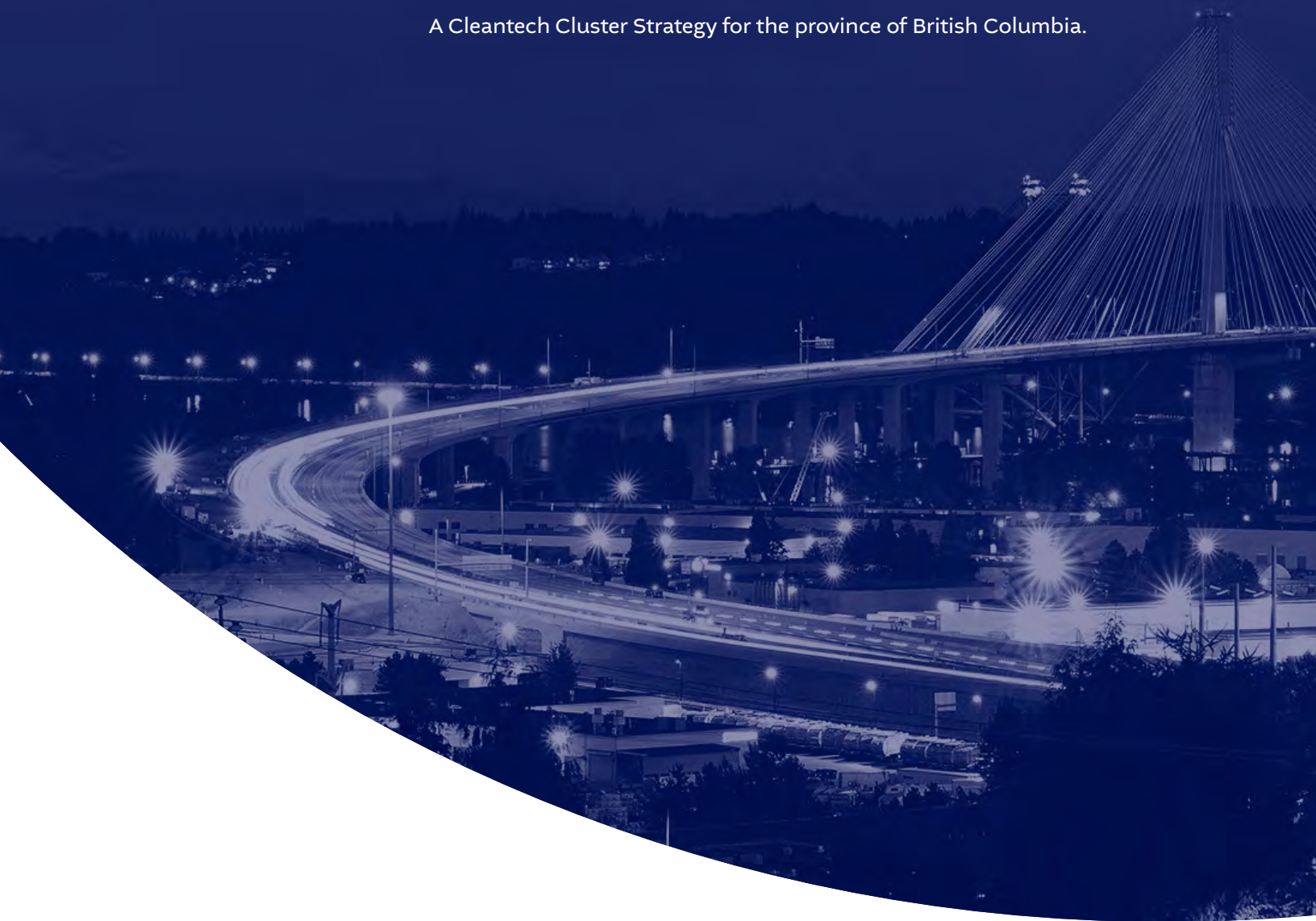




Accelerating British Columbia's Clean Economy

A Cleantech Cluster Strategy for the province of British Columbia.



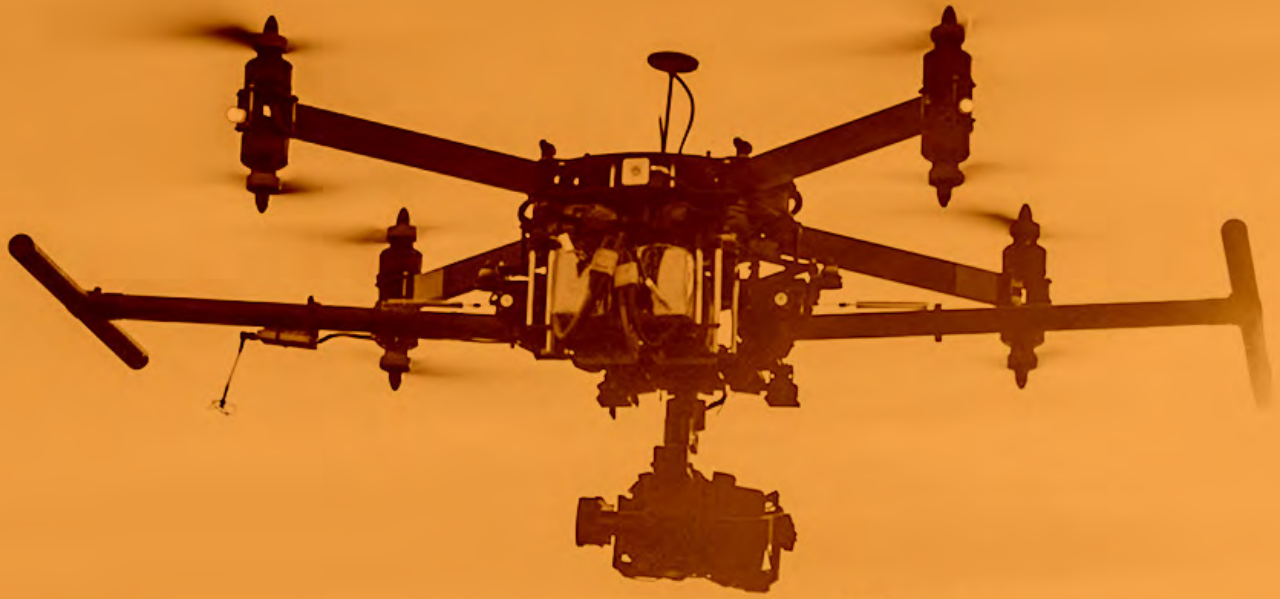


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Foreword

I am pleased to present this Cleantech Cluster strategy for the province of British Columbia - a roadmap of engagement, collaboration and programming to accelerate the growth of BC's promising sustainable economy.

It should come as no surprise that BC is well positioned to formalize a cleantech cluster. With over 290 cleantech SMEs, several of which are growing and scaling to become anchor companies across several key sectors, as well as \$3.4 billion invested into our local sector since 2017. All of the elements are here and ready to be mobilized.

Clusters demonstrate a thriving economy. A cluster organization signifies a commitment from all stakeholders to align and mobilize resources. When all of the elements work well and grow together, the cluster becomes stronger. The cluster stakeholders benefit from a boost in prosperity, revenue, investments, exports and jobs.

Clusters also energize the economy. They foster innovation. They create an ideal environment for talent development, capital deployment and strategic market development. And they attract large industry players and service providers to support the cluster's mission. Not only does this coordinate all of the right pieces for growth, it establishes a healthy competitive environment, pushing everyone in the ecosystem to perform better.

The power of a formalized cluster network is profound. Cluster organizations and strategies across the world show us what happens when a cluster is launched and energized. People connect and work together. They create thousands of new jobs, they build tech parks, and they launch groundbreaking initiatives. They attract investment and start scaling huge infrastructure projects - and they do it collaboratively and profitably.

This strategy is unique to BC and is designed with our history in resources and innovation top of mind. It also considers that while Vancouver is a natural hub for the cluster's foundation, several regions across BC have critical elements to connect to the cluster. Connecting the hubs of diverse innovation activities that are happening in multiple regions of the province not only takes advantage of one of BC's most enduring strengths, it is also an ideal scenario to advance a world-class, distributed cluster model and support CleanBC objectives.

I'd like to thank several groups and teams that helped with the process of developing this strategy. Thank you to all of the individuals, experts, leaders, associations, cleantech SMEs, industry partners and stakeholders across the province for supporting this endeavour. Thank you to the project Advisory Group and entire Foresight team for working along a fast-paced project timeline. Thank you to our project advisor, John Tak, and researcher, writer, editor and colleague, Diane Sam.

And, a very special thank you to my colleague and project lead, Catriona Power. Your leadership, commitment and unwavering work ethic were instrumental in bringing this strategy together.

This forward would not be complete without addressing the impact COVID 19 is having globally. We are in the midst of a massive health crisis and an unprecedented global economic crisis. And while this is true, most thought-leaders still maintain that the biggest crisis ahead of us is the climate crisis. A cluster that addresses both economic and climate priorities is an ideal path forward for our Province, and as a leader for the rest of Canada.

We look forward to working with everyone on bringing this strategy to life.

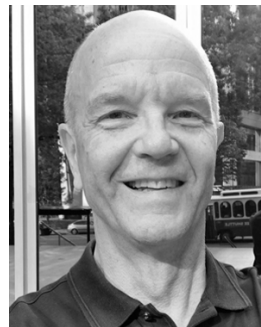
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Western Economic
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Executive Summary

CALL TO ACTION

In September 2019, Foresight Cleantech Accelerator Centre embarked on a 6 month Cleantech Cluster Initiative for the province of British Columbia. The result is a recommendation for a new CORE Cleantech Cluster organization and a series of programs, unique to British Columbia, taking inspiration from our regional strengths, core competencies and competitive advantages in the industry.

The global cleantech industry is on a growth trajectory (with an estimated market of 2.5 trillion USD by 2022), and CleanBC has set the stage for BC to lead Canada. However, if we are to meet CleanBC goals and capitalize on this significant economic opportunity, the pace of technology development, commercialization, investment and industry adoption must accelerate.

As British Columbia transitions to the future clean economy, it needs an approach to market acceleration that elevates the role of clean technology and innovation across many sectors. Clean technology is solving the hardest problems faced by industry today - decoupling growth from emissions, repurposing used materials, and adopting new products and processes that sustainably maximize efficiency and minimize waste. These are complex challenges that cannot be solved alone. Collaboration between key stakeholder groups including cleantech SMEs, industry, academia, government and investors is critical to accelerating the pace of this transition.

What's missing in British Columbia is a model for collaboration for clean technology stakeholders that accelerates the major institutional, industrial and technological change that is required to achieve both climate goals and shared economic prosperity in the long-term, across the entire province. This type of activity happens best when a "cluster" of interconnected businesses both cooperates and competes - often referred to as "co-opetition".

Our call to action is to engage all stakeholders in building the CORE Cleantech Cluster and form a stronger clean technology innovation ecosystem that accelerates the pace of innovation, gets new ideas to market faster and scales the cleantech industry.



A NEW CLEANTECH CLUSTER FOR BRITISH COLUMBIA

The CORE Cleantech Cluster Vision and Strategy is a guide to shape the growth of the clean economy in British Columbia. Clusters are an effective collaboration tool that achieve economic growth by capitalizing on existing strengths and enabling partnerships and new business relationships to thrive, while generating significant revenue, attracting investment and creating jobs.

The proposed cluster organization is designed to align with the Government of British Columbia's mandate to support growth of globally competitive industry clusters as part of the Government of British Columbia's Technology and Innovation Policy Framework, the Emerging Economy Taskforce Recommendations as well as Western Economic Diversification's Grow West Strategy. It is aligned with the CleanBC plan to enable reduction of GHG emissions across sectors, to increase competitiveness of industry, and to scale clean technology companies to become future anchor companies in BC. The cluster will also launch with a distributed hub and node model that serves all regions of the province and leverages their strengths, ensuring all stakeholders and networks engaged in scaling cleantech have access to the cluster.

The word CORE stands for the most basic and important part of something, the centre. The very heart of the earth is called the earth's core. It represents the importance of this work to the future of our province. We believe cleantech is the core of our future economy.

In a perfect world, clusters would just exist without much effort. But the truth is - it takes a very focused and strategic approach to bring companies and organizations from the value chain together to form partnerships for funding, research and revenue opportunities. Clusters drive innovation through breaking down silos, facilitating connections and providing "strength in numbers" - the ability to speak with one voice when it's time to tackle business, regulatory and policy issues, particularly for issues that impact emerging industries (who may not have fully-formed or mature industry associations), or big picture issues that impact multiple sectors.

Cluster organizations are proven forces of change - by coordinating and steering activities designed to strengthen relationships between cluster stakeholders and promote collaborative actions around shared opportunities and challenges, a cluster enhances competitiveness for BC's industries and draws investment to the region. This is a win-win for the entire ecosystem.

This report outlines recommendations for programs and activities to scale cleantech in the province and abroad through a cluster organization and approach. This is an approach that all stakeholders can contribute to and benefit from.

