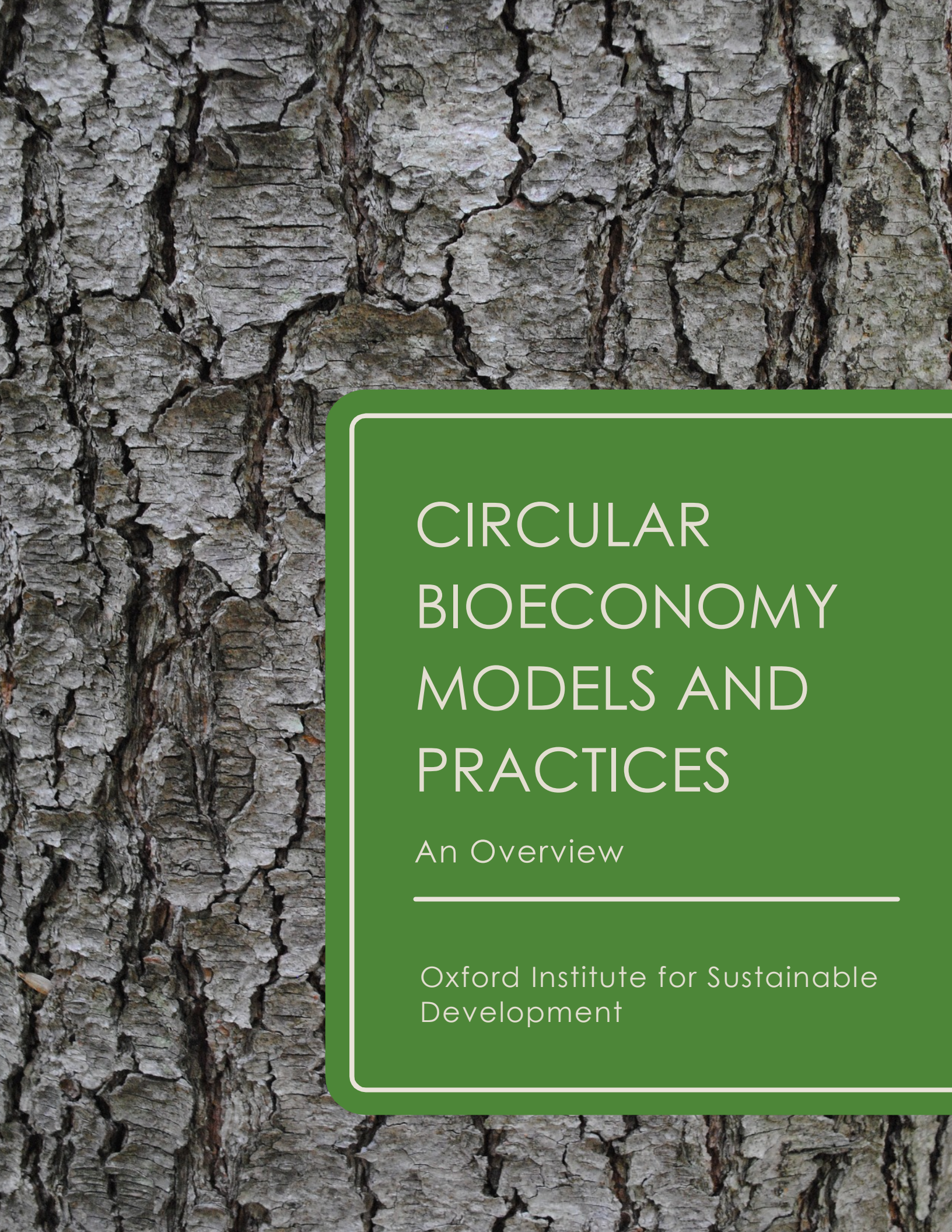

CIRCULAR BIOECONOMY MODELS AND PRACTICES

An Overview

Oxford Institute for Sustainable Development

CIRCULAR BIOECONOMY MODELS AND PRACTICES

An Overview

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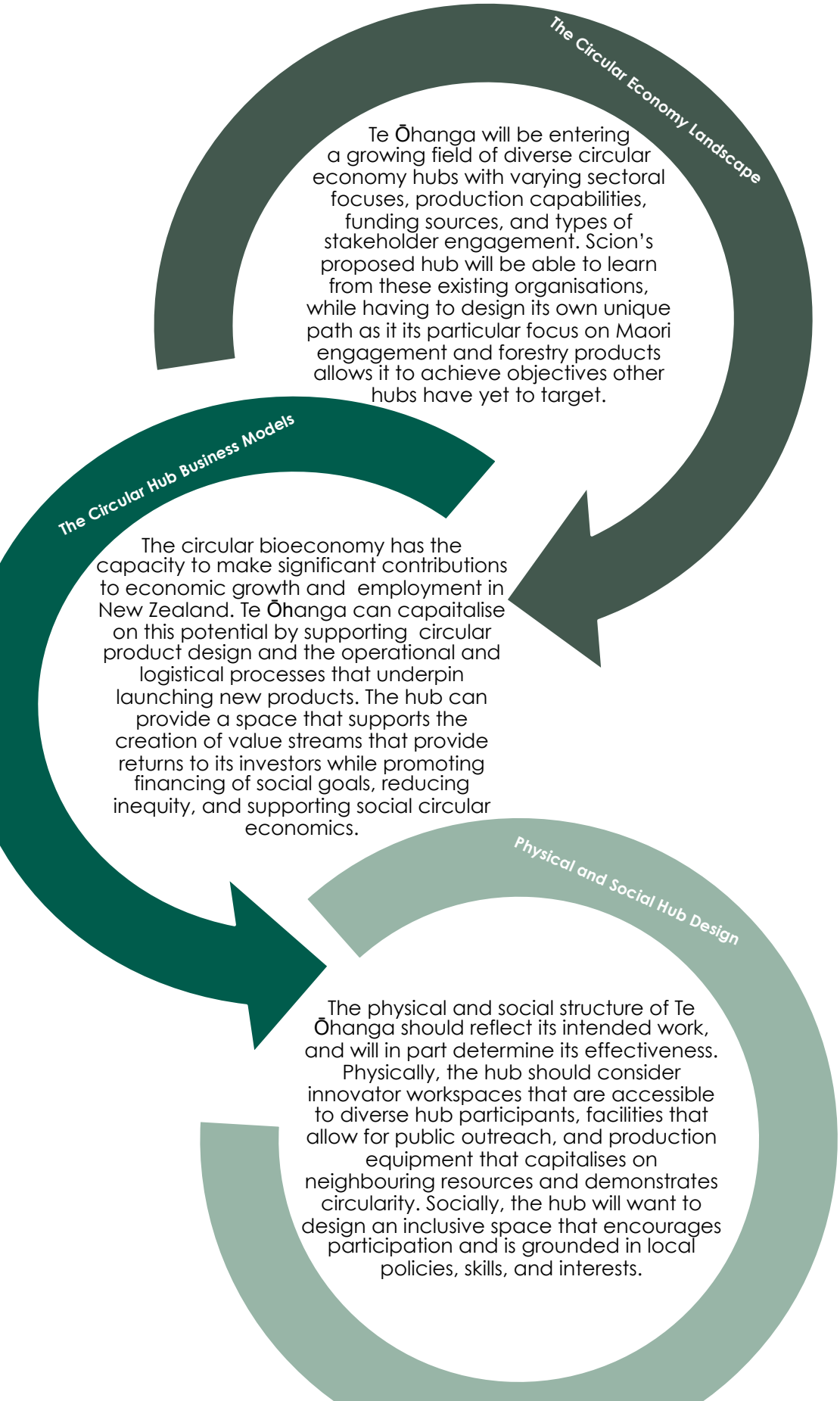
SCION
FORESTS • PRODUCTS • INNOVATION

TABLE OF CONTENTS

TABLE OF TEXT BOXES

TABLE OF FIGURES

EXECUTIVE SUMMARY

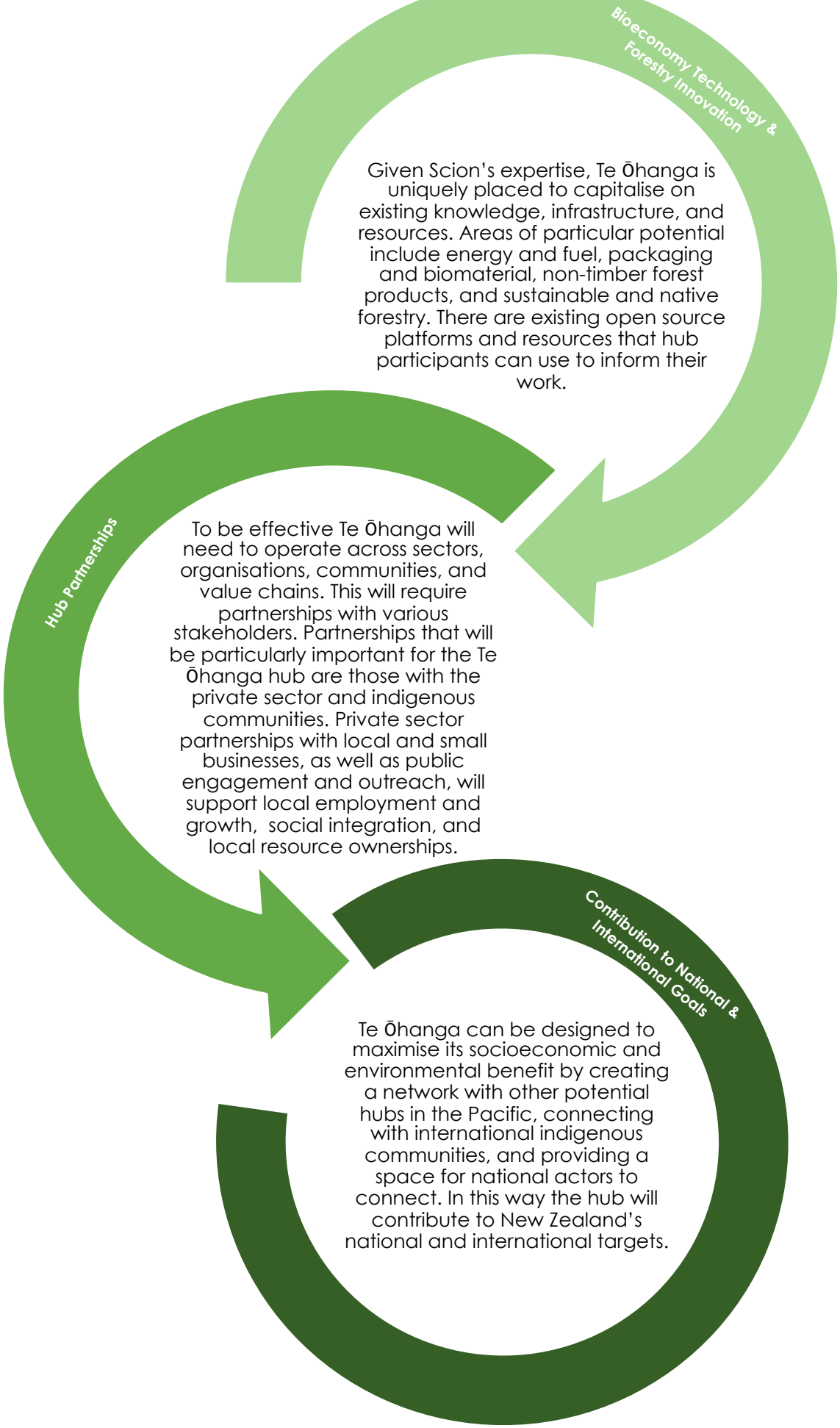


A Reader's Guide

On the left hand side of this page is the report executive summary. Each ring provides a brief synopsis of the main conclusions in one of the report's six core chapters. For readers with limited time this is an ideal way to understand the general content of the report and identify chapters of particular interest. However, these summaries do not provide the actionable and detailed analysis contained in the body of the report. The introduction further summarises each chapter and provides an overview of circular economy concepts and the report preparation process, while the conclusions synthesises findings into a summary of action items for the future.

Each chapter is framed as a question about circular bioeconomy hubs, and begins with a chapter summary that addresses that question and provides a detailed overview for easy reading. The first chapter is a landscape analysis of relevant case study hubs, and serves as the evidence base for the following chapters that engage with particular topics of interest.

