Cleantech Group

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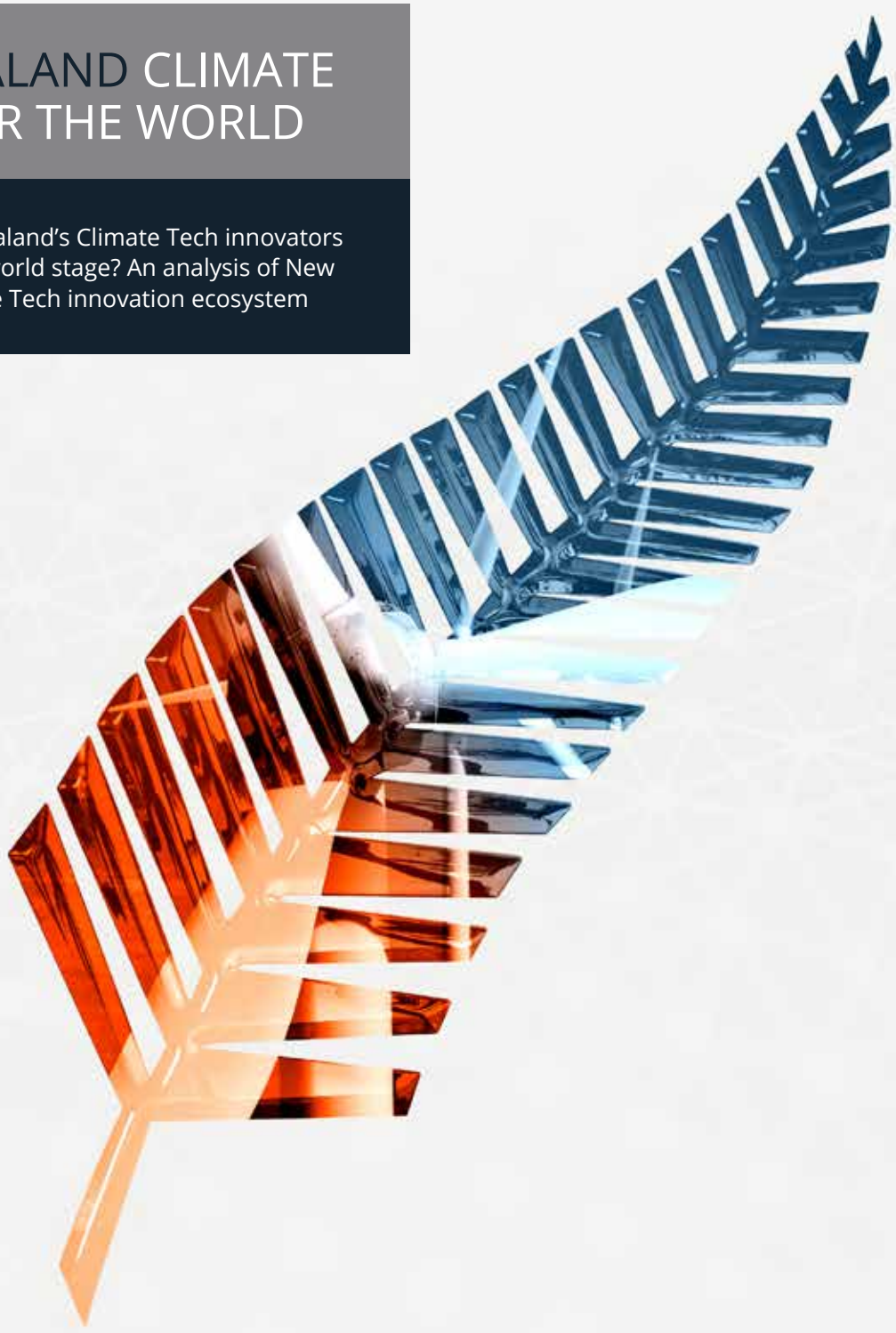
NEW ZEALAND CLIMATE TECH FOR THE WORLD

How can New Zealand's Climate Tech innovators succeed on the world stage? An analysis of New Zealand's Climate Tech innovation ecosystem



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Scope and Purpose

This research seeks to answer the question, "How will New Zealand climate tech businesses succeed on the global stage?"

Climate tech is defined as technology that reduces or eliminates greenhouse gas emissions (directly or indirectly) or improves use of natural resources. This report summarises opportunities for New Zealand climate tech companies to compete on the global stage, and for the surrounding innovation ecosystem to support and foster climate tech innovation. Becoming competitive on the global stage requires innovators to successfully transfer research into commercialised products, raise requisite funds to scale and expand beyond the immediate New Zealand market, and most importantly, connect to owners of demand (direct customers, technology development partners, joint venture partners) in a way that secures New Zealand innovators a place in the global supply chain. Likewise, a proficient ecosystem is defined as one in which innovators can, in theory, access the research, finances, network and connections to demand necessary for global expansion without having to relocate headquarters overseas.

The intended audience for this report is New Zealand's innovation ecosystem of innovators, customers, investors, government agencies, corporates, universities and others responsible for supporting and sustaining climate tech innovation. This report summarises findings during a detailed analysis process, examining global climate tech trends, New Zealand innovators' positioning in relation to those trends, and the innovation ecosystem's ability to support innovators navigating those trends. Further detail on the analysis is provided in the appendices of this report.

Methodology

This report analyses five climate tech sectors (Agriculture & Food, Energy & Power, Resources & Environment, Materials & Chemicals, Transport & Logistics) to identify technology areas in which New Zealand innovators can innovate ahead of trends and potentially compete globally.

The analysis combines macroeconomic markers of market attractiveness (market size, growth rate, level of competition, policy drivers), a comparison of New Zealand innovators against comparable innovators globally, and a comparison of the New Zealand innovation ecosystem supporting relevant innovators.

Findings generated from this research serve to help the New Zealand climate tech innovation ecosystem to:

- Benchmark existing strengths and weaknesses relevant to global climate tech trends.
- Draw comparisons with other small, advanced economies (SAEs) that have successfully pushed climate tech innovations into global markets.
- Identify critical gaps holding New Zealand's innovators back from innovating on a global scale.
- Re-evaluate changes in approach, both strategic and tactical, to create the conditions necessary for New Zealand climate tech to thrive globally.

Executive Summary

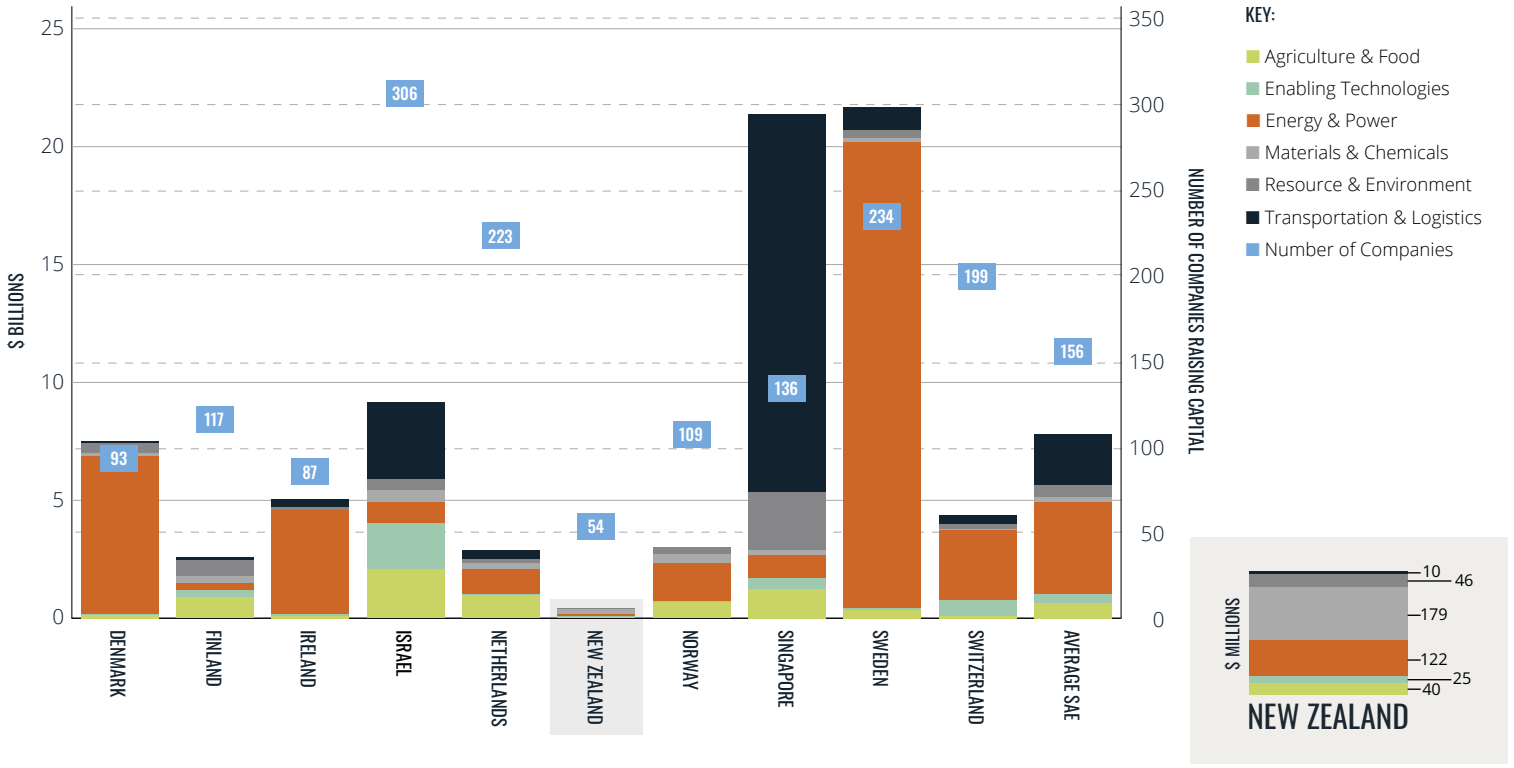
New Zealand has come to be known as a global thought leader on climate change issues, perhaps most visibly in the form of its ambitious commitment to net zero by 2050 and its impressive results in already being 85% of the way to a fully renewable electrical grid. New Zealand has launched world-leading innovators in climate tech areas in recent decades as well, including LanzaTech and AllBirds.

However, when compared to other small advanced economies (SAEs), New Zealand's climate tech innovators struggle to raise the same amounts of funds that innovators in comparable economies are able to, well below the SAE average in terms of aggregate financing to climate tech, number of companies getting funded, and average investment amounts. As observed in Figure 1 below, among SAEs, New Zealand saw both the lowest amount of investment in climate tech and the fewest climate tech innovators receiving funding. New Zealand climate tech innovators raised 95% (19 times) less funding than climate tech innovators in the average SAE, and 84% (6 times) less than those in Finland, which ranks one spot above New Zealand in climate tech fundraising. New Zealand's climate tech innovators received 55 times less funding than the leading country, Sweden, 22 times less than those in Israel, 18 times less than those in Denmark, and 12 times less than those in Ireland. Some of this gap is explained by the variance in industry focus found in each SAE. For example, globally transportation and energy innovators receive far more funding on average versus agriculture or resources innovators. However, even countries in which agriculture or resources hold a similar economic importance (e.g. Israel, Finland, Sweden), all outpaced New Zealand's amount of financing by wide margins in those sectors.

DEFINING SMALL ADVANCED ECONOMIES (SAES)

"Small" economies are defined here as having a population of less than 20 million. "Advanced" economies are identified according to International Monetary Fund criteria of per capita income, export diversification, and integration into global financial system. The SAEs analysed in this report all have GDPs per capita of over US $30,000.

Figure 1: Number of Companies Raising Capital 2011-2021



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Another trend that can be observed from the cross-SAE climate tech financing comparisons, is that the largest chunks of financing are coming in the later stages, stages that are notably missing from New Zealand's financing stack, indicating that New Zealand innovators are not surviving long enough to access the types of financing necessary to grow or are not perceived by investors as holding significant growth potential. As observed in Figure 2 below, at the earlier stages, New Zealand's innovators are funded far less than SAE peers: Finland, Netherlands, Norway, and Switzerland all have aggregate funding numbers below the SAE average but have Series A and B figures close to average and have launched at least double New Zealand's number of funded innovators.

Figure 3 below illustrates the average financing mix in SAEs 2011-2021, compared with the financing mix in New Zealand. New Zealand's financing was concentrated significantly more in the early stages (Grants through Series B) at 55% compared to the SAE average of 13%. However, much of the later stage funding in these years was received by LanzaTech (approximately $117 million raised when it was based in New Zealand)[267] and, with LanzaTech excluded from the investment analysis, if, 70% of financing is concentrated to companies in the early growth stages. Public sector funds are the primary source of financing in New Zealand 17% of the funding mix (23% without LanzaTech) versus 1% in the SAE average.
A lack in volume of private-sector financing risks presenting innovators with shorter lifelines to growth, subsequent financing, and an overall aversion to innovation in capex-intensive sectors. For innovators to mature, it is necessary to be able to access capital that supports scaling of the business into new geographies and markets, as well as long-term access to debt financing that supports expansion of operations.
An innovation ecosystem with an effective financing mix should see ample capital available at each stage of the growth journey, in order to effectively launch world-leading companies.

Figure 2: Financing Mix, New Zealand and SAE Average

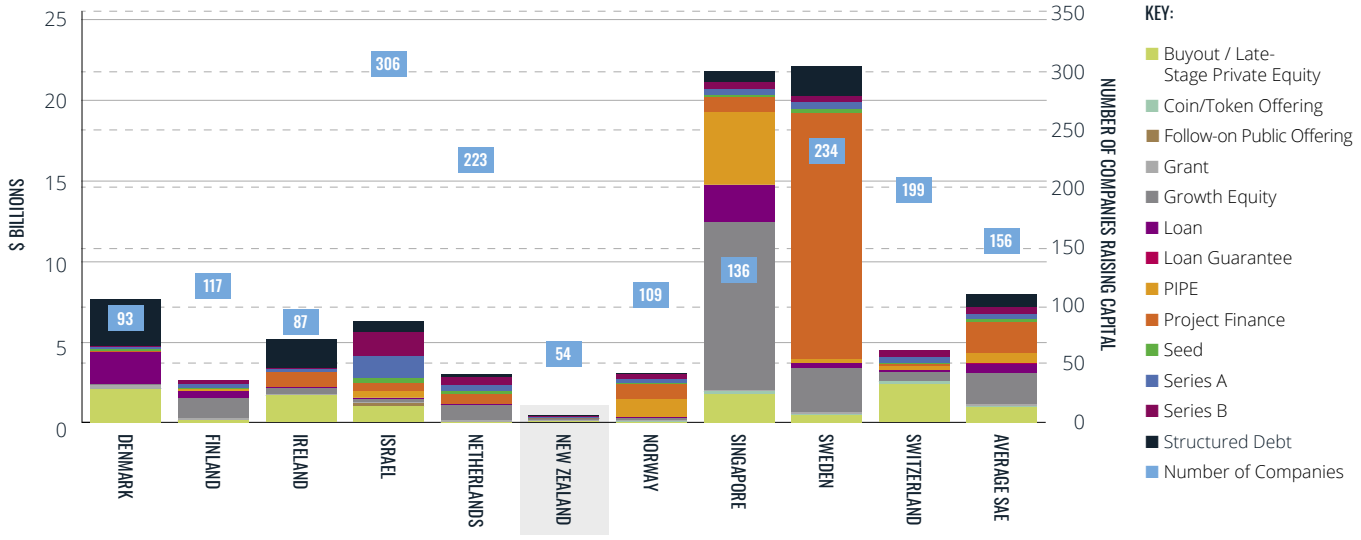
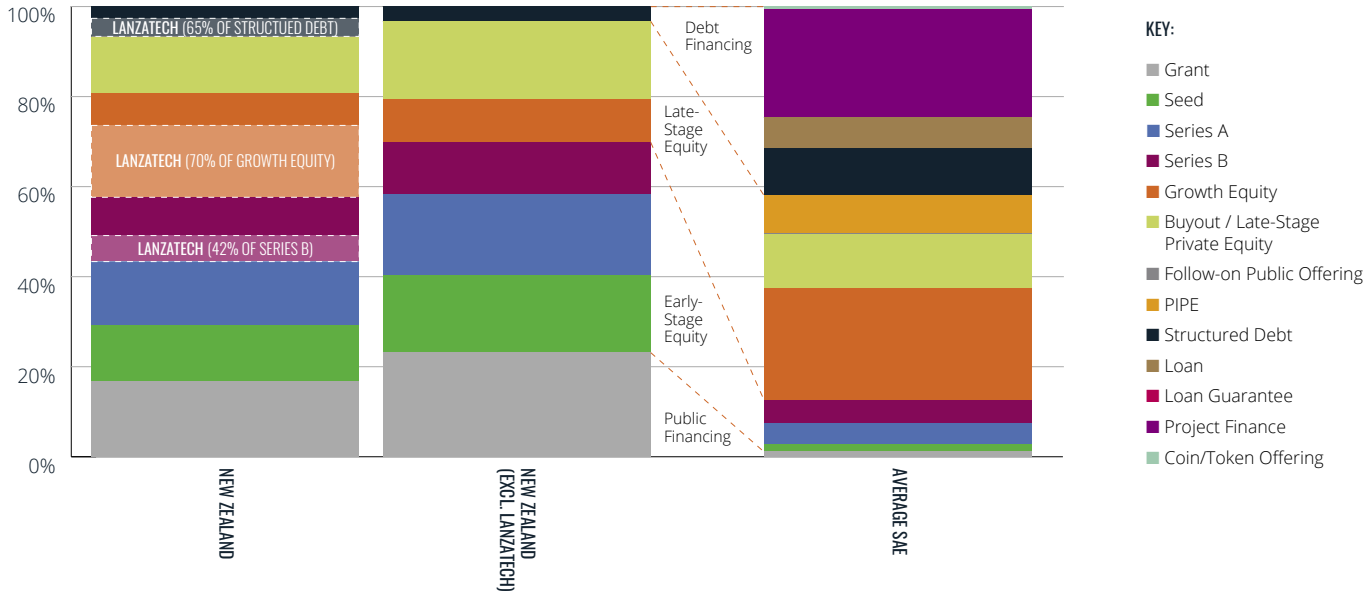


Figure 3: Financing Mix



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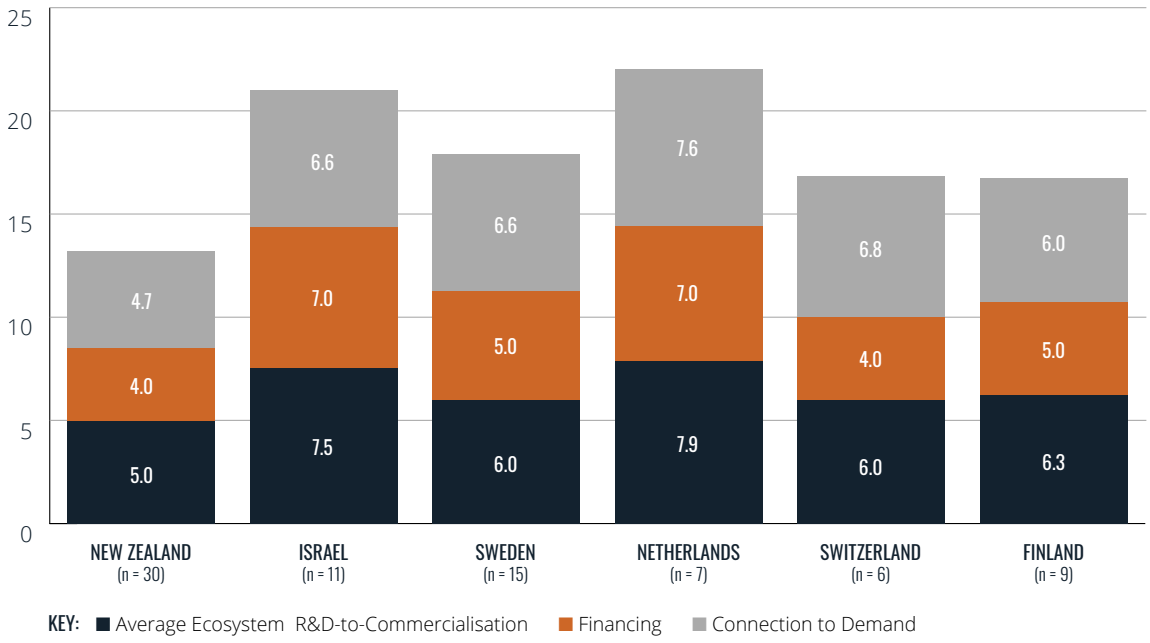
A lack of multinational companies is an additional challenge that New Zealand faces. Beyond the prototypical SAE challenge of a small home market, solutions for scaling innovation will involve an additional layer of complexity versus those adopted by other SAEs. As a result, New Zealand's innovation ecosystem must view engagement with multinationals as a necessary component to scaling innovation and a goal of sustaining innovation. New Zealand's innovation ecosystem will be tasked with pushing innovation out to global corporates but also pulling global corporates into the ecosystem (see Figure 8 for a conceptual framework for a "virtuous cycle" of climate tech innovation).

Most critically, a lack of multinational presence contributes to a lack of dynamism in the fundraising ecosystem – venture financing is often a lagging indicator of value to downstream customers, i.e. investments will move geographically to wherever financiers see new supply opportunities to meet demand. There is a symbiotic relationship between multinational presence and investments. Successful innovators need to understand their target markets and relationships with multinationals intimately at the early stages. This helps to ensure that innovators' solutions are best tailored to demand owners' pain points. See New Zealand's Role in Global Climate Tech for suggestions on how New Zealand can both create innovation ecosystems that spurn leading-edge innovators but also attract multinationals for pilot testing and technology exploration engagements.

This research compared innovation ecosystems in target climate tech sectors on their ability to help companies succeed in three stages of the entrepreneurial journey (R&D-to-commercialisation pipeline, financing, connection to demand), and rated each layer of the ecosystem on a scale of one to ten, with ten indicating that a company could access all necessary opportunities through local resources. The methodology utilised involved first assessing global potential (i.e. market size, growth rate, level of competition), then comparing the support system (R&D resources, talent sources, investors, customers, technology development partners) engaged by stand-out innovators, and culminating in a side-by-side comparison of innovation ecosystems through the lenses of the three layers mentioned above. Figure 4 below summarises the average ratings of each of the three ecosystem layers in the countries most frequently observed during the research. Out of a highest possible score of 30, (30 indicating a "perfect ten" in all three categories), New Zealand scored the lowest, with the largest gaps coming in connection to demand. See Appendices for detailed analysis of technology areas and ecosystems.

THERE IS A SYMBIOTIC RELATIONSHIP BETWEEN MULTINATIONAL PRESENCE AND INVESTMENTS. SUCCESSFUL INNOVATORS NEED TO UNDERSTAND THEIR TARGET MARKETS AND RELATIONSHIPS WITH MULTINATIONALS INTIMATELY AT THE EARLY STAGES.

Figure 4: Ecosystem Average Ratings (ecosystems most frequently reviewed during this research)



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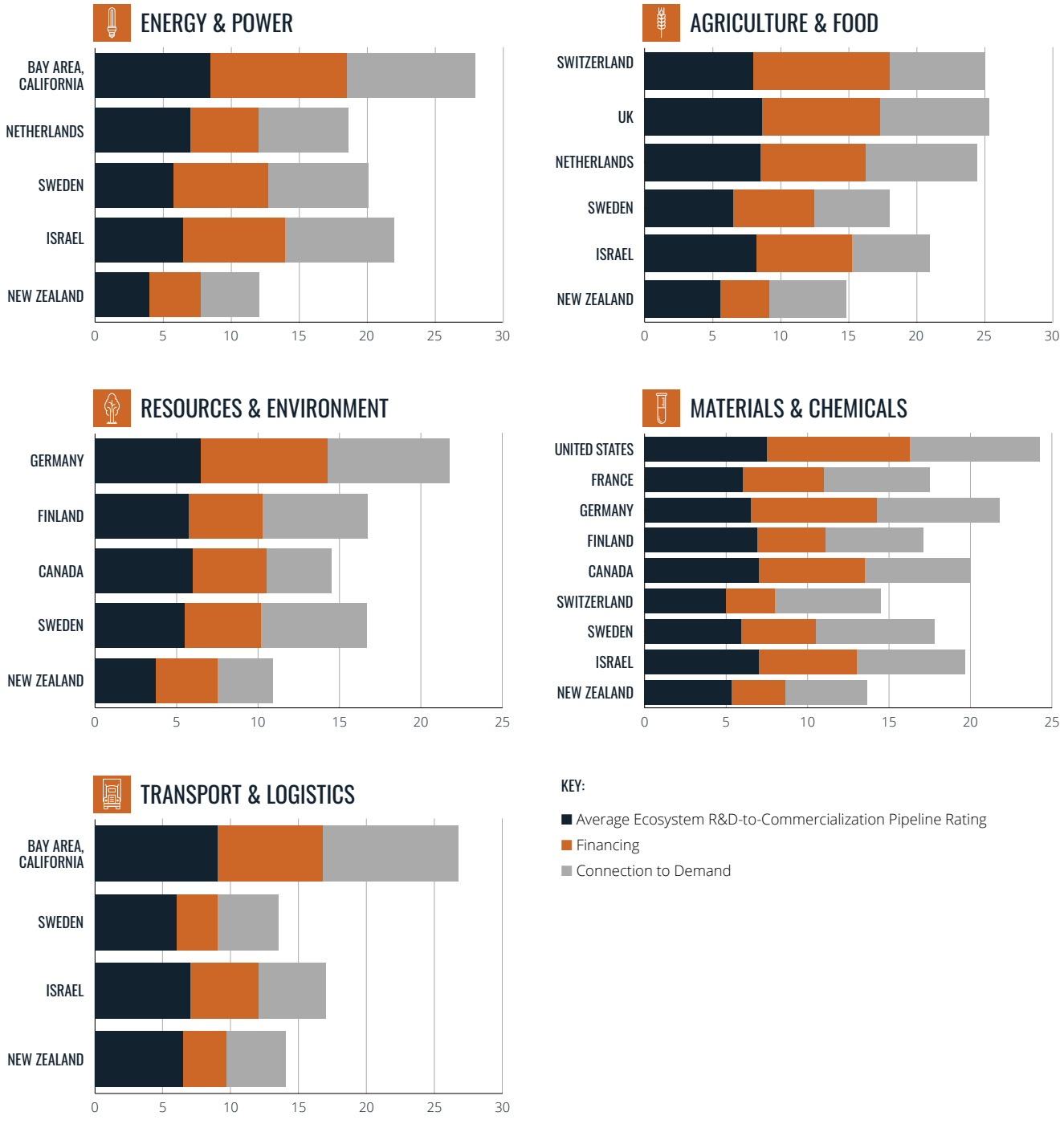
While SAEs have an inherent economic disadvantage versus larger economies, there are still examples of SAE innovation ecosystems in a competitive position versus the incumbent ecosystem in larger economies (for example, Israel within five points of the US and Germany in materials and chemicals, Sweden and Finland as near-peers to Germany in resources and environment). Across the different industry groups, New Zealand's innovation ecosystem lags that of other SAEs, even in the sectors that New Zealand considers central to its economy. New Zealand's innovation ecosystem in Agriculture & Food is ahead of New Zealand's innovation ecosystem for other industry groups. As indicated in Figure 5 below, SAEs that can consistently produce innovation in climate tech leverage adjacencies in industry and actively leverage multi-sector synergies. For example, Israel and Sweden are used as comparators in almost all of the industry group analyses and their ecosystems score above the SAE average in each industry category.

This report seeks to understand the gaps between New Zealand's climate tech innovation ecosystems and those of other SAEs. Additionally, it is meant to identify latent opportunities for New Zealand's innovators and ecosystem and potential strategies to capitalise on those opportunities to carve out a stronger presence for New Zealand climate tech on the world stage.

Figure 5: Example Ecosystem Ratings (broken out by industry group)



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Critical Findings:

- Successful New Zealand innovators that the government has backed have mostly received support at an individual level, rather than the more intentional approach to lift an entire industry, comprised of multiple technology verticals and not necessarily individual companies, into export markets observed in comparable economies such as Israel (e.g. the Israel Innovation Authority), Europe (e.g. Cleantech for Europe) and Sweden (e.g. Swedish Cleantech). SAEs that have successfully launched innovative climate tech industries have done so through a process of investing in ecosystems of innovation, not through backing companies one-by-one. Investing in a full ecosystem requires a vision of long-term growth for a full industry, across multiple links of the supply chain, with a firm connection to demand that allows innovators to collaborate among each other to solve practical industry challenges. See the example of the Israeli energy transition catalogue in the Digitising Decarbonisation section.

- New Zealand's R&D infrastructure has demonstrated capabilities to commercialise competitive technologies (e.g. Engender's launch by a U. Auckland professor) and be involved as research partners in the development of high-potential innovators (e.g. the MacDiarmid Institute's partnerships with Avertana, Mint Innovation, Aquafortus). The low scores, relative to other SAEs, observed from New Zealand in the R&D-to-Commercialisation Pipeline layer of the innovation ecosystem, implies that researchers do not have the incentives to bring new technologies out of the lab and into companies. Private sector players are not involved in motivating these commercialisation moves at a significant level. This observation is borne out further in the scale stage, as New Zealand innovators face significant difficulties in accessing financing and, more critically, connecting to demand owners. SAEs that have produced market-leading climate tech innovators have succeeded, in part, through a strong and consistent connection to demand owners, that help innovators tap into demand challenges, and solve real world market problems.

- In other SAEs, cross-sector innovation collaborations have demonstrated spillover effects, including the ability to compete in related niche markets, e.g. the Israeli agricultural drone sector (from defense origins) and energy storage in Sweden (from renewables industry). New Zealand has similar potential, especially in agriculture-adjacent industries such as agricultural digitalisation (see Leading the Way in Low Emissions Agriculture and Own Low and No-emissions Agriculture).

- SAEs, by definition, lack large home markets. The SAEs that have succeeded in establishing an export market for innovators have done so in part by organising coordinated efforts to drive innovators into export markets through innovation agencies (sometimes called "outposts") that act as both a business promotion mechanism and a source of information flow back into the ecosystem, helping the ecosystem to orient itself toward global demand needs. Examples of innovation outposts launched by SAEs include Swissnex (San Francisco, Boston, Shanghai, Tokyo, Seoul, New Delhi, more), Swedish Cleantech Hubs (San Francisco, London, Shanghai), and Netherlands Innovation Network (San Francisco, Boston, Shanghai, Tokyo, Seoul, New Delhi, Singapore, Berlin, and more).

- New Zealand will have an additional challenge in that, different from Switzerland, Sweden, and the Netherlands, it will not necessarily have dual efforts of multinationals and innovation outposts to generate synergies between each other in export markets. Overcoming this challenge will involve bringing multinationals into the conversation early, through investment and trade promotion, as the innovation ecosystem is being built out, to participate in the discussions around areas of focus and standards for technology. An example is that of Mekerot, the national water supply company of Israel, that leveraged a relationship with Microsoft to open testing opportunities for wastewater treatment innovators (see more detailed example in Wastewater Treatment). This type of collaboration not only provides live pilot-testing opportunities for innovators, but also hedges risk for the demand owner by leaning on the experience of a seasoned corporation and allowing the corporation exposure to innovative local companies in a hands-on way.

As this report indicates, New Zealand's natural resources and intellectual capital are most likely to produce competitive advantages when the ecosystem focuses on achieving an effect in the market. Achieving a market effect is fundamentally different from supporting individual innovators; New Zealand's small domestic market requires innovators to be pooled together in value chains that provide step-change gains to demand owners (i.e. remove years from R&D processes, open brand new markets, exponentially increase efficiency), involves government efforts to promote to demand owners, and long-term engagement between the innovation ecosystems and demand owners to ensure that innovation is targeted toward the broader, more consequential markets.

To demonstrate how certain actions can help New Zealand build its success in Climate Tech, this report illustrates a potential framework identifying areas where New Zealand can commit to market effects, pool innovators and resources, coordinate stakeholders, and connect innovation to areas with growing demand.

This conceptual framework is proposed to ensure that New Zealand has coordinated efforts to support innovators in fields with promising global markets and where New Zealand has competitive innovation advantages. A goal is to avoid one-by-one backing of companies and to instead create an environment that consistently produces winners by having strong connections to global demand and facilitates fluid networking interactions between innovators and resources.

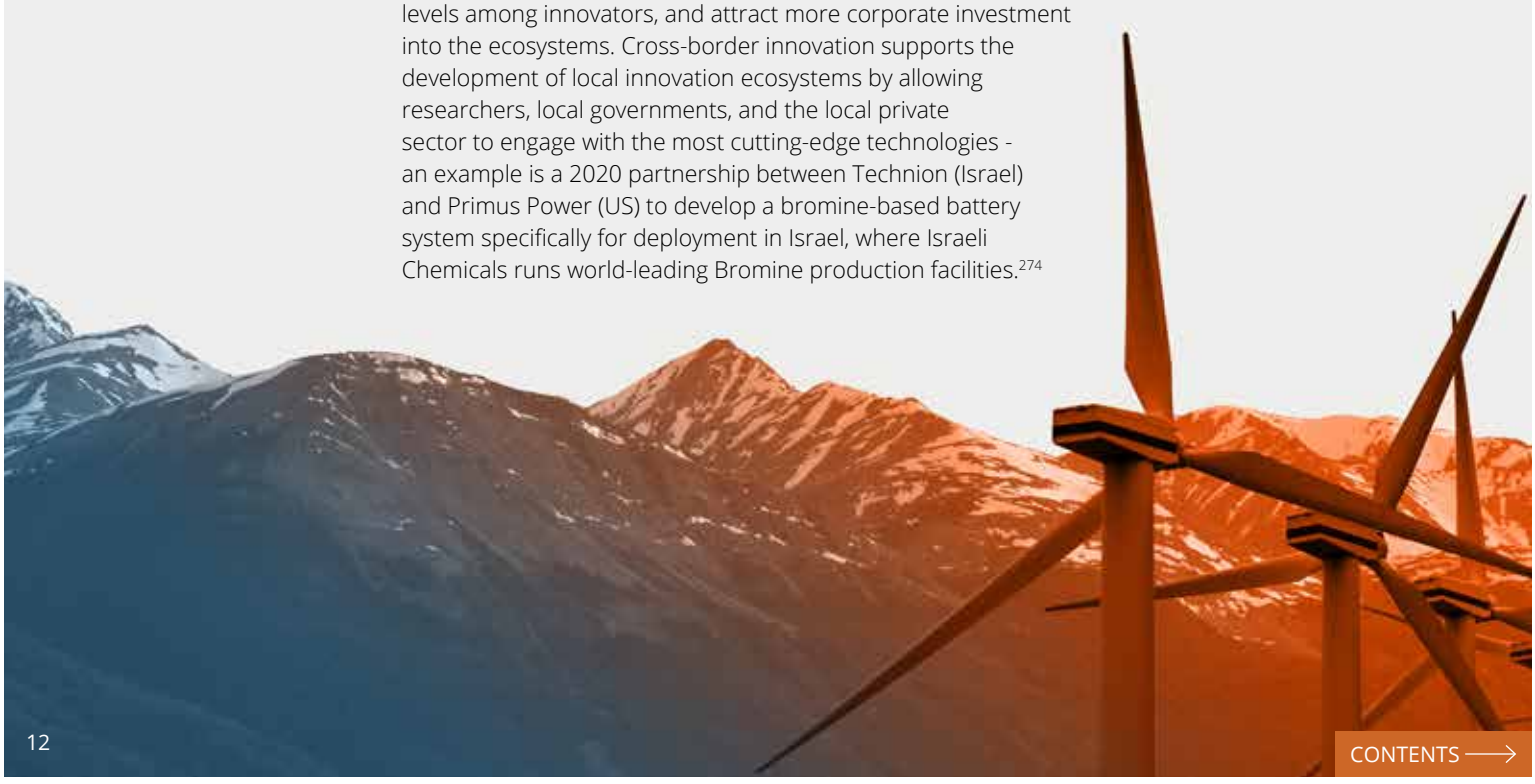
Recommendations: Improving the Ecosystem

- Commit – Focus objectives on ways that New Zealand innovation can impact markets in a meaningful way. Some examples in this report include the development of an agricultural digitalisation value chain and the development of a unique New Zealand model of industrial symbiosis around geothermal energy and forestry.

- Cluster – Organise resources around achieving the market effect by identifying technology discipline crossovers that leverage New Zealand industrial and resource strengths. Organise collisions for innovators between industries through pilot testing and experimentation programmes.

- Coordinate – Make intentional efforts to develop suites of products around New Zealand natural advantages and organise resources to lift suites of innovators into markets. An example highlighted in this report is that of developing a low-methane livestock supply chain that consists of both sets of technologies but also systems of operating models between technologies that can be exported as a New Zealand Model.

- Connect to Demand – Systematically place coordinated solutions sets in front of demand owners worldwide. An example is innovation outposts that consist of the government promoting New Zealand solutions sets, groups of technologies, that together solve large efficiency or emissions-reduction challenges for customers in overseas markets and pulling global corporations into innovation programmes within New Zealand to create a market feedback loop. Another example put forward is to develop unique ecosystem advantages around technology piloting and launch in New Zealand to attract global innovators, raise competitiveness levels among innovators, and attract more corporate investment into the ecosystems. Cross-border innovation supports the development of local innovation ecosystems by allowing researchers, local governments, and the local private sector to engage with the most cutting-edge technologies - an example is a 2020 partnership between Technion (Israel) and Primus Power (US) to develop a bromine-based battery system specifically for deployment in Israel, where Israeli Chemicals runs world-leading Bromine production facilities.[274]



Laboratory New Zealand – New Zealand Technologies for Global Climate Challenges

To place New Zealand's innovators in a position to become climate tech exporters, we recommend the ecosystem take the below actions to leverage New Zealand's unique natural and intellectual advantages to create meaningful solutions for global climate challenges.

Own Low and No-emissions Agriculture

Commit to becoming the world's leading source of innovation for low methane livestock raising and low or no-emissions crop raising.

Cluster digitalisation innovation with innovation in new and alternative livestock feeds. Leverage digitalisation to reduce waste and control energy use on farms. Place protein replacements in the stack of research priorities to complement low-emissions meat products and stay relevant to global consumers, leverage specialty crops innovation to support development of protein replacements industry.

Coordinate experimentation between farmers and innovators to test technologies but also pull in adjacent industries. Consider establishing experimentation zones to promote symbiosis between forestry, agriculture, and potentially geothermal energy.

Connect low emissions agriculture stack to Demand through intentional initiatives (such as an agricultural digitalisation body) and development of low-emissions agriculture value chain catalogues for overseas demand owners. Take an "innovation outpost" approach to bringing demand owners through experimentation zones to observe symbiosis and connect with innovators. Establish a consortium with multinationals directly involved.

Pioneer No-Impact Geothermal Models

Commit to exploring models that not only push forward energy-generating technology, but systems of developing local microeconomies, built on circular industries to be co-located in areas of natural geothermal resources.

Cluster players that have high needs for energy inputs, use for waste heat, and significant water needs in the low impact zones, e.g. dairy production and food processing. Encourage involvement of companies with significant by products that can be used for inputs to other industrial processes, especially forestry.

Coordinate opportunities for innovators to test technologies live in the low impact zones. Actively assess needs of companies operating in the zones and look for innovators operating at the nexus of indirectly related industries (e.g. as Hot Lime Labs does with forestry and horticulture). Don't just bring in companies to be directly involved in processes, also create opportunities for digitalisation companies to participate in the form of "command centers" that oversee transmission of resources between actors and promote efficiencies, e.g. using the philosophy of the Rio de Janeiro Operations Center that invites innovators to test smart city and transportation technologies through their platforms.

Connect low impact zones to demand owners in industrial companies that have targets to reduce energy use and production of by-products, but also promote models to local governments in overseas regions that have similar geothermal resources that they wish to develop economic effects around. Provide training on the models developed and promote value chain participants for direct involvement in other regions' projects developed with these models.

Potential to Succeed in Niches: Ecosystem Needs Wide Reach, Innovators Need to Go Deep

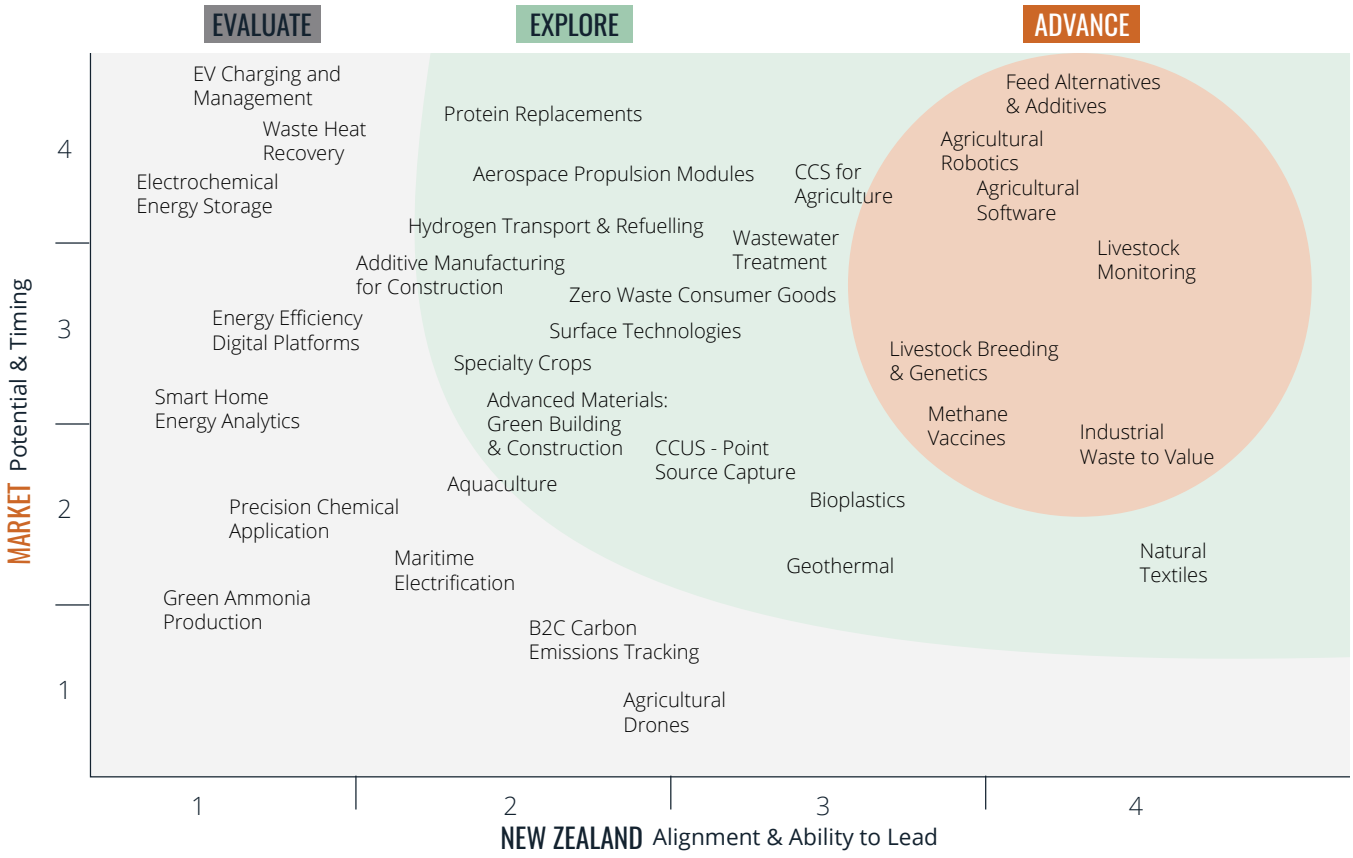
Which trends should be pursued and how can innovators succeed?

The primary objective of this research is to understand which comparator innovation ecosystems offer a cohesive continuum of support from initial research, through growth financing, large-scale commercialisation, and finally to global competitiveness. New Zealand, as a small, innovative economy that is geographically isolated from much of the world, must use innovation resources efficiently and focus attention on those technologies which combine high global economic potential with significance to the local market. Accelerating climate tech innovation will involve a two-pronged ecosystem approach of coordinating parties to ensure innovators are innovating for the real world as soon as possible, with early exposure to pilot testing and value chain integration opportunities and backing winners by facilitating connections to overseas demand owners and coordinating public and private financing resources to bridge growth.

Underpinning this report is a research process that reviewed climate innovation trends in each of Cleantech Group's five taxonomy trees: Energy & Power, Agriculture & Food, Resources & Environment, Materials & Chemicals, and Transport & Logistics. The analysis then identified sectors of technology relevant to New Zealand's economy, and specific technology development trends within those sectors that could potentially impact New Zealand's economic development (positively or negatively) and had existing global market gaps for technology innovation (i.e. areas where innovators had potential to solve market needs, not only incumbents).

The chart below (Figure 6) demonstrates results of the analysis, with advice on technologies that New Zealand should attempt to advance efforts to develop, ones that New Zealand should explore developing, and ones that should simply be monitored and evaluated for potential New Zealand participation. The market trends (Y axis) suggest a level of benefit to pursuing the technology, considering market size, growth rate, and saturation of competition within the market. New Zealand Alignment and Ability to Lead (X axis) analyses the existing presence of high-potential innovators and the requisite local resources to support them, as well as the strength of the surrounding innovation ecosystem to generate sustained launch and growth of innovative companies in that technology area.

Figure 6: Proposed Prioritisation of Climate Technology Development



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These technology areas have then been grouped into action categories of intentional advancement through ecosystem actions (active coordination and promotion), exploration and testing (pilot tests, incubation, some grant funding), and evaluation (light touch interventions, on a case-by-case basis to start).

New Zealand innovates well in niches, and while niches tend to have less competitive saturation, niche demand owners typically require step-changes in gains from engaging new suppliers. As a result, the success of many of the technologies displayed in Figure 6 depends on the development of other technologies in the same or adjacent niches (see Figure 7 below). Creating and backing global winners on an individual basis is challenging in niches, as a result, ecosystems that have been successful in climate tech niches have been able to tie together multiple adjacent solutions that can lift productivity for demand owners and reduce impact by orders of magnitude.

One goal of this research was to also identify areas of innovation that New Zealand's innovators could collaborate to generate spillover learning effects that offer cross-industry research and economic benefits. Spillover effects may emerge from talent that can transfer skills between industries, from technologies that are found to have multiple uses, and replication of business models from one industry to another. Examples of SAEs benefiting from industry spillover effects include Finland's development of leading carbon emissions tracking technology by information and telecommunications (ICT) industry veterans, Israel's success in agricultural drones built of a larger base of drones proficiency for the defence industry. Figure 7 identifies technology areas that the New Zealand ecosystem may seek to support integrations between in order to amplify potential benefits to demand owners and create a more cohesive value chain that can be positioned to export markets. A parallel goal was to propose areas for New Zealand's innovation ecosystem to develop a more intentional, coordinated approach to lifting New Zealand value chains, i.e. suites of solutions to resolve global demand owners' needs, versus an approach of attempting to pick winners on a one-by-one basis. Figure 7 below identifies areas of technology innovation covered in this analysis that have dependencies, and that are more likely to demonstrate value-to-market if value chain and cross-value chain integrations, defined as coordination of innovation within the same value chains and collaborative experimentation across adjacent industry value chains, are achieved.

Our high-level recommendations for climate tech in New Zealand involve actions that coordinate innovators to create step-change efficiency, cost, or decarbonisation gains for demand owners and incentivise the long-term engagement of demand owners with the New Zealand innovation ecosystem (overseas or in New Zealand), i.e. the virtuous cycle visualised in Figure 8. In order to not only create companies that win on the global climate tech stage, but also to facilitate continued and perpetual climate tech innovation, New Zealand's ecosystem of government, research, and private sector actors will need to coordinate efforts to identify differentiated New Zealand value chains and actively promote them to overseas demand owners. Furthermore, through these engagements, global demand owners' goals and needs should be internalised in New Zealand's national climate tech innovation targets and coordinated efforts. Examples may be consortiums of companies, universities, and investors, that seek to solve a given industry's global emissions challenges, or a system of pilot testing locations that not only engage multinationals but offer leadership roles in determining targets and standards of pilots.

Figure 7: Value Chain Dependencies and Potential Shifts in Priorities

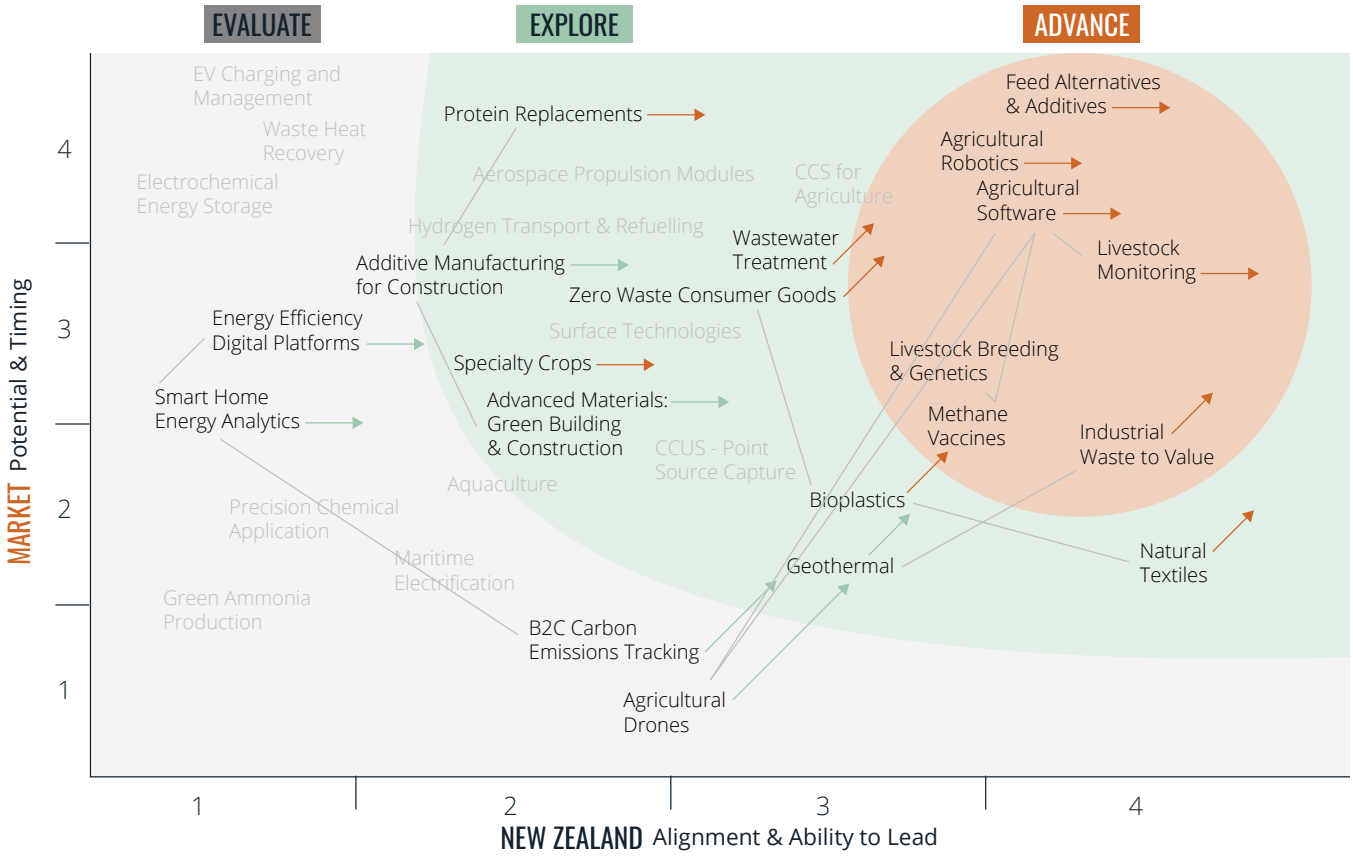

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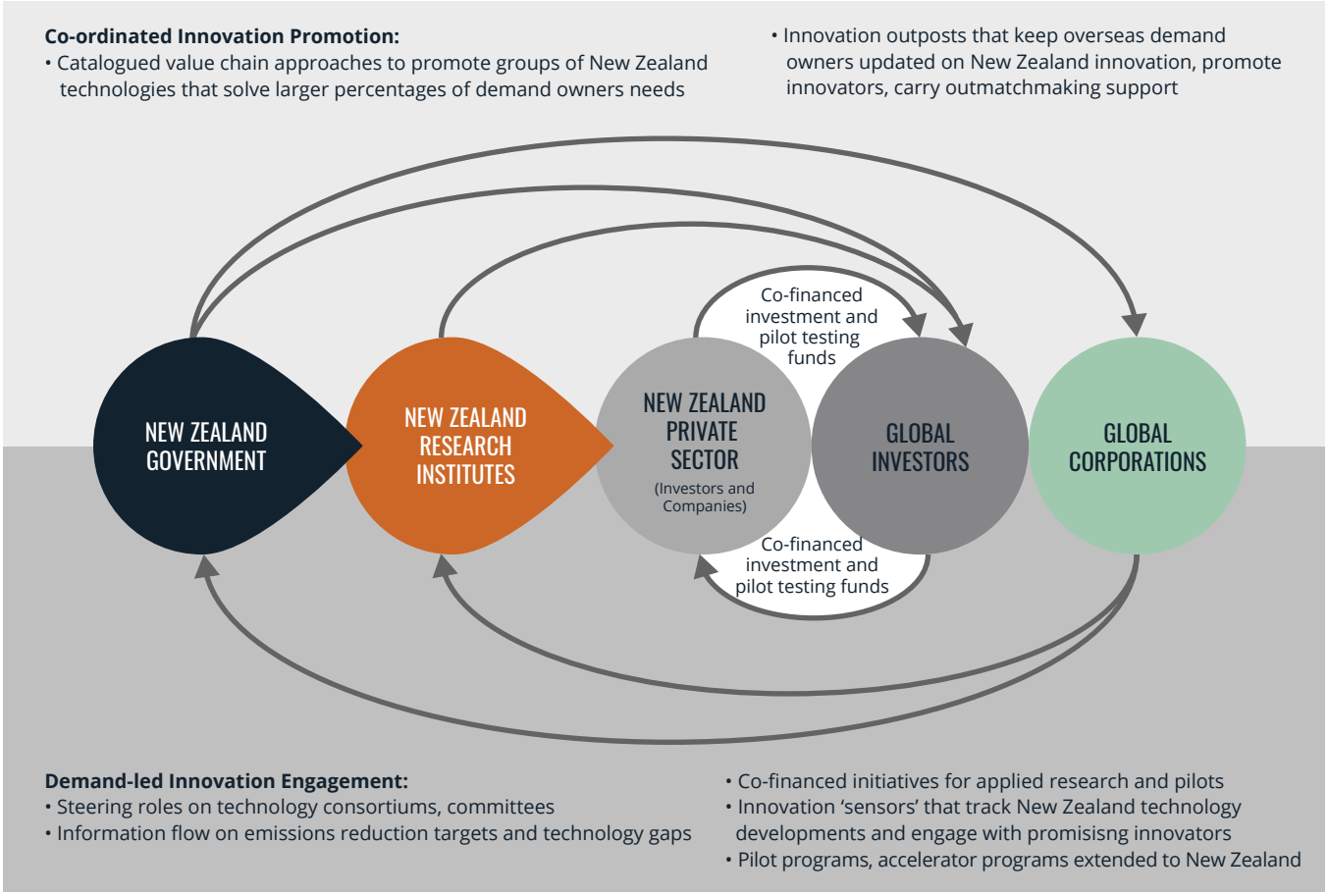
Figure 8: Virtuous Cycle of a Sustained, Coordinated Approach to Cleantech Innovation Promotion



Leading the Way in Low-Emissions Agriculture

New Zealand agricultural products and practices have achieved global renown. The industry is the bedrock of New Zealand's export strategy, as well as a key testing ground for new technologies in the country. Agricultural products accounted for 70% of New Zealand's total merchandise exports in 2014, horticulture alone accounted for 10.3%.[52]

New Zealand holds critical competitive geographic advantages in maintaining its position as an agriculture supplier, largely down to key geographical factors:

- Dual-seasonal dynamic – Production during Northern hemisphere off-season gives innovators an opportunity to test and pilot technologies nearly year-round.
- Proximity to key Asian export markets.

New Zealand is home to more than 950 agricultural technology firms, primarily comprised of growth and harvesting technology (29%), data solutions (26%), and animal and crop health (22%).[7]

- The top 20 New Zealand agritech firms generated $1.4 billion in revenue in 2019, with revenues growing at a 6.3% 5-year CAGR.[7]
- New Zealand exports approximately $1.2 billion of agritech annually ($800 million by top 20 firms).[7]
- Government estimates posit that better uptake of new agritech could be worth $17 billion for New Zealand farms; $9.8 billion increase in output, $7.3 billion increase in exports.[7]

However, in the most innovative pockets of agricultural technology, New Zealand innovators have received considerably less investment than its SAE counterparts. For example, Figure 9 below shows that while New Zealand has had approximately an average (amongst SAEs) number of innovators accessing financing, the amounts of investment received is significantly less than in other SAEs. This observation was echoed in a separate study from Hon. Phil Twyford (Minister for Economic Development) which stated concerns that despite New Zealand's strong position in agricultural innovation, it lacks a superstar billion-dollar agritech firm.

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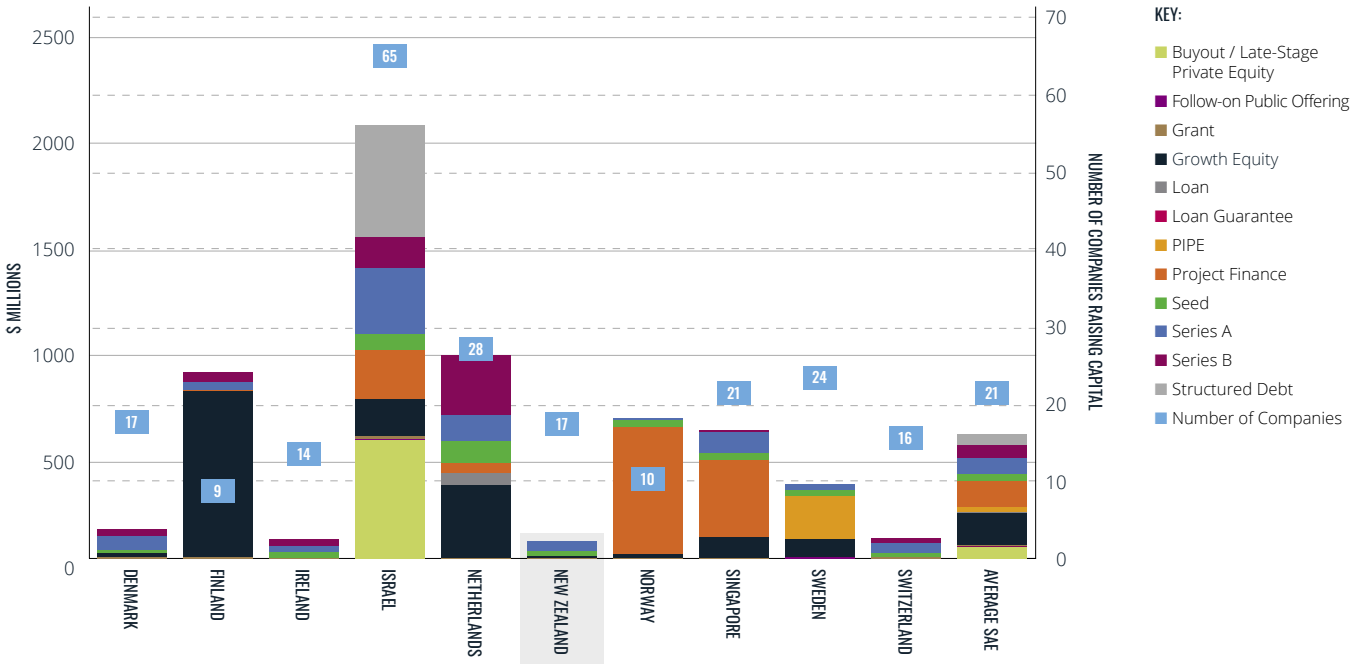
Figure 9: Funding Raised by Agriculture & Food Climate Tech Innovators in SAEs, 2011-2021



New Zealand's Agricultural Decarbonisation Moment

New Zealand has a unique position to innovate for low or zero-carbon agriculture, given its strength in horticulture and pastoral agriculture, but also its national emissions profile that places agriculture at the top of its sector emissions list as a result of New Zealand's agricultural output volume. Agriculture is New Zealand's primary source of GHG emissions, with 37.7 Mt CO2-*e* (48% of emissions) in 2018[2], and will feature prominently in New Zealand's push for net neutrality by 2050. New Zealand's agricultural emissions' profile is also unique among SAEs, at a level significantly above other SAEs, providing additional pressure for New Zealand innovators to accelerate the decarbonisation of New Zealand's agricultural industry within a small domestic market. These dynamics also place New Zealand in a position to be a one-of-a-kind agricultural decarbonisation laboratory.

Opportunities and Challenges for Innovators

Livestock

Methane gas accounts for 43% of New Zealand's gross emissions, coming from dairy cattle, sheep, and beef production.[2] Dairy cattle are a significant, and growing, source of emissions, accounting for 22.9% of all emissions (18.9%- methane, 4.1%-Nitrous oxide), and the dairy herd has grown 85.6% since 1990.[2]

Methane abatement in the livestock sector will be critical not only to reach 2050 net-neutral goals, but to maintain New Zealand's position as a high-quality agricultural products exporter as more synthetic (plant-based and lab-grown) meats become commercially viable.

Globally, the meat-substitute industry is shifting into a more central position in methane reduction targets, with net greenhouse gas emissions from the protein industry set to fall by 45% by 2030 through the move to more environmental sources of protein.[54] AT Kearney predicts that by 2040, up to 60% of the meat industry could consist of meat products made from alternative proteins, with cultivated meat comprising 35% and plant-based meat reaching 25%. New Zealand has produced some alternative protein innovators, such as Sunfed, who has raised capital from New Zealand and Australian-based investors and had distribution through several retail chains. However, New Zealand's innovation ecosystem is far behind those of even comparable economies such as Israel and the Netherlands in terms of demonstrated ability to launch competitive innovators in this space: meat-substitute innovators in Israel and the Netherlands received $167 million and $263 million in investment between 2011-2021 respectively, compared to $6.9 million for New Zealand innovators. While this area of innovation specifically may not be an obvious innovation priority for New Zealand, potential impact on meat sales it presents must be recognised. Meat exports are worth $5.3 billion to the New Zealand economy annually, 60% of export revenue. Competition from substitute products in global demand zones, especially as a part of low-emissions programmes, can threaten New Zealand meat exports. Even as the global consumer market expands, New Zealand would need to find angles to create cost efficiencies, driving down price for emerging markets, or flatten emissions from livestock in order to maintain market share in high-income countries. As a result, participating in or at least benchmarking against this trend is important for New Zealand to maintain a high-performing meat-export industry.

At the earliest innovation stages, the New Zealand Agricultural Greenhouse Gas Research Centre has begun carrying out in vivo testing for methane vaccines, ahead of other agencies experimenting with similar technology globally.[74] A methane vaccine, if successfully developed, could prevent 25-30% of enteric fermentation from ever occurring. Further downstream, New Zealand has recently produced innovators in alternative livestock feeds and additives, such as CH^4 Global, that aims to reduce up to 90% of methane emissions from livestock. For those innovators already operating in markets, the New Zealand innovation ecosystem presents two critical gaps: lack of adequate risk capital and lack of multinational corporation activity. Innovators in other active SAEs, such as the Netherlands and Switzerland, are accessing financing from agri-banks (such as Rabobank in the Netherlands) and able to work directly with feed multinationals in the home market (such as DSM, Nutreco in Netherlands and Syngenta in Switzerland). A critical challenge for livestock innovators in New Zealand is the lack of significant involvement in innovation engagement by domestic corporations, such as Fonterra.

New Zealand has been able to leverage a strong R&D base in livestock breeding and genetics to commercialise innovative products. Engender, a New Zealand start-up offering a gender-sorting technology based on research from nanotechnologists at the University of Auckland, raised nearly $6 million, an above-average amount compared with other innovators in the same technology area, before being acquired by New Zealand-based CRV Holdings in 2018. The breeding and genetics market globally is likely to be affected by AI-driven breeding-decision optimisation which, in some cases, may present cheaper alternatives to traditional genetic engineering but might also enable efficient processes and cost savings. The potential to leverage multiple technologies for genetics-based decarbonisation efforts presents a unique opportunity to develop a value chain around digital farm management and existing genetics and biotech capabilities.