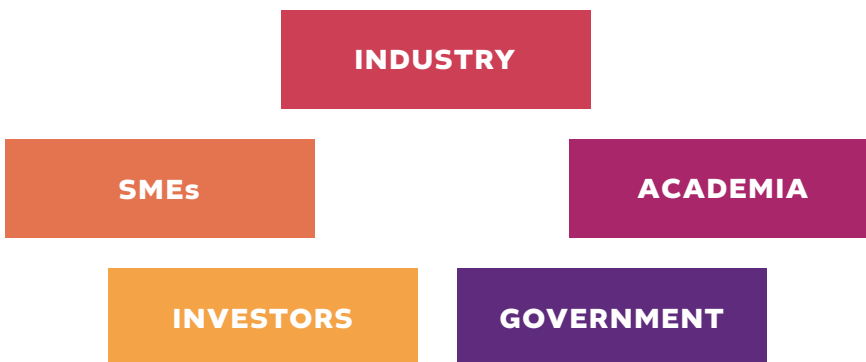


VISION

By 2030, the province of British Columbia will have an established Cleantech Cluster with a global reputation for rapidly building, scaling and anchoring technology companies that address climate change, enhance competitiveness and deliver shared sustainable prosperity through collaborative initiatives, ultimately supporting quality jobs and attracting investment to the region.

MISSION

Our mission is to support a clean economy and position BC as a global centre for innovation, talent and capital to scale cleantech innovation. The activities will be based on a collaborative Helix-5 cluster model that fosters partnerships with 5 key stakeholders - industry, SMEs, academia, investors and government. The cluster supports economic development goals of job growth, company growth, investment attraction and trade opportunities, by identifying gaps, facilitating engagement, and developing collaboration opportunities through an internationally recognized cleantech cluster.



GOALS

These five measurable goals align with the mission and vision of the CORE Cleantech Cluster.

- Strengthen local and global partnerships to accelerate activities for a clean economy
- Showcase BC as a place to invest in clean technology companies and projects
- Facilitate and engage stakeholders for impactful collaborative cleantech projects in BC
- Foster talent and skills for cleantech commercialization and scale-up in BC
- Promote opportunities and programs to increase international exports





SECTOR OPPORTUNITIES

The cluster team has crafted a matrix of BC technology competencies, gaps, competitive advantages and ecosystem players to understand the greatest opportunities for:

- 1) rapid scale-up of clean technology, including commercialization, industry adoption, investment attraction and export market development
- 2) solving industry challenges related to achieving CleanBC goals, including decoupling growth from emissions, repurposing used materials and creating diversified added value products across six sectors.

The six areas of focus are:

- Built Environment
- Energy
- Natural Resources
- Transportation
- Water
- Agriculture and Food

FOUNDATIONS OF A SUCCESSFUL CLUSTER

When creating a cluster organization, the following foundational elements are strongly correlated to the long-term success of the cluster:

- A robust governance model and team
- Programs based on an understanding of the region's strengths and competitive advantages
- Programs that address market-driven gaps
- Commitments from stakeholders
- Creating value early for the cluster constituents

Our recommendations are designed to lay the foundations of a successful model and build a cluster unique to British Columbia. In the table below are Foundational and Priority Program recommendations (See Section 3 for a full list of recommendations) .

	FOUNDATIONAL RECOMMENDATIONS	BENEFIT
Foundation	<p>Cluster Foundation Formally establish the CORE Cleantech Cluster team and governance model.</p>	<p>An official and dedicated hub for cleantech in BC that coordinates and builds networks, partnerships and collaborations leading to impactful actions.</p>
	<p>BC Cleantech Marketing Campaign Support key activities that market the broader BC cleantech industry, as well as sub-sectors and SMEs, to global markets and investment communities to drive and maximize trade and investment.</p>	
	<p>Collaboration & Partnerships Engagement Support key activities that mobilize strategic networks of BC, pan-Canadian and international partners (corporations, investors, accelerators, clusters) across 6 core sectors to fast-track adoption, scaleup, investments and exports for companies.</p>	

	PRIORITY PROGRAM RECOMMENDATIONS	BENEFIT
Talent	<p>Cleantech Education Program for Post-Secondary A program that formally connects industry and later stage SMEs to all post-secondary institutions, fostering talent development for the cleantech industry and developing cleantech leadership skills.</p>	<p>Future job growth and problem focused R&D for BCs core sectors.</p>
Market	<p>Local & Export Market Landscape Intelligence Program A program to support market intelligence sharing by providing up-to-date local and export market reports to industry.</p>	<p>Enabling targeted market activities supporting exports.</p>
Capital	<p>Company Profile Program A program to showcase profiles of companies on the CORE cleantech cluster website and a dedicated cleantech portal to support investment and business development activities.</p>	<p>Investment attraction by marketing of pre-vetted companies to investors and customers.</p>
Network	<p>Community & Regional Clean Economic Development Program A curated networking series of online and in-person events to support achieving clean economy and clean technology goals at the municipal level.</p>	<p>Knowledge and network exchange to support adoption of cleantech solutions.</p>
Technology	<p>Sector & Tech Roadmap Landscape Research-Report Program A program of research to review, communicate and revise technology adoption roadmaps to ensure key alignment with BC cleantech strengths, improve industry competitiveness and meet climate goals.</p>	<p>A mechanism to engage Helix-5 stakeholders on future cleantech projects to meet CleanBC goals.</p>
Policy	<p>Policy Cleantech Exchange Forum A program that curates multi-stakeholder events to share practical learnings, and offer market driven insights to policy and regulation modernization.</p>	<p>Cleantech innovation and technology is taken into account by policy-makers.</p>

01

Why Do We Need A Cluster?



1.1 Introduction

The cleantech industry is on a growth trajectory worldwide, and is being recognized as a foundational element driving the future global economy. Technology innovation is rapidly reshaping our economic landscape and impacting how we solve climate challenges. Today, we see how clean technologies such as software analytics, battery storage, carbon capture and utilisation (to name a few) can lower GHG emissions and reduce our environmental footprint while producing positive economic outcomes.

According to a report from Canada's Clean Technology Economic Strategy Table, Canadian cleantech exports are valued at \$7.8 billion and could reach \$20 billion by 2025.¹ Globally, it is expected that by 2022, the market for cleantech activity will reach \$2.5 trillion dollars.² British Columbia is well positioned to capitalize on these trends and capture a significant part of this growth-oriented market: 290+ of clean technology businesses have chosen the province as their home and an industry cluster is emerging.³ And there are already some great examples to be proud of with leadership in hydrogen and fuel cell deployment, carbon capture utilization and storage (CCUS) technology development, and projects that are a world's first, such as the fully electric air flight by local company Harbour Air.

In addition to industry leadership, emerging clusters and entrepreneurial success stories, cleantech is bolstered by progressive policy. The Government of British Columbia announced significant milestones for reduction of carbon emissions through the CleanBC plan, which includes new legislated targets of a 40% reduction in carbon emissions levels by 2030, and a 60% reduction by 2040, all with the baseline of 2007 levels.⁴

Economic development officers, municipalities, and regional organizations across the province - including Vancouver, Castlegar, Kamloops, Victoria, New Westminster, Prince George, Summerland, and many others - have created their own action plans and goals highlighting that a clean economy is central to their future economic development. Academic institutions and colleges are also starting to introduce policy, technical and practical courses supporting climate change mitigation and adaptation.





However, challenges remain. The pace of technology deployment, commercialization and industry adoption needs to accelerate if we are to meet local and global net zero goals. And while change is happening, there are silos between stakeholder groups and sectors that are impeding growth and hindering the adoption of cleantech solutions. A perception of high costs, the inertia of industry and conflicting policy across countries, provinces, and even local regions are slowing adoption curves. This makes validation of technologies slow, delays time-sensitive investment cycles for companies and projects, and sometimes puts a halt on promising commercialization projects. These pain points are known and understood by key stakeholders. The path forward requires new and more collaborative approaches.

The time is ripe for industry, SMEs, academia, investors and government to work collaboratively to achieve goals and overcome existing ecosystem gaps. Mobilizing resources at scale and with efficiency will help increase the pace of activity. This is why we need a cluster approach and a cluster organization.

The cluster organization will identify gaps, facilitate collaboration, and implement or recommend programs and projects that maximize the benefits of efficiency and scale. It provides the framework for the cleantech industry to take a strategic and powerful role in achieving the sustainability, climate and economic plans for the Province outlined in the CleanBC Plan.

Clusters are not a new concept. They are found across the world and are proven to be extremely effective mechanisms

for creating market collaboration between corporations and SMEs, increasing company growth, supporting jobs and attracting investment. At its simplest level, a cluster is a group of firms and institutions operating in the same sector that are in close geographical proximity to each other. Think of California's Silicon Valley, Bangalore's tech support hub, Detroit's auto region or even Vancouver's film industry.

Professor Michael Porter (leading academic on cluster theory) describes clusters as:

“... geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions (e.g. universities, standards agencies, trade associations) in a particular field that compete but also cooperate.”⁵

And despite the fact that the world is becoming more interconnected and most services can be obtained online, Porter points out that clusters still benefit from ‘knowledge, relationships and motivation’⁶ which exist within that close proximity.



1.2 Mandate & Scope

To understand the clustering opportunity for the cleantech industry in British Columbia, Foresight Clean Technology Accelerator undertook a research and stakeholder engagement project in late 2019, called the BC Cleantech Cluster Initiative. The project partners and funders for this initiative were Western Economic Diversification Canada, Government of British Columbia and Vancity.

This project is born out of the need for the government to better understand how to support the growing domestic clean technology industry as a means to achieve sustainability, climate and economic plans including the CleanBC Plan and pan-Canadian Framework on Climate Change. In Western Economic Diversification Canada's Grow West strategy, cluster development is highlighted as an area of interest to seed government investment for programs and achieve economic growth and in the Government of British Columbia's Technology and Innovation Policy Framework, one of the goals is to grow globally competitive industry clusters across the province.

To ground our perceptions of the emerging cleantech industry we collected data to determine the current gaps, commercialization challenges, investment cycles, technology strengths, industry progress and by doing so create a vision and cluster strategy that ties together common goals and objectives.

1.3 Our Research Process

To gather data, we framed our process with the following questions:

- Is there an emerging cluster of economic activities?
- Are these activities significant enough to have the desired impact on the economy?
- What are the characteristics, challenges and opportunities of the emerging cluster?
- What more needs to happen to help this take off?

To answer these questions, the team conducted an extensive combination of secondary and primary research to articulate:

1. Successful cleantech cluster models
2. Cleantech clustering opportunities in BC, including areas of expertise and specialization
3. Requirements of industry to scale up technologies and access talent, markets and capital
4. Projects and programs that will accelerate and support a growing sector

TABLE 1. METHODOLOGY



PRIMARY RESEARCH

In total, we engaged over 1000 stakeholders. Primary research was a mix of interviews and roundtables that were either regional, industry or stakeholder focussed. The team also attended over 20 sector specific conferences. (See Appendix A for detailed methodology)

SECONDARY RESEARCH

For secondary research, the team conducted an analysis and review of key reports and studies to help understand best practice in cluster development. In addition, the team analysed cleantech offerings from SMEs based in BC (250+) and mapped technology competency to market sectors. These assumptions on markets were then tested and validated through roundtable sessions and interviews. The team also consulted with Invest in Canada who shared data relating to cleantech investments in BC SMEs from the period 2016-2019.

GOVERNANCE

An advisory group of fifteen industry leaders representing industry, SMEs, government, academia and investors provided direction on the overall project, and important contextual and strategic information about the background and history of the regional cleantech industry. (See Appendix B for participants)

SECTION 2

02

Our Findings



2.1 Benefits of a Cluster

Our research into global cluster models shows that a market-driven and mission-oriented cluster provides great value for public and private funding partners. A cluster that is underpinned by an informed strategy provides a framework for effective programs and collaborative projects that result in economic advantages, such as job growth, talent retention and investment:

“Research demonstrates that regional economies with strong clusters have higher levels of innovation, more patents, more entrepreneurship, more successful start-ups, higher export and economy, higher wages and better productivity. Regions with strong clusters are particularly successful in attracting new investment and attracting talent”⁷

In Europe, cluster strategies have been deployed for over 20 years to meet economic and strategic objectives. A recent study by the European Observatory for Clusters and Industrial Change conducted an analysis of 2900 clusters, key findings (summarized in Figure 1) show how clusters are contributing to European economic competitiveness.

On average, regions with active cluster programs have higher wages, their startups are twice as fast to succeed and their companies are growing (77% of the companies across the 2900 clusters are hiring more than 20+ people per year).⁸

These metrics of success are a blueprint for what we want to achieve with the CORE Cleantech Cluster.