All of the topical chapters explicitly identify relevant innovations, technical or non-technical, and case studies for Scion's future reference. Also, as social inclusivity and Maori participation are key objectives for Te Ōhanga each topical chapter includes a section that addresses indigenous hub participation or inclusivity on a larger scale. This integrated approach demonstrates the reality that encouraging diverse hub participation will require consideration in all aspects of hub design and operation.


Bioeconomy Technology & Forestry Innovation
Given Scion's expertise, Te Ōhanga is uniquely placed to capitalise on existing knowledge, infrastructure, and resources. Areas of particular potential include energy and fuel, packaging and biomaterial, non-timber forest products, and sustainable and native forestry. There are existing open source platforms and resources that hub participants can use to inform their work.
Hub Partnerships
To be effective Te Ōhanga will need to operate across sectors, organisations, communities, and value chains. This will require partnerships with various stakeholders. Partnerships that will be particularly important for the Te Ōhanga hub are those with the private sector and indigenous communities. Private sector partnerships with local and small businesses, as well as public engagement and outreach, will support local employment and growth, social integration, and local resource ownerships.
Contribution to National & International Goals
Te Ōhanga can be designed to maximise its socioeconomic and environmental benefit by creating a network with other potential hubs in the Pacific, connecting with international indigenous communities, and providing a space for national actors to connect. In this way the hub will contribute to New Zealand's national and international targets.

INTRODUCTION

The current global economic model is predominantly linear: resources are extracted, processed, consumed, and disposed of as waste. A linear economic model remains viable only as long as a supply of resources persists,[1] the impacts of extraction and waste disposal are tolerated by society, and economic activities do not do irreparable damage to the biosphere the economic model depends upon. Increasing anthropogenic environmental degradation and rising global resource consumption[2] suggest the linear model is not viable in the long term. It is expected that, because of economic expansion and an increase in standards of living,[3] the world will see an increase of three billion middle-class consumers by 2030 and that global resource consumption of raw materials will almost double by 2060. [4] Increasing resource scarcity, concerns regarding the impacts of resource extraction, and the risks of reliance on external resource providers[5] all threaten the legitimacy of the linear economic model. The Circular economy model, as the name would suggest, is a direct response to the problems associated with the current linear global economic model. It seeks to reform economic processes in a way that responds directly to these issues.

The circular economy is based on three fundamental principles: designing out waste and pollution, keeping resources in use at their highest possible value, and restoring natural systems. [6] It aims to detach economic growth from the consumption and constraints of limited resources[78]. As an economic model, the circular economy not only seeks to reduce environmental damage, but also promises broader opportunities and benefits for society, including cost savings, business opportunities, and technological innovation.[9] [10]

Creating a circular economy requires engagement with the bioeconomy. The bioeconomy is "the aggregate set of economic operations in a society that use the latent value incumbent in biological products and processes to capture new growth and welfare benefits for citizens and nations".[11] It includes eco-innovation to derive more industry inputs from renewable biological sources, particularly forestry and agriculture [12] . Defined as "innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole lifecycle," [13] eco-innovation encompasses moving towards a circular economy model that is resource-efficient, changing the way citizens approach resources and improving value generation.[14]

The circular economy model is also aligned with the wider green economy movement, [15] including global environmental and socioeconomic goals such as a reduction of carbon emissions, strong waste management strategies, and improved welfare. It is also based on a shift towards renewable energy sources.[16]

In the New Zealand context, circular economy practices have the potential contribute to the achievement of the country's targets set by its *Zero Carbon Act 2050*, *2010 Waste Strategy*, and Nationally Determined Contribution under the Paris Agreement.[17]

Scion intends to support and shape the development of the circular economy in New Zealand by establishing a hub focused on innovation within the circular bioeconomy.

The Scion circular bioeconomy hub, Te Ōhanga, in Rotorua is proposed as a space open to collective ideation on issues surrounding circularity and the transition to a low carbon economy. The concept of social inclusivity is central to the hub, and its design will have a relationships-first focus that emphasises adding local value and encouraging collaboration. Critically, the hub aims to collaborate with Maori partners, drawing on indigenous knowledge and seeking to maximise the hub's social, economic, and environmental, value both for local communities and for the wider national and international audience.

The use of a hub model itself will be valuable to attaining these objectives. The clustering of resources within hubs encourages collaboration [18] by enabling continued face-to-face interactions and relationships. [19] This in turn facilitates the transmission of knowledge and ultimately sparks innovation.[20]

A further component of the Hub is the inclusion of biopilot facilities. These are testing facilities that allow piloting and scale-up and potentially the production of new biobased products or biotechnology, and Te Ōhanga will be particularly focused on the scalability of circular bio-based products. By piloting new biomass based materials and products the Hub will contribute to increasing circularity in, and the biologising of, the economy by transitioning from dependency on fossil fuel powered production to production based partially on renewable biomass.[21]

This report has been prepared by the Oxford Institute of Sustainable Development, following discussions between Scion and the University of Oxford students. To support Scion as it participates in shaping the growing circular economy field, this report provides an overview of similar projects that are physical, inclusive spaces for individuals and organisations from the public and private sector to collaborate on advancing circular design and practices. The report also includes the most current thinking on encouraging resource circularity and creating circular economy hubs. In doing so, the report identifies key insights to assist Scion as they establish Te Ōhanga.

The report approaches the issue by taking six key questions about circular bioeconomy hub design and answering those questions with a particular focus on informing the proposed Scion Te Ōhanga project. Each chapter includes a summarised answer to the proposed question, as well as the complete answer, a section on inclusivity, and text boxes on relevant case studies and operational innovations within the field (to provide practical insight).

Chapter 1 outlines the current global circular economy innovation and advocacy spaces, drawing on case studies to provide information on hub business models; relevant sectors and products; hub outreach activities; and hub pilot and production facilities. Chapter 2 discusses what constitutes a sustainable hub financial model and summarises the values circular

bioeconomy hubs provide to circular enterprises. Chapter 3 includes high-level insights into the design of the physical and social structure of hubs and focuses particularly on the requirements for the creation of innovative, inclusive, and collaborative spaces. Chapter 4 considers what bioeconomy technology and forestry innovation the Te Ōhanga hub can capitalise on with reference to forestry waste streams; innovation in energy and fuel, and packaging and biomaterials; forestry diversification; and native forestry practices. Chapter 5 details the ways in which the hub may cooperate with other actors, including local partners, the private sector, non-governmental organisations, and other initiatives, as well as design features for meaningful partnering and collaboration. Chapter 6 explores the potential contributions the hub can make at the national and international levels, situating it within the context of socioeconomic and environmental objectives.

1. HOW DO CURRENT SPACES FOR CIRCULAR ECONOMY INNOVATION AND ADVOCACY OPERATE GLOBALLY?

A growing global interest in the circular economy has resulted in the establishment of physical spaces that provide resources and services to enable the transition to circular economies and the development of circular societies. These sites go by many names, but will be referred to as hubs in this report. The circular economy hub sector is ***undergoing rapid development,*** *and is characterised by a rich diversity of actors, structures, social values, and sectors serviced.*

To support Scion as it participates in shaping this growing field and launches its own circular economy hub, this report provides an overview of similar projects that are physical, inclusive spaces for individuals and organisations from the public and private sector to collaborate on advancing circular practices. This landscape analysis is not exhaustive, but rather tailored to the vision Scion has expressed - raw data on the overseas projects considered can be seen in Annex 1 of the report. The geographic spread of the selected projects, their accessibility, and the number of hubs they include are indicated in Figure 1. These hubs span the following sectors: food and additives, waste and water, energy and fuel, construction material and furniture, textiles, plastics and packaging, green chemicals, health, and personal care. Of the hubs studied, ***83% include an outreach component****, 32% had medium to high product piloting capabilities, 36% rely on grants and donations and 64% operate on the basis of income. The kinds of business models, sectors, pilot facilities, and outreach activities included in our sample are discussed in detail below.*

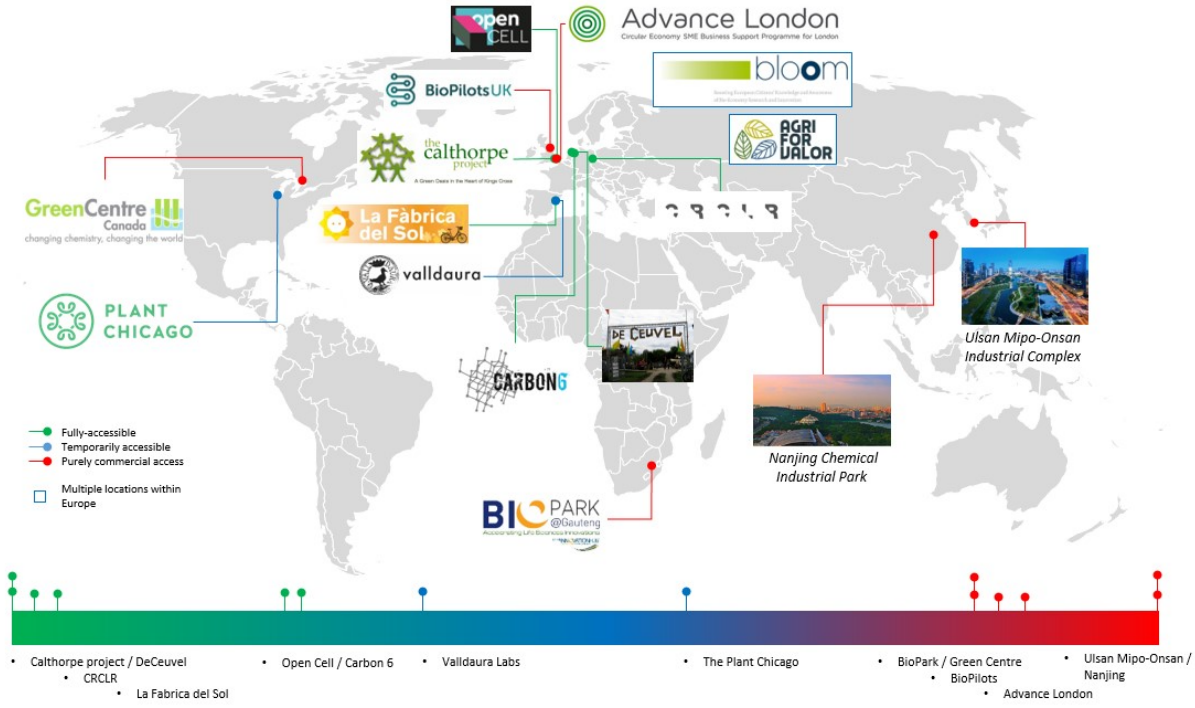


Figure 1. Landscape Map

HUB FINANCING

The current global regulatory and economic framework does not necessarily favour the circular over the linear, in part because of negative externalities of the linear economy - such as carbon emissions - are not accounted for in the market. Therefore, to promote the circular model, interested actors from the public and private sector have provided funds to enable the creation of hubs to support the circularity transition. How subsequent income is generated depends strongly on the hubs' intended outcomes. For the hubs displayed in Figure 1, **four different approaches** to financing have been identified.

