and practices may mean reductions in market access, additional trade costs, or loss of competitive advantage.

Examples of international developments with implications for New Zealand include:

- changes to Australian sustainability and recyclability requirements which will need to be met by New Zealand exporters for Australia's 2025 Packaging Targets.
- EU reporting and disclosure measures that will have implications for some products placed on the market in the EU, including recyclability or recycled content requirements, labelling, eco-design, traceability, and product data.

New Zealand has limited ability to influence design and manufacturing abroad. This makes strategic collaboration with trade partners on circular economy approaches important to mitigate risks of supply chain disruptions and market volatility. Government has roles through our information networks and trade relationships to monitor developments and support our exporter community to adapt to these global transitions.

Source:

International developments toward more circular economies and the implications for New Zealand

d. Data, information, and digital tools can help track and manage resources more efficiently, supporting the functioning of markets and transparency for consumers

Sophisticated use of data and information enabled by digital tools will be needed to significantly increase resource efficiency and extend the lifespan of products, buildings and infrastructure. Information will need to flow not only along supply chains, but also as feedback loops in systems to signal optimal resource use.

Digital tools under development include sharing platforms, reverse logistics support and product passports (which can provide advanced barcode-like information about what is in a product, how it is made and how it can be reused or recycled). These digital tools will involve the use of artificial intelligence, big data analytics, internet of things, 3D printing, digital engineering, and digital twins.

Digital twins are ‘a dynamic and interconnected digital representation of a physical asset or system, enabling comprehensive insights and informed decision making.’ They can help track materials in the value chain, facilitate predictive maintenance of machines, and fill gaps in information about product composition and availability to enable markets to function well for product reuse or recycling. In a manufacturing industry context, digital twins are part of the shift to Industry 4.0, allowing more automated and connected supply chain management. For built environment uses, digital twin technology could unlock cost and resource savings by allowing virtual trials of design changes, material and equipment choices, and infrastructure upgrades.

There are a wide range of digital twins in development or early-stage use in New Zealand. Most twins are of cities, buildings, or infrastructure, often developed by councils to enable efficient design, planning and management of resources and assets. Sector-oriented R&D programmes include forest, vineyard and orchard twins to support sustainable and productive growing systems. These current uses are consistent with circular objectives for resource efficiency.

Digital twins are not yet being developed in a way to realise their full potential in New Zealand. A lack of data literacy is reducing the effective exchange and use of data. Limits in collaboration across industry and data standardisation mean digital twins are being developed without optimal interoperability. Adoption of standardised frameworks and technical capabilities, such as artificial intelligence, would enable digital twins to operate in more connected ways.

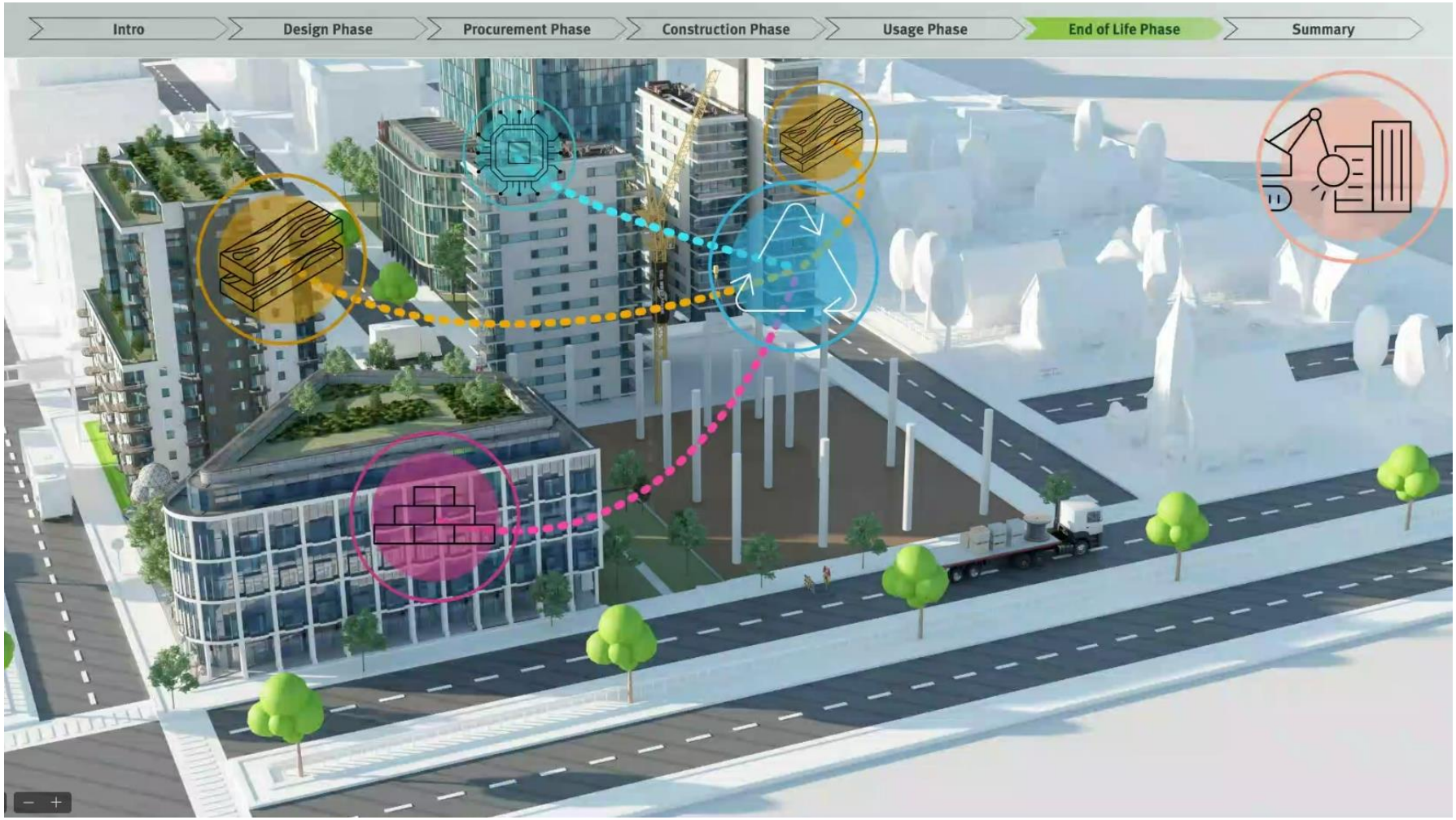
Our research included a workshop designed to demonstrate the potential of digital twin technology in the built environment and for other applications (Figure 3).