FIGURE 1. SUCCESS OF EUROPEAN CLUSTERS

KEY CRITERIA FOR A SUCCESSFUL STRATEGY

The lessons we have learned from other global clusters tell us the essentials for a cluster to thrive:

- **Aligning Strategies with Regional Strengths**

While there are best practices, there is no “one size fits all” model for cluster development. Clusters are successful when they are based on pre-existing activity and aligned with regional strengths. It is essential to know where regional strengths are and how these can add up to competitive advantages in domestic and international markets. Identifying these strengths to enable business linkages and growth will lead to a higher number of anchor companies and make it attractive for them to stay in their home market.
- **Creating a Market Driven Approach**

An approach that takes SMEs and industry needs into consideration is key, as these are the stakeholders who are creating wealth and jobs in regions. It's important for academia, government and investors to be aligned with this market driven approach in order to seed their role in an effective cluster.
- **Creating Value Early**

Cluster development is typically publicly funded in the initial one-to-three years and needs to demonstrate value to the constituents through their programs and services within a short time frame. Once the constituents start seeing value, they start to pay for the services and government funding can decrease, a sliding scale model.
- **Ensuring a Robust Governance Model**

A robust governance model that retains accountability to government funders, but also allows for impact-oriented, agile delivery is important. The governance structure should :

 - » Be representative of the Helix-5 (Industry, SMEs, Academia, Investors, Government)
 - » Include a Board to ensure funding and services are delivered effectively and
 - » Include sector specific advisory committees of experts to help prioritize sector activities.
- **Securing Commitment from Key Players**

It's essential to bring a diverse range of constituents together within each sector that feel galvanized and are committed to achieving economic outcomes. Whole system transformation requires (as much as possible) whole system collaboration. This will ensure that effective programs are designed and networks are created that foster talent, build skills and develop technology competencies that contribute to the economy over the long-term.
- **Aligning Cluster Strategy with Policy**

To be effective, a cluster must have strong and consistent alignment with national, provincial, and local green economy policies and strategies, while remaining an entity separate from government.
- **Developing Strong, Mission-Driven Branding and Marketing**

Crafting a brand early as an independent agent of change with a clear mission supports collaboration efforts, program activities and international marketing.
- **Developing Strategic Funding Models**

Leveraging both public and private capital to support cluster activities and programs that benefit the constituents of the cluster.

SUCCESSFUL CLUSTERS

While there was no single cluster that exactly mirrored the economy of BC, there were a number of global clusters in regions with economic similarities to British Columbia that have been particularly successful in creating public-private partnerships, driving impactful collaborations across sectors and generating economic growth.

GreenCape Cluster in South Africa's Western Cape province has been tremendously successful in creating jobs, mobilizing industry projects and attracting investment in key sector areas - renewable energy, waste and resources. Launched in 2010, the organization was set-up and seed funded by the local government. Given the country's underlying strengths and alignment of policy, their initial focus was on the renewable energy sector and activities undertaken were building networks, providing policy support to encourage renewable energy businesses to do business, building relationships with financiers and institutions, ensuring skills and training and driving local manufacturing of renewable energy components. Due to their success, they are now launching a Green Outcomes Fund to incentivize local South African fund managers to increase investment in green SMEs by paying for outcomes, such as green job creation, climate mitigation, and improved water and waste management.

Key Learning

By aligning their green policies with economic activity, this cluster facilitated \$1.6 billion in renewable energy projects and renewable energy manufacturing resulting in 2700 jobs over a 5 year period.⁹

TopSector Approach in the Netherlands has taken a highly collaborative and sector-based approach (the "topsector" approach). They identified a total of 9 Top Sectors (similar sectors to BC include Energy, Water and Agri-food). Their operational framework encourages collaboration between industry, academia and government (known as the Triple Helix) in order to promote innovation, attract talent, and ensure solid international presence in priority sectors. Each Topsector has a Board of Chairs that consist of representation from each partner. This Board is responsible for identifying priorities for each sector and disseminating these priorities to their associated stakeholders—consensus based decision making.

Key Learning

The sector-focused governance approach has resulted in adaptive and collaborative decision making and multiple successful private and public collaborations.

Bioindustrial Innovation Canada (BIC) initiative is a hybrid chemistry cluster in Sarnia-Lambton, Ontario, Canada. BIC is notable for three of the traits of a successful cluster initiative. Founded in 2008, they are industry-driven, university-fueled, and government-funded. Recognizing that the development of a sustainable chemical industry will require industrial partners, they have secured project-driven partnership agreements and funding with local and national industry partners, academia and government. Their focus on the bioindustrial and chemical sector was based on regional strengths and expertise.

Key Learning

This market and industry-driven cluster has resulted in 3600 jobs, and 20 collaborative projects, with significant economic impact across the Sarnia-Lambton region over the last 12 years.

Innovation Cluster in Peterborough, Ontario is focused on four key sectors: cleantech, agtech, healthcare and digital. Their model is entrepreneur-focused and centred on programs that ensure startups have space to innovate. The cluster is closely aligned with Fleming College's Centre for Advancement of Water and Wastewater Technologies (CAWT), and recently launched the Trent Makerspace located at Trent University, a world-class lab facility for clean-tech companies to produce, test and commercialize IP based biotechnology products.

Key Learning

Collaborations with academia, supportive programming and providing lab and testing facilities resulted in \$15 million in economic impact.

Greentech Cluster is an Austrian cluster with a robust public-private model, including 200 cluster constituents of anchor firms, SMEs and research institutions. In 10 years, they have more than tripled the sales of environmental products and services (making up more than 10% of GDP) and the number of employees has more than doubled. The Cluster has been awarded for excellent cluster management, the most innovative growth project in the EU (European Commission) and the No. 1 Environmental Technology Cluster worldwide (US ranking).

Key Learning

A 10 year robust funding model with public and private partnerships, combined with a strategic understanding of regional strengths and strong marketing and membership programs have resulted in large scale economic impact.

CLEAN is Denmark's green cluster with more than 170 members from the public and private sector and knowledge institutions. The cluster thematic areas of focus are energy, environment, smart city and internationalization. The services they provide range from internationalization support to support of technology transfer to facilitation of networking opportunities. When initiating the cluster, in 2010 - 2015, they attracted €20 million in public investment for programming and in turn created over 1000 jobs during that period. They have since established an association with a fee paying membership and robust governance model. Membership fees make up 8.5% of their total annual €7 million budget.

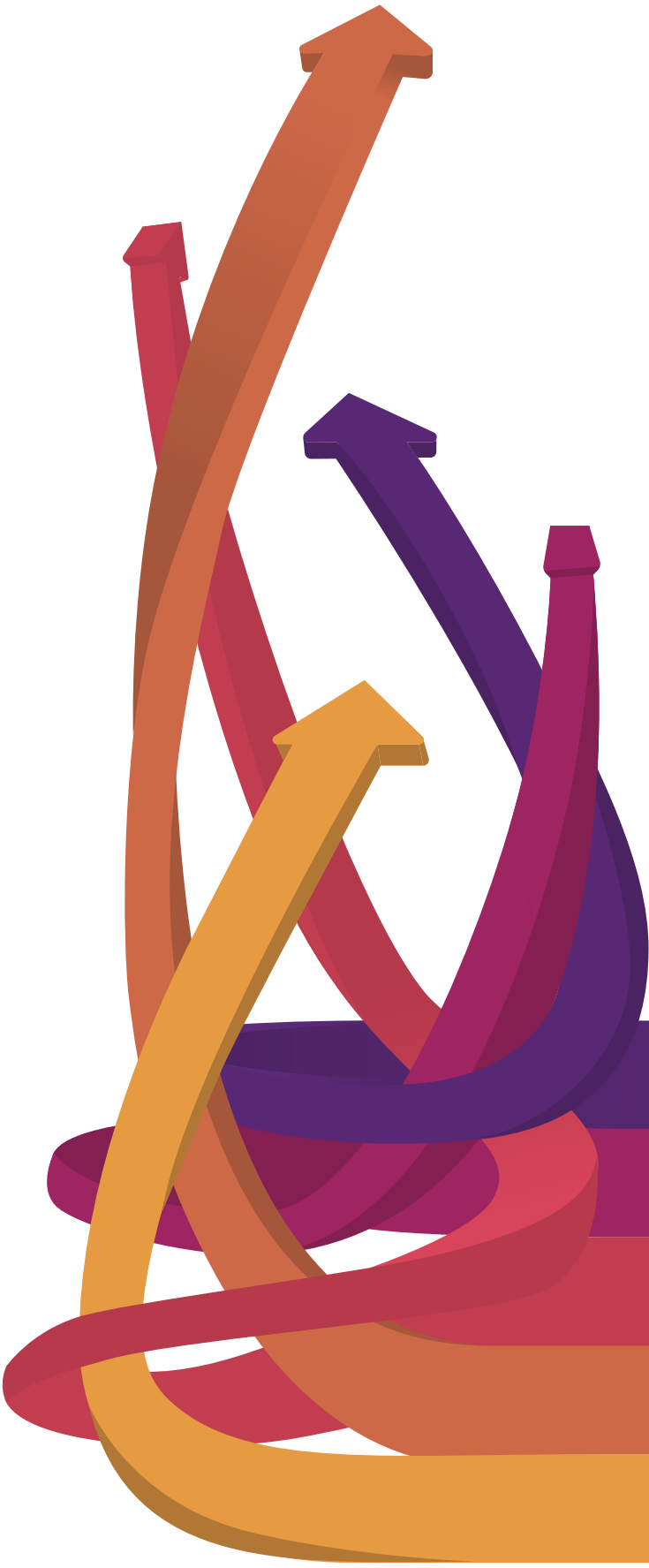
Key Learning

At launch, the government provided the bulk of upfront capital to support resourcing and launch of the cluster organization and brand. However, once programs were established and shown to provide value to cluster constituents, they transitioned to a successful fee for services.

VINNOVA, the Swedish Innovation Agency, is a global leader in cluster programs. Sweden's national innovation agency locks in funding of €1 million (approx CAD \$1.5 million) per year for 10 years to share with prioritized clusters, subject to a three-year review. Input for the review comes from the cluster management team, the cluster's Board, local businesses, academic and political leaders and the Vinnova program management team.

Key Learning

Committed funding partners, strong governance and strategic programming have resulted in large scale economic impact.



CLUSTER STAKEHOLDERS

While many clusters adapt a Triple-Helix model for stakeholder engagement focused on industry, academia and government (eg. TopSector, CLEAN and GreenCape clusters noted above), we are recommending expanding the stakeholder model to a “Helix 5” model that makes a distinction between SMEs and industry (taking into account differing needs as they scale) and introduces investors as distinct stakeholders (as we see them as key players for scaling and investing into the ecosystem).

This unique model is tailored to the needs of the BC market and was developed based on our analysis of the cleantech ecosystem in the province. This expanded stakeholder model allows a highly targeted approach to scale and mobilize resources for collaborative cleantech projects and programs.

Leveraging government funds to attract venture capital (VC) plays a crucial role in helping clusters scale-up by providing necessary resources for research, development and deployment. For example, Silicon Valley is a well-known technology cluster but it is also recognized as the place to go for VC funding.

Outlined in Table 3 below is the role of each stakeholder group in the CORE Cleantech Cluster and the benefits of their participation.

INDUSTRY

INVESTORS

SMES

ACADEMIA

GOVERNMENT

TABLE 3. ROLE OF HELIX-5 IN A CLUSTER

GROUP	ROLE IN CLUSTER	BENEFITS
<p>Industry (Industry is corporations with employees >500 and industry associations)</p>	<p>Partners with SMEs and academia on collaborative projects with targeted technology development and deployment, and provides access to facilities. A paying member of the cluster. Part of governance model.</p>	<p>Access the latest innovations, technology and learnings to deploy on sites or as part of a new business strategy to maintain competitiveness. Opportunities to learn from parallel initiatives.</p>
<p>Academia (Postsecondary Institutions and Knowledge Centres)</p>	<p>Partners with SMEs and industry on targeted R&D and provide access to facilities. Fosters talents to enable a competitive economy. Part of governance model.</p>	<p>Gain a reputation for fostering talent to attain jobs. Understand sector needs and train students either at university or technical college to meet the skills required. Access opportunities for collaborative research projects.</p>
<p>Government</p>	<p>Understands sectors needs. Can adapt flow of funding or programs according to direct needs or towards parallel initiatives that elevate competitive advantages and create jobs. Part of the governance model and a potential funder of the cluster.</p>	<p>Realize a value for money model of deploying public resources and capital to support clean economy, grow jobs and align policy. Access greater information on the cleantech sector. Ensure companies are anchored and grow locally. Invest in economic development and diversification. Diversify and increase export base and tax revenue.</p>
<p>Investors</p>	<p>Provides private capital perspective. Takes part in networking events, selects investor match-making programs and governance model. A paying member of the cluster. Observes companies for investability.</p>	<p>Access to deal flow, investable companies and latest innovations. Leverage private capital to public funding and resources. Invests in company growth and projects. Access greater information on the cleantech sector.</p>
<p>SMES (Startups and SMES <500 employees)</p>	<p>Utilizes programs and services of the cluster to drive company growth and accelerate commercial opportunities. Engages with committed investor and capital networks. Works with other Helix-5 stakeholders on projects, programs and initiatives. A paying member of the cluster. Part of governance model.</p>	<p>Lessen the time to validate technology, get to market and raise capital. Access to programming and projects to support technology development and commercialization and pilot and deployment with industry and government buyers to enable growth. Access to investor networks. Access to a larger talent pool from which to draw. “Co-opetition” with other SMEs.</p>

2.2 Building on BC Strengths

There is no 'one-size fits all' cluster framework. It's clear that for a cluster strategy to be successful, it must be unique and designed in response to a deep understanding of the economic activities and strengths of the region, and how they might be aligned with stated economic, climate and sustainability goals.