	Opportunities	Challenges
LIVESTOCK	Triangulate optimal livestock methane abatement value chain between alternative feeds, digital livestock management, and an eventual methane vaccine (See Commit, Cluster)	Feed-additive companies and digital livestock management companies operating out of different R&D spheres. The earliest-stage development of underlying technologies happens in very different settings, i.e. in biotech and chemical engineering settings for feed additives and in computer science settings for IoT and digital technologies.
		Global markets are in a critical time period regarding GHG-abatement. Despite the potential impact of a methane vaccine, the time it takes to get to the rollout phase makes integration and marketing of a livestock methane abatement value chain critical even before the methane vaccine completes its multi-year approval process.
		In theory, New Zealand provides an innovation test bed for this suite of solutions. However, in practice, a lack of corporate involvement leaves the supply chain stratified, with too many low-value entry points for innovators.
	Approach alternative proteins as a complement to, not replacement for, livestock and meat. Leverage New Zealand expertise in crops and grains as feedstocks and capabilities in biotech to develop an alternative protein value chain (See Commit)	Will likely require an export-first approach to achieve levels of profitability necessary for industry players. Potentially contingent on a major trade deal like Israel Innovation Authority's 2017 deal with China for sales of lab-grown meat and emissions-reduction technology co-development.

Agricultural Digitalisation

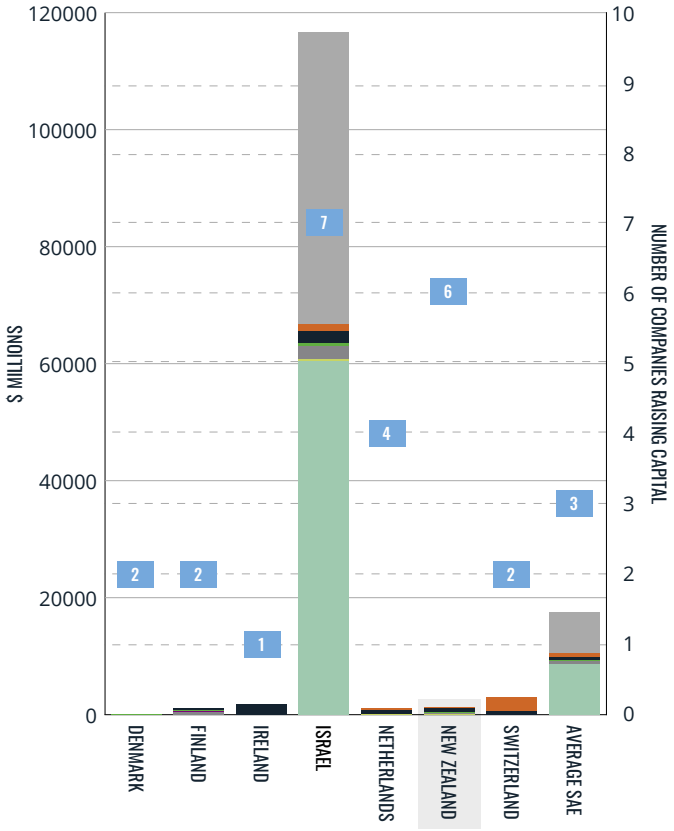
The ubiquity of artificial intelligence (AI), cloud computing, robotics, and drones are bringing about a wave of agricultural technology solutions with safety enhancing, loss-preventing, and cost-reducing capabilities in agricultural innovation clusters, such as the California Bay Area, Boston, Israel, and Switzerland. New Zealand is competing, too in agricultural robotics, livestock monitoring, and enabling software (device interoperability systems, cloud data analysis, signals processing, etc.). Within SAEs, Israel has been the leader regarding growth of innovative start-ups in digital agriculture. However, New Zealand innovators in agricultural digitalisation have raised funds at a level comparable to that of the SAE average.

In addition to having a domestic market with potential to gain traction, New Zealand has plenty of technical talent waiting in the wings to support growth in this area. In fact, New Zealand developers scored highest of 120 countries on a global coding proficiency assessment in 2019. In 2019 there were 8,605 full-time computer science and IT students in New Zealand universities.[14]

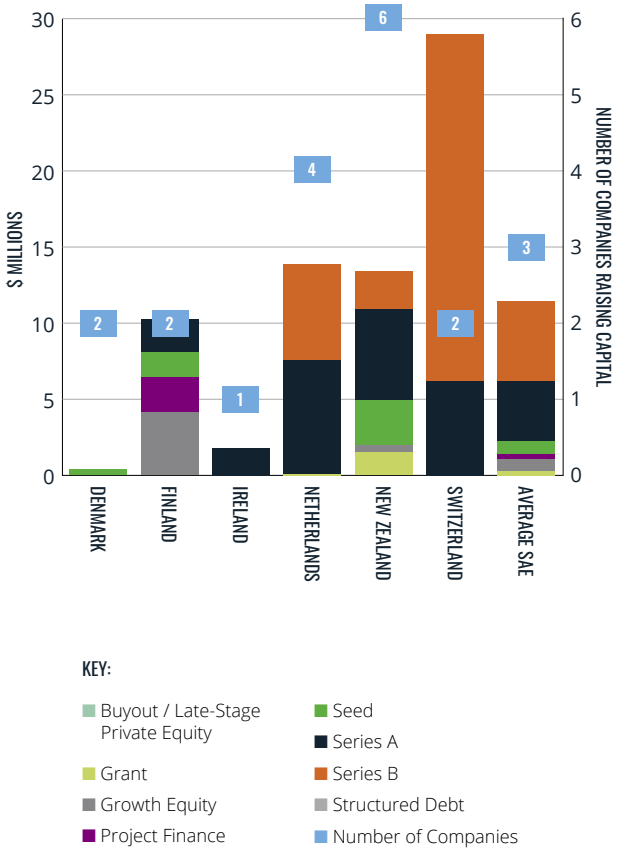
Globally, uptake of agricultural digitalisation technologies is likely still only at the beginning of an upward-facing trend, with labor shortages still reported as a challenge for farmers (55% of farmers surveyed in California reported experiencing labor shortages even before the Covid-19 pandemic). Additionally, the prices of underlying digitalisation components (data storage, cameras, sensors, signal processors) dropping year-by-year and the cost of data acquisition dropping as more providers of satellite and drone-generated imagery enter the market.[35]

Taking advantage of trends will involve getting the attention of corporations early, and for innovators, especially in New Zealand, to look beyond their own borders for corporate participation in financing rounds and pilot tests. An early example is that of Robotics Plus, which, in 2018, raised $10 million in seed funding all from Japanese Yamaha Motor, a capital raise similar to seed and Series A rounds of comparable international agricultural robotics companies. Important to this example is Robotics Plus's relationship with Global Pac Technologies, which has helped it achieve distribution throughout New Zealand, Australia, and the US. Patterns of innovation around agricultural robotics tend to place innovators in key robotics clusters (e.g. California, Massachusetts, Switzerland) and serving nearby local agricultural production markets. As a result, there is not a clear centre of global export for agricultural robotics, and New Zealand innovators will have to engage with international financiers and corporates early on to be able to compete in other innovators' home markets.

Figure 10: Funding Raised by Agricultural Digitalisation (robotics, software, drones) Innovators in SAEs, 2011-2021



Funding Raised by Agricultural Digitalisation Innovators in SAEs, 2011-2021 (excluding Israel)



Farm-management software innovation is expanding from traditional planning and workflow software to include comprehensive real-time monitoring, learning, and optimisation capabilities. Companies such as Gamaya in Switzerland are releasing drone-imaging and data-analysis products to create agricultural digitalisation stacks for customers to detect problems early and administer crop treatments with precision. This trend is likely to accelerate as more connected machines are able to make direct interventions in agriculture, such as fruit-picking robotics and crop-spraying drones. New Zealand innovators should seek out opportunities to form a unique New Zealand digitalisation stack that combines multiple solutions for planning, oversight, automation, and interventions on farms (including for livestock, through New Zealand innovators such as Halter). Value-chain integration is critical, especially to New Zealand companies who have not had large-scale adjacent industries to serve at home, the way that the Israeli drone industry has served defense customers, and the robotics industries in Switzerland and Boston have access to strong local talent markets, significant inbound talent flows to local universities and innovators generated by incumbents such as ABB and Boston Dynamics.

NEW ZEALAND INNOVATORS SHOULD SEEK OUT OPPORTUNITIES TO FORM A UNIQUE NEW ZEALAND DIGITALISATION STACK THAT COMBINES MULTIPLE SOLUTIONS.

	Opportunities	Challenges
AGRICULTURAL DIGITISATION	Create innovation support programmes to develop a New Zealand agriculture digitalisation stack that encompasses real-time tracking of livestock and/or crop growth, monitoring and management platforms, and precision interventions (See Cluster, Coordinate)	Lack of coordinated outbound innovation push, e.g. Swissnex in Switzerland that has made deliberate efforts to introduce Swiss drone technology into overseas markets.
		Drastically different levels of investment necessary to finance software and hardware solutions. Hardware innovators in New Zealand face challenges accessing adequate financing from domestic funds.
	Circulation of agricultural digitalisation technologies out of and into New Zealand through innovation outposts, i.e. find places for New Zealand innovators in foreign agricultural digitalisation value chains and vice versa (See Connect to Demand)	Attracting innovators from overseas into collaborations in New Zealand will require demonstrable engagement potential with farms' corporations. Current momentum does not support a defensible case for this.

Resilience and Circularity in Crops

Crops remain a critical area of innovation and innovation export potential for New Zealand; horticultural exports were valued at US $6.2billion in 2019, 79.6% (value) from specialty crops (kiwifruit, wine, apples)[34]. While the market for specialty crops has continued to grow and is expected to reach $1.2 billion by 2027[55], barriers for entry are dropping consistently as low-cost genetic editing technologies (e.g. CRISPR) have become increasingly accessible and expanded options for trait selection, potentially opening the door for more competition.

CROPS ARE AN AREA IN WHICH NEW ZEALAND INNOVATORS HAVE BEEN ABLE TO LAUNCH COMPANIES AND RAISE FUNDS AT AN ABOVE-AVERAGE LEVEL.

Crops are an area in which New Zealand innovators have been able to launch companies and raise funds at an above-average level, compared to other SAEs, partially a result of strong agricultural research labs in New Zealand and the presence of early-stage financiers active in agtech investments. Developing a low-emissions value chain will require a multi-pronged effort of reducing crops' vulnerability to natural threats (pests, weather pattern changes), reducing or avoiding fertiliser waste, but also developing circular inputs to agriculture, potentially making use of waste streams from other industries.

A case of highly niche New Zealand innovation in crop circularity is that of Hot Lime Labs, which has developed a compartmentalised system for gasifying (converting biomass to gas) wood waste from forestry and capturing CO2 from the product. The company's technology allows CO2 to be pumped into greenhouses, all while recovering heat from the process to warm the greenhouses at night. This is an example of industrial symbiosis between two prevalent New Zealand industries (forestry and horticulture) that is created by an entirely unrelated discipline (carbon capture engineering, materials engineering) and acts as an impact reduction multiplier (reducing forestry waste as well as chemical and heat inputs to horticulture).

RESILIENCE AND CIRCULARITY IN CROPS	Opportunities	Challenges
	Develop niche expertise in precision farming for New Zealand's highly-demanded crops: kiwifruit, grapes, and apples. Focus efforts on export markets for technology sales where crops sales are captive to a competitor (See Commit)	Existing crops sales channels will likely hit a limit. Sustained agricultural innovation will eventually require development of a new set of supply-chain relationships to sell technology and not agricultural products into some markets.
	Promote value-chain efficiencies between precision agriculture technologies and agricultural digitalisation to develop a New Zealand model of low-impact, high-yield crop farming to be exported to overseas markets (See Cluster, Coordinate)	Precision crop treatment technologies are highly competitive in countries with strong pharmaceutical and heavy-machinery industries. The cost savings and efficiencies offered to demand owners would need to represent step-changes for demand owners.

Suggestions for the Agriculture & Food innovation ecosystem

- Launch New Zealand agritech innovation outposts in key global markets – these outposts should be tasked with both observing and promoting innovative agricultural technologies (Connect to Demand)

  - New Zealand innovation outposts should be in regions with significant demand ownership and innovation supply, such as the California Bay Area, ShenZhen (China), the Netherlands, and Israel.

  - New Zealand agritech should be promoted alongside agricultural products where markets are receptive, but separate promotion efforts should be made for technology irrespective of New Zealand agricultural exports' place in the deal.

  - The innovation outpost should actively engage agritech innovators in overseas markets in order to a) feed observations on agritech capabilities overseas back to New Zealand innovation agencies and b) identify collaboration and value-chain integration opportunities with overseas innovators (e.g. Japan's JETRO efforts to coordinate Japanese corporate innovation outposts in Silicon Valley).

  - Teams in outposts should be tasked with identifying co-financing and technology-development programme opportunities with states and regions that are similarly supporting agritech, i.e. do not seek to replicate, but to plug innovators into innovation ecosystems where possible (e.g. the EU's Startup Europe Comes to Israel, and Low Carbon Business Action Canada).

  Create a specialised entity for agricultural digitalisation – over and above supporting existing programmes, such as Callaghan Innovation's Horticulture Automation Catalyst – form larger-scale entity with ability to support both innovation and connection to demand (Commit, Coordinate)

  - Task the entity with creating an agricultural digitalisation plan that involves setting targets for cost, process, and resource efficiency, and support innovators with ability to reach those metrics.

  - Create a panel of advisors by actively seeking input of major global agricultural demand owners, and pulling in corporations and large groups of farms to support the entity.

  - Offer robust corporate participation opportunities, such as public-private research opportunities, financed project pilots. Foster competition between innovators within the entity and do not favour domestic corporations over overseas options.

  - Aim to create a catalogue of digital solutions for agriculture developed in New Zealand, and compatible with digital infrastructure (sensors systems, cloud platforms) globally, that can be actively promoted to demand-owning countries systematically.

  - Work with a similar innovative region that has a comparable interest in advancing supply and accelerating demand for agricultural digitalisation technologies to raise an investment fund that supports underlying technologies (e.g. the Israel-Colorado Innovation Fund that finances artificial intelligence for water, agriculture, energy, and circular economy).

- Create intentional programme for adjusting to the rise of alternative proteins – pursue low and zero-emissions agricultural processes to circumvent export markets' concerns over emissions content (Commit, Cluster)

- Include genetics and livestock-management innovators in methane-reduction programmes Market the New Zealand ecosystem as a development zone for multinationals and global corporations to test their low-emissions agriculture innovations (especially around livestock) and later 'import the New Zealand model back to their home countries.

  - Consider how the methane-abatement ecosystem model can support development of a future market for methane vaccines, i.e. help other markets develop enough momentum so that the methane vaccine is relevant as one of the final steps to livestock methane abatement.

PURSUE LOW AND ZERO-EMISSIONS AGRICULTURAL PROCESSES TO CIRCUMVENT EXPORT MARKETS' CONCERNS.

Digitalising Energy Decarbonisation

Critical to New Zealand's success in progressing toward a net-zero carbon target has been its significant carbon abatement in the energy sector, New Zealand's second-largest source of emissions, with 31.9 Mt CO2-*e* (41% of emissions) in 2018.[2] New Zealand has achieved 85% completion of its 2035 target to derive all electricity from renewable sources, geothermal (17%) and hydroelectric power (60%) account for most renewables deployed.[4] At the same time, New Zealand is among the most energy-intensive OECD economies.[63] Energy-related emissions are rising, driven by increasing energy use and automobile transport.[64] The large proportion of hydroelectric generation means the production is dependent on fossil-fuel substitutes in times of drought.[64]

Energy usage is a component of nearly every industrial process and economic activity, so developing a comprehensive and exportable climate tech value chain will require some level of emphasis on energy innovation in New Zealand. Although many of New Zealand's current innovation activities in energy have received a recommendation of "Evaluate" or "Explore" in this analysis (see Figure 7), leveraging the right synergies between multiple innovation activities may open space for better problem-solving capabilities.

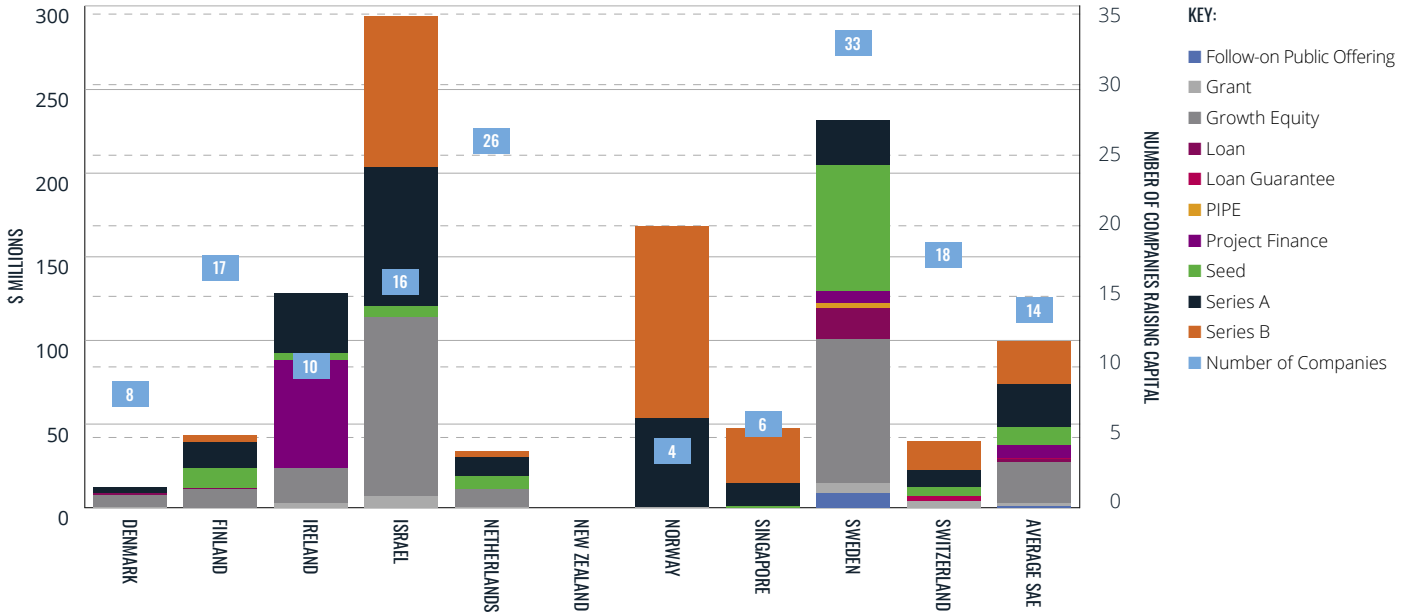
New Zealand's access to unique energy sources (namely geothermal and hydroelectric) enable it to develop novel models of energy innovation, as well as innovation in industrial sectors able to capitalise on this access. Likewise, New Zealand's innovation ecosystem can differentiate itself based on niche approaches to leveraging geothermal for the build-up of low-emissions micro-economies, systems of local industries and companies that collaborate in an industrial symbiosis model.

Making New Zealand energy and materials innovation successful on the global stage will, again, involve developing a value-chain approach to improving innovators' potential to grow at home and promoting them overseas, once matured to a stage that allows for mass scaling.

New Zealand's unique position as a nation that has achieved high-majority renewables penetration removes some pressure for businesses and consumers to decarbonise their energy usage, but it does create continued opportunities for cost savings through energy efficiency – businesses account for 48% of non-transport energy usage in New Zealand.[15] Energy-efficiency solutions encompass sensor and software systems e for tracking energy use at granular levels in commercial buildings and homes, that can be sold to businesses and individual consumers to support energy-use choices.

At the global level, building energy efficiency is expected to become a $122 billion market by 2024 and, while most of the investment toward energy-efficiency technologies is still concentrated in the San Francisco Bay Area, energy efficiency technologies are being successfully developed and marketed globally by SAE-based companies.

Figure 11: Energy Efficiency Fundraising and Funded Companies in SAEs (2011-2021)



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New Zealand has seen some initial activity from power companies and corporates in the energy-efficiency innovation ecosystem, for example Lightning Lab Electric support from General Electric, Westpac, and Genesis Energy.[5] But is noticeably absent among peer SAEs regarding companies receiving investment in the sector.

An instructive case lies with the example of Israel, which leveraged strengths in adjacent technologies but has also taken a coordinated approach to connecting Israeli energy efficiency technology to key markets. While Israel has a significant hardware and especially sensor development base to build an energy efficiency industry off, software has played a pivotal role in the industry's development as well: over $300 million was raised by 60 Israeli energy efficiency companies since 2011, with $157 million from 23 companies in software. While to some level, clustering the development of these multiple technology components together is creating success for the overall industry, the Israel Export & International Cooperation Institute and Ministry of Economy collaborated in 2019 to create the "Israeli Innovation for Energy Transition 2019" catalogue of innovators. Through this catalogue, the two departments built a diverse offering of Israeli technology solutions to energy efficiency problems, that could not only be engaged directly by a demand owner, but could be put together, forming a cohesive suite of technologies to enable an energy efficiency step-change. A mix of local market (commercial developments – Phoebus Energy) and international customers (McDonald's, Sprint, IBM – Panoramic Power) have engaged Israeli energy efficiency start-ups for technology solutions, and multinational collaboration with Israel Electric Corporation has yielded energy efficiency spin-outs (e.g. Fsight). A result of this dynamic is that Israeli innovators can create products for the global market through the local ecosystem, and the industry has potential to be sustained long-term by continued launch of new innovators out of R&D pipelines and corporate spin-outs.

An additional energy-efficiency market is the consumer smart home efficiency market. New Zealand enjoys a high penetration of renewables (~85%[6]) and high level of smart meter uptake in New Zealand homes (estimated 70-90%[5]), and while the global market for home energy efficiency is much smaller than that of commercial energy efficiency, there are technological approaches that can be carried over from the home energy efficiency market.

Sweden has successfully marketed its home-grown smart-home energy solutions to neighboring markets. Swedish start-up Eliq, for example, entered the Norwegian market through a collaboration with Innlandskraft, and into the UK with Bristol Energy. Like New Zealand, Sweden has a high penetration of renewable energy (54%) in homes, Sweden has leveraged adjacent capabilities in microgrids and district heating

	Opportunities	Challenges
DIGITALISING DECARBONISATION	Develop a value chain around green digital finance, including microloans and digital payments systems that allow customers to deploy a suite of resource-use reduction and impact tracking products to networks of users (See Commit, Cluster)	Business models for energy efficiency and personal emissions tracking require strong networking effects and channels tend to exist through corporations (power suppliers, real estate companies, banks).
	Integrate with resource-specific and industry-specific technologies (see industrial symbiosis) to form high-value energy efficiency hardware and software stacks in niches (See Coordinate).	Target markets overseas will have significantly larger markets and New Zealand innovators will still likely need to compete for the niches.
	If an agricultural digitalisation value chain is pursued, there would be opportunities to serve energy efficiency customers along the agriculture supply chain, strengthening the New Zealand agricultural digitalisation suite of solutions (See Commit, Cluster, Coordinate).	Energy efficiency companies will undoubtedly compete with some aspects of agricultural software companies' energy use reduction value proposition.

POTENTIAL NEW ZEALAND ADVANTAGES IN THIS SEGMENT LIE IN A GROWING WORKFORCE OF COMPUTER SCIENTISTS.

to create a baseline market for home energy efficiency, with a "prosumer" higher-end class that innovators of new technologies can market to.

Although operating in a much larger home market, the US State of Colorado offers an example of how to build an energy efficiency ecosystem outside of a major software hub. As the home to National Renewable Energy Laboratory (NREL) and Rocky Mountain Institute (RMI), Colorado serves as the de facto energy transition research capital of the US. These national labs serve as a magnet for talent and R&D commercialisation (e.g. NREL IN2 incubator residential housing innovation programme). Efficiency is being addressed by innovation at all levels, including investments of nearly $2 million invested into university energy efficiency engineering programs in Colorado Office of Energy Efficiency & Renewable Energy[3], a multi-layered ecosystem of energy efficiency innovation can be observed in Colorado. Nationwide, US power companies and global energy-service corporations are purchasing technology solutions and forming partnerships with Colorado-based innovators and, perhaps more significantly, Colorado energy efficiency companies have grown large enough to carry out regional mergers and acquisitions (e.g. Tendril and Simple Energy merger into Uplight).

New Zealand has seen some initial traction in digital entrepreneurs solving problems for overseas customers through personal emissions tracking software products. New Zealand innovator CoGo (Connecting Good) has signed up 20,000 customers to their carbon footprint tracker and are prepared to roll out the solution to hundreds of thousands of New Zealand-based customers, through a partnership with Westpac NZ. CoGo has crossed the difficult threshold of addressing international consumer carbon footprint tracking needs through a partnership with Natwest in the UK, along with research and talent partnerships with University of Leeds and University of Lancaster for long-term growth in the UK.

Potential New Zealand advantages in this segment lie in a growing workforce of computer scientists. However, significant difficulties lie in the relatively small size of the domestic market and lack of major financial/retail incumbents. Any long-term success in this sector will require innovators to be able to plug into a broader fintech ecosystem and have access to a talent pipeline skilled in launching and managing large software companies.

Suggestions for New Zealand's Energy Efficiency and Carbon-tracking Ecosystem

- Work to concentrate development of energy digitalisation around New Zealand's centres of R&D expertise– the energy transition cluster in Colorado has been developed mostly around the gravitational pull of NREL and RMI but now is dynamic enough that start-ups can launch, raise funds, grow, and, in some cases, even be acquired in Colorado. (Cluster)
- Most of the world has not achieved the same level of renewables penetration as New Zealand, New Zealand innovators should be encouraged to pursue opportunities to carry out pilot tests and experiment with data from overseas customer bases where energy costs for customers may be a more pronounced pain point. (Coordinate, Connect to Demand)
- New Zealand is an ideal testing location for energy-efficiency companies that want to experiment with 'top-of-the-pyramid' energy efficiency and personal carbon-reduction customers, i.e. those customers with enough capital and motivation to address their hardest-to-abate carbon emitting activities. This applies to both business-to-business and business-to-consumer innovators that want to perfect digital solutions for "post-net zero" economies. (Coordinate)
- Like Israel's capitalisation on the sensors and tech hardware advantage to pursue energy efficiency technology, consider areas in which New Zealand innovators have potential to solve energy issues (e.g. geothermal innovation, agricultural industrial symbiosis) and direct energy efficiency or emissions digitalisation to those sectors best addressed by adjacent New Zealand innovations. (Commit, Cluster, Coordinate)
- Digital uptake is most likely to occur in areas of supply chains that are already technology-enabled. As a result, innovators will have more receptive home-market customers in geographical areas already engaging digitalisation. A dynamic digitalisation ecosystem may be built around agriculture, using the operational efficiency technologies discussed in Agricultural Digitalisation above, but also complementing these with agriculture-focused energy efficiency solutions for agricultural facilities and digital finance products for farmers. (Commit, Cluster)

Capitalising on Circularity in Energy and Materials

Central to innovating for sustainability is maintaining an underlying principle that by-products are better re-used, or never created, than managed. As a result, many of the sustainability technology fields with the most significant global uptake are predicated on business models that off-take (receive) resources from one business and make use of them elsewhere.

While New Zealand does not have the heavy industrial and corporate ecosystems out of which innovation ecosystems typically tend to emerge, New Zealand does have the unique advantage of being able to access geographically-limited sources of renewable energy such as geothermal and hydroelectric power. New Zealand also has strengths in operating natural resource-dependent industries, such as forestry and agriculture. With the emergence of innovators in waste-to-value concepts as well, there is a case to be made to embrace industrial symbiosis in New Zealand as an enhancement not just to local industries but also to sustainability innovators.

Industrial symbiosis is a concept pioneered in the late 1970's by the city of Kalundborg, Denmark, in which a systematic network of heat, water, energy, and materials exchanges are facilitated across dozens of businesses for a circular industrial cluster. Industrial symbiosis concepts have sprung up around the world since, with notable presence in SAEs aiming to leverage unique local resources, such as the Norrköping Industrial Symbiosis Network in Sweden built around an E-On combined heat and power plant and Svensk Biogas plant and the HS Orka Resource Park, centered around a geothermal resource, in Iceland. New Zealand, too, is innovating in industrial symbiosis, leveraging resources such as biomass from wood processing and geothermal at Kawerau in the Central North Island of New Zealand.[66] A similar concept of energy asset repurposing is currently the subject of a $2 million feasibility study between Meridian and Contact Energy: the two companies are exploring potential for a hydrogen production facility as an off-taker of hydropower once the Tiwai Point aluminum smelter on the South Island comes offline.[268]

Geothermal

New Zealand has reached 85% of its 2035 target to derive all electricity from renewable sources, chiefly using geothermal (17%) and hydroelectric power (60%).[4] Energy-generation innovators typically expand primarily through partnerships with utilities, power companies, and energy service companies (ESCOs), but geothermal energy's geographic restrictions also often requires that innovators form partnerships in industrial value chains as well. New Zealand innovator Geo40 is an example of an innovator that presents both operational efficiencies and resource circularity to clients – recovering silica from geothermal reinjection fluid for reduced operational expenses and selling the silica by-products on international markets. Geo40 has partnered at different levels of the value chain with international companies, including with leading Swedish innovator Climeon to improve the cost-effectiveness and emissions-reduction properties of Climeon's Heat Power Modules. Miraka, a Māori-owned firm in New Zealand's central North Island, processes up to 250 million litres of milk per year using geothermal energy. Both companies are examples of the potential to maximise circularity within New Zealand's energy industry, but also in adjacent industries, and build a unique operating advantage around geothermal resources as a production asset.

Wastewater Treatment

Wastewater treatment, one of the turnkey segments in the industrial symbiosis technology stack, is driven by innovations that reduce energy usage, discharges, and materials usage. In other words, wastewater treatment innovation requires multidisciplinary technology innovation to achieve the step-change process efficiencies and capacity expansion that demand owners need, and with the complexity to address increasingly challenging water scarcity issues. Despite being considered a 'water-rich' nation, New Zealand has already seen global uptake of some of its wastewater treatment innovations. For example, Derecto, a New Zealand energy management for wastewater innovator, was acquired by Suez Environmental (France) in 2014, and Auckland-based osmotic technology innovator, Aquafortus, announced a 2020 joint venture with Warren Buffet-backed Pilot Corporation to deploy its technology in the US oil and gas sectors.

Globally, wastewater treatment is estimated to have a market size of $54.6 billion globally, and continue growing at 6.1% through 2045, driven in large part by the compounding issues of increased water scarcity and commitments by corporations to reduce energy use.[67]

Given the integrated nature of wastewater treatment (existing as a component in larger municipal or industrial processes), value-chain efficiencies are critical, and examples can be drawn from other SAEs that have been able to significantly scale wastewater treatment innovation beyond their borders. Sweden, for example, has a long history of operating wastewater treatment systems, dating back to the 1930s, and continues to fund specialised research in wastewater treatment, through the Sweden Royal Institute of Technology. Swedish innovators have cropped up across the supply chain; in technologies for electrochemical water treatment (Stockholm Water Technology), digital water-saving technologies (Aqua Robur, Xylem), and consumer-facing devices (Orbital Altered). There are also coordinated efforts by the Swedish government to promote Swedish wastewater treatment technologies to the rest of the world through Swedish Cleantech, a state-funded export platform that is a part of Smart City Sweden. The Swedish Cleantech portal contains a list of 146

Swedish water and wastewater innovators, with functions to directly contact the company. In addition, the agency regularly hosts technical delegations to actively promote innovators to overseas demand owners.

Israel is a leading example of a country that has transformed itself from a water-stressed nation to a water management innovation powerhouse, reusing almost 90% of its wastewater. Since 2000, the Israeli government has invested more than $750 million into centralised water reclamation, spurring a domestic industry.[68] Much of the country's water management is centralised with national water company, Mekerot. Mekerot actively seeks the participation of innovators in its projects, collaborating directly with digital water management and quality testing start-ups as well as working with Microsoft Startups for Israel to open an accelerator and establish conduits into real-world testing for innovators.[69] Israel's wastewater innovation ecosystem has seen more than $1.4 billion worth of transactions since 2011, between Israeli demand owners and Israeli start-ups, innovators and global demand owners, and between overseas innovators and Israeli demand owners (e.g. Israel Chemicals Limited aka ICL and Swedish wastewater treatment innovator Tiami). Israel has transformed itself into both a testbed and launchpad for wastewater treatment innovators, domestic and foreign, that seeks to solve challenges associated with creating leading-edge solutions. Israel has also focused on forging direct connections with global demand and supply hubs, for example with Colorado through the Israel Colorado Innovation Fund with Innosphere Ventures, the fund invests in technology for water, agriculture, industry 4.0, and transportation.

Waste-to-value

While data from the World Bank suggests New Zealand may be a substantial waste producer (as a ratio to GDP size[269]), the level of industrial waste streams are not well understood due to a lack of data.[61] However, local industries such as steelmaking, aluminum manufacturing, and mining are all sources of feedstock for waste-to-value initiatives. In Auckland, construction and demolition waste is estimated to make up around 40% of all waste going to landfill.[65] Moreover, the primary means of waste disposal is landfill, and these are significant sources of GHG emissions, despite the use of gas capture systems.[65]

Emissions from manufacturing industries and construction accounted for just under 18% total New Zealand emissions in 2018.[56] Industrial waste streams from these sectors provide feedstock for waste-to-value initiatives including carbon capture and use (CCU), capturing carbon at point source from industrial processes, and mineral recovery. Partnerships with waste stream owners are vital to secure supply in this area.

On the demand side, the level of success differs by type of usage. The construction industry is slow to adapt, which provides a challenge for innovations such as cement and concrete substitutes. On the other hand, minerals and advanced composite or nanotech materials may command a price premium if the technology is sufficiently differentiated.

New Zealand's location means innovators face additional questions about the appropriate business model. Technology licensing may be more appropriate given the climate costs of transporting heavy products. Indeed, New Zealand has produced innovators competing at high levels in the circular economy, for e-waste (Mint Innovation) and heavy industrial processes (Avertana); both companies have raised funds at levels on par with, or ahead of, comparable companies in other SAEs. Perhaps the best-known example of waste-to-value innovation scaling out of New Zealand is LanzaTech, which grew to become one of the world's leading point-source carbon capture-to-value companies, but eventually relocated headquarters to the US in order to be closer to demand owners. Preventing further cases of company relocation or ensuring that similar companies maintain a sizeable New Zealand presence, will require that the ecosystem prioritises creating promotion channels for the technology exports and licensing, so that innovators do not need to engage trade-offs between accessing waste sources and paying off-takers, and maintaining a meaningful presence in New Zealand.

The ecosystem can take further inspiration from Iceland, whose entrepreneurs have looked outwards to find customers and development partnerships. An example from Iceland is that of the Icelandic innovator Carbon Recycling International's partnership with Henan Shuncheung Group, which, upon completion will capture 160,000 tons of CO2 per year, equal to the emissions of nearly 60,000 cars.[270] Technology export opportunities may be found in Asian countries with high waste production and limited existing industrial waste processing infrastructure.

Suggestions for the Industrial Symbiosis Ecosystem

- Embrace the Māori waste avoidance philosophy and whole-of-ecosystem systems thinking to identify opportunities for industrial symbiosis testing, research, and eventual development of technological models that can be promoted to export markets. (Commit)
- Explore latent (or active) Māori industry innovation and potential use around the technologies discussed in this section. Identify opportunities to infuse the Māori approach into future innovation efforts and make deliberate attempts to plug innovation into Māori industries that maintain a waste avoidance guiding philosophy. (Commit)

- New Zealand geothermal innovators should consider where their solutions add a unique value to production inputs or other downstream applications and form partnerships that can open new markets – the ecosystem should identify not just companies, but industrial processes that geothermal can power (e.g. food processing) and adjacent power sources (e.g. wood biomass from forestry) that can be piloted in geothermal sites, offering the opportunity to export a New Zealand model of industrial development around geothermal sites. (Cluster, Coordinate)

- Geothermal is a sector that New Zealand companies seem to be able to access capital in, on a level like that of peers overseas. Multilaterals (e.g. Breakthrough Energy) are investing globally in the geothermal space. The value for investors is that New Zealand-created geothermal technologies (including waste heat) can be developed, piloted, and deployed in New Zealand. (Connect to Demand)

- In wastewater treatment, identify industrial challenges that sit at the nexus of water efficiency, energy efficiency, and process efficiency (ability to address volume and improve speed), make concentrated efforts to zero in on these problems through challenges organised by New Zealand investors, government, and ideally global multinationals in New Zealand. Make challenge goals big and seek to induce multiparty pursuit of step-changes that can motivate overseas demand owners to engage New Zealand suites of solutions or invest directly in the ecosystem. (Commit, Coordinate)

- If executed upon, use the South Island hydrogen facility not just for production, but also for pilot testing and demonstration of hydrogen production and hydrogen use innovation. Pull in multinational corporates to issue challenges at the testing facility and invite global innovators to use facilities and participate in challenges.

	Opportunities	Challenges
ENERGY & MATERIALS	Granular technologies are more likely to be noticed by export markets when part of a value chain solution – think the Israeli energy efficiency for energy transition catalogue and Swedish Cleantech's strategy of presenting technology suites as a tactic to achieve big-picture sustainability strategies of industrial corporates and governments with similar industrial fabric and geographic conditions to New Zealand. (See Commit, Cluster, Coordinate, Connect to Demand)	Will require coordination across multiple R&D disciplines, multiple industries, and with overseas demand owners. Achieving the desired effect will require government promotion efforts, but also efforts to infuse demand owners' priorities into the beginning loop of R&D prioritisation.
	Leverage New Zealand's unique geographic position and resources to welcome overseas innovators to experiment with and pilot new technologies. (See Coordinate, Connect to Demand)	Benefits are obvious for the private sector but allowing foreign participants in government-funded or even government-guided innovation programmes is often controversial. A comprehensive and long-term forward-facing plan would need to be developed to express the benefits to stimulating and maintaining innovation in the given technologies through such an exercise.
	Forge links with high need – highly experimental wastewater clusters, e.g. Israel, UK, California, Texas. Look to innovation clusters with similar goals and challenges regarding wastewater and consider co-financing acceleration (e.g. Israel-Colorado Innovation Fund water programme). (See Coordinate, Connect to Demand)	The lack of multinationals headquartered in New Zealand leaves most investment with domestic venture capital funds, which, while potentially motivated to partner with other investors, may not have the requisite funds to support comprehensive cross-border innovation.

Advanced Materials for Green Building and Construction

Low carbon construction materials include low carbon cements, concretes and concrete substitutes such as timbercrete, hempcrete and clay-based materials. Clinker production accounts for the largest share of cement emissions, and alternative cement formulations may substitute clinker with fly ash, pozzolan, slag derivatives or other materials. Geopolymers may be used in both cement and concrete as a low-carbon substitute ingredient. This section focusses on materials destined for end-use in the construction industry, but there is some overlap with waste-to-value (covered in a subsequent section) as increasingly, construction materials carry a proportion of waste-derived material.

The global cement and concrete products market is forecast to grow at a CAGR of 7% between 2020 and 2025, and over one third of global demand is in the Asia Pacific region.[57] Adoption of low carbon cement and concrete is driven mostly by regulation. Concrete substitutes are still mostly at proof-of-concept stage and market size and decarbonisation impact will become clearer as models are defined. Other interesting construction trends are advanced manufacturing (3D concrete printing) – currently experiencing market growth of 100% per year, albeit from a small starting point – and industrialisation of the construction process, often using timber as a construction material. While timber is a promising low-carbon construction alternative with some growth potential, deployment at scale will ultimately be limited by availability of exploitable forest growth.

On the demand side, the conservative nature of the construction industry hinders adoption of innovative products and solutions. Successful companies have prior construction industry experience, which helps them engage with contractors and talk the same language. New Zealand's Green Star certification is a promising demand-side support, especially when combined with local incentives such as reduced development costs for certified buildings. Public procurement, based on Environmental Product Declarations and embodied carbon limits, is another mechanism for kick starting demand.

Building codes, regulations and standards, which may not have been updated for recent materials developments, present a second barrier to adoption. CyBe Construction, a Netherlands-based 3D printing company (and partner of Hamilton-based innovator Qorox) has created a global community to facilitate adoption of their solution.[58] Construction companies discuss how to ensure compliance, sharing tips between regions with similar requirements, for example earthquake-resistance.

SAEs generally do not show strong investment activity in green construction, except for Norway, which has invested around $80m over the last ten years, of which $50m went to sustainable wood producer Kebony.[31] In Finland, Tekes and VTT provide early-stage funding for sustainable construction innovation but have not yet produced innovation at scale. Denmark's Create SDU researches additive manufacturing in architecture, and DTU FABLAB allows students to experiment with 3D printing equipment. Denmark has taken a particularly proactive approach in additive manufacturing for construction with the Green Transition Fund, which funded an initial investigation into world best in class techniques. Danish 3D construction innovator Cobod was a result of this initiative.[58] The Danish government also employs a corporate matchmaking program which allows startups to meet potential partners and investors.

While not an SAE, France has been successful in developing a vibrant early-stage ecosystem for construction startups, through a combination of financial incentives and construction or concrete focused accelerators. Corporates such as Lafarge Holcim, Bouygues Construction and Vinci Construction also actively invest and partner with innovators.

Israel has also demonstrated a proactive approach in developing the construction-focused startup ecosystem. Until recently, Israeli construction sector startups were found only in hi-tech subsectors such as robotics and VR/AR. The Contech 'Construction Innovation Zone' was founded with the goal of turning Israel into an international leader and attractor-point in the construction tech and real estate tech sectors. The organisation connects innovators with contractors, developers, corporates, regulatory bodies, policy makers and investors. It also invites international delegations to Israel to discover new startups and develop funding programmes and accelerators in partnership with international corporates. The number of active startups tracked by the initiative has increased from 60 in 2018 to 175 in 2020, with an overall increase in startup activity of 800% over the last four years.[59] Startups are grouped based on position in the value chain, allowing stakeholders to engage with solutions along the construction lifecycle.

	Opportunities	Challenges
MATERIALS	Promote innovation along the whole value chain, either through industrialised models or by creating collaborative solutions with innovators along the building lifecycle. Target export markets with need for end-to-end solutions combining value with speed and environmental benefits.	New Zealand's geographic location means product / machinery exports may not be the best option in terms of emissions intensity. For in-situ production, product formulations may need to be adapted according to local availability of raw materials.

Productising Low-impact Consumer Goods

Globally, zero waste products have increased in popularity in recent years, due partially to increasing response from the public against climate change but also improvements in the quality of products coming from companies employing differentiated production techniques. The zero-waste product industry already has a large market and wide commercial availability on a global scale, especially through consumer packaged goods (CPG) sales channels in North America and Europe, with many corporates engaging waste reduction techniques and products in consumer goods and food.[72] New Zealand is already ahead of most advanced economies with regard to uptake of waste reduction in consumer retail, as an example, from July 1st, 2019 single-use shopping bags were banned in New Zealand.[70]

While the size of the New Zealand market is an ever-present challenge to innovators, low-impact consumer goods is one area in which the local customer base can serve as a true-north indicator of potential uptake in export markets. Bioplastics, biomimicry, and natural textiles are all potential opportunity areas for New Zealand innovators to innovate with the guidance of the local market, which in this case, can act as an indicator of demand owner preferences.

The New Zealand biotechnology research and talent community creates a base knowledge pool from which bioplastics can be innovated. Indeed, some biomaterials innovation commercialisation can be observed through cases such as Aduro Biopolymers, a University of Waikato spinout company. One critical challenge facing bioplastics innovators is the lack of a dynamic recycling ecosystem in New Zealand, which blunts motivation to innovate for new recycling models and keeps demand owners complacent. A contrast would be Germany, where high rates of recycling are mandated, bioplastics innovation is being supported by the German Federal Ministry of Food and Agriculture.[272]

Some New Zealand innovators are finding success in developing products that circumvent waste altogether, such as Ethique, a personal care brand that produces solid products without any need for bottles to begin with. Perhaps most notable, though, is AllBirds, the pioneer in wool-based sneakers that set a global trend followed by dozens of large shoemakers after them. AllBirds is an example of a company that crossed over between industries (livestock raising and fashion) to develop a distinct advantage around New Zealand resources that significantly reduces environmental impact (production requires 60% less energy than materials in synthetic shoes) and captures global consumer attention. Allbirds has raised over $202 million and is selling products in New Zealand, North America, Europe, and China.

Further developing novel production methods around sustainable consumer goods will likely require efforts to innovate toward demand owners from the research-level up. Take for example, the Swedish Energy Authority's RE:Source Innovation Program, that supports R&D of resource-efficient textiles and has produced successful innovations built around novel production methods, such as Renewcell, a textile-to-textile recycler that has developed patented production technology and has listed on the Swedish stock exchange.

	Opportunities	Challenges
CONSUMER GOODS	Key driver of sustainability in consumer goods and textiles is reduction of plastics. Novel production techniques, and development of products that remove the plastic need are a potential niche for New Zealand innovators to explore. (See Commit)	Capex for consumer goods is especially high, given the need for a comprehensive supply chain and physical production facilities. Innovators will need to look beyond New Zealand for requisite financing.

Suggestions for the Low-impact Consumer Goods Innovation Ecosystem

- New Zealand has critical supply chain elements (natural raw materials, production scrap). Value chain effects should be explored with agricultural production, i.e. where New Zealand bioplastics innovators can partner with local agricultural producers to develop unique approaches to bioplastics production (e.g. Lactips' use of caseins for packaging material in France[271]). (Cluster).

- Look for opportunities exist for co-location of agricultural / dairy production and bioplastics production. Consider establishing coordinated pilot-testing zones for innovators crossing over between the two industries – for New Zealand innovators but also for overseas innovators testing technologies and production methods. (Cluster, Coordinate).

- New Zealand is the 4th largest producer of wool globally, with an existing success case in wool textile products. The ecosystem should push for synergies with the agricultural and even robotics industries to develop novel production techniques and develop capabilities around turning wool into new products, not just supplying wool. (Commit).

- In natural textiles, there is no clear winning innovation ecosystem, the critical relationships are with brands and retailers, most of which will reside overseas. Promoting New Zealand textile innovators to global accelerators, e.g. Factory45 (global, online), Fashion for Good (Netherlands), Plug-n-Play Sustainable Brands (US). (Connect to Demand).

- Biggest challenge for the ecosystem will be on access to the major consumer goods incumbents (i.e. potential licensors and acquirors of technology) and global brand recognition. (Connect to Demand).

  - Capabilities around inbound logistics (procurement, management of materials) and low-impact production can provide opportunities for innovators in this sector to expand backward in the value chain, acquiring sources of natural raw materials, or to developing standalone products (as Ethique has).

  - Strong export promotion push will be necessary given the size of the home market.

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NEW ZEALAND CLIMATE TECH FOR THE WORLD

Appendix 1
Energy & Power

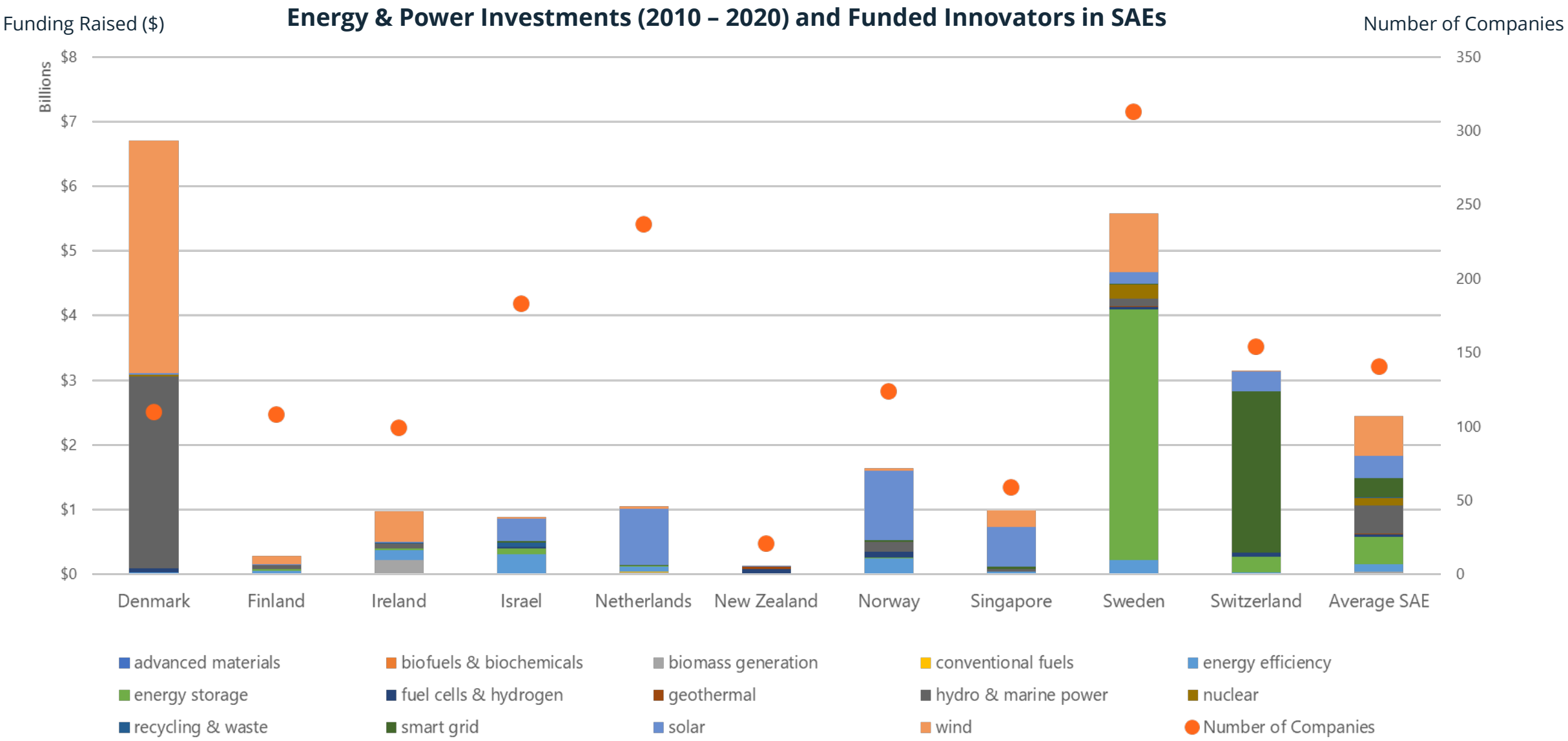
Contents

Energy & Power – Comparison between Small Advanced Economies (SAEs)

Energy & Power Analysis

- Waste Heat Recovery
- Smart Home Energy Analytics
- Electrochemical energy storage
- Geothermal
- Energy efficiency - digital platforms
- Hydrogen - transport & refueling

Overview – Energy & Power Innovation in Small Advanced Economies (SAEs)



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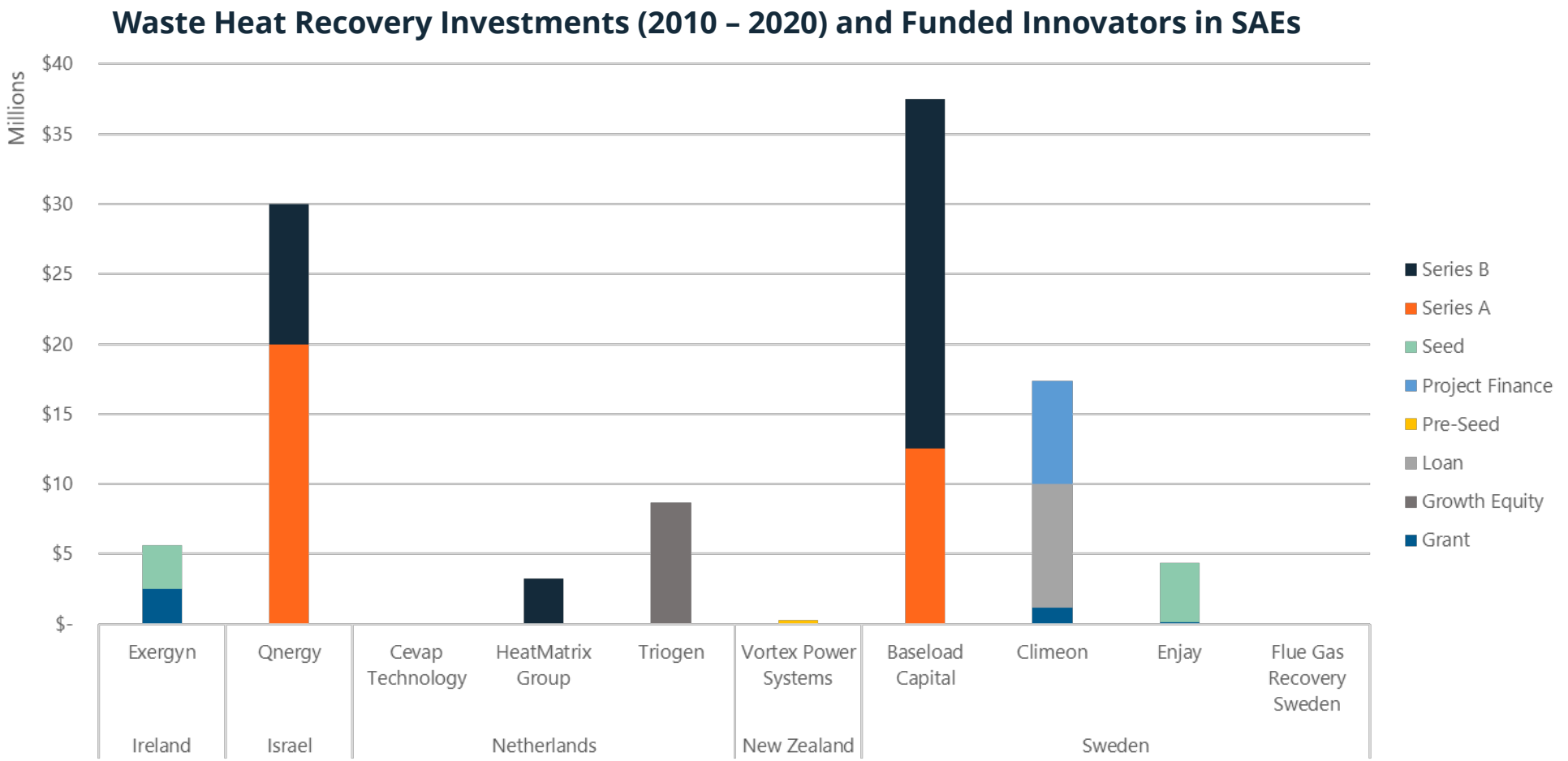
Waste Heat Recovery Innovation in SAEs



Waste Heat Recovery – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** Waste heat from a range of different processes is captured and reused, either within the same process, on the same site, or by another company/market.
- **External potential:** Market estimated to be around $50.4 billion globally, with an 8% CAGR through 2025.[20] Enhancing heat transfer and optimizing system performance is cheaper than building new systems, players are building retrofit systems in-house.[74]
- **Timing:** New recovery technologies providing opportunities to capture low-grade heat from broader range of sources. Industrial market leads with exhaust heat, flue gas from burners and boilers as the major heat source. With technological advances, there are growing opportunities for low-temperate heat capture, which was previously expensive and inefficient. Europe is the largest supplier of waste heat-to-power systems, driven by emission regulations, but China is the fastest growing, driven by industrialization.
- **CO2 reduction potential:** Electric turbo compounding technology can reduce engine exhaust, fuel consumption, CO2 emissions of existing system by 15%, or generate 10% extra power. In North America and Europe, water heat recovery could replace 1.5b MWh annually of the natural gas consumption used to provide space heating and domestic hot water.[75]
- **Environmental impact reduction potential:** Efficiency gains allow for less use of oil and other feedstock use, less eventual waste of raw materials.

Example innovators

CLIMEON

Organic rankine cycle (ORC) tech, converting hot water-to-electricity for geothermal, power generation, maritime.

Sweden

BOWMAN

Electrified turbomachinery products for improving internal combustion engines.

Southampton, UK

Key Clusters

Sweden

- North Sweden Cleantech is a regional innovation and export platform for green technology, clean energy and sustainable solutions from Västerbotten and Örnsköldsvik, including in waste heat recovery
- Smart City Sweden is a state-funded platform for sustainable city solutions that engages global delegations interested in investing in smart & sustainable city solutions from Sweden. Smart City Sweden has supported waste heat recovery companies like Againity, Climeon, and Swerod.
- Sweden has the largest percentage of industrial heat recovery in its district heating systems in the world[21]. In Sweden, 20% of buildings use geothermal heat pumps.

United Kingdom

- $67 million from the UK Industrial Strategy Challenge Fund awarded to 4 smart energy pilot projects, including Smart Hubs Smart Local Energy System project will combine air-source heat pumps and gas boilers into 250 properties, supplied by Passiv Systems, and Switch2 Energy will create a heat network fed by a marine-source heat pump provided by ICAX.
- The Energy Superhub Oxford private-public project in pilots using 320 ground heat pumps connect to batteries across UK (Habitat Energy, Kensa, Oxford City Council, RedT Energy and the University of Oxford).
- Increasing demand in UK, driven by Renewable Heat Incentive (RHI) tariff extension.

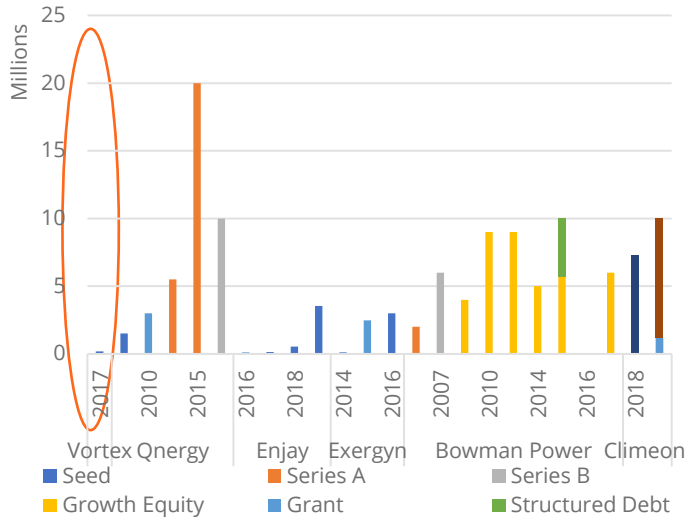
Innovators and Ecosystems: Waste Heat Recovery

Alignment w/ Strength

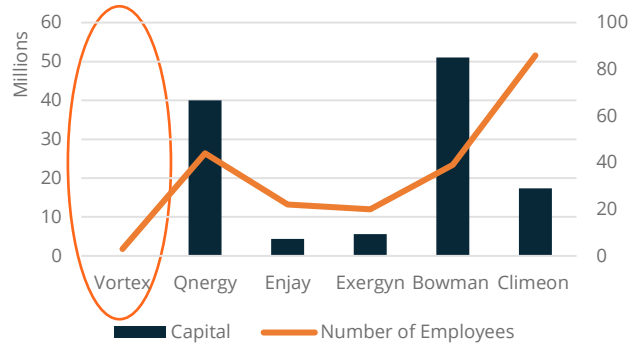
2

Ecosystem	VORTEX (Auckland, NZ) Zero-carbon method of capturing low-grade waste heat from thermal processes to generate electricity	Qnergy (En Harod, Israel / Utah, US) Micro-combined heat and power (CHP), solar power generation, and remote power	ENJAY (Malmö, Sweden) Profitable energy recovery from restaurant ventilation	eXergyN (Dublin, Ireland) Technology that commercially converts low-grade waste heat to power	BOWMAN (Southampton, UK) Electrified turbomachinery products for improving internal combustion engines	CLIMEON (Sweden) ORC tech, converting hot water-to-electricity for geothermal, power generation, maritime
Diversity in mgmt. / ownership						
Grants		• Israeli Ministry of Industry, Trade and Labor • EASME - EU Executive Agency for SMEs	• Swedish Energy Agency	• Irish Gov. Disruptive Tech. Innovation Fund • Enterprise Ireland • EU Horizon 2020	• UK Department for Business, Energy, and Industrial Strategy	• Swedish Energy Agency
Incubators / Accelerators	• Auckland UniServices	• Net Zero Mission	• Climate-KIC	• The UK BEIS Industrial Energy Efficiency Accelerator		
Angel Financing			• Peter Enberg			
Equity Financing	• Pacific Channel	• OGCI Climate Investments • Tene Capital. Kibbutz EH		• Keiretsu Forum Northwest, NDRC	• Ombu Group, Octopus Ventures, Fjord Capital, Asster, I2BF Global Ventures, WHEB, RAB Capital	• Breakthrough Energy • Gullspång Invest, LMK Forward, Blue
Debt Financing					• Boost&Co	• The Swedish Export Credit Corp • DNB, EU Investment Fund
Customers			• Burger King Sweden & Scandanavia • Svecon	• Cummins	• + 800 systems deployed worldwide across 20 countries. • Cummins, Wartsila	• Baseload Power Taiwan, WWF, Virgin Voyages • Viking Line
Partnerships		• Abengoa Solar. A.O. Smith	• SWEP		• Aggreko • Powertech System Integrators	• SSAB • Geo40
Talent Pipelines	• University of Canterbury • University of Auckland	• Tel Aviv University • Weber State University	• Lund University • Umea University	• Uni. College Dublin • Dublin Institute of Technology • Loughborough Uni.	• Uni. of Leicester • Uni. of Cambridge	• Luleå Uni of Technology, • Uni of Göttingen
Emissions Reduction	• 5-7% conversion of waste heat energy to electricity		• 500mn tones CO2 per annum		• 5-7% fuel savings, up to 10% additional power.	• 98mn tonnes CO2 annual for 100K systems

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Waste Heat Recovery

Ability to Lead

1

		New Zealand		Sweden		Netherlands		United Kingdom	
	Overview	• Increasing significant projects (e.g. waste water heat recovery at new Christchurch sports complex) but slow-growing pool of innovators. [76]		• Waste heat recovery baked into many industrial and commercial processes and new construction projects (e.g. data centres) are leveraging the technology		• Local heavy industry provides significant testing network and programmes for innovators through Horizon 2020 have set up a robust partnership network		• 40% of UK industrial energy use is in process heating, creating a wide surface area for application. Government has programmes for technology development and application	
35%	**R&D-to-commercialization pipeline strength**	2	• Gen Less (EECA) has identified key potential markets in NZ (especially in dairy process heat) and is carrying out international technology scans[77] • Beyond Vortex, limited examples of home-grown innovation	7	• Support from Swedish Energy Agency for early-stage innovators (including Climeon and Enjay) • Local supply chains able to support technology commercialization (Climeon units produced by Swedish Mastec)	6	• REWARDHeat programme under Horizon 2020 brings together 27 corporates and research universities at 8 demonstration sites to develop waste heat capture and use technology. • Research and spin-outs happening at TU Delft (e.g. Nowi Energy)	6.5	• Universities (Bath, LSE) generating research on opportunities for technology application in UK industries. • Grants from Department for Business, Energy, and Industrial Strategy (BEIS) including the Energy Entrepreneurs Fund
25%	**Financing strength**	4	• Gen Less finances waste heat recovery on an individual project basis. • Some participation from private investors (e.g. Pacific Channel investment in Vortex), but still limited.	8	• 11 deals for $59 m between 2011 – 2021 • Support at the early stages from gov't and EU agencies • At the later stages, pan-European funds and corporates participating (e.g. Breakthrough – Baseload, Climeon)	4	• 4 Deals for $12 m between 2011 – 2021 • Specialized local energy & environment investors, e.g. Dutch Greentech Fund • Early-scale research and industry demand only being bridged partially	8.5	• 23 deals for $68.8 m between 2011 – 2021 • Strong mix of local investors (Fjord, Ombu, Octopus) and global corporates (BP Ventures) • Global accelerators engaging local innovators (e.g. Techstars – Supercritical)
40%	**Connection to demand**	4	• Collaborations possible with outside companies and other fast-growing innovators (Geo40 – Climeon partnership is good template). • Gen Less connecting businesses to providers of waste heat recovery equipment, provides a conduit into local markets.	7	• Baseload Capital bringing innovators into global geothermal projects (e.g. Climeon in Taiwan) • Energy companies participating as investors (Chevron – Baseload) and partners (SSAB – Climeon)	6	• Energy service / maintenance companies engaging with innovators as technology partners (e.g. Alliander – Kiwa, LF Energy, Spectral, Locamotion) • Local and global corporates engaging innovators as customers for manufacturing solutions (e.g. Carlserg, BMW, Smurfit – HeatMatrix Group	7	• Local uptake (hotels, health clubs) of technology supports expansion in home market • Global energy equipment and systems integrators working with UK innovators (e.g. Speed ElectroService, Projectioneering, Alternative Energy Systems, Powertech Systems Integration – Bowman Power Group)
Evaluation		**3.3**		**7.3**		**5.5**		**7.2**	

Takeaways: Waste Heat Recovery

Takeaways for NZ Climate Tech Innovators

- Many areas of potential collaboration between innovators creating unique technology around waste heat capture and those innovating for use of waste heat – see Geo40 and Climeon partnership as an example of cross-sectoral (and international) collaboration. NZ capabilities around geothermal as an industrial process input can potentially be leveraged as an advantage.
- Multilateral financing organisations (OGCI, Climate-KIC, Breakthrough Energy) providing significant support to the sector in Europe, NZ innovators should seek out multilaterals that support the Pacific region and be aware of projects that may have multilateral backing (e.g. ADB, AIIB) that are occurring in the Pacific.