1. Hubs that focus on **physical outreach** and **showcasing technologies** tend to be **fully funded by governments, non-profits, or the private sector** (most commonly, 'clean tech' companies). No income streams are expected, and the stakeholders consider the wider impact on society to be the main aim. The main expenses are staff, rent or lease of building, acquisition of showcase technology or demonstration units, as well as facility management. An example would be **"La Fàbrica del Sol"** in Barcelona, which invites visitors and groups to experience the sustainable and circular principles for buildings and resource management first-hand.[22]

2. **Networking** and **knowledge sharing** hubs are generally fully funded by **governments, participating industries, and academia**. These might have a physical space, to meet for events and workshops, but derive their effectiveness from a well-constructed online platform and accessible resources. The main expenses are administrative staff, web service management, and grants for travel and events. The main aims are to share existing knowledge, spread best practices, and facilitate cooperation between different entities within the circular economy space. An example of this is the **"Bloom"** network, which operates in a range of EU countries, each with a different specialisation depending on the focus of the local economy and research institutes.[23]

3. **Physical maker- and work- spaces** are usually **partly funded by private donors and governments**. They obtain income from rental of equipment and office and event space, while being aware that the supported individuals, start-ups and Small and Medium-sized Enterprises (SMEs), could not survive when rental cost are on market level. An example is **OpenCell in London**, which is a collection of shipping containers, each hosting a start-up that conceptualises and tests their products onsite. The rent is heavily subsidised and the agglomeration of bioeconomy entrepreneurs is beneficial for idea sharing and seen as a benefit to the wider community and society.[24]

4. Hubs that are comprised of **physical pilot plants** and **production facilities** can be **financially self-sufficient, and commonly operate as non-profit enterprise**. They primarily draw income from equipment, office, or space rental (with proportional pay to either company revenue or valuation) and workshops and employee training (mainly targeting large industry). They either work as testing facilities, which allow piloting and scale-up of technology or host a range of start-ups with actual production capacity. An example would be **"The Plant" in Chicago,** which was bought by a private entity and now hosts a significant number of smaller companies, about 25 of which are for-profit, that all produce their own product while harnessing synergies from mutual waste utilisation. As they have an acknowledged mission and operate as non-profit, they might still have some degree of reliance on grants, donations or volunteer work.[25]

HUB SECTORS AND PRODUCTS

The circular bioeconomy encompasses a multitude of products and eventually aims to replace most produced consumer and industrial goods with materials that are derived of bio-mass.

Given the breadth of possibilities, hubs tend to specialise in certain sectors and product types. The selection of specialisation usually depends on the available funds and space, the local resources, and the makeup of the regional economy. This report has identified nine relevant sectors for Scion, excluding non-bio-based sectors such as electronics and high-tech consumer goods. They are listed in Figure 2 by the frequency of occurrence and the number in the brackets indicates how many hubs are known to operate in this field within our landscape review (see further details in Annex 1).

Low-Tech, Sector Diversity: Every One Every Day

Every One Every Day is a neighbourhood project, which is an experimental area stretching over different buildings and patches of land with the inclusion of different sectors, e.g. a renewable energy park, a large urban garden, a factory-turned-makerspace with manufacturing equipment, textile and clothes production space for designers, workshop for wood-work and furniture.

About Every One Every Day," Every One Every Day, accessed February 17, 2019, https://www.weareeveryone.org/every-one-every-day.

Text Box 1. Case Study: Every One Every Day

High-Tech, Encompassing All Sectors: Bio Base Europe

BioBase Europe is a large bioeconomy piloting facility with equipment catering to all sectors, hence high capital investment and sophisticated technical infrastructure is required, and the facility resembles a chemical plant. The breadth of knowledge expertise is guaranteed through ad-hoc cooperation with different industries and specialists.

"About The Pilot Plant," Bio Base Europe Pilot Plant, accessed March 20, 2019, http://www.bbeu.org/pilotplant/.

Text Box 2. Case Study: Bio Base Europe

Sector	Capital intensity of equipment	Details
Waste and Water (16)	Low to High	Waste treatment, e.g. metals recycling, plastic depolymerisation and recycling, organic waste valorisation (tumble composter, anaerobic digestion, bio-CHPs, pyrolysis and gasification, insect larvae rearing [e.g. black soldier fly]) and novel sanitation concepts, (e.g. source separation, nutrient and heat recovery, constructed wetlands, biofilter and reactors)
Materials (16)	Low to Medium	Construction materials (e.g. slabs, plates, timber), furniture, manufacturing materials (e.g. fibres, resins)
Food and Additives (14)	Low to Medium	Urban agriculture practices (hydroponics, aquaponics, vertical farming, organic community farming), bio-fertiliser (usually made from organic waste material or plant biomass such as algae), bio-pesticides, bio-growth stimulants (both extracted from living cultures), food colouring, dietary supplements (e.g. algal omega 3, protein powder)
Energy and Fuel (13)	Medium to High	First- and second- generation biofuels (e.g. bio-ethanol, biodiesel), waste-derived biofuels (e.g. bio-methane, syngas, biochar, hydrochar), heat-pumps, geothermal heat, solar (PV and solar heating), energy storage and carriers (e.g. green methanol, green hydrogen)
Plastics and Packaging (10)	Medium to High	Bio-based degradable and non-degradable plastics, ranging from hard plastics to duroplasts (for construction, manufacturing and household goods) over soft plastic or thermoplasts (plastic bottles, any receptacles, packaging material) to elastomers (rubber)
Textiles (8)	Medium	Bio-based fibres, yarns and textile polymers (ranging from cotton to biorefined products), biologically produced dyes
Green Chemicals (8)	Medium to High	Platform chemicals to allow production of intermediates used in the chemical industry (e.g. phenol, glycerine) and high-value specialty chemicals, mainly produced through biorefining (i.e. converted via microorganisms or enzymes and without harsh reaction conditions such as high temperatures or pressures) biomass such as wood or waste organic material
Personal Care (5)	Low to Medium	Cosmetics, toiletries, and cleaning items produced from renewable sources, such as moisturiser with plant oils and extracts, shampoos and soaps made from naturally occurring surfactants
Health (2)	Low to High	Life sciences employing biological processes for the extraction and production of valuable compounds used for medicinal and nutritional purposes, such as ginseng derived products (both conventional medicine and homeopathy)

Figure 2. Circular Economy Hub Sectors

Waste management is maybe the most ubiquitous sector for circular economy hubs. Waste management is universally applicable, does not necessarily require high capital costs to effect meaningful change, and can utilise mainly established technologies. The materials sector is also a relatively common circular economy hub - furniture or building boards can be made in almost any workshop, and the use of waste material is commonly accepted.

Energy, **plastic**, **textile**, and **chemical production** bear significant economic and environmental potential, however they tend to require more complex machinery and less commonly known technologies. For health and personal care, products can range from simple nature-derived balms to highly bio-engineered microorganisms, hence the capital intensity varies substantially.

Figure 3 shows how "specialised" or focused the selected hubs are, with a high number of sectors (x-axis) meaning companies within the hubs are quite diverse and the focus is broad.

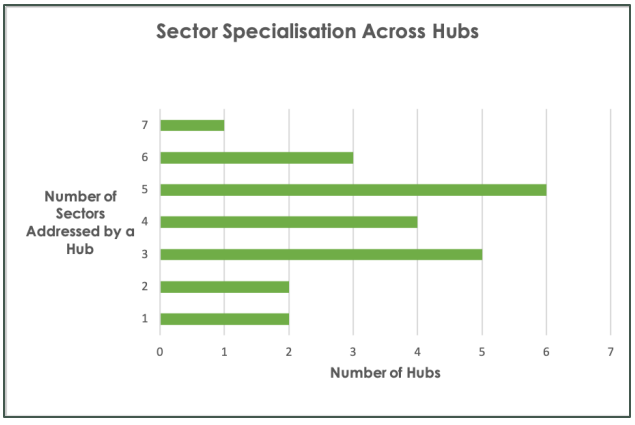


Figure 3. Sector Specialisation Per Hub

OISD's analysis suggests that most hubs operate across multiple sectors. Relatively few hubs only work in one sector. This may reflect the potential synergies that exist including where multiple waste streams are received and utilised (which is more likely if multiple sectors are involved). There is, however, a trade-off with the machinery and knowledge expertise required where a larger number of sectors are addressed by a hub. OISD's analysis indicates that this encourages most hubs to **focus on three to five inter-related sectors** only.

HUB OUTREACH ACTIVITIES

Of the projects reviewed, **83% included an outreach component**. The nature of outreach varied by organisation and mission: broadly outreach was either focused on government actors and the private sector or directed at the broader public audience.

Outreach focused on the private sector, and increasing industrial circularity, includes employee training and encouraging a community of practice around circular business models through workshops and facilitating networking. Employee training, as a form of outreach and engagement with industry, can help encourage individuals to act as champions of circularity within their organisations, identify and act on opportunities to increase circularity, and form important connections between the hub conducting the trainings and the attendees that could foster future product partnerships. The **London Waste and Recycling Board (LWARB)** trains London Borough officers to become "champions" of the circular economy by sponsoring online trainings and attendance at the Circular Economy 100 Acceleration

Workshop, as well as working with the selected champion to identify local opportunities for circularity. While this is a relatively new programme, it has already led to a champion attempting to embed circular economy practices in new local housing developments. [26] Beyond providing an educational service, encouraging industry professionals to **attend circular economy workshops** can also strategically contribute to building a circular community of practice and network of circularity champions within different industries. Connecting industry professionals with their peers, academics, and government employees that share their interest in circularity can facilitate the creation of a powerful knowledge sharing network and intellectual community. **The AgriForValor Biomass Innovation Design Hub**, with its explicit purpose of connecting diverse actors throughout the forestry and agriculture sectors, is a strong example of building such a community. [27] While government and private sector outreach was generally less common that outreach to the broader pubic within our sample, the majority of the reviewed projects do work with, or in, the private sector and there may be opportunities to capitalise on those relationships as a means of championing circular business models, as the above examples showcase.

Circular economy hubs can also communicate the value of circular practices to the broader public. More than half of the reviewed organisations included public outreach in their programming by **facilitating tours and visits**; **running workshops**, **certifications**, **and classes**; **local community engagement**; and **marketing circular products**. Public outreach by **welcoming visitors**, **conducting tours**, and **hosting events and exhibits** was a particularly common form of community engagement.

La Fàbrica del Sol

La Fàbrica del Sol is a demonstrative environmental education building, supported by the Council of Barcelona. It communicates ideas about environmentally conscious, waste-reducing architecture to the general public by letting them view and interact with an operation building that includes advance circular feature like a geothermal heat pump, natural ventilations, and a vertical garden, among others.

The Barcelona City Council, "La Fàbrica Del Sol," accessed February 27, 2019, http://ajuntament.barcelona.cat/lafabricadelsol/en/canal/la-f%C3%A0brica-del-sol.

Text Box 3. Case Study: La Fàbrica del Sol

Carbon6, a redevelopment of a building in the Netherlands emptied during an economic downturn that is now a creative cluster and complex hosting start-ups and organisations committed to green innovation and collaborative working, is an example of this technique.[28] Alongside office space, Carbon 6 also hosts a Dutch National Mining Museum, which discusses the regions history with coal, creating important dialogue and nuance in this innovative space.[29] Hubs that are focused on adding local community value, like Every One Every Day and their mission to create a shared sustainable space, conduct outreach by serving as a community hub and a circular hub hosting community maker spaces, festivals, and kitchens.[30] [31]

HUB PILOT AND PRODUCTION FACILITIES

The hubs, which focus on providing a space for product development and production scale, generally have one of two philosophies about their purpose. Either:

(a) products are developed completely at the hub (e.g. for citizens who want to engage in DIY or start-ups that "live" in those hubs)

or

(b) hub serves to provide equipment which allow to test or scale-up a lab-proven study on a larger scale (e.g. for recent research degree graduates or smaller companies with limited lab equipment).

In both cases, the capital intensity of the associated equipment varies greatly depending on the aim of the hub. Some have no equipment, and only serve as office space and a place from where product development and production is planned. Others have low cost equipment, usually rented out for free, to allow product and prototype development in small quantities. To scale the production of a product for an industrial or international customer base, usually large and capital-intensive equipment is required.

HUB ACCESSIBILITY AND COMMUNITY ENGAGMENT

The **transition to the circular economy is as much a socio-economic one** as a technological one (e.g. change of consumption habits, product preferences, daily waste behaviour). Hence, the raison d'etre for some projects is ensuring the benefits are shared rather than privatised and inspiring the community to become local co-producers and active neighbours and citizens. Hence hubs have tried to be open to interested citizens, practicing artists and hands-on DIY enthusiasts. Further, **cultural events** attract a younger generation to connect the place to a vision and spread the circular economy model indirectly. They are showcasing circular principles, inviting people to craft and tinker, provide co-working space for aspiring entrepreneurs, and organise concerts.

UK Biopilots

High capital intensity, purpose scale-up (b)
Alliance of 4 large-scale bioprocessing/biorefinery facilities each specializing on certain processes with associated equipment and infrastructure. Their aim is to bring academic breakthroughs and industry experience together to enable the testing and scale-up of novel products, usually requiring larger up-front capital investment

"About – BioPilotsUK," BioPilotsUK, accessed March 20, 2019, https://biopilotsuk.com/about/.