CLEANTECH INDUSTRY

Our research confirmed that cleantech in BC is clearly a growing industry. From nascent beginnings in 2006 with just 70 companies, it has grown four fold since then to 290+ companies. It is still a young industry, with around two thirds of organisations less than 10 years old.¹⁰ But with over 22,000 BC based jobs in the sector today with an average salary of \$78,000 the industry is starting to make its mark.¹¹ What's more, BC cleantech companies are gaining international recognition by being consistently included on the Global Cleantech 100 list - 55% of Canadian companies on the 2020 list (7 out of 12) come from BC.¹² From 2017 - 2019, \$3.4 billion of cleantech deals took place in the province.

To get a more detailed understanding of BC's clean technology strengths, the CORE Cleantech Cluster team has crafted a matrix of technology competencies, gaps, competitive advantages and ecosystem players mapped to six market sectors - Built Environment, Water, Agriculture & Food, Energy, Transportation and Natural Resources. See Section 4 for an in-depth analysis.

Overall, British Columbia is now home to one-third of Canada's cleantech companies. This is a result of having a solid underpinning of academic and technical institutions, favourable government innovation programming and strong research and development activities. This good-news story illustrates the potential, as it has led to leading companies and research institutes spinning out new cleantech ventures, attracting international and Canadian public sector capital as well as attracting new actors in related activities to the region.

Cleantech in BC is primarily an export market - 87% of revenue is expected to be generated outside of the province in the next 3-5 years.¹³ Often technology validation takes place in BC but scales elsewhere as most often the demand for solutions in BC and Canada is not mature or strong enough to become a core market.

Proximity to the USA, the Cascadia Innovation Corridor and relatively easy trade links and relationships with Asia is a strength. This is bolstered by the Cleantech Economic Strategy Table recommendation for the government to support the cleantech industry in meeting 20 billion in cleantech exports by 2025.¹⁴

All this activity denotes an emerging cluster and we are starting to see the early stages of the benefits, such as spinoff companies, talent retention, increasing number of jobs in the sector and attraction of capital. In this section we outline our regional strengths, ecosystem challenges and opportunities to overcome gaps.

BC CLEANTECH SNAPSHOT

290+

COMPANIES

22,000

JOB

\$3.2 B

IN CONTRIBUTIONS TO BC'S GDP.
INCREASE OF 6.1% SINCE 2017

\$78,000

AVERAGE SALARY

30%

GROWTH IN CLEANTECH
EXPORTS SINCE 2012

55%

OF THE CANADIAN COMPANIES ON GLOBAL
CLEANTECH 100 LIST ARE FROM BC

\$3.4 B

IN CLEANTECH DEALS (2017-2019)



INVESTMENT ATTRACTION

AVL, headquartered in Austria, is one of the world's largest companies focused on development, simulation and testing technology of powertrains (hybrid, combustion engines, transmission, electric drive, batteries and software) for passenger cars, trucks and large engines.

In 2018, they invested in a technology centre in Burnaby to capitalize on local expertise in hydrogen and fuel cell development. The centre now performs cutting edge fuel cell research and development for multiple automotive applications.

The AVL Fuel Centre in Burnaby employs fuel cell experts experienced in technology development, engineering, simulation, testing, software development, and system integration.

REGIONAL CONSIDERATIONS

Approximately 70% of clean technology companies in BC are headquartered in the Lower Mainland. This is where the bulk of clean technology activity in terms of research, development and deployment of projects. This is primarily because of proximity to customers, investors, research and facilities.

Some of the area's known competitive advantages are global leadership in the hydrogen and fuel cell industry with established markets in Asia and Europe. This is a success story born out of early government investment that is paying off.

Another strength is the industry and SME collaborative projects underway to support technology commercialization and adoption in the region. For example, Project Greenlight, initiated by the Vancouver Economic Commission, is a collaborative industry demonstration project. The project brings together key asset owners in the Metro Vancouver region (including TransLink, City of Vancouver, City of New Westminster, Quadreal and FortisBC), to identify and adopt solutions that meet their sustainability objectives. By allowing emerging cleantech companies access to assets and infrastructure (i.e. buildings, streets, vehicles, digital infrastructure) for product testing and showcase opportunities, it helps accelerate the commercialization of their technology, attract investment and gain traction and sales in the marketplace.

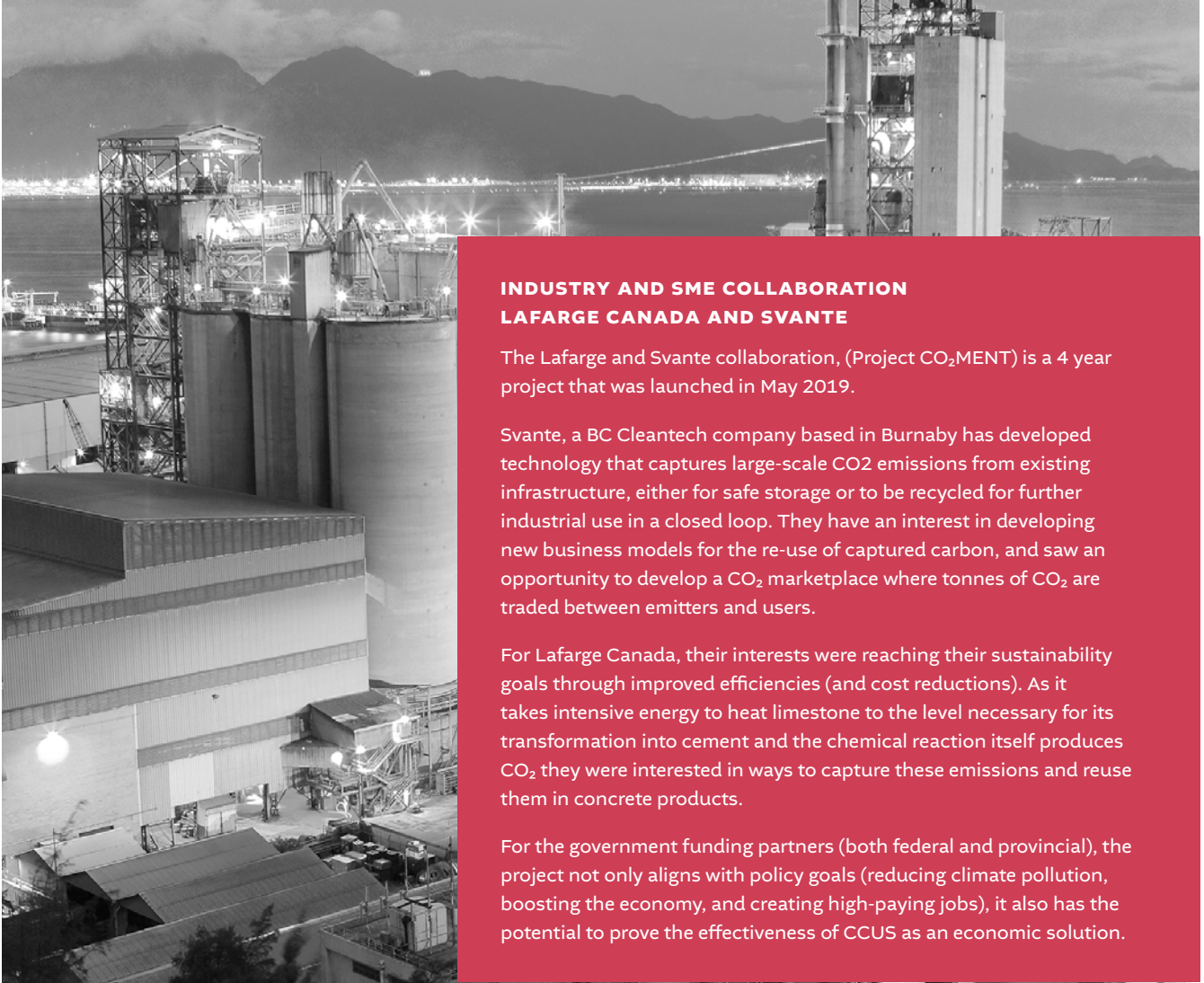
The region is also starting to emerge as a leader in Carbon Capture, Utilization, and Storage (CCUS) development due to the proximity of the Carbon Capture and Conversion Institute as well as a combination of commercial SMEs in the province, such as Svante, Carbon Engineering and CarbonCure.

Significant CCUS projects are underway, for example, LaFarge Canada, one of the largest cement producers, based in Richmond BC, partnered with Svante, a carbon capture and utilization cleantech company to develop and demonstrate

the first full-cycle solution to capture and reuse CO₂ from a cement plant while also reducing greenhouse gas emissions. The funders for this project partnership are CCP (CO₂ Capture Project), the Province of BC, and Canada's federal government through the National Research Council of Canada Industrial Research Assistance Program (NRC IRAP), LaFarge Canada Holcim and international energy company Total.¹⁵

MAP OF CLEANTECH HOTSPOTS IN BRITISH COLUMBIA





INDUSTRY AND SME COLLABORATION LAFARGE CANADA AND SVANTE

The Lafarge and Svante collaboration, (Project CO₂MENT) is a 4 year project that was launched in May 2019.

Svante, a BC Cleantech company based in Burnaby has developed technology that captures large-scale CO₂ emissions from existing infrastructure, either for safe storage or to be recycled for further industrial use in a closed loop. They have an interest in developing new business models for the re-use of captured carbon, and saw an opportunity to develop a CO₂ marketplace where tonnes of CO₂ are traded between emitters and users.

For Lafarge Canada, their interests were reaching their sustainability goals through improved efficiencies (and cost reductions). As it takes intensive energy to heat limestone to the level necessary for its transformation into cement and the chemical reaction itself produces CO₂ they were interested in ways to capture these emissions and reuse them in concrete products.

For the government funding partners (both federal and provincial), the project not only aligns with policy goals (reducing climate pollution, boosting the economy, and creating high-paying jobs), it also has the potential to prove the effectiveness of CCUS as an economic solution.

This is an example of industry and SME collaboration that is demonstrating a business case for GHG reduction and leveraging public funds to attract strategic private capital. The captured carbon can be utilized by companies such as CarbonCure and others. This is a blueprint model of collaboration that should be replicated.

It is important to note that activity is not just limited to the Lower Mainland. Our research uncovered cleantech activity and early cluster development taking place regionally. These activities are designed to leverage their competitive advantages, attract talent and investment:

Prince George

The city of Prince George has an established cleantech cluster and is home to 70 clean technology firms - the majority of which are focused on bioeconomy and land management. This cluster is underpinned by many competitive advantages in the region including facilities like the UNBC biomass gasification system, the City's downtown renewable energy system, the Wood Innovation Research Lab and companies like Canfor and Pacific Bioenergy. The cluster was formalized in 2018 by the economic development office at the City of Prince George in partnership with Community Futures Fraser Fort George.¹⁶ The cluster markets the activity of the firms internationally to increase business transactions as well as working to attract and foster talent, and provide market intelligence to interested groups.

Impact: \$1.5 million in additional business activity in Prince George.



OPEN OCEAN ROBOTICS - ONE TO WATCH

Open Ocean Robotics, based in Victoria, BC, produces energy-harvesting unmanned autonomous boats equipped with sensors and cameras to make oceanic observations and instantly relay them. Using solar or wind power, their boats produce no greenhouse gases, noise pollution or risk of oil spills, and can travel non-stop for a year, always on and always collecting information, transforming how we research and protect oceans. The company was recently highlighted on the One-to-Watch list by Cleantech Group. They are part of Foresight Cleantech Accelerator's Launch program.

Trail

Metal Tech Alley is a cluster based in Trail, initiated by the Lower Columbia Initiative Corporation in 2017.¹⁷ As part of their economic development strategy, they developed a cluster that embraces the unique strengths of the area, specifically metallurgy and technology. It was initially co-funded by the government and industry with an emphasis on marketing local services to attract technology providers and talent to strengthen the cluster. Their programs and facilities focus on digital fabrication, advanced metallurgy, industrial recycling and circular economy.

Impact: Multiple value-added metallurgical products now being produced in the region. Supported 20 jobs since initiation. Regional talent retention: highest number of Phds per capita in BC.

Vancouver Island

On Vancouver Island, there is growing interest in cleantech and ocean technologies. The Vancouver Island Economic Developers Association (VICEDA) based north of the Malahat developed a technology attraction strategy in 2018. Their analysis shows clean technology is identified as a key area of growth to leverage existing assets. In addition to that, a newly established Ocean Futures Cluster and Marine Innovation Hub in Victoria is being set-up to capitalize on the region's significant and emerging strengths in marine and maritime industries, ocean science, technology and environmental innovation.