Takeaways for NZ Climate Tech Ecosystem

- Uptake of waste heat recovery innovation is happening through large-scale manufacturers and energy companies – the ecosystem should look for opportunities to market NZ waste heat-to-value value chain solutions to such manufacturers versus on-off solutions.
- Look to areas of manufacturing locally that can benefit from geothermal and waste heat inputs for production methods – food & beverage products (e.g. Miraka), materials & chemicals (e.g. Geo40), and support innovators in accessing end-market customers overseas.
- High CAPEX involved with pilot-testing waste heat applications, successful companies are supported by a dynamic Series B and beyond (growth equity, structured debt) financing mix.

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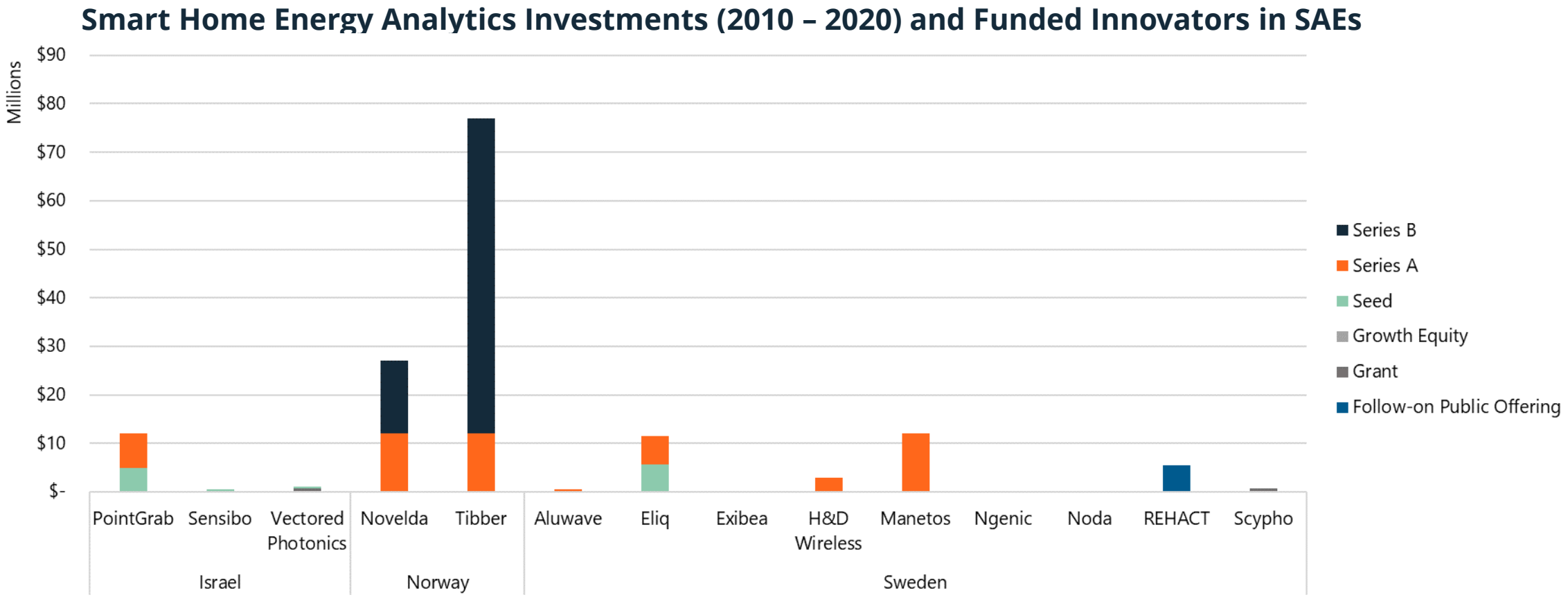
Smart Home Energy Analytics Innovation in SAEs



Smart Home Energy Analytics – Trend Analysis

External Potential	Timing of Trend
3	3

Summary

- **Description:** Consumer-centric monitoring and smart control of energy consumption enabling platform-level data collection and analytics
- **External potential:** Estimated market of $7.7bn in 2019, expected to grow to around $27bn in 2025 (23.3% CAGR)[80]. Power-as-a-service business models are enabled by improvements in sensor and connectivity technology and decreasing cost of AI and analytics. Mostly national, US market is consolidating, leading EU innovators beginning to internationalize, emerging trend in Asia, powered by electricity market deregulation
- **Timing:** Smart features could reduce the friction associated with consumption shifts, which have been difficult to implement before now. Data-driven business models require attention to privacy issues.
- **CO2 reduction potential:** up to 2.93Gt CO2e[81]
- **Environmental impact reduction potential:** May encourage switch to more energy efficient devices, predictive analytics could extend appliance lifetimes. Load-shaping reduces deployment of (usually fossil fuel powered) peak load. More efficient load-balancing at system level could eventually lead to avoidance of grid extensions.

Example innovators

tibber

Developer of smart home and energy services. Platform provides real time efficiency and price data to help lower consumption and includes smart EV charging (Førde, Norway)

eliq

Provider of energy management systems which help utilities improve customer engagement (Gothenburg, Sweden)

Key Clusters

Norway

- Equinor Ventures invests in ambitious, early-stage energy companies (including eSmart). Statkraft drives partnerships that will transform industry and aims to demonstrate leadership in new technologies, invested in Deepki and Metron.
- Cleantech Scandinavia supports innovation throughout Scandinavia and the Baltics, connecting innovators with investors, cities, corporates and government organisations.
- BKK GreenInvest, Nysno are investors in sustainable businesses and technologies.
- Research Council of Norway distributes funding for a portfolio of energy, transport and low emissions projects.

Sweden

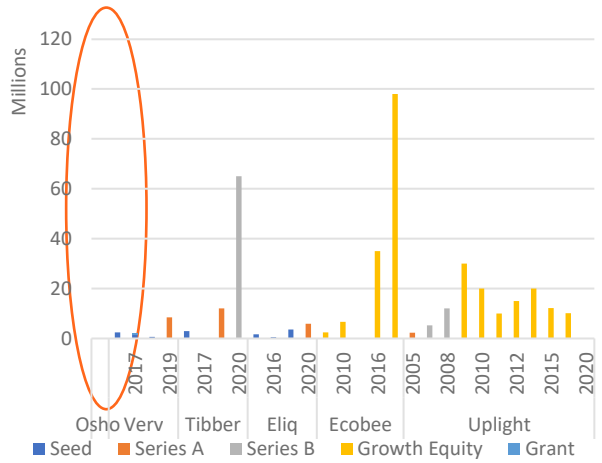
- Vattenfall was an early pioneer in smart home technology, with an unsuccessful project cancelled in 2001. Company is focused on digitalisation of the value chain.
- University of Gothenburg, Chalmers university. Eliq was born out of a master's thesis and the company actively pursues internship and thesis collaborations.
- Cleantech Scandinavia supports innovation throughout Scandinavia and the Baltics, connecting innovators with investors, cities, corporates and government organisations.
- National research institution Ri.Se partners with industry, academia and the public sector to find solutions for sustainable energy systems.

Innovators and Ecosystems: Smart Home Energy Analytics

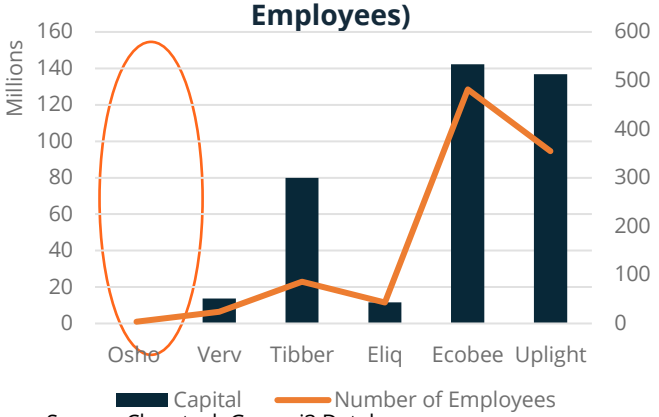
Alignment w/ Strength: 1

Ecosystem	osho (Auckland, NZ)	tibber (Førde, Norway)	elia (Gothenburg, Sweden)	verv (London, UK)	ecobee (Toronto, Canada)	uplight (Colorado, US)
	Home operation / automation	Developer of smart home and energy services	Provider of energy management solutions to help with engagement for utilities	home monitoring and data analytics platform	Smart thermostats for residential and commercial applications	Provider of Energy Services Management (ESM) solutions
Diversity in mgmt. / ownership						3/9 in C-suite women, 2/9 non-white
Grants		• RFF Vest		• Ofgem	• Ontario Ministry of Energy	
Incubators / Accelerators			• Plug and Play Tech centre	• Free Electrons • CrowdCube, UK Dept for Business, Energy, and Industrial Strategy		
Angel Financing		• Petter Stordalen, BKK GreenInvest	• CBC Investment Group		• Ontario Emerging Technologies Fund	• Greenstart
Equity Financing		• Eight Roads Ventures • Balderton Capital • Founders Fund • WellStreet	• Inven Capital , Contrarian Ventures	• InnoEnergy • Earthworm, Centrica	• Export Development Canada, Ontario Capital Growth Corporation, BDC Capital • Amazon,, AGL Energy, Tech Capital, GXP, Thomvest Ventures , Relay Ventures	• Rubicon Venture Capital , Morgan Stanley, Zoma Capital, Engie, NV, Sunpower, Siemens, GE
Debt Financing		• Nordea				
Customers		• Customers in Sweden, Norway & Germany	• Bristol Energy, Green Yellow • Vattenfall, CGE Eidsiva, Bixia	• Centrica		• 80 global utilities
Partnerships			• Grönare	• Energy Web	• Enbala • Carrier • Uplight	• Google • Enel X • Ecobee
Talent Pipelines	• University of Otago	• NTNU • University of Cambridge, KTH Royal Institute, Tesla	• Chalmers University of Technology • University of Gothenburg	• University of Hertfordshire • University of Manchester	• Cambridge University, Queens University • Uni. Western Ontario, Uni/ of Waterloo	• Stanford University • Syracuse University
Emissions Reduction		• 9.3% reduction in energy usage with smart heating				• 5.33 TWh offset

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Smart Home Energy Analytics

Ability to Lead

1

		New Zealand		Sweden		Norway		Colorado, US	
	Overview	• High penetration of renewables (~85%[6]) and high level of smart meter uptake in NZ homes (estimated 70-90%[5]),		• High penetration of renewables (54%), microgrids, and district heating create baseline market for home energy efficiency. Large "prosumer" class.		• Special challenges to solve related to distributed generation resources, specific opportunities due to high electric vehicle ownership.		• De facto energy transition research capital of US – home to National Renewable Energy Laboratory (NREL) and Rocky Mountain Institute (RMI).	
35%	**R&D-to-commercialization pipeline strength**	4	• Talent - 8,605 full-time computer science and IT students in NZ universities [7] • Early-stage support infrastructure for energy efficiency innovators developing (Lightning Lab Electric, Callaghan Digital Energy Hub).	6	• Swedish Energy Agency supplies early-stage innovators with grants, project finance, and loans (~$20m since 2011). • Chalmers University and Uppsala University have early-stage commercialization funds with energy seed investments.	4	• R&D efforts in smart home energy still developing - In 2016 the Norwegian National Smart Grid Laboratory at Norwegian University of Science & Technology (NTNU) and SINTEF Energy research was formally opened.[12]	9.5	• National labs serves as magnet for talent and R&D commercialization (e.g. NREL IN2 incubator residential housing innovation programme). • Office of Energy Efficiency & Renewable Energy invested nearly $2m into university energy efficiency engineering programmes in Colorado.[3]
25%	**Financing strength**	2	• Low presence of specialized energy investors in ecosystem, both domestic and foreign.	5	• 17 smart home energy efficiency deals totaling $33.3 m 2011-2021. • EU investors contributing significant % of capital (e.g. Innoenergy, Inven, Contrarian).	6	• 6 deals for $107 m 2011-2021, low volume of domestic investors but strong ability of ecosystem to attract investments where high-potential start-ups lie.	7	• Early-stage accelerators (e.g. Techstars) have local operations investing in smart home • 27 smart home energy efficiency deals 2011-2021 totaling $131m • Local investors with successful smart home exist (supporting both local and outside start-ups)
40%	**Connection to demand**	3	• Some corporate and utility participation in innovation ecosystem, e.g. Lightning Lab Electric support from General Electric, Westpac, and Genesis Energy. [84]	7	• IKEA investing in and partnering with energy efficiency and storage start-ups. • Foreign customers buying smart home energy solutions from Swedish innovators (e.g. Bristol Energy – Eliq deal). • Innovators tapping into neighbouring markets (see Norway analysis)	4	• Utilities bringing innovators into market – Innlandskraft partnered with Eliq (Sweden) to pilot test in 1,100+ homes[8] • Corporate efforts focused mostly on grid modernization – distributed nature of generation resources makes home efficiency goals highly localized.	8	• Start-ups able to achieve scale at home, and even carry out mergers & acquisitions in Colorado (e.g. Tendril and Simple Energy into Uplight). • Energy majors Enel and Engie have formed technology partnerships with CO smart home innovators. • NV Energy, Sunpower, Think Energy buying technology from CO smart home start-ups.
Evaluation		**3.1**		**6.2**		**4.5**		**8.3**	

Takeaways: Smart Home Energy Analytics

Takeaways for NZ Climate Tech Innovators

- Most of the world has not achieved the same level of renewables penetration as NZ - pursue opportunities to carry out pilot tests and experiment with data from overseas customer bases where energy costs for customers may be a more pronounced pain point
- Energy service companies (ESCOs) and utilities may have financing or services bundles that they deliver to residential customers – consider opportunities to leverage these channels as an additional market conduit
- Experiment in remote regions of NZ to develop advantages around delivering value in off-grid or far-from-grid markets

Takeaways for NZ Climate Tech Ecosystem

- Pursue opportunities for utilities to bring innovators into pilot tests or even to market (e.g. example of Innlandskraft bringing Eliq to homes in Norway)
- Make efforts to concentrate innovation around Crown labs – the energy transition cluster in Colorado has been developed mostly around the gravitational pull of NREL and RMI but now is dynamic enough that start-ups can launch, raise funds, grow, and in some cases even be acquired in Colorado

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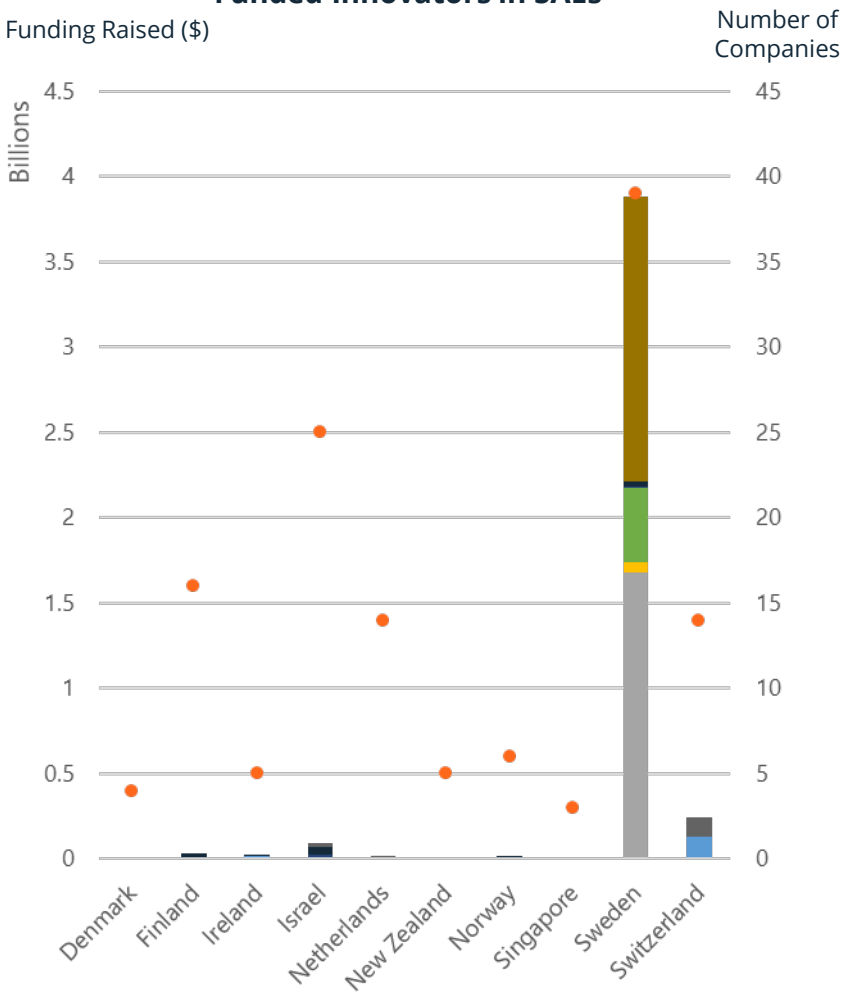
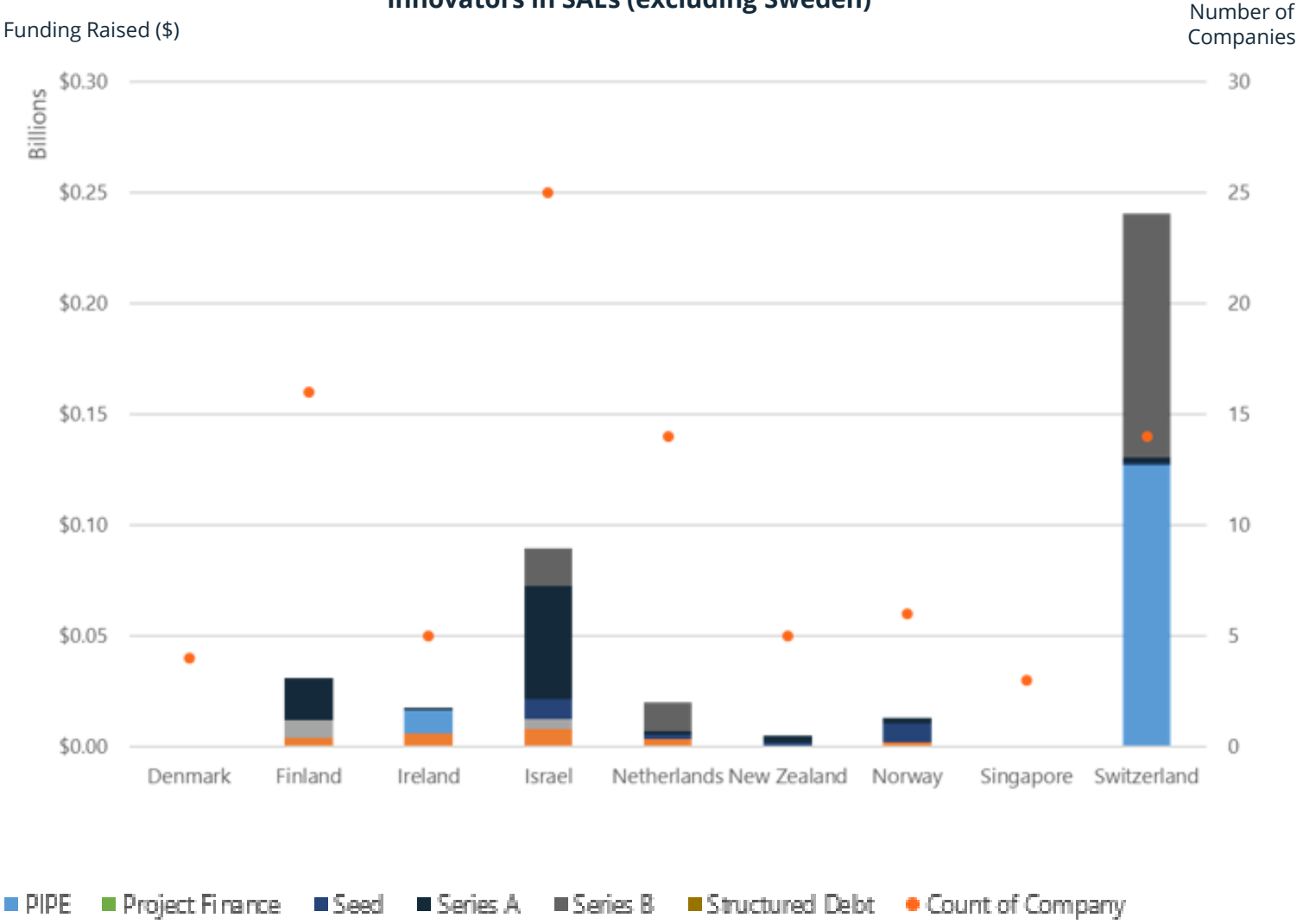
Energy Storage Innovation in SAEs

Energy Storage Investments (2010 – 2020) and Funded Innovators in SAEs



Energy Storage Investments (2010 – 2020) and Funded Innovators in SAEs (excluding Sweden)



Electrochemical Energy Storage – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** Energy storage systems generating energy from chemical reactions, with applications in consumer electronics and EV sectors
- **External potential:** $120bn global market in 2018[89]. Global manufacturing tripled from 2013 to 2018, driven by increasing EV demand. Over the same period costs decreased by 73%. Demand for EVs and storage, combined with further performance improvements and cost decreases, are expected to contribute to at least a further 700% sales growth to 2040.
- **Timing:** With over 350 new EV models planned by manufacturers for the coming years, and increasing demands for energy storage, this sector is on a sustained growth trajectory. Manufacturing was originally concentrated in Asia (especially China, Japan and Korea). With €60bn committed investment in production capacity, the EU may attain shares of up to 25% by 2028. North America is also investing in capacity.
- **CO2 reduction potential:** With 80% EV adoption and 80% grid decarbonization, 2050 vehicle emissions can be reduced to 20% of 1990 levels[90]
- **Environmental impact reduction potential:** Chemical batteries are not carbon neutral and end-of-life strategies (second life or recycling) are important to avoid negative environmental impact. Extraction and processing of raw materials is also a challenge to be addressed.

Example innovators

PHINERGY

Developer of high-density energy storage systems based on metal-air battery technologies

Lod, Israel

northvolt

Developer of high-performance batteries and battery systems with one of Europe's largest battery factories, due to start production in 2021.

Stockholm, Sweden

Key Clusters

Israel

- Technion and five other top research universities collaborating on the Israel National Research centre for Electrochemical Propulsion (INREP) to reduce Israel's reliance on fossil fuels.
- Collaboration between City of Haifa, Technion, and Primus Power (US) to pilot at-scale grid batter storage
- The Israel-US Binational Industrial Research and Development (BIRD) Foundation invests annually ($7.15 m in 2020) in cleantech collaboration projects between Israeli and American companies

Sweden

- Norsk Hydro and Vatenfall are actively purchasing from and partnering with innovators through joint ventures, project developments, and technology developments, accelerating growth of key start-ups (Northvolt, SaltX, ferroamp)
- The Swedish Energy Agency has deployed over $200m in capital to clean energy start-ups in the form of grant, loans, and project financing since 2011.
- ALMI Invest is a Swedish is a $150m evergreen fund with half of its capital from European Union structural funds, and has invested over $50m in clean energy start-ups since 2011.

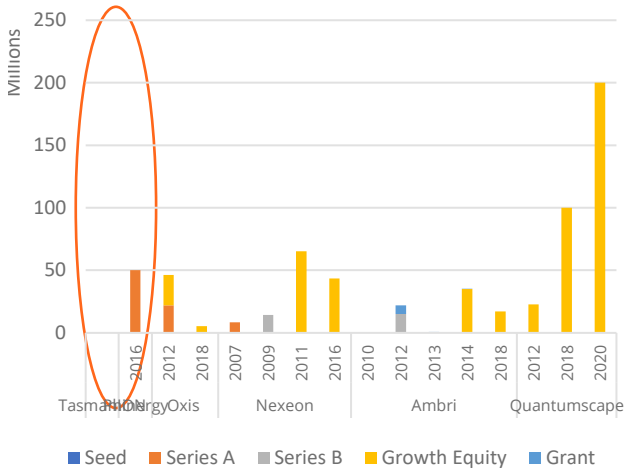
Innovators and Ecosystems: Electrochemical Energy Storage

Alignment w/ Strength

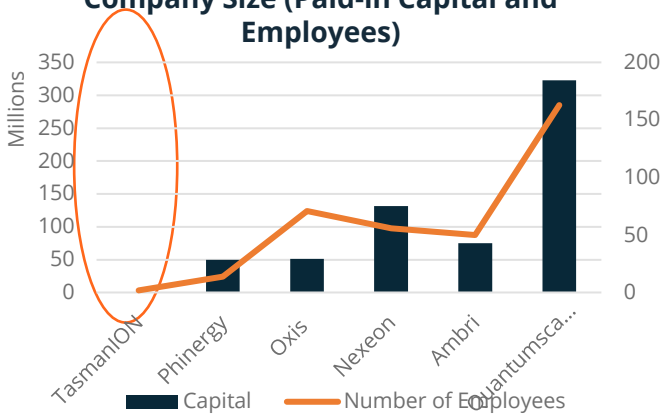
1

Ecosystem	TASMANION (NZ) Aluminium-ion battery technologies for grid storage and portable applications	PHINERGY (Israel) High energy density energy storage systems based on metal-air battery technologies	northvolt (Sweden) Battery storage technology and infrastructure solutions	Quantum Scape (CA, United States) Novel battery technology utilizing electron/hole redox for energy storage applications	SILA (CA, United States) Developer of silicon anode-based lithium-ion solutions	AMBRI (MA, United States) Liquid metal battery for grid-scale energy storage
Diversity in mgmt. / ownership	Non-white co-founders, woman CTO / co-founder			Non-white CEO, 3/9 C-suite non-white		
Grants		• Israel Innovation Authority			• ARPA-E • US DOE	• Alberta Innovates, ESTEP Office of Naval Research, NYSERDA
Incubators / Accelerators	• Wellington Univentures					• Massachusetts Clean Energy Center • Elemental Excelerator
Angel Financing			• Siemens, ABB • InnovFin			• Massachusetts Development Finance Agency, Massachusetts Military • Total Ventures, Bill Gates
Equity Financing		• Alcoa , Indian Oil Corporation, Alten • ILAN Holdings	• Volkswagen , Goldman Sachs , BMW • Vestas, Scania, IKEA, AMF Pension, Folksam	• Volkswagen, Breakthrough Energy Ventures, SAIC Motor • Khosla Ventures, Capricorn, Kleiner Perkins Caufield & Byers	• Sutter Hill Ventures, Bessemer Venture Partners, 8VC, Matrix Partners • Daimler,,Coatue , T. Rowe Price , 8VC, Canada Pension Plan	• KLP, Building Insurance Bern , KLP Enterprises , GVB
Debt Financing			• KfW , European Investment Bank • Vattenfall, Vargas			
Customers		• Eicsson, Mahindra Electric, Ashok Leyland, IndianOil • Doral Group	• Epiroc		• ATL • Daimler • Samsung	• Raytheon
Partnerships	• The MacDiarmid Institute • Fraunhofer IKTS	• Renault-Nissan • Johnson Controls	• Siemens, SECI, BMW, Norsk Hydro, Volkswagen, Umicore • Malarenergi	• Volkswagen	• Volkswagen	• TerraScale, NEC Corporation
Talent Pipelines	• Victoria University of Wellington • U. of Canterbury • INSEAD	• Tel Aviv Uni.,Israel Institute of Tech • Uni of Chicago	• Stockholm School of Economics, Halmsted Uni. • Harvard Business School	• Stanford, Berkeley • University of Vienna	• Stanford • Colorado School of Mines, • Uni of Notre Dame	• MIT • U. of Arizona • Dartmouth College • Uni of Toronto
Emissions Reduction			• Batteries from 50% recycled materials by 2030 • Starting 2022, capacity to recycle 25,000 batteries annually			• Ambri batteries require less than 1% of current annual production of these anode and cathode materials

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Local Participants

External Participants

Acquirer

NZ Ecosystem in Global Context: Electrochemical Energy Storage

Ability to Lead

1

		New Zealand		Sweden		Israel		Bay Area, US	
	Overview		• Efforts in next-generation batteries just beginning, however, capabilities around lithium extraction (Geo40) and strong materials R&D		• Success of Northvolt has begun to put Sweden in a position to compete globally in battery production, recycling, and underlying materials supply chain		• Synergies with multinational energy and automotive companies help innovators go direct to global markets without a large home automotive or energy market.		• Strong local university proficiency in materials engineering for batteries, heavy involvement of battery multinationals and world-leading financing ecosystem
35%	**R&D-to-commercialization pipeline strength**	2	• MacDiarmid Institute for advanced materials has spun out 19 start-ups, which have raised $23.2 million • Callaghan Innovation providing grants to early-stage battery companies[93]	6	• Swedish Energy Agency has provided nearly $10m in grants to energy storage companies since 2011. • Presence of local automotive and energy corporates allows for re-absorption of talent back into entrepreneur pool.	6	• Strong base in chemicals and chemical engineering for constituent battery materials – Israel Chemicals is the world's largest bromine producer. • Technion has dedicated research to electrochemical and corrosion.	8	• Significant grant funding available from gov't agencies like ARPA-E and DOE. • McCloskey Laboratory at U. California Berkeley and Stanford Global Climate & Energy Project have dedicated research on Electrochemistry and storage
25%	**Financing strength**	2	• Few observable financing events for batteries outside of grants. Some minor participation from incubators such as AstroLab (Series A in Flow Holdings) • No notable investments from outside or corporate investors.	9	• 14 deals for $3.9 b from 2011-2021. • European Investment Bank providing significant project financing. • Heavy participation from Swedish corporates in funding rounds (IKEA, Volvo, Vatenfall)	7	• 8 deals for $196 m from 2011-2021. • Significant overseas corporate participation in funding, e.g. $20 m BP Ventures – StoreDot, $50 m Alcoa – Phinergy. • Low deal volume but funding needs of top innovators met	10	• 93 deals for 16.8 b from 2011 to 2021. • In addition to blue chip Silicon Valley investors, there are a number of large VCs with a clean tech in thesis, e.g. DBL ($540 m) and Venrock ($900 m)
40%	**Connection to demand**	2	• No local market for electric vehicle production. Local demand in transportation may pick up with EV uptake. • Grid-scale storage M&A transactions most notable in the project developer and energy services spaces (e.g. Vector 2017 acquisition of PowerSmart)	8.5	• Domestic and foreign automotive corporates heavily involved in ecosystem as customers (BMW, Cake – Northvolt), joint venture partners (Volkswagen, Norsk Hydro – Northvolt), and technology partners (Incell – Samsung, SaltX- Vatenfall)	7.5	• Overseas automotive companies collaborating with local innovators for development partnerships (e.g. BP, Nissan Daimler – StoreDot, Renault-Nissan – Phinergy). • Overseas power companies collaborating on technology and projects (AREVA, Schnieder Electric, Princeton Power EnStorate)	9	• Leading corporates forming joint ventures (Volkswagen – Quantumscape) and technology partnerships (Boeing – Cuberg). • Bay Area innovators being acquired (Shorai by NEAH, Fenix by Engie) and more recently listing on public markets through SPACs (Quantumscape through Kensington)
Evaluation		**2**		**7.8**		**6.9**		**8.9**	

Takeaways: Electrochemical Energy Storage

Takeaways for NZ Climate Tech Innovators

- Pursue opportunities to engage open innovation with global automotive and energy companies – strategic investors from industry incumbents is a critical source of equity financing through the growth stages of battery companies
- Leading battery companies are now taking ownership over parts of the supply chain (e.g. Northvolt, Tesla), attempt to access unique innovations in supply chain and reverse logistics within NZ to develop a unique model around materials handling

Takeaways for NZ Climate Tech Ecosystem

- Avoid isolated approaches to supporting development of battery technology – supply chain elements (raw materials and refining) and value chain elements (opportunities to apply in utilities, electric vehicle infrastructure, microgrids, etc.) and reverse logistics (battery recycling and material recovery) need to be built up to create opportunities for success in battery innovation
- Lack of domestic automobile producers makes the importance of utilities' engagement with innovators more pronounced
- Lack of chemicals industrial base (most NZ chemicals imported) creates a distinct disadvantage, try to build up capabilities around materials recovery and re-use (e.g. Avertana and Mint Innovation), industrial waste processing (e.g. Geo40) and connect with battery innovators

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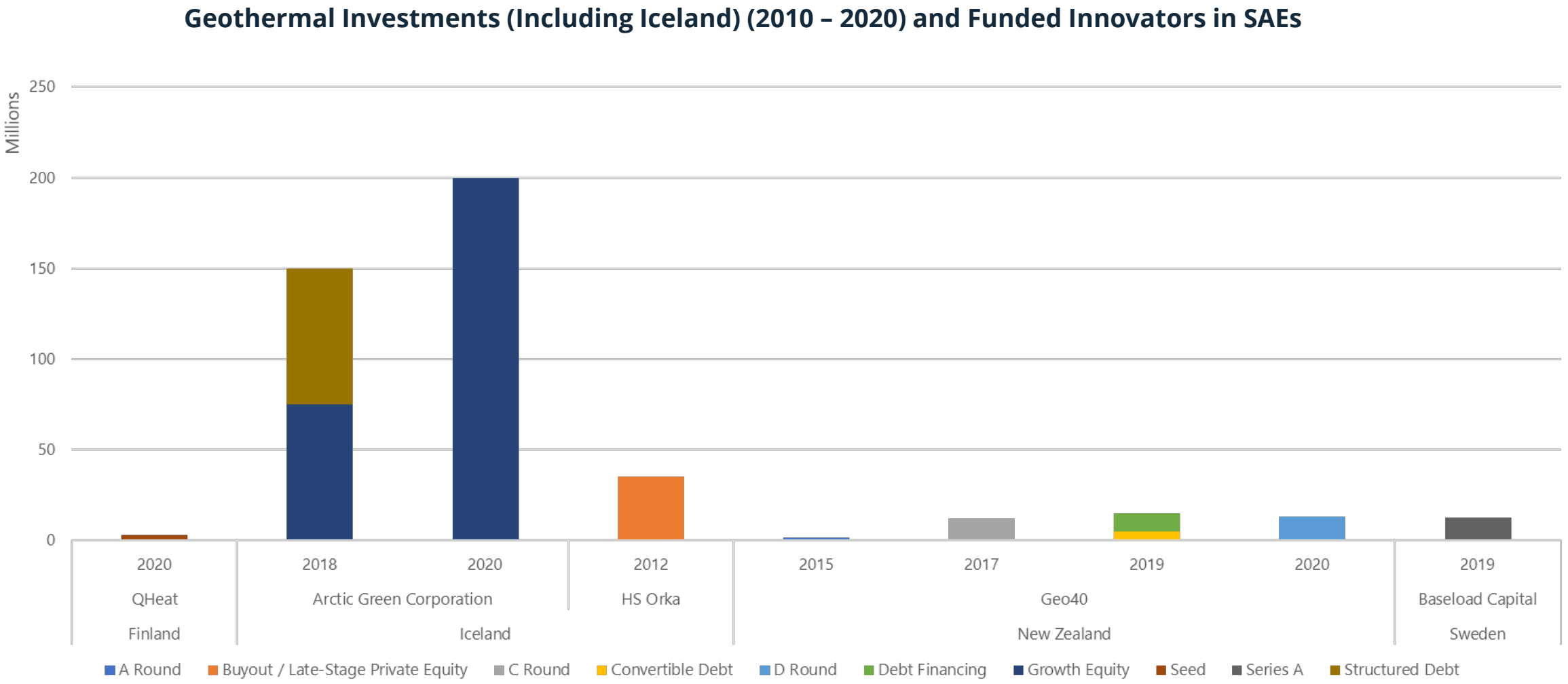
Geothermal Innovation in SAEs



Geothermal – Trend Analysis

External Potential	Timing of Trend
2	2

Summary

- **Description: :** Geothermal energy, derived from natural sources of heat in both high enthalpy (volcanoes, geysers) and low enthalpy (hot rocks in Earth's crust) is being harvested for electricity generation through hydrothermal plants, flash steam power plants, and subsurface rock fracture techniques, as well as direct use through ground source heat pumps.
- **External potential:** Market size of $5.07 billion with a CAGR of 5% through 2026. The USA, Indonesia, Philippines, Turkey, New Zealand & Mexico had 73% of global installed geothermal power capacity, in 2018. Despite growth in 2019, geothermal electricity generation increased by only 3% that year, a level below average growth in the previous five years. [94, 95, 96, 97]
- **Timing:** Geothermal as a 24-hour source of electricity generation and heating is estimated to be able to meet 3-5% of global energy demand by 2050, and with incentives could meet as much as 10% of global energy demand by 2100. Most growth is happening in emerging economies, given the concentration of geothermal capacity in emerging countries and the growing need for energy. Upcoming changes in incentive schemes are likely to slow the momentum in some otherwise fast-growing markets, including Italy, Turkey, and France. [94, 95, 96, 97]
- **CO2 reduction potential:** Geothermal power plants produce as little as 15% of the carbon emissions of natural gas power plants. [94]

Example innovators

CLIMEON — ORC tech, converting hot water-to-electricity for geothermal, power generation, maritime

(Sweden)

HS ORKA — Largest privately owned energy company in Iceland

(Iceland)

Key Clusters

Sweden

- Swedish district heating and geothermal heat pump value chain of innovators promoted by Swedish Cleantech.
- Corporate activity in district heating projects, e.g. a stated goal by E.ON to build 5 geothermal plants in Malmo by 2028.[99]
- Strengths in district heating and cooling, with an estimated 20% of Swedish homes using geothermal heat pumps, a number that increases each year.[100]

Iceland

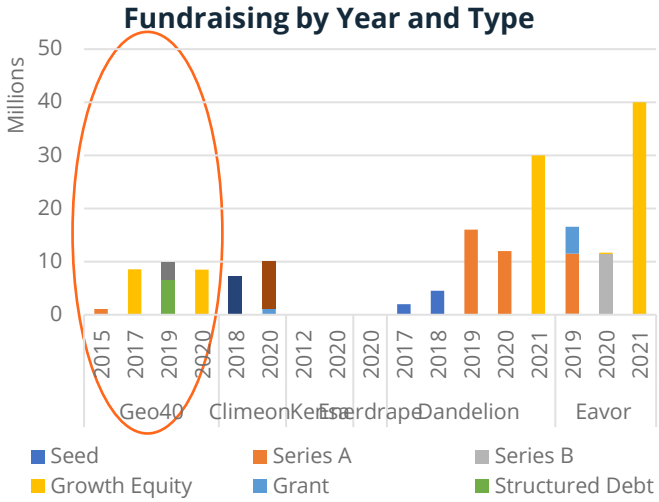
- The HS Orka Resource Park has demonstrated a geothermal "microeconomy" in real-life, powering science labs, spas, hotels, and offices.
- Iceland has positioned itself not only as a leading exploiter of geothermal energy, but a cutting-edge technology developer, becoming one of the geothermal technology research hubs of the world, leading geothermal training in developing countries, and catalyzing investments in Africa.

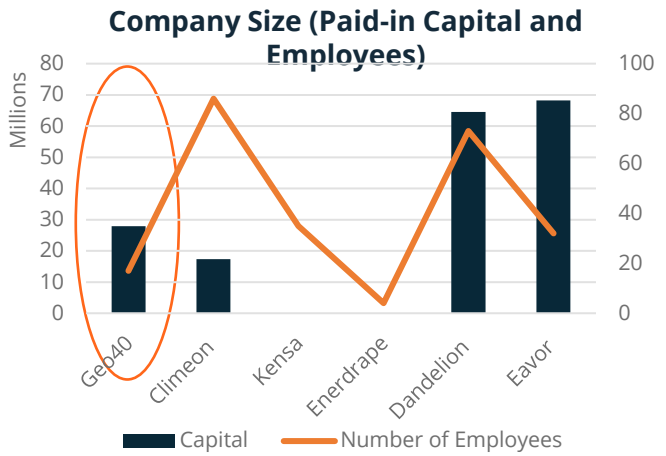
Innovators and Ecosystems: Geothermal

Alignment w/ Strength

3

Ecosystem	geo40 (NZ) Producer of silica from geothermal fluids after electricity generation	CLIMEON (Sweden) ORC tech, converting hot water-to-electricity for geothermal, power generation, maritime	enerdrape (Switzerland) Developer of modular geo-thermal panels for buildings	HS ORKA (Iceland) Largest privately owned energy company in Iceland	Eavor (Calgary, Canada) Closed-loop conduction-only geothermal energy solutions	DANDELION (New York, US) Software-enabled residential geothermal systems
Diversity in mgmt. / ownership			Woman CEO			Woman CEO
Grants	• Callaghan Innovation					
Incubators / Accelerators			• Switzerland Innovation		• Joules Accelerator	• NYC ACRE
Angel Financing	• Ice Angels		• Venture KICK, InnoSeed			
Equity Financing	• Euroz Broker (AU) • Baseload Capital • Efu Investment • Lindsay Investments • Climeon • Jarden	• Breakthrough Energy • Gullspång Invest, LMK Forward, Blue		• Jarovarmi	• Vickers Venture, BP Ventures, Temasek, Eversource Capital, Chevron Technology Ventures BDC Capital	Breakthrough Energy, GV, Comcast Ventures , Collaborative Fund, NEA, Lennar, Building Ventures, Catchlight Venture, Zhen Fund, BoxGroup , Borealis Ventures , Transcendent Holdings
Debt Financing	• Provincial Growth Fund	• The Swedish Export Credit Corp • DNB, EU Investment Fund				
Customers		• Baseload Power Taiwan • WWF, Virgin Voyages, Viking Line		• Carbon Recycling International • Svartsengi • Reykjanes		
Partnerships	• Tohuku Electric • Norske Skog • Contact Energy • Mercury	• SSAB • Geo40			• Royal Dutch Shell • Enex Power Germany	• ConEdison Solutions
Talent Pipelines	• University of Otago	• Luleå Uni of Technolog, • Uni of Göttingen	• Ecole polytechnique fédérale de Lausanne • Ecole Centrale Paris		• Queen's University • University of Saskatchewan	• Stanford University • Northwestern University • Harvard Law School
Emissions Reduction		• 98mn tonnes CO2 annual for 100K systems	• 90% reduction			





Source: Cleantech Group i3 Database

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Local Participants

External Participants

Acquirer

NZ Ecosystem in Global Context: Geothermal

Ability to Lead

3

		New Zealand		Iceland		Sweden		Calgary, CA	
	Overview	• One of the few nations with geothermal resources to support utility-scale projects. Innovators in geothermal energy, industrial processes, and digitalisation.		• Geothermal is critical to energy sector – 66% of primary energy use and 25% of all electricity generation.		• ~20% of Swedish homes have a geothermal heat pump, with 25,000 expanding every year. Significant market uptake. Corporates involved in district heating projects (e.g. E-on in Malmo)[100, 99]		• Not traditionally a geothermal leader due to availability of other resources, but has seen strong innovation and at-scale deployment in recent years.	
35%	**R&D-to-commercialization pipeline strength**	6	• Focused research on seismology occurring at Crown Research Institutes, especially GNS Science. • Geothermal Institutes at U. Auckland. • Institute of Earth Science and Engineering at U. Auckland and Auckland UniServices	8	• Iceland Energy University at U. Reykjavic and U. Iceland strong on geothermal engineering. • Iceland is research hub for thermodynamics and renewable energy – U. Florida, NC State, U. Oregon have all offered study opportunities in Iceland to engineers.	4	• Geothermal energy research taking place at Uppsala U. • Geothermal spinouts into start-ups not necessarily observed as a trend.	4	• Geothermal Energy Lab at U. Calgary, strong research in geosciences and geophysics.
25%	**Financing strength**	5.5	• 8 deals for $41.5 m from 2011-2021 • Geo40 is a case of an NZ company bringing in investment from overseas partners and funds (e.g. Climeon and Baseload Capital)	8	• 4 deals for $385 m from 2011 – 2021 • Strong synergies with Chinese investors both directly in Iceland companies and in joint ventures.	6	• 5 deals for $54.8 m from 2011 – 2021 • Innovators attracting capital from major international players (e.g. Baseload – Chevron, Breakthrough)	9.5	• 9 deals for $1.27 billion 2011-2021 • Significant involvement of leading strategic investors (e.g. BP Ventures, Eversource Ventures, Chevron) • Robust government financing from BDC Capital, Sustainable Development Technology Canada, Natural Resources Canada
40%	**Connection to demand**	5.5	• Where proficiencies are demonstrated, international partners are willing to collaborate on projects and pilots within NZ. • Some adjacent technologies have successfully grown and exited, e.g. Seequent in the geothermal imaging and analysis, acquired by Bentley Systems 3/2021.	8	• Home market is strong enough for companies to build entire business off – HS Orka alone serves 9% of country's power needs and 10% heating. • Strong industrial symbiosis culture – HS Orka Resource Park powers 9 businesses and hundreds of people working in the park.	7	• Innovators able to crack overseas markets through partnerships and establishment of subsidiaries (e.g. Climeon in Taiwan, Climeon collaboration with Geo40) • Coordinated effort by Swedish Cleantech to promote Swedish geothermal equipment value chain for district heating and heat pumps.	7	• Deployment projects by Eavor have attracted corporate involvement, Royal Dutch Shell will support drilling, and Enex will help bring Eavor technology to Germany to build a geothermal heat and power projects
Evaluation		**5.7**		**8**		**5.7**		**6.6**	

Takeaways: Geothermal

Takeaways for NZ Climate Tech Innovators

- Innovators in geothermal expand heavily through partnerships with both utilities and ESCOs (Geo40 has already done so) but also with other companies in the geothermal value chain
- NZ geothermal innovators should consider where their solutions add a unique value to production inputs or other downstream applications and form partnerships that can open new markets

Takeaways for NZ Climate Tech Ecosystem

- Geothermal is a sector that NZ companies seem to be able to access capital in, on a level similar to that of peers overseas. Multilaterals (e.g. Breakthrough Energy) are investing globally in the geothermal space. The value for investors is that NZ-created geothermal technologies (including waste heat) can be developed, piloted, and deployed in NZ
- The ecosystem should pull together innovators that can offer a value chain effect – geothermal extraction, usage in industrial processes, residential / commercial building usage, etc. and market as a suite of solutions to overseas companies

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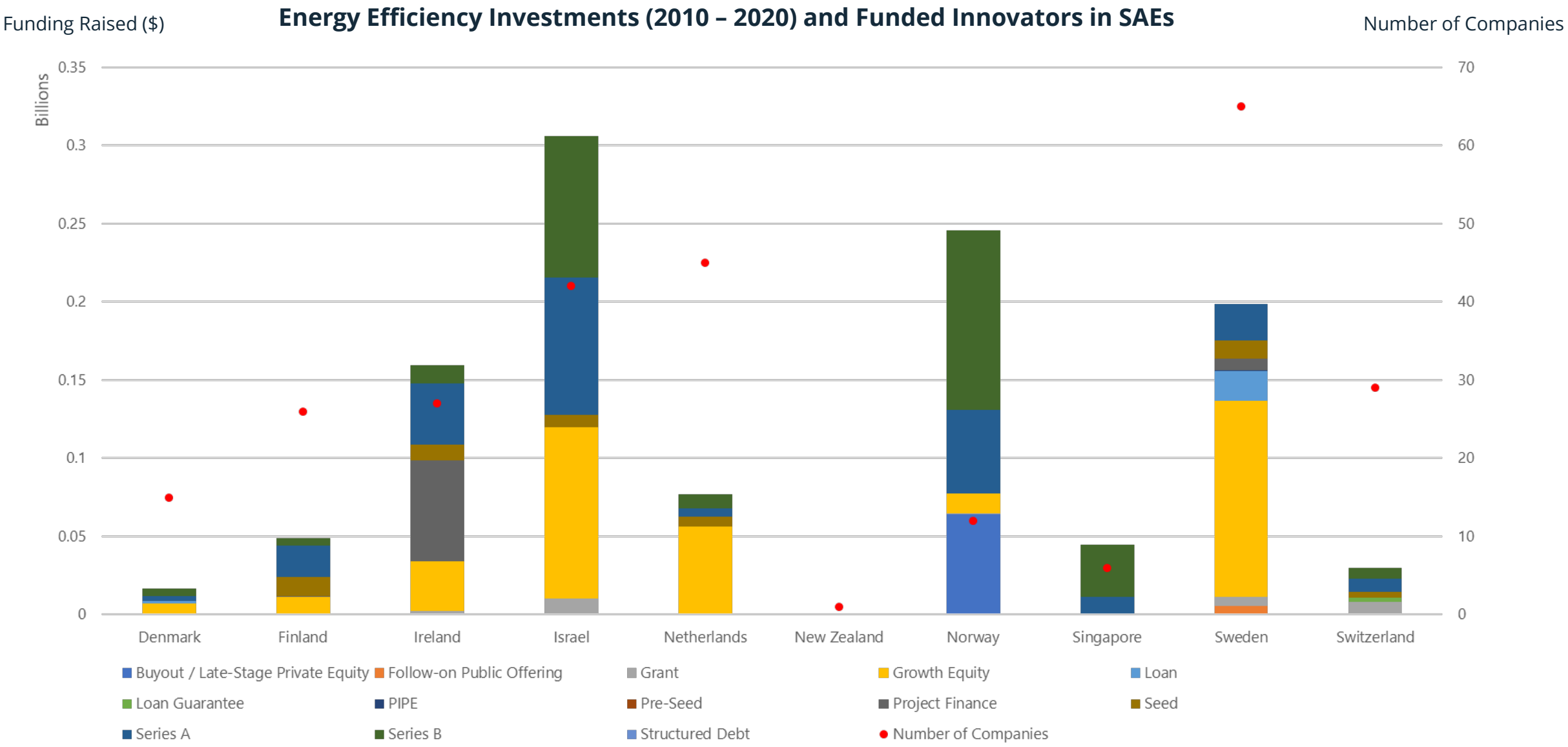
- Hydrogen - transport & refueling

Energy Efficiency Innovation in SAEs



Energy Efficiency: digital platforms – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** Connection, monitoring and control of a building; including hardware, software and services, used to improve operational and energy efficiency
- **External potential:** Global market size of $75bn in 2018, forecast to grow to $121bn in 2024. This is a fragmented market which is beginning to mature. Commercial buildings segment showing rapid adoption. Europe is fastest market growth area, with customers focused on energy savings. Emerging market in Asia; worker productivity and personal comfort are key considerations.[102]
- **Timing:** Enormous potential still to be exploited. Accelerated market adoption will be driven by improvements in sensor and connectivity technology, country level implementation of building-related climate targets and industrial incumbents with global customer reach integrating startup technology into broader IoT platforms[102]
- **CO2 reduction potential:** 7.5Gt CO2e / year (50%[101] reduction of 2017 global building emissions – 28%[102] of 53.5Gt CO2e[103])
- **Environmental impact reduction potential:** Opportunity to save up to 50% energy usage for lighting, heating and cooling. Specific savings vary by sector.

Example innovators

energyworx

Customizable, cloud-based energy data management platform for energy and utility companies

Utrecht, Netherlands

FSIGHT

Developer of an AI system that automates, predicts, optimizes and trades energy behind the metre

Hod Hasharon, Israel

Key Clusters

Netherlands

- Shell: Energy Inside bundled package for commercial buildings; partnered with Sparkfund and Gridpoint for Building Subscription Service
- Aggressive national policy on building energy efficiency has driven strong innovation base
- Shell GameChanger programme works with start-ups on unproven ideas with potential to impact the future of energy
- Energy sector government-assigned Top Sector, ECN research institute partners on projects (including H2020) with business and universities

Israel

- Energy cost is a pain point for companies operating in Israel – there is significant technology collaboration activity between multinationals, Israeli corporates, and local innovators to solve corporate problems from multiple angles. E.g. Johnson Controls collaborations with 3D Signals (predictive maintenance), TIGI (solar), and Phinergy (storage).
- Dedicated efforts by Israel Export & International Cooperation Institute to promote energy efficiency solutions to overseas corporates

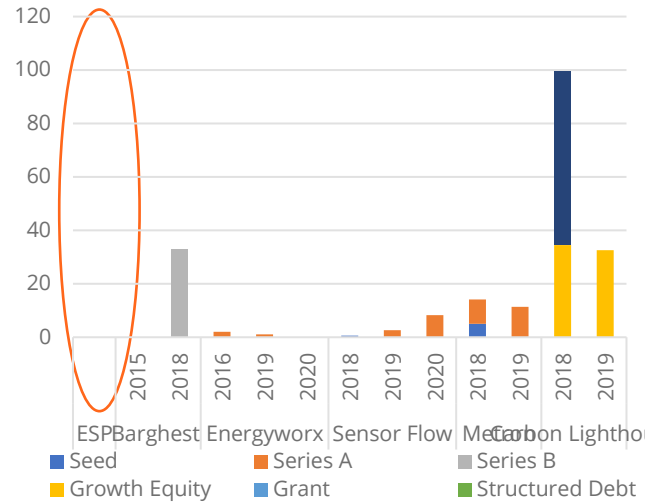
Innovators and Ecosystems: Energy Efficiency: digital platforms

Alignment w/ Strength

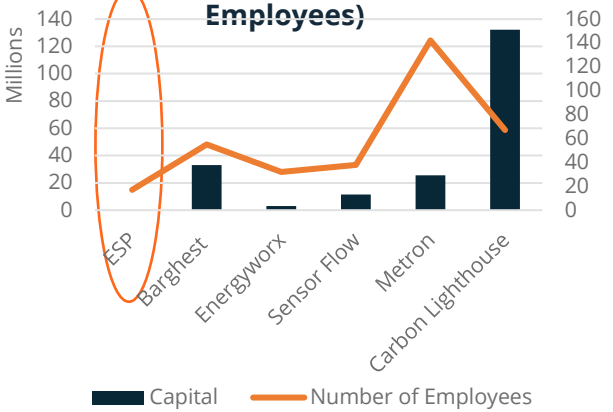
1

Ecosystem	esp (Auckland, NZ) Software and services for carbon emissions reduction	FSIGHT (Israel) AI system that automates, predicts, optimizes and trades energy behind the meter	energyworx (Utrecht, Netherlands) Developer of a platform analyzing energy data	SENSOR FLOW (Singapore) Wireless room automation & energy management solutions	METRON (Paris, France) Energy management platform for industrial groups	CARBON LIGHTHOUSE (Bay Area, US) Energy Savings-as-a-Service for commercial real estate portfolios
Diversity in mgmt. / ownership						2/5 C-suite women
Grants						
Incubators / Accelerators			• Free Electrons, Via-ID	• Entrepreneur First • SparkLabs	• EIT Digital Accelerator	• Elemental Excelerator • StartX Stanford
Angel Financing				• Pierre Lorinet • SGInnovate		• Steve Girsky • JB Straubel
Equity Financing	• New Zealand Green Investment Finance, unnamed strategic investors	• SBP Beteiligungsverwaltung	• ENGIE New Ventures, EDP Ventures • SET Ventures, henQ	• Openspace Ventures , Gaw Capital , Aurum Investment	• NTT Docomo Ventures , Statkraft Ventures, , Breed Reply • BNP Paribas. Financiere Fonds Prives	• Cox Enterprises, CEAS Investments. GRC Sino Green Fund, JCI Ventures, Ulupono Initiative, Ekistic Ventures • SV Tech Ventures , Radicle Impact
Debt Financing						• Generate Capital
Customers	• ASB Bank, Webstar, Goodman, Wilson Hellaby	• SAP • LIMAK • RD Energy • Delek • OPC Energy	• EDP • Engie		• Danone. Arcelormittal	• Alexander & Baldwin, Carlyle Group. L&B Realty Advisors
Partnerships			• Google. ATOS. SIA Partners • Greenbird		• NTT Facilities, Nanyang Technological Uni. of Singapore. ADVANTIS . Edison • Airflux. Dalkia	• Onset
Talent Pipelines		• Tel Aviv University	• Berlin College, Avans University of Applied Sciences	• UCLAN • National University of Singapore	• ESCP Europe • Université Paris - Val-de-Marne (Paris XII)	• University of Cambridge • Stanford University
Emissions Reduction	• 10-40% savings (depending on sector)			• Hotel room 30% every savings per year	• 10-15% total energy savings • 5-12%	• 40% of U.S. carbon emissions created by buildings

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Energy Efficiency: digital platforms

Ability to Lead

1

		New Zealand		Israel		Netherlands		Bay Area, US	
	Overview	• Despite high renewables penetration, drivers for energy efficiency are still clear – businesses account for 48% of non-transport energy usage[111, 112]		• Strong sensors and software industry provide local supply chain, cases of globally successful industrial efficiency platforms (Augury)		• Strong research in IoT technology development at the early stage and connections to EU programmes, domestic corporates skipping over domestic innovators		• Highly concentrated digital technology hub, with critical corporate players and leading innovators (Carbon Lighthouse, Ohmconnect, Particle)	
35%	**R&D-to-commercialization pipeline strength**	**4**	• The NZ Energy Efficiency & Conservation Authority (EECA) is supporting up to 40% (max $100,000) funding for innovative energy efficiency technology development. [111] • Early-stage support (Lightning Lab Electric, CI Digital Energy Hub).	**7**	• Presence of multinationals that collaborate with Israel Electric Corporation has yielded spin-outs (e.g. Fsight). • The Office of the Chief Scientist (Ministry of Energy) funds R&D in advanced energy and efficiency, including seed funding.	**6**	• Early-stage support available to energy efficiency innovators through Climate-KIC • Research commercialization in IoT technologies occurring through Delft University and the centre for Wireless Technology Eindhoven	**9**	• University incubators spinning out market-beating energy efficiency technologies (e.g. Stanford StartX – Carbon Lighthouse, Verdigris, Brilliant).
25%	**Financing strength**	**2**	• Low presence of private sector energy investors in ecosystem, both domestic and foreign. • Few significant fundraising events for NZ innovators.	**8**	• 23 deals for $157 m between 2011 – 2021 • Corporate deeptech investors also participating in energy efficiency rounds (Qualcomm) • Strong mix of local (Israel Cleantech Ventures) and global investors	**5**	• 29 deals for $29 m between 2011 – 2021 • Strong cluster of incubators supporting energy efficiency – Techleap.nl, Shell E4, Rockstart • Some local investors engaging local innovators (e.g. Enfuro – HelloEnergy)	**10**	• 119 deals for $1.76 b between 2011-2021 • Strong support at the early stages through leading accelerators like Y Combinator and Elemental. • Investment from diverse corporate sectors
40%	**Connection to demand**	**3.5**	• EECA is providing connections to energy-saving technology for high energy usage businesses and public sector organisations • Some corporate and utility participation in innovation ecosystem, e.g. Lightning Lab Electric support from General Electric, Westpac, and Genesis Energy. [111]	**8.5**	• Israel Export & International Cooperation Institute, Ministry of Economy, collaborated to create the "Israeli Innovation for Energy Transition 2019" catalogue of innovators • Mix of local market (commercial developments – Phoebus Energy) and international customers (McDonald's, Sprint, IBM – Panoramic Power)	**5**	• Heavy engagements in innovation ecosystems globally by leading Dutch corporates Royal Dutch Shell and Philips, but few domestic energy efficiency engagements. • Domestic energy service and maintenance providers partnering selectively with innovators (e.g. Alliander – Spectral Energy)	**10**	• Local corporates partnering with innovators (e.g. Nest – Ohmconnect) and heavy presence of outside corporates engaging ecosystem (Shell – igrenEnergi, Siemens, IBM – Vigilant, Dell – Modius) • Heavy M&A activity (e.g. Johnson Controls – Qolsys, Siemens – Comfy, Kock – EFT Energy, Engie – Opterra Energy)
Evaluation		**3.3**		**7.9**		**5.4**		**9.7**	

Takeaways: Energy Efficiency: digital platforms

Takeaways for NZ Climate Tech Innovators

- Demonstrating integration capability is critical to achieving scale – successful innovators, including those from SAEs, all have corporate partnerships (with leading software and sensor / hardware companies) as a common component of their growth journey.
- Energy efficiency pilots for corporate buildings / real estate portfolios can be carried out in essentially any urban setting, some companies (e.g. Fsight in Israel) have grown through a combination of solving efficiency issues for heavy users of energy locally and then working through larger corporate customers to achieve scale.

Takeaways for NZ Climate Tech Ecosystem

- Synergies between an underlying hardware / sensor tech base and software proficiencies can be observed in the case of Israel: over $300m raised by 60 energy efficiency companies since 2011, with $157m from 23 companies in software. It is clear that to some level, clustering developments of these components together is creating success for the overall industry.
- Israel has marketed the value chain of its energy efficiency solutions to overseas markets through a coordinated inter-departmental effort, with the result that international corporates are coming to Israel to buy energy efficiency technology.
- Volume of output is important to achieve the same results as Israel. As a contrast, about half of Netherlands investments in energy efficiency were in software (although in a much smaller number than Israel's), and Netherlands's corporates are buying energy efficiency technology from overseas innovators, in many cases skipping over the pool of domestic innovators.
- Conduits into corporate ecosystems are critical, both on partnerships and on product marketing – Silicon Valley companies enjoy an outsized benefit in global markets as a result of their ability to fund very expensive R&D and product development at home, while partnering with leading tech firms to co-develop technology, and market to industrial incumbents that have a presence in Silicon Valley or who are existing customers of leading tech companies.