Source:

Digital technologies, digital twins and the circular and bioeconomy

Figure 3: Screenshot from the digital twin technology workshop demonstrating opportunities for digital twins in the built environment.

Source**:** [Digital technologies, digital twins and the circular and bioeconomy]



e. New Zealand is at an early stage of the shift to more circular economy; there is emergent activity in sustainable businesses and communities

New Zealand's economy, like most other countries, is not very circular. We are one of the highest generators of waste in the OECD, with an average of 700kg per person sent to municipal landfills in 2021. Our research estimated that less than 1% of materials that flow into the New Zealand economy are recovered through recycling.

There is a growing niche of businesses adopting circular practices. Organisations such as the Sustainable Business Network have been supporting circular business practices for many years. Their Circular Economy Directory lists 129 organisations and has had 34,000 users since 2019.

Many circular businesses remain small and have difficulty scaling in an economic system and business environment that is still fundamentally linear. Product end-of-life considerations tend to be the focus for many businesses wanting to be more circular. Reinventing products and designing out waste in the first place has been less prominent but is growing.

Regional initiatives using circular practices are emerging in New Zealand, particularly in the bioeconomy. For example, Northland's Ngawha Innovation and Enterprise Park is a collaborative hub for business and process innovation, focussed on kaitiaki, circular economies, employment opportunities and regional capability development. Communities are involved in networks supporting avoidance of waste and circular approaches; these include Para Kore, Zero Waste Network, New Zealand Food Waste Champions and Repair Café Aotearoa.

Modest government investments have supported these initiatives while the circular concept is beginning to be embedded in some areas of government policy.

Source:

Impacts of circular approaches on emissions, jobs, and other factors

f. Material shifts to circular economy and a higher value bioeconomy would need to be supported by sustained Government support

Shifting towards a more circular economy could support market competitiveness, supply chain resilience for critical materials, reduce emissions and environmental degradation, and generate local jobs. The scale of change will require action from across the business sector, consumers and communities, as well as a substantive role for government. Experience from other countries shows the shift can be slow and requires multiple levers. Governments are turning to stronger market-shaping interventions to accelerate the shift to reduced and more efficient use of resources.

Moving to higher-value, lower-emission products in the bioeconomy will be needed for New Zealand's transition to a low emissions economy and to achieve the government's goal to double the value of exports. Moving from volume to value has been a long-term and challenging goal for New Zealand.

Collectively, the research programme finds that New Zealand's shift to a circular economy and to a high-value bioeconomy could be a means to achieve a range of government goals: emissions reduction, as well as economic productivity and growth, growing export value, and supply chain resilience. A material shift will require sustained investment and multiple initiatives across different policy areas supporting coordination, information availability, and innovative activity.

Sources:

Emerging and future platforms in New Zealand's bioeconomy

Barriers, enablers and approaches for a more circular economy