Impact: Cleantech companies emerging from this region working in water, data and oceans.

Okanagan

In the Okanagan region, there is demonstrable activity taking place in the built environment sector. A group of architects, academics and SMEs are working together to create a local initiative for advanced building products, leveraging the expertise and education programs from both Okanagan College and UBC Okanagan. They hosted a first event called "Building Net-Zero" in February 2020 to start focussing their activities. This has early promise for cluster development, harnessing the expertise of local knowledge centre activity.

Impact: Potential impact is high for reducing GHG emissions through promoting green building technology and practices in the region. Also high economic potential for trades training and developing local expertise.

First Nations (Province Wide, Rural & Urban)

Across the province, there is great potential for the cluster model to unlock co-benefits for First Nations communities. Utilizing existing assets (e.g. land, forestry licences, buildings) for clean technology deployment was of interest to the groups engaged in this cluster consultation process. A cluster program that takes into account indigneous economic development, development of local jobs, talent and skills that would stay in the community, and co-ownership of the technology is a compelling opportunity to achieve environmental and economic outcomes.

To date, the BC Indigneous Clean Energy Initiative, financially supported by the Federal and BC Government, supports deployment of renewable energy and energy efficiency projects. There could be opportunities to expand beyond a clean energy remit to include deployment of clean technologies that provide co-benefits.

Impact: Potentially high, particularly in renewable energy, water technologies and rural economic development.

British Columbia

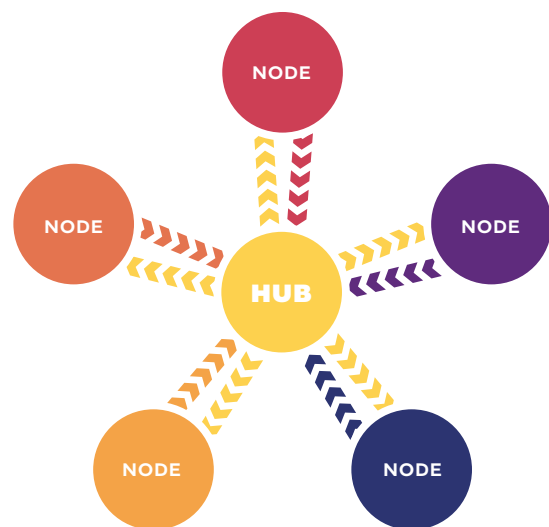
BC is the homebase of the Federal Digital Technology Supercluster, presenting funding opportunities for capacity building and collaborative projects advancing digital technology in key sectors including Natural Resources and Digital Twins. Digital technology is becoming ubiquitous across sectors and a number of software companies are operating in the cleantech sector. These programs have potential to deploy capital to digital technology that increases efficiencies and present environmental and economic benefits.

Impact: Potentially high, plug in a funnel of digital clean-tech related projects for funding consideration.

Overall, we found the regional economic development officers, associations, community managers and cluster managers in regions across the province very engaged. All groups will be invited to participate in the CORE Cleantech Cluster network to share learnings and develop collaborative projects in their locality that can support industry transformation, company retention, talent attraction and job growth. This is part and parcel of the cluster approach we are proposing - a distributed hub and node model designed to connect and mobilize innovation in these regional clusters while achieving province-wide, economic and sustainability goals.

The CORE Cleantech Cluster Strategy for BC will mobilize, accelerate and give structure to the multiple relationships within these regional clusters and strategically connect them into a meta-cleantech network - an ecosystem. It fills in a myriad of network gaps (see section 2.3 below).

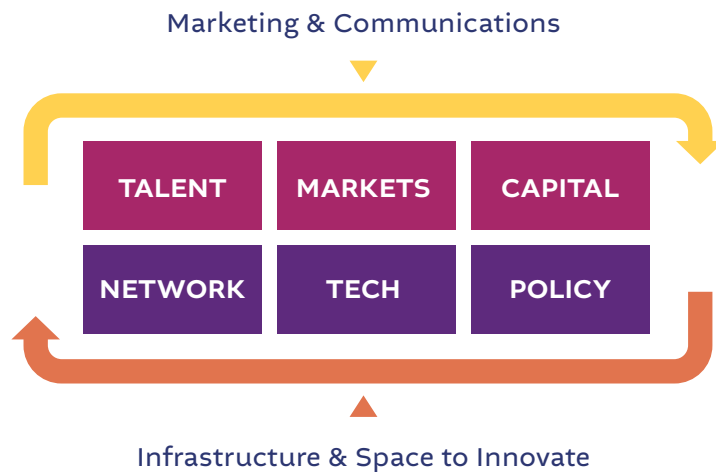
FIGURE 1: DISTRIBUTED HUB & NODE MODEL



2.3 Gaps And Opportunities To Enhance Competitiveness

Although there are promising collaborative projects happening and signals, such as the emergence of regional economic clusters and initiatives, in order to deliver a clean economy domestically and grow the export market, we need to first overcome a number of gaps. In overcoming these gaps we also reveal opportunities to enable cleantech at scale and elevate the role of cleantech in solving the hardest problem faced by industry today - transitioning to a low carbon economy while maintaining competitiveness.

FIGURE 2: CORE ECOSYSTEM FRAMEWORK



The overall approach and framework needed to accomplish these goals must reflect the characteristics of the emerging cleantech economy and the complex, dynamic relationships that cluster stakeholders have with each other including the locations where they interact - an ecosystem framework that connects and energizes multiple networks.

In Table 4, is an outline summary of gaps, rationale and opportunities built on this ecosystem framework. This forms the basis of the CORE Cleantech Cluster Strategy program recommendations that will help us to overcome ecosystem gaps and establish BC as a global hub of cleantech innovation. It is recommended these gaps and opportunities will be evaluated using the framework on an annual basis.

TABLE 4. ECOSYSTEM GAPS

GAPS	RATIONALE	OPPORTUNITIES
<p>Talent</p> <p>Leadership Talent & Problem Focused R&D</p>	<p>There is limited access to leadership, senior business and marketing talent creating a big issue for SMEs and industry alike. This hinders the growth of SMEs and cleantech adoption by industry. There is also a need to connect industry needs with budding entrepreneurs and innovators, giving early startups a higher chance of success.</p>	<p>Attract leadership to the sector to help companies anchor in BC and grow. Connect industry and cleantech senior leadership with postsecondary institutions.</p>
<p>Market</p> <p>Industry Engagement Across Sectors</p>	<p>A large amount of effort, time and cost goes to networking, relationship building and finding strategic industry partners in-province, interprovincially and internationally to buy cleantech.</p>	<p>Prioritize a market driven approach to business development. Develop partnerships and leverage programs to attract local, pan-Canadian and international industry and support export.</p>
<p>Capital</p> <p>Scale-up Capital for Companies and Projects</p>	<p>There is an insufficient amount of scale-up capital (venture and debt) for both companies and projects. Later stage venture capital and strategic corporate partners to support cleantech company growth is absent. Strategic capital is needed to support project development.</p>	<p>Develop an integrated capital plan for BCs cleantech industry. Attract venture and strategic capital from domestic and international markets for companies and projects.</p>
<p>Network</p> <p>Coordination and Partnerships</p>	<p>Siloes exist in the cleantech industry, in-province, interprovincially and internationally, and between Helix-5 stakeholders across sectors. These siloes are stifling the scaling up and deployment of cleantech innovation. While networks of activity are forming to support the cleantech industry, since they are all at different stages, there is a lack of information sharing occurring between sectors (and in some cases within sectors). As a result, opportunities are missed, and time for effective collaboration and market intelligence sharing is not prioritized. Collaboration is seen as time consuming and is often not accounted for in budgets.</p>	<p>Establish a cluster organisation with a dedicated team to bridge network and information silos, gather up-to-date market intelligence and seed collaboration within and across sectors that bring about co-benefits.</p> <p>Help everyone working towards CleanBC goals and enhance programs to link parallel opportunities and activities.</p>

GAPS	RATIONALE	OPPORTUNITIES
<p>Technology</p> <p>Alignment of Industry to Deploy Solutions</p>	<p>Limited financing and incentives are available to support later stage SMEs with technology deployment and for industry to adopt solutions. A roadmap will help to amplify needs and existing programs can be tailored. Missing strategic alignment of medium and large industry partners in-province to support technology deployment.</p>	<p>Develop and communicate roadmaps to encourage adoption of technologies across sectors. Technology roadmaps should reflect the needs of industry and benefit SMEs and other Helix-5 stakeholders by allowing them to identify and align with the industry needs. This supports industry adoption of solutions and harnesses talent to drive a thriving ecosystem. Communicate roadmaps widely to align industry and attract funders to invest in clean technology.</p>
<p>Policy</p> <p>Regulation, Policy and Incentives</p>	<p>While the CleanBC plan is presenting a market opportunity, regulatory barriers exist to achieve the “how”, resulting in a significant gap between targets and implementation. Industry and stakeholders are on-board and aligned with CleanBC and wider sustainability targets, however, existing policy and incentives can make it hard to develop a business case to craft collaborative projects. This is a missing link.</p>	<p>Iterate on policy, market, regulatory incentives to achieve CleanBC plan and net-zero carbon economy. Bring the voice of the cleantech innovation economy and ensure it is taken into account by policy-makers.</p>
<p>Marketing & Communications</p> <p>Showcasing BC Cleantech Industry Globally</p>	<p>British Columbia is not a known global hub of clean technology talent and expertise internationally. This is a lost opportunity to market our potential to attract talent and investment. Most cluster engagement participants thought organizations are not sharing success stories or utilizing market intelligence to attract private sector interest in BC cleantech.</p>	<p>Put BC cleantech on the global map by having a known agent of change who is the amplifier of cleantech success stories, case studies and market intelligence to support expansion of BC cleantech globally. Implement a strategic, mission driven approach to branding and telling the story of BC as a cleantech powerhouse.</p>
<p>Infrastructure</p> <p>Space to Innovate</p>	<p>There continues to be challenges in accessing land and infrastructure, including land for pilot testing, manufacturing facilities and lab space in urban areas.</p>	<p>Provide affordable access to office space, and labs and facilities to free up operational costs. Design a new pass system to access a wide range of facilities that support testing and accelerate technology validation.</p>

Overcoming these innovation gaps will enable a competitive advantage for BC. and as a result we will attract more talent, investment and partnerships to support our cleantech industry.

03

A Forward Plan 2020-2025

The CORE Cleantech Cluster has a unique made in BC strategic plan that takes inspiration from regional strengths, competitive advantages and challenges, market opportunities and learnings from global cluster approaches. This section outlines a 5 Year strategy with foundational and program recommendations.



3.1 Strategy

The vision, mission and operative framework is the backbone of the CORE Cleantech Cluster. The BC cleantech industry is promising for the economy, as emerging industries yield the highest potential for future growth and competitiveness of firms, especially SMEs.¹⁸

VISION

By 2030, the province of British Columbia will have an established Cleantech Cluster with a global reputation for rapidly building, scaling and anchoring technology companies that address climate change, enhance competitiveness and deliver shared sustainable prosperity through collaborative initiatives, ultimately supporting quality jobs and attracting investment to the region.

MISSION

Our mission is to support a clean economy and position BC as a global centre for innovation, talent and capital to scale cleantech innovation. The activities will be based on a collaborative Helix-5 cluster model that fosters partnerships with 5 key stakeholders groups - industry, SMEs, academia, investors and government. The cluster supports economic development goals of job growth, company growth, investment attraction and trade opportunities, by identifying gaps, facilitating engagement, and developing collaboration opportunities through an internationally recognized cleantech cluster.

GOALS

Our five measurable goals align with the mission and vision of the CORE Cleantech Cluster.

TABLE 5. GOALS OF CORE CLEANTECH CLUSTER

GOALS	MEASURABLE
Strengthen local and global partnerships to accelerate activities for a clean economy	Number of Partnerships
Showcase BC as a place to invest in clean technology companies and projects	Amount of Capital Attracted
Facilitate and engage stakeholders for impactful collaborative cleantech projects in BC	Number of New Projects
Foster talent and skills for cleantech commercialization and scale-up in BC	Number of Jobs Created
Promote opportunities and programs to increase international exports	Increase in Export Revenue

STRUCTURE

The CORE Cleantech Cluster will be a distributed hub and node model that serves all the regions in BC where strengths that can be leveraged into cleantech industry competitive advantages. As highlighted in section 2.2 regional stakeholders across BC are interested in the partnership opportunities and benefits the CORE Cleantech Cluster can bring to their locality. It is assumed that the CORE Cleantech Cluster will be initially incubated by Foresight Cleantech Accelerator.