Text Box 4. Case Study: UK Biopilots

CRCLR

CRCLR consists of office spaces for "ecopreneuers" and green architects and a community garden, while hosting sustainable fashion shows and clothes exchange, art exhibitions portraying green and CBE topics, pop-up stores for books, clothes etc. and organises workshops on everything surrounding the circular bioeconomy as well as festivals (e.g. open source days)

"CRCLR Spaces," The CRCLR House, accessed March 20, 2019, https://crclr.org/spaces/.

Text Box 5. Case Study: CRCLR

2. WHAT ARE SUSTAINABLE BUSINESS MODELS FOR A CIRCULAR ECONOMY HUB?

A number of different business models have been successfully implemented for circular economy hubs, reflecting the various ways hubs can add value to society, and how that value can be seen as financial returns. The landscape analysis in the first chapter of this report summarised the ways hubs fund their activities – external funding, internal income, or a mixture of both. This chapter builds on these definitions to summarise the types of value a circular bioeconomy hub provides to burgeoning circular enterprises – technical product development, legitimacy and security, and operations support and community of practice creation - and how this value can be understood as a return on investment. The value produced by hubs can support meeting social goals, reducing inequity, and enabling social circular economics. In the case of Scion, Te Ōhanga has the potential to capitalise on all of these value streams, and the hubs design and operations will determine the extent to which it provides various kinds of financial returns to its stakeholders.

CREATING FINANCIALLY SUSTAINABLE HUBS

Businesses are usually described as financially sustainable when the financial return they receive from their product or service (the value they contribute) covers their costs and therefore allows them to continue operations over time.[32] In the case of circular bioeconomy hubs, this definition is not entirely applicable as the returns of their work can be very diffuse and do not always constitute a direct funding stream. In this context, it is more strategic to think of the broader financial impact a hub has, and the various streams of value it creates. This understanding of value and funding streams not only ensures that a hub is providing tangible financial returns through the success of enterprises it supports and the change it produces, but also acknowledges the role of hubs as enablers that frequently rely on stable and long term investment.

Much as businesses can employ multiple circular economy business models to both reduce costs and generate income (through things like product creation, or membership fees), hubs can contribute to multiple value streams that ensure they are financially sound investments, regardless of whether they are externally funded or use internal income streams.[33] The main value streams hubs provide, and the financial returns they produce, are as follows:

Advance London

Advance London, an initiative under the London Waste and Recycling Board, was designed to support SMEs capitalising on the opportunities circularity can provide throughout their development process.

Advance London, as a case study, provides a strong example of valuing and communicating the diffuse financial returns that hubs can provide through the success of the businesses they support. Advance London sees the returns of their investment in municipal GDP growth, job creation, and capturing new revenue streams, as well as the important health and environmental impacts of waste reduction.

"Investing into Circular Economy SMEs," London Waste and Recycling Board. Accessed February 28, 2019. https://www.lwarb.gov.uk/what-we-do/advance-london/investment-for-businesses/.

Text Box 6. Case Study: Advance London

PRODUCT DEVELOPMENT

One significant value stream for a circular hub is circular **product development**, **supporting research**, and the

development of innovative ways to use waste. In the bioeconomy context, circular product development can range from creating new products from bio-based materials (either from waste streams or renewable sources), to making products biodegradable, and designing products and materials that are alternatives to single-use or difficult to recycle materials. [34] Hubs facilitate product design and development by providing facilities for testing and piloting products and by being a place for collaboration and knowledge exchange.[35]

The product development within the circular bioeconomy is directly linked to the creation of financial value by launching businesses, expanding the labour market, and reducing the money lost to waste by valorising waste streams.[36] The role of new product design in launching new enterprises is significant. By providing free-of-cost start up facilities to allow the testing of new ideas, hubs support the creation of small enterprises, which are often important economic drivers and employers. In New Zealand, 97% of businesses have fewer than 20 employees, while employing 29% of the country's population and providing 28% of its GDP. [37] The inherent value of circular practices as a way of supporting new businesses and promoting the labour market is relevant to all circular bioeconomy hub value streams but is particularly relevant in the case of product creation.

While it is beyond the scope of this report, the handling of intellectual property should also be considered, as it will impact how the value generated by the hub will be distributed.

Business Ecosystems

One way of reducing waste, and providing support for new, smaller circular businesses is facilitating the creation of a business ecosystem. Business ecosystems are clusters of organisations where small companies can profit from the waste products of a larger firm, similar to some eco-industrial parks but with more of a focus on development around a single large company source.

An example would be the Metsä Group Äänekoski bioproduct or biorefinery mill in Finland. The Äänekoski mill primarily produces pulp, but has also developed an ecosystem of production around its waste products - smaller enterprises use the mill's waste streams to produce electricity, transportation biogas, plywood, and more.

Hubs, as relationship brokers and facilitators, can help organisations identify opportunities to build business ecosystems. Depending on their location and their physical site, some hobs can even host business ecosystems.

Business ecosystems both improve resource efficiency and contribute to growing the economy by turning waste into new products. The value hubs can produce through innovations like business ecosystems can promote business and job growth, providing substantial, if diffuse, returns.

Lauri Hetemaki et al., "Leading the Way to a European Circular Bioeconomy Strategy," From Science to Policy, n.d., https://www.efi.int/sites/default/files/files/publication-bank/2018/efi_fstp_5_2017.pdf, p.30.

Text Box 7. Innovation: Business Ecosystems

LEGITIMACY AND SECURITY

Related to product development, hubs can also provide new circular business models with legitimacy and security.

A challenge facing the growth of a circular bioeconomy is the high degree of risk associated with the growth of this sector. The circular economy concept is rooted in a historical precedent across

societies of **innovatively valorising waste**. However, as waste management and resource extraction capacity improved consumption became more standardly linear and circularity became seen as a new concept. New business innovations can be seen as risky and prone to failure, so this perception of circularity as a new concept associates it with risk.[38] That said, risk does not necessarily indicate a bad investment and failures are not meaningless. Investing in even "failed" circular bioeconomy projects can have tremendous societal value, if it successfully highlights areas for growth and indicates what is needed to enable success in the future.[39] Hubs are a critically important part of this learning process. By providing resources for entrepreneurs and inventors to develop and pilot circular bioeconomy products and processes, they lend these individuals **legitimacy**, provide investors with a measure of **certainty** in their ability to produce, and reduce the overall amount of start-up capital required. This reduction and sharing of risk can help secure funding for innovative projects, which might have struggled finding funding independently.[40]

Nested under product design, this value stream produces wider financial returns through the development of new business, high-value jobs, and opportunities. It encourages economic growth in an environmentally sustainable way, and the value of maintained resources and new skilled jobs in the circular economy demonstrates how the provision of legitimacy and security to the burgeoning circular bioeconomy can return more than is invested across a national economy. [41]

OPERATIONS SUPPORT AND COMMUNITY OF PRACTICE CREATION

Implementing the circular bioeconomy requires more than just scientific knowledge, or experience with material engineering - **operational expertise** in areas like **law**, regulations, business acumen, marketing, **management**, IP, and **communication** is also required to turn a scientific innovation into a new product or business.[42] By providing insight on strategic communications, intellectual property law, and other operational areas hubs can reduce the barrier to success that new ideas face when trying to enter the mainstream economy. [43] Hubs also provide operational support by serving as a relationship broker and building a community of practice around the circular bioeconomy. These connections support the operations of organisations and inventors by building relationships that can secure investment, mentorships, and more.

This operational support for circular bioeconomy innovation gives individuals and organisations that might not have the tools to participate competitively in the market the resources they need to engage more fully in this sector. Financially, the return of this investment in building circular capacity can be seen beyond the value of new business and jobs to the value of increased engagement across different communities that may not have been able to access financing and marketing opportunities in the circular bioeconomy sector. **This new source of knowledge**, **experience**, and **demand to change markets** can address system inequities while promoting circularity.

CONNECTING WITH LOCAL AND INDIGENOUS BUSINESSES

The value hubs produce can support in social circular economy organisations, organisations working to achieve social goals and with an interest in circular, to maximise their impact. Hub investment in supporting circularly at organisations that are driven by a social mission, and are designed around increasing public good, can help achieve these meaningful social objectives and address issues like inequity, which is a social concern and comes with its own financial costs.[44]

Hubs providing particular support for increasing circularity within social enterprises operating in the bioeconomy field increase their value by adding a social dimension to their work. They transform the circular economy into a way of connecting with local and indigenous business, addressing inequality, accessing marginalised communities, and responding to other social challenges.

The concept of a social circular economy captures this idea of using a circular bioeconomy hub to **create value that is social**, as well as **financial** and **environmental**. Specifically, "*the social circular economy unites the circular economy and social enterprise concepts to deliver benefits for people, planet and profit. It allows a fully systemic view by drawing on the environmental principles of the circular economy and the societal vision of social enterprise, both of which are underpinned by a pursuit for economic prosperity*."[46] It is important to keep in mind that **the bioeconomy is not inherently sustainable**. Concepts like social enterprise and circularity need to be explicitly articulated to make sure it is socially and environmentally viable in the long-term.[47]

Figure 4: Circular Economy Visualisation[45]

3. HOW DO YOU DESIGN THE PHYSICAL AND SOCIAL STRUCTURE OF A HUB?

The conscious creation of ecosystems of innovation in collaborative spaces - like hubs, FabLabs, and makerspaces - is increasingly being seen ***as central to facilitating entrepreneurship and pioneering new designs and products****.*[48] *The physical and social structures of such spaces are critical. This chapter provides high-level insights into hub design that can inform Scion's social and physical design for Te Ōhanga, focussed particularly on the following areas:*

- *Innovator Work Spaces: Innovator workspaces should be designed to reflect the type of openness the hub encourages and the determined role for the shared space. The space should have generic working spaces designed to accommodate all interested stakeholders to encourage collaboration and support innovators in adopting circular processes and identifying circular product opportunities. Curating an online platform with technical guidance documents, discussion platforms, and educational resource is also likely to increase the hub's reach and accessibility.*
- *Publicly Accessible Spaces and Outreach Facilities: Incorporating publicly accessible spaces for community events into hub design, and hosting site tours, can increase the overall effectiveness of a hub and encourage diverse participation. Hubs that engage with the public are often adding local value, increasing awareness of circular economy practices, and therefore cultivating a market for new products they design.*
- *Pilot Facilities, Equipment, and Green Design: An innovation hub might start with basic accessible "GreenLab equipment", like Biochemistry laboratory benches, and piloting capacity can be expanded based on the needs of the hub community. When possible, hubs should reflect in-house circularity.*
- *Context and Location Driven Design: Effective hubs capitalise on the facilities, resources, and waste streams from neighbouring organisations to minimise expense and waste.*
- *Public Policies that Enable Hub Success: Hub success can, to a certain degree, be defined by the micro-, meso-, and macro- level policies influencing their operating environment. Hubs should increase awareness of policy opportunities and challenges for participating individuals and organisations.*
- *Inclusive Social Structures that Encourage Diverse Participation: Hubs can benefit from the variety of ideas diverse participation brings. Reducing barriers to accessing the hub, creating a space that is open to those with varied levels of technical experience, and incorporating multiple views on circularity into the hub's missions can create a hub that is socially structured to encourage diverse participation.*

DESIGNING HUB FACILITIES

INNOVATOR WORKSPACE

The design of a workspace within a collaborative innovation setting should reflect the way in which the hub intends to facilitate innovation (Figure 4) and the types of openness it will deploy. Collaborative spaces often rely on policies about open participation to facilitate the sharing of ideas like **open governance** (decentralised self-management), **open access** (hub is accessible to all), **open source technologies** (use and development of open source technologies), **open business**

model (value of creation in the space are shared), and **open production** (collaborative production processes). [49] For example, if the proposed Scion hub were to be an "Innovation Intermediary" with a focus on open access, it would be strategic to design the hub to have formal conference rooms for professional collaboration, as well as more informal kitchen or café space for public engagement.