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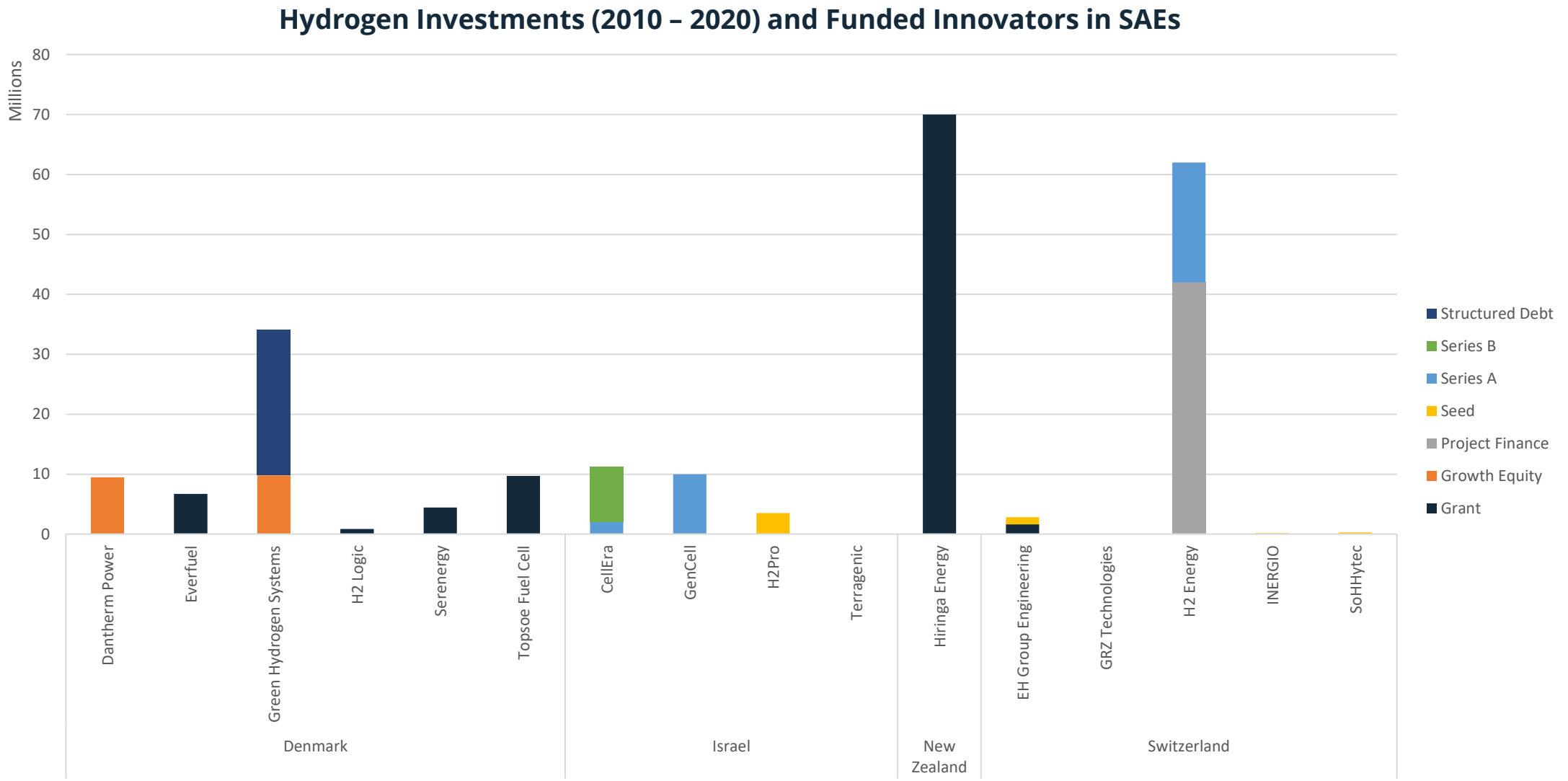
Hydrogen Innovation in SAEs



Hydrogen (transport & refueling) – Trend Analysis

External Potential	Timing of Trend
3	3

Summary

- **Description:** Hydrogen refueling infrastructure and supply of hydrogen produced from renewables (green hydrogen) for transport applications, including FCEVs and heavy duty
- **External potential:** Growth driven by increasingly strict emissions regulation globally: hydrogen is the only feasible route to decarbonization in sectors such as heavy industry and some heavy-duty transport. Business models continue to evolve as value chain projects demonstrate optimal routes to commercialisation
- **Timing:** Sustained growth depends on balancing supply with demand scaling. Mass vehicle production and reducing delivered cost of fuel is a priority for trucks; shipping and aviation represent opportunities due to limited low-carbon fuel alternatives[1,], heavy duty trucks and long-distance coaches expected to be competitive by 2030 and this will drive demand[114]. Clusters of innovation in Europe, USA, China, South Korea and Japan: 50% hydrogen startups globally are located in Europe[115].
- **CO2 reduction potential:** 3.15Gt CO2e if 50% of global transportation converts to hydrogen[116]
- **Environmental impact reduction potential**: Trucks currently account for over one third of global diesel demand and 3% global energy use.[117] Conversion of the fleet to hydrogen would also reduce air pollution, especially diesel particulate matter and nitrogen oxides[118]. As an alternative to EVs, FCEVs avoid the resource and energy-intensity of battery production[119]

Example innovators

HyET Hydrogen Efficiency Technologies

Developer of electrochemical compression equipment for refuelling stations

Arnhem, Netherlands

Everfuel

Installer and operator of hydrogen fueling stations

Herning, Denmark

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Key Clusters

Netherlands

- Shell working on multiple hydrogen refueling projects with on-site production, joint sponsor (with Toyota) of H2 Refuel Accelerator.
- TU Eindhoven and ECN involved in EU-sponsored hydrogen research projects
- Arnhem cluster brings together local SMEs and universities, transport infrastructure projects in the Netherlands, Latvia and Estonia[120]
- Government has targeted 3-4GW electrolyser capacity by 2030, €9bn investment plan, public-private partnership in hydrogen safety innovation; FCH-JU very active promoter of hydrogen throughout Europe

Denmark

- Triangle region aims to be a global hub for green fuels, FCH-JU very active promoter of hydrogen throughout Europe
- DTU involved in EU-sponsored hydrogen research projects
- Danish Energy Agency funds startups and demonstration projects such as Orsted offshore floating production project
- City of Copenhagen, Copenhagen airport and 5 other companies involved in world's largest production project, aiming to supply fuel for heavy road vehicles, shipping and aviation

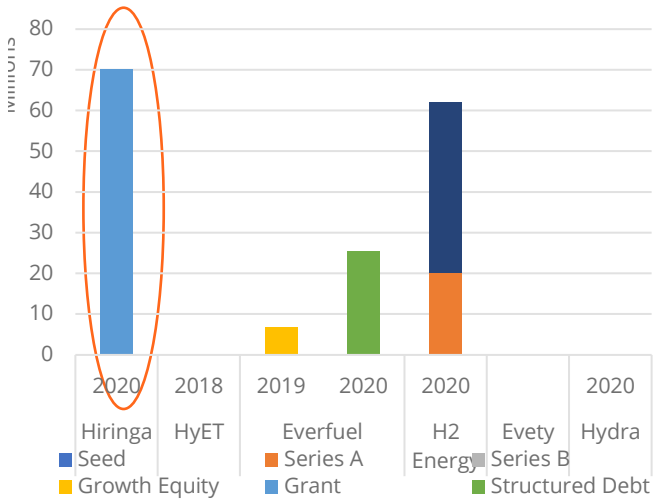
Innovators and Ecosystems: Hydrogen (transport & refueling)

Alignment w/ Strength

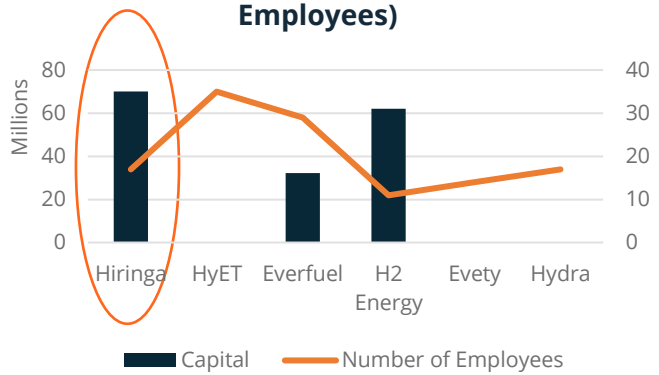
3

Ecosystem	HIRINGA (NZ) Building and operating hydrogen generation and distribution infrastructure	HyET Hydrogen Efficiency Technologies (Netherlands) Operator of the largest fuel cell testing and development facility in The Netherlands	Everfuel (Denmark) Installer and operator of hydrogen fueling stations	H2 energy (Switzerland) Hydrogen production and supply, refueling stations	evety (Essen, Germany) Hydrogen usage processes and professional implementation	hydra (Delta, Canada) Hydrogen as a Service for diesel-powered heavy-duty vehicles
Diversity in mgmt. / ownership	15%					50%
Grants	New Zealand government		Danish Energy Agency			
Incubators / Accelerators						• Foresight Cleantech Accelerator
Angel Financing						
Equity Financing		• Shell Ventures, AP Ventures		• Trafigura		• Sustainable Development Technology Canada • Just Business
Debt Financing			• European Investment Bank	• Trafigura		
Customers		• Shell Technology Centre • US Naval Research Lab	• Province of South Holland			
Partnerships	• Mitsui, TR Group, Hyzon Motors • FirstGas, Ballance Agri-nutrients, Waitomo	• ITM, HyGear • H2H Energy (entry into Australian and NZ markets)	• Hydrogen Sweden, NL government • Green Hydrogen Hub, Orsted	• NEL ASA, Hyundai Motor • Alpiq	• OGE, TUV, Horvath & Partners	
Talent Pipelines						
Emissions Reduction						

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Local Participants

External Participants

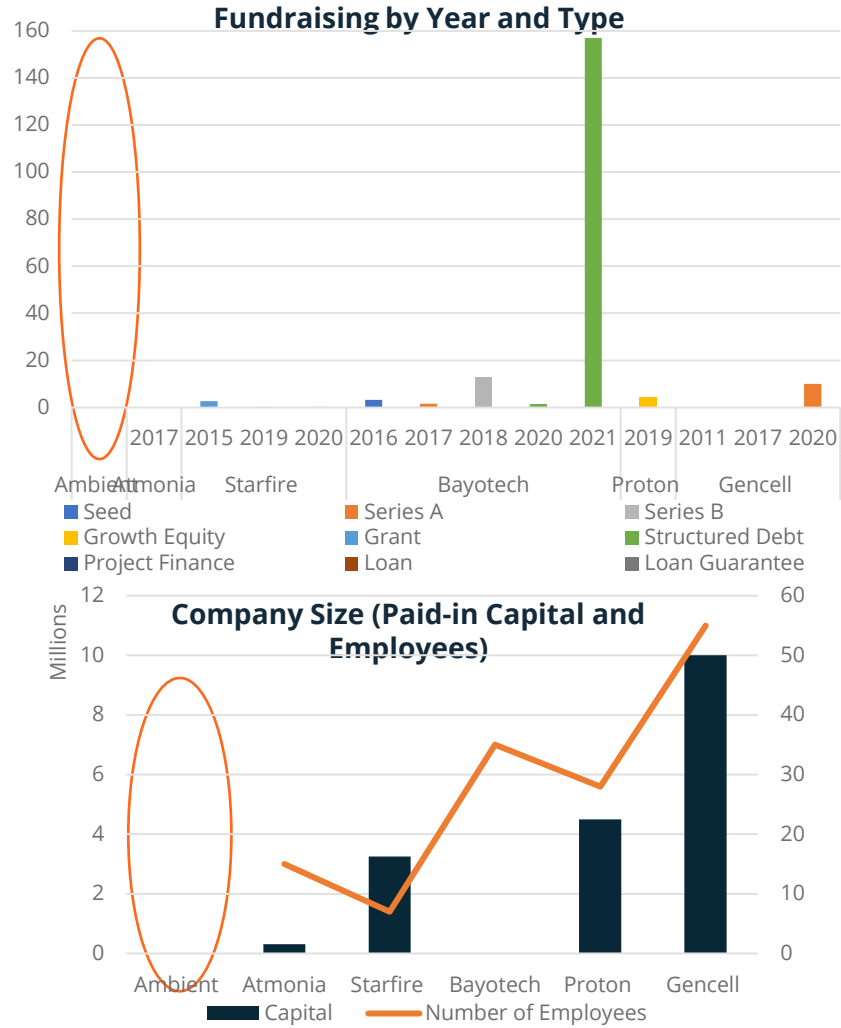
Acquirer

Innovators and Ecosystems: Green Ammonia Production

Alignment w/ Strength

1

Ecosystem	Ambient Ammonia (NZ) Nitrogen breaking at mild conditions	Atmonia (Iceland) Developer of novel ammonia production methods for crop fertilizer	Proton Ventures (Netherlands) Pressurized and cooled ammonia storage facilities	Bayotech (New Mexico, US) On-site hydrogen production solutions using gas-as-a-service	Starfire Energy (Colorado, US) Producer of clean ammonia for energy storage and fuel
Diversity in mgmt. / ownership		Female CEO		3/5 non-white C-suite, 1/5 female C-suite	
Grants		• Iceland Technology Development Fund	• SABIC Hydrogen Challenge, Horizon2020		• Colorado Office of Economic Development and International Trade • ARPA-E, SBIR
Incubators / Accelerators	• Wellington Univentures	• Startup Energy Reykjavík Accelerator • Plug & Play Tech Center	• New Energy Challenge (finalist)	• The Yield Lab	
Angel Financing					
Equity Financing		• Eyrir Invest	• Koolen Industrie	• Newlight Partners , Cottonwood, Sun Mountain Capital, Fortista	• AP Ventures • Rockies Venture Club
Debt Financing				• Cross River Infrastructure Partners	
Customers				• Nutrien	
Partnerships		• MAN	• Trammo, Haldor Topsoe • Duiker Combustion Engineers	• DLL. H2Gen Technical Services. H2 ZEST. iGas Energy, Intralink Japan, Hyzon, New Mexico Gas	• Idaho National Lab
Talent Pipelines	• Victoria University of Wellington	• Chalmers Uni of Technology • Uni. Of Iceland, Lund Uni	• University Delft	• Uni of Southern California • Harvard Business School	• Colorado School of Mines • Uni of Alaska Fairbanks • Worcester Polytechnic
Emissions Reduction		• Zero carbon ammonia production		• -300 gCO2e / MJ carbon intensity	



Source: Cleantech Group i3 Database

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Local Participants

External Participants

Acquirer

NZ Ecosystem in Global Context: Hydrogen (transport & refueling)

Ability to Lead

2.5

		New Zealand		Netherlands		Denmark		Switzerland	
	Overview	• Good renewable resources, no decisive strategy on import vs produce, political will to drive renewable energy and hydrogen economy		• Strong hydrogen policy • Leading academic & research centres • Most innovation by corporates • Regional industry & transport hub		• Strong academic activity • Renewable energy potential and track record • Public sector, venture and debt funding		• Academic – industry links • Aims to export refueling capability to neighbouring countries • Investment mostly at seed stage	
35%	**R&D-to-commercialization pipeline strength**	6	• University of Auckland, Otago programmes in clean mobility • Joint German-New Zealand research centre on green hydrogen[121]	9	• TU Delft, TU Eindhoven, ECN involved in next-generation production research • Horizon 2020, European Green Hydrogen Accelerator • Lack of dedicated hydrogen incubators / accelerators	7	• DTU active in next-generation production research • Horizon 2020, European Green Hydrogen Accelerator • Lack of dedicated hydrogen incubators / accelerators	8	• Energypolis co-locates research and commercial applications, Cleantech Alps supports SMEs, research and startups with funding and internationalisaton • Switzerland Innovation Foundation runs 4 innovation parks with energy and transportation specialisations
25%	**Financing strength**	7	• Dedicated green financing instruments • Provincial Growth Fund $19.9m South Taranaki production facility[124] • Funding events in production, distribution & utilisation	6	• Most funding by corporates	8	• €66m invested in last decade • Everfuel $25.5m; Green Hydrogen Systems $24.3m • Funding for production and delivery scaleup	5	• $3.3m invested in last decade • No significant venture investments
40%	**Connection to demand**	8	• Memorandum of cooperation with Japan, export possibilities with Asia-Pacific, Japan and Korea[122] • Meridian and Contact investigating production investment[122] • Overseas partners collaborating with local innovators (Mitsui, Hyzon Motors)	9	• Gas network provides opportunity to convert for transport to neighbouring countries • Xebec – HyGear acquisition • Shell, Gasunie; Neste, Engie, Paul Wurth, Sunfire involved in project collaborations	8	• Strong corporate – innovator partnership activity with local and overseas partners • Everfuel – H2Fuel/H2CO acquisitions • Haldor Topsoe, Gas Storage Denmark, Corre Energy investing in projects	8	• Strong innovator - corporate partnership activity • Sunfire – Industrie Haute Technologie acquisition • Alpiq partnership with H2 Energy for hydropowered production • H2 Mobility Switzerland partnership to develop a commercial cycle for renewable hydrogen
Evaluation		**7.1**		**8.3**		**7.7**		**7.3**	

Takeaways: Hydrogen (transport & refueling)

Takeaways for NZ Climate Tech Innovators

- Some off grid applications are already cost-effective for zero-carbon hydrogen
- Heavy duty trucking expected to be cost-competitive by 2030, delivered cost of fuel and vehicle cost/availability will be key drivers. Shipping is also an opportunity due to limited low carbon alternatives
- Collaboration with corporate partners can help to share the high CAPEX needed for hydrogen investments
- Consider storage and transport applications for export opportunities
- Green ammonia technology development is CAPEX-intensive, seek to engage grants and non-dilutive financing where possible
- Demonstration of technology requires work with utilities and automotive companies, many of which are overseas, consider how to engage through open innovation challenges and also pursue export promotion support from relevant government bodies

Takeaways for NZ Climate Tech Ecosystem

- The game isn't over yet, at the moment we are judging success mainly by size and amount of project investments. Successful business models will become clearer over next five years
- Decisive policy is needed to send a clear demand signal and drive market investments
- Ensure support for each part of the value chain as the industry develops.
- Near-term cost decreases will be driven by improvements in electricity production and balance of plant; on a 10-20 year time frame electrolysers will become the cost-bottleneck – invest now in R&D to deliver next-generation technologies which will drive future cost improvements
- No de facto global leading cluster for green ammonia innovation, markets likely to be moved by corporates with hydrogen proficiency – however, innovation in the US (although spread out geographically) tends to be tied closely to work with national labs and government grant-awarding bodies.
- Consider opportunities to push domestic innovators into global innovation challenges, e.g. the SABIC Hydrogen challenge
- Partnerships with utilities are critical for at-scale technology demonstrations

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Appendix 2
Agriculture & Food

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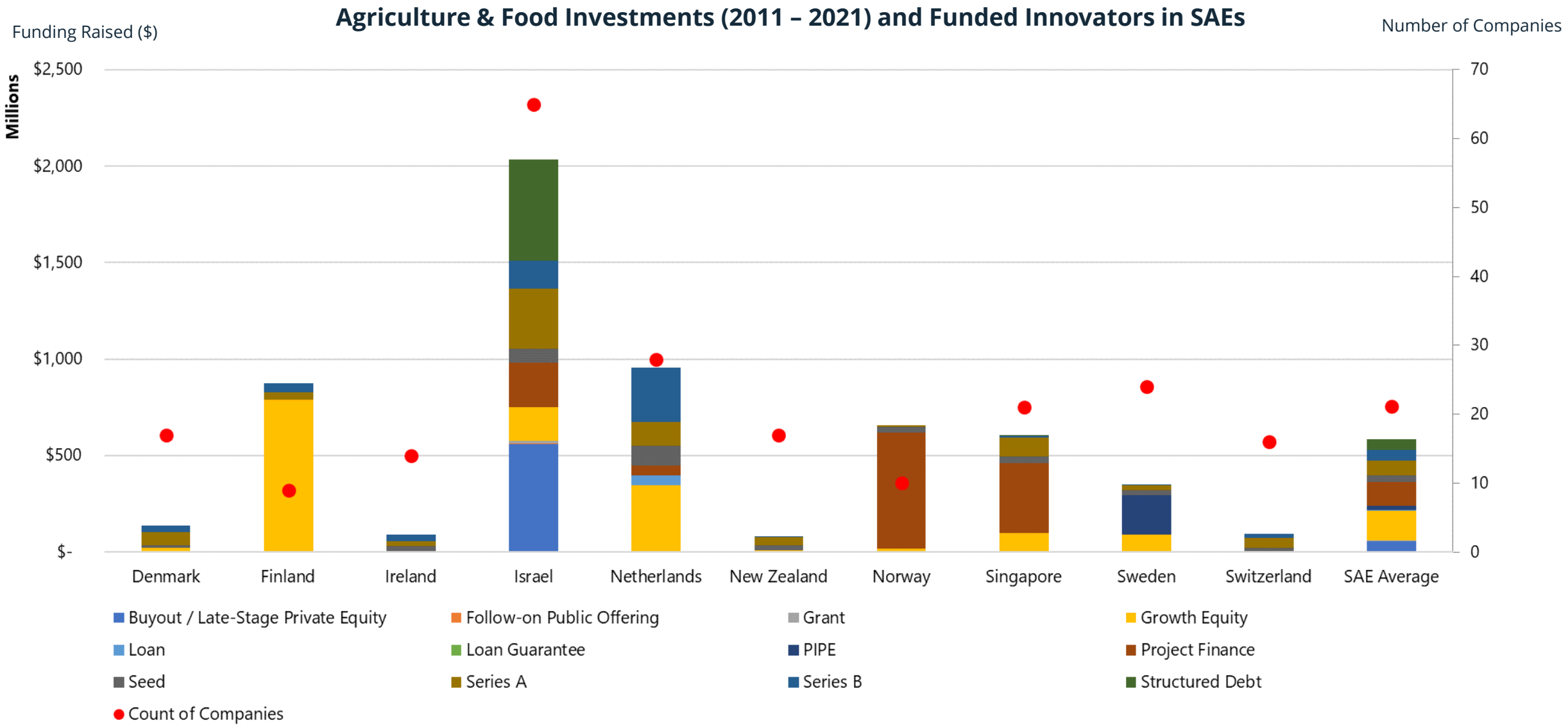
  - Livestock Breeding & Genetics
  - Methane Vaccines
- Feed Alternatives and Additives
- Protein Replacements
- Aquaculture
- Crops
  - Specialty Crops
  - Precision Chemical Application
- Agricultural digitalisation
  - Agricultural Robotics
  - Agricultural Drones
  - Agricultural Software
- CCS for Agriculture

Overview – Agriculture & Food Innovation in Small Advanced Economies (SAEs)



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- Feed Alternatives and Additives
- Protein Replacements
- Aquaculture
- Crops
  - Specialty Crops
  - Precision Chemical Application
- Agricultural digitalisation
  - Agricultural Robotics
  - Agricultural Drones
  - Agricultural Software
- CCS for Agriculture

Livestock Monitoring – Trends Analysis

External Potential	Timing of Trend
4	3

Summary

- **Description:** The use of hardware and/or software to detect disease and optimize management of animals.
- **External potential:** The livestock monitoring market is expected to grow from $1.4 billion in 2021 to $2.3 billion by 2026 at a CAGR of 10.4% during this period. Growth is fueled by camera and tag-based IoT technology for in beef and dairy operations where costs, land-value, and retail price are high, and adoption of basic monitoring technologies in lower value markets. In the US, consolidation into large herds is occurring to bring economies of scale, despite an increasing number of bankruptcies in the dairy industry. In Europe, smaller average herd sizes offer a better route to market for high tech. solutions aimed at the livestock industry. [125, 126, 127]
- **Timing:** Livestock operations are looking for high efficiency operation as the market enters a further decade of consolidation. Significant headwinds include supply chain bottlenecks highlighted by Covid-19 related supply chain shock and reduced consumer demand for livestock-based products. Incumbents in this industry are looking to east Asian markets for growing demand of livestock products in line with growing middle-class populations.
- **Environmental impact reduction potential:** Animal health monitoring and illness prevention is estimated to have a decarbonization potential of ~411 $MtCO_2e$, at cost savings of ~$5/$tCO_2e$, by 2050. Livestock contribute 24% of all anthropogenic greenhouse gas emissions, and 45% of all methane emissions. More efficient livestock practises reduces the total number of livestock required for the same output, and so early disease detection and optimization of management is critical to reduce this sector's environmental impact. [125, 126, 127]

Example innovators

iotag

Developer of a livestock eartag system

NSW, Australia

Connecterra

Developer of AI engine to deliver data analytics to dairy farmers

Amsterdam, Netherlands

Key Clusters

Australia

- Strong domestic and export market for livestock innovation, second only to Brazil on beef exports. Australian red meat domestic and export market valued at $28.5 billion in 2018-19.
- National science agency CSIRO provides a broad range of grant funding and startup support to catalyze innovation. Recent livestock monitoring research includes Ceres Tag, eGrazor, and Agersens.

Netherlands

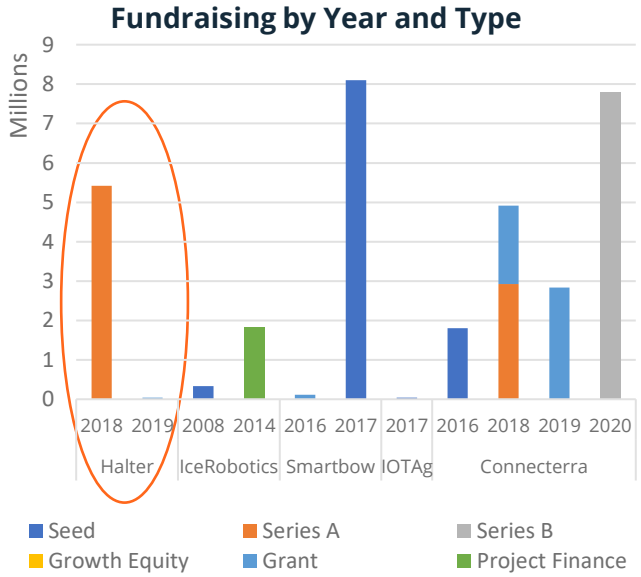
- Land availability is key constraint on Netherlands agricultural industry, particularly for dairy and other livestock operations.
- Key livestock machinery developers, such as Lely, are based in the Netherlands, offering an important talent pool focused on livestock operational efficiency.
- Major agriculture and food brands have HQ in Netherlands, including Cargill, Kraft Heinz, Danone, and Kikkoman.
- Strong R&D network through leading research institutions like Wageningen University and the Dairy Campus.

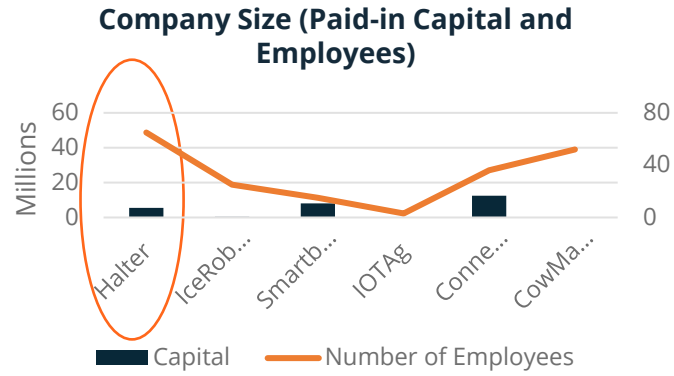
Innovators and Ecosystems: Livestock Monitoring

Alignment w/ Strength

4

Ecosystem	Halter **Auckland, New Zealand** Developer of livestock tracking collar	iCEROBOTICS **Edinburgh, United Kingdom** Developer of dairy livestock tracking collar	SMARTBOW **Weibern, Austria** Developer of a livestock eartag system	iotag **Finley, Australia** Developer of a livestock tracking collar	Connecterra **Netherlands** Developer of AI engine to deliver data analytics to dairy farmers	CowManager **Harmelen, Netherlands** Developer livestock tracking eartag system
Diversity in mgmt. / ownership				• 1/5 founding team non-white	• Female sales director	
Grants	• Callaghan Innovation	• Innovate UK	• Finodex Accelerator	• SproutX	• Horizon 2020	
Incubators / Accelerators			• Finodex Accelerator • Pearse Lyons Accelerator		• Breed Reply	
Angel Financing					• Elias Tabet	
Equity Financing	• Data Collective DCVC • Founders Fund • Ubiquity Ventures • Promus Ventures • Tuhua Fund • K1W1			• Artesian VC • Wayra	• ADM Capital • Kersia • PYMWYMIC • Breed Reply • Sistema VC • AgFunder	
Debt Financing						
Customers						
Partnerships			• Zoetis		• DSM • Danone • Yara • Syngenta • Cargill	
Talent Pipelines	• Auckland University of Technology • University of Canterbury	• Herriot Watt University • Edinburgh Napier Uni. • ETH Zurich • Uni. Of Gottingen		• Charles Sturt University • Visvevaraya Tech. Uni. • Bauhaus Universitat Weimar	• INSEAD • Endhoven University • University of Amsterdam	• Wageningen • HAS • HU Utrecht
Emissions Reduction						





Source: Cleantech Group i3 Database

Livestock Breeding & Genetics – Trend Analysis

External Potential	Timing of Trend
4	2

Summary

- **Description:** Improving the genetic traits of farmed animals through optimized selective breeding and genetic engineering techniques.
- **External potential:** The global animal genetics market size was estimated at $6.11 billion in 2018 and is anticipated to grow to $8.54 billion by 2026. This market has mainly focused on animal feed efficiency. Countries such as the US have seen an overall reduction in the number of cattle, but beef and milk production has increased. Genetics are looking to improve disease resistance and methane emissions in order to respond to antibiotic resistance, consumer preferences, and environmental regulation. [128, 129]
- **Timing:** AI-driven farm decision support tools are taking herd data and providing breeding intelligence in order to optimize selective breeding. This level of technology could be used in developing markets where more expensive genetics-based solutions are prohibitively expensive. While there is no market currently, a market that prices methane reduction from genetic engineering could incentivize the technology's adoption to reduce the methane emissions intensity.
- **Environmental impact reduction potential:** Greenhouse gas–focused genetic selection and breeding could have a ~506 $MtCO_2e$ impact, at zero cost, by 2050. 20% of an animal's methane emissions can be attributed to genetics alone. Assuming other factors, such as productivity, remain steady, applying such commercial genetics in the United States could reduce methane emissions from about 53 kilograms per cow to about 42 kilograms per cow. [128, 129]

Example innovators

Acceligen™

Spin-out from Recombinetics, focused on genetic improvement for animal welfare, methane emission reduction, and disease resistance

MN, USA

INOVO

Developer of a biotech solution to sex chicklets before hatching

Leiden, Netherlands

Key Clusters

USA – Mid-West

- The US has a more permissive regulatory framework for genetic engineering compared to other advanced agricultural economies.
- Global soybean production centre with 75% of agricultural land devoted to soy bean production. Animal feed is a key market for export, and so supporting innovation for the livestock sector is well supported.
- Well funded R&D centres such as AgriNovus in Indiana and the Donald Danforth Plant Science Centre.

Netherlands

- Strong R&D network through leading research institutions like Leiden University and Wageningen University.
- Long history of genetic R&D, with a particular expertise in pig and poultry breeding.
- Land resource constraints increase the need for genetic optimization and selective breeding.

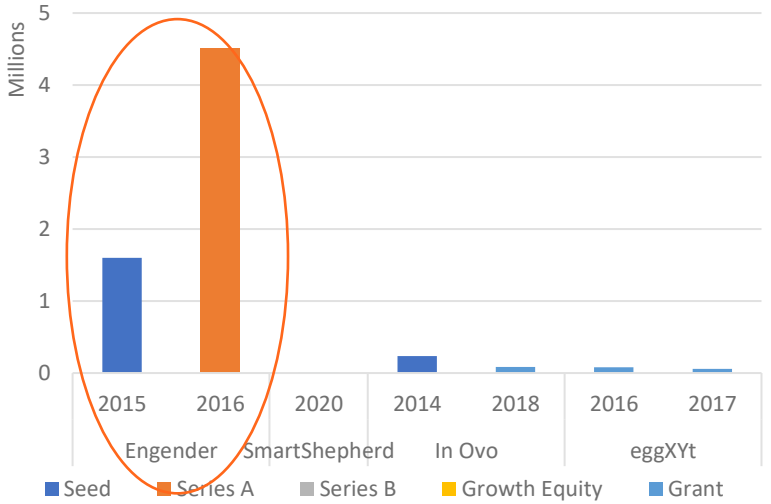
Innovators and Ecosystems: Livestock Breeding & Genetics

Alignment w/ Strength

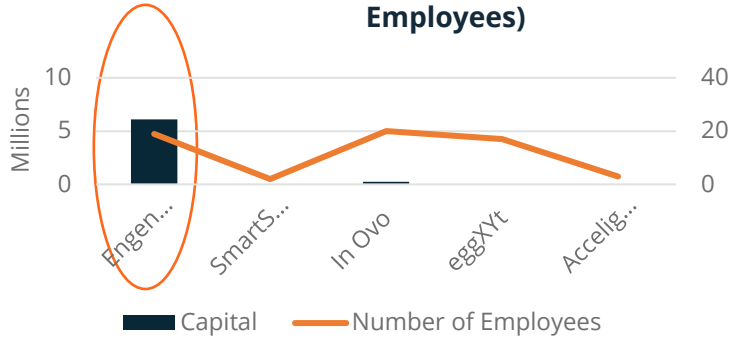
4

Ecosystem	ENGENDER **Hamilton, NZ** Developer of a sperm sorting system for genetic optimization	Smart Shepherd **Australia** Developer of a livestock tag and pedigree data platform	IN OVO **Leiden, Netherlands** Developer of a biotech solution to sex chicklets before hatching	eggXYt **Israel** Developer of a solution to sex chicklets before hatching	acceligen **Minnesota, USA** Developer of selective trait breeding systems
Diversity in mgmt. / ownership				• No diversity among founders / C-suite • Advisory 2/15 female	• Female director
Grants	• Callaghan Innovation	• University of New England	• EASME	• EASME • MassChallenge	• FFAR
Incubators / Accelerators		• SOSV • Hax Accelerator	• EIC Accelerator Pilot	• Pearse Lyons Accelerator • Creative Destruction Lab	
Angel Financing	• ICE Angels Nominees • Enterprise Angels • Arc Angels				
Equity Financing	• Pacific Channel • New Zealand Venture Investment Fund	• SOSV • Indie Bio	• VisVires New Protein • Evonik Venture Capital • Leiden University		• Bill and Melinda Gates Foundation
Debt Financing					
Customers					
Partnerships	• CRV		• Pas Reform Hatchery Technologies • DSM Twilmij • Philips NatureDynamics	• Tropic Biosciences	• Recombinetics (Parent) • Kheiron Biotech • Semex
Talent Pipelines	• Auckland University of Technology	• University of New England	• Leiden University • TU Delft • Utrecht University	• Tel Aviv University • The Hebrew University • University of Haifa	• University of Minnesota • Iowa State University
Emissions Reduction				• 50% incubation reduction: reduced electricity, transport & waste disposal	• Reduced greenhouse gases & water usage (not quantified)

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

Methane Vaccines – Trend & Ecosystem Analysis

External Potential	Timing of Trend	Alignment w/ Strength	Ability to Lead
2	3	4	3

Summary

- **Description:** Methane-inhibiting vaccines for ruminants that reduce methane emissions from enteric fermentation by at least 20% while not negatively impacting livestock production.
- **External potential:** Specific market size unclear – animal vaccines market size estimated at just under $10 bn in 2021 with a 6.3% CAGR through 2026 [73]. Demonstration of profitability is more difficult than for traditional animal vaccines (that reduce loss of livestock due to disease) or alternative feeds for methane reduction (that may market a price advantage) – requiring vaccines to rely on potential cost savings to farmers in regions under regulatory pressure to reduce methane emissions.
- **Timing:** Reduction of enteric fermentation is a critical line item in any national 1.5C or GHG abatement strategy, some countries are beginning to develop targeted programmes for reduction of agricultural methane reduction, e.g. Australia's Agriculture Methane Research and Monitoring programme.
- **Environmental impact reduction potential:** Enteric fermentation from livestock accounts for 5% of all GHG emissions from human activity worldwide – methane (CH4) emitted from enteric fermentation is able to trap heat 30 times more than carbon dioxide. [130] Studies as early as 2004 indicated that a 7.7% reduction in CH4 emissions from enteric fermentation was possible with a methane vaccine [131] but have recently been estimated at 25-30% by leading experts in NZ [132]

New Zealand Highlights

agresearch

- The NZ Government will fully fold agriculture emissions into an emissions pricing scheme, with a price on emissions beginning in 2025[135]
- The NZ Climate Change Commission released a 2021 plan including suggestions that methane from livestock drop 6.5 per cent annually, and end up with an annual average of about 16 per cent below 2018 levels 2031-35 [138]

NEW ZEALAND AGRICULTURAL GREENHOUSE GAS Research Centre

- New Zealand Agricultural Greenhouse Gas Research Centre is conducting research on methane vaccines as a part of $50m of funding 2010-2020 and $50m for 2021-2025[134]

PGgRc PASTORAL GREENHOUSE GAS RESEARCH CONSORTIUM

- Methane vaccine development efforts in NZ have led to a stage of maturity allowing for in vivo testing, a critical step prior to being able to carry out live animal testing[136]

NZ Ecosystem in Global Context: Livestock

Ability to Lead

3

	New Zealand	UK	Netherlands	Australia
Overview	• Strong agriculture R&D • Low presence of financing • Strong agriculture market • Low presence of multinationals • Strong reputation for quality	• Leading academic institutions • Leading R&D in agriculture • Global financial centre • Extensive internationalization of Ag. services and innovation	• World class agricultural exporting economy • World class agricultural R&D • Strong domestic and export market for livestock products	• Resource-based economy with focus on minerals, mining and agricultural exports • Strong public research support and connection to export markets.
35% **R&D-to-commercialization pipeline strength**	**7**	**8**	**8**	**7**
	• Massey U, U. Auckland, Waikato U. spinning companies out • Callaghan Innovation loans are available • Demand-driven R&D tax credit (15% at $430 million/year) [21]	• Innovate UK well funded coordinator of public grants and early-stage support • UK BEIS and DEFRA active in support innovation through grants and pilots • 5+ research universities looking at livestock and agriculture	• Wageningen University and HZ University are centres of European agricultural research • Strong public support through DOEN, Invest-NL, and other public funded grant and support institutions.	• CSIRO responsible for R&D coordination • Strong presence of livestock management corporates due to high volume of trade • Small number of commercial scale innovations
25% **Financing strength**	**5**	**9**	**8**	**6**
	• Seed and early-stage financing supporting ag tech evident • Few NZ-based investors to support larger equity and debt rounds • Corporate and external investors are accessing companies in standout cases	• 10+ VC and equity investors based in London dedicated to agtech investment. • Over $3.6 billion invested in UK agtech companies in 10 years	• 10+ agri-focused VC investors • Active local agri-banks to connect innovation to global investors (RaboBank) • Strong presence of multi-sector VC and private equity finance to scale startups	• 10+ equity investment funds with ag technology in thesis, typically early-stage investors • Active angels and family offices • Lack of domestic Series B+ funding even for leading startups (AgriWebb Series B led by Telus Canada)
40% **Connection to demand**	**8**	**8**	**9**	**8**
	• Meat exports worth $5.3 billion to New Zealand economy annually 60% of export revenue • Strong international reputation for NZ branded meat products • Lack of innovation outposts in overseas markets to promote innovation • Strong private companies (Fonterra) in this sector yet meagre innovation activities	• Total income from farming industry $14.4 billion (0.53% GVA, 2019) [141, 142] • Livestock is around 58% of market share by value • Exports account for only 17% of revenue. [141, 142] • Traditionally an entrepot for European expansion • Uncertain trade situation post-Brexit	• Livestock sector contributes $10.9 billion to the Dutch economy • Dutch agricultural exports worth $110 billion (2019) • Leading feed and animal welfare companies based here to connect innovation to global markets (DSM, Nutreco)	• Livestock (cattle & sheep) industry turnover $72.8 billion in 2018-19. Key sector for Aus. economy. • 12,000 jobs supported in Indonesia, a major recipient of live trade animals • Importance of export market has driven significant scrutiny on animal management and welfare innovation
Evaluation	**6.9**	**8.3**	**8.4**	**7.2**

Scoring: Livestock

Trends	Market		NZ Position	
	External Potential	Timing of Trend	Alignment w/ Strength	Ability to lead
Livestock Monitoring	4	3	4	3
Livestock Breeding & Genetics	4	2	3	3
Methane Vaccines	2	3	4	3

Takeaways for NZ Climate Tech Innovators

- Focus on data-driven farm management and improved genetic selection as these are key tools for this trend. Cost and emissions intensity will put pressure on finding efficiency gains in livestock production systems.
- Leverage NZ's existing livestock products supply chain to develop solutions that improve quality, safety, welfare, and traceability. These characteristics have value globally and can be easily exported.
- Do not rely on private sector partnerships in NZ. There is little evidence of investment and innovation support from large companies operating in this sector.
- Develop strong use case studies to increase adoption. Adoption rates correlate with good communication of benefits to farmers.

Takeaways for NZ Climate Tech Ecosystem

- Prepare for a reduced size of the livestock industry (number of farms and head of animals), but potentially increased value.
- Nurture sales channels with Asian markets. This is where NZ has strong export volumes and where demand is likely to grow. In these markets key differentiators will increasingly be animal welfare, product safety, and traceability.
- Accelerate corporate engagement with innovation. To remain competitive, they need to engage innovation through accelerators, pilot opportunities, and commercialization partnerships.
- Key areas to develop for NZ livestock industry include innovative farm management systems, methane reduction ingredients, and supply chain tracking solutions.

Contents

Agriculture & Food– Comparison between Small Advanced Economies (SAEs)

Livestock

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- Livestock Breeding & Genetics
- Methane Vaccines

Feed Alternatives and Additives

Protein Replacements

Aquaculture

Crops

- Specialty Crops
- Precision Chemical Application

Agricultural digitalisation

- Agricultural Robotics
- Agricultural Drones
- Agricultural Software

CCS for Agriculture

Feed Alternatives and Additives – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** Animal feed with lower emissions intensity and resource use in production and feed additives that benefit animal health and the environment.
- **External potential:** The global animal feed additives market was valued at $37.83 billion in 2019 and is projected to expand to $49.1 billion in 2027 at a CAGR of 3.8%. The animal feed market is valued at around $370 billion, with expected CAGR of 3.5 – 4% over the next four years. 40% of this growth is expected to come from Asia Pacific due to the 78% rise in protein demand expected by 2050. [143, 144]
- **Timing:** Innovation in this industry is critical. The GHG intensity of current livestock practises is unsustainable. For farmers, rising global feed costs is putting pressure on an industry that struggled to meet demand during supply chain shock due to covid-19, where high wholesale prices for meat products were not passed down to the farmgate. Antibiotic resistance, particularly in hog farming, has led to pathogenic crisis such as African Swine Flu. Optimizing nutrition and vaccination through a feed mix that is more sustainably sourced has become critical to the industry's future.
- **Environmental impact reduction potential:** Optimization of the animal feed mix could have a ~370 $MtCO_2e$ impact, at cost of ~$131/$tCO_2e$, by 2050. The expanded use of animal feed additives could have an impact of ~299 $MtCO_2e$, at cost of ~$88/$tCO_2e$ by 2050. While there are proven chemical feed additives in the market such as Bovear from DSM, many seaweed-based alternatives are becoming available claiming 80+% methane reduction through >1% feed addition. [143, 144]

Example innovators

PROTIX

Developer of insect farming systems

Netherlands

V0LTA

Developer of seaweed production system for livestock methane reduction

Sweden

Key Clusters

Netherlands

- Strong R&D network through leading research institutions such as Wageningen University.
- Major feed and animal-product corporations and are based, or have their European base, in the Netherlands including DSM, Cargill, Danone, and Kikkoman.
- Strong agri-finance support through institutions such as Rabobank to deliver agricultural loans, specialty finance for the agricultural sector, and support for startups through The Rabobank Innovation Fund, Rabo Food and Agri Innovation Fund, and Startup Bootcamp.

Sweden

- Strong innovation R&D ecosystem including SLU, Lantmännen, Dataväxt, Federation of Swedish farmers, the cooperative Lantmannen, and SMHI.
- Strong technology talent pool through innovative corporates including Ericsson, Telia, and Volvo.
- Low commercialization of agricultural startups, but many examples of food and sustainable food and forestry products internationalization.

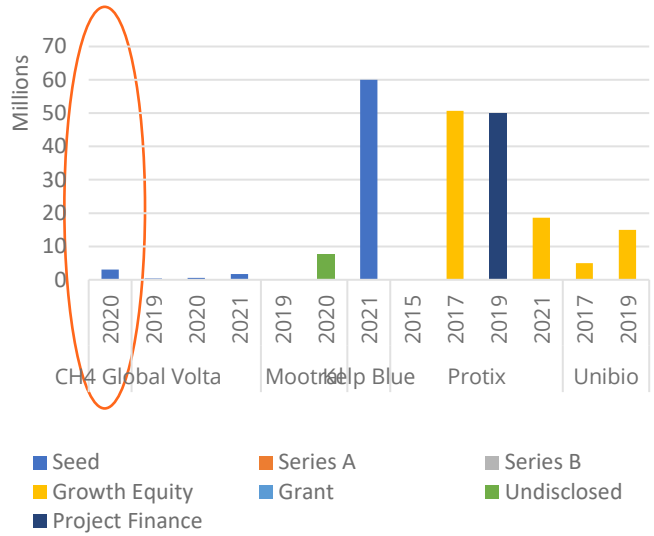
Innovators and Ecosystems: Feed Alternatives & Additives

Alignment w/ Strength

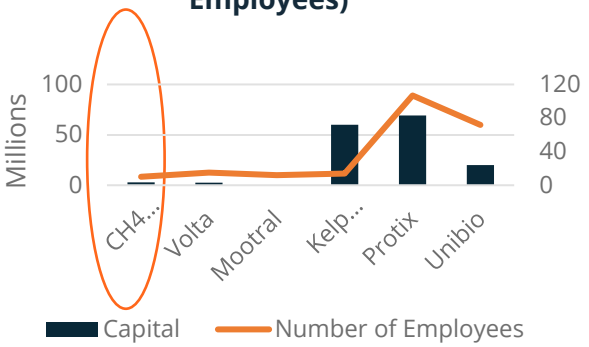
3

Ecosystem	CH4 GLOBAL NZ / San Francisco Developer of seaweed production system for livestock methane reduction	V0LTA Solna, Sweden Developer of seaweed production system for livestock methane reduction	MOOTRAL Rolle, Switzerland Developer of seaweed production system for livestock methane reduction	kelp blue Zeist, Netherlands Developer of ocean kelp farming systems	PROTIX Dongen, Netherlands Developer of insect farming systems	unibio Roskilde, Denmark Developer of bacterial fermentation methane-to-feed production
Diversity in mgmt. / ownership	• Gender and cultural diversity		• Female COO,	• 2/3 management team women, 1/ 3 non-white		• 1/6 female executive management
Grants	• Callaghan Innovation		• Swiss Climate Foundation			
Incubators / Accelerators						• SDG Accelerator programme
Angel Financing		• Claes Dinkenspiel • Hampus Jokobsson • Daniel Skaven Ruben				
Equity Financing	• NZ Provisional Growth • South Australian R&D Institute • Australian Fisheries R&D Corporation	• Kjell & Marta Beijers Foundation	• SchindlerAM Ventures	• Climate Fund Managers	• Buhler Group • Aqua-Spark • Rabo Corp. Investments • Brabant Development Cooperation • Invest-NL	• West Hill Capital • Mitsubishi Corporation • SAGIA • Innovation Fund Denmark
Debt Financing				• Namibia Infrastructure Development and Investment Fund		
Customers						• National Energy Corporation of Trinidad & Tobago • SAGIA
Partnerships		• AFRY • Lantmannen	• Corsia		• Hendrix Genetics • Buhler Group • Chitotex • Eucodis Bio Science	• Protelux Russia • Skretting
Talent Pipelines	• Victoria University of Wellington • University of Adelaide • Uni. of Melbourne	• KTH • Uppsala University • Stockholm University	• Freie Universitat Berlin • HEC Lausanne • University of Lausanne	• Technische Unversiteit Delft • University of Namibia	• Wageningen University	• DTU • University of Copenhagen • Aarhus University
Emissions Reduction	• Up to 90% reduction in enteric methane emissions	• Up to 80% reduction of enteric methane emissions	• Up to 38% reduction of enteric methane emissions	• 1m tons CO2/year (2029 vision)		

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Feed Alternatives & Additives

Ability to Lead

3

		New Zealand		Sweden		Netherlands		Switzerland	
Overview			• Strong agriculture R&D in universities, and gov't support • Low presence of financing • Strong agriculture market • Low presence of multinationals		• Strong public R&D spending with good Universities • Small but active and well funded VC community focused on climate tech. solutions		• World class agricultural exporting economy • World class agricultural R&D • Strong domestic and export market for livestock products		• Outward-facing economy, emphasis on technology exports • Strong multinationals with AgroSciences divisions
35%	**R&D-to-commercialization pipeline strength**	**7**	• Massey U, U. Auckland, Waikato U. spinning companies out • Callaghan Innovation loans are available • Pastoral farming system reduces focus on feed additive research • Demand-driven R&D tax credit (15% at $430 million/year) [21]	**7**	• RISE Foundation supports R&D in collaboration with Ag. industry • 3% of GDP spent R&D, focusing on green technology and life sciences (Volta, Mycorena)	**9**	• Wageningen University and HZ University are centres of European agricultural research • Strong public support through DOEN, Invest-NL, and other public funded grant and support institutions.	**7**	• ETH Zurich, EPFL ag talent / spin-offs • Relevant gov't agencies & NGOs – Innosuise, Agroscope, Swiss Climate Foundation
25%	**Financing strength**	**5**	• Seed and early-stage financing supporting ag tech (e.g. Powerhouse) • Few NZ-based investors to support larger equity and debt rounds, corporate and external investors are accessing companies in standout cases (e.g. Robotics Plus)	**6**	• Strong Seed and Series A investors including public, private, and corporate investors • Later-stage funding and exit opportunities through 'small' IPO options on Stockholm exchanges	**8**	• 10+ agri-focused VC investors • Active local agri-banks to connect innovation to global investors (RaboBank) • Strong presence of multi-sector VC and private equity finance to scale startups	**6**	• 10+ equity investment funds with ag technology in thesis, • Active angel networks and family offices supporting early stage
40%	**Connection to demand**	**5**	• Meat exports worth $5.3 billion to New Zealand economy annually. 60% of export value • Typically grass-fed herd, low use of lot feeding for additives • Lack of multinational feed companies • Lack of innovation outposts in overseas markets to promote innovation	**4**	• Small domestic market for feed alternatives and additives • Good agricultural export channels • Reputation for high animal welfare standards and food quality • Few mulitnationals to aid global expansion	**9**	• Animal feed market in Netherlands is the fastest growing in Europe. • Livestock sector contributes $10.9 billion to the Dutch economy • Dutch agricultural exports worth $110 billion (2019) • Leading feed companies based here (DSM, Nutreco, Skretting)	**7**	• Syngenta, BASF, Dow Agrosciences, Bayer Crop Sciences, Dupont all active in Switzerland • Key commodity trading houses with presence here (Bunge) • Strong science & tech global promotion infrastructure through Swissnex, Swiss Global Enterprise
Evaluation		**5.7**		**5.6**		**8.8**		**6.8**	

Scoring: Feed Additives & Alternatives

Trends	Market		NZ Position	
	External Potential	Timing of Trend	Alignment w/ Strength	Ability to lead
Feed Additives & Alternatives	4	4	3	3

Takeaways for NZ Climate Tech Innovators

- Focus on new sources of protein such as insect farming, biomass fermentation and gas-to-protein technologies. Production facilities are coming online, and the support and service industry to this new protein supply chain is still being built.
- Focus on feed additives that improve animal health and reduce methane emissions. These are being pursued by investors and governments to solve the greatest contributor to GHG emissions in the agricultural sector.
- Leverage New Zealand's existing technical and industrial capabilities in the sector.

Takeaways for NZ Climate Tech Ecosystem

- Work with seaweed production systems for animal feed additives are exploring funding options and suitable growing sites. New Zealand has the natural resources to support the expansion of this industry.
- Develop alternative feed sources to sustain NZ's reputation for high animal welfare and quality standards. Alternative sources of protein, particularly for the growing aquaculture industry, are a major environmental issue for the livestock industry.
- Learn from competitive ecosystems (Australia) are already looking to develop coastal fishing communities by encouraging seaweed farming infrastructure.
- Improve emissions regulation to ensure methane reduction innovation is not disincentivized from locating in New Zealand due to biogenic methane exceptions in NDC.

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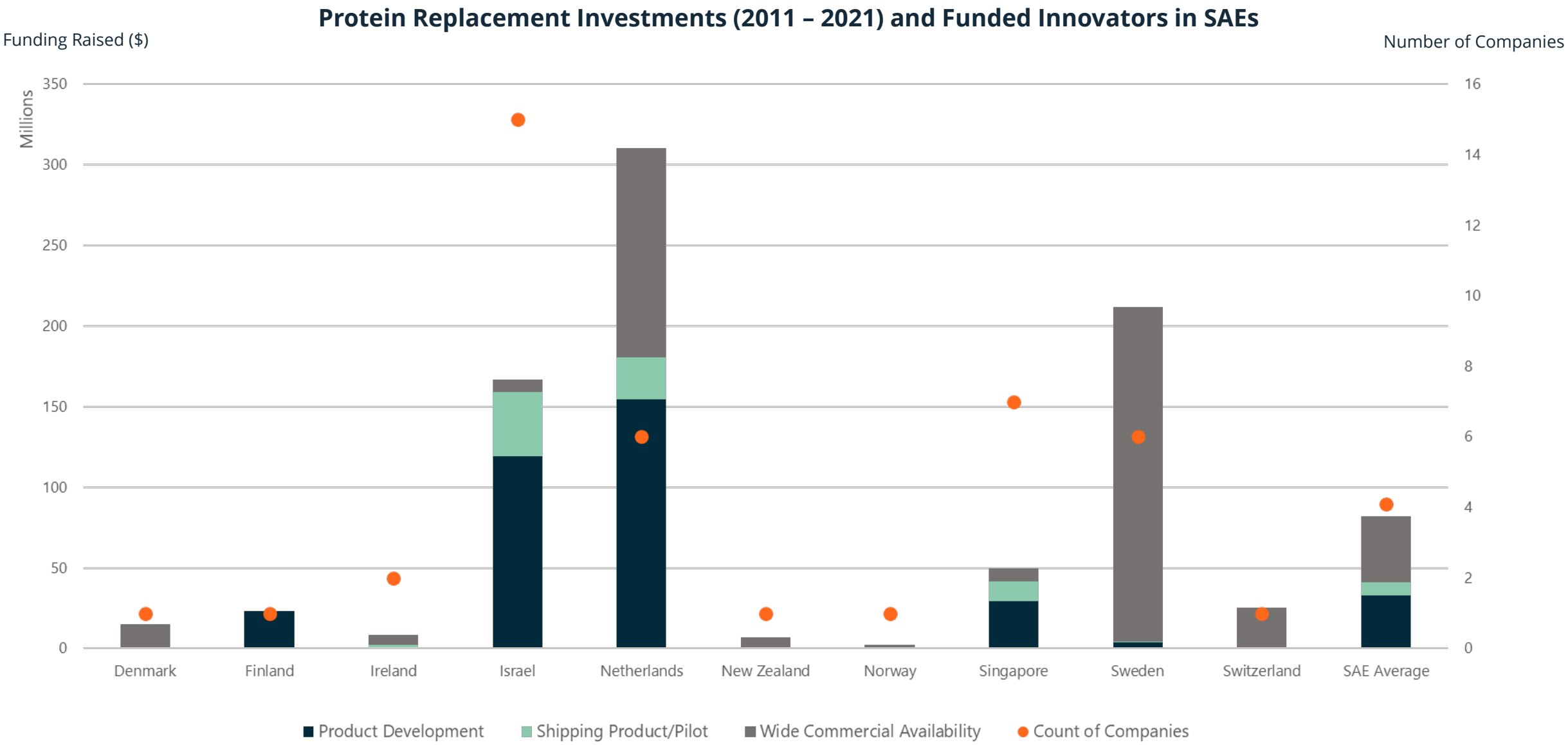
Overview – Protein Replacement Innovation in Small Advanced Economies (SAEs)



Protein Replacements – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** Protein-based foods for human consumption that are made without animals.
- **External potential:** Traditional protein farming will be turned on its head this decade as new products and production techniques disrupt the industry. Barclays estimates the alternative meat market will grow from 1% of the global market share in 2019 to 10% in 2029 with $140 billion in market share. AT Kearney predicts that by 2040, up to 60% of the meat industry could consist of meat products made from alternative proteins, with cultivated meat comprising 35% and plant-based meat reaching 25%. In Asia, meat and seafood consumption will rise 78% by 2050. [145, 146]
- **Timing:** The Good Food Institute reported over $3.1 billion was invested in alternative protein companies in 2020, more than half of the total raised over the previous ten years.
- **Environmental impact reduction potential:** Net greenhouse gas emissions from the protein industry are set to fall by 45% by 2030 through the move to more environmental sources of protein. Simultaneously, land use change from the reduced pressure on agricultural land to support livestock cultivation will present an opportunity for carbon sinks and regenerative agricultural practises. [145, 146]

Example innovators

FUTURE MEAT

Developer of cellular agriculture technologies for the growth of animal proteins

Jerusalem, Israel

Mosa Meat

Developer of cellular agriculture focusing on beef replacements

Maastricht, Netherlands

Key Clusters

Israel

- Strong government support through innovation agency activity has seen the growth of cellular protein growing technologies particularly.
- Incubators including the Kitchen Hub (founded by Strauss Group) and Fresh Start coordinate technical university spin outs with industry to support early stages of growth,
- Investment from China in Israeli protein technologies has been significant since a $300 million deal with the Israeli innovation authorities in 2017 to support the growth of this sector.

Netherlands

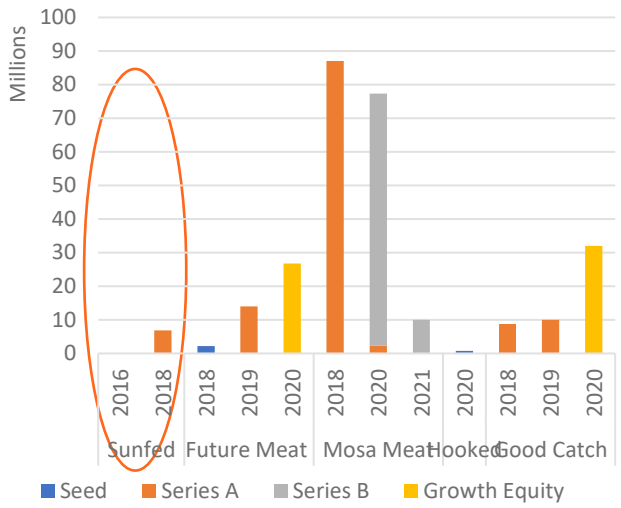
- The first lab-grown burger was developed in Maastricht University by Mosa Meat founder Mark Post.
- Strong participation in startup development from key corporations such as Nutreco and banks such as Rabobank.
- Technology-led approach to agriculture with strong support for R&D through technical universities.

Innovators and Ecosystems: Protein Replacements

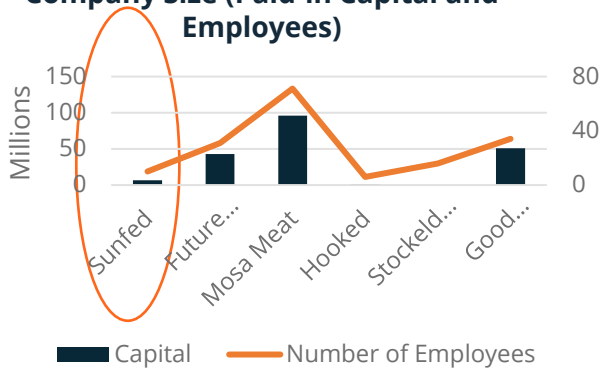
Alignment w/ Strength: 1

Ecosystem	Sunfed — Auckland, New Zealand Pea protein-based chicken alternative	Future Meat — Rehovot, Israel Developer of cellular agriculture technologies	Mosa Meat — Maastricht, Netherlands Developer of cellular agriculture	Hooked — Stockholm, Sweden Developer of plant-based salmon alternatives	Stockeld Dreamery — Solna, Sweden Developer of plant-based dairy alternatives	Good Catch — Pennsylvania, USA Developer of plant-based tuna alternative
Diversity in mgmt. / ownership	• Female, non-white founder	• Female EVP R&D		• 1/3 C-suite non-white	• Non-white & female co-founders	
Grants		• The Hebrew University				
Incubators / Accelerators		• Bits X Bites • Thrive Accelerator		• Katapult Ocean		• Thrive Accelerator
Angel Financing	• Chris Hadley		• Jitse Groen		• Henry Soesanto • Joshua Ismin • Eric Wahlforss	• Woody Harrelson • Shailene Woodley • Paris Hilton • Lance Bass
Equity Financing	• New Crop Capital • Blackbird Ventures • Quadrant Private Equity • NZ Growth Capital Partners • K1W1	• Tyson Ventures • S2G Ventures • Emerald Tech. Ventures • Archer Daniels Midland • ADM Capital • Neto Group	• Merck • Bell Food Group • Mitsubishi • Lowercarbon Capital • Blue Horizon Ventures • Nutreco	• Katapult Ocean • ProVeg International • Wave Ventures • Veg Capital • Kale United	• Astanor Ventures • Northzone Ventures, Inventure Capital • Purple Orange • Martas Explorers • Creandum	• New Crop Capital • PHW group • Stray Dog Capital • Blue Horizon • 301 Inc • CPT Capital
Debt Financing						
Customers	• Coles			• Kaiso • Hawaii Poke • Foodora • Mahalo		• Whole Foods Market • Thrive Market
Partnerships			• Nutreco			• Bumble Bee Foods
Talent Pipelines	• Auckland University of Technology	• The Hebrew University • Technion • Weizmann • Ben-Gurion	• Cambridge University • Maastricht University • Eindhoven University • Zuyd Hogeschool • Wageningen University	• NA	• Stockholm University • KTH Royal Institute • Lund University	• Ibmec • Harvard University • Ohio University
Emissions Reduction		• 80% less GHG • 99% less land use • 96% less freshwater	• Working on calculation of impact			

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Protein replacements

Ability to Lead

2

		New Zealand		Israel		Netherlands		Sweden	
Overview			• Low R&D in universities, and gov't support • Low presence of financing • Strong conventional protein • Low presence of multinationals		• World-leading biotech cluster • Coordinated public-private support for innovation • Strong internationalization of technology solutions		• World leading agritech cluster • Strong technical universities • Strong startup support ecosystem beyond agri. and food technologies		• Leading public R&D spending intensity • Good Universities and connection with Nordic R&D cluster • Small but well funded VC investors
35%	**R&D-to-commercialization pipeline strength**	**2**	• Good universities provide talent pool (Auckland University of Technology) • Little evidence of further support in this sector	**9**	• Technion, Weizmann Institute, Hebrew University participating in spinoffs[49] • Strong biotech capability • Specialist accelerators incl. corporates (e.g. Strauss) • Strong international support (E.g. investment from China 2017)	**9**	• Wageningen University & research has produced 15 spinoffs since 2011[47] • Specialist incubators; corporate involvement from e.g. Rabobank, Unilever	**9**	• Strong public funding for R&D (3.3% 2018) • Bloomer accelerator, Nordic Foodtech • Strong Nordic R&D cluster (VTT, Wageningen, KTH)
25%	**Financing strength**	**3**	• Some availability of early-stage finance, often targeting Australia and New Zealand. • $6.9M invested in protein replacement startups since 2011[1]	**7**	• 50+ agtech investors (ave. amount <$5m)[50] • $167M invested in protein replacement startups since 2011[1] • Partnerships with local investors and international corporates to support local ecosystem[51]	**9**	• European hub for VCs in alt. proteins (Anterra, Unovis) • $263M invested in protein replacement startups since 2011[1] • Engaged conventional protein service companies	**6**	• >$5m invested in protein replacement startups since 2011[1] • Small but active and well funded VC community focused on climate tech. solution-
40%	**Connection to demand**	**4**	• Meat exports worth $5.3 billion to New Zealand economy annually, 60% of export revenue[147] • Lack of multinational feed companies • Lack of innovation outposts in overseas markets to promote innovation	**6**	• Mars, Mondelez developing local solutions • Small domestic sales market but kosher principles increase alt. protein adoption • Strong internationalization of technology solutions in alternative proteins	**7**	• Livestock sector contributes $10.9 billion to the Dutch economy • Dutch agricultural exports worth $110 billion (2019) • Leading feed companies based here (DSM, Nutreco, Skretting)	**7**	• Leading international brands in alternative foods categories (Oatly) • Strong consumer association with quality and healthy products • Strong regional market for alternative proteins
Evaluation		**3**		**7.3**		**8.2**		**7.5**	

Scoring: Protein Replacement

Trends	Market		NZ Position	
	External Potential	Timing of Trend	Alignment w/ Strength	Ability to lead
Protein replacement	4	4	1	2

Takeaways for NZ Climate Tech Innovators

- Strong NZ capabilities in biotechnology offers talent pool and expertise required to develop cultured and fermented alternative proteins.
- Compete with vested interests in conventional protein production. While it could reduce the number of key industrial partners available to innovators, there will be food companies looking to strike partnerships.
- Leverage New Zealand's expertise in specialty crops and grains as it could provide new feedstocks for protein alternatives (similar to Sunfed's yellow pea protein).
- Explore export opportunities in countries with high population growth and industrialization rates.
- Successful innovators in this area display strong branding. Positioning may need to be reconsidered for each market as consumer perceptions of meat and meat alternatives differ by country.

Takeaways for NZ Climate Tech Ecosystem

- Prepare for alternative protein production techniques cannibalizing conventional meat market share. Countries with strong reputations for quality protein foods are investing heavily in alternative protein innovation.
- Israel's Innovation Agency deal with China in 2017 offers an example of how to establish a new technology in a country's innovation ecosystem. In less than three years the country has become a leading SAE in alternative proteins.

Contents

- Agriculture & Food– Comparison between Small Advanced Economies (SAEs)
- Livestock
  - Livestock Monitoring
  - Livestock Breeding & Genetics
  - Methane Vaccines
- Feed Alternatives and Additives
- Protein Replacements
- **Aquaculture**
- Crops
  - Specialty Crops
  - Precision Chemical Application
- Agricultural digitalisation
  - Agricultural Robotics
  - Agricultural Drones
  - Agricultural Software
- CCS for Agriculture

Aquaculture– Trend Analysis

External Potential	Timing of Trend
3	2

Summary

- **Description:** Aquaculture is the farming of aquatic organisms including fish, mollusks, crustaceans, and aquatic plants.
- **External potential:** The global market was valued at $285 billion in 2019 and is projected to reach $378 million by 2027 (5.8% CAGR). There is growing global demand for protein, as 15% of human protein consumption comes from fish. Strongest demand growth is in Asia, with China the leading market by volume with increasingly high value species being farmed. A stagnant captured fish industry has kept the total captured fish at around 80-90 million tons/year since 1990, due to overfishing and cost of marginal gains. Sale price of aquaculture-raised fish is increasing, with a doubling of price since 2004 (~$2000/ton to ~$4000/ton in 2015).[148]
- **Timing:** Particular attention is being paid to feed, as current practises use 20% of all ocean catch as feed for farmed fish. Corporates in global aquaculture are committing to 100% traceable and certified (ASC/IFFO RS) feed. Few are setting goals for the scope three emissions due to the carbon footprint of their feed sources.
- **Environmental impact reduction potential:** 65.8% of wild fisheries are currently unsustainable. Studies show that up to 80% of a farmed trout's lifecycle emissions from hatchery to eating were due to feed. In open water farming systems, nutrient build up in the water column create algal blooms and other ecological damage. Parasites and sea lice spread more quickly, often affecting native fish populations.