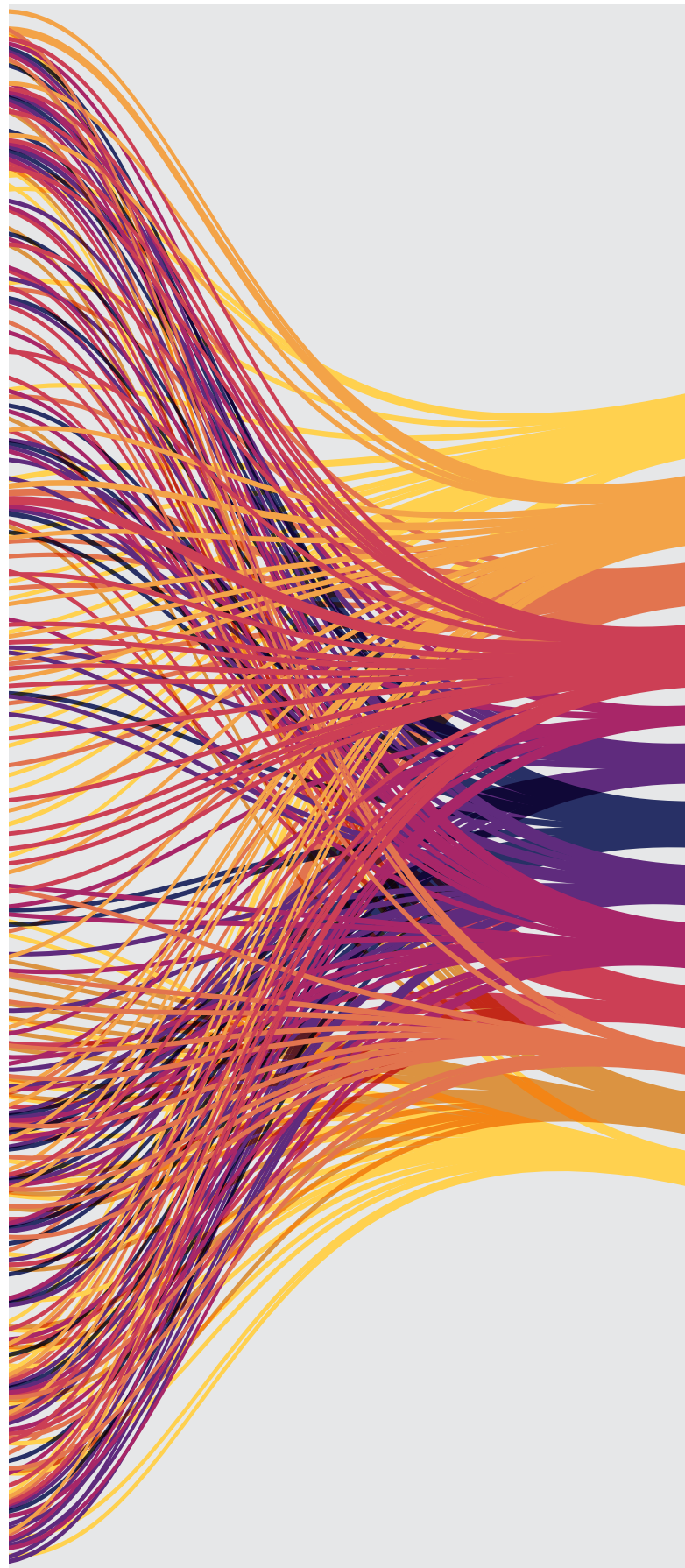
The cluster model will be seeking initial funding contributions from stakeholders, and once value is demonstrated to the cluster constituents, it will move to a sliding scale funding model. Constituents of the cluster will pay for the services provided through a combination of membership fees and additional income may come in the form of specific industry and government related projects.

STAKEHOLDER MODEL

Our Helix-5 model of stakeholder engagement will enable effective partnerships and collaboration. This model is different and unique as it makes a distinction between SMEs and industry (taking into account differing needs as they scale) and the introduction of investors, who are key players for scaling and investing into the ecosystem. This form of collaboration is designed to promote innovation, attract talent, and ensure solid international presence in six priority sectors: Built Environment, Energy, Natural Resources, Transportation, Water and Agriculture and Food. Regular engagement with stakeholders will help to maintain a flexible approach to our strategy to enable us to adapt to market needs.

GOVERNANCE AND MANAGEMENT

The governance structure will be an Advisory Board with Helix-5 representatives. This Advisory Board is responsible for ensuring funding and services are delivered effectively. In addition to this, sector specific advisory committees of experts will be established to help prioritize program activities across six sectors. This structure also allows for impact-oriented and agile delivery. For the management of the CORE Cleantech Cluster, a small executive team is proposed with experience and leadership in fostering growth in the cleantech industry, who can build relationships and identify and curate projects that benefit the constituents of the cluster.



Now is the time when western Canadians must work together to tackle challenges and explore creative ideas for growth. We need to better connect with one another, as well as grow partnerships across Canada and the world.

- Western Economic Diversification Canada “Grow West: The Western Canada Growth Strategy”, 2019



3.2 Program Recommendations

To foster the growth of this cluster from emerging to established, it is essential to lay a solid foundation and put in place programs and activities to address the ecosystem gaps. Cluster organizations and their managers bring together cluster stakeholders to work together to pool resources, reduce duplication, and produce winning initiatives and outcomes that benefit all.

CREATING VALUE EARLY

Successful clusters take time and it's critical to lay the foundations properly. To demonstrate value, showcasing early tangible benefits for the cluster constituents is key. Early projects that deliver this include access to communications and marketing tools, cost reduction of accessing services and space, developing new business opportunities and commercial collaboration as well as hosting regular events.

In terms of early value creation, the foundational and priority program recommendations will produce benefits relatively quickly by:

- **Establishing meaningful connections for the cluster constituents with interested industry customers, investors and academic partners.**
- **Connecting job seekers with roles and therefore increasing jobs in the sector.**
- **Marketing the industry through an extensive campaign.**
- **Implementing market and technology landscape projects to set a precedent for engagement with Helix-5 groups and help identify meaningful and collaborative projects across six sectors.**
- **Supporting the cluster team in developing a sustainable funding model.**

Other key recommendations complement activities and are part of a complete 5 year plan.

TABLE 6. CORE CLEANTECH CLUSTER RECOMMENDATIONS

	FOUNDATIONAL RECOMMENDATIONS	BENEFIT
Foundation	<p>Cluster Foundation Formally establish the CORE Cleantech Cluster team and governance model.</p>	<p>An official and dedicated hub for cleantech in BC that coordinates and builds networks, partnerships and collaborations leading to impactful actions.</p>
	<p>BC Cleantech Marketing Campaign Key activities that market the broader BC cleantech industry, as well as sub-sectors and SMEs, to global markets and investment communities that can drive and maximize trade and investment.</p>	
	<p>Collaboration & Partnerships Engagement Key activities that mobilize strategic networks of BC, pan-Canadian and international partners (corporations, investors, accelerators, clusters) across 6 core sectors that fast-track adoption, scaleup, investments and exports for companies.</p>	
	PRIORITY PROGRAM RECOMMENDATIONS	BENEFIT
Talent	<p>Cleantech Education Program for Post-Secondary A program that formally connects industry and later stage SMEs to all post-secondary institutions, fostering talent development for the cleantech industry and developing cleantech leadership skills.</p>	<p>Fosters talent, supporting future job growth and ensuring problem focused R&D for BCs core sectors.</p>
Market	<p>Local & Export Market Landscape Intelligence Program A program to support market intelligence sharing by providing up-to-date local and export market reports to cleantech industry</p>	<p>Supports targeted business development activities and project development.</p>
Capital	<p>Company Profile Program Showcase profiles of companies on the CORE cleantech cluster website and a dedicated cleantech portal to support investment raising and business development activities. This will also support the marketing campaign activities.</p>	<p>Attracts investment by marketing pre-vetted companies to investors and customers.</p>
Network	<p>Community & Regional Clean Economic Development Program A curated networking series of online and in-person events to support delivery of clean economy and clean technology goals at the municipal and regional level.</p>	<p>Enables knowledge and network exchange to support adoption of cleantech solutions.</p>
Technology	<p>Sector & Tech Roadmap Landscape Research-Report Program A program of research to review and revise technology adoption roadmaps to ensure key climate goals are met.</p>	<p>Offers a reliable mechanism to engage Helix-5 stakeholders on future cleantech projects to meet CleanBC goals.</p>
Policy	<p>Policy Cleantech Exchange Forum A program of events or webinars that curates multi-stakeholder events to share practical learnings, and offer market driven innovation insights to policy and regulation modernization.</p>	<p>Ensures cleantech innovation and technology is taken into account by policy-makers</p>

	PRIORITY PROGRAM RECOMMENDATIONS	BENEFIT
Talent	<p>Cleantech Talent Matchmaking Initiative A program to match-make people with diverse skills and talent with growing cleantech companies.</p> <p>International & National Talent Program Attract senior talent pan-Canada and international to work with cleantech companies to advise on export market and capital raising.</p>	<p>Increases in jobs in the cleantech industry.</p> <p>Helps BC cleantech companies grow.</p>
Market	<p>Portal for BC Cleantech Data An online web portal of BC cleantech companies and key data points for customers, investors and trade services to get the most up-to-date market intelligence.</p> <p>Tailored SME Sector Missions A program to leverage existing trade mechanisms and tailor them for the cleantech industry, including online roundtables and trade missions with targeted international audiences to support industry adoption.</p>	<p>Increase in connections with customers and number of cleantech projects deployed.</p>
Capital	<p>Investor Matchmaking Program Curate a program of tailored investor match-making events (either online or in-person) leveraging existing resources.</p> <p>Federal & Private Sector Capital Matching Program A program focused on engaging Federal agencies, global investment groups and strategic industry partners to properly capitalize all cluster programs and projects.</p> <p>Tailored SME Investor Mission A program to leverage existing trade and invest mechanisms to curate targeted missions to support company investment.</p>	<p>Supports uptake of existing program mechanisms by utilizing market intelligence to support capital raising activities.</p>
Network	<p>First Nations Clean Technology Capacity Building Program Support a program that builds on the recent cluster team's engagement with First Nations communities starting with a knowledge hub to accelerate deployment of cleantech solutions in indigenous communities in BC.</p> <p>Virtual & Live Networking Series A curated networking series of online and in-person events, pitches and panels to build relationships across Helix-5 stakeholder groups.</p> <p>Annual BC Cleantech Conference Establish an annual event with a strong investor and industry attraction focus to showcase BC as a global hub for cleantech.</p>	<p>Coordinates and builds networks across communities and sectors to support co-benefits.</p>
Technology	<p>Integrated Cleantech Adoption Program A program working with industry / SMEs/ academia/ investors in Canada and internationally to identify opportunities for cleantech adoption and facilitate connections.</p> <p>Facility Access - CleantechPass Program Establish the cleantech pass facility access program for companies to access R&D and testing facilities at preferential rates.</p>	<p>Improves cost and time for technology validation.</p>

3.3 Evaluation

As the CORE Cleantech Cluster is currently classified as emerging (or growing), it is important to use performance metrics that fit within a 3 to 5 year cycle. The suggested evaluation criteria for CORE Cleantech Cluster are:

TABLE 7. EVALUATION METRICS

Number of Partnerships	Number of commercial partnerships established as a result of cluster activities and programs
Investment Attraction	Amount of capital attracted to BC as a result of cleantech cluster activity and targeted programs
Number of New Projects	Number of new projects established as a result of cleantech cluster activity and targeted programs
Number of Jobs Created	Number of jobs created as a result of cleantech cluster activity and targeted programs
Increase in Export Revenue	Export revenue increases as a result of international marketing and facilitated networking opportunities

To enable us to continue to learn best practice, the CORE Cleantech Cluster is a full member of the International Cleantech Network (ICN). This is an exclusive global network of cleantech clusters, aiming to generate new business opportunities, enhance competitive advantages and create value for companies, knowledge institutions and local authorities across cluster regions.

One of the purposes of becoming a member is to learn best practice in cluster management. For example, members of ICN are leading cleantech clusters like CLEAN in Denmark and Green Tech Cluster in Austria that have achieved Gold level certification from the European Secretariat of Cluster Analysis for cluster management.¹⁹ These excellence labels are based on the structure of the cluster, governance, financing, strategy and services and recognition and are valuable to learn from.

04 Driving Competitiveness Across Six Sectors

To get a more detailed understanding of BC's clean technology strengths, the CORE Cleantech Cluster team consolidated technology competencies, gaps, competitive advantages and ecosystem players mapped to 6 market sectors - Built Environment, Energy, Natural Resources, Transportation, Water and Agriculture and Food.