	The role of shared workspaces	Key papers
Innovation Hub	Focus on community members to: • Share knowledge • Foster innovation and entrepreneurship • Build a network with and between professionals and firms	(Vrgovic et al., 2012; Bell et al., 2014; Sanderson, 2015)
Innovation Intermediary	Focus on what spaces can offer in relation to: • Private sector: a place for technology diffusion such as Internet of Things, open hardware, 3D printing, etc. • Public sector: a place for fostering citizen engagement usually by co-running events or projects such as open government data competitions	(Bakici et al., 2013; Capdevila, 2014; Eskelinen et al., 2015; Kim & Shin, 2016)
Ecosystem Participant	Refers to the broad network that the shared workspaces are building: • Inter-workshop networks such as the FabLab global ecosystem • Networks with other entrepreneurs and manufacturers in the local region	(Frolund et al., 2014; Ruberto, 2015; Osunyomi et al., 2016)

Figure 5. Workspace Roles[1]

Given the variety of clients a hub can potentially service, and the multiple objectives most hubs have, design should prioritise versatility and multiuse spaces. For example, having open offices with meeting rooms that can be converted to conference space for professional events. A hub could include spaces ranging from a **community garden** to a **woodwork shed** or a **repair café** (an area in the hub where common items, anything from smartphones to bicycles depending on the expertise available, can be brought for repair). This could be an opportunity for community engagement and skills work for hub participants. The nature of these services will depend on an innovative workspace's mission and participants, but a space that can uniquely use facilities to service multiple stakeholders will be able to reach a wide audience and maximise the impact of their efforts.

PUBLIC SPACES

Transitioning to a more circular economy will require top-down, government-led, initiatives as well as bottom-up support for circularity.[50] If hubs include outreach and public interaction within their mission, they can make considerable contributions to cultivating bottom-up support. In terms of hub design, possible public outreach should be considered from the beginning of the planning process. The facilities required will depend on the kinds of outreach the hub will conduct, but examples of outreach activities can be seen in the landscape analysis, and a particular example is the work of **Plant Chicago** (Text Box 8). During hub design it is also worth considering how the hub can use an online presence to share information on circular practices the

Plant Chicago

Plant Chicago the Non-Profit

Plant Chicago is a non-profit founded by a social enterprise that is dedicated to modeling ecologically responsible urban development.[1] In order to encourage community engagement with circular practice and planetary health, Plant Chicago hosts a farmers market and offers classes on everything from aquaponics to local circular economy principles.[2]

Plant Chicago the Site

Plant Chicago is located within a retired meat packing facility, the refurbished 93,500 sq. ft space hosts more than a dozen small businesses. The space is dedicated to in-house circularity, and working to use an anaerobic digester to turn waste into energy and other valuable outputs.[3]

1. "Research, News + Events," Plant Chicago, accessed March 5, 2019, https://plantchicago.org/news-events/.
2. "Who We Are," Plant Chicago, accessed March 5, 2019, https://plantchicago.org/who-we-are/.
3. "The Plant," Bubbly Dynamics LLC, accessed March 5,

Text Box 8. Case Study: Plant Chicago

public can engage with – like composting and other methods for valorising agricultural waste – and advertise public events. This kind of engagement does require building the website infrastructure to inform and involve interested parties, but **online collaboration** is seen as a way of encouraging group innovation in the 21st century.[51]

PILOT FACILITIES AND GREEN DESIGN

Providing the technology needed for developing products and testing innovation designs is a significant contribution that hubs can make to developing the circular economy, and it is particularly important in the case of the circular bioeconomy. Within the private sector, and particularly large enterprises, interesting new ideas may be overlooked on the grounds of not having the time or money to invest in piloting. If entrepreneurs can produce and pilot their promising innovations, they are likely to leverage the support and investment of larger industrial players. The production of prototypes can also accelerate the "idea generation" process and increase the likelihood of the designer's product and core product values receiving resources and attention.[52] For a new hub, it is best to start by providing basic equipment and space. Depending on the hubs focus this might include equipment such as power tools, a chemical lab space with basic lab equipment, or 3D printers. However, depending on the participants in the hub these basic facilities may not be sufficient - during the planning phase space should be set aside to allow for the future development of a more capital-intensive green chemistry and biorefinery facilities once the hub's value has been demonstrated.

When purchasing equipment is it important to look for "green lab equipment". Lab research can have a significant environmental impact that should be mitigated in a hub when possible. [53] Universities and research institutes can often provide guidance on how to reduce the environmental impact of laboratories. One such example is **Cambridge's Green Lab project**. When hubs demonstrate a commitment to circularity in their design and operations, they confirm their values and create an opportunity for hub users to observe and test circular systems. Hubs may also want to consider reusing or repurposing older equipment that larger companies may be willing to donate. When possible, hubs should encourage in-house circularity through processes like **food waste processing** (vermicomposting or anaerobic digestion, soil-based or water-based agriculture as sinks for compost and digestate, grey-water recycling, urine-diverting toilets and struvite reactors and tumble composters, vertical biofilters for greywater, heat-pumps, and more) and **energy productivity** (solar roofs and energy efficient building design such as Passivhaus). **The Plant Chicago** provides an example of building in-house circularity (Text Box 8).

Throughout the process of equipment selection, it is critical to consider inclusivity and selecting instruments that ensure the ability of participation for individuals who lack a technical background. 3D printers are an example of an accessible piece of equipment, in part because they are

associated with open source designs, and can connect the accessible **Internet of Things** to the development of physical products.[54]

CAPITALISING ON THE HUB'S CONTEXT AND LOCATION

WORKING WITH NEIGHBOURING ORGANISATIONS

In order for hubs to maximise the efficient use of resources, they can capitalise on the resources around them and design the hub specifically to suit its context. This will usually require surveying the hub site, evaluating the potential synergies with neighbouring facilities, and conducting a local community review prior to hub design. One important possible synergy to consider is how the hub could use and repurpose neighbouring organisations' waste streams and if there would be any potential to use neighbouring production capacity if it is greater than the hub's. Hubs can also identify ways in which participants in the hub could find innovative solutions to neighbouring organisations' challenges, particularly in relation to circularity. One example of designing to maximise synergies between different organisations operating in one site is the creation of eco-industrial parks. An example would be the Ulsan Mipo-Onsan Industrial complex in South Korea. The Ulsan complex used to be a conventional industrial complex. It was designed to include whole supply chains, not to manage by-products and waste streams. [55] In 2007 the **Ulsan Eco-Industrial Park Centre** was established and it worked to implement industrial symbiosis in Ulsan complex, bringing together individuals and organisations with diverse goals to convert the park to an eco-industrial model.[56]

Peer Production

Peer Production is an interpretation of co-design that emphasises open-source software and valuing collaboration and mutual cooperation over efficiency and profit.

It is a co-working philosophy that is being tested in innovation spaces and can be used to emphasise sharing and co-production in future hubs.

Ryoung Seo Zindy and Richard Heeks, "Researching the Emergence of 3D Printing, Makerspaces, Hackerspaces and FabLabs in the Global South: A Scoping Review and Research Agenda on Digital Innovation and Fabrication Networks," EJISDC: The Electronic Journal on Information Systems in Developing Countries, no. 80 (2017), p. 11.

Text Box 9. Innovation: Peer Production

CAPITALISING ON THE POLICY ENVIRONMENT

It should be noted that the effectiveness of a circular bioeconomy hub will be at least partially decided by the policy environment it is operating in, and encouraging the creation of, or capitalising on existing, enabling policy will help hubs develop. Polices that enable the circular economy across sectors can be **regulatory** (like mandating producer responsibilities, setting standards, and creating product certifications), **economic** (creating financial assessments, direct funding, procurement practices), **research and development** (grants for piloting activities, creating research and development infrastructure), **information and network support** (trainings, networking promotion supporting public private partnerships), and **voluntary measures** (performance labels and product guarantees).[57] Green public procurement is an example of an

enabling policy that hubs could use to help launch small businesses and entrepreneurs. **Green Public Procurement** is defined by the European Union as "*a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life-cycle when compared to goods, services and works with the same primary function that would otherwise be procured.*" [58] This type of procurement increases the demand for circular goods, and, in a country like New Zealand where more than 30% of the general government expenditure is procurement spending, it can have a significant impact.[59]

CREATING AN INCLUSIVE AND INNOVATIVE SOCIAL SPACE AND ENGAGING INDIGENOUS KNOWLEDGE AND PARTICIPATION

Hubs thrive on diversity in participation and ideas. Creating a context where that diversity flourishes requires active intervention and intentional planning. Ensuring inclusive innovation requires inclusivity from the very beginning; marginalised populations need to be included from hub design through product development and the new innovations or products being produced by a hub must meet the needs of the society as a whole and marginalised communities in particular.[60] Two ways of ensuring inclusion are incorporating the values of historically marginalised voices, such as indigenous populations, in the articulation of The Hub's purpose and reducing barriers to participation that might discourage more marginalised groups from participating.

In the New Zealand context, one way of encouraging Maori participation is by including their perspective in hub design. Ideally this would involve a consultative co-design process with local communities. One part of this design could be including the Maori concept of wellbeing and **te ao Maori,** which values land beyond its economic potential and embraces the idea that equitable access to resource and opportunities is a cornerstone of wellbeing.[61]

An example of reducing barriers to marginalised communities participating in hubs, or innovation spaces, would be the use of **makerspaces**, which are spaces meant to enable those with a limited technical background to take part in smaller scale, do-it-yourself style, projects. [62] The "maker movement", described as "the increase in do-it-yourself and do-it-together projects and is related closely to the hacker ethic of sharing, collaboration, and learning through deconstruction and reconstruction," [63] is inherently inclusive and accessible regardless of experience level. This accessibility ensures that marginalised communities that may not have access to technical training can still participate in hub spaces.

Consciously creating an inclusive space within Scion's proposed hub will be critical to its success and depend in part on careful analysis of the values and experience of generally marginalised communities.

4. WHAT BIOECONOMY TECHNOLOGY AND FORESTRY INNOVATIONS CAN THE HUB CAPITALISE ON?

As a research institute specialising in science and technology development related to forestry, wood products, wood-derived materials, and other biomaterial sectors, Scion is uniquely placed to capitalise on existing knowledge, infrastructure and resources in the creation of its new circular bioeconomy hub. This is particularly true of its existing work with Maori partners, but also extends to the potential resources currently contained in its waste streams, natural capital, and innovations in sustainable technologies relating to packaging and energy. Scion can improve on technology for, and expand the use of, forestry by-products, as well as encourage innovative uses of the resource. Scion already has world-leading research underway in a number of key areas, for which the hub can provide a new forum for development, testing, and implementation. These include:

- *Innovation in energy and fuel technologies such as Gasification and Pyrolysis*
- *Innovations in packaging such as use of lignin and biochar additives, Fungal Mycelium, and forestry waste*
- *Non-Timber Forest products such as fungi and ginseng*

CAPITALISING ON FORESTRY WASTE STREAMS

The Hub would be well placed to capitalise on forestry waste streams, and to expand this to explore routes for recycling municipal and construction timber waste and other waste biomass. An area of focus for Te Ōhanga might be small-scale onsite processing of **hard to access waste** left at felling sites and currently overlooked in waste reuse. By 2020, an estimated 6.7 million m^3 of forestry by-products potentially suitable for new uses are calculated to be available in New Zealand, much of it in the forestry heartlands of the North Island. [64] This represents a considerable potential circular economy resource that could both add economic value and improve the sustainability of the forestry sector. While some of it is already used in Rotorua and around the world in the form of biomass for low-grade energy generation, there is room for expansion and improvements to the technology. Innovative new uses are also being developed for this resource, which could be a focus for users of Te Ōhanga.

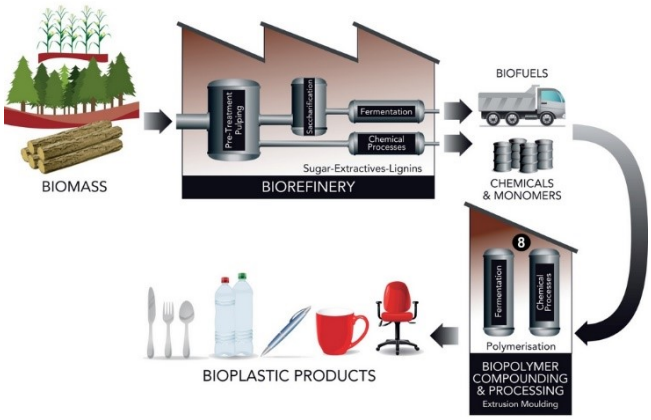


Figure 5. Biorefineries and Biomaterials[65]

The main constituent of forestry waste is low-grade timber not suitable for traditional timber products such as bark, sawdust, shavings, and offcuts,[66] but by-products are also produced in the processing of pulps and fibres for paper and construction materials, all of which represent **potential resources** in a circular economy.[67] Approximately 4% of timber is wasted during processing,[68] but this value does not include non-stem waste left at the felling site, for which new onsite technologies urgently need to be developed if forestry waste streams are to be fully capitalised on.