Example innovators

AQUINOVO Accelerating Fish Growth

Developer of bio-materials for improving the yield of farmed fish

Misgav, Israel

AquaMaof

Developer of Recirculated Aquaculture Systems (RAS) for onshore fish farms

Rosh Ha'ayin, Israel

Key Clusters

Israel

- Key innovators in onshore systems, such as Aquamaof, founded in Israel due to strong technical skills in water management technologies.
- Strong biotechnology research and development through Israel Innovation Authority and Universities has created leading biotech. Innovation in feed, feed additives, vaccines, and pest control such as Aquinovo and Biofishency.
- Aquaculture infrastructure in coastal Eliat has benefited from a $1.42 billion infrastructure regeneration programme funded by international investors (US) and Qatar.

Netherlands

- Despite poor conditions in local aquaculture market due to strong competition from abroad, high input prices, and falling retail prices, innovation in aquaculture production systems remains strong due to agricultural production and services expertise.
- Kingfish Zeeland is an established example of a successful onshore RAS facility, farming yellowtail kingfish.
- Strong local and specialist investor ecosystem (Aqua-Spark) and feed companies (Nutreco) contributes knowledge, expertise, and pathways to internationalization for Netherlands-based innovation.

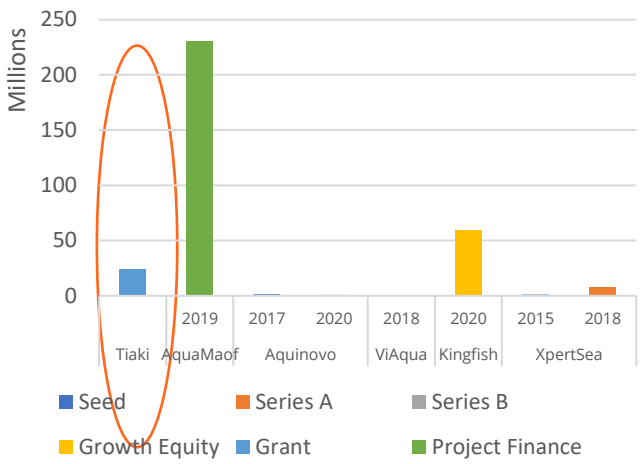
Innovators and Ecosystems: Aquaculture

Alignment w/ Strength

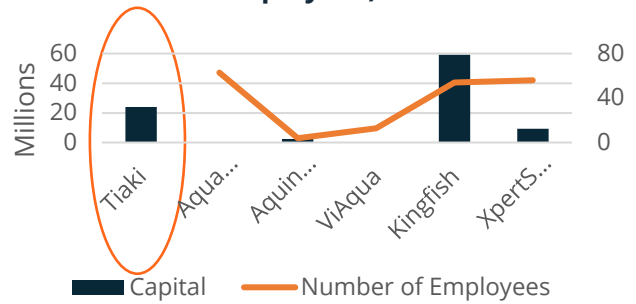
2

Ecosystem	TIAKI **Auckland, New Zealand** Precision Seafood Harvesting	AquaMaof **Rosh Ha'ayin, Israel** Developer of Recirculated Aquaculture Systems (RAS)	AQUINOVO **Israel** Developer of microbially fermented animal health products	VIAQUA **Haifa, Israel** Developer of oral aquaculture health products	KINGFISH **Kats, Netherlands** Developer of onshore grow out facilities for Kingfish	xpertSea **Québec, Canada** Developer of aquaculture monitoring hardware and management software
Diversity in mgmt. / ownership		• 4/18 women on management team	• 1/3 senior team female	• 1/5 women on leadership team,	• 1/12 female / non-white management	
Grants	• Primary Growth Partnership with Ministry of Primary Industry					
Incubators / Accelerators			• The Trendlines Group			• Founder Fuel
Angel Financing						• Bradley Horowitz
Equity Financing			• The Trendlines Group • Neovia	• VisVires New Protein • Nutreco • The Trendlines Group	• ADM Capital • Creadev • Rabo Corporate Investment • Nutreco	• Aqua-Spark • Obvious Ventures • Real Ventures • YUL Ventures
Debt Financing						
Customers		• Greig NL (Canada) • Pure Salmon (France/Poland) • Proximar (Japan)				
Partnerships	• Moana New Zealand (Māori) • Sealord Group • Sanford Limited	• 8F Asset Management		• Technion Israel Institute of Technology	• Billund Aquaculture	• Bayer
Talent Pipelines		• Ben Gurion Uni. • Weizmann Institute • Uni. of Stirling	• Tel Aviv University • The Hebrew University	• Tel Aviv University • The Hebrew University • University of Haifa	• Wageningen • IDC Herzliya • Uni. of Stirling	• Université Laval • Ghent University
Emissions Reduction	• Reduced damage/stress to fish (not quantified)			• 'Significant' reduction in viral infections in shrimp	• Minimizes environmental impact esp. on outflow water	

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Aquaculture

Ability to Lead

2

		New Zealand		Israel		Netherlands		Canada	
Overview			• Strong agriculture R&D in universities, and gov't support • Low presence of financing • Strong agriculture market • Low presence of multinationals		• Low water availability • Strong R&D in water tech. • Early-stage R&D in aquaculture • Strong bio-tech R&D • Poor domestic demand		• World class agricultural exporting economy • World class agricultural R&D • Small domestic market for aquaculture with low innovation		• Good public/private funding system • Outward-facing economy • Strong domestic market for aquaculture due to presence of multinationals and natural resources
35%	**R&D-to-commercialization pipeline strength**	**6**	• Massey U, U. Auckland, Waikato U. spinning companies out • Demand-driven R&D tax credit (15% at $430 million/year)[21]	**8**	• Tel Aviv University, The Hebrew University, University of Haifa, Technion, and National centre Of Mariculture major R&D centres • $1.42 billion aquaculture infrastructure regeneration programme funded by US and Qatar	**8**	• Wageningen University and HZ University are centres of European agricultural research • Dedicated aquaculture incubator programme (Hatch) • Kingfish Company founded here	**9**	• Canadian Aquaculture Institute, University of Guelph, University of BC Grad programme, all contribute to talent pool and R&D • Govt. funding matched with large domestic market and strong R&D creates innovation commercialization pathways
25%	**Financing strength**	**2**	• Little evidence of New Zealand based venture investors in Aquaculture sector • Few NZ-based investors to support domestic innovation	**7**	• A few Israel-based venture investors looking at aquaculture (The Trendlines Group, Mofet Accelerator) • Growing seed stage investment • Good support for water technologies and onshore farming systems (Aquamoaf)	**6**	• Aqua-Spark, a dedicated aquaculture VC, based here and investing globally • 10+ agri-focused VC investors • Active local agri-banks to connect innovation to global investors (RaboBank)	**8**	• Strong grant funding programmes (Agriculture Canada, Province-based funding, SDTC) • SDTC, BDC Capital, Export Development Canada public funds for supporting innovation • 20+ venture investors targeting aquaculture technologies
40%	**Connection to demand**	**7**	• Lack of multinational and tech companies • Lack of innovation outposts in overseas markets to promote innovation	**3**	• Balance of trade in agriculture is $2.3B export to $6.9B import[150] • 65% of all fish consumed is frozen imports[150] • Aquaculture is 4% of total livestock production value	**8**	• Small (>$4 bn revenue) domestic fishing fleet focused on shellfish and small fisheries[149] • Dutch agricultural exports worth $110 billion in 2019[149] • Leading feed and animal welfare companies based here to connect innovation to global markets (Nutreco, Skretting, Cargill)	**9**	• $5.4 billion in aquaculture economic activity in Canada[151] • $2.2 billion contribution to GDP[151] • Aquaculture Export Volume >103,000 tonnes with a value of $897 million, 94% to US • Mowi, Cermaq, Cooke Aquaculture, Grieg, Marine Harvest all active in Canada
Evaluation		**5.4**		**5.8**		**7.5**		**8.8**	

Scoring: Aquaculture

Trends	Market		NZ Position	
	External Potential	Timing of Trend	Alignment w/ Strength	Ability to lead
Aquaculture	3	2	2	2

Takeaways for NZ Climate Tech Innovators

- Take advantage of NZ's investment in new aquaculture infrastructure. Both land-based RAS systems and open water pens are increasingly sophisticated and capable of farming higher value species more reliably.
- New Zealand's natural resources are a competitive advantage as open ocean farming further offshore is developed to combat environmental challenges posed by near-shore aquaculture systems.
- Work on support and service infrastructure for both open ocean systems and onshore systems. Opportunity exists across the value chain from genetics, feed inputs and additives, fish health, and the farming hardware/software for growing systems.

Takeaways for NZ Climate Tech Ecosystem

- New Zealand's aquaculture industry is primed for development and is anticipating increasing its export earnings to NZ$3 billion by 2035 from $600+ million today.[152, 153]
- While government support may enable large infrastructure projects for farming systems, innovative support and services that are more easily exported to other markets may be challenged by lack of R&D infrastructure and financing in NZ.
- The lack of multinational presence creates a partnership and learning-by-doing gap for NZ innovators compared to their counterparts in other clusters. This also reduces the options for eventual exits.
- organisations such as The Trendlines Group in Israel are working with a portfolio of solutions, many in aquaculture, that they are investing in and introducing to investors through their global network (Singapore, SF).

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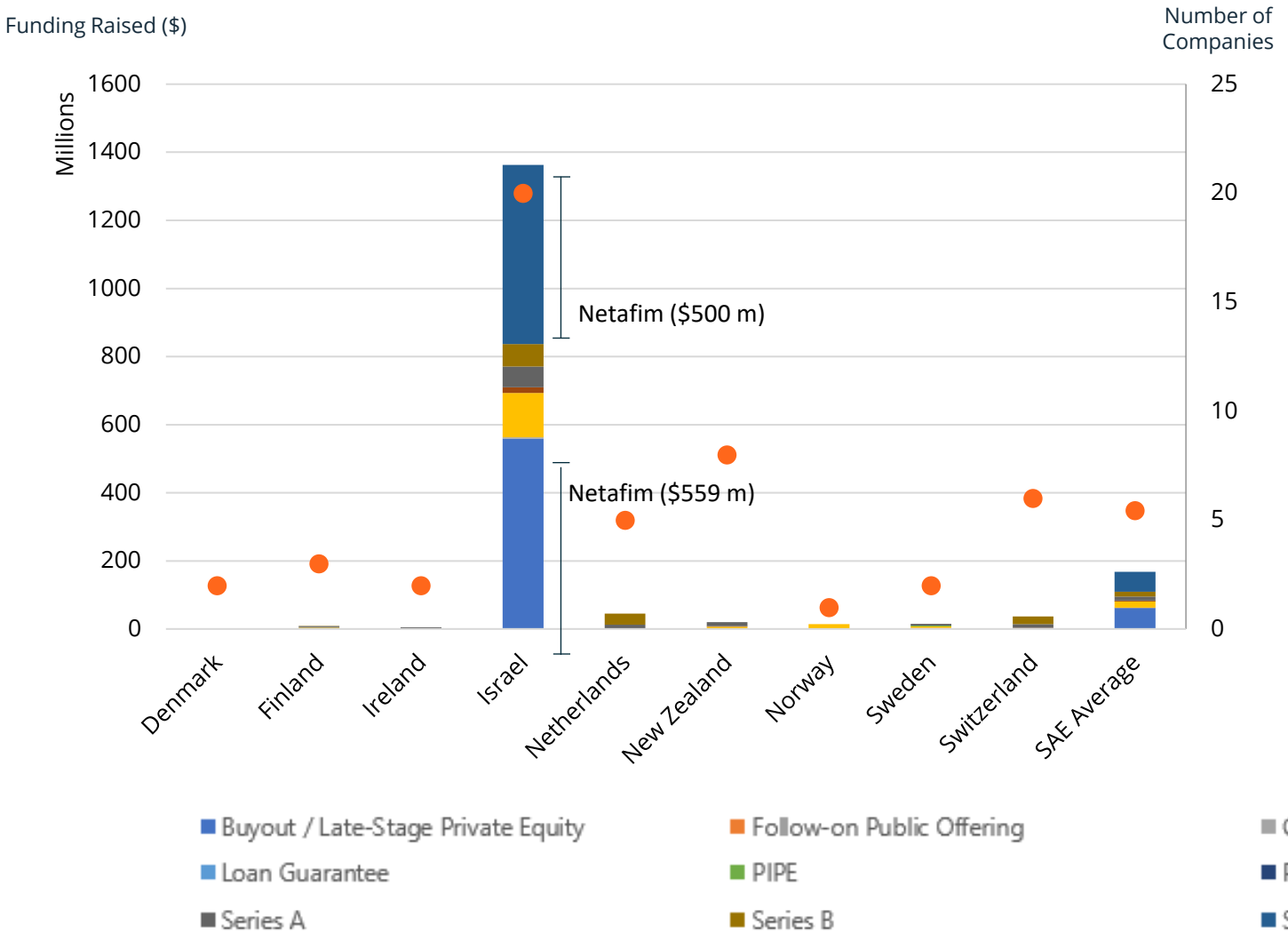
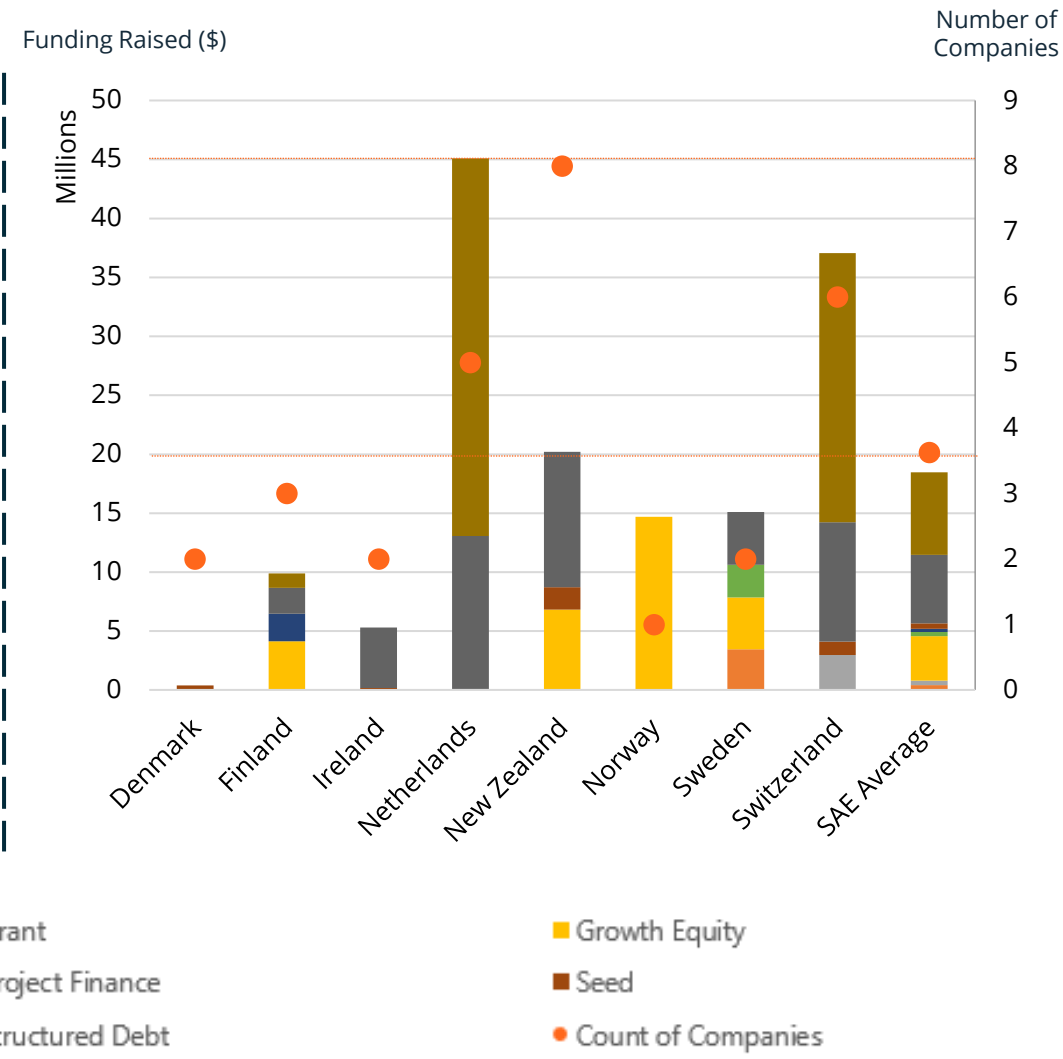
Overview – Crop Innovation in Small Advanced Economies (SAEs)

Crop Investments (2011 – 2021) and Funded Innovators in SAEs



Crop Investments (2011 – 2021) in SAEs Excluding Israel



Specialty Crops – Trend Analysis

External Potential	Timing of Trend
4	2

Summary

- **Description:** Intensively cultivated fruit, vegetable, nut, and horticulture crops often bred to optimize growing and environmental resilience characteristics.
- **External potential:** The specialty crops market was valued at $982.2 million in 2019 and is projected to reach $1.2 billion by 2027, giving a CAGR of 2.6% from 2020 to 2027. The industry is driven by increasing abiotic stress from climate change leading to yield losses in specialty crops, which are often grown in equatorial climates which are the most vulnerable. Specialty crop companies are also breeding new strains that are more resistant to disease and pests, and well as increasing measures of quality and functionality such as protein content.[154]
- **Timing:** The adoption of low-cost genetic editing tools such as CRISPR has lowered the barrier to entry for startups in this market and broadened the potential range in-field and quality traits that can be optimized for. World food prices remained low between 2015 – 2020 but are set to increase. As food prices increase more focus will be put on in-field trait development of specialty crops.
- **Environmental impact reduction potential:** Varies significantly by crop and geography.

Example innovators

Tropic Biosciences

Developer of commercial varieties of tropical specialty crops

London, UK

EQUInom

Developer of food quality traits such as protein content in food crops

Israel

Key Clusters

United Kingdom

- Access to strong talent pool through Oxford, Cambridge, and Imperial College London Universities.
- Public funding for innovation is easily available through organisations like Innovate UK and the Seed Enterprise Investment Scheme.
- Crop and agricultural science research centres such as Rothamstead, Cirencester Agricultural College, Harper Adams, create a strong talent pool and lower R&D and trial costs.

Israel

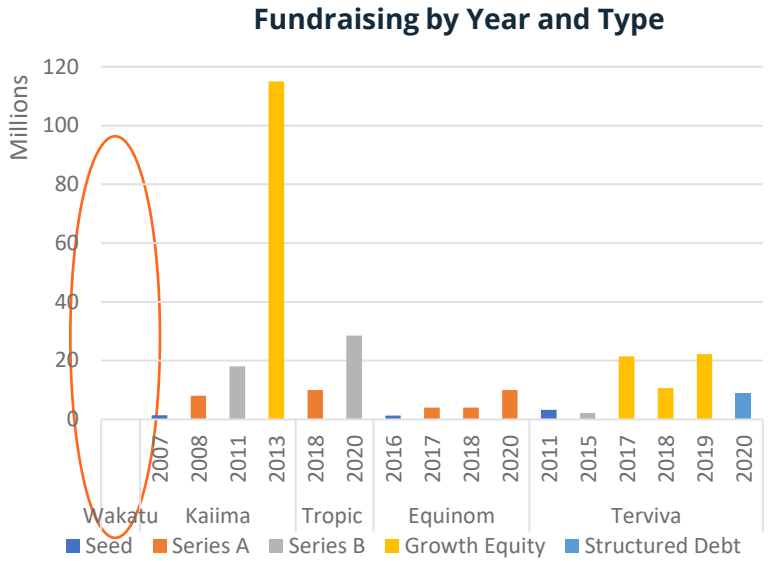
- Strong biotechnology research and development through Israel Innovation Authority, Technion and Universities has created leading biotech.
- Strong local ecosystem of venture and growth investors in agriculture including The Trendlines Group, Terra Venture Partners, Hanaco Ventures.
- Strong internationalization through government supported foundations such as the BIRD Foundation to support US-Israel joint development.

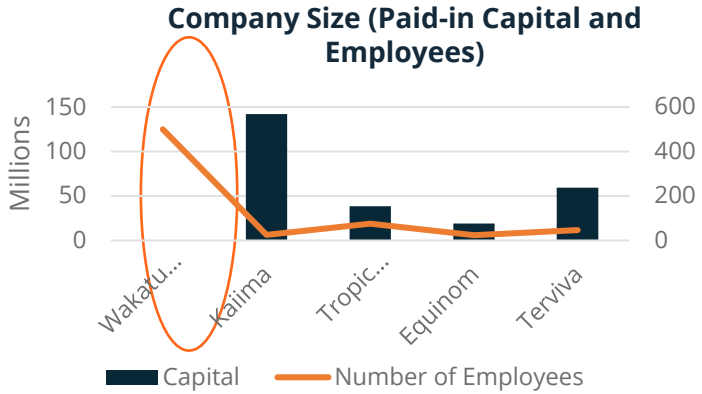
Innovators and Ecosystems: Specialty Crops

Alignment w/ Strength

2

Ecosystem	Wakatū **Nelson, New Zealand** Natural asset managers with specialty crops, food and beverage products	kaiima **Moshav Sharona, Israel** Developer of breeding technology that develops Castor hybrids	Tropic Biosciences **Norwich, UK** Developer of commercial varieties of tropical specialty crops	Equinom **Givat Brenner, Israel** Developer of food quality traits such as protein content in food crops	Terviva **California, USA** Developer of pongamia trees for protein and oil to replace soy crops
Diversity in mgmt. / ownership	• Indigenous (Māori) owned, Kono (subsidiary) indigenous (Māori) woman CEO	• 1/7 female management	• 2/11 female leadership team	• 1/6 women on executive team	• 2/7 women, 4/7 non-white senior leadership
Grants					
Incubators / Accelerators			• Bits x Bites		• Thrive Accelerator • Elemental Excelerator • Wells Fargo IN2 • The Yield Lab
Angel Financing			• Taz Patel		• Howard Fischer • Astia Angel
Equity Financing		• Horizon Ventures • IFC • KPCB • DFJ • Mitsui	• Temasek • Sumitomo • Pontifax • Emerald Tech. Ventures • UK Science & Innovation Seed Fund	• BASF Venture Capital • Roquette • Trendlines • Fortissimo Capital • Hazera	• Evan Properties • Allotrope Ventures
Debt Financing					
Customers					
Partnerships		• Terasol Energy • BASF • Beck • Horizon Ag	• BASF • Agribody Technologies • eggXYt • Genus Plc		• Farmer Mac
Talent Pipelines		• The Hebrew University • Tel Aviv University • FGV	• Imperial College London • Uni. Of Cambridge • Tel Aviv University • Weizmann Institute	• The Hebrew University • Tel Aviv University • Bar Ilan University	• Ibmec • Harvard University • Ohio University
Emissions Reduction					• Carbon negative





Source: Cleantech Group i3 Database

Precision Chemical Application – Trend Analysis

External Potential	Timing of Trend
3	2

Summary

- **Description:** Use of precision spraying and microencapsulation technologies for more targeted and controlled release of agricultural inputs.
- **External potential:** The global microencapsulated pesticides market is expected to grow from USD 334.16 Million in 2017 to USD 817.45 Million by 2025, at a CAGR of 11.83% during the forecast period from 2018-2025. The precision farming market more broadly is predicted to grow from $16.7 billion in 2021 to $16.4 billion in 2028. The development of new chemical and biological crop inputs is required to meet regulatory and environmental targets. New products are typically more expensive than conventional chemicals, and so precision application aims to reduce the quantity used, reducing overall resource intensity of production. [155, 156]
- **Timing:** As chemical usage in agriculture is increasingly controlled by regulation and the banning of chemicals such as neonicotinoids in Europe and Glyphosate (most recently in Mexico), the improved efficiency and targeting of higher cost chemicals is required.
- **Environmental impact reduction potential:** 70% of pesticide currently used does not reach the crop, leading to overuse and high water usage in spraying processes. Increased adoption of controlled-release and stabilized fertilizers could decarbonize the agriculture sector ~75 $MtCO_2e$, at cost of ~$65/$tCO_2e$, by 2050. Reducing nitrogen over-application in China and India alone could account for ~88 $MtCO_2e$ decarbonization at cost savings of ~$97/$tCO_2e$ by 2050. [155, 156]

Example innovators

MagGrow
A better way to spray

Developer of precision spraying technology

Ireland

Greeneye TECHNOLOGY

Developer AI to improve pest control processes

Israel

Key Clusters

Israel

- With water use being a national security priority as well as a key innovation sector (Netafim) in Israel, effective chemical use in agricultural land reduces water use intensity.
- Incubators including the Kitchen Hub and Fresh Start coordinate technical university spin outs with industry to support early stages of growth,

Ireland

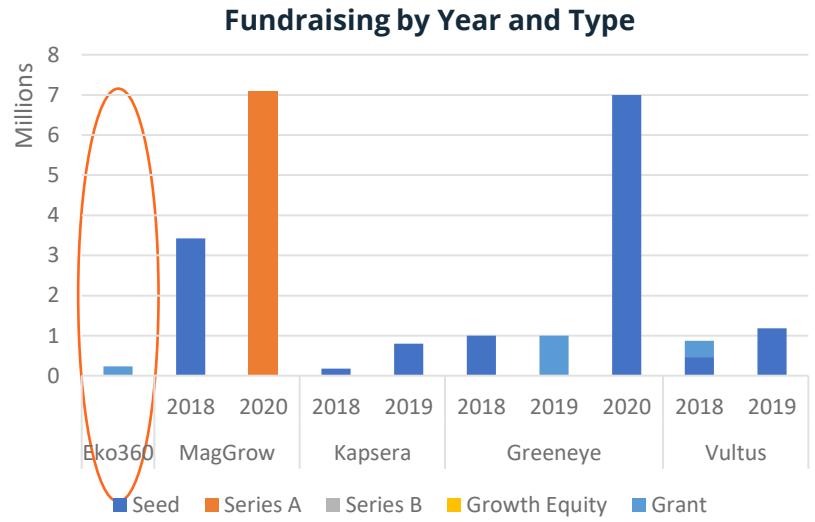
- Good agricultural accelerator network with European headquarters for US-based programmes The Yield Lab and Thrive.
- Connection to European Union and favorable tax regimes attracts large international corporations despite small domestic agricultural market.

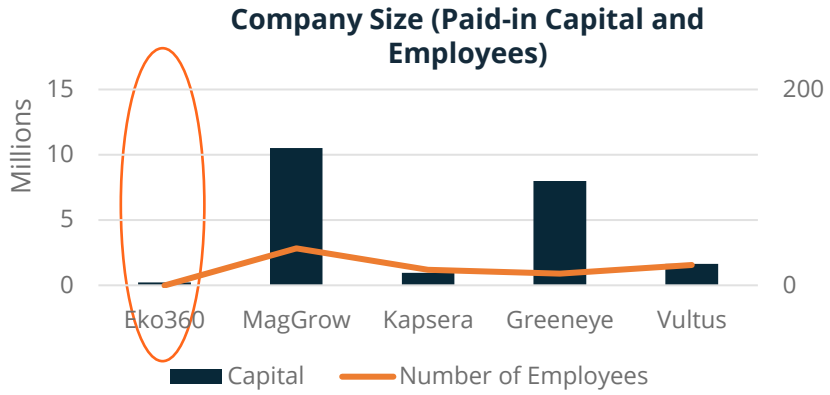
Innovators and Ecosystems: Precision Chemical Application

Alignment w/ Strength

1

Ecosystem	Auckland, New Zealand Developer of a controlled release nitrogen fertilizer	Dublin, Ireland Developer of precision spraying technology	Paris, France Developer of fluidic encapsulation technology	Tel Aviv, Israel Developer AI to improve pest control processes	Lund, Sweden Provider of satellite imagery to help reduce fertilizer use
Diversity in mgmt. / ownership					• 1/3 C-suite non-white
Grants	• Callaghan Innovation				
Incubators / Accelerators		• Thrive Accelerator • Pearse Lyons Accelerator	• Wilco	• Microsoft AI for Good • Techstars	• Rockstart • Fast Track Malmo
Angel Financing				• 2B Angels	
Equity Financing		• Astanor Ventures • WakeUp Capital • SVG Ventures	• Demeter IM • BPIFrance	• Jerusalem VP • Syngenta Ventures • One Way Ventures • Panache Ventures • Hyperplane VC	• Seedrs • Norrsken VC • Almi Invest
Debt Financing					
Customers	• Farmlands Coop • PGG Wrightson				
Partnerships	• Ballance Agri-Nutrients	• Trimble • Groenoord • PAR • Senwes • Airtec		• Israel Innovation Authority • Volcani centre	• FarmLEAP • Agdata • Tanibox • Don State TU • UP42
Talent Pipelines	• Auckland University of Technology	• University College Dublin • Harper Adams University	• ESPCI Paris • Chimie ParisTech • AgroParisTech	• The Hebrew University • Ben-Gurion University • IDC Herzliya • University of Oxford	• Stockholm University • KTH Royal Institute • Halmstad University
Emissions Reduction		• Reduce drift 70% • Reduce water usage 25-50%			





Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Crops

Ability to Lead

2

		New Zealand		Israel		UK		Ireland	
Overview		• Strong agriculture R&D in universities, and gov't support • Low presence of financing • Strong agriculture market • Low presence of multinationals		• World-leading biotech cluster • Coordinated public-private support for innovation • Strong internationalization of technology solutions		• Leading academic institutions • Leading R&D in agriculture • Global financial centre • Extensive internationalization of Ag. services and innovation		• Small domestic market • Connected to EU with attractive business tax rates • Strong relative size of early-stage support organisations	
35%	**R&D-to-commercialization pipeline strength**	**6**	• Massey U, U. Auckland, Waikato U. spinning companies out • Callaghan Innovation loans are supporting crop innovation • Demand-driven R&D tax credit (15% at $430 million/year) [21]	**8**	• Technion, Weizmann Institute, Hebrew University participating in spinoffs[49] • Strong biotech capability • Specialist accelerators incl. corporates (e.g. Strauss) • Strong international support	**9**	• Innovate UK well funded coordinator of public grants and early-stage support • UK BEIS and DEFRA active in support innovation through grants and pilots • 5+ research universities looking at livestock and agriculture	**5**	• SVG Thrive has European outpost • The Yield Lab European outpost • Strong Universities (Trinity College Dublin, Teagsac) • 1.5% of GDP spent R&D, 25% tax credit for small businesses • US-Ireland R&D Partnership Call (DAERA / NIFA collaboration)
25%	**Financing strength**	**2**	• Seed and early-stage financing supporting ag tech (e.g. Powerhouse) • Few NZ-based investors to support larger equity and debt rounds, corporate and external investors are accessing companies in standout cases	**7**	• 50+ agtech investors (avg. amount <$5m)[50] • Partnerships with local investors and international corporates to support local ecosystem	**8**	• 10+ VC and equity investors based in London dedicated to agtech investment. • Over $3.6 billion invested in UK agtech companies in 10 years	**4**	• Few early-stage investors based in Ireland • Many investors focused on connection to international finance (Atlantic Bridge) • Active role for Enterprise Ireland in agriculture & food investment
40%	**Connection to demand**	**4**	• Horticultural exports valued at $6.2 bn in 2019 • 79.6% (value) from specialty crops (kiwi, wine, apples) • Lack of innovation outposts in overseas markets to promote innovation	**6**	• Small domestic sales market but kosher principles increase alt. protein adoption • Strong internationalization of technology solutions in alternative proteins	**8**	• Total income from farming industry $14.4 billion (0.53% GVA, 2019) • Livestock is around 58% of market share by value • Exports account for only 17% of revenue. • Traditionally an entrepot for European expansion • Uncertain trade situation post-Brexit	**5**	• Agri-food generated 7% of gross value added (€13.9 billion), 9.8% of Ireland's merchandise exports and 8.5% of employment. (2016) [157] • Grass-based agricultural system attracts few innovative technologies due to low-intensity farming practises • Favorable tax regime could attract European market entrants
Evaluation		**4.2**		**7.0**		**8.4**		**4.8**	

Scoring: Crops

Trends	Market		NZ Position	
	External Potential	Timing of Trend	Alignment w/ Strength	Ability to lead
Specialty Crops	4	2	2	2
Precision Chemical Application	3	2	1	2

Takeaways for NZ Climate Tech Innovators

- Leverage New Zealand's high agricultural R&D spending combined with its focus on specialty crop types such as kiwifruit, grape, apple. This provides a good market to integrate precision farming technologies.
- Focus on digital solutions. Hardware solutions such as microencapsulation and precision sprayers are being developed in economies with experience in pharmaceuticals and heavy machinery. Significant improvements can be made by combining digital solutions with existing hardware.
- New Zealand's nitrogen cap provides good regulatory framework to integrate precision chemical application in high value crops.
- Develop strong use case studies to increase adoption. Adoption rates correlate with good communication of benefits to farmers.

Takeaways for NZ Climate Tech Ecosystem

- Precision chemical technologies in other markets have been created through chemical clusters and biopharmaceutical expertise, both of which are lacking in New Zealand.
- Despite specialty crops being a significant part of the agricultural economy, little evidence of crop innovation (in genetics especially) was evident.
- Other SAEs are seeing innovators move to international clusters (e.g. Tropic Biosciences Israel -> London) due to the level of expertise required and small global talent pool.
- Promoting international R&D partnerships could be a path towards increased innovation.

Contents

- Agriculture & Food– Comparison between Small Advanced Economies (SAEs)
- Livestock
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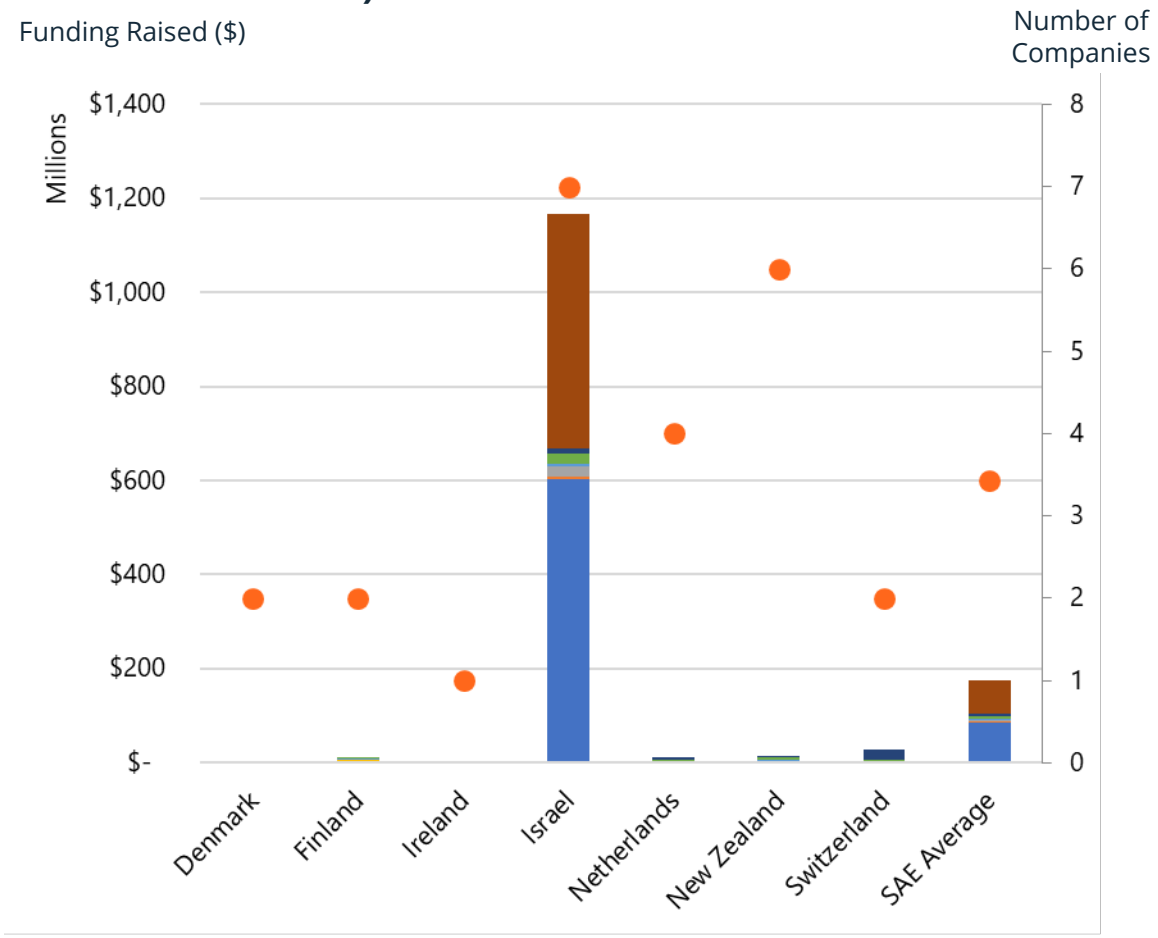
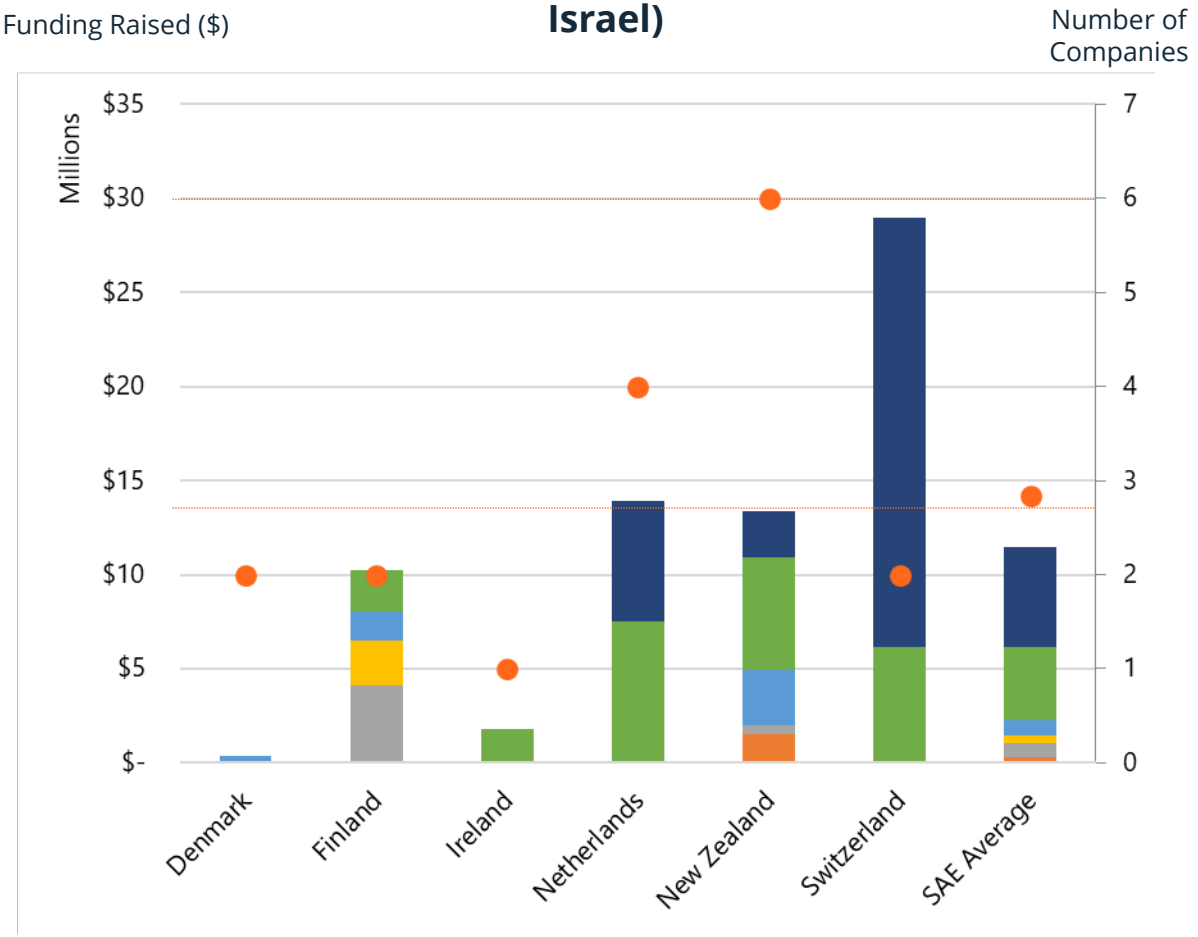
  - Methane Vaccines
- Feed Alternatives and Additives
- Protein Replacements
- Aquaculture
- Crops
  - Specialty Crops
  - Precision Chemical Application
- **Agricultural digitalisation**
  - Agricultural Robotics
  - Agricultural Drones
  - Agricultural Software
- CCS for Agriculture

Overview – Agricultural Digitalisation Innovation in Small Advanced Economies (SAEs)

Agricultural Digitalisation Investments (2011 – 2021) and Funded Innovators in SAEs



Agricultural Digitalisation Investments (2011 – 2021) and Funded Innovators in SAEs (excluding Israel)



Buyout / Late-Stage Private Equity | Grant | Growth Equity | Project Finance | Seed | Series A | Series B | Structured Debt | Count of Companies

Agricultural Robotics (Outdoor) – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** Hardware tools to increase speed, accuracy, timing, and reduce human error in outdoor farming (as opposed to indoor / vertical farming). Solutions include automation for picking, packing, irrigation, and weeding.
- **External potential:** Estimated global market size of $7.4 billion in 2021, $10.8 bn by 2023 for outdoor agricultural robotics (figure includes UAV and software, in addition to robotic hardware). Driver error accounts for between 15%-22% of operational costs for tractor usage on outdoor farms. [163] Problem of weeding is growing each year – weeds more resistant to herbicides, requiring 3 billion pounds of herbicides ($25 billion) to be used each year. [160] Robotics-as-a-service models are coming online, with potential to drop cost barriers and access new markets.[159]
- **Timing:** 55% of farmers surveyed in California reported that labor shortages are a challenge, a challenge that preceded Covid-19 and has been exacerbated by the pandemic. Technologies with the ability to automate single processes are mature in the market, however, multi-purpose automation is largely still in the R&D phases and will be key to unlocking the most lucrative productivity gains. Clusters of innovation are observable mostly in the US, Northern Europe, and Western Europe, with innovators located close to demand pools, but without large-scale servicing of global demand by one cluster. [160]
- **Environmental impact reduction potential:** Potential for up to 2.5 billion lb reduction in herbicide usage globally, reducing demand by 83%. [162]

Example innovators

FarmWise

Developer of connected and autonomous robots for outdoor weeding applications

San Francisco, CA, USA

HARVEST AUTOMATION

Mobile robot for transport and arrangement of potted plants in horticultural environments

Billerica, MA, USA

Key Clusters

Northern California

- Google X – Project Mineral, applying Waymo technology to autonomous agricultural robots
- Thrive Accelerator (SVG Ventures)– Recognized as top global agriculture accelerator, with investments in Farmwise, Harvest, and Tortuga
- Comet Labs – Legend (Lenovo) Holdings-backed robotics and AI-focused incubator / VC
- RAPID (Robot Assisted Precision Irrigation Delivery) – Cal. U. Berkeley, UDSA, NSF collaboration to develop low-cost autonomous irrigation robots and UAVs

Massachusetts

- Life Science Partners – 5+ funds in firm history totaling over $1 bn, solving urgent health needs and funding solutions including precision agriculture and agricultural robotics
- MassRobotics – Industry network of 350 Boston-area robotics companies and 18 universities
- Greentown Labs – MIT-spinoff incubator, North America's largest cleantech incubator, has incubated local champion agricultural robotics companies such as Root.AI
- MIT 77 Lab – Autonomous robotics research lab focused on human-robotic collaboration, with specific divisions focused on agricultural robotics

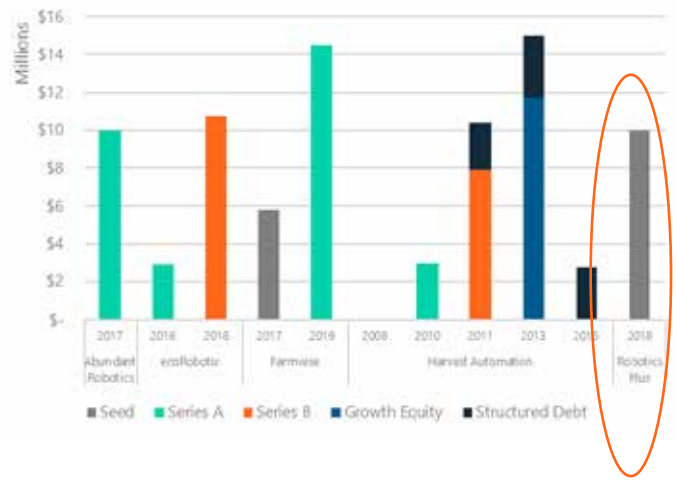
Innovators and Ecosystems: Agricultural Robotics

Alignment w/ Strength

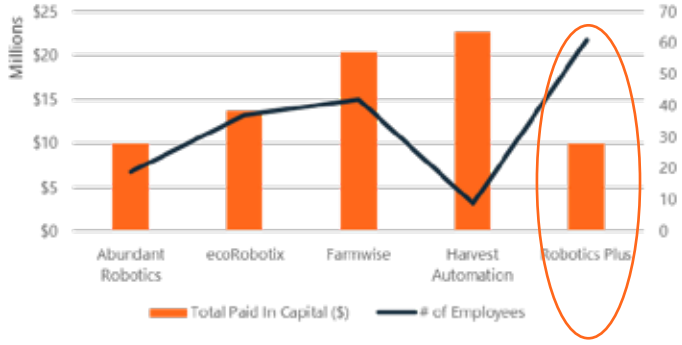
3

Ecosystem	RoboticsPlus **Tauranga, New Zealand** Developer of robotics solutions for agricultural and horticultural use	SAGA ROBOTICS **Norway** Developer of farm robots	ecorobotix **Yverdon-les-Bains, CH** Designer, developer and vendor of autonomous agriculture robots for weeding fields	FarmWise **San Francisco, CA., USA** Developer of smart and autonomous robots for weeding	abundant ROBOTICS **Hayward, CA, USA** Developer of robotics for the agricultural produce picking industry	HARVEST AUTOMATION **Billerica, MA, USA** Developer of a robot for use in the transportation of potted plants in horticultural agriculture
Diversity in mgmt. / ownership	• 2/5 C-suite women					
Grants		UK Department for Business, Energy and Industriall Strategy				
Incubators / Accelerators			• Thrive Accelerator	• Thrive Accelerator	• Comet Labs • Thrive Accelerator • SRI International	• Thrive Accelerator
Angel Financing			• Business Angels Switzerland			
Equity Financing	• Yamaha Motors	• Propogator Ventures • Rabo Food and Agri Fund • Nysno Climate Investments • ADM Capital	• CapAgro • BASF Venture Capital • 4FO Ventures	• Calibrate Venture • Alumni Ventures • Felicis Ventures • Cavallo Ventures	• Google Ventures • KPCB Edge • Yamaha Motors • Tellus Partners	• Cultivian Ventures • Life Science Partners • MassVentures • Entrée Capital
Debt Financing						• Mousse Partners • Cultivian Ventures • Life Science Partners
Customers	• Global Pac Technologies (Distribution US, AUS, NZ)		• Bucher Landtechnik (Distribution)	• Farms – Salinas Valley (CA) • Farms – Yuma (AZ)	• Apple farms in CA and WA • T&G Global (NZ) [41]	• 30+ nurseries and farms in US Northeast
Partnerships	• U. Auckland Centre for Automation and Robotic Engineering	• NMBU • University of Lincoln	• EPFL • Swiss Climate Foundation • Innosuisse	• U. California Dept. Ag • Western Growers Association	• Kubota • Washington Tree Fruit Research Commission	• Jaybridge Robotics
Talent Pipelines	• Massey University	• Norwegian School of Economics • NTNU	• EPFL • HES-SO • HEIG-VD • ETH Zurich	• Stanford • Cal. State Polytech San Lius Obispo	• Stanford • Brigham Young • Carnegie Mellon	• Umass Amherst • MIT
Emissions Reduction			• 95% herbicide reduction • No loss of yield			

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

Agricultural Drones Trend Analysis

External Potential	Timing of Trend
1	2

Summary

- **Description:** Unmanned aerial vehicles (UAVs) for agricultural oversight (planning, coordination, analysis) and direct intervention (seeding, spraying, irrigation)
- **External potential:** Market estimated at over $1.5 bn this year, to expand to $3.5 bn by 2027. [165]
- **Timing:** Cost of underlying components that enable precision is dropping (sensors, cameras), however, up-front costs of drones and drone services are still challenging for many small and mid-sized farms to take on. Drones are most valuable when combined with a comprehensive ecosystem of data analysis, automation, and precision agriculture procedures, farms that are able to employ such integrated systems will be in a position to achieve significant cost savings. Market incumbents are mostly innovators (i.e. not large corporates), such as DJI (founded 2006) and DroneDeploy (founded 2013), indicating that there are still potential opportunities for new entrants to the market.
- **Environmental impact reduction potential:** Drones for nutrient dispersion have been found to increase uptake by nearly 75% [166] and reduce fertilizer usage by up to 20% [167] ·Many drone applications are created with the goal of tracking coastline changes, wildlife movement, and weather patterns, these processes in and of themselves help to increase farmers' visibility over potential environmental concerns and make more precise adjustments.

Example innovators

See Tree

An end-to-end Intelligence Network providing visibility, monitoring, and actionable analytics to optimize farming

Israel

AGRO

Developer of a precision crop spraying drone

Switzerland

Key Clusters

Israel

- In 2018, 7% of all transactions in high-tech agriculture were partnerships with Israeli startups [168]
- Israel's agricultural sector has its origins in the kibbutz movement, but 58% of all active agritech companies were established only about a decade ago, and 40% in the past five years. [168]
- Heavy investment in drone development for military applications in Israel, with knowledge and value chains spilling over into adjacent applications for drones (e.g. Blue White Robotics – a military-turned-agriculture drone company).
- "Drones in the air, sensors in the ground" capabilities for full-scale ecosystem effects

Switzerland

- The "Drone Valley" between the Swiss Federal Institute of Technology at Lausanne (EPFL) and ETH Zurich has produced over 80 drone startups in recent years[68]
- The PA 22+ government strategy for agricultural modernization includes goals for digitalisation and improved aerial capabilities[170]
- Agroscope, a government agricultural research body, put forward plans and suggestions for improved uptake of drones in agriculture. In 2019, Switzerland became the first European country to make crop spraying by drones legal [171]

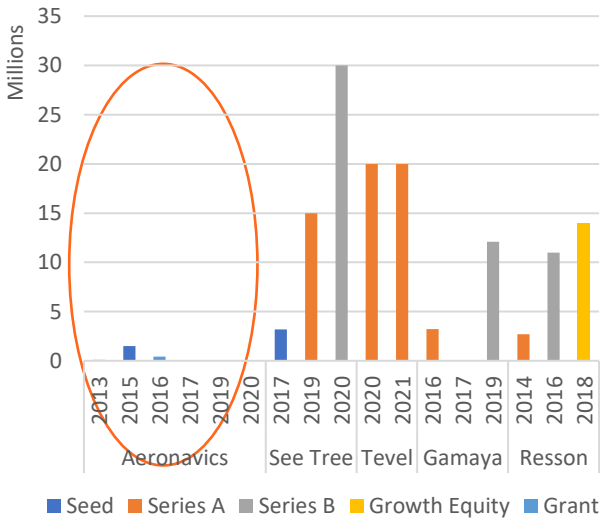
Innovators and Ecosystems: Agricultural Drones

Alignment w/ Strength

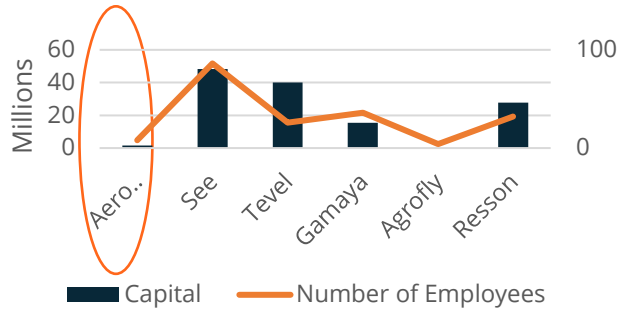
2

Ecosystem	New Zealand Aerial robotic systems, based on advanced multi-rotor airframes, ready-to-fly aircraft.	Israel An end-to-end Intelligence network providing visibility, monitoring, and actionable analytics to optimize farming	Israel Developer of fruit-picking drones	Switzerland Developer of software that uses hyperspectral imaging and analytics technology	Switzerland Developer of a precision crop spraying drone	Canada Developer of precision analytics tools for large agricultural farms
Diversity in mgmt. / ownership	Woman Co-founder	1/6 C-suite women		• 1/3 C-suite non-white		
Grants	• Callaghan Innovation			• Nvidia Inception Award		
Incubators / Accelerators				• EIT Digital Accelerator		• Thrive Accelerator
Angel Financing		• Iangels • Uri Levine	• Ziv Aviram • Amichai Steimberg			
Equity Financing	• Crowdfunding	• Canaan Partners Israel • International Finance Corporation (IFC) • Hanaco Ventures	• Maverick Ventures Israel • OurCrowd • AgFunder	• VI Partners • Sandoz Foundation • Mahindra • ICOS Capital • Seed4Equity		• BDC Capital • New Brunswick Innovation Foundation • Monstanto • Mahindra • McCain Foods
Debt Financing						
Customers	• BBC • Fox Sports • NASA	• Farm customers in Israel, South Africa, the US, Brazil	• Pilots in Spain, US, Italy, in apple plantations over 100 Ha			
Partnerships					• Swiss Federal Office of Environment • Syngenta • Global Aerospoace	
Talent Pipelines	• U. Canterbury	• Hebrew University of Jerusalem • Tel Aviv University • Technion	• Tel Aviv University • Technion	• EPFL • ETH Zurich • INSEAD		• U. New Brunswick • McGill U.
Emissions Reduction						

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

Agricultural Software – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** Farm management software to optimize and manage farm activities using data analytics and machine learning technology.
- **External potential:** Farm management software market is estimated to grow from $2.1 billion in 2021 to $4.2 billion by 2026 at a CAGR of 14.7%. Agriculture is one of the last industries to digitize due to rural connectivity and analog measurement and monitoring systems. New data streams are becoming available as rural connectivity increases and remote monitoring through sensors and satellite imagery are increasingly available for agricultural applications. [164]
- **Timing:** This is an ongoing trend. Cost of satellite data acquisition continues to drop, agricultural sensors are increasingly a commodity rather than a product, and the key barrier of connectivity is being combatted by government-backed schemes for rural connectivity such as the US Government's $20 billion fund to connect rural communities using 5G. Legislation in European, US, and UK markets is looking to incentivize good agricultural practises with ecosystem service payments which will require a significant investment in monitoring and verification, which in turn will increase the data streams to power agricultural software which improves the quality of software products.
- **Environmental impact reduction potential:** Farm management optimization introduces better farm practises in many verticals from livestock, arable, aquaculture, and other crop systems.

Example innovators

TARANIS

Developer of AI for disease prediction through imagery analysis

Israel

GAMAYA

Developer of software that uses hyperspectral imaging and analytics technology

Switzerland

Key Clusters

Israel

- With water use being a national security priority as well as a key innovation sector (Netafim) in Israel, effective chemical use in agricultural land reduces water use intensity.
- Strong local ecosystem of venture and growth investors in agriculture including The Trendlines Group, Terra Venture Partners, Hanaco Ventures.
- Strong internationalization through government supported foundations such as the BIRD Foundation to support US-Israel joint development.

Switzerland

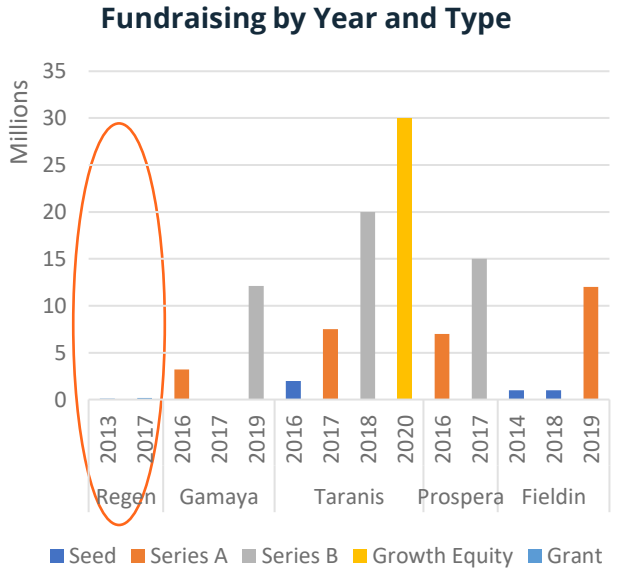
- Strong technical Universities such as École polytechnique fédérale de Lausanne and ETH Zurich for innovation spin-out and strong talent pool.

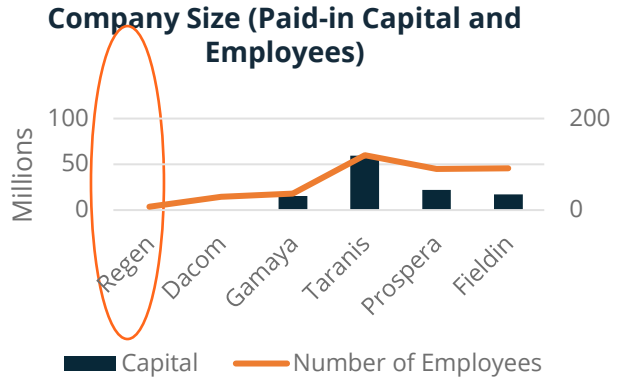
Innovators and Ecosystems: Agricultural Software

Alignment w/ Strength

3

Ecosystem	Wellington, New Zealand Developer of a farm management software tool	Emmen, Netherlands Provider of hardware and software for yield optimization	Morges, Switzerland Developer of software that uses hyperspectral imaging and analytics technology	Tel Aviv, Israel Developer of AI for disease prediction through imagery analysis	Israel Developer of agronomic data analytics	Yokne'am Illit, Israel Developer of farm activity management systems
Diversity in mgmt. / ownership	• Female CEO	• No information	• 1/3 C-suite non-white	• No diversity	• Female COO	• No diversity
Grants	• Callaghan Innovation		• Nvidia Inception Award	• Israel Innovation Authority	• The Hebrew University	
Incubators / Accelerators			• EIT Digital Accelerator	• Thrive Accelerator	• Thrive Accelerator	• John Deere Startup Collaborator programme
Angel Financing				• Marc Benioff • iAngels		• Karl Wills • Richard Salvage
Equity Financing	• Pacific Channel VC		• VI Partners • Sandoz Foundation • Mahindra • ICOS Capital • Seed4Equity	• Eshbol Ventures • Kaeden Capital • Finistere Ventures • Vertex Ventures • Cavallo Ventures • Miitsubishi	• Bessemer Venture Partners • Qualcomm Ventures • Cisco Investments • ICV • More VC	• Terra Venture Partners • Cavallo Ventures • AgFunder • Germin8 • Gal Ventures
Debt Financing						
Customers	• Farmlands Coop • PGG Wrightson	• Sensus • NEC • McCain • 26000 farmers				
Partnerships	• CropX			• Nutrien • Syngenta • Wilbur Ellis • BASF • John Deere	• Valmont Industries • Bayer • Valley Irrigation	• Wilbur Ellis
Talent Pipelines	• Lincoln University, Canterbury • Massey University	• University of Groningen • Wageningen • Het Van Hall Institute	• EPFL • ETH Zurich • INSEAD	• The Hebrew University • Ben-Gurion University • Bar Ilan University • Tel Aviv University	• The Hebrew University • Tel Aviv University • Ben-Gurion University • Technion • Weizmann Institute	• The Hebrew University • Technion • University of Haifa
Emissions Reduction					• Reduced fertilizer / chemical use (not quantified)	





Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Agricultural Digitalisation

Ability to Lead

3

		New Zealand		Israel		Massachusetts (USA)		Switzerland	
Overview			• Strong agriculture R&D in universities, and gov't support • Low presence of financing • Strong agriculture market • Low presence of multinationals		• World-leading biotech cluster • Coordinated public-private support for innovation • Strong internationalization of technology solutions		• Top US academic zone • Significant robotics cluster • Top US life sciences cluster • Robotics / plant science / agricultural automation bleed overs		• Outward-facing economy, emphasis on technology exports • Strong multinationals – Robotics, Chemicals & pharmaceuticals (some with AgroSciences divisions)
35%	**R&D-to-commercialization pipeline strength**	**8**	• Massey U, U. Auckland, Waikato U. spinning companies out • Callaghan Innovation loans are supporting ag robotics (e.g. Greentech Robotics) • Demand-driven R&D tax credit (15% at $430 million/year) [21]	**8**	• Technion, Weizmann Institute, Hebrew University participating in spinoffs [49] • Resource constraints increase use of optimization technologies • Specialist accelerators incl. corporates (e.g. Strauss) • High military investment in tech.	**10**	• Ag. Robotics research winning NSF grants in MA • MIT, Harvard, Umass ag robotics talent / spin-offs • 35 research universities with robotics programmes • 10+ incubators with robotics programmes	**9**	• ETH Zurich, EPFL ag robotics talent / spin-offs • Relevant gov't agencies & NGOs – Innosuise, Agroscope, Swiss Climate Foundation • Corporate participation – Google, Microsoft, IBM, founding members of digitalsuisse
25%	**Financing strength**	**5**	• Seed and early-stage financing supporting ag tech (e.g. Powerhouse) • Few NZ-based investors to support larger equity and debt rounds, corporate and external investors are accessing companies in standout cases (e.g. Robotics Plus)	**7**	• 50+ agtech investors (avg. amount <$5m) [50] • Partnerships with local investors and international corporates to support local ecosystem • BIRD Foundation active at bringing Israeli tech. to US market.	**8**	• MassVentures, the state's VC, is seeding ag robotics companies • 20+ equity investment funds with ag technology in thesis [31] • Approximately $1.5 bn invested in Boston-area precision agriculture startups since 2011 [31]	**6**	• 10+ equity investment funds with ag technology in thesis, $35 m invested since 2011 (Ecorobotix and Gamaya account for $26 m) [31] • Active angel networks and family offices supporting early stage
40%	**Connection to demand**	**7**	• Horticultural exports alone valued at $5.5 bn in 2018 [34] • $48 bn invested in horticultural products in 2018 [34] • Lack of multinational robotics and tech companies • Lack of innovation outposts in overseas markets to promote innovation	**8**	• Good number of innovative companies with experience of internationalization (Netafim) • International corporates have innovation centres in-country to facilitate connection to demand. • Israeli drone sector widely recognized for contributions to innovation in military applications	**8**	• Leading robotics corporates – Boston Dynamics, Irobot, Rethink Robotics, Jaybridge, 350 robotics companies • Leading agtech corporates HQ'd in MA – Indigo, CiBO, American Robotics • John Deere, Monsanto active partnerships w/ MA agtech startups	**7**	• ~$6 bn revenues in non-livestock agriculture [43] • BASF, Dow Agrosciences, Bayer Crop Sciences, Dupont all active in Switzerland • Strong digital industry – ABB • Google has innovation outpost for robotics in Zurich • Strong science & tech global promotion infrastructure – Swissnex, Swiss Global Enterprise
Evaluation		**6.9**		**7.8**		**8.7**		**7.5**	

Scoring: Agricultural Digitalisation

Trends	Market		NZ Position	
	External Potential	Timing of Trend	Alignment w/ Strength	Ability to lead
Agricultural Robotics	4	3	3	3
Agricultural Software	4	3	3	3
Agricultural Drones	1	2	2	3

Takeaways for NZ Climate Tech Innovators

- The trends in agricultural robotics are strong, and the demand pull is likely on the upswing – independent of Covid-19 labor shortages, automation of outdoor agricultural production stands to gain important improvements in efficiency, cost, safety, and compliance through more automation.
- The technology is mature enough to be commercialized large-scale, but multifunctionality of robots will be a force multiplier on efficiency and cost gains once it comes to commercial maturity.
- New Zealand has technical and business capabilities in the sector – companies are being spun out of universities and able to serve the market.