4.1 Sector Analysis Through A Transformative Lens

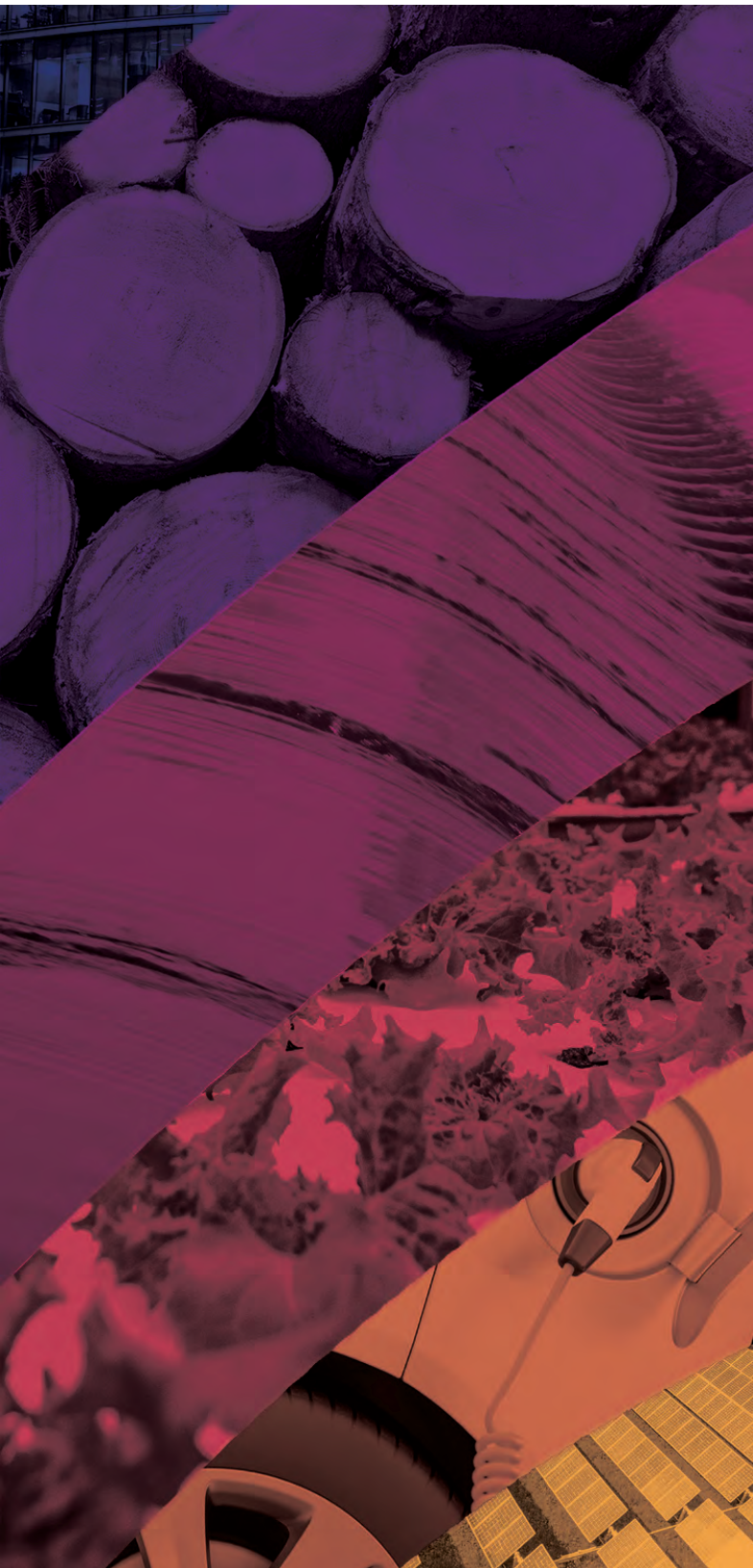
DEFINING CLEANTECH

Understanding and categorizing the cleantech industry in BC, starts with a simple but important definition of terms - what do we mean by cleantech? While most other categories of technology (mechanical, electronic, chemical, digital) refer to what is actually created or produced, a technology gets placed in the cleantech category based on what it is trying to achieve - better environmental and economic outcomes, such as reducing greenhouse gas (GHG) emissions, or improving land, water and air quality.

Given the urgency of the climate change mandates, and the regulatory policies in place to support those mandates, almost every technology company is exploring ways to become a 'cleantech' company, for example by expanding their product lines or making incremental improvements. Large industry is pivoting to cleaner operations and exploring cleantech-related projects and opportunities. Service providers such as engineering firms or equipment installers are adapting and developing new cleantech-focused ways of serving their clients. For example, in the Thompson-Okanagan region, there is an encouraging number of heating and cooling companies developing an expertise in installing and servicing geothermal and other low-energy systems.

These companies, while they form an important part of the ecosystem, are not included in the following analysis, which is focused on "Pureplay Cleantech" - companies who are primarily engaged in research and development (R&D) or the manufacture and sale of clean technologies. KPMG, in their British Columbia Cleantech 2019 Status Report, had a similar approach, as they defined Pureplay Cleantech companies as follows:

"companies that are generating new intellectual property, business models or service offerings which does not include the much larger set of companies that implement these products and services in their own operations."²⁰



DEFINING SECTORS

The six market sectors arise from the target markets of pureplay cleantech SMEs in BC. Given that a company is classified as cleantech based on what it is primarily trying to achieve, the next question to look at is what market sector is it developing this technology for and what markets are they selling into (or intending to sell into)? By asking this question, and categorizing the companies accordingly, it became clear that these were the sectors that not only had the most cleantech activities, but also had the most potential for transformative growth (revenue, investment, jobs) and environmental impact. These sectors are: Built Environment, Energy, Natural Resources, Transportation, Water and Agriculture and Food.

TECHNOLOGY COMPETENCIES

The technology competencies provide us with a snapshot of the technological expertise that is being developed in each sector around cleantech. These competencies range across hardware and software.

ASSOCIATIONS

The list of associations provides a snapshot of the ecosystem happening within each sector. A mature sector with a range of products selling into multiple markets is likely to have a wider variety of associations organized by end product (for example, agriculture and food), while an emerging sector may have less, and may be organizing themselves by technology type rather than end-product (for example, in energy with Canadian Hydrogen Fuel Cell Association). It provides a glimpse into how the sector is organizing itself, and from the perspective of developing a cluster strategy, it allows us to understand potential synergies between groups, or possible information sharing gaps.

INDUSTRY CUSTOMER TYPES

The industry customer types provide more details about the markets and customers the cleantech SMEs are selling into. The overall sector categories are broad - a snapshot of the customer types combined with the technology competencies allows targeted and strategic program development for the cluster.

ACADEMIA AND KNOWLEDGE CENTRES

The list of academia and knowledge centres also provides us with a snapshot of activities. In an economic cluster, educational and knowledge centres play a dual role in both R&D and training and education. It allows us to see how the sector has organized itself from the perspective of education and research, and from that understand potential synergies, and see potential knowledge or information gaps.

ALIGNMENT WITH CLEANBC PLAN

The cluster strategy must align with the CleanBC goals. Understanding how the technologies and the customer types align with CleanBC goals helps with strategic program planning and priority setting.

EXISTING COLLABORATIONS

While hundreds of small or short term collaborations happen daily across multiple industries, a look at some of the larger and unique collaborations that are happening in the sector provides real life case studies in how the industry itself is seeking to develop opportunities and close innovation gaps. Were these collaborations formed as a result of a technology or market gap? What are they trying to achieve? If it worked well in one sector would it work in another sector, and if so how?



It can't just focus on green buildings, there has to be a transformation in the whole construction industry.

4.2 Built Environment

ECONOMIC SIGNIFICANCE:

High. Sector Employs +200,000

EMISSIONS PROFILE:

High. Building and construction is responsible for 39% of global carbon emissions.²¹

Building and construction is a pillar of the economy of British Columbia. Construction is a \$16.5 billion dollar industry providing 8.7% of the Province's GDP and employs more than 200,000 workers. The GHG emissions profile of the building sector is significant and there is great possibility to lower it, both in existing and new buildings.

With the construction industry set to grow over the coming years and with ambitious plans in place for better energy efficient buildings such as the BC Energy Step Code and those outlined in the CleanBC Plan, we expect this will drive a multiple billion dollar market demand for higher efficiency and carbon neutral products across the province.

In Metro Vancouver alone, it is a \$3.3 CAD billion market.²² Given the wider interest in the Lower Mainland, Okanagan and other regions in this sector, this is a promising sign for the cleantech companies interested in working with the domestic construction and real estate industry.

Products that enable electrification, high efficiency and embodied carbon are of high interest. Lowering emission profiles of the built environment is not just unique to BC, but also in Canada and internationally, representing a significant market overall.



ZEBx - FACILITATING KNOWLEDGE EXCHANGE

ZEBx is a collaborative platform that strengthens the public, private and civic capacities for zero emission buildings in Vancouver and British Columbia. By bringing together all facets of the industry (from developers, builders, architects and designers spanning single family homes to high rise residential and commercial buildings), and facilitating knowledge exchange, they are accelerating market transformation.

ZEBx uses a collaborative model unique to the building industry, and works with a wide range of partners, including industry associations, governments, researchers, trades programs, suppliers and global experts.

TABLE 8. SNAPSHOT OF BUILT ENVIRONMENT ECOSYSTEM

NO. OF CLEANTECH SMES	43
Technology Competencies	H2/Fuel Cells, Battery Storage, Geothermal, Renewable Generation, Biogas/Other Renewable Gas, Biomaterials/Biocomposites, CCUS, Thermal Energy Technologies eg. heat pumps, IoT Technologies & Platforms, Digital Analytics/AI/ML, 3D Printing
Associations	<p>Urban Development Institute; Fenestration Association of BC; Canadian Homebuilders Association; Home Builders Association Vancouver;</p> <p>Passive House Canada; Canada Green Building Council; Vancouver Regional Construction Association; ZebX; Embodied Carbon Network, Canada Wood Group, BC Wood Specialties Group; FPInnovations, Canadian Wood Council/WoodWORKS! BC, BC Housing, CanBIM, Independent Contractors and Business Association</p>
Industry Customers Types	Government; Developers; Home Builders; Material Manufacturers; Designers/Architects; Utilities: First Nations
Knowledge Centre Activity	<ul style="list-style-type: none"> » BCIT - School of Construction & the Environment / Renewable Energy Electrical Systems Installation & Maintenance » University of Northern BC - Wood Innovation and Design Centre » UBC - Sustainable Building Science and Timber Engineering & Applied Mechanics » Okanagan College - Sustainable Construction Management » SFU - School of Sustainable Energy Engineering » Northern Lights College - Centre of Excellence, Clean Energy Technology/ Clean Energy House
Alignment With Cleanbc Plan	<ul style="list-style-type: none"> » Make every building more efficient by improving the BC Building Code and increasing efficiency standards – until every new building is “net-zero energy ready” by the year 2032 » Incentives to make heat pumps more affordable and homes more energy-efficient » Incentives for public sector organizations to invest in capital projects that reduce energy costs and lower carbon emissions. » Upgrade B.C.’s stock of 51,000 public housing units to make these homes less polluting, more energy-efficient, and more affordable » By 2030, 70,000 homes and 10 million m² of commercial buildings will be retrofitted to use clean electricity in space heating » 60% of homes and 40% of commercial buildings will be heated with clean electricity » Better Homes and Better Buildings incentives: rebates that save energy and lower greenhouse gas emissions » CleanBC Building Innovation Fund: provides funding for projects and programs that accelerate the availability, acceptability and affordability of low-carbon building solutions including advanced building designs, new construction methods, and ultra-efficient building components.
Existing Collaborations	Building Electrification Coalition, Vancouver Economic Commission and Foresight Project Greenlight Challenges, Forestry Innovation Investment - Wood First Program (municipalities, province & industry), ZEBx, CleanBC Building InnovFund, FP Innovations

Built Environment

Competitive Advantages in the Sector

- Progressive legislation, regulations, building codes and climate goals from the Government of Canada, Province of British Columbia and at the municipal level is driving demand for clean technology products and services.
- A number of SMEs work with industry to deploy technology for building management, modular housing and energy efficiency.
- A notably higher number of ecosystem actors who operate in the space compared to other sectors who are coalescing around key issues such as electrification or mass timber (e.g. Building Electrification Roadmap, Wood First Initiative, ZEBx).
- Emerging demand for green building products will be significant in BC and along the Cascadia Corridor as a result of electrification initiatives like the Clean Grid Initiative.
- A known centre of excellence in mass timber with potential to include added value wood products in the construction value chain.
- Construction companies see the importance and advantage of abiding by regulations and voluntary certifications (e.g. LEED, BC Energy Step Code).

Gaps in the Sector

- While each sub-sector of the green building and construction sector markets their products and innovations, there is a gap in that there is no cohesive story being marketed around BC as an innovation hub with distinct geographic, product and policy advantages that put us on the world map as a place to test, manufacture, launch and scale innovations for the sector.
- Distinct lack of financing models that can support both retrofits and new construction due to perceived risk by the investor community.
- Consumers lack the education and confidence they need to access incentives programs and make purchase decisions about the latest technologies available - this gap impacts demand.
- The full suite of products and services available that are needed to reach Passive House or carbon neutral standards are not available in BC because many are imported and subject to product testing and certification barriers.
- Distinct lack of manufacturing facilities to assemble and build products in BC.
- A knowledge flow gap regarding advanced building technologies across the entire construction value chain preventing uptake. To implement the BC Energy Step Code and other goals and targets, there is a large trades and skills gap in construction and maintenance of buildings.