As well as forestry waste streams, The Hub could also capitalise on expertise and resources onsite to broaden research into **wider bio-waste recycling innovations**. Large amounts of biomass and waste timber are generated in the agricultural and construction industries and municipal waste for example,[69] and their re-use is often complicated by the various processing and treatments they may have been subject to during manufacturing. In the UK, a DEFRA report[70] suggested that creating regional hubs for the collection and processing of timber from small businesses would be extremely beneficial both in terms of the amount of waste wood that could be recycled and the economic benefits it could bring local authorities. As a regional hub, this is also something that could be explored by Te Ōhanga.

INNOVATING IN THE ENERGY AND FUEL SECTORS

Scion has an extensive research programme for the processing of biomass for energy and fuels, and as a central innovation hub, Te Ōhanga can help support the development of these and any other innovative by-products.

Materiom

Materion is a materials experimentation open platform supporting the circular economy. Materiom is staffed by an interdisciplinary team of designers, material scientists and ecologists collaborating to "unlock" materials for the circular economy that are regenerative by design. They use open source data and the varied expertise of a multi-talented group of designers and researchers to produce innovative new materials, often from waste streams and biomass.

It is an open platform source that may be of use to participants at Te Ōhanga.

"About" Materiom, accessed March 21, 2019, https://materiom.org/about

Text Box 10. Innovation: Materiom

Biomass from forestry waste streams has been calculated as having the potential to provide around 10% of New Zealand's current energy demand,[71] but that figure rises to more than 65% for Rotorua.[72] This calculation was made based on existing biomass technology providing low-grade heat energy, but innovations could potentially improve the efficiency and increase this estimate or render forest waste usable in other forms of energy production. The International Energy Agency [73] describes **Modern Bioenergy**

Technologies as the fastest growing Renewable Energy Sector of the next five years, accounting for around 50% of renewable energy. Crucially, modern bioenergy technologies can be used in the transport sector, which traditional biomass cannot contribute to and represents the largest single energy consumer in New Zealand.[74]

Scion has developed a **pre-treatment process for woody biomass** that improves the enzymatic conversion of softwoods into biofuels such as ethanol. Similarly, in Spain, anaerobic reactors are being used to transform organic materials at **Saica Paper Mill** into bio-gas, which can then be used for power generation.[75]

One of the most promising technologies for increased biomass energy efficiency is Gasification and the related process of Pyrolysis. **Gasification** is a means of converting solid biomass such as forestry waste into a gas stream for other uses including energy production. In New Zealand it has considerable potential as a source of heat, electricity, and materials for liquid biofuel synthesis.[76] Finnish firm **VTT** have developed a new gasification-based technique for turning forestry waste biomass into liquid fuels for transport and other biochemicals, reducing carbon dioxide emissions by around 90% of those of fossil fuels.[77]

Pyrolysis is the thermal decomposition of biomass in oxygen-free conditions and forms the first step in Gasification. It produces a valuable by-product in the form of biochar, which can be used in **biomaterials** (see below), but also in **filtration**, **soil improvement** and **carbon sequestration**.[78] This last use could potentially lead to carbon negative biofuels. Pyrolysis can also be undertaken at a relatively small-scale and in difficult to access terrains and localities like those found in forestry plantations. Products can then be shipped to larger refineries for further processing.

Scion already has active research programmes for these technologies, and the Te Ōhanga hub will offer the opportunity to develop them further, with the potential for a particular focus on small-scale pre-treatment of felling-site forestry biomass, which can then be transported more easily for further refinement at larger facilities.

INNOVATING IN THE PACKAGING & BIOMATERIALS SECTORS

The processing of forestry waste biomass for fuels also presents the opportunity to produce **secondary products** like biopolymers, which can be used to synthesise bioplastics and other biomaterials for packaging.

Packaging is an integral part of the global economy but presents a major obstacle to circular economy models because of difficulties in recycling and re-using materials, especially plastics. A number of organisations globally are working to overcome this challenge by replacing plastics with biomaterials, which can be made with non-fossil fuel, biodegradable materials. These can often be best sourced from agricultural and forestry waste streams, tying into a circular bioeconomy model.

Ecovative Design

The US biomaterials firm Ecovative uses Fungal Mycelium to produce building, clothing, and packaging biomaterials; replacing plastics and other non-biodegradable, energy-intense materials in manufacturing processes.

Specifically, their MycoComposite material binds organic agricultural and forestry waste into construction and packaging products, such as the wine bottle container depicted in the image below. Their Dutch partner, CNC Exotic Mushrooms, distributes the spores within the EU to companies and initiatives wishing to develop similar ideas. The large biomass resource available to Te Ōhanga, makes this an exciting potential model.

"Ecovative Design," Ecovative Design, accessed March 21, 2019, https://ecovativedesign.com/.

Text Box 11. Case Study: Ecoative Design

A leading example is the Norwegian company **Borregaard**, which has one of the most developed biorefineries worldwide, producing products for industries as diverse as construction, hygiene and cosmetics filtration, textiles, paints, and foods. Their lignin additives are especially valuable in reducing the ecological impact of concrete through improved water and energy efficiency.[79] Meanwhile, Swedish packaging firm **Tetrapak** are working with US partners to replace the HDPE plastics in their cartons with ones made from forestry waste.[80] This has the advantage over other plant-based biodegradable plastics using feedstocks like sugar cane in that it does not require diverting agricultural land from food production. Biochar has also been explored as a potential additive to improve these bio-composite materials.[81]

Te Ōhanga can provide space for organisations looking to develop these secondary biomaterials produced in the refining of biomass for fuels into innovative solutions to the global plastic packaging crisis.

DIVERSIFYING FORESTRY PRODUCTS (NON-TIMBER FOREST PRODUCTS)

Te Ōhanga's greatest physical resource will be its proximity to New Zealand's forestry heartlands and industry, and as well as waste biomass, a number of other **underutilised resources** are ripe for innovative exploration within this sector. Traditionally forestry has been a single product industry, with potential secondary resources under-developed or unexplored. **Non-Timber Forest Products** (NTFPs) offer huge potential to improve the economics and sustainability of forestry by diversifying forest management strategies and making use of waste streams or underutilised space like the forest floor. NTFPs are often associated with indigenous knowledge and traditional practice.[82]

Ginseng (*Panax ginseng*) is a popular NTFP associated with health benefits, especially in China, and increasingly worldwide. Forestry organisations in the USA have developed a thriving export industry to China and Korea,[83] and the cultivation of the crop in New Zealand's North Island appears promising. Scion has led the way partnering with Maori Forestry group **Maraeroa C Incorporation**. Scion calculates it could add 154-188% value

per hectare of planted forest compared to timber-only forestry.[84] Scion is also working with **Maori Partners Tarawera Land Company** to assess other potential NTFP crops such as the native Kawakawa (*Piper excelsum*) for commercial viability. These projects are a valuable example of adding layers to a circular bioeconomy model, maximising the potential of an under-utilised resource. This model could be further developed and disseminated to other Forestry partners through the hub provided by Te Ōhanga.

Fungi and edible mushrooms are another popular NTFP. Mirroring Ginseng, forestry plantations in the North West of the United States of America have developed an export industry to Japan of the fungal delicacy **Matsutake** (*Tricholoma matsutake)*, which thrives in recently logged pine forests.[85] In Central Europe, research was undertaken into the use of forestry waste and low-quality timber as a substrate for the cultivation of edible oyster mushrooms (*Pleurotus ostreatus)*.[86] This could be particularly valuable for the use of forestry waste that is hard to remove for processing due to inaccessible terrain, which is likely to be a substantial portion of the total.[87] Alternatively, more accessible forestry waste could be processed into substrates offsite and either used to develop mushroom cultivation in-house or sold to other commercial enterprises, like the model adopted by Dutch company **CNC Exotic Mushrooms** (see Text Box 11).

ENCOURAGING SUSTAINABLE & NATIVE FORESTRY

To meet its bioenergy goals, New Zealand will need to use new forestry as well as existing waste biomass in energy production.[88] As such, in addition to the resources that could potentially be generated from forestry waste streams, Te Ōhanga could also capitalise on Scion's **existing expertise in sustainable forestry**, especially in developing the propagation and cultivation of native timber species. The Minginui Nursery project was developed in partnership with local Maori partners Ngati Whare, leading to the commercialisation of production for four iconic native species: Rimu, Kahikatea, Totara and Miro.[89]

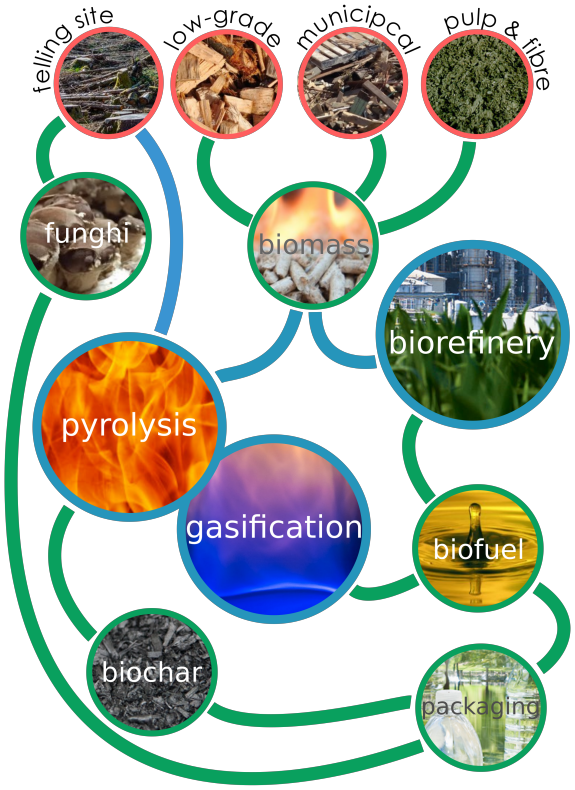


Figure 6. Material and Product Relationships

5. HOW WILL THE HUB PARTNER WITH OTHER ORGANISATIONS, INITIATIVES, AND ACTORS?

An effective circular economy hub operates across sectors, organisations, communities, and value chains. The expansive reach and vision of these hubs requires partnerships with various stakeholders including business and industry, research organisations, civil society and the general public, and central and local governments. Partnerships that will be particularly important for the Te Ōhanga hub are those with the private sector and indigenous communities, as a subset of the general public.

In terms of private sector partnerships, partnerships with local SMEs are important to producing local bioeconomy innovation. Hubs often support local SMEs by facilitating their partnerships with larger industry actors.

In the New Zealand context, working with Maori partners be essential to fostering inclusive innovation at the Te Ōhanga hub. Within the context of circular economy spaces, strong partnerships with indigenous communities can be encouraged by consultative design and position creation, inclusive hub management, and continual evaluation of the progress and equity of these partnerships. In pursuing its goal of generating local value, Te Ōhanga is likely to create local benefits such as income and job generation, social integration, awareness raising and education, and the promotion of local resource ownership and production.

IDENTIFYING KEY STAKEHOLDERS

How Te Ōhanga participates in, and facilitates partnerships will be determined by which possible stakeholders it engages with. The key stakeholders commonly involved with circular economy hubs can be categorised as follows:

Business and Industry: The private sector is a critical stakeholder for all circular economy undertakings. Within the private sector there is considerable diversity in terms of **business size**, **sector, organisational structure**, and **mission** - depending on these factors business may be advocates or supporters of a circular hub or they may be direct participants in the hub. Buy-in from private sector participants, and providers of funding, resources, and connections, will impact a hub's ability to meet its objectives.

Research Organisations: **Academic institutions**, **think-tanks**, and other **research focused organisations** interact with hubs as possible participants and as important providers of information, techniques, and materials that the hub will share with entrepreneurs and innovators.