Takeaways for NZ Climate Tech Ecosystem

- Growth is potentially challenged by lack of financing in NZ, which may not affect innovators' ability to serve the domestic market, but will ultimately create struggles to export robotics products, given that innovators in other ecosystems have access to comparable or superior R&D resources and significantly more capital.
- The lack of multinational presence creates a partnership and learning-by-doing gap for NZ innovators compared to their counterparts in other clusters. This also reduces the options for eventual exits.
- NZ does not have the same overseas innovation promotion in this sector that counterpart clusters do, creating a heavier lift for innovators seeking to expand globally. A good example is Swissnex, promoting Swiss science & technology through innovation, education, and business promotion exchanges globally, Swissnex has achieved success in promoting Swiss drones in the US and China (Solar Impulse world tour was once a Swissnex project).

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  - Precision Chemical Application
- Agricultural digitalisation
  - Agricultural Robotics
  - Agricultural Drones
  - Agricultural Software
- **CCS for Agriculture**

CCUS for Agriculture – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** The capture of carbon dioxide for agricultural purposes including increasing yield in greenhouses and carbon sequestration.
- **External potential:** The global carbon capture and storage market, including all industries, was valued at $6 billion in 2020 and is expected to reach $10.45 billion by 2026 giving a CAGR of 11.5%. Significant market share is taken by energy intensive industries that use high quality and concentration CO2 waste for other industrial purposes, but technology such as Direct Air Capture to combat climate change are increasingly funded. In agriculture, carbon capture occurs through pyrolysis of biomass to create biochar to use as a soil amendment. CO2 is also used to enrich greenhouse environments to stimulate plant growth. Finally, an emerging market is being created around carbon sequestration payments for farmers who are sequestering carbon in agricultural soils.[173]
- **Timing:** Several government initiatives and policies to reduce greenhouse gases emission across the sectors will further propel the market. CO2 enrichment is a niche application, but carbon sequestration payments could offer a new revenue stream to farmers and increase the value of soil amendments and biological fertilizer in the next two to five years.
- **Environmental impact reduction potential:** Low- and no-tillage practises could have a decarbonization potential of~119 $MtCO_2e$, at cost savings of ~$41/$tCO_2e$, by 2050. The environmental impact of CO2 enrichment in greenhouses has not been calculated, as fuel is often burnt to supply the CO2.[174]

Example innovators

ccmtechnologies

Developer of a CO2 to fertilizer and plastics technology (UK)

carbo culture

Developer of biochar from waste biomass methane emissions (Finland)

Key Clusters

UK

- Access to strong talent pool through Oxford, Cambridge, and Imperial College London Universities.
- Public funding for innovation is easily available through organisations like Innovate UK and the Seed Enterprise Investment Scheme.
- Crop and agricultural science research centres such as Rothamstead, Cirencester Agricultural College, Harper Adams, create a strong talent pool and lower R&D and trial costs.

Finland

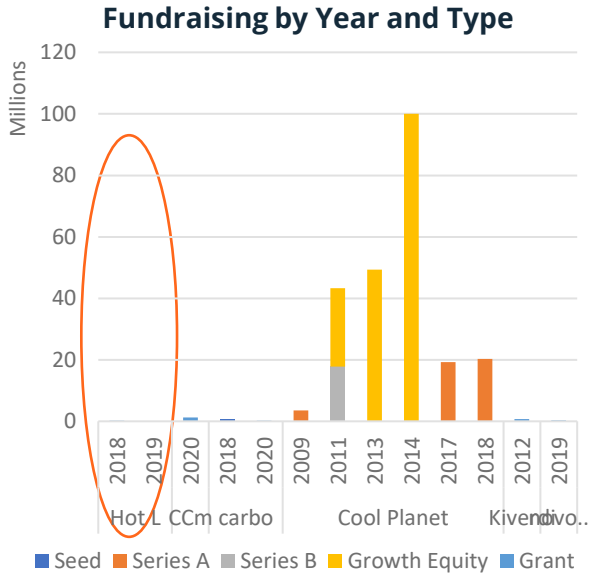
- Finland has a strong science base, high public expenditure on R&D, and highly ranked universities.
- In 2017 Finland merged Finpro – the Finnish trade promotion organisation – and Tekes – the Finnish Funding Agency for Innovation –as Business Finland to administer public funding for R&D and innovation combined with internationalization efforts.
- Small but active venture investor community (Loudspring, Inventure, Fortum).
- Focused on biomass waste solutions due to significant forestry industry.

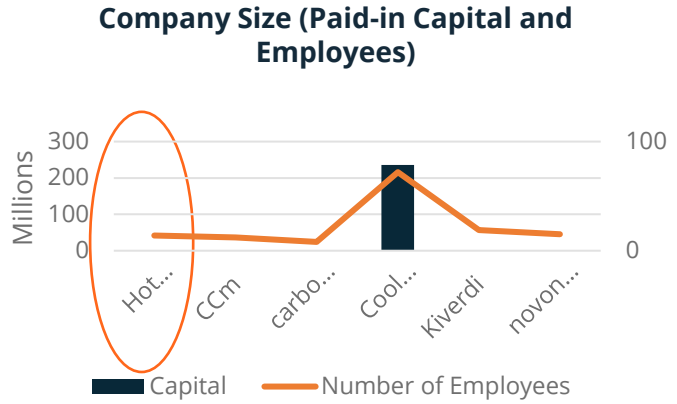
Innovators and Ecosystems: CCUS for Agriculture

Alignment w/ Strength

2

Ecosystem	HOTLIMELABS **Lower Hutt, NZ** Developer of wood biomass conversion to CO2 for greenhouses	ccmtechnologies **Swindon, UK** Developer of a CO2 to fertilizer and plastics technology	carbo culture **Helsinki, Finland** Developer of biochar from waste biomass methane emissions	coolplanet **USA** Developer a biochar product for drop-in fuels and soil enhancement	KIVERDI **Pleasanton, CA, USA** Developer of microbial conversion of CO2 to feed, materials, and chemicals	novonutrients **Sunnyvale, CA, USA** Developer of technology that transforms CO2 into protein products
Diversity in mgmt. / ownership		• 1/5 female directors	• 1/2 female co-founder			• 1/5 female, 2/5 non-white management
Grants		• Department for Business Energy and Industrial Strategy		• USDA	• California Energy Commission	• US Department Of Energy
Incubators / Accelerators			• StartX Stanford	• Thrive Accelerator		• Feed X • IgniteX • Indie Bio • Chevron Tech Ventures
Angel Financing	• Chris Hadley		• David Helgason • Bragiel Brothers • Mika Ihamuotila	• Agustin Coppel		
Equity Financing	• New Crop Capital • Blackbird Ventures	• Wittington Investments	• Lifeline Ventures • Wave Ventures • Starlight VC	• BP Ventures • Constellation TV • Concord Energy • GV • North Bridge Venture Partners	• California Energy Commission • Kapor Capital	• Joyance Partners • Purple Orange Ventures • Indie Bio • Dreamworx
Debt Financing						
Customers	• Coles					
Partnerships		• Innovate UK • Viridor • Severn Trent		• Concord Energy • Google • National Carbon Technologies	• Microvi Biotechnologies • Air Protein	• Skretting
Talent Pipelines	• Auckland University of Technology • Victoria University of Wellington • Sharif UT	• Royal Agricultural University	• Vienna University of Economics and Business • Kiel University	• UC Santa Barbara • Harvard Business School	• Uni. Of Cali., Berkeley • Uni. Of California, Davis	• Uni. Of Cali., Berkeley • Uni. Of California, Davis • Harvard University • Denmark TU • INSEAD
Emissions Reduction	• Uses locally sourced wood residue in modest quantities	• 90% carbon footprint reduction compared to conventional fertilizer production	• 1 ton of Carbo Culture biochar keeps 3.2 tons of CO2 from returning to the atmosphere			





Source: Cleantech Group i3 Database

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Local Participants

External Participants

Acquirer

NZ Ecosystem in Global Context: CCUS in Agriculture

Ability to Lead

1

		New Zealand		UK		Finland	
Overview			• Strong agriculture R&D in universities, and gov't support • Low presence of financing • Strong agriculture market • Low presence of multinationals		• Leading academic institutions • Leading R&D in agriculture • Global financial centre • Extensive internationalization of Ag. services and innovation		• Innovation-led economy • Good Universities and connection with Nordic R&D cluster
35%	**R&D-to-commercialization pipeline strength**	3	• Callaghan Innovation loans are supporting innovation • Demand-driven R&D tax credit (15% at $430 million/year)[21]	9	• Innovate UK well funded coordinator of public grants and early-stage support • UK BEIS and DEFRA active in support innovation through grants and pilots • 5+ research universities looking at livestock and agriculture	4	• Good R&D facilities (VTT, ABS School, Uni. Of Helsinki • Well funded startup support from Sitra, Business Finland • Research activities support industrial needs • Fragmented research initiatives
25%	**Financing strength**	3	• Seed and early-stage financing supporting ag tech • Few NZ-based investors to support larger equity and debt rounds	9	• 10+ VC and equity investors based in London dedicated to agtech investment. • Strong material and chemical innovation for CO2 and decarbonization solutions • Over $3.6 billion invested in UK agtech companies in 10 years	6	• 7 deals for $24.85 million 2011-2021 • Innovators using sequestered carbon for soils and food production are being supported primarily by domestic investors, but with adequate funding.
40%	**Connection to demand**	5	• Horticultural exports alone valued at $5.5 bn in 2018 [34] • $48 bn invested in horticultural products in 2018 [34] • Lack of innovation outposts in overseas markets to promote innovation	8	• Traditionally an entrepot for European expansion • Uncertain trade situation post-Brexit • Strong decarbonization drive expected in domestic market with ELMs regulation	5	• Total agrifood industry added value $22.5 billion (2019)[175] • Low export totals in agricultural products, typically specialty oats
Evaluation		**3.8**		**8.6**		**5.3**	

Scoring: CCUS for Agriculture

Trends	Market		NZ Position	
	External Potential	Timing of Trend	Alignment w/ Strength	Ability to lead
CCUS for Agriculture	4	4	2	1

Takeaways for NZ Climate Tech Innovators

- Focus on CCU applications that replace high value and high emission intensity production systems such as animal feed and fertilizer production.
- Look for partnerships that bridge high quality CO2 feedstock with agricultural sales channels such as large resource-based conglomerates.
- There are significant opportunities for marine and land-based carbon sequestration technology and business model innovation.

Takeaways for NZ Climate Tech Ecosystem

- Low levels of activity in materials, chemicals, oil, and gas reduces the number of investors and corporate partners for carbon sequestration solutions.
- Leverage NZ's biotechnology expertise to develop CO2-to-X bio-fermentation innovation for feed, feed additive, and other specialty chemicals with agricultural applications.
- Making exceptions for biogenic methane in Nationally Determined Contribution (NDC) disincentivizes carbon sequestration technology.
- Promote and incentivize agricultural soil-based carbon sequestration solutions. Ecosystem service payment business models are being developed around the world to provide a new revenue stream to responsible farmers while reducing atmospheric CO2 levels.

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Appendix 3
Resources & Environment

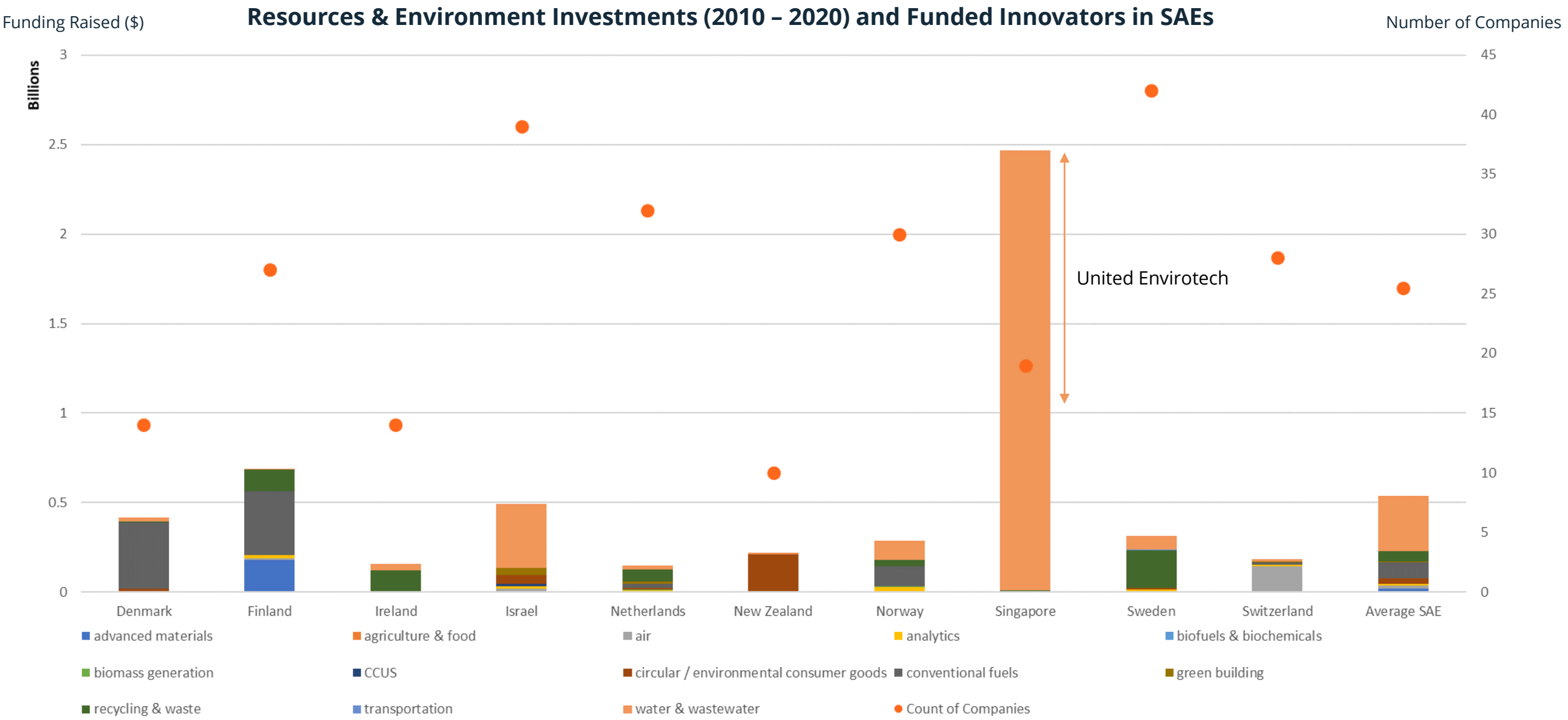
Contents

Resources & Environment – Comparison between Small Advanced Economies (SAEs)

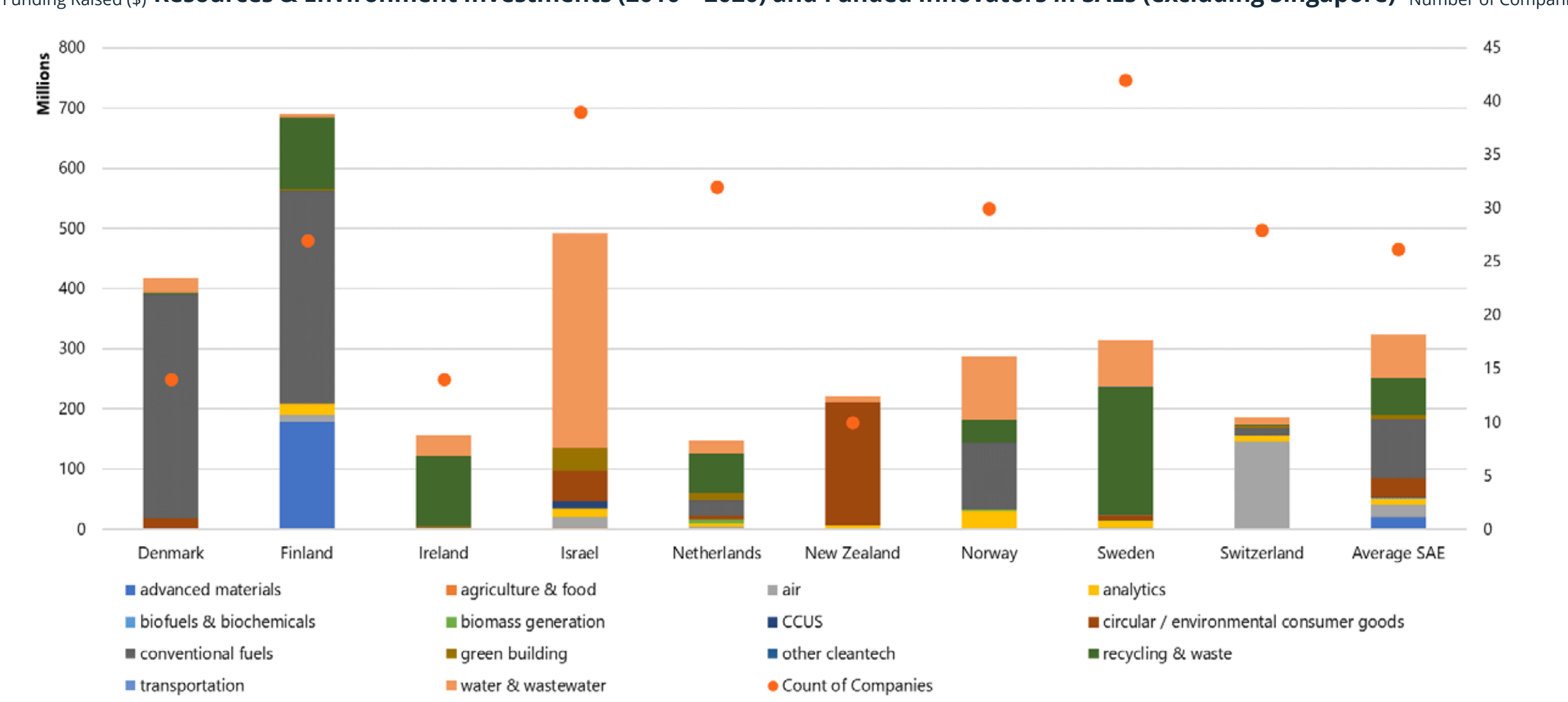
Resources & Environment Analysis

- Wastewater Treatment
- B2C Carbon Emissions Tracking
- Bioplastics
- Zero Waste Products
- Natural Textiles

Overview – Resources & Environment Innovation in Small Advanced Economies (SAEs)



Overview – Resources & Environment Innovation in SAEs (excluding Singapore)



Contents

Resources & Environment – Comparison between Small Advanced Economies (SAEs)

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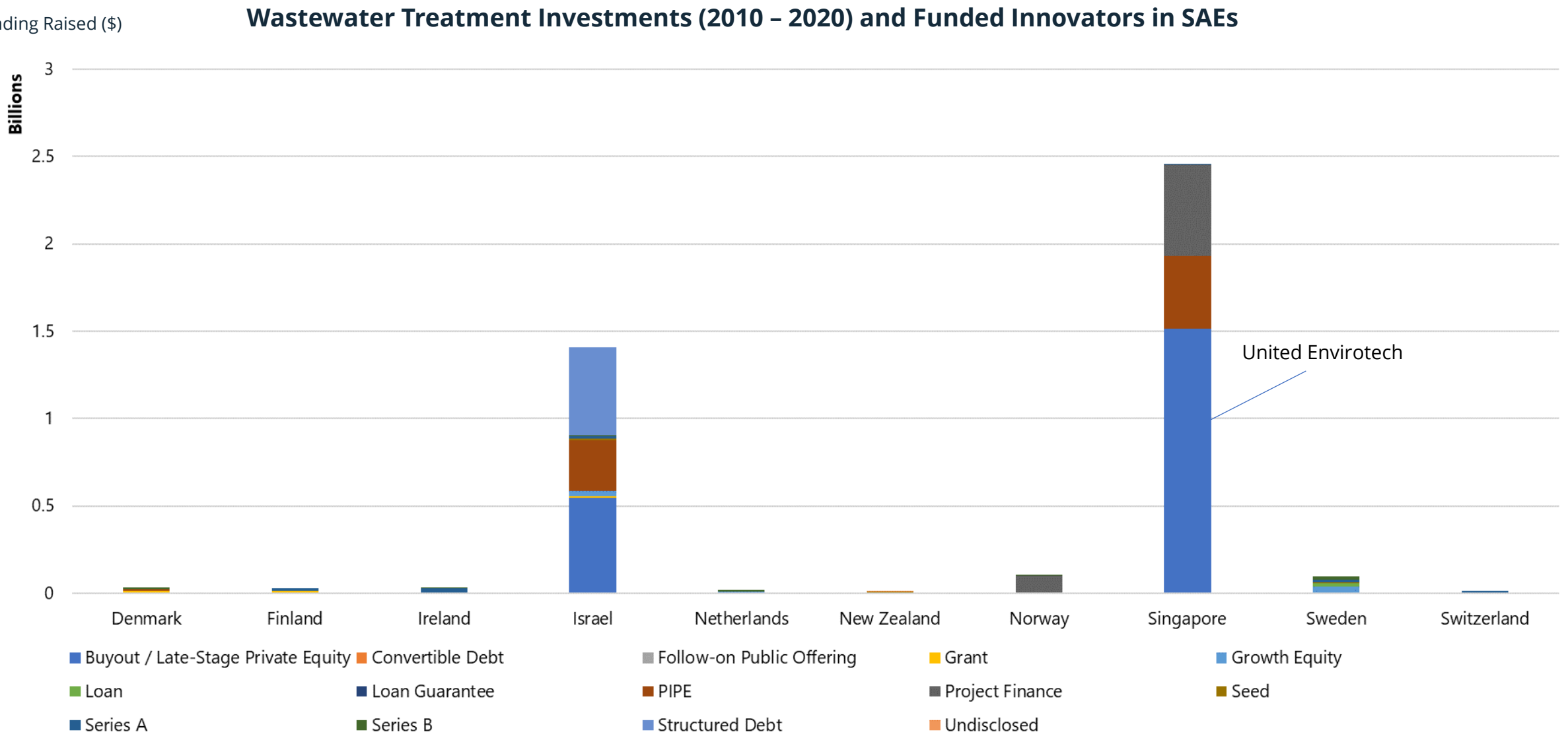
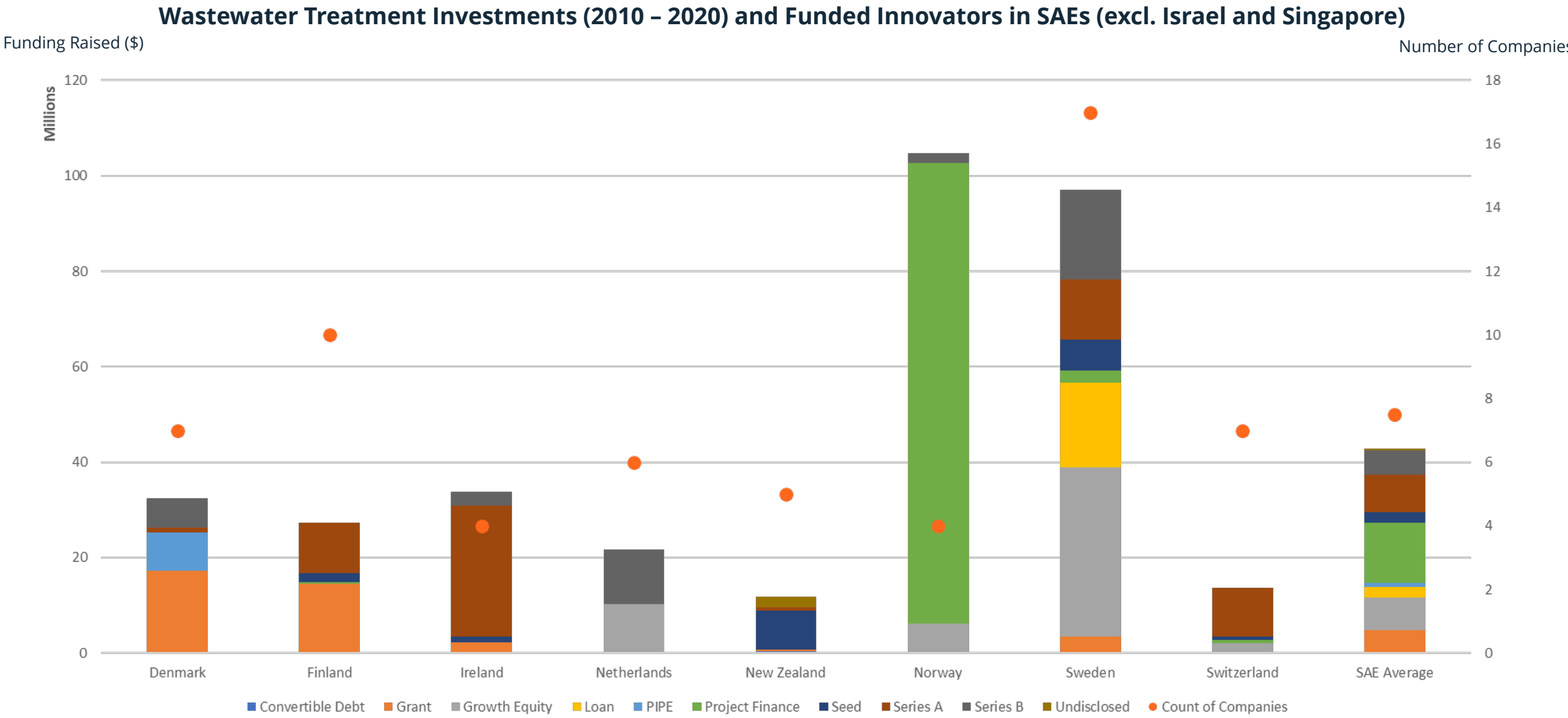
- Zero Waste Products
- Natural Textiles

Overview – Investments into Wastewater Treatment in SAEs

Funding Raised ($)



Overview – Investments into Wastewater Treatment in SAEs (excl. Israel and Singapore)



Wastewater Treatment– Trend Analysis

External Potential	Timing of Trend
4	3

Summary

- **Description:** Wastewater treatment systems used to filter, purify and separate water from dissolved and suspended materials, harmful bacteria, virus', fungus and chemicals.
- **External potential:** The market size for wastewater treatment is estimated to be worth $48.5 billion in 2019, growing at a CAGR of 6.1% to reach $65.1 billion by 2045[176].
- **Timing:** Wastewater treatment technologies vary greatly and many like membranes are well established. Most innovations seek to reduce electricity and chemical input and save as much water as possible, often for commercial and industrial reuse. Compounding issues of water scarcity and commitments to reduce energy use have increased corporate interest and investment in a typically slow-moving industry.
- **CO2 reduction potential**: Wastewater and water utilities use a lot of energy particularly for aeration, the process by which oxygen is pumped into water to accelerate biological treatment. In the US water and wastewater utilities account for 35% of typical U.S municipal energy budgets, resulting in 45 million tons of GHGs annually[177].
- **Environmental impact reduction potential:** Potential to reduce the 2 million tons of sewage and other effluents discharged into the world's waters, every year more people die from unsafe water than all forms of violence.[178]

Example innovators

Stockholm Water Technology

SWT specializes in the development of low cost and low energy electrochemical water desalination system

Vallingby, Sweden

Atlantium
Illuminating Water Technologies

Atlantium provides safe and sustainable water treatment solutions based on UV disinfection, fiber optics, and hydraulics.

Bet Shemesh, Israel

Key Clusters

Sweden

Advanced wastewater treatment systems, with a long history (dating back to 1930s). Sweden's proficiency in adjacencies (digital infrastructure for water, consumer water-saving devices) offers a more comprehensive value chain for the big picture of overall water savings

- Sweden Royal Institute of Technology operates specialized research in wastewater treatment through the Department of Industrial Biotechnology
- Cleantech Sweden actively promotes Swedish innovation in wastewater to other countries, especially developing countries

Israel

87% of wastewater is treated, making Israel the world leader. As a comparison, the US reuses roughly 10% of wastewater

- Heavy government investment created a high-performing wastewater treatment industry, mostly centralized at high-volume plants, however, a trend of decentralized treatment is developing through innovators
- Water-specialized cross-border investment funds between Israel and other innovation clusters, e.g. the Israel – Colorado innovation fund

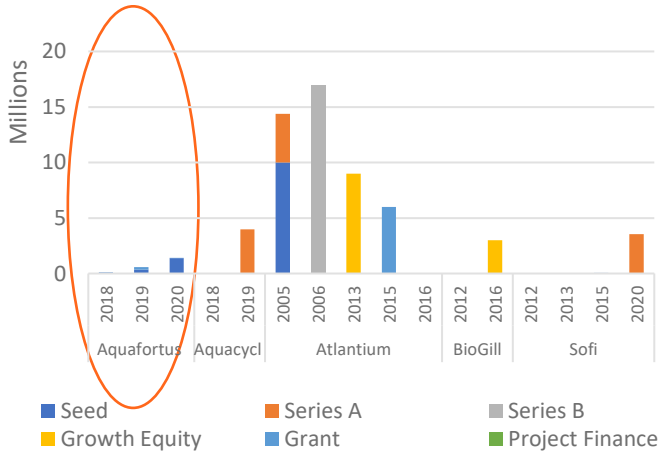
Innovators and Ecosystems: Wastewater Treatment

Alignment w/ Strength

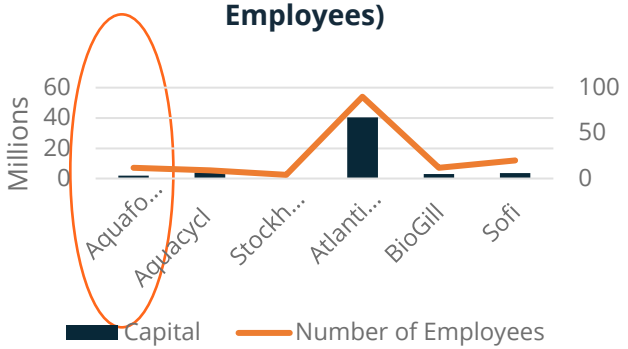
3

Ecosystem	Auckland, NZ **Aquafortus** specializes in high water recovery and ZLD brine management technologies.	San Diego, US **Aquacycl** provides the Bioelectrochemical Treatment Technology for onsite wastewater treatment	Vallingby, Sweden SWT specializes in the development of low cost and low energy electrochemical water desalination system	Bet Shemesh, Israel **Atlantium** provides safe and sustainable water treatment solutions based on UV disinfection, fiber optics, and hydraulics	Milwaukee, Australia **BioGill** is a clean tech company established to commercialize advanced water treatment technology	Espoo, Finland **Sofi Filtration** is a high capacity polishing filter.
Diversity in mgmt. / ownership	2/3 C-suite women, 2/3 non-white	2/3 C-suite women, 1/3 non-white	3/5 C-suite non-white	2/14 C-suite women	2/5 C-suite women	
Grants	• Callaghan Innovation			• Aster Capital		
Incubators / Accelerators	• Imagine H2O • Astrolab	• Plug and Play Tech Centre • The Roddenberry Foundation • ImagineH20	• Vinnova • EU, EIT InnoEnergy		• Imagine H2O	• Tekes - Finnish Funding Agency for Technology and innovation
Angel Financing	• Launch Taranaki	• Tech Coast Angels • The Chemical Angel Network				
Equity Financing	• NZ Growth Capital Partners	• Cavendish Impact Capital • Next Wave Impact	• Almi	• Aeris Capital • Aurum Ventures • Elron Electronics • Pitango Venture Capiatal	• Softbank China Venture Capital, • BW Ventures, Southern Cross Venture Partners.	• Emerald Technology Ventures, • Loudspring
Debt Financing						
Customers		• Swine farm in CA • Residential sewage plant in Mexico		• Ontario Power • Unnamed North American power plant • Namdal Rensefisk (Norway)	• The Coastal Brewing Company	• Fortum • GTK • Terrafame • Lindstrom • Anglo American
Partnerships	• PetroH20 (Aquafortus US licensee) joint venture w/ Pilot Corporation		• Sweden's Royal Institute of Technology • Vinnova • Almi	• Alstom	• DOW Chemicals	
Talent Pipelines	• MIT • Yale • Oxford • University of Otago	• Waseda University • U. Southern California	• Waseda University • U. Southern California	• Tel Aviv University • Technion • Ben-Gurion U. of Negev		• LUT University • ETH Zurich
Emissions Reduction	• Zero liquid discharge, clean water output.	• Eliminates 80% of incoming primary sludge • 90% reduction in treatment footprint	• 10-15% water saving • 80-90% water recovery	• Reduced chemical and energy use in wastewater treatment	• Improving reaction rate in biological wastewater treatment	• Resilient self-cleaning filters, reducing the need for chemicals.

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Wastewater Treatment

Ability to Lead

2/3

		New Zealand		Sweden		Israel		Australia	
	Overview	• Although considered a "water rich" country, water shortages (as in Auckland) have occurred recently. Observable class of innovators emerging, including some with a global footprint.		• 90% of population connected to conventional wastewater treatment facilities. Innovation occurring around circularity e.g. sludge management for biofuels.		• Historically afflicted by water scarcity – now reuses 87% of its wastewater. Government has put over $750 m into centralized water reclamation since 2000, spurring a domestic industry. [180]		• Australia's persistent droughts and history of water-intensive industries (mining, agriculture), give it unique experience in managing wastewater under very specific circumstances	
35%	**R&D-to-commercialization pipeline strength**	**5**	• Water treatment research occurring at Massey U., environmental engineering dept at U. Auckland. • Innovation in water and effluent management for agriculture (e.g. Regen, acquired in 2020) creates relevant research adjacency.	**7.5**	• Swedish Energy Agency supporting wastewater start-ups with significant grants. • Strong in downstream digital water-saving technologies (leak detection, e.g. Aqua Robur, Xylem) and consumer-facing systems (Orbital, Altered).	**9**	• Adjacent innovation industries have grown to serve the wastewater industry (energy efficiency, digital facility management) • Government and universities frequently cooperate with innovators to solve specific problems (e.g. Technion – Kando Covid-19 detection project)	**5.5**	• Innovation capabilities more observable in domestic wastewater treatment solutions (e.g. Nexus eWater) • Universities collaborating with innovators (e.g. U. Queensland – Unitywater) and making seed investments (e.g. ANU Connect – Nexus eWater)
25%	**Financing strength**	**5**	• 10 deals for 7.13 m between 2011–2021 • Companies able to access grant and seed funding at the early stages from a mix of local players • NZ innovators able to access international acceleration opportunities (e.g. Aquafortus – ImagineH2O)	**7**	• 35 deals for $97.14 m between 2011 – 2021 • Innoenergy providing seed financing to wastewater innovators • Project financing coming from consortia of Swedish-foreign investors	**9**	• 36 deals for $1.4 b between 2011 – 2021 • Innovators accessing global acceleration opportunities (e.g. Kando – Elemental, Utilis – Microsoft AI for good) • Strong capital market between Israeli investors and global corporates participating	**6.5**	• 10 deals for $64.2 m between 2011 – 2021 • Standout start-ups are able to access growth financing through a mix of local and global investors, e.g. BioGill through BW Ventures, Softbank, and Southern Cross
40%	**Connection to demand**	**6**	• Initial success cases of joint ventures / licensing deals in larger markets • Local wastewater entities are engaging with innovators but mostly on digital technologies (e.g. Bay of Plenty, Nat'l Institute of Water & Atmospheric research – Aquatic Informatics) and energy efficiency (Derceto)	**8.5**	• Swedish Cleantech promotes "sustainable water solutions for the world" and has a portal on their website to search innovators and request meetings • Innovators accessing overseas investment and exit opportunities (e.g. Tiami – ICL) • Global corporates engaging Swedish innovators as development partners (e.g. ConocoPhillips – Xzero)	**9**	• Innovators achieving technology partnerships and deals with global incumbents (e.g. Atalantium with Alstom). • Innovators being acquired by overseas wastewater developers (e.g. Emefcy with RWL Water Group) • Local corporates undertaking cross-border acquisitions (ICL – Tiami)	**6**	• Global corporates engaging innovators as channel partners (e.g. Dow – BioGill) and development partners (Veolia – Unitywater, Cemex - Calix). • Australian corporates were forming partnerships with innovators in early part of the decade but have slowed down.
Evaluation		**5.4**		**7.8**		**9**		**6**	

Takeaways: Wastewater Treatment

Takeaways for NZ Climate Tech Innovators

- Imagine H2O accelerator is a common denominator player among standout innovators in not only the wastewater segment but water management in general, Aquafortus is an example of an NZ innovator competing in this venue. Elemental Exclerator (Hawaii) is a similar, highly selective, springboard to market for water innovators.
- Although based on limited analysis, wastewater treatment is one of the most diverse sectors observed during this exercise (thus far) – while it would be conjecture to state a conclusion tying diversity to company performance, a hypothesis is that attracting and retaining key talent to compete against the highest-performing innovators requires a diverse c-suite and/or board.

Takeaways for NZ Climate Tech Ecosystem

- Similar to other sectors, a "value chain" approach will be most critical to ensuring that NZ wastewater treatment innovators end up in larger markets – Suez's acquisition of Derceto (2014) and Aquafortus's initial licensing success overseas are initial examples of NZ innovators' solving energy management / efficiency issues for overseas water utilities using different technologies.
    - Consider where the Māori waste management philosophy and whole-of-ecosystem systems thinking can play a role – is there latent (or active) Māori innovation around this issue? Are there opportunities to infuse the Māori approach into future innovation efforts?
    - Granular technologies are more likely to be noticed by export markets when part of a value chain solution – think the Israeli "energy efficiency for energy transition catalogue" and Sweden's "sustainable water solutions for the world" strategy of presenting technology suites as a tactic to achieve big-picture sustainability strategies.
- Look to innovation clusters with similar goals and challenges regarding wastewater and consider co-financing acceleration (e.g. Israel-Colorado Innovation Fund water programme)
- Forge links with "high need – highly experimental" wastewater clusters, e.g. Israel, UK, California, Texas.

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- Bioplastics
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- Natural Textiles

B2C Carbon Emissions Tracking – Trend Analysis

External Potential	Timing of Trend
1	2

Summary

- **Description:** B2C emissions tracking platforms, usually mobile apps, for individuals to monitor their personal carbon footprint. Some companies act as carbon offset retailers allowing individuals to offset their calculated carbon footprint. Some solutions also integrate metrics already monitored by individuals on apps like travel and food consumption.
- **External potential:** The total Carbon Management System Market was valued at USD 9.0 billion in 2020 and expected to reach USD 12.2 billion by 2025 and grow at a CAGR of 6.21%. However, the B2C footprint tracking market is a smaller part of this total market which includes B2B tracking services and consultancy services[181].
- **Timing:** Consumer interest in climate change is at an all time high, a Pew Research Centre 2019 survey found that the majority of publics across the globe see climate change as a very serious problem and think their government is doing too little to address it[182]. This market is in early and pilot stages, although as its software-based and capitalizing on existing tracking measures and established services like voluntary carbon markets, the market is developing quickly.
- **CO2 reduction potential:** C40 Cities assessed the consumption-based emissions of its 79 C40 cities, calculating 3.5GtCO2 annually[182].
- **Environmental impact reduction potential:** Potentially to reduce emissions in consumption-based emissions via positive purchasing or reduction in transportation, the food system and even financial services products. The engagement with the voluntary carbon offset market will also drive mitigation and carbon sequestration.

Example innovators

Enfuce

Developer of purchase-based carbon footprint tracker

Espoo, Finland

TOMORROW

Tomorrow is a bank that funds and promotes renewable energy, solar and wind power, and sustainable agriculture

Germany

Key Clusters

Finland

- Finland was the home of nearly 2,000 fintech investments between 2011 – 2021, creating a full-fledged fintech industry that has come to count emissions tracking as one of its sub-sectors.
- History of Nokia as a once-global leader has provided a base for Finland's continued development of TMT and digital technologies
- Software from Finland – an industry consortium in Finland that brings together innovators and corporates for networking, sets standards, and provides trainings to global players

Germany

- Fraunhofer Institutes around Germany have created an efficient public-private mechanism for experimenting with otherwise risky innovation and creating "heat maps" around digital technologies that can be applied to multiple industries
- Major credit card providers collaborating with German fintech start-ups for digital payment processing, financial management, and personal carbon accounting services

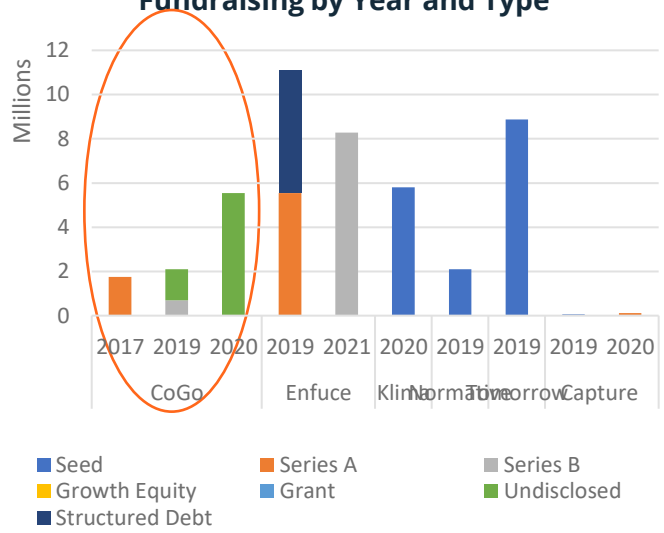
Innovators and Ecosystems: B2C Carbon Emissions Tracking

Alignment w/ Strength

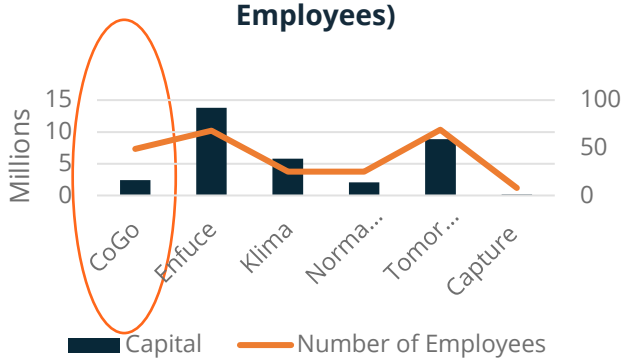
3

Ecosystem	CoGo Wellington, NZ CoGo helps consumers to find ethical and sustainable businesses in NZ through a mobile app	Enfuce Espoo, Finland **Enfuce** offers payment and open banking services to banks, fintechs, financial operators, and merchants	klima Berlin, Germany **Klima** provides CO2 offsetting services used to reverse the effects of climate change	normative Stockholm, Sweden **Normative** calculates the sustainability impact of economic activities on the planet	ToMORROW Hamburg, Germany **Tomorrow** is a bank that funds and promotes renewable energy, solar and wind power, and sustainable agriculture	CAPTURE Singapore **Capture** is an app that empowers you to track, reduce and remove your carbon footprint.
Diversity in mgmt. / ownership	1 / 4 C-suite women	2/7 Board of Directors women	1 C-suite woman	1 C-suite woman		2/4 C-suite women, 2/4 non-white
Grants	• Callaghan Innovation					
Incubators / Accelerators				• Joules Accelerator		
Angel Financing	• James Watt, Mark Sainsbury, Andrew Thorburn, Jason Stockwood, Richard Collier Keywood • Angel HQ • ICE Angels		• Christian Reber (founder of Pitch), Jens Begemenn, (Founder of Wooga), Niklas (co-founder of Blinkist)			
Equity Financing	• Growth Capital Partners	• Nordea Bank, Maki.vc • Finnvera, LähiTapiola	• E.ventures • HV Capital, 468 Capital	• ByFounders, Wave Ventures, • Luminar Ventures • Eric Wahlforss	• ETF Partners	• Antler
Debt Financing						
Customers	• B2C: 7,000 customer	• Pleo • St1 • Rocker • Indo • Asiakastieto	• B2C	• B2C • Summa Equity • Sortera, Bonavva, Castellum, Elekta	• B2C – 50,000 customers	• Novartis, PropertyGuru, Experian • Dulwich College International, Quintet Private Bank
Partnerships	• 15,000 partners on app • Living Wage Foundation • Social Enterprise UK	• Card issuing partnerships: Visa, Mastercard, AWS, Verizon	• Gold Standard • Verified Carbon Standard • Climate, Community & Biodiversity Standards	• SME Climate Hub — co-hosted by the International Chamber of Commerce (ICC),	• Visa – Tomorrow has a visa debit cart	• South Pole, Pachama
Talent Pipelines	• Victoria U. of Wellington • U. Auckland	• Hanken School of Economics • Aalto U.		• Uppsala U. • Stockholm School of Economics • Lund University	• U. Hamburg • Leuphana U. of Luenburg • Freiie U. Berlin	
Emissions Reduction	Not Applicable	Not Applicable	Not Applicable	Not Applicable	9,436 sqm of rainforest protected by investments	Not Applicable

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: B2C Carbon Emissions Tracking

Ability to Lead

2

		New Zealand		Sweden		Finland		Germany	
	Overview	• NZ advantages lie in a growing class of computer science scholars, difficulties lie in size of home market and lack of major financial / retail incumbents		• History of digital and telecommunications engineering proficiency (Ericsson, Spotify, etc.), successful B2B carbon accounting innovators		• Significant pool of software engineering talent and innovation, highest utilization rate of digital technologies (Digital Economy and Society Index)[186]		• Strong presence of innovators in B2C and B2B innovators. Significant talent pool from local universities and top software companies.	
35%	**R&D-to-commercialization pipeline strength**	**6.5**	• NZ is developing talent in digital technologies – NZ developers scored highest on a global coding proficiency assessment in 2019. In 2019 there were 8,605 full-time computer science and IT students in NZ universities [184]	**4**	• This area of innovation is not a key focus of the ecosystem, amongst the larger digital climate tech sectors (e.g. commercial and residential energy management, digital transportation management)	**7.5**	• Software talent pools strong due to consistent focus of Finland on ICT and participation in cross-EU projects • Innovation occurring in adjacencies, e.g. One Click LCA for construction. Spillover effects and industry buy-in	**8**	• Public-private research institutions, most notably the Fraunhofer Institutes, taking on software experimentation. • Presence of SAP supplies a pool of talent that can develop cross-industry software, not just in one niche.
25%	**Financing strength**	**2**	• 4 deals for $5.5 m 2011 – 2021 • Early stage investors (angel groups, seed / series A funds) supporting this sector.	**2**	• 3 deals for $3.27 m 2011 – 2021 (2 investments in Normative, one in CarbonCloud) • Innovators accessing overseas acceleration opportunities (e.g. Normative – Joules Accelerator) • Few examples of substantial capital raises	**6**	• 2 deals for $17.24 2011 – 2021 (both deals in Enfuce) • Scandinavian banks participating (e.g. Nordea Bank – Enfuce)	**7.5**	• 7 deals for $28.14 m 2011 – 2021 • Major European investors participating in the B2C and B2B sectors (e.g. Demeter, BCG Digital – Plan A, Environmental Tech Fund – Tomorrow)
40%	**Connection to demand**	**2**	• Retailers and users participating in the space, presence of large retailers and banks not observed in ecosystem.	**5**	• Despite the limited focus on this area in Sweden, diverse groups of corporates and NGOs are engaging: Oatly, Estrella, WWF with CarbonCloud and Heimfrid (cleaning services), Summa Equity with Normative	**8**	• Strong synergies across Finnish software industry – Software from Finland industry association has brought together hundreds of software start-ups and corporates. • Global card-issuers collaborating with Finnish innovators (e.g. Visa, Mastercard, AWS – Enfuce)	**9**	• Presence of major software companies (SAP is especially active with climate companies) is a home-market advantage. • Major card services engaging with innovators (e.g. Visa – Tomorrow). This is ultimately the best conduit into engaging consumer spending and accessing transaction percentages.
Evaluation		**3.6**		**3.9**		**7.3**		**8.3**	

Takeaways: B2C Carbon Emissions Tracking

Takeaways for NZ Climate Tech Innovators

- Market based on consumer interest and concern, reliant on the offset market which is insecure. There is security in demand in the offset market, but all other market infrastructure is nonexistent making it unstable.
- Solutions can be localized e.g., apps display local recycling schedules, making it easy to promote in local clusters. Which may explain the geographical fragmentation of this market.
- Low cap-ex, investment needed to promote use. Most innovators are providing free versions of the app to encourage loyalty which they can convert to a paid-for version.
- Another stable income stream is corporations, who buy app access in bulk, giving employees access as both CSR, action on their scope three emissions and an employee benefit.
- At time present, partnerships with card companies (see Visa – Tomorrow partnership, Enfuce's ability to read card transactions) is the most efficient way to 1) access scalable user pools and b) sustain a business model off of transaction percentages. These partnerships leapfrog the one-by-one relationship-building stage with retailers.

Takeaways for NZ Climate Tech Ecosystem

- A competitive environment in this sector is most likely to emerge from digital payment / microloan innovators that layer on the carbon monitoring capabilities. A critical decision to develop an ecosystem that supports this technology is whether the ecosystem intends to compete in fintech.
- Business model dependent on networking effects (users, businesses), natural disadvantage in NZ. To export, will need big banks and retailers engaging an innovator that has a) cutting-edge software / algorithms and market-beating performance or b) highly cross-compatible back-end infrastructure with rapid deployment capabilities (infrastructure agnostic).
- Standout software solutions generated in NZ should be promoted to credit / debit card companies (Visa / Mastercard / UnionPay, etc.) and payment processors (Paypal, Stripe, Plaid, etc.) for the most efficient conduit into scalable markets.

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- Zero Waste Products
- Natural Textiles

Bioplastics – Trend Analysis

External Potential	Timing of Trend
2	3

Summary

- **Description:** Around 50% of all bio-based plastics produced are drop-in plastics — bio-based, non-biodegradable materials obtained from renewable sources with identical technical properties as their petroleum counterparts, such as bioderived-PE and PET. Certain plastics (biobased and non-biobased) may be biodegradable and/or compostable. Biodegradable plastics are those which degrade over time with the help of micro-organisms, while compostable plastics degrade under conditions and within a certain timeframe (and are certified as such). According to the New Plastics Economy, producers reported using an average of 62% renewable feedstocks, and an average of 42% feedstock from responsibly managed sources [187].
- **External potential:** Across the world we produce 300 million tons of plastic per year [9], technically 85% of plastics can be substituted with bio-based plastics[10]. The bioplastics market was valued at $4.6 billion in 2019 and expected to be worth $13.2 billion by 2027 growing at a CAGR of 13.8% [190].
- **Timing:** China's 2018 National Sword Policy, banning imports of all but the cleanest waste imports, started a chain reaction with other major importers implementing bans[191]. In turn, the EU has banned exports of unsorted plastics to non-OECD countries[13]. Initially, this shifted recycling from a money earner to a cost due to additional processing costs, thus disincentivising plastic use and funnelling investment into plastic alternatives. Similarly, the US, China, EU and many other countries have all introduced regulations to enforce EPR or ban some single-use plastics[193].
- **CO2 reduction potential:** In 2019 alone, the production and incineration of plastic will add more than 850 million metric tons of greenhouse gases to the atmosphere—equal to the pollution from 189 new 500-megawatt coal-fired power plant. This contribution is growing, by 2030, emissions could reach 1.34 gigatons per year. [194]

Example innovators

TIPA Compostable Packaging

Compostable packaging for food and fashion industries

Hod Hasharon, Israel

SULAPAC

Developer of compostable bioplastic from wood and plant-based binders

Helsinki, Finland

Key Clusters

United Kingdom

- **July 2019**: Sky Ocean Ventures launched the Ocean Plastics Innovation Challenge to search for innovative solutions to solve single-use plastic and ocean pollution.
- **August 2020:** Biome Bioplastics received a $360 thousand from Innovate UK. The funding was awarded as part of a collaborative project to scale-up Biome's compostable bioplastic materials with the University of Nottingham's Department of Chemical and Environmental Engineering.
- **October 2020:** The English ban on supplying plastic straws and stirrers and plastic-stemmed cotton buds has come into force in England. This also follows a raise on plastic bag tax, a ban on microbeads and plans to establish a £500 million Blue Planet Fund to protect the ocean from plastic pollution, warming sea temperatures and overfishing.

United States

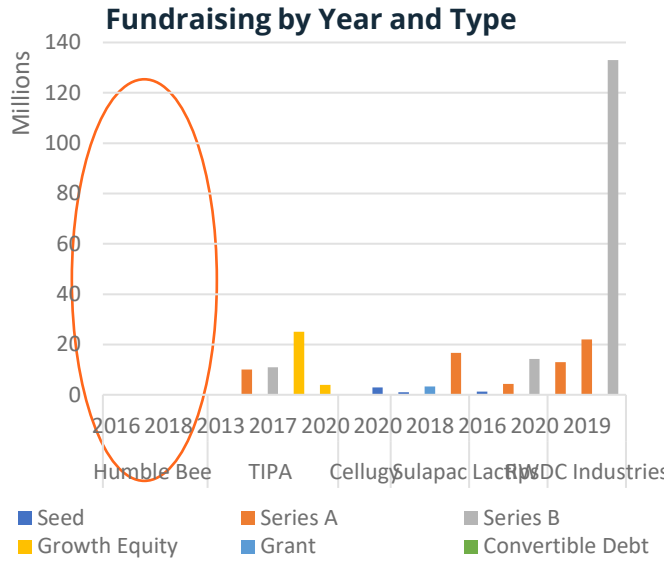
- **April 2020:** Mobius, developer of processes for production of renewable chemicals, materials, and energy from waste - primarily biodegradable plastics made from lignin, raised $250,000 in Grant funding when selected to join cohort 6 for the Wells Fargo IN2 (1) accelerator programme.
- **January 2020:** Loliware, developer and supplier of seaweed-based material including alternative drinks straws, raised $6 million in a seed round. Investors included New York Ventures and Closed Loop Partners.

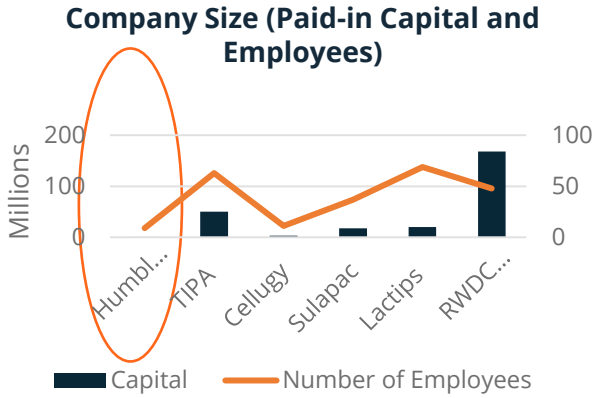
Innovators and Ecosystems: Bioplastics

Alignment w/ Strength

4

Ecosystem	Wellington, NZ **Humble Bee** aims to replace existing unsustainable plastics with superior, biologically-inspired materials	Hod Hashoron, Israel **TIPA** is an **Israeli** company manufacturing biodegradable plastic packaging	Arhus, Denmark **Cellugy**, is a biotech startup replacing single-use plastics with 100% natural bio-cellulose	Helsinki, Finland **Sulapac** is a fully biodegradable material innovation made of sustainably sourced wood and plant-based binders	Saint Jean Bonnefonds, France Lactips has created water-soluble, biodegradable plastic substitute made of casein (a milk protein) that is edible	Georgia, US **RWDC** is the developer of Solon, an environmentally safe alternative to petroleum-derived, single-use plastics
Diversity in mgmt. / ownership	1/3 C-suite women	4/10 Board of Directors women	6/7 C-suite women, 2/7 non-white	2/7 C-suite women Women co-founders	Woman CEO ½ C-suite women	1/9 C-suite women, 4/9 non-white
Grants	• Callaghan Innovation			• Green Alley Award, EASME		
Incubators / Accelerators			• Sky Ocean Ventures & National Geographic via Ocean Plastics Innovation Challenge Accelerace		• Thrive Accelerator	
Angel Financing	• ICE Angels			• Austin Hearst		
Equity Financing	• Sparkbox Ventures, Go Global Day One, NZVIF, NZ Growth Capital Partners	• Horizon Ventures, Tridos Bank, Blue Horizon • GreenSoil Investments, Aviv Venture Capital, Millennium Food-Tech	• The European Innovation Council	• CHANEL, Ardent Venture, Sky Ocean Ventures, Bonnier Ventures • Lifeline Ventures, Tekes	• Mitsibishi Chemical Holdings, BASF • BPI France, Demeter, BNP Paribas, Phitrust	• WI Harper Group, Flint Hills Resources Eversource Retirement Plan Master Trust • Vickers Venture Partners
Debt Financing						
Customers		• Riverford Organic Farmers, Abel & Cole		• Stora Enso	• BASF • IMCD Group	
Partnerships		• Commonwealth Packaging Company, ULMA Packaging, PerfoTec	• Agro Food Park • Eit Food • Cleantech Scandinavia • Sky Ocean Ventures		• ITOCHU • IMCD • Plastribution	
Talent Pipelines	• U. Otago • Victoria U. Wellington • Queen Mary U. London	• Bar-Ilan U. • Tel Aviv U. • Ben-Gurion U.	• Aarhus U. • Duke Fuqua	• U. Helsinki • Tampere U. of Technology	• Université Jean Monnet Saint-Etienne	• U. Georgia
Emissions Reduction						





Source: Cleantech Group i3 Database

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Local Participants

External Participants

Acquirer

NZ Ecosystem in Global Context: Bioplastics

Ability to Lead

1

		New Zealand		Canada		Germany		France	
	Overview	•	From July 1st, 2019 single-use shopping bags were banned. The NZ Government Government's Provincial Growth Fund (PGF) has previously invested in bioplastic infrastructure[195].	•	March 2021 the Canadian Minister of Agriculture announced project funding of over $4.5 CAD for bioplastic research to manage on farm waste[196].	•	Germany has the highest recycling rate in Europe. The German Government have also invested project financing into bioplastics for food[18].	•	Strong history of action on plastic, banned some single use plastics in 2019 extending this ban in 2020 and plans to ban all single use plastics[198].
35%	**R&D-to-commercialization pipeline strength**	**3**	• The science behind many companies originates from local universities including the University of Waikato. • Aduro Biopolymers is a spin-out company formed by WaikatoLink Limited, the technology transfer office of the University of Waikato.	**6**	• Government research agencies involved in the commercialization of technologies e.g., the National Research Council of Canada Development Partnership with Solegear.	**5**	• The Germany government have invested in bioplastics via the German Federal Ministry of Education and Research. • The Institute for Bioplastics and Bio composites is based in Germany and supported by the University of Hannover.	**3**	• Strong action on plastic waste in France, however single-use plastic bans contain some bio-based alternatives. Efforts are being made to change this.
25%	**Financing strength**	**2**	• 2 deals for <$200k between 2011–2021 • Companies able to access seed, Series A and Growth Equity funding from players in Australia and New Zealand. • Local players include New Zealand Growth Partners and Sparkbox Investments Limited.	**4**	• 13 deals for $28 m between 2011–2021 • Access to local accelerator programmes include Sustainable Development Technology Canada and the Natural Gas Innovation Fund.	**8**	• 4 deals for $2.175bn between 2011–2021 • Access to European funding including the European Regional Development Fund.	**5**	• 7 deals for $74 m between 2011 – 2021 • Investment from local corporates and customers like L'Oreal • Local VC investors include Demeter and BPI France. • Local accelerator programmes include Holding Incubatrice Chimie Verte
40%	**Connection to demand**	**1**	• Little engagement with local partners.	**6**	• Partnerships with external Fast Moving Consumer Goods (FMCG) companies like ABinBev with its 100+ Accelerator programme, as they meet its sustainability commitments. • Partnerships between innovators to advance technology offerings e.g. Teknor Apex and Cerestech.	**6**	• Local chemical expertise in companies like BASF and Evonik. These corporates are partnering or acquiring startups like LACTEL or developing their own technologies	**6**	• Development partnerships with large local chemicals companies like BASF to commercialize technologies and for distribution.
Evaluation		**2**		**5.5**		**6.2**		**4.7**	

Takeaways: Bioplastics

Takeaways for NZ Climate Tech Innovators

- High-CAPEX business models, over $100m investments needed to build pilot plants and scale to commercial scale.
- Issues with some bioplastics in local recycling systems, needs to be biodegradable within a reasonable timescale to be placed into compost (the most environmentally positive option).
- Large incumbents are innovating in house including chemical companies like DOW, BASF, and SUEZ as well as plastic producers. There are already strong leaders – consider where exit opportunities are as CAPEX is invested.

Takeaways for NZ Climate Tech Ecosystem

- Market-sizing data likely understates true potential, mostly capturing only the current demand for bioplastics, not necessarily the "true" market for plastic substitutes (assuming cost favorability).
- NZ does not have the domestic chemical industrial base to provide investments, pilots, and eventual M&A for innovators – overseas partnerships will be critical for developing this sector.
- NZ has critical supply chain elements (natural raw materials, production scrap). Value chain effects should be explored with agricultural production, i.e. where can NZ bioplastics innovators partner with local agricultural producers to develop end-to-end value chains? Do opportunities exist for co-location of agricultural / dairy production and bioplastics production?

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Zero Waste Products – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** Developers of Fast-Moving Consumer Goods (FMCG) product usually made without plastics or packaging, leaving zero waste or only biodegradable materials.
- **External potential:** The global zero waste shampoo market size was valued at USD 101.78 million in 2018 and is estimated to expand at a CAGR of around 7.18% over the forecast period from 2019 to 2025[15]. Similarly, The global zero-waste packaging market was valued at USD 1312.16 million in the year 2018 and is anticipated to grow at a CAGR of 8.78% over the forecast period 2020-2027[200].
- **Timing:** Zero waste products are gaining popularity in recent years, due to increasing response from the public against climate change. Nielsen's report revealed that demand for zero-waste sustainable products and packaging are growing twice as fast as other items.[17] The zero-waste product industry already has a large market and wide commercial availability on a global scale– with an emphasis on North America and Europe, with many corporates leading the charge for zero-waste in consumer goods and food.[203]
- **CO2 reduction potential:** Cutting emissions associated with plastics requires reducing waste, retaining materials by refurbishing or remanufacturing, and recycling. Under this type of circular business model, the CIEL report say carbon dioxide emissions would decrease by 62 million metric tons per year.[204]
- **Environmental impact reduction potential:** Globally, about 40% of plastics are used as packaging.[204] A centre for International Environmental Law (CIEL) report found that as of the end of 2015, 8,300 million metric tons of virgin plastic had been produced globally, two-thirds of which remains in the environment. [21] Wide adoption of zero-waste products has the potential to significantly reduce plastic wastes and other pollutants, on both land and water.

Example innovators

Loop

Developer of a low-waste shopping and delivery service with reusable packaging

New Jersey, United States

LastObject

LastObject creates a reusable, sustainable and sanitary alternative to single-use items

Copenhagen, Denmark

Key Clusters

United States

- The US is home to many companies that are leaders in the zero-waste product industry. Unilever claims that zero waste not only saved them over $225 million but also created many jobs in the process. [206]
- Subaru reuses or recycles everything. Subaru manufacturing plants in the U.S. and two of the company's manufacturing plants in Japan haven't sent waste to local landfills in over 12 years. Once their U.S. plant became zero waste, Subaru saw a savings of $1 – $2 million annually. [207]
- The EPA conducts Zero Waste Alliances all over the United States, through bringing together communities, corporations and public servants to guide business and lifestyle changes.

Europe

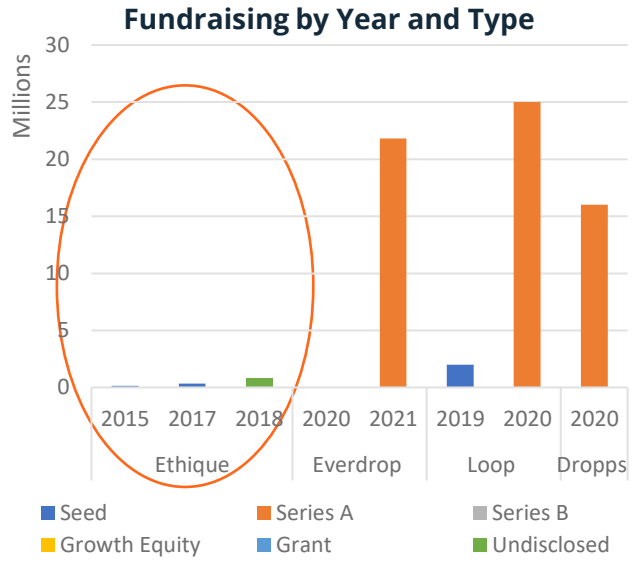
- Several European cities are now offering people a greener way to shop. Sara Wolf and Milena Glimbovski are about to open their first zero waste store Original Unverpackt in Berlin, Germany, which has received enormous public support and has raised over €100,000, exceeding its initial target of €45,000. [208]
- Zero Waste Europe is a Brussels-based NGO that connects and supports a vibrant network of 31 national and local NGOs promoting the zero-waste strategy as a way to make Europe more sustainable. [209] Local groups are responsible for promoting zero waste, managing and monitoring the network of zero waste municipalities, and engaging with companies and decision-makers.