Civil Society and the General Public: Civil society organisations, from **non-profit advocacy groups** to **religious organisations** and **trade unions**, can be important allies and advocates for hubs and the circular economy overall. Of course, the hub will also be supported by, and look to influence and support, members of the general public. It is important to recognise, however, that the public is not a single homogenous group, but rather **encompasses considerable diversity**, interests, and expertise. Hubs may wish to specifically engage with certain subsets of the general public and

should plan their programming accordingly.

Central and Local Government: Central government actors interact extensively with all circular economy projects: they serve as funders, create the **regulatory context**, encourage and facilitate **programme participation**, facilitate **connections**, and **support the provision of physical and intellectual resources** to the hub.

While Te Ōhanga will likely interact with all of the stakeholder types listed above, this chapter will focus on partnering with Maori communities, and business and industry.

ENSURING PARTICIPATION BY INDIGENOUS PARTNERS

An explicit aim of the Te Ōhanga hub is to engage Maori stakeholders in the circular economy. In order to **foster partnerships** with indigenous communities the hub can take certain proactive steps, starting during the design and start-up phase.

Starting with hub design, Scion can draw on existing relationship with Maori partners from previous projects to collect input on what research projects, educational programming, and employment opportunities may be of specific interest or benefit. The hub can also be designed to include internships and fellowships dedicated to collecting and building on **indigenous knowledge** of circular, waste valorisation processes. This early outreach can often be effectively conducted using **online platforms**, as well as **focus groups** and **local meetings**. For active and operational hubs, tactics for establishing and maintaining partnerships with indigenous communities include ensuring diverse and indigenous participation in hub management and providing training on cross-cultural communication to staff. Staff trainings to increase awareness of cultural differences and indigenous values should be inclusive, delivered by external parties, and involve all participants in the hub, from researchers to leadership.[90]

In order to maintain partnerships with local indigenous communities, and in fact with any stakeholder, it is useful to consistently reflect on and evaluate the partnerships. It is critical to create opportunities for all partners to provide feedback.

Triple Helix Partnerships

Triple helix partnerships are considered to be those that include the three large stakeholders in the bioeconomy: business, government, and research/universities. The inclusion of triple helix partnerships in organisations, like boards, that oversee circular bioeconomy projects has been known to bring together important, diverse viewpoints when pursuing project goals.

An example of successfully mobilising a triple helix partnership is the Netherlands' Biobased Delta Initiative (BbD). Established by provincial authorities, BbD is a project focused on encouraging the bio-based economy and governed by a board of companies focused on producing development projects like biorefineries. BbD has sub-clusters focused on different topics from packaging to green building materials, which foster triple helix partnerships to create networks, organise events, and support biobased business cases. It is a strong example of good public and private engagement in a circular bioeconomy initiative.

David Charles et al., "Case Studies of Regional Bioeconomy Strategies Across Europe" (BioSTEP - The European Union, August 2016), http://www.bio-step.eu/fileadmin/BioSTEP/Bio_documents/BioSTEP_D3.2_Case_studies_of_regional_strategies.pdf, p. 12, 17, 20.

Text Box 12. Innovation: Triple Helix Partnerships

With the concept of social inclusivity as central to Te Ōhanga, the hub emphasises adding local value and becoming a collaborative space. By cooperating with Maori partners and drawing on indigenous knowledge, the hub seeks to maximise the local social, economic, and environmental value created.

There are likely to be two broadly defined categories of local value: the wider social value and the more specific indigenous value. As addressed previously, Te Ōhanga is expected to generate local jobs and income, contributing to localised growth. Furthermore, and more closely related to indigenous peoples, the hub will promote local resource ownership and production. The presence of the hub in Rotorua will also hold a key position in raising awareness on circular economy practices and the wider issues they address. As a **community space**, the hub also has the potential to create a sense of community and foster local, social interaction[91]. Furthermore, the integration and awareness of indigenous knowledge in the initial conceptualisation and designing of Te Ōhanga is likely to aid the integration of this knowledge into The Hub's operations[92]. An example of a Scion initiative that has already generated local value is the ginseng project, discussed in more detail in Chapter 4.

OISD has been unable to find many examples of international circular economy hubs focused specifically on indigenous peoples. The Te Ōhanga hub and New Zealand will be **leaders in the field** in this regard. Additionally, though this scholarship and research is beyond the scope of the report, OISD recognises that the appropriate partnership between government and indigenous people will form a critical part of the design and function of the Te Ōhanga hub.

Para Kore

The term Para Kore means zero waste, and the Para Kore programme works with marae towards a zero waste society by encouraging and institutionalizing increased reuse, recycling, and composting. This programme has an extensive network, considerable engagement from Maori communities, and has diverted form than 280 tonnes of waste from landfills.

A critical strategy for Te Ōhanga will be partnering with, and learning from, these kinds of programmes that are based in Maori values and communities and have already had some success. They can be a great source of learning, and the hub can support these important initiatives and efforts.

Parakore NZ. "What Is Para Kore?," Accessed April 2, 2019, http://www.parakore.maori.nz/para-kore/what-is-para-kore/.

Text Box 13. Case Study: Para Kore

PARTNERING WITH THE PRIVATE SECTOR

Private sector cooperation, particularly with the **forestry and agriculture** sectors, is crucial to supporting research into circular bioeconomy methods, and to ensure acceptance and implementation of new developments, technologies, and processes.

While partnerships with large businesses and leaders in target sectors will provide Te Ōhanga with key inputs and an audience, educating SMEs and enabling their involvement with the circular bioeconomy will also play a role in achieving the Hub's goals. As discussed in Chapter 2, SME growth stimulates overall economic growth, and by supporting

local SMEs The Hub will be supporting organisations that are small enough to be connected with the local economics, needs, and values while being established enough to interface with local authorities and larger industry actors.[93]

GreenCentreCanada

GreenCentreCanada is a private sector organisation, and as a company it is an example of facilitating the link between research and commercial opportunities to promote the circular economy.

Specifically, by capitalising on the knowledge of experts in industry, commercialization and management, and chemistry, GreenCentreCanada Centre can offer assessments and analysis of new technologies, intellectual property, markets, scale-up potential, business plans, and marketing.

"Academia," GreenCentre Canada, accessed March 21, 2019, https://www.greencentrecanada.com/working-with-us/academia/.

Text Box 14. Case Study: GreenCentreCanada

A part of a hub's role in **supporting SMEs** will be facilitating partnerships between SMEs as well as SMEs and larger businesses with shared interests. Within a circular economy, economic growth is generated from circulating existing materials, instead of extracting more raw materials in the current linear economic model. As such, organisations need to collaborate to optimise the efficiency of materials used within every step of the value chain. Collaboration between organisations working across sectors is also crucial.[94] By facilitating partnerships within value chains and across sectors a hub helps highlight waste streams that can be valorised.

As a facilitator and host of collaborative space, the hub will also partner with the private sector by connecting industry actors with other stakeholders, like civil society and research institutions, to identify overlapping interests, and foster exchanges of information and resources.

6. WHAT CONTRIBUTIONS CAN THE HUB MAKE AT THE NATIONAL AND INTERNATIONAL LEVEL?

Scion's proposed Te Ōhanga hub will contribute to the achievement of New Zealand's national and international targets as set in its Zero Carbon Act 2050, 2010 Waste Strategy, and Nationally Determined Contribution (NDC) under the Paris Agreement. The hub can be designed to maximise its socioeconomic and environmental benefit by creating a network with other potential hubs in the Pacific, connecting with international indigenous communities, and providing a space for national actors to interact. The hub can also provide practical support to businesses facing difficulties reducing emissions and can aid a broader policy shift from waste management to circular economics, with a focus on well-being.

A circular bioeconomy hub such as Te Ōhanga can create the **socioeconomic** and **environmental benefits** found to be attributed to circular economy. The innovative solutions generated at such a hub can lead to gains in resource efficiency, which translate into net material savings [95] and reductions in carbon emissions. [96] By virtue of being regenerative by design, these circular solutions and technologies can increase social capital and reduce negative externalities for society, such as water, air and soil pollution, [97] and thus create resilient living systems. [98] However, rather than simply relying on the derived benefits of circular economy, it is essential to set up the Te Ōhanga hub in such a way as to maximise its potential contributions to New Zealand and the international community.

NATIONAL CONTRIBUTIONS

The New Zealand government is currently drafting *Zero Carbon Act 2050* as a cornerstone for New Zealand's legislation over emissions reduction. The target to reduce emissions by 50% below 1990 levels by 2050 was set in 2011, and since the 2015 Paris Agreement, New Zealand has committed to setting targets that are increasingly ambitious. [99] Reaching these targets will require significant action by both the public and private sector. In achieving these targets, there is recognition of the importance of protecting local investment and employment and not simply transferring emissions to other countries with less developed emissions regimes. [100] In this context of **ambitious climate leadership**, there is an opportunity for Te Ōhanga to provide regulatory support to businesses. Te Ōhanga can be a central contact point to help ensure that climate-exposed businesses can successfully adapt and grow their businesses while also supporting the achievement of national targets set out in the Zero Carbon Act.

Te Ōhanga can also contribute to the widespread adoption of New Zealand's 2010 Waste Strategy. While the first goal of the strategy is to reduce the harmful effects of waste, the second goal is to improve the efficiency of resource use, [101] which is particularly relevant to the aims of the bioeconomy hub. Te Ōhanga would directly contribute to the strategy's aspiration of **decoupling waste generation**

from economic growth. The strategy lists the actors involved – central government, regional councils and territorial authorities, waste industry, businesses and communities – and how each can take responsibility in the management and minimisation of waste.[102] Te Ōhanga can build on this by encouraging these actors to interact, providing a space and means for these actors' implementation activities to link up. Moreover, just as the EU recently saw a shift from a waste management approach to a circular economy approach in its mainstream policy agenda,[103] so too can Te Ōhanga actively guide New Zealand's policy evolution towards a circular economy.

Many of the socioeconomic benefits of the envisioned hub have already been touched upon in the business model chapter of this report, such as implications on job growth and the maintenance and improvements in value streams. Getting all societal actors to be involved, to **collaborate**, **connect** and **exchange** is key in enabling a transition towards a circular economy.[104] This would ensure that the circular bioeconomy hub's activities expand within the context of a well-being economy (see Text Box 15). By contributing to New Zealand's planned low carbon transition, Scion's hub has the potential to minimise, in a managed way, any disruption the transition may cause New Zealand's socioeconomic fabric.[105][106]

Well-being economy

A growth-driven economy relies on the extraction of finite resources and has increasingly resulted in greater wealth inequality.[1] In response, some economists have suggested a shift towards an economy that prioritises well-being rather than growth. Such an economy would be more adaptable, integrative and empowering,[2] and would value social capital to the same extent as physical capital.[3] Even policy makers are taking notice: policy makers in Wales passed the Well-being of Future Generations Act in 2015 obliging public bodies in Wales to ensure and improve the economic, social, environmental and cultural well-being of Wales.[4]

It has been suggested that, although circular economy can remediate linear resource use, it could also lead to negative rebound effects if applied narrowly and within a profit and growth-driven context.[5] Adopting a well-being approach to circular economy would make sure that the advantages of circularity are equally distributed, and that social capital is captured for the benefit of the community.

"[A]n economy that aspires to achieve wellbeing should be designed by those who live it, in accordance with their values and motives."[6] Social inclusion in Scion's circular bioeconomy hub is therefore paramount if it is to contribute to the social, economic, environmental and cultural well-being of New Zealand.

[1] Mark Lang and Terry Marsden, "Rethinking Growth: Towards the Well-Being Economy," *Local Economy: The Journal of the Local Economy Policy Unit* 33, no. 5 (August 2018): 503, https://doi.org/10.1177/0269094218792474.
[2] Lorenzo Fioramonti, "Well-Being Economy: A Scenario for a Post-Growth Horizontal Governance System," n.d.: 4, https://thenextsystem.org/sites/default/files/2017-08/LorenzoFioramonti.pdf.
[3] Lang and Marsden, "Rethinking Growth," 501.
[4] Lang and Marsden, "Rethinking Growth," 510.
[5] Lang and Marsden, "Rethinking Growth," 503.
[6] Lorenzo Fioramonti, "Growth is dying as the silver bullet for success: Why this may be good thing," *The Conversation*, May 28, 2017, https://theconversation.com/growth-is-dying-as-the-silver-bullet-for-success-why-this-may-be-good-thing-78427.