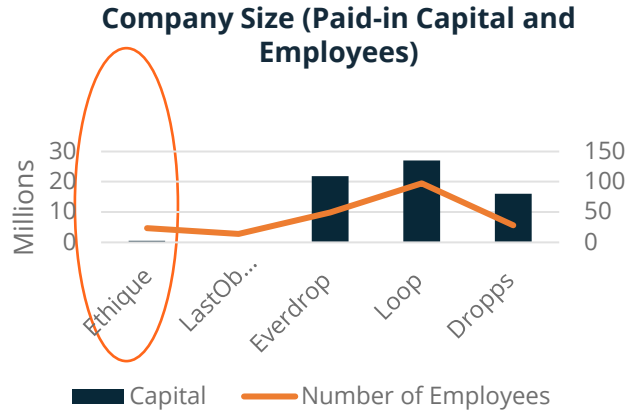
Innovators and Ecosystems: Zero-waste Products

Alignment w/ Strength

4

Ecosystem	ethique (Christchurch, New Zealand) Ethique is the world's first zero-waste beauty company	LastObject (Denmark) LastObject creates a reusable, sustainable and sanitary alternative to single-use items	everdrop (Germany) Develops cleaning product tablets, where customers reuse and add water at home to create liquid cleaning products	Loop (New Jersey, US) Developer of a low-waste shopping and delivery service with reusable packaging	dropps (Philadelphia, US) Developer of plastic-free detergent pods
Diversity in mgmt. / ownership	½ C-suite women	Woman founder, 1/5 C-suite women			2/3 C-suite women, 1/3 non-white
Grants					
Incubators / Accelerators		• Kisckstarter			
Angel Financing	• Ice Angels (IceHouse Ventures)				
Equity Financing	• Bansk Group LP • Equity Financing		• HV Capital, Vorwerk Ventures, Holtzbrinck Venture • Better Ventures, Felix Capital	• Nestle, Impact assets, Proctor and Gamble, Aptar • Suez Ventures, Sky Ocean Ventures, Quadia	• The Craftory, Ernesto Schmitt
Debt Financing					
Customers	• B2C – global through e-commerce	• B2C – EU, US, Canada AUS, NZ, China, Thailand	• B2C – EU through e-commerce	• B2C – US through major retailers (Walgreens, Kroger, Tesco)	• B2C – US through major retailers (Walgreens, Kroger, Tesco)
Partnerships		• Distribution through EU, US, Canada, AUS, NZ, China, Thailand		• SUEZ • McDonalds • Tesco • Kroger • Walgreens	
Talent Pipelines	• U. Canterbury • U. Auckland	• Copenhagen Business School • Technical U. of Denmark	• Munich U. of Applied Sciences • Technical U. of Munic	• McGill U. • ESSCA Ecole de management • Rutgers U.	
Emissions Reduction	Saved 9 million single-use plastic bottles (250+ tonnes of plastic). 7m litres of water saved. 1000+T carbon offset				2 million plastic bottles saved, carbon neutral shipping





Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Zero Waste Products

Ability to Lead

2/3

		New Zealand		Canada		United States		United Kingdom	
	Overview		• March 2021, announced plans to add a levy for plastic packaging, thus disincentivizing the use of plastics [210].		• Majority of innovation in business models, multiple bricks and mortar zero waste stored in Canadian Cities where environmental awareness is high.		• US has strong history of facilitating reverse logistics, as needed with refill and reuse business models, with its bottle bill in 11 states [210]. However, the biggest plastic waste producer in the world [213].		• Bans on single use plastic and a strong cleantech ecosystem to address plastic waste positions the United Kingdom as a leader in this sector.
35%	**R&D-to-commercialization pipeline strength**	2	• May 2019, a situational analysis report by the National Resource Recovery Taskforce (set up to consider options for New Zealand's resource recovery sector considering China's import restrictions on recycling) was released [211].	6	• Canada has spearheaded the international Ocean Plastics Charter, committed to a ban single-use plastics by 2021, collaborated with the Canadian Council of Minister of the Environment (CCME), an organisation comprised of 14 federal, provincial and territorial ministers of the environment, on a national Strategy on Zero Plastic Waste.	6	• US advantages with thriving cleantech ecosystem and research expertise in global trade and logistics.	6	• The UK Research Institute (UKRI) launched the sustainable packaging challenge to develop a more sustainable packaging supply chain. • However, Plans to implement deposit return scheme for plastic packaging and strong waste-to-energy industry, which may undermine zero waste models.
25%	**Financing strength**	2	• 4 deals worth a total of $1.2 million between 2011–2021. • Limited financing in this NZ, deals which have occurred are from local investors like Icehouse Ventures. • Majority of innovators providing zero-waste shopping via refill business models which can bootstrap.	5	• 28 deals worth a total of $283 million between 2011–2021. • Local investors are 50% of total investors for Innovators including the Government of Canada, Sustainable Development Technology Canada and BDC Canada.	9.5	• 238 deals worth a total of $4 bn between 2011–2021. • Majority of investments early stages seed to Series A	5	• 26 deals worth a total of $241 million between 2011–2021. • Range of deals in seed, Series A and Growth Equity.
40%	**Connection to demand**	4	• Local consortiums like Zero Waste New Zealand are facilitating partnerships with innovators via its partnership programme. Although majority of these partnerships are non-commercial.	2	• Partnerships with local accelerator programmes including EcoFuel.	7	• Partnerships with Ocean Focused Accelerator programmes concerned with reducing plastic waste e.g. Ocean Solutions Accelerator. • Other US accelerator programmes include Third Derivative and ABinBev's 100+ Accelerator.	7	• Innovators developing alternative materials in zero waste packaging have established long-term vendor partnerships with local food distributers e.g., Transcend Packaging have partnered with McDonalds UK to supply paper straws.
Evaluation		**2.8**		**4.2**		**7.3**		**6.2**	

Takeaways: Zero Waste Products

Takeaways for NZ Climate Tech Innovators

- Driven by action on plastic, particularly in relation to Ocean pollution.
- Regulatory element, The US, China and EU have all introduced regulations to enforce EPR or ban some single-use plastics.
- Consumer awareness of environmental and health impacts of plastics drives demand for plastic free products.
- Plastic has deep and long-lasting impacts on the environment. The Ocean Conservancy found over 60% of all seabirds and 100% of sea turtles had plastic in their bodies. With 40% of the global economy relying on biodiversity, plastic pollution is causing serious economic impact. In 2018, plastic pollution cost the APAC region $1.3 billion, impacting fishing, tourism and shipping industries.
- Alternative materials can have equally negative environmental impacts. For example, McDonalds came under scrutiny last year because its paper straws (supplied by Transcend Packaging) were not recyclable.
- Recycling as an option has also come under scrutiny for poor collection rate, number of recyclables sent to incineration and inefficient export markets.
- Not much innovation, mostly business model innovation like subscription-based models for FMCGs e.g. Deodorant.

Takeaways for NZ Climate Tech Ecosystem

- Natural value chain effects with bioplastics and sustainable production of underlying natural ingredients. Biggest challenge for the ecosystem will be on access to the major consumer goods incumbents (i.e. potential licensors and acquirors of technology) and global brand recognition.
    - Capabilities around inbound logistics (procurement, management of materials) and low-impact production can provide opportunities for innovators in this sector to expand backward in the value chain, acquiring sources of natural raw materials, or to developing standalone products (as Ethique has).
    - Strong export promotion push will be necessary given the size of the home market.

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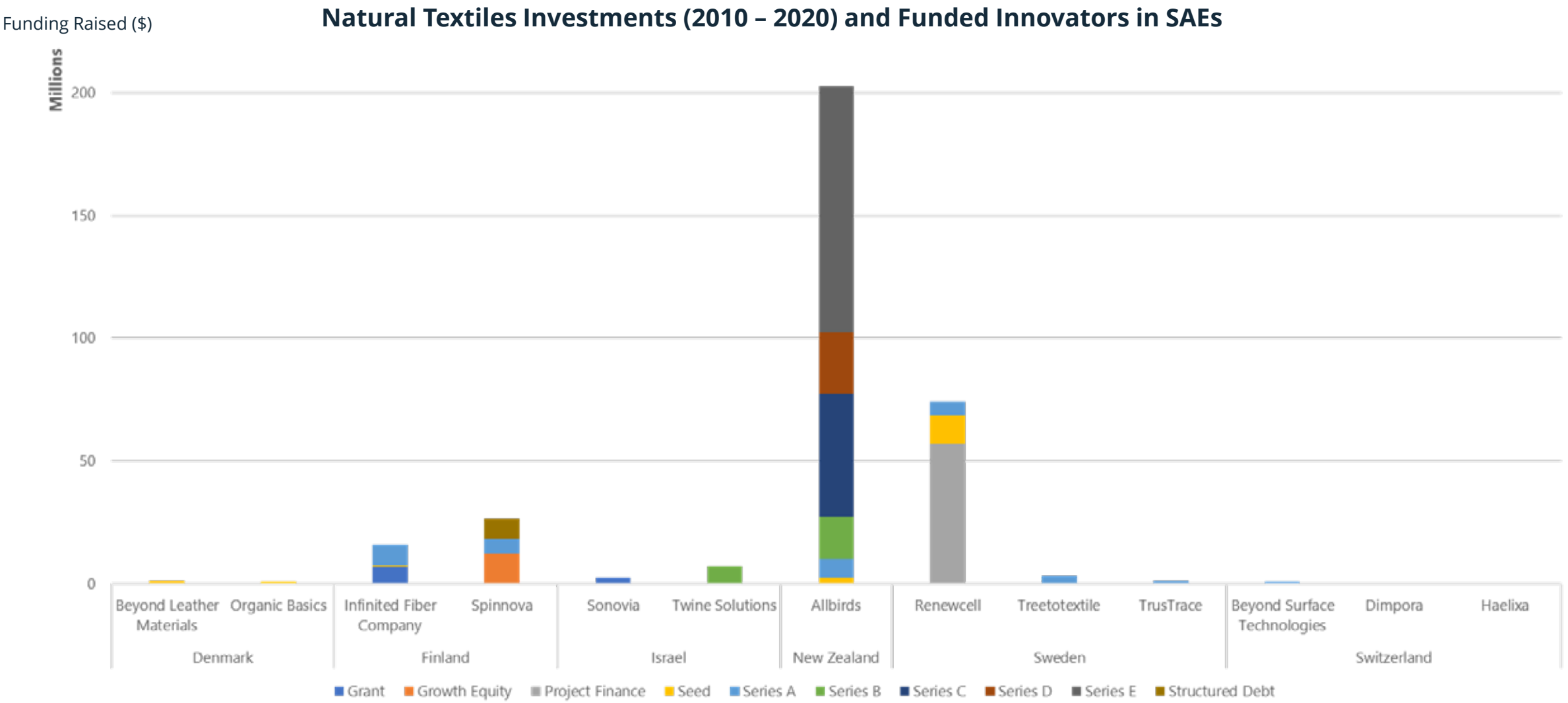
Overview – Investments into Natural Textiles in SAEs

Funding Raised ($)



Natural Textiles – Trend Analysis

External Potential	Timing of Trend
2	2

Summary

- **Description:** Textiles or accessories created with biodegradable fibers from sustainable and renewable sources, often replacing synthetic fibers created with polymers e.g., Polyester.
- **External potential:** The production of apparel doubled between 2000-2014, while the average number of garments purchased rose by 60% [26]. The ethical fashion industry has also risen and is expected to grow from $6,345.3 million in 2019 to $8,246.1 million in 2023 at a compound annual growth rate (CAGR) of 6.8% [214]
- **Timing:** The EU has plans to implement mandatory sorting and separate collections for EU 27 nations for textiles (by end 2024), Extended Producer Responsibility regulations will also force producers of textile waste to pay for these measures [30]. Global policies, like that proposed in the US[31], will likely lead to restrictions on synthetic fibres.
- **CO2 reduction potential:** It is estimated that about 63% of all textiles are derived from petrochemicals, all releasing a considerable amount of CO2 emissions [215].
- **Environmental impact reduction potential:** ~60% of garments contain plastic-based textiles, polyester, nylon and acrylic, these are non-biodegradable and cause micro-plastic pollution from washing. Some natural fibress can be very resource intensive, the worst offender, cotton, required almost double the water as growing vegetables.

Example innovators

Developer of a chemical recycling technology that turns cellulose-based raw materials, like cotton-rich textile waste, into new more sustainable textile fibres

(Finland)

Developer of plant-based textile alternatives including leather and recycled cotton

(Illinois, USA)

Key Clusters

Finland

- **October 2019:** Fortum, a Finnish energy company, and innovator, Spinnova have jointly developed a highly sustainable textile fibre using wheat straw.
- **October 2020:** Finland based The Infinited Fiber Company partnered with Alto University, Adidas, H&M and other commercial players to launch the New Cotton Project to demonstrate circularity with cotton across the value chain
- **November 2017:** The Infinited Fiber Company invited to ESO Fashion for Good's scaling programme.
- **June 2019:** Researchers from the Sustainability in Business research group in Aalto's Universities launched a new sustainable textile consortium called Finix, to rethink how we make, use and dispose of textiles.

United States

The US Environmental Protection Agency (EPA) estimated that the generation of textiles in 2018 was 17 million tons. This figure represents 5.8 percent of total MSW generation that year.

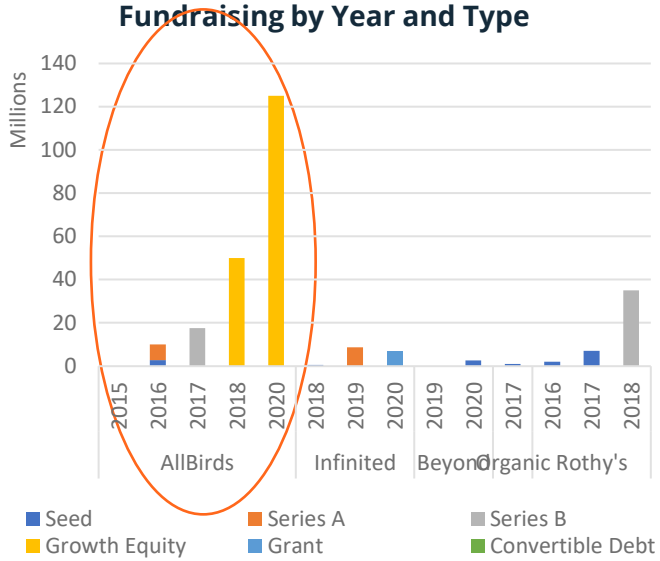
- **April 2018:** US-based Ecovative Design and Bolt Threads partnered with designer Stella McCartney to create a bag made from mushroom textile as a replacement for leather.
- **March 2021:** Algiknit, announced investment from ESO Fashion for Good and VC investor Horizon Ventures to further develop its Ocean Algae to bio-yarn technology.
- [Gov't / public-private research lab activity]

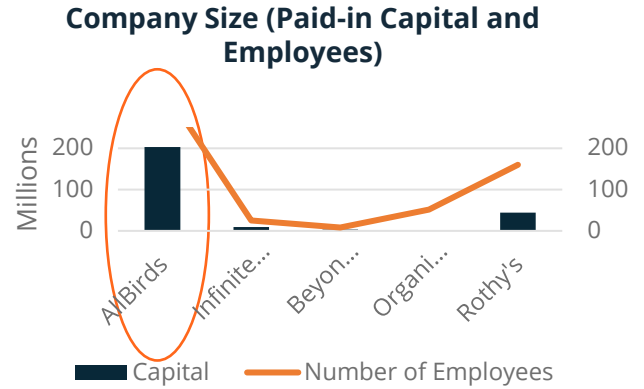
Innovators and Ecosystems: Natural Textiles

Alignment w/ Strength

4

Ecosystem	allbirds (New Zealand / San Francisco)	Infinited Fiber Company Espoo, Finland	BEYOND LEATHER MATERIALS Copenhagen, Denmark	organicbasics Copenhagen, Denmark	ROTHY'S San Francisco, US
	Allbirds: Developer and retailer of footwear made with natural materials like merino wool and eucalyptus fiber	Developer of a chemical recycling technology that turns cellulose-based raw materials, like cotton-rich textile waste, into new more sustainable textile fibers	Producer of plant-based and alternatives to animal leather based on waste fruit	Manufacturer and retailer of essentials clothing made with recycled materials and organic cotton	Developer and retailer of shoes, handbags and accessories made from recycled plastic.
Diversity in mgmt. / ownership	2/3 C-suite women	1 / 4 C-suite women	1 /2 C-suite women		3/6 C-suite women
Grants		• European Commission • Business Finland			
Incubators / Accelerators			• Rockstart Accelerator		
Angel Financing			• Steen Ulf Jensen		
Equity Financing	T. Rowe Price, Bailie Gifford, TDM Growth Partners, Rockefeller Capital, Franklin Templeton, Fidelity Management , IPD Capital, Tiger Global Management	• EU Executive Agency for SME's, Virata Crop, H&M, RGE, • Business Finland, Fortum, Valve Ventures	• Jensengroup • Vaekstfonden	• Bumble Ventures • Nordic Eye	• Goldman Sachs Investment Partners, Brian Spaly • Lightspeed Venture Partners, M13, Finn Capital Partners, Grace Beauty Capital
Debt Financing					
Customers	• B2C – NZ, US, EU, China	• Piloting with potential future customers (below)		• B2C – global through e-commerce	• B2C – SF, Boston, DC, NY, LA
Partnerships	• Chinatown Market, World Central Kitchen, JUST • Jeff Staple, Air New Zealand, Shake Shack	• Adidas, H&M, RGE • Fashion for Good, VTT Technical Research Centre of Finland			
Talent Pipelines	• U. California Berkeley • San Francisco State • U. Auckland • Stanford			• Aarhus University • Copenhagen Business School	• San Francisco State U. • U. California Berkeley
Emissions Reduction	Using sheep's wool, Allbirds' process uses 60% less energy than materials used in typical synthetic shoes.	Gives viscose factories a new fiber and a safer process by getting rid of Carbon Disulfide (CS2).	Eco friendly. Claims to reduce CO2 emissions by 85% using zero harmful chemicals.		Transformed 100 million plastic water bottles and kept 100 tons of ocean bound marine plastics out of waterways





Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Natural Textiles

Ability to Lead

2/3

		New Zealand		Sweden		Finland		Switzerland	
	Overview	• New Zealand leads the world in the production of Wool exporting more wool than any other nation except for Australia [220].		• Sweden has a long history in natural textile, in December 2020 Sweden passed Extended Producer Responsibility regulations for textiles [221].		• Strong forestry industry enables stable feedstocks of cellulose fibers for natural textiles. Finland has a history of making the majority of fabrics domestically.		• Switzerland has a thriving textile manufacturing equipment industry. However, most textile production occurs outside of Switzerland.	
35%	**R&D-to-commercialization pipeline strength**	**2**	• Research expertise in textile construction, fibre and new material development at Massey University. • The University of Otago, the top 1% ranked university in the world, has a leading Centre for Material Science and Technology.	**5**	• The Swedish Energy Authority's RE:Source Innovation programme supports the research and development of innovations of resource efficient textiles including innovator Re:newcell.	**4**	• The VTT Technical Research Centre of Finland and Aalto University has several natural textile innovation projects under development.	**2**	• The International Textile Manufacturers Federation supports research and innovation with incumbents. • Research expertise is lacking in this area.
25%	**Financing strength**	**8**	• 5 deals worth a total of $202 m between 2011–2021. • External VC investors from the US and UK.	**5**	• 13 deals worth a total of $86 million between 2011–2021. • Range of deals in Sweden from Early to later stages. • Local corporate investors and corporates including IKEA and H&M.	**3**	• 10 deals worth a total of $42 million between 2011–2021. • Local investors include Business Finland and European Inv Business Finland • The European Commission including the EU Executive Agency for SMEs are key investors.	**1**	• 5 deals worth a total of $1.4 m between 2011–2021. • Majority early-stage investments Grant to Series A • Key investors include apparel incumbents, H&M and Patagonia. • Local climate funds include Technology Fund.
40%	**Connection to demand**	**4**	• The Textile Product Stewardship Project sits within the Textile Reuse programme which was established in 2016. The partnership programme drives large scale, collaborative projects creating new technologies and solutions [222].	**6**	• Partnerships with local chemical and materials players are providing project finance for commercial scale plants e.g. TreeToTextile partnership with Stora Enso in February 2021. • Accelerator programmes in Europe include Fashion for Good and H&M Global Change Awards.	**5**	• Project development partnerships with large apparel corporates including Adidas and H&M. • Beneficiaries of accelerator programmes in Europe include Fashion for Good and H&M Global Change Awards.	**6**	• Local accelerator programmes include the Circular Economy Transition. • The Federal Office for the Environment, programme for Sustainable Textiles Switzerland 2030 as a as a multi-stakeholder dialogue to support sustainable textile development.
Evaluation		**4.3**		**5.4**		**4.2**		**3.4**	

Takeaways: Natural Textiles

Takeaways for NZ Climate Tech Innovators

- Clothing consumption is rising. Due to economies of scale, globalization, supply chain efficiencies and increased consumer spending on apparel, production doubled between 2000-2014, while the average number of garments purchased rose by 60%.
- Key driver is action on plastics, ~ 60% of garments contain plastic-based textiles, polyester, nylon and acrylic. These are non-biodegradable and cause micro-plastic pollution from washing,
- Another key driver is consumer demand due to increased awareness of environmental impact of traditional fabrics.
- Natural fibers need to be resource efficient. Over 75% of garments made have some element of cotton, which is land- and resource intensive, depletes soils and causes leaching from the heavy use of pesticides and fertilizers. Land use change for cotton is a significant contributor to habitat loss across the world.
- Brands are big investors in this space looking to create secure supplies of more sustainable materials e.g.. Renewcell & H&M. However, brands are not used to investing high cap-ex in new systems like chemical recycling infrastructure.
- Functionality is a key concern for brands, new materials need to perform the same if not better than synthetics.
- Majority of brands are not acting on fast fashion.

Takeaways for NZ Climate Tech Ecosystem

- NZ is the 4th largest producer of wool globally, with an existing success case in wool textile products. The ecosystem should push for synergies with the agricultural and even robotics industries to develop novel production techniques and develop capabilities around turning wool into new products, not just supplying wool.
- There is no clear winning innovation ecosystem, the critical relationships are with brands and retailers, most of which will reside overseas. Promoting NZ textile innovators to global accelerators, e.g. Factory45 (global, online), Fashion for Good (Netherlands), Plug-n-Play Sustainable Brands (US)

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Appendix 4
Transport & Logistics

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Transport & Logistics – Comparison between Small Advanced Economies (SAEs)

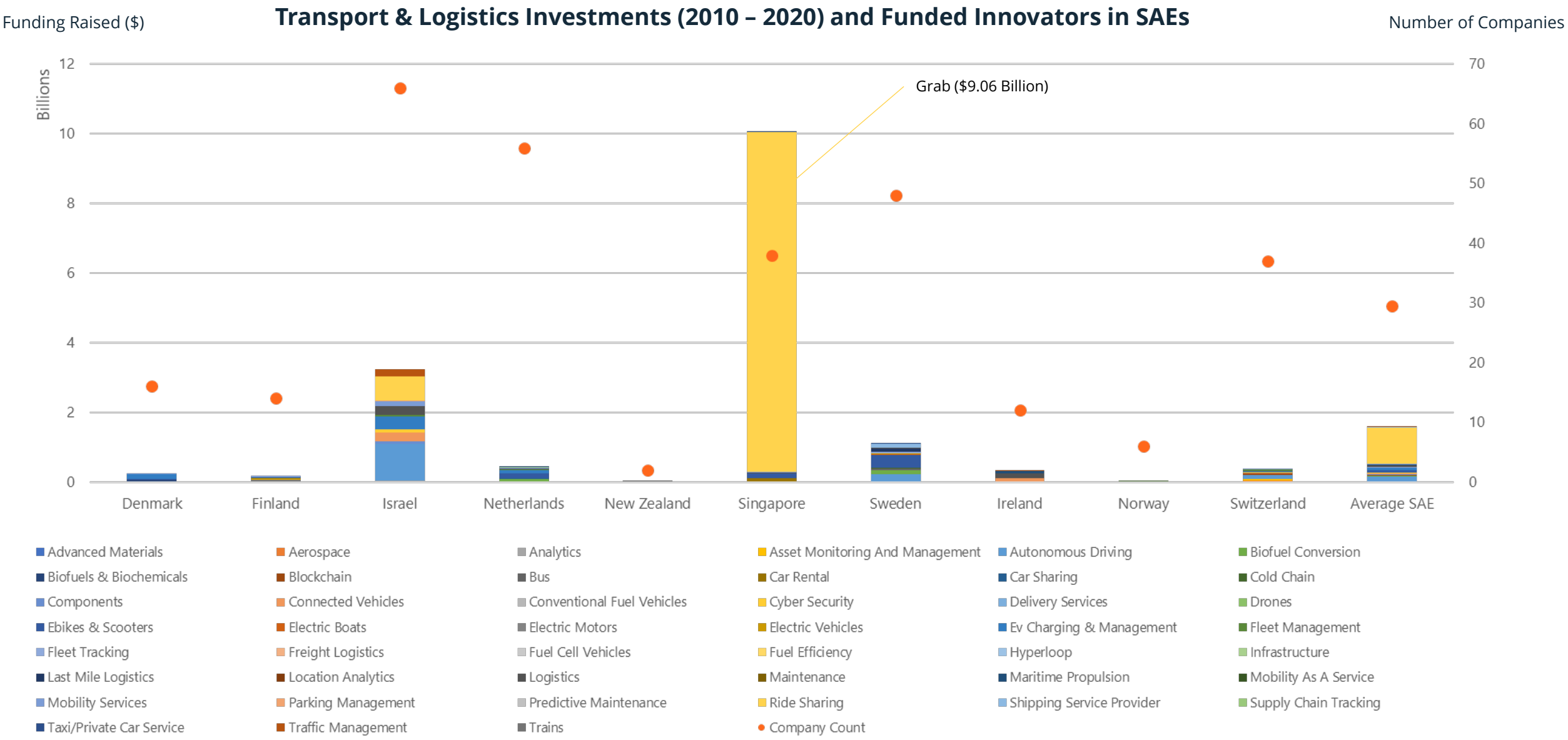
Transport & Logistics Analysis

EV charging and management

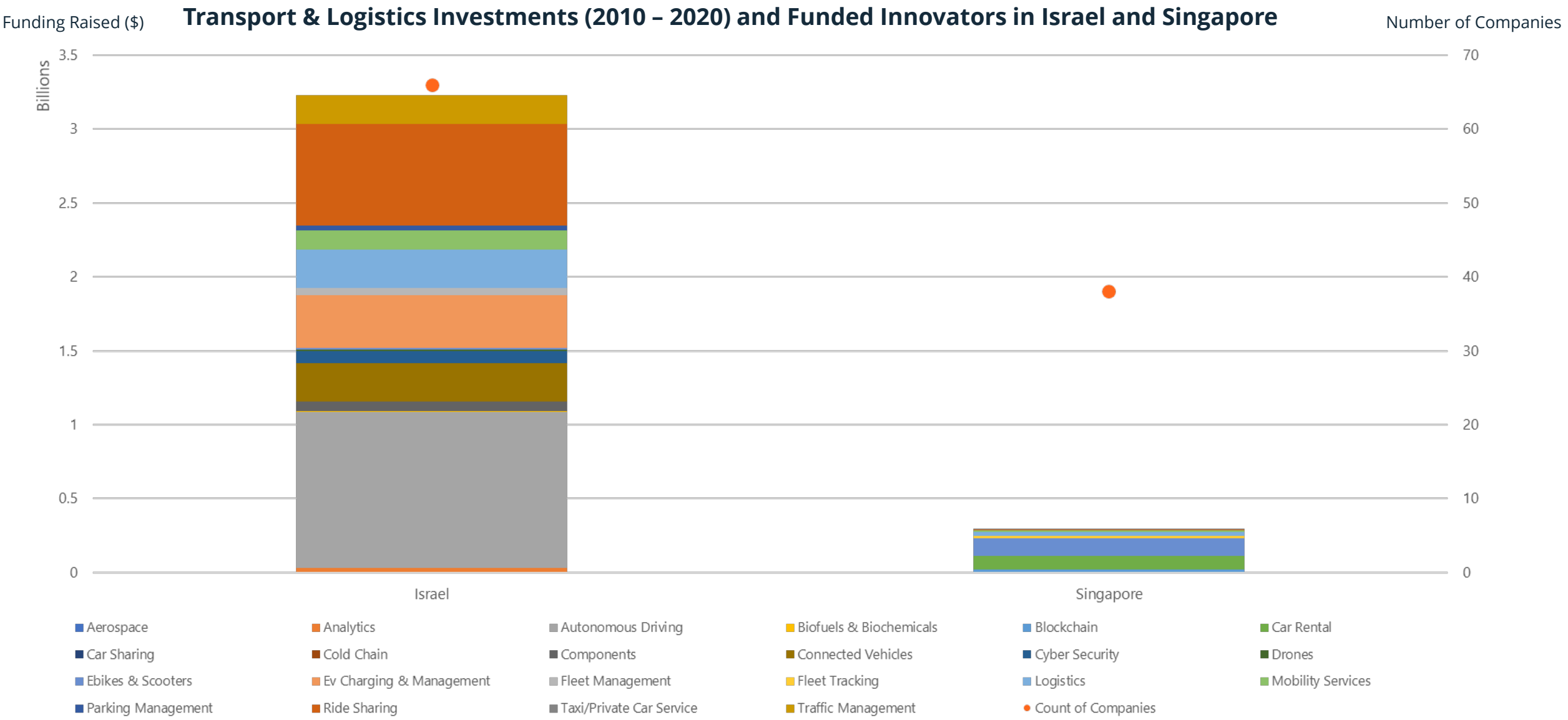
Aerospace propulsion modules

Maritime electrification

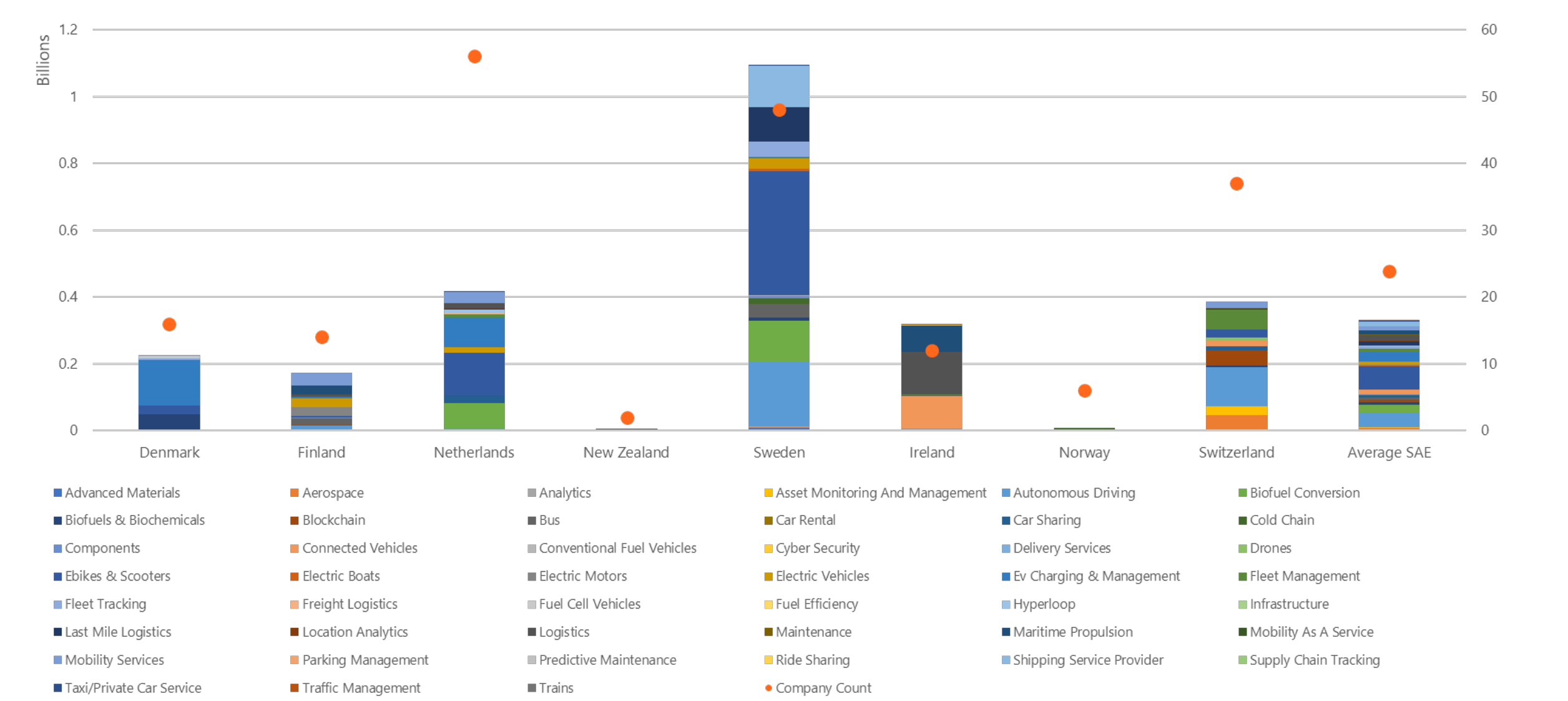
Overview – Transport & Logistics Innovation in Small Advanced Economies (SAEs)



Transport & Logistics Innovation in Israel and Singapore



Transport & Logistics Innovation in SAEs (Excluding Israel and Singapore)



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Transport & Logistics Analysis

- **EV charging and management**
- Aerospace propulsion modules
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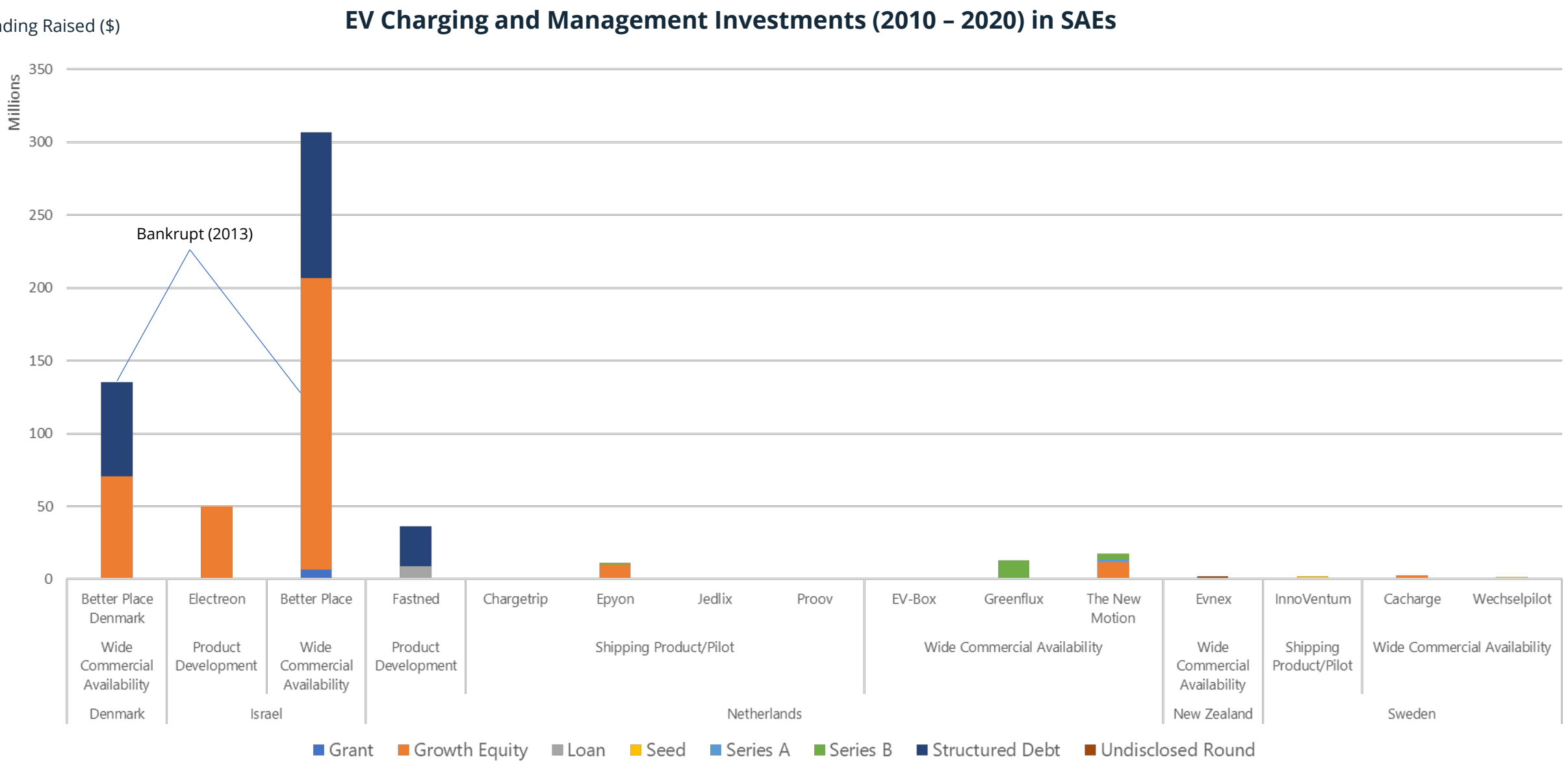
EV Charging and Management in SAEs

Funding Raised ($)



EV charging and management – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** Software platforms used to develop and deploy EV charging products and services. Customers include energy providers; technology companies and charge point operators. Technology stack includes hardware, connectivity services, software platform and APIs to integrate functionality and develop custom branded applications. Other services include pricing and billing.
- **External potential:** Global electric vehicle charging stations market size was valued at $39.7 billion in 2019 and is expected to reach $100 billion by 2027. Residential segment accounts for most of the market share of EV chargers and this will continue in the coming years, driven by growing individually-owned passenger EV sales. The commercial segment will also see significant growth, driven by increasing government funding for public charging station development[244].
- **Timing:** 17 countries have announced 100% zero-emission vehicle targets or a phase-out of internal combustion vehicles through 2050[2]. The market is young but maturing quickly as EV charging station rollout accelerates to help meet these targets. The sector has seen multiple acquisitions and IPOs/SPACs in recent years.
- **CO2 reduction potential:** With 80% EV adoption and 80% grid decarbonization, 2050 vehicle emissions can be reduced to 20% of 1990 levels[245]

Example innovators

evconnect

Developer of a flexible cloud-based platform for managing electric vehicle charging.

Southern California, US

ev.energy

Provider of software to manage EV charging.

London, UK

Key Clusters

California, US

- Utilities - SCE Charge Ready programme, PG&E EV2-A and EV-B rate plans and SDG&E Power Your Drive.
- UC Davis Plug-in Hybrid & Electric Vehicle Research centre – Launched with support of California Energy Commission funding to work with industry stakeholders and help develop a sustainable market for electric vehicles.
- Supporting incubators/accelerators - Elemental Excelerator, Plug and Play, Los Angeles Cleantech Incubator, Cleantech Open, Y Combinator, Cyclotron Road, Activate. Other supporting entities - Electric Power Research Institute (EPRI)/Incubatenergy Labs, California Mobility centre.
- California Energy Commission (CEC) - targeting $384 million over the next three years for EV charging infrastructure. NREL partnership with CEC to conduct research. California Public Utilities Commission (CPUC) - develops policies to support the development of zero-emission vehicles and works with utilities. Environment California - Research and Policy centre.

UK

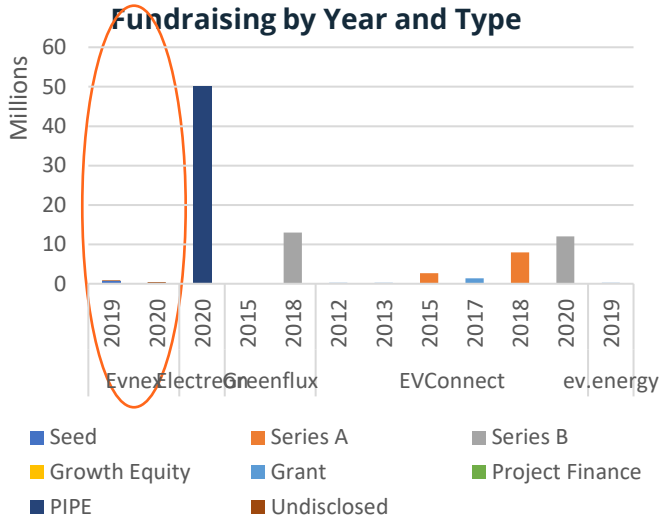
- EDF Energy - provides home charging points, EV tariffs, EV leasing, partnership with Pod Point. BP – operates EV charging network, acquired Chargemaster.
- University of Hertfordshire (EValu8 Transport Innovations), The University of Warwick, The University of Sussex (eCharge4Drivers) and Cardiff University (The Electric Vehicle Centre of Excellence).
- Supporting incubators/accelerators - Future Mobility Incubator, Carbon Limiting Technologies Incubator.
- UK to ban sales of petrol and diesel cars by 2030. Innovate UK – provides grant funding. UK Government Road to Zero Strategy.

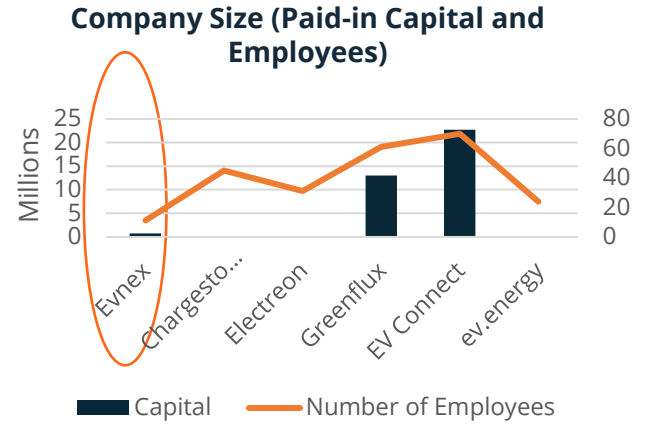
Innovators and Ecosystems: EV charging and management

Alignment w/ Strength

2

Ecosystem	EVNEX	chargestorm / CTEK	ELECTREON	GreenFlux	evconnect	ev.energy
HQ	Christchurch, NZ	Sweden	Israel	Netherlands	California, US	UK
Diversity in mgmt. / ownership						
Grants	Vodafone Xone				New York State Energy Research and Development Authority	Innovate UK
Incubators / Accelerators	• Vodafone Xone				• Plug and Play Tech Accelerator	• The Future Mobility Incubator, Incubatenergy, Free Electrons • Microsoft AI For Good, Entrepreneur First
Angel Financing	• Angel HQ • Canterbury Angel Investors • Enterprise Angels					
Equity Financing		• Altor Equity Partners	• Afcon Holdings • Migdal • Halman Aldubi	• Eneco Group • SET Ventures, BOM Brabant Ventures, ICT Group		
Debt Financing		• EQT Partners				
Customers	• Vector, Openloop, Parkable, Singer Electrical	• Equipment and battery retailers in USA and Europe		• Offers commercial and residential solutions to EV charging management	• Yahoo, New York Power Authority, Audi, Marriot, Verizon	
Partnerships		• EVC, Vattenfall, Cadez Electronics	• A35 Toll Road (Italy) • Eurovia • EnBW • Tel Aviv-Yafo Municipality	• Eneco, Smappee, Gireve • ICT Netheralnds	• FreeWire Technologies, Hilton, Current, Kore Telematics	• American Electric Power, Silicon Valley Clean Energy, VW/Elli +3 • National Grid, EDF Energy, UK Power Networks, Igloo Energy +2
Talent Pipelines		• Dalarna University, Uppsala University, Linkoping University	• Tel Aviv University • Ben-Gurion U. of Negev • Technion	• University of Amsterdam, University of Groningen	• UCLA, • Arizona State University,	
Emissions Reduction						





Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: EV charging and management

Ability to Lead

1

		New Zealand		Israel		Sweden		California, US	
	Overview	• Historical proficiencies in charging research, lack of automotive industry and low penetration of EVs domestically makes for a weak demand pull.		• Key proficiencies in chemical and electrical engineering. Government dedication to "smart roads" with built-in charging capabilities.		• Strong proficiency in energy storage for EVs (e.g. Northvolt), spillover effects beginning but not yet emergent in mainstream innovation.		• Innovation at every level of the value chain – battery systems (Proterra), vehicle production (Proterra – buses), system management (Chargepoint, Driivz, EVConnect).	
35%	**R&D-to-commercialization pipeline strength**	**6**	• U. Auckland has a history of successfully developing wireless charging IP – Qualcomm acquired Inductive Power Technology and Halo IPT in 2015.[250] • U. Auckland undertaking research into inductive power tech and EV infrastructure.[251]	**7**	• Research into energy storage and EV batteries has produced competitive start-ups (e.g. Phinergy, StoreDots), learnings and talents spilling over. • Research into both electric road technology and policy being undertaken at local universities.[247]	**5**	• Uppsala University has an Electric Transport Group applying Swedish proficiency and know-how in energy storage to the built and urban environment. [248] • Uppsala research partnership with Vatenfall and China Euro Vehicle for smart EV charging.[249]	**9**	• Deep research into the cutting edge of EV charging, e.g. current Stanford research into wireless charging (published 2020) • Arpa-E collaboration with UC Berkeley on bi-directional charging • Studies on charging behavior at UC Berkeley
25%	**Financing strength**	**1**	• 3 deals for $1.85 m 2011 – 2021 • Financing available primarily through grant agencies (e.g. Callaghan Innovation) and angel networks (e.g. Enterprise Angels) • No observable participation from international or corporate funds.	**5**	• 5 deals for $830 m 2011 – 2021 • Bankruptcy of Better Place in 2013 still deters investors from the sector to a degree.[35] • Large growth equity rounds can be raised, but require large teams of co-investors (e.g. Electreon).	**2**	• 6 deals for $5.73 m 2011 – 2021 • Swedish EV charging companies accessing grants from EU entities such as EIT Innoenergy. • Companies turning mostly to angel investors for financing in this sector, little VC and corporate involvement	**10**	• 53 deals for $1.7 b 2011 – 2021 • Heavy participation from automotive CVCs – BMW i-Ventures, Daimler, etc. • Heavy participation from large global funds – Soros Capital, Canada Pension Plan, Braemar Energy Ventures
40%	**Connection to demand**	**2**	• Some local corporate partnership with overseas innovators – Vector electric / gas partnered with Chargetrip (NL) in 2019. • A key challenge is that NZ does not have a local automotive industry. • Low EV penetration creates weak demand from consumers for charging infrastructure.	**5**	• The "smart road" angle of Israeli innovators is very niche, but is gaining strong support in the home market, likely softening costs to deployment in the future. Some overseas parties are gaining interest in the sector, e.g. Electreon's multiple projects developing in Europe.	**3**	• Examples exist of local corporate engagement with innovators from outside of the country (e.g. Scania – Evbox, Vatenfall Connected Kerb), few local collaboration examples. • Engagement by local municipalities and companies with micro-DER companies, which could be plugged into charging infrastructure.	**10**	• High EV penetration in California creates a local demand pull. Automotive corporates (e.g. Tesla – Fastned, Uber – Ample), heavy vehicle producers (Freightliner Custom Chassis Corporation – Proterra) and industry associations (e.g. National Association of Trucks Stop Owners – Chargepoint) are partnering with innovators.
Evaluation		**3.2**		**5.7**		**3.5**		**9.7**	

Takeaways: EV charging and management

Takeaways for NZ Climate Tech Innovators

- Innovators should look to connections with corporates overseas to ensure that products are future-proof. Innovators should pursue acceleration and piloting opportunities overseas, in areas where EV penetration is high, to develop real-life capabilities around serving markets with high EV ownership.
- Strategic investors (auto makers, power companies, battery companies) are critical to accessing growth financing in EV charging and management, innovators should pursue opportunities where they exist (likely overseas) to ensure that technology can, in theory, clear standards for strategic investors once EV uptake begins in earnest in NZ.
- Where possible, consider what the next gen will be – Israel is a good case study in innovators leapfrogging the current technological convention to innovate for tomorrow's EV charging environment (wireless and "smart road") charging.

Takeaways for NZ Climate Tech Ecosystem

- Ministry of Transport has indicated that around 1.2 million EVs could enter the national fleet by 2034/35. For NZ companies to own the charging, management, and infrastructure markets, it is likely that the ecosystem will need to form comprehensive value chain partnerships that maximize customization to local market conditions and incentivize auto makers to use local networks versus importing their existing partners from overseas.
- The research base can support experimentation to drive down cost of technology commercialization. Innovators that can create cost-effective solutions can play a critical role in making uptake of EVs affordable for consumers.
- Feedback loops need to be established between NZ innovators, battery companies, battery recycling companies, and auto makers to ensure that NZ innovators are able to innovate *for where the market is going* and don't wait for the market to pick up in NZ to get started. Foreign competitors will be too strong and cheap by 2035.

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- Maritime electrification

Aerospace propulsion modules – Trend Analysis

External Potential	Timing of Trend
3	4

Summary

- **Description:** Sustainable propulsion modules for small low orbit satellites.
- **External potential:** Global space propulsion market is $6.7 billion in 2020, projected to grow to $14.2 billion by 2025[252]. Global small satellite market size was $3.07 billion in 2019 and is projected to reach $9.75 billion by 2027. Nano satellites held the largest share of the market in 2019 (market segmented by nano, micro and mini). Growth is driven by increasing R&D activity and rising number of space laboratories for planned missions to asteroids, the moon and mars. Mini satellite segment is estimated to experience significant growth due to increasing use for earth observation; micro segment will witness moderate growth due to rising use of CubeSat for space research and scientific applications. Communications application is predicted to witness highest CAGR through 2027 due to increasing adoption of communication antennas in government and commercial sectors[253].
- **Timing:** Industry is driven by federal initiatives and subsidies. As per International Space Law, every state must register their space objects with the international registry. Five United Nations Treaties on outer space (Outer Space Treaty, Rescue Agreement, Liability Convention, Registration Convention, Moon Agreement)[2]. Many upcoming launches delayed due to the Covid-19 pandemic. Industry also faced a slight decline from 2018 to 2019, but number of space launches expected to steadily increase after 2021[252].

Example innovators

ROCKET LAB

Developer of a range of rocket launch systems and technologies for small satellites.

(New Zealand / Los Angeles, US)

BELLATRIX AEROSPACE

Developer of propulsion systems for satellites specifically water-based propulsion systems.

(Bangalore, India)

Key Clusters

United States

- Spire Global - locations in DC, San Francisco and Boulder. SpaceX – private satellite launch, partnership with NASA. Boeing HorizonX – investor and partner. Spin Global, Spaceflight and General Atomics are active as customers to startups.
- Universities with strong aerospace research programmes include MIT, Embry Riddle Aeronautical University, University of North Dakota and Texas A&M.
- Active investors and incubators/accelerators include AeroInnovate, BoomStartup, Iowa Startup Accelerator, NASA Frontier Development Lab, NASA Research Park Ames Research centre, Light Speed Innovations, Khosla Ventures and Space Angels Network.
- NASA, U.S. Department of Energy and U.S. Army are active in research, funding and development support.

India

- Indian Institute of Technology (IIT) Madras Incubation Cell – research and startup incubation
- Artha Venture Fund – investments in aerospace and spacetech. Speciale Invest – venture fund with investments in spacetech. CIIE.Co – government-backed incubator and centre of excellence.
- Indian Space Research organisation – government-run space agency, maintains one of the largest fleets of communication satellites and remote sensing satellites.

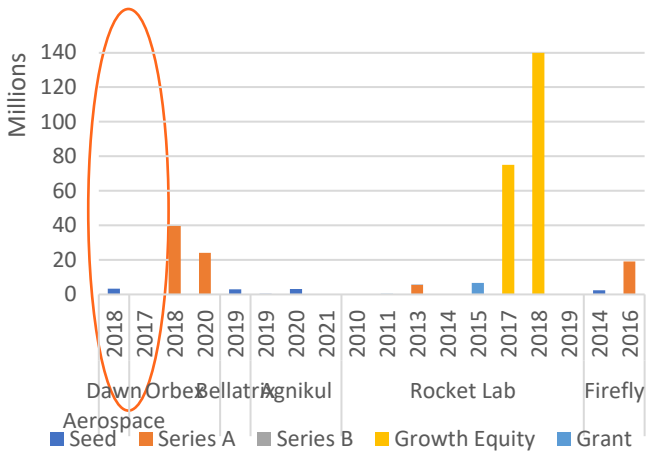
Innovators and Ecosystems: Aerospace propulsion modules

Alignment w/ Strength

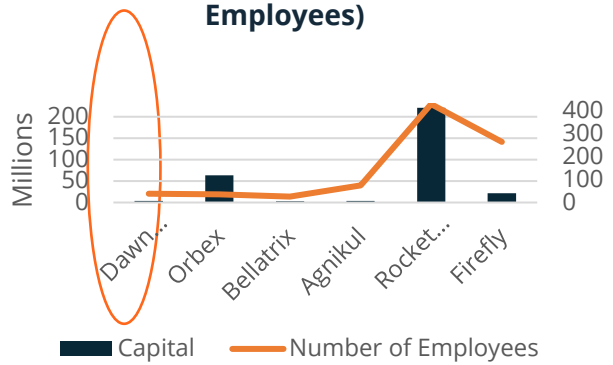
2

Ecosystem	DAWN AEROSPACE	ROCKET LAB	BELLATRIX AEROSPACE	AGNIKUL	ORBEX	FIREFLY AEROSPACE
HQ	Christchurch, NZ	NZ / CA, USA	Bangalore, India	Chennai, India	UK	TX, USA
Diversity in mgmt. / ownership						
Grants	• Callaghan Innovation	• Callaghan Innovation • NASA			• EASME, Horizon 2020 • UK Space Agency	
Incubators / Accelerators	• YES!Delft • Callaghan Innovation		• CIIE.CO, SINE	• Airbus Bizlab Accelerator • IIT Madras Incubator, CIIE.CO		
Angel Financing				• Anand Mahindra		• Dylan Taylor, SeedInvest
Equity Financing	• InnovationQuarter • Icehouse Ventures, Aera VC, Tuhua Fund, New Zealand Ministry of Business, Innovation and Employment		• First Cheque, groX Ventures, KA Enterprises, StartupXseed Ventures, IDFC-Parampara Fund, Karsemven Fund, Suryam Partners	• Globevestor, LetsVenture, LionRock Capital • Speciale Invest, Pi Ventures, Artha India Ventures	• High-Tech Grunderfonds, ELECNOR, Heartcore Capital • BGF Ventures, Octopus Ventures	• SK Ventures, Tank Stream Ventures
Debt Financing						
Customers	• European Space Agency, HOSTmi, Arianespace, Hiber, US Airforce	• OHB Group, Synspective • Astro Digital, Rideshare, Capella Space, DARPA				• NASA, General Atomics, Spaceflight Industries, Spire Global, Geometric Space Corporation
Partnerships	• Orbital Transports, SpaceX • Oamaru Airport, Waitaki District Council, TriasRnD		• Skyroot Aerospace, SatSure	• Leaf Space, HOSTmi • Indian Space Research organisation	• Highlands, Island Enterprise, Calor	• Exoluanch, Satlantis, Isilaunch Israel Aerospace Industries, Airbus Defense • NASA
Talent Pipelines	• Delft University of Technology			• Indian Institute of Technology, Madras, Anna University, Madras Institute of Technology	• NASA, European Space Agency	• Texas A&M, Texas Tech, University of Texas at Austin
Emissions Reduction						

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Aerospace propulsion modules

Ability to Lead

2

		New Zealand		India		US		UK	
	Overview	• Multiple successful innovators (Rocket Lab, Dawn Aerospace) with international presence. Unique geographic position for orbital launches.		• Still emerging, India recently drafted the Spacecom Policy which is expected to open up its space sector to private companies and foreign investors.		• Beyond the gravitational demand pull of NASA, a competitive and dynamic private sector has emerged with companies like SpaceX, Blue Origin, and Rocket Lab		• Private space industry growing with government designation of 3 commercial spaceports 2014-2020. Leadership in innovation by Virgin Orbit, Orbex, Skyrora.	
35%	**R&D-to-commercialization pipeline strength**	**7.5**	• Aerospace research at U. Auckland and U. Canterbury • High-performing NZ students are being supported for participation in NASA internships. • Companies spinning out of universities – e.g. Kea Aerospace – U. Canterbury,	**4**	• Indian innovation in non-propulsion space technologies (satellites, imaging, robotics), is increasing and will likely be the primary space sector, potentially generating spillovers.	**10**	• Top global aerospace universities (Stanford, MIT, Georgia Tech, U. Michigan) building large talent pools. • Significant grants available from supporting / buying bodies – NASA, DARPA	**8**	• Aerospace research happening at UK universities and through research consortiums. • History of aviation and aerospace industry domestically, although producers have noted a degradation in local supply chain competitiveness. [256]
25%	**Financing strength**	**6.5**	• $4.7 million invested through 5 deals 2011 – 2021[47] • Heavyweight angel investors supporting early-stage innovation (Mark Rocket, Michael Fay – Rocket Lab) • Rocket Lab successfully accessed critical grants (e.g. NASA) and financing from blue chip investors	**5**	• $10.5 m invested through 7 deals 2011 – 2021[255] • Financing coming mostly in small amounts from large groups of local investors. Mix of angel groups and seed funds. • Start-ups accessing global corporate accelerators (e.g. Manatsu – Shell E4)	**10**	• $2.4 b invested through 117 deals 2011 – 2021 • Blue chip tech investors (Sequoia, Lighthouse, Lightspeed, Morgan Stanley Alternative Investments) investing in propulsion	**8**	• $196.6 m invested through 18 deals 2011-2021 • Access to financing from the UK Space Agency and EU Horizon 2020 programmes. • Early stage and growth stage equity financing from both local and foreign investors.
40%	**Connection to demand**	**6**	• NZ will not be the demand owner for this sector but has demonstrated ability to bring innovators to key demand owners. • Presence of small aircraft manufacturers in-country, e.g. Pacific Aerospace.	**5**	• First deals with Indian Space Research organisation and innovators for piloting / test (Pixxel) provide optimism for innovators' potential to participate in the space.	**9**	• Proximity to NASA and US Military are important for accessing demand pull. • Presence of large aerospace and defense firms places critical buyers and supply chain in the US – Boeing, GE Aviation, General Dynamics, Lockheed Martin, Northrop Grumman, United Technologies Corporation	**8**	• Active partnership ecosystem, with UK aerospace, defense, and commercial jet companies partnering with innovators, although with more noticeable partnerships with overseas innovators. • UK Innovators being contracted for launch missions by both local (e.g. In-Space Missions – Orbex) and global clients (e.g. TriSept – Orbex)
Evaluation		**6.7**		**4.7**		**9.6**		**8**	

Takeaways: Aerospace propulsion modules

Takeaways for NZ Climate Tech Innovators

- Larger markets (US and UK) are receptive to working with overseas innovators pursuing partnerships, acceleration, and financing opportunities. Larger markets can also facilitate more exposure to resources and understanding of key demand owners' priorities.
- Accessing industry insiders (who have connections, experience at potential partners and customers) will require some overseas presence – Rocket Lab has successfully recruited former US Military, SpaceX talent, and graduates of Harvard, MIT, Stanford, etc., through their production operations in the US.

Takeaways for NZ Climate Tech Ecosystem

- "Market" for aerospace propulsion modules is going to be with large space exploration agencies and companies that deliver satellites into space. NZ has successfully bridged two companies into those markets, continuing this success will require ensuring access to pilot and joint R&D opportunities early in the technology development lifecycle of companies.
    - The market size as currently understood likely does not fully capture the potential for growth in coming years – between 2009 and 2019 2,298 satellites were launched, whereas just less than 10,000 are predicted to be launched between 2019 and 2028.[257, 258]
    - The market size is also potentially underestimated in that the space tourism industry has not yet emerged. In theory, orbital launches may increase by an order of magnitude in the coming years.
- Testing is possible on the Banks Peninsula due to its conditions for Sun-synchronous orbital (satellite passes over any given point of the planet's surface at the same local mean solar time) launch.[45] Rocket Lab has carried out multiple launches from a site there and was constructing new pads as of 2020. The ability for physical tests to be carried out in NZ is an advantage that can be exploited not only for continued testing of entrepreneurial solutions but development of local clusters.

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Maritime electrification – Trend Analysis

External Potential	Timing of Trend
2	2

Summary

- **Description:** Zero-emission propulsion systems based on battery electric drives. Segment includes small boats and tenders.
- **External potential:** Market for hybrid and pure electric boats and ships is projected to grow to >$20 billion globally by 2027[259]. Recreational boats is largest and fastest growing subsegment (by sales), followed by underwater leisure and autonomous underwater vessels. By value, on-water commercial is largest market. Leisure vessels on inland water waterways (particularly in Europe and the U.S.) will become largest sector, driven by regulations and voluntary commitments by operators. Ideal application is small to medium craft.
- **Timing:** Early market activity in areas large amount of water transport, especially with presence of ambitious climate initiatives (Northern Europe, Singapore, Washington State).
- **CO2 reduction potential:** In the period 2007-2012, shipping emitted 1,000 Mt CO2 per year (3.1% of annual global emissions). If other sectors reduce emissions to keep global temperature increase below 2 degrees Celsius, shipping could represent 10% of global GHG emissions by 2050[2]. A single 5 HP four-stroke engine has the same emissions impact as 38 cars[3]. Outboards do not have comparable emissions reduction technologies as cars, such as exhaust gas reticulation and catalytic converters, making the level of nitrogen oxide and hydrocarbon emissions dramatically higher.
- **Environmental impact reduction potential:** No pollutants (e.g. NOx, Sox) distributed into waterways, safer environment for marine life[262]

Example innovators

X SHORE

Manufacturer of high-end electric boats.

Stockholm, Sweden

AZURA MARINE

Designer and builder of solar-electric yachts and commercial catamarans.

Singapore

Key Clusters

Sweden

- Vattenfall, Echandia Marine, Callenberg Technology Group, Stena Line
- Swedish Transport Administration; Sweden has goal to become fossil fuel-free by 2045; Swedish Maritime Administration (funding)
- Finnboat (Finnish Marine Industries Foundation)

Singapore

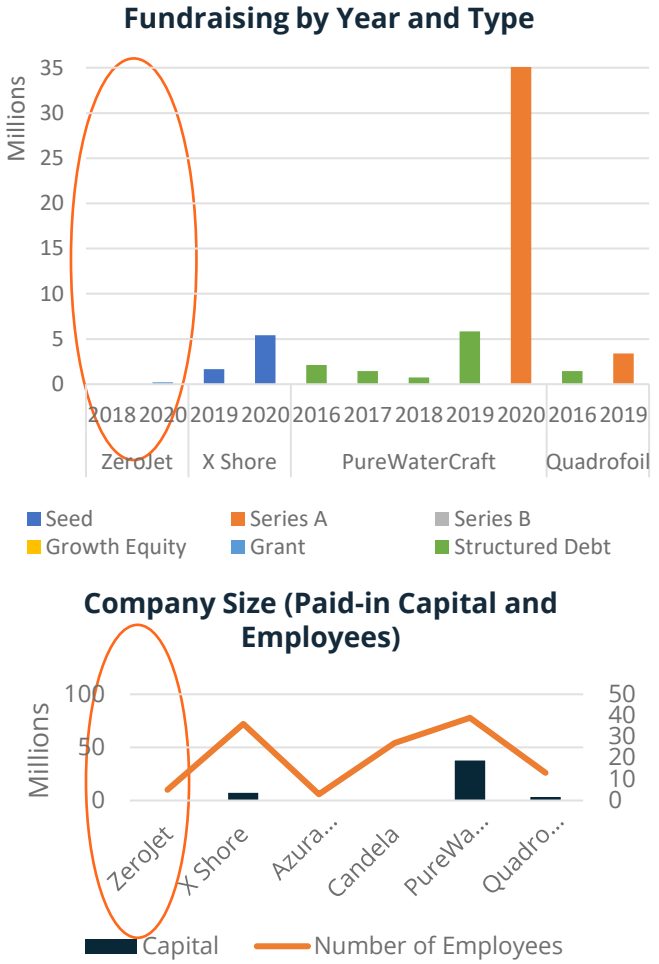
- BOS Offshore & Marine, BH Global, Penguin, Durapower Technology and Bureau Veritas Maritime are part of plug-in hybrid electric fast launch project.
- Nanyang Technical University (NTU) active in research on electric propulsion for marine vessels.
- PSA Container Port and Jurong Port acting as testbeds for innovation.
- Maritime Port Authority (MPA) and Singapore Maritime Institute are seeking proposals on electrification of harbourcraft.

Innovators and Ecosystems: Maritime electrification

Alignment w/ Strength

2

Ecosystem	ZEROJET	X SHORE	AZURA MARINE	Candela	PUREWATERCRAFT	QUADROFOIL
HQ	Auckland, NZ	Sweden	Singapore	Sweden	WA, USA	Slovenia
Diversity in mgmt. / ownership	Female founder/CEO	Female CEO				
Grants	• Callaghan Innovation Project Grant					
Incubators / Accelerators	• Startmate					
Angel Financing	• Arc Angels	• Peter Dahlberg		• Chris Anderson • Christer von der Burg	• Duffy Duffield • Megan Smith • Jeff Wilke • Tom Alberg	
Equity Financing	• New Zealand Growth Capital Partners • K1W1 • Icehouse • NZGCP	• Hi8Capital • SynerLeap			• L37 Venture Partners	• Alpvent
Debt Financing						
Customers					• Marin Rowing Association	• Electric Water Sports
Partnerships	• Offshore Cruising Tenders		• Bintang Timur Samudera • Maldive Yacht Support • Allmode • Z-Power Automation • Penguin International	• Torqeedo	• Highfield Boats • Bass Pro Shops • Still Water Design	• Alumero Group • Impol • Ansys • Sava Zavarovalnica • Podkriznik
Talent Pipelines		• KTH Royal Institute of Technology, Uppsala University		• KTH Royal Institute of Technology, Chalmers University of Technology	• University of Washington	
Emissions Reduction	• One 5 HP four-stroke engine has same environmental impact as 38 cars.		• Zero CO2 emissions if the batteries are charged with solar energy. • CO2 emissions cut by 50% if electricity comes from fossil fuel power plants.	• 99% reduced local emissions when charging with an average EU electricity mix	• Eliminates 125X as much pollution as switching from a typical gas-powered car to an electric car.	• Zero emissions released



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Maritime electrification

Ability to Lead

2.5

		New Zealand		Sweden		Washington, US	
	Overview	• History of know-how in shipbuilding and design, first jet boat was invented in NZ. Comprehensive marine science research ecosystem.		• Emerging maritime electrification scene with Candela, GreenStar Marine, and X Shore. Swedish proficiency in battery manufacturing places important know-how in country		• Washington State is a key supply and demand market – 2% of the state's employment is maritime related, nearly 25% of the US's shipyards are in Washington. [263]	
35%	**R&D-to-commercialization pipeline strength**	6	• Research at a half dozen universities in marine science – NZ is good testbed for marine environment protection. • Dedicated recreational vessel research – U. Auckland Yacht Research Unit in the mechanical engineering dept.	7	• Key supply chain advantages – local producers of maritime electric motors (Electro-Mobile, Nordic Genset) and batteries (Lime Power).	6	• Washington's maritime industry creates an important knowledge base around production and go-to-market.
25%	**Financing strength**	2	• $350 k in 5 deals from 2011 – 2021 • Key missing element is investment (domestic and foreign) in underlying battery and electric motor start-ups	4	• $7 m in 2 deals from 2011 – 2021 • Financing for innovators coming in significant part from crowdfunding (GreenStar Marine - $577k, X Shore - $1.6 m) and angel investors (X Shore - $5.4 m)	6	• $37.5 m in 6 deals from 2011 – 2021 • Involvement from high-profile angel investors, e.g. Amazon Worldwide Consumer CEO Jeff Wilke. • "Maritime Blue" programme accelerating and financing local innovators
40%	**Connection to demand**	5	• Home market estimated at around 215k recreational boats[263] • In the short term, NZ is one of the few recreational boating markets expected to expand (during Covid-19 recovery).	6	• Sweden began hosting an all-electric boat show in 2019, with most of the exhibitors being Swedish companies. • Marketplaces for electric boats, including Go Electric, are providing distribution and promotion channels for local innovators.	6	• Recreational market is local – there are over 1 m recreational boats on the water on the US West Coast (CA, WA, OR). [264] • Major recreational boat manufacturers have shown willingness to partner with producers of electric boat engines (e.g. Tracker – Pure Watercraft)
Evaluation		**4.6**		**5.9**		**6**	

Takeaways: Maritime electrification

Takeaways for NZ Climate Tech Innovators

- No de facto global innovation hub, customers (globally) are fairly dispersed. Connections to export markets through traditional means (export promotion, international distribution, etc.) are likely necessary to keep pace with demand as it picks up.
- Achieving economies of scale will be mutually inclusive with battery development proficiency and charging. Companies that succeed in this sector, as in electric vehicles, will need to have deep connections through the value chain. Talent, investors, and other resources with automotive backgrounds should not be overlooked when developing a company in this sector.
- Electric boats are expensive everywhere – there is still time for NZ innovators to make breakthroughs and develop cost advantages that beat competitors on a global scale.
- NZ's strengths in marine science can be leveraged to develop, test, and pilot maritime technologies that have distinctly lower impact on natural environments.

Takeaways for NZ Climate Tech Ecosystem

- A fractured and slow-growing market. The ecosystem is likely better poised to serve maritime electrification through a dual track of: a) developing energy storage and charging solutions and b) a general "zero-emissions" boating innovation pursuit, including biofuel / drop-in fuel development and hydrogen fuel cells for marine applications.
- Building export capabilities will require an ability to compete on price, necessitating underlying efficiencies on production and supply chain. Both issues are typically challenging for island / remote countries. First-loss capital and grants that absorb the supply chain / procurement learning curves are likely necessary to develop competitive innovators.

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Appendix 5
Materials & Chemicals

Contents

Materials & Chemicals – Comparison between Small Advanced Economies (SAEs)

Materials & Chemicals Analysis

Advanced Materials: Green Building & Construction

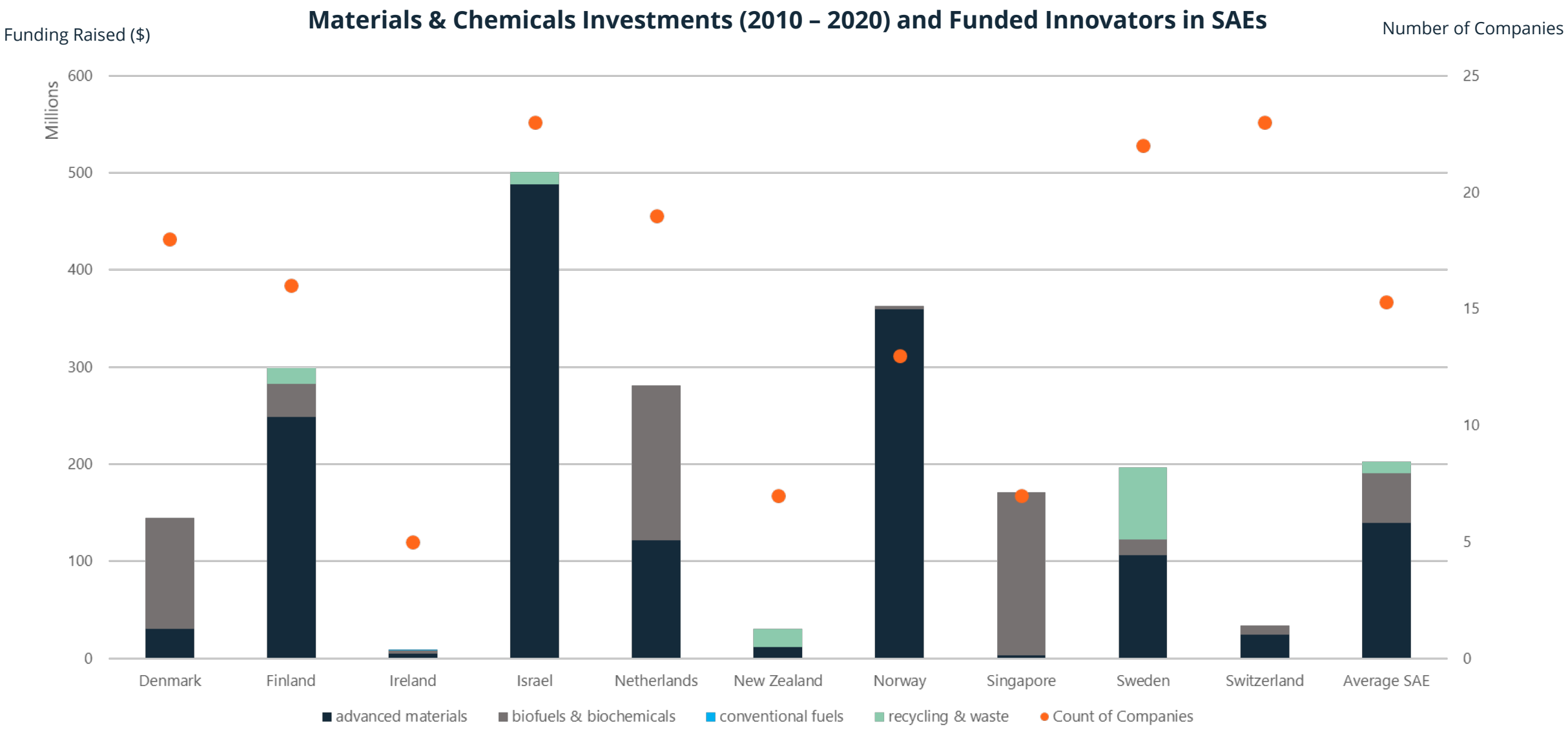
Additive Manufacturing for Construction

Industrial Waste to Value

CCUS – Point Source Capture

Surface Technologies

Overview – Materials & Chemicals Innovation in Small Advanced Economies (SAEs)



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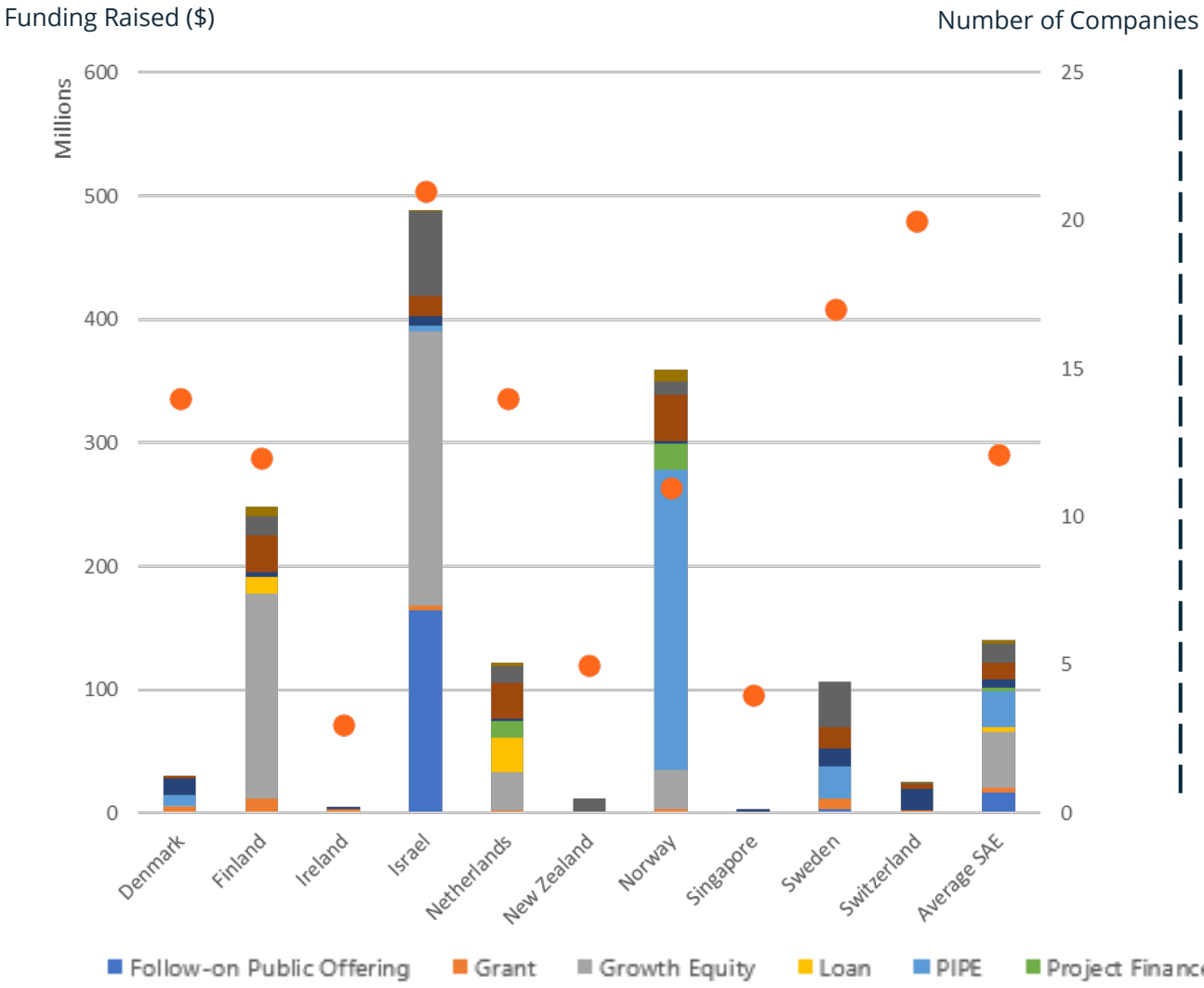
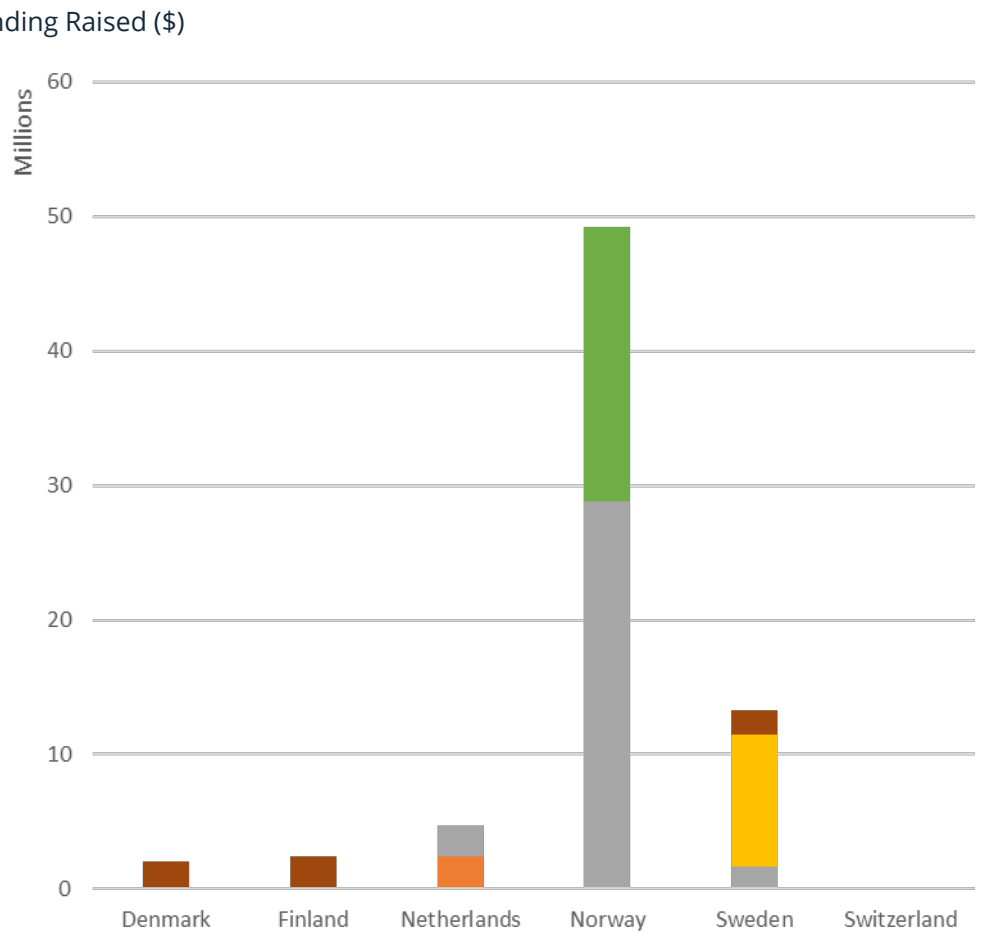
Advanced Materials Innovation in Small Advanced Economies (SAEs)

Advanced Materials Investments (2010 – 2020) and Funded Innovators in SAEs



Advanced Materials: Green Building and Construction Investments (2010 – 2020) and Funded Innovators in SAEs



Advanced Materials – Green building & construction: Trend Analysis

External Potential	Timing of Trend
3	3

Summary

- **Description:** Alternative cements, low carbon concrete and concrete alternatives
- **External potential:** The global cement and concrete products market size was $333.26bn in 2020 and is expected to reach $481.23bn in 2025, growing with CAGR of 7%[223].
- **Timing:** Cement production is accelerating in emerging regions, driven by economic development and population growth[3]. Cement and concrete accounted for 9-10% of global energy-related CO2 emissions in 2019[3] and adoption of green materials will be driven by stricter emissions targets at national level.
- **CO2 reduction potential:** Potential savings of 264Mt CO2e by 2050, based on 80% of current cement and concrete emissions [225]
- **Environmental impact reduction potential:** Building materials should be considered in the context of overall lifecycle emissions for the building: materials which increase overall energy efficiency also reduce operational emissions of the building. Potential for better land use, reduction in disruption of wildlife habitats, dust/visual pollution due to limestone quarrying.

Example innovators

ECOncrete®

Concrete sea defences which foster biodiversity

Tel Aviv, Israel

MATERR'UP
low carbon solutions

Crosslinked clay cement

Aquitaine, France

Key Clusters

Israel

- Government support in attracting international corporates for collaboration / investment
- ConTech specialist incubator connects innovators with industry, funding and government support. Assists startups with product-market fit

France

- Lafarge Holcim, Vinci, Saint-Gobain pursuing in-house innovation, external collaboration and investment in innovators
- Université Gustave Eiffel, CNRS participating in H2020 projects
- Impulse Partners, Cement Lab, CSTB Lab all construction-focused, have accelerated 600+ construction sector startups
- Many schemes (government and private) providing grants and financing to early-stage ventures

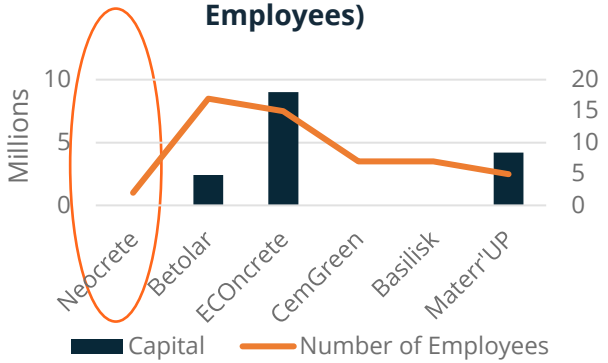
Innovators and Ecosystems: Advanced Materials – Green building & construction

Alignment w/ Strength: 3

Ecosystem	NEOCRETE **Auckland, NZ** Additive for low-cement concrete	BETOLAR **Kannonkoski, FInland** Geopolymer based construction materials	ECOncrete **Tel Aviv, Israel** Biodiversity-fostering concrete sea defences	CemGreen **Roskilde, Denmark** SCM from clay mineral rich raw material	Basilisk **Delft, Netherlands** Micro-organism based tech to heal concrete	MATERR'UP low carbon solutions **Aquitaine, France** Cross-linked clay cement
Diversity in mgmt. / ownership	50%	33%	40%			
Grants	• Callaghan Innovation		• H2020	• Climate-KIC • Innovation Fund Denmark		
Incubators / Accelerators				• EIC Accelerator		• Impulse Partners
Angel Financing						
Equity Financing		• Ajanta Oy, Voima Ventures, Valve Ventures, Taaleri	• Goldacre • Bridges Israel		• SHIFT Invest	• BPI France, Sofimac Innovation, Ademe, Argiduna Capital, Irdi Soridec Gestion
Debt Financing						
Customers						
Partnerships	• eHaus		• Lafarge Holcim, DTU, Port of Vigo, Cardama shipyard	• DTU; talks with Aarlborg Portland	• Conmix, ECMAS, Markham • Corbion	
Talent Pipelines		• University of Oulu, Aalto U, Teknillen Kork,	• Tel Aviv U, Technion	• Harvard, Caltech • DTU, U. Copenhagen,	• TU Delft, TU Eindhoven, Rotterdam U	
Emissions Reduction	• Up to 33% reduction • 34% stronger	• Up to 80% reductio • Up to 95% side stream based materials in cust. products				• 50-80% reduction[2]

Fundraising by Year and Type

Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Green Building & Construction

Ability to Lead

1

		New Zealand		Finland		Israel		France	
	Overview	• Local availability of pozzolan, key ingredient in green concrete • Green Star & EPD basis for demand-side pull		• Research & commercial links with other Nordic countries • Exploitation of tech sector spillovers		• Strong track record in tech. innovation • Construction sector disruption driven by safety concerns & labor shortages		• Early-stage funding and ecosystem support has led to a surge in startup activity • Main growth opportunities in corporate partnerships	
35%	**R&D-to-commercialization pipeline strength**	6	• U. Canterbury research into earthquake-resistant construction materials • Auckland Uni services supports commercialization in materials innovation	8	• Aalto university's A Grid houses several accelerators • Tekes, VTT research and commercialize sustainable construction innovation	7	• ConTech accelerator connects startups with ecosystem and government support • Israel Innovation Authority subsidizes innovation for low-tech applications	9	• Government incentives for startups/commercialization • Lafarge, Impulse Partners construction-focused accelerators provide industry exposure and promote corporate partnerships • U. Gustave Eiffel, CNRS involved in H2020 research projects
25%	**Financing strength**	0	• No notable investments in last decade	3	• $2.4m invested in last decade (Betolar Series A) • Sitra Innovation fund invests in forward-looking SMEs • Homegrown VCs, not specialized	2	• No notable investments in last decade • Digital / robotics focused startups attracting more funding	5	• $15m invested in last decade • Good availability of early-stage funding, gap in growth equity and scale-up support
40%	**Connection to demand**	7	• Allied Concrete / eHaus adopting progressive construction materials • Green Star rating system enables demand-side evaluation	5	• Presence of multinationals in other sectors supplies executives with international experience and contacts	5	• Israel Export Institute & Foreign Trade Administration organized Contech / Proptech Expo to present Israeli innovators to international corporations • Absence of local corporates means strong focus on internationalization	7	• Lafarge Holcim, GCC Groupe, Bouygues Construction, Saint-Gobain partnering with innovative startups for project development • Strong domestic construction industry, slow to adopt innovation
Evaluation		**4.9**		**5.6**		**5**		**7.2**	

Takeaways: Advanced Materials – Green building & construction

Takeaways for NZ Climate Tech Innovators

- Collaborate with decision makers (architects, designers, specifiers, buyers) to communicate performance benefits of innovative materials
- Marketing is key: measure the environmental impact of your solution and communicate it
- Target regions where local authorities offer reduced development costs to Green Star certified buildings
- Industry knowledge and contacts can help combat construction industry inertia
- Opportunities in construction materials incorporating locally available raw materials (e.g. pozzolans) as an alternative to SCM imports
- Future opportunities around the intersection of construction and technology (e.g. incorporation of sensors, AI for real-time curing data)

Takeaways for NZ Climate Tech Ecosystem

- Ensure regulation, certification & standards are updated for green materials
- Educate buyers about advantages of green materials
- Green procurement, materials performance requirements based on Environmental Product Declarations & Green Star ratings to kick start markets
- Consider investment support for production of local materials inputs (e.g. pozzolans)

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Additive Manufacturing for Construction – Trend Analysis

External Potential	Timing of Trend
4	4

Summary

- **Description:** The process of joining materials, in this case concrete, layer upon layer from 3D model data, enabling realisation of designs which use less material. Includes prefabricated and on-site construction.
- **External potential:** Global market size of $310.9m in 2019, expected to reach $4.06bn in 2027, with CAGR of 106.5%[226], driven by faster construction times and reduced cost/environmental footprint by using less material. Also enables innovative designs which are unviable with conventional construction techniques. Suppliers sell or license equipment, together with design services, or offer printing-as-a-service[227].
- **Timing:** High potential in developed countries with shortage of skilled labour and in developing countries with housing shortages needing fast solutions. Main clusters in California/USA, China and northern Europe/Scandinavia. Industrial suppliers exporting globally.
- **CO2 reduction potential:** 25% construction market share would reduce emissions by 410m tonnes CO2e (based on 30% reduction of cement & concrete industry 2019 emissions).
- **Environmental impact reduction potential:** Enables designs which use 30-50% less material, some companies claim up to 70% on certain applications. Lowers transport-related emissions (e.g. particulate matter), less disruption due to faster construction times.

Example innovators

hyperion robotics

Design and manufacture of reinforced concrete elements

Espoo, Finland

MIGHTY BUILDINGS

Prefabricated homes using 3D printing and robotics

California, USA

Key Clusters

Finland

- Aalto university, university of Turku provide entrepreneurial support to potential spinoffs. Innovators can also access support from other Nordic institutions, e.g. Create SDU (Denmark)
- Kiuas has accelerated 250+ startups across sectors, connects founders with entrepreneurs, investors and advisors across Nordic area
- Tekes (The Finnish Funding Agency for Technology and Innovation) and VTT (Technical Research Centre of Finland) fund sustainable construction research and innovation

USA

- Leading accelerators provide access to industry expertise, support and networks
- Globally recognized VC funds investing significant growth capital. Mighty Buildings has raised $56m since 2018
- Californian ecosystem attracts global talent
- DIU/USMC collaboration with 3D printing company Icon to additive manufacturing demonstrate commercial-scale for military use

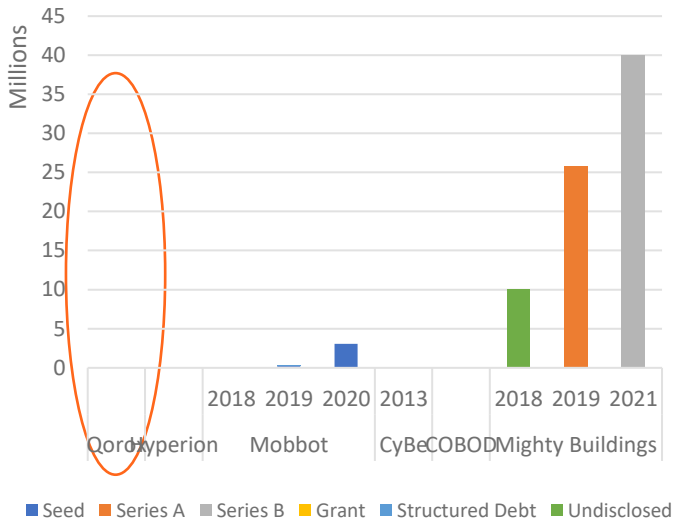
Innovators and Ecosystems: Additive Manufacturing for Construction

Alignment w/ Strength

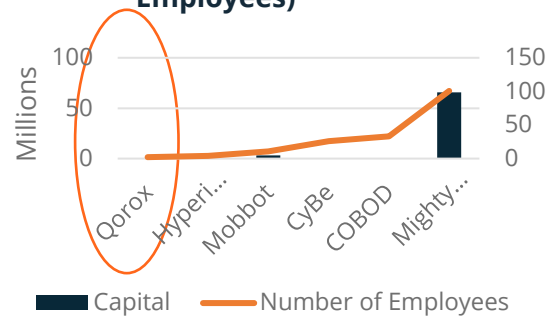
2

Ecosystem	Hamilton, NZ Additive manufacturing & construction 4.0	Espoo, FInland Design & manufacture of concrete components	Fribourg, Switzerland 3D concrete printing technology for construction	Oss, Netherlands 3D concrete printers and design software	Copenhagen, Denmark 3D construction printers and automated processes	San Francisco, USA Prefabricated homes by 3D printing & robotics
Diversity in mgmt. / ownership	Founder	100%	40%			
Grants			• Kickstart, VentureKick	• Climate-KIC	• Green Transition Fund	
Incubators / Accelerators		• Kiuas	• Kickstart, VentureLab			• Y Combinator
Angel Financing						
Equity Financing			• Mutschler Ventures • Investiere, Swiss Immo Lab, Capital Risque Fribourg			• ArcTern Ventures • Khosla Ventures, Zeno Ventures, BOLD Capital Partners
Debt Financing						
Customers	• Hamilton City Council		• RWB Groupe, Monod-Piguet		• Printed Farms, L&T Construction, Peri Group	
Partnerships	• CyBe Construction	• Kuka, Iberdrola, Thinking Huts, Create SDU • Aalto Universty	• Holcim Switzerland	• Korodur (materials), Qorox (distribution)	• Lafarge Holcim, GE • DTU	
Talent Pipelines		• Aalto university	• IMD	• TU Delft, Avans U, TU Eindhoven,	• DTU, Copenhagen Bus. School, KEA, Aalborg U, Oregard Gymnasium	• Tomsk Polytechnik U, Tomsk State U, Bauman Moscow State Tech. U, Higher School of Econ.
Emissions Reduction	• 40% less CO2 emissions • 70% less waste	• 40-50% material saving		• Up to 30% CO2 reduction		• Up to 2kg/home • Committed to net zero by 2028

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Additive Manufacturing for Construction

Ability to Lead

1

	New Zealand		Finland		Denmark		USA	
Overview	• Progressive green building standards provide market pull		• Combination of sustainable construction research priorities and tech capability • Access to Nordic network		• Forward-looking government innovation agenda • Access to Nordic / wider EU network		• World class tech accelerators • Availability of funding with specialized, knowledgeable investors	
35% **R&D-to-commercialization pipeline strength**	7	• Massey U, U. Auckland offer robotics & AI programmes and commercialization support; U. Wellington has a number of tech spinoffs • PreFab NZ advocates for construction innovation	8	• Aalto university, university of Turku supporting spinoffs • Tekes and VTT provide funding for sustainable construction innovation • Kiuas accelerator has 250+ alumni companies (no sector focus)	9	• Proactive government support for construction innovation e.g. Green Transition Fund • Create SDU researches additive manufacturing in architecture • DTU FABLAB best equipped machine fleet in the Nordics	9	• Many world-class accelerators producing high growth startups • R&D funding available to corporates as well as SMEs • Size of ecosystem produces entrepreneurs with prior startup/accelerator experience
25% **Financing strength**	0	• No notable investments in last decade	0	• No notable investments in last decade	7	• Peri Group equity participation in Cobod, 2018	8	• $131m invested in last decade • Icon and Mighty Buildings account for $110 • Funding focused on seed to Series B • Active network of Venture Funds investing in construction tech
40% **Connection to demand**	6	• Green procurement (e.g. Hamilton City Council) kick-starting new markets • Property Developers (e.g. Mansons TLCM) following Green Star certification can drive demand	3	• Construction exports have fallen due to weakened demand	7	• Investment by EU corporates (eg Cobod/Peri Group) • Cobod/Lafarge/GE wind turbine development partnership • Government-led corporate matchmaking programme	9	• Residential offers can be configured online by potential buyers • DIU/USMC collaboration to additive manufacturing demonstrate commercial-scale for military use
Evaluation	**4.9**		**4**		**7.7**		**8.8**	

Takeaways: Additive Manufacturing for Construction

Takeaways for NZ Climate Tech Innovators

- New ventures can establish credibility through demonstration / show projects
- Customers need design support to realize full potential efficiency gains (machinery and software go hand in hand)
- Opportunity for increased climate impact by developing green concrete formulations using locally-available raw materials
- Opportunity to work proactively with authorities to develop new standards and regulations
- Partnerships with building materials companies can provide a route to market
- Other opportunities in innovative applications e.g. GE/Lafarge/Cobod wind towers; Hyperion Robotics/Iberdrola transmission infrastructure
- High-growth Asian countries where housing demand outstrips supply are potential export targets
- Partner with universities to expose future talent to technology solutions
- Market dynamics currently enable 100% yearly growth financed by sales; however well-financed players could start to increase market share internationally as the market matures

Takeaways for NZ Climate Tech Ecosystem

- Adapt regulations and standards for performance-based rather than specification-based evaluation, with flexibility to allow for locally-available raw materials
- Encourage revision of university curricula to incorporate state of the art construction technologies
- Market is in early stages and currently supports a variety of business models, which may coalesce with development
- Higher growth business models (as a service) need large fundraises

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Industrial Waste to Value: Trend Analysis

External Potential	Timing of Trend
4	3

Summary

- **Description:** Raw materials or products derived from industrial waste streams.
- **External potential:** Construction waste expected to double to 2.2bn tons by 2025[231]. Global non-ferrous slag volumes are forecast to reach 133.7m tons by 20292[232]. New processing techniques allow 10% raw material substitution in plasterboard manufacturing[7], up to 100% cement substitution in concrete[236]
- **Timing:** Global waste production is increasing, driven by population growth and industrialization[4]. Clusters in Asia Pacific (driven by high waste production, esp. China and India), North America and Europe (driven by increasing environmental restrictions).
- **CO2 reduction potential:** 50% cement substitution with waste-derived alternatives could reduce cement & concrete emissions by 40% (1.3bn tonnes CO2e)[236]
- **Environmental impact reduction potential:** Reduction of slag heaps, avoidance of demolition piles or landfill disposal.

Example innovators

CRIATERRA EARTH TECHNOLOGIES

Construction elements from advanced earth materials

Holon, Israel

CarbiCrete

Cement-free, carbon-negative concrete using steel slag

Montreal, Canada

Key Clusters

Israel

- High technology capability means many construction startups focus on robotics and automation aspects[237]
- Government has acted proactively to widen innovation via grants to low-tech and promotion of whole construction value chain internationally
- ConTech incubator works with startups along whole value chain, connects innovators with investment, assists with product-market fit

Canada

- COSIA, Harsco supporting innovation through development partnerships and innovation challenges
- Funding availability from early-stage to growth equity
- Carbicrete is an alumnus of McGill University's entrepreneurship centre

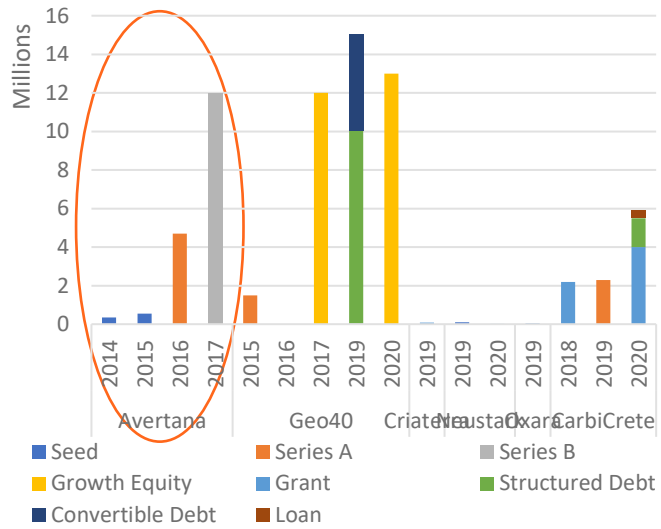
Innovators and Ecosystems: Industrial Waste to Value

Alignment w/ Strength

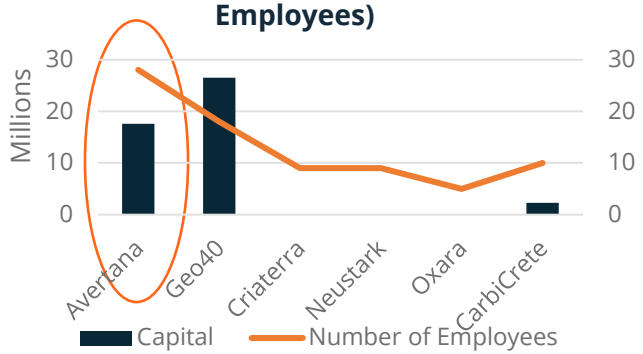
4

Ecosystem	Avertana **Auckland, NZ** Mineral & chemical products from industrial waste streams	geo40 **Taupo, New Zealand]** Silica from geothermal fluids	Criaterra **Israel** Circular building elements	neustark **Berne, Switzerland** Recycled concrete as CO2 reservoir	oxara **Zürich, Switzerland** Cement-free concrete mix from construction waste	CarbiCrete **(Montreal, Canada)** Low-cost building materials from CO2
Diversity in mgmt. / ownership	Diversity	20%	50%		28%	
Grants	• Callaghan Innovation	• Callagnhan Innovation	• EASME/Horizon 2020 • Israel Innovation Authority	• Climate-KIC • Mass Challenge	• Horizon 2020 • Innobooster	• SDTC, Technoclimat
Incubators / Accelerators	• LevelTwo		• ConTech	• Climate-KIC • Kickstart	• Innobooster	• Innovobot
Angel Financing	• Enterprise Angels	• Ice Angels				
Equity Financing	• GRC Sino Green Fund, EFU Fukutake • K1W1, Ice Angels, lewis Holdings Ltd,, Sparkbox Investments Ltd	• Euroz Broker, Baseload Capital, Efu Investment, Lindsay Investments, Climeon • Jarden	• Undisclosed seed round			• Harsco • Innovobot
Debt Financing		• Provincial Growth Fund				• SQN Capital • Canada Economic Development for Quebec
Customers						
Partnerships	• Nzanza Light Materials • MacDiarmid Institute (R&D)	• Tobuko Electric, Nroske Skog, Climeon • Contact Energy, Mercury		• Holcim		• CO2 Solutions
Talent Pipelines	• U. Auckland	• University of Otago	• Ben-Gurion U, Technion	• ETH Zurich	• ETH Zurich, école d'architecture de Grenoble	• McGill U,
Emissions Reduction			• 92% GHG savings • 70% upcycled natural quarry waste	• 30kg/ton fresh concrete • Climate neutral concrete by 2025	• 90% CO2 reduction	• Carbon-negative

Fundraising by Year and Type



Company Size (Paid-in Capital and Employees)



Source: Cleantech Group i3 Database

NZ Ecosystem in Global Context: Industrial waste to value - Global Leading Ecosystems

Ability to Lead

4

		New Zealand		Israel		Switzerland		Canada	
	Overview	• Strong university/innovator R&D collaboration • Maturing ecosystem support • Machinery and raw materials export track record		• Proactive government support to bridge gap in lower-tech construction solutions		• Materials and cities research centre • Strong early-stage ecosystem support • Construction corporates engaging in innovation		• Well-educated workforce with high engineering skills • Availability of funding • Corporates supporting & participating in innovation	
35%	**R&D-to-commercialization pipeline strength**	8	• U. Auckland, AUT, U Otago, Victoria U. R&D partnerships, commercialization offices • MacDiarmid Institute R&D collaboration • LevelTwo has supported several deeptech success stories	5	• ConTech incubator takes value chain approach, connects startups with investment and industry	8	• ETH Zurich has 15 materials research groups, future cities lab investigates waste as a building material • Kickstart, H2020, Climate-KIC nurturing early stage innovators	7	• Carbicrete is a product of McGill university's Dobson Centre for entrepreneurship
25%	**Financing strength**	7	• $43m invested between Avertana, Geo40 & Mint Innovation since 2016 • Early stage and growth funding available • Icehouse Ventures/LevelTwo partnership will boost innovation funding	6	• Criaterra has raised around $3m in grant funding • Wider Israeli Contech & proptech sector saw investment increase from $30m <2015 to $900m in last five years	5	• $370k invested in sector since 2011 • Exclusively grant and seed funding	8	• $44.5m invested since 2011, of which $10m to Carbicrete • Funding availability at all growth stages
40%	**Connection to demand**	8	• Machinery and raw materials export track record	6	• Government-organized programmes to promote domestic startups with international corporates	7	• Neustark / Holcim partnership • Lafarge / Solidia development partnership	9	• Harsco/Carbicrete/concrete block manufacturer development consortium • organisations such as COSIA supporting waste to value innovation
	Evaluation	**7.8**		**5.7**		**6.9**		**8.1**	

Takeaways: Industrial Waste to Value

Takeaways for NZ Climate Tech Innovators

- Build partnerships with waste producers / owners of waste streams to ensure access to raw materials
- Look for export markets with supportive regulatory framework (potential issues: slag transport, getting waste-derived materials into construction cycle)
- Testing & certification to prove that product has requisite performance
- Local partners can help with certification, standardization
- Construction industry inertia is a barrier to adoption: inside industry knowledge can help
- Promote awareness of performance / environmental benefits of product amongst decision makers (designers, architects, potential end customers)
- Expansion into finished goods, incorporation of sensors / analytics future opportunities to add value

Takeaways for NZ Climate Tech Ecosystem

- Educate industry and consumers about circular construction benefits
- Adapt standards & certification to provide clear, performance-based guidelines about materials derived from waste streams
- Mandate low carbon products, green procurement (based on Environmental Product Declaration performance data)
- Invest in R&D into incorporation of sensors / analytics

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- Advanced Materials: Green Building & Construction, Concrete
- Additive Manufacturing for Construction
- Industrial Waste to Value
- **CCUS – Point Source Capture**
- Surface Technologies

CCUS – Point Source Capture: Trend Analysis

External Potential	Timing of Trend
4	3

Summary

- **Description:** Carbon capture directly from plants, for example from exhaust flues, to lower emissions, plus storage or utilization of the captured CO2.
- **External potential:** Carbon utilization products could create a market of over $800bn by 2030[2], but technologies need to scale to reach full potential. Business models are still undefined and will differ by application[240].
- **Timing:** CCUS technologies are expected to be critical for decarbonization of industry and are the most cost-effective solution for emissions reduction in certain applications[239]. To reach full potential, more innovation and regulatory incentives are needed for projects to become commercially viable[240]
- **CO2 reduction potential:** In the IEA clean technology scenario >28 billion tonnes CO2 is captured to 2060, mostly from cement, steel and chemicals industries[3]
- **Environmental impact reduction potential:** CCUS provides a 'last mile' decarbonisation route for emissions which cannot be abated by other methods. Some techniques (e.g. Icelandic mineralisation technologies) could be adapted for SOx and NOx.

Example innovators

Liquid Wind

eMethanol from waste carbon emissions

Gothenburg, Sweden

CARBON RECYCLING INTERNATIONAL

Methanol from waste CO2

Reykjavik, Iceland

Key Clusters

Sweden

- Corporates forming consortia with innovators for CO2 supply and offtake (e.g. Liquid Wind, Axpo, Haldor Topsoe, Siemens partnership)[214]
- Chalmers university of technology innovation & entrepreneurship centre offers comprehensive startup support including acceleration[242]
- Ri.Se working will academia and industry to research cost-efficient CCS systems[243]

Iceland

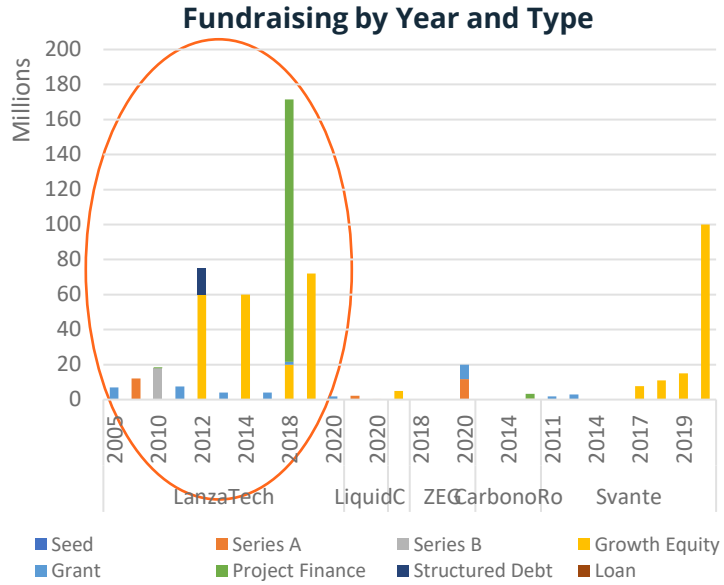
- Small but growing innovation ecosystem, strong focus towards external markets
- Reykjavik energy partnering with industrials to combine geothermal energy and CO2 mineralization for carbon neutrality
- University of Iceland participated in development of CarbFix technology with Reykjavik Energy, CNRS, Columbia Uni.
- CleanTech Iceland consortium supports growth of cleantech cluster mainly through advocacy

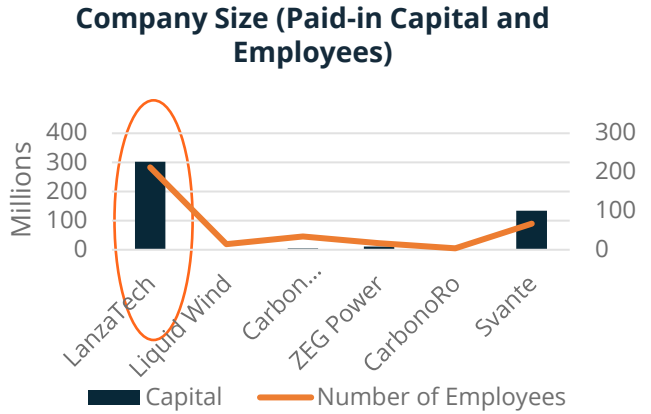
Innovators and Ecosystems: CCUS – Point Source Capture

Alignment w/ Strength

3

Ecosystem	LanzaTech (Auckland, NZ) Waste to fuel technology	Liquid Wind Gothenburg, Sweden eMethanol from waste carbon emissions	Carbon Recycling International Reykyavik, Iceland Methanol from waste CO2	ZEG Power Oslo, Norway Energy from hydrocarbons with integrated CO2 capture	CarbonoRo Nijmegen, Netherlands Carbon capture & biogas upgrading	Svante Canada Technology for carbon capture from industrial sources
Diversity in mgmt. / ownership		27%	25%	20%		Some diversity in board and management
Grants	• US Dept of Energy • Government of New Zealand		• Horizon 2020	• Startup Lab, Enova	• Climate-KIC • Ministry of Economic Affairs	• UK T&I • NRCC, SDTC, IRAP
Incubators / Accelerators				• Startup Lab		
Angel Financing						
Equity Financing	• Khosla Ventures, BASF Venture Cap. • K1W1, NZ Superannuation Fund,	• EIT InnoEnery, crowdfunding	• Methanex	• AP Ventures, Toyota, Danske Bank • Nysno Climate Investments, Stratel	• Undisclosed	• OGCI Climate Inv, Chevron Tech. Ventures • Suncor Energy, Export Development Canada
Debt Financing	• Western Technology Investment				• Viridor • Rabobank	
Customers	• Shougang Steel					• Enhance Energy
Partnerships	• Total, SkyNRG	• Övik Enerji	• Henan Shuncheng Group, Oorja Fuel Cells • Innovation centre Iceland	• Coast Centre Base	• Viridor Waste Management • TNO (research)	• Total, Lafarge Holcim, Climeworks • Suncor (R&D)
Talent Pipelines	• U. Illinois, Northwestern • University of Auckland	• Aalborg U. • Chalmers U Swedish university of ag. Sciences	• Háskóli Íslands, Reykjavik U.	• Institute for Energy Technology, Christian Michelson Research		• U. Brit. Colombia, BCIT
Emissions Reduction		• China plant will recycle 150k tonnes CO2 /year		• [Reduction Claim] • >70% efficiency including capture	• 30% cost of capture reduction compared to state of the art MEA	• One plant can capture 1m tons CO"7yr





Source: Cleantech Group i3 Database

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Local Participants

External Participants

Acquirer

NZ Ecosystem in Global Context: CCUS – Point Source Capture

Ability to Lead

2.5

		New Zealand		Sweden		Iceland		Canada	
	Overview	• Strong universities with commercialization support • Emerging deeptech ecosystem		• Strong decarbonization roadmap • Low presence of financing • Development through corporate partnerships		• Geothermal resources • Domestic biotech capability • International outlook		• Geology favorable for sequestration • Good availability of financing • Industrial corporates investing in decarbonization	
35%	**R&D-to-commercialization pipeline strength**	**7**	• U. Auckland, AUT, U Otago commercialization offices • MacDiarmid Institute R&D collaboration • LevelTwo has supported several deeptech success stories	**6**	• Chalmers University venture creation company has accelerated 50+ startups • ISIA created 30 engagements with Indian market • Ri.Se working with academia and industry for cost-efficient CCS systems	**5**	• University of Iceland pursues international collaboration • Technology Development Fund offers startup grants	**9**	• BCIT has 200+ technical programmes • Canmet Energy Ottawa runs several R&D projects to facilitate large scale CCUS deployment • Alberta Carbon Conversion Technology Centre is a purpose-built demonstration facility
25%	**Financing strength**	**2**	• No recent venture investments in sector • LevelTwo / Icehouse Ventures partnership could boost funding in this area	**4**	• $2.6m invested in CCUS tech since 2011 • Mainly early-stage funding, relatively small amounts	**4**	• $5m invested in CCUS since 2011 (one deal, CRI growth equity) • Only 3 domestic VC funds, limited angel investors	**9**	• $402m invested in CCUS since 2011 • Svante $100m growth equity, Feb 2021 • Equity funding at all stages, debt / project finance also • Government support at federal & provincial levels
40%	**Connection to demand**	**5**	• Lanzatech transferred to Chicago in 2010 for 'ease of shipping and doing business'	**8**	• Ovik Enerji, Swedish biofuels in project development partnerships • Vattenfall JV with Aker Carbon Capture • Swedish industry roadmaps to carbon neutrality provide stable demand signals	**7**	• CRI partnership with Henan Shuncheng Group for China development • Reykjavik energy industry partnerships to neutralize emissions • CRI – Statkraft partnership for commercial scale Norway plant	**9**	• Oli & gas corporates recognize need to clean up • Corporate experience in well-drilling, injecting into geological formations • Several industry innovation alliances focused on decarbonization • Shell Canada Energy, Chevron consortium retrofit capture programme (government funded)
Evaluation		**4.7**		**6.3**		**5.6**		**9**	

Takeaways: CCUS – Point Source Capture

Takeaways for NZ Climate Tech Innovators

- Establish collaborative research partnerships with public or private entities
- For point source capture look for industrial emitter partners to supply CO2 – may not be in primary line of business to start, but important to begin testing at the device level
- Many successful ventures involve co-development with utilization partner (off taker) – important to quantify at early stages how big a market tor potential market for the end product of the capture is going to be.
- Think about internationalization from day one – US, China, Canada, EU are going to be critical markets, demonstrating value to incumbents in these countries is critical

Takeaways for NZ Climate Tech Ecosystem

- Supportive regulatory environment is essential to allow these technologies to scale and reach commercial viability
- Significant CAPEX and time to demonstrate pilots, successful companies have accessed national and regional government funding
- Research centres are fundamental to drive continued technology development
- A significant challenge in NZ is that there is a difficulty accessing supply (CO2) and demand (off takers, primarily buyers of alternative fuels). In general, this will be a difficult industry to keep at home, building advantage around point source CCUS capture is most likely to come in the form of value chain efficiencies that promote larger schemes of NZ solutions for alternative energy inputs to production (e.g. geothermal) and production of alternative fuels (e.g. biofuels).

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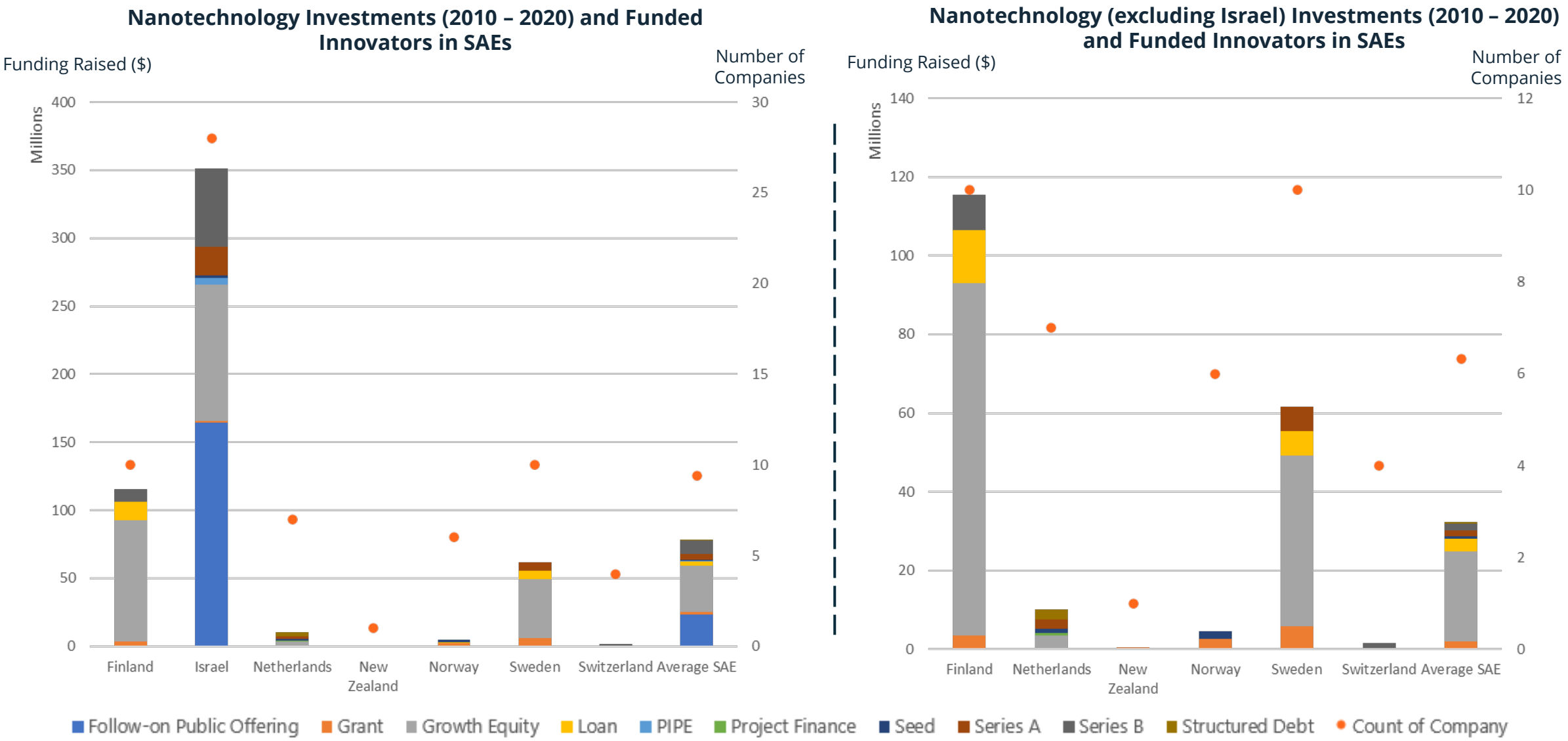
Nanotechnology Innovation in Small Advanced Economies (SAEs)



Surface Technologies: Trend Analysis

External Potential	Timing of Trend
4	3

Summary

- **Description:** Advanced surface technologies and coatings applied to surfaces in order create or improve a material's functionalities, e.g. for corrosion protection, water and ice protection, friction reduction, antifouling properties, self-cleaning, heat and radiation resistance, and thermal management.
- **External potential:** Coatings are used globally across sectors including automotive, energy, industrial and electronics. Enabler of better batteries and fuel cells, and lighter parts in aerospace and automotive applications.
- **Timing:** Application for solar e.g. thin film is more developed. Interest in electronics, aerospace/automotive, batteries and fuel cells is growing.
- **CO2 reduction potential:** Enabling reduction in other applications.
- **Environmental impact reduction potential:** An innovative PV thin film coating might improve solar PV efficiency by 10%.

Example innovators

CANATU

Thin film and carbon nanomaterials

Helsinki, Finland

IMPACT COATINGS

PVD-coatings for fuel cells and other application

Linkoping, Sweden

Key Clusters

Finland

- International corporates invest and partner e.g. DENSO and 3M in Canatu
- Canatu formed as a spinout from Aarhus University and has since collaborated with Tampere University. Aalto University, Aarhus University, Helsinki University of Tech (TKK) provide talent pipeline
- Otanano research platform operated by VTT and Aalto University has track record in commercializing nanotech spinoffs
- Grant funding and research support from EU programmes. Finnish Funding Agency for Innovation (TEKES) invests in leading companies directly

Sweden

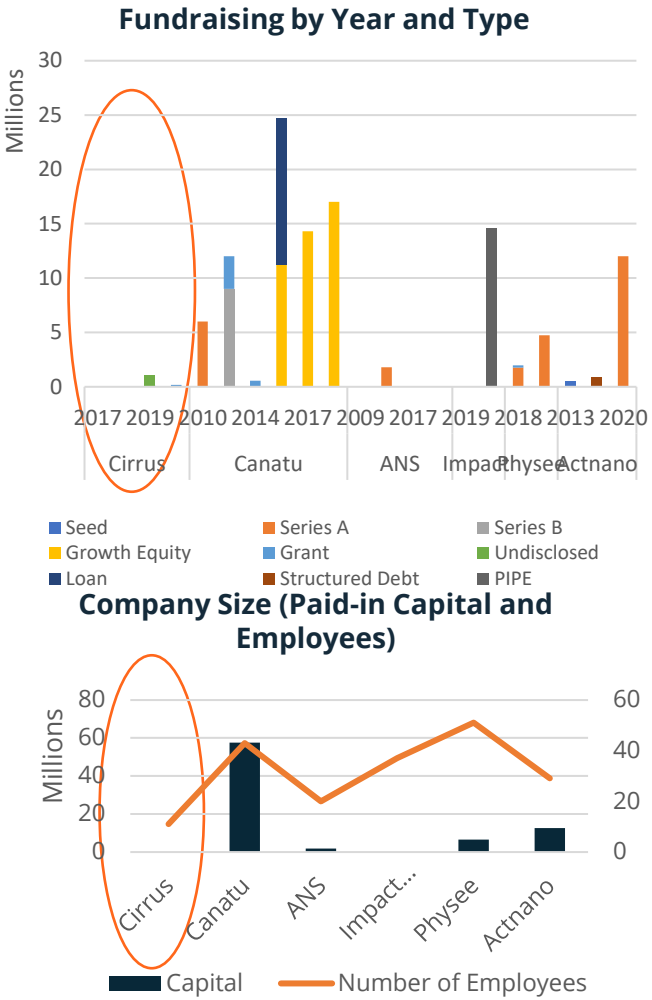
- Local and international corporates investing and partnering e.g. Scania with ANS
- Strong talent pipeline from Uppsala University, Linkoping University and KTH
- Limited ESO activity
- Grant funding and research support from EU programmes including Eurostars

Innovators and Ecosystems: Surface Technologies

Alignment w/ Strength

3

Ecosystem	CIRRUS MATERIALS SCIENCE (Auckland, NZ) Nanoparticle additives and coatings	CANATU Helsinki, FInland thin film and carbon nanomaterials	ANS Sweden low-friction coatings	IMPACT COATINGS Sweden PVD-coatings for fuel cells and other application	PHYSEE Netherlands Engineering coatings, solar, and sensor solutions	actnano Boston, USA Protective nanocoatings
Diversity in mgmt. / ownership	16%					
Grants	• Callaghan Innovation	• Horizon 2020 • Business Finland	• Eurostars	• Eurostars SME programme (2015)	• Climate-KIC • EASME	
Incubators / Accelerators	• Callaghan Innovation	• Plug and Play Tech Center			• Techleap	
Angel Financing	• UniServices, K1W1, ICE Angels	• Aarhus University	• Sixth Swedish National Pension Fund		• Coen van Oostrom, Daan van der Vorm	• Undisclosed participants (2013)
Equity Financing	• Powerhouse Ventures (Christchurch)	• Tekes (Finalnd) • Denso , 3M New Ventures , Faurecia Ventures	• BASF Venture Capital , Fouriertransform, • Attentus Göteborg	• Hyundai Motor	• Clean-Tech Real Estate Consortium • Timeless Investments , Shape Capital ,	• Material Impact Fund • Ireon Ventures, Henkel Tech Ventures, Emerald Technology Ventures
Debt Financing		• European Investment Bank	• Swedish Energy Agency			• Undisclosed participant
Customers	• 5 unnamed blue-chip clients	• Denso (licensing)	• 'Major automotive OEM'	• Beijing Shouhang Resources Saving	• ABM Composites • Daikin Industries, ECO Group	• Tesla, Ford • LG
Partnerships	• University of Auckland	• Faurecia • Tampere University of Technology	• Ford, Sunnen • Scania	• Hyundai Motor • NET (China)	• Kusumoto Chemicals • NSG Pilkington	• Henkel
Talent Pipelines	• The University of Auckland	• Aalto University, Aarhus University, Helsinki University of Tech. (TKK)	• Uppsala University, Linkoping University • KTH	• Linkoping University	• TU Delft (majority)	• MIT, Northeastern University, University of Iowa
Emissions Reduction						



Source: Cleantech Group i3 Database

NEW ZEALAND CLIMATE TECH FOR THE WORLD

Local Participants

External Participants

Acquirer

PVD= physical vapor deposition

NZ Ecosystem in Global Context: Surface Technologies

Ability to Lead: 3

		New Zealand		Finland		Sweden		Massachusetts, USA	
	Overview	• Talent pipeline and research from Auckland university. National equity and grant funding support. Global partnerships		• Talent pipeline and research from several universities. Strong equity fundraising. Global partnerships and investment. Access to EU grant funding		• Talent pipeline and research from Linkoping and Uppsala Universities. Global partnerships and investment. Access to EU grant funding		• Talent pipeline and research from MIT. Global partnerships and investment. Leading incubators	
35%	**R&D-to-commercialization pipeline strength**	7	• University of Auckland active in research. Cirrus Materials founded on research from UoA • Callaghan innovation provides research grants. Funded Cirrus research on Surface Finishing	7	• Aalto, Helsinki and Tampere Universities leading research. • AoF and Sitra provide research and innovation funding • National venture ESOs. Some with Cleantech focus. • Innovators access EU funding and specialized ESOs	7	• Linkoping University and Uppsala University source of innovation. Impact Coatings (LU) and ANS (UU) founded on research • Innovators access EU funding e.g. Eurostars grants for Impact Coatings and ANS	9	• MIT source of innovation and talent. Actnano founded MIT-led technology hub in Boston in 2018 • Access to national grant funding from NSF and others • Innovators accessing national accelerators including Plug and Play e.g. Metalmark Innovations
25%	**Financing strength**	5	• $100k invested in 1 company since 2011* • Limited number of innovators and investment across the investment cycle	9	• $122M invested in 4 companies since 2011 • Canatu raised $17M in 2019 Picosun raised $14M in 2019 • Recent funding in growth equity stage (external funders)	5	• $2.5M+ invested in 2 companies since 2011* • Applied Nano Surfaces raised an undisclosed amount of growth equity in 2017	8	• $63M invested in 5 companies 2011* • Actnano raised $12M in 2020 (external/internal) • Recent funding in seed and series A stages
40%	**Connection to demand**	7	• Cirrus Materials has joint R&D development in 24 locations. 5 (unnamed) blue chip clients	9	• Innovators accessing external customers and partnerships • Denso partnered and invested in Canatu in 2019. 3M also invested.	9	• Innovators accessing external customers and partnerships • BASF invested in ANS in 2017. A 'major automotive OEM' became a customers in 2021 • Hyundai partnered and invested an undisclosed amount in Impact Coatings in 2019.	9	• Actnano has had global presence (China and South Korea) since 2017. Henkel partnered and invested in 2020. PTT is also an investor via GC ventures • Henkel partnered and invested in NBD Nano in 2017. BASF has also invested
Evaluation		**6.5**		**8.3**		**7.7**		**8.8**	

*Some funding likely undisclosed e.g. funding in Cirrus from Uniservices

**Some funding not included e.g. for Impact Coatings is now public but has attracted 2 funding rounds since 2019 ($14.6M + $undisclosed)

Takeaways: Surface Technologies

Takeaways for NZ Climate Tech Innovators

- External funding in this area tends to be specialized & global, consider international as well as domestic financing
- Investors are materials specialists / experts (e.g. Canatu/3M New Ventures)
- Develop partnerships with chemicals / materials companies to validate technology and refine use cases

Takeaways for NZ Climate Tech Ecosystem

- R&D funding for research institutes and university programmes to keep up with technological developments
- Promote demand-led development through challenge programmes
- Ensure university curricula are developing skills for the future

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