Text Box 15. Innovation: Well-Being Economy

INTERNATIONAL CONTRIBUTIONS

Following on from the above recommendations for connecting national actors and communities, we suggest Scion strive for a similar connectivity at the regional and international level. As potentially the first hub to integrate indigenous knowledge and practices, **Te Ōhanga can take on a leadership role by working with**

indigenous partners worldwide to help develop other bioeconomy hubs with a strong regard for indigenous culture. Taking inspiration from Bloom's network of hubs in Europe (see Text Box 16), in the long run, Scio could contribute to a network of hubs that purposefully retain the value generated from circular economy for indigenous communities.

Likewise, Scion has the opportunity to **promote a network of circular bioeconomy hubs** in the Pacific region. Many Pacific nations are also shifting towards a circular economy approach to waste management, as evidenced by the **Secretariat of the Pacific Regional Environment Programme (SPREP)**'s *Pacific Regional Action Plan on Marine Litter*.[107] At the launch of the Samoa Recycling and Waste Management Association, the Director General of SPREP, Leota Kosi Latu, also referred to the circular economy framework.[108] As a metropolitan member state of SPREP, New Zealand has an interest in the regional coordination of waste management. Te Ōhanga can contribute to and capitalise on this growing emphasis on circularity by providing assistance and best practices guidelines to other SPREP members intent on setting up circular bioeconomy hubs.

Lastly, having ratified the **Paris Agreement**, New Zealand will have to submit Nationally Determined Contributions (NDCs), with increasingly ambitious targets over the years. So far, New Zealand has set itself the target to reduce greenhouse gas emissions to 30% below 2005 levels by 2030, a target covering all sectors including waste and forestry.[109] Just as Scion's circular bioeconomy hub will help implement the Zero Carbon Act's objectives by reducing emissions in the forestry and waste sectors, it will equally contribute to New Zealand's efforts to meet its NDCs. In the first round of NDCs submitted worldwide, only a handful of countries (Barbados, the Seychelles, Monaco, Burkina Faso and China) specifically mentioned circular economy as part of their targets and strategies.[110] By serving as an exemplary centre for circular innovation, Te Ōhanga could not only help achieve the NDC, but also provide reason for the inclusion of circular economy in New Zealand's upcoming NDCs.

Bloom
The Bloom project focuses an EU Coordination and Support Action that aims to boost bioeconomy research and innovation and to spread awareness about the potential of bioeconomy. It is comprised of five hubs spread out across several regions of Europe. While the Spanish and Polish hubs focus on food and agriculture, the Austrian & German hubs concentrate on innovative circular materials, the Dutch hub on bio-chemicals and bio-plastics, and the Nordic hub on wood based products. They work in conjunction with each other to provide co-creation workshops and outreach materials.

The major benefit of this network of hubs is the establishment of a far-reaching community around bioeconomy and the prevention of the fragmentation of knowledge, action and awareness across the region. Together, they have a greater reach and a greater potential to instigate a region-wide transition.

"Hubs," Bloom, accessed March 4, 2019, https://bloom-bioeconomy.eu/.

Text Box 16. Case Study: Bloom

CONCLUSIONS

This report has outlined key aspects of circular economy models, principles, and practices relevant to Scion's proposed Te Ōhanga hub. It first explored the **global circular economy landscape**, providing information on a range of **hub models, relevant economic sectors, the social outreach hubs engage in**, and methods for ensuring **hub sustainability**. Drawing on Scion's expertise within the forestry sector, the report then included **bioeconomy** and **forestry technology**, which the hub can capitalise on, as well as recent innovations in the field. Given that Scion hopes to create a hub that is collaborative and socially inclusive, the report incorporated information on **physical** and **social structures** of a hub design that would facilitate these objectives. In this regard, potential **local**, **national**, and **international contributions** and **partnerships** the hub can engage in were addressed, situating the project within a wider context. Finally, each report chapter included **recommendations** relevant to Scion and its projects. These are summarised below:

WHAT INSIGHT DO CURRENT GLOBAL SPACES FOR CIRCULAR ECONOMY INNOVATION AND ADVOCACY PROVIDE FOR THE HUB?

The hub should decide on an area of specialisation, depending on available funds and space, local resources available, and how the activities fit into the regional economy. It is unusual for a hub to try to encompass all sectors or specialise in one field only. The sectors the report **identified as relevant** to Scion include: waste and water, materials, food and additives, energy and fuel, plastics and packaging, textiles, green chemicals, personal care, and health.

The report found the majority of the hubs participate in **outreach** to government actors and the private sector or directed at a broader public audience. In this regard, the training of private sector employees encourages individuals to act as **champions of circularity** within their positions and helps build a circular community of practice and network of circularity champions within different industries. Moreover, public outreach through hubs acting as community hubs, as well as circular hubs, is encouraged as a way of communicating the value of circular practices more broadly. This can be accomplished through community maker spaces, festivals, and kitchens. Inspiring the community to become **local co-producers** and **active citizens** can be achieved through sharing the benefits the hub produces. This can be encouraged by opening the hub to interested citizens, artists and DIY enthusiasts, and through cultural events to attract younger generations

HOW CAN THE HUB ENSURE A SUSTAINABLE BUSINESS MODEL?

It is important for a hub to account for the various ways in which it adds **value to all levels and aspects of societies**, and how this value can be seen in financial returns. In other words, it may be more strategic to think of the hub's financial impact with the various, diffuse value streams it creates.

The **values identified** by the report include: circular product development, legitimacy and security, operations

support and community of practice creation. Additionally, Scion can capitalise on all the types of value it can produce to support social bioeconomic circular enterprises to meet social objectives such as reducing inequality.

HOW CAN THE HUB'S PHYSICAL AND SOCIAL STRUCTURE BE DESIGNED?

Consciously designing the physical and social structures of a hub to be innovative and collaborative is central to its success. The report included the following insights into hub design:

- **Innovator work spaces:** Should be designed to reflect the type of openness the hub encourages and the defined role of the shared space. Facilitating a hub-associated online space would increase the reach and accessibility of the hub.
- **Publicly accessible spaces and outreach facilities:** Incorporating publicly accessible spaces for community events or site tours can increase the overall effectiveness of the hub and encourage diverse participation.
- **Piloting facilities, equipment and green design:** An innovation hub should start with basic accessible Green Lab equipment (e.g. 3D printers) and piloting capacity can be expanded based on the needs of the hub community.
- **Capitalising on context and setting:** Effective hubs capitalise on the resources and waste streams from neighbouring organisations to minimise expense and waste.
- **Public policies that enable hub success:** Hub success can to a certain degree be defined by the micro-, meso-, and macro- level policies influencing their operating environment, hubs should increase awareness of policy opportunities and challenges.
- **Inclusive social structures that encourage diverse participation:** Hubs can benefit from the diversity of ideas diverse participation brings. Reducing barriers to accessing the hub, creating a space that is open to those with varying levels of technical experience, and incorporating multiple views on circularity into the hub's missions help ensure inclusivity

HOW CAN THE HUB CAPTIALISE ON BIOECONOMY TECHNOLOGY AND FORESTRY INNOVATIONS?

In designing the Te Ōhanga hub, Scion is uniquely placed to capitalise on existing knowledge, infrastructure, and resources. It can build upon existing work with indigenous partners to further consider the resources contained in its **current waste streams, natural capital, and sustainable technologies** (particularly relating to packaging and energy within the hub's collaborative space). Scion can improve on technology for, and expand the use of, forestry by-products, as well as encourage innovative uses of the resource. Scion already has world-leading research underway in a number of key areas, for which the hub can provide a new forum for development, testing, and implementation. These include:

- **Innovation in energy** and fuel technologies such as Gasification and Pyrolysis
- **Innovations in packaging** such as use of lignin and biochar additives,

Fungal Mycelium, and forestry waste
- **Non-Timber Forest products** such as fungi and ginseng

HOW CAN THE HUB PARTNER WITH OTHER ORGANISATIONS, INNITAITVES AND ACTORS?

Te Ōhanga can draw on regional synergies and create an enabling environment that encourages the participation of a variety of actors. An effective circular hub operates across sectors, organisations, communities, and value chains, and requires partnerships with various stakeholders including business and industry, research organisations, civil society, and the general public, and central and local governments.

It is also important for the hub to be **grounded** in and **conscious of local needs**, while engaging in public outreach and encouraging the public use of facilities. In pursuing its goal of generating local value, Scion's collaboration with Maori partners will be essential to fostering inclusive innovation at Te Ōhanga. Though **consultative design**, **inclusive management** and **continual evaluation**, the hub is likely to create local benefits such as income and job generation, social integration, awareness raising and education, and the promotion of local resource ownership and production. Nevertheless, there is limited international precedent for this scale of indigenous participation and engagement. The proposed Te Ōhanga hub is at the international forefront of circular economy research, and offers a powerful opportunity for New Zealand to be a **global leader**.

HOW CAN THE HUB CONTRIBUTE AT NATIONAL AND INTERNATIONAL LEVELS?

The Hub can be designed to maximise its socioeconomic and environmental benefits by creating a network with other potential hubs in the Pacific, connecting with international indigenous communities, and providing a space for national actors to connect. The Hub can also be used to contribute to the achievement of New Zealand's national and international targets set in its *Zero Carbon Act 2050, 2010 Waste Strategy* and Nationally Determined Contribution (NDC) under the Paris Agreement. To enhance its impact, the hub can provide regulatory and best practice support to businesses seeking to reduce emissions or wanting to engage in circular economy practices. Additionally, the hub can be used to aid New Zealand in a policy shift from waste management to circular economy, with a focus on well-being. Overall, The Hub provides Scion with an opportunity to achieve connectivity on all scales and strengthen its position as a leader in bioeconomy practices.

FURTHER CONSIDERATIONS

This report has done its best to address core aspects of circular economy hub design and operations within the specific context of Te Ōhanga, however this document does not claim to be exhaustive and it is limited by the resources and time available.

To build upon the report's findings, this section proposes areas for further research within all of the report's main topical areas.

SUSTAINABLE BUSINESS MODELS

To build upon the findings regarding business models, Scion could benefit from an analysis of The Hub's financial opportunities, including possible funding sources, for cost sharing with other organisations in the Innovation Park space, hub earning potential, and reinvestment opportunities for any profit turned. Additionally, further research into intellectual property is encouraged.

PHYSICAL AND SOCIAL HUB DESIGN

As indicated in Chapter 3, physical and social hub design is most effective when informed by surveys of context to capitalise on opportunities like possible facilities partnerships with neighbouring organisations, and the needs of end users to tailor the space to the skill level and interests of those Scion wishes to engage. These local surveys could prove useful to ensuring the hub is designed to maximise its potential. OISD contacted certain case study hubs, and can provide contact information and introductions if relevant and desired.

BIOECONOMY TECHNOLOGY AND FORESTRY INNOVATIONS

Specifically studying the potential of waste streams available to those working in the hub, from neighbouring organisations to other Scion projects, could help focus early projects and ensure the hub is working towards supporting the creation of circular products from its inception.

HUB PARTNERHIPS

Future research could be particularly impactful within the area of hub partnerships. Conducting detailed stakeholder interviews will help refine hub design and ensure that The Hub is aware of projects already being implemented by local communities and private sector partners that could have synergy with Te Ōhanga's purposes.

ACHIEVING NATIONAL AND INTERNATIONAL OBJECTIVES

Finally, in regards to national and international objectives, it is important to consider that national and international policy is always changing. In terms of future research, it would be valuable to assess upcoming and future agreements and policies from the perspective of Te Ōhanga and how The Hub is impacted by, and can contribute to, these varied objectives.

As a general comment, circularity, and the circular bioeconomy, is the focus of considerable academic and practitioner attention right now, and the literature and knowledge base is constantly growing. This report should serve as a guide to the main concepts shaping the circular bioeconomy space, but there is much more to be learned and considered going forward.

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ANNEX 1: CASE STUDY MATRIX

For ease of use, Annex 1 is available and submitted in spreadsheet form. The Annex is an informal document, but provides process details on the report case study analysis.

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