Built Environment

Opportunities for Cluster Activities to Drive Competitiveness

This is a sector at the tipping point in British Columbia and is on the verge of becoming a global centre of excellence. The technology exists, the ecosystem exists, but getting projects in the ground is challenging.

- Coordinate the network working on carbon neutral buildings across the province. There is a perception of competing priorities rather than collaboration to get projects in the ground.
- Share the story of our key strengths to help meet CleanBC targets, and in particular to emphasize electrification, progressive policy, and the availability of mass timber that can be used in new construction.

"We're recognised as a global cluster of Mass Timber, but we're only serving a small, innovative community of people — if we're going to really hit embodied carbon at a large scale, then we need to broaden the reach and impact of the mass timber story."

- Develop blended finance models for projects like green mortgages for new construction or Property Assessed Clean Energy (PACE) finance for retrofits that take into account co-benefits and long term return of investments and maximise affordability. This will drive greater consumer demand for high-performance building retrofits.
- Accelerate the rate of adoption of technology products by removing policy barriers, streamlining new technologies, and supporting testing and certification.
- Engage industry to work with knowledge centres and academia to train construction trades and engineers on new technology solutions that deliver co-benefits.
- Attract investment from global manufacturers of electrification products and make BC a manufacturing hub to meet demand for electrification products that are expensive to import (e.g. heat pumps).

We already have a cluster.
We need to figure out how
to maintain it and stop
playing defense.

4.3 Energy

ECONOMIC SIGNIFICANCE:

High. Demand for Low Carbon Energy Growing Globally.

EMISSIONS PROFILE:

High. 68% of energy demand is met through refined petroleum products and natural gas.

In BC, almost all the electricity we produce is from clean and renewable resources. But when it comes to the energy consumed in buildings, cars and industrial operations – nearly three quarters of the energy used across in the economy still comes from fossil fuels, in fact 68% of energy demand is met through refined petroleum products and natural gas.²³

Globally, we are seeing a shift. Market forces are creating change leading to what we call the 'Energy Transition' shaped by end-use demand, policy, finance and availability of clean technology solutions.

Fossil fuel energy remains the backbone of economies and will continue to be for the near future as we transition towards a clean energy pathway. In British Columbia, significant investment has been made in transition fuels, particularly liquid natural gas (LNG) development. These investments build on our strengths in natural gas resources and present a significant commercial opportunity in export markets.



WEST COAST REDUCTION

PROGRESSIVE POLICY LEADS TO BUSINESS OPPORTUNITY

As a result of low-carbon and renewable fuel standards, some of the emissions from cattle, poultry, hog and fish production are now being offset by turning animal waste into renewable fuels at the West Coast Reduction facility in Vancouver.

Other major alternative fuel suppliers are interested in setting up in BC as a result of this progressive legislation and proven business model.



THE HYDROGEN/FUEL CELL CLUSTER

British Columbia has a global reputation as a centre of excellence in hydrogen and fuel cell development. Companies are producing systems and components for all types of hydrogen and fuel cell applications, with 90% of these products exported to China, Japan, Germany and South Korea.

As a result of targeted investment in R&D in the 90's and 00's in the hydrogen and fuel cell technology sub-sector, a significant amount of talent and expertise resides in the province.

This is a sector that can and should be energized and leveraged, as other regions around the world are challenging BC's leadership in this rapidly growing industry.



Natural gas is a cleaner burning fuel emitting less greenhouse gas emissions compared to coal and oil. BC's LNG will be primarily exported to other countries to support their energy transition from coal to gas. The LNG development in BC is seeking to be the least emissions set-up compared to other countries. This presents a market opportunity for SMEs to utilize these assets for CCUS deployment and hydrogen development in the province, technologies we are highly competent in.

About 25% of cleantech companies in BC identify as working in the energy sector (KPMG 2019 report). These technology companies are working on a variety of value propositions across the energy value chain - hydrogen and fuel cells, solar, geothermal, carbon capture utilization and storage (CCUS), renewable liquid fuels and low carbon intensity gases (low carbon intensity gases include biomethane or renewable gas

from anaerobic digestion of municipal and agricultural waste, hydrogen from electrolysis or natural gas and sequestering CO₂, and using biomass to create synthesis gas and displace natural gas).

Coupled with these, there is an additional layer of software and digital technology companies that play an important role, particularly in optimization and energy efficiency. These technologies analyze utility and grid data and optimize renewable sources, balancing the intermittency challenge and ensuring productivity of energy at all times.

TABLE 9. SNAPSHOT OF THE ENERGY ECOSYSTEM

NO. OF CLEANTECH SMES	47
Technology Competencies	Battery Storage, Renewable Generation, CCUS, Digital, IoT and Platforms, Hydrogen/Fuels Cells
Associations	Clean Energy BC, Canadian Hydrogen Fuel Cell Association, BC Bioenergy Network, Community Energy Association, CMC Research, Canadian Association of Petroleum Producers, Advanced Biofuels Canada, BC Sustainable Energy Association, Petroleum Services Association of Canada, Canadian Energy Pipeline Association, Explorers and Producers Association of Canada, Canadian Gas Association, Wood Pellet Association
Industry Customers Types	Utilities, Grid Operator, Industry, Buildings, Homes, Oil & Gas
Knowledge Centre Activity	<ul style="list-style-type: none"> » UBC Clean Energy Research Centre » UBC School of Engineering » UNBC » College of New Caledonia » BCIT Centre for Energy Systems Applications » Carbon Capture and Conversion Institute » SFU School of Sustainable Energy Engineering » UVic Institute for Integrated Energy Systems
Alignment With Cleanbc Plan	<ul style="list-style-type: none"> » To help meet increased demand for lower-carbon fuels, B.C. will support the production of 650 million litres of renewable fuels per year » Help communities to achieve 95% organic waste diversion for agricultural, industrial, and municipal waste – including systems in place to capture 75% of landfill gas (if diverted waste is converted into renewable gas can help to support achieving the target) » Help remote communities reduce their dependence on diesel » Work with natural gas providers to put in place a minimum requirement for 15 per cent renewable content in natural gas by 2030 » By 2030, 70,000 homes and 10 million m² of commercial buildings will be retrofitted to use clean electricity in space heating » 60% of homes and 40% of commercial buildings will be heated with clean electricity
Existing Collaborations	Building Electrification Roadmap, BC Hydrogen Roadmap (under development), CleanBC Industry Fund, Innovative Clean Energy Fund, First Nations Clean Energy Business Fund, Natural Gas Innovation Fund

Energy

Competitive Advantages in the Sector

- Metro Vancouver is a known global hub for hydrogen and fuel cell technology, anchored by companies such as Ballard Power (a 500+ employee company in Burnaby).
- CleanBC Plan is driving electrification for transportation and the built environment, creating demand for low carbon electricity management and heating solutions.
- Significant policy signals like Low Carbon Fuel Standard and achieving 15% renewable content in natural gas are driving innovation by SMEs and attracting major industry stakeholders in the oil and gas value chain (eg. LNG Canada, Fortis BC, Parklands Refinery) to explore opportunities and prioritize projects.
- A strong research and academic ecosystem across BC.
- Extensive biomass resources exist in the Province that can be utilized for both renewable liquid fuels and low carbon intensity gases.
- BC is a known hub of talent for digital and software development with anchor firms setting up offices here. (Microsoft, Amazon etc.)

Gaps in the Sector

- For renewable liquid fuels and low carbon intensity gases, there is a feedstock supply uncertainty that needs to be urgently addressed to provide clarity to the industry.
- Diversity and attracting talent (required by scale-up companies) in the fields of chemical and biological engineering, artificial intelligence and big data. There were also gaps in attracting senior leadership talent in business and marketing to scale cleantech companies.
- Slow permitting obstacles to get projects in the ground (e.g. biogas, electric vehicle charging infrastructure).
- Access to growth capital for SMEs to scale beyond BC into international markets.
- Ability to deploy new technology in a non-regulated environment (regulatory sandbox) to test feasibility and commercial readiness.
- The hydrogen and fuel cell cluster is not as prominent as it once was and is facing competitive pressures from other jurisdictions.

Energy



Opportunities for Cluster Activities to Drive Competitiveness

- Tailored matchmaking to fill the senior talent gap in SMEs who require skills in chemical and biological engineering, artificial intelligence and big data by engaging with key actors in the ecosystem such as the oil and gas and high technology industries.
- Create a supportive ecosystem to facilitate rapidly scaling up of new technology through projects that align with larger scale goals of export and economic development for the province and CleanBC/sustainability goals,
- Space to innovate, an opportunity to deploy products outside of a regulated environment to test.
- Support industries in transition, such as pulp & paper mills, who are looking for strategies to diversify their market - an opportunity to leverage sites for low carbon energy.
- Ensure better ecosystem coordination and network building across various sector activities.
- Tell the story of BC's obvious competitive advantages in hydrogen/fuel cells as other jurisdictions have set-up clusters and we risk losing the competitive advantage.

The world is moving towards a circular economy and advanced bioproducts can be a major answer for not only meeting CleanBC targets, but also diversifying forestry and helping rural communities.

4.4 Natural Resources

The forestry and mining sectors are significant sources of GDP and jobs for the province. For the purpose of this strategy, we approach natural resources through the lens of both applied cleantech technology to meet environmental needs, as well as the ability to create value-added products from both forestry and mining.

Forestry

ECONOMIC SIGNIFICANCE:

High. \$12.9 Billion Contribution to BC's GDP.²⁴

EMISSIONS PROFILE:

High. Total net emissions of CO2 equivalent from Canada's managed forests: 217 million tonnes (Mt).²⁵

In BC, forests play a significant role in mitigating CO2 emissions, by their carbon sequestration capability as well as contributing to the substitution of fossil-based materials in downstream industries. The forest sector aims to be a zero-waste industry, and is working hard to achieve carbon neutrality. By adopting advanced technologies, companies are maximizing the value of every tree cut and reducing waste, using whatever is remaining to generate clean energy. Logs can be processed into high quality lumber, engineered and mass timber products; manufacturing residuals such as wood chips are used for engineered panels and paper, and sawdust and bark are used in mouldings, engineered cabinets and flooring.



**BC PULP & PAPER BIOALLIANCE
BUILDING VALUE THROUGH
COLLABORATION**

BC Pulp and Paper BioAlliance (BioAlliance) is working on “best bet” technologies for the provincial industry to accelerate the forest bioeconomy and the opportunity for creation of value-add products.

The BC Pulp and BioAlliance is a partnership between UBC BioProducts Institute and FPInnovations, as well as a number of industry partners including Domtar, Canfor, Paper Excellence, Mercer, West Fraser and Harmac Pacific.



The vast majority of Canadian wood pellets are made from sawmill residuals – sawdust, followed by harvest residues, unmerchantable species, and salvage logs from areas hard hit by insects, disease or fire. At the same time, some harvested wood debris must remain in the forest to ensure that healthy forests and forest productivity continue in terms of soil-function and tree growth, as well as ecosystem and habitat functions.

As a way to capture added-value, new opportunities continue to emerge to convert wood-based biomass into everything from electricity and heat to transportation fuels, bio-chemicals, plastics and next generation bio-materials and engineered building products.

This varied new forest “bio-economy” has the potential to become an important segment of Canada’s forest economy as well as ensuring a more environmentally sustainable forest industry.

Wood is the only natural resource material with third-party certification programs in place to verify that products originate from a sustainably managed source. Forestry certification is vital worldwide to ensure forest practices are both legal and sustainable for the environment. Forests in Canada are certified by third-party organizations that ensure Canadian forestry operations are legal, sustainable and in compliance with global standards.

At the end of 2019, Canada is the international leader in forest certification, with BC contributing more than any other province. In B.C., these certification programs are supplemental to internationally-recognized, comprehensive laws that guide the management of its public forests.

TABLE 10. SNAPSHOT OF THE FORESTRY ECOSYSTEM

NO. OF CLEANTECH SMES	11
Technology Competencies	Hydrogen/Fuel Cells, Biogas/Other Renewable Gas, Biofuels, Biomaterials/Biocomposites, IoT Technologies & Platforms, Digital Analytics/AI/ML
Associations	BioAlliance, BC Bioenergy Network, Forest Products Association of Canada, BC Council of Forest Industries, Forest Stewardship Council of Canada, BC Wood, Interior Lumber Manufacturers Association, International Wood Products Association, Council of Forest Industries, Forest Stewardship Council of Canada, Wood Pellet Association, Canada Sustainable Forest Management, Sustainable Forestry Initiative
Industry Customers Types	Forestry companies, government, construction, pulp mills, bio-refineries, industrial chemicals, pharmaceuticals, textiles, renewable materials, personal care products, manufactured goods.
Knowledge Centre Activity	<ul style="list-style-type: none"> » BioProducts Institute at UBC » UBC Sustainable Forestry Management » FPInnovations
Alignment With Cleanbc Plan	<ul style="list-style-type: none"> » The CleanBC program for industry will reduce industrial emissions by 2.5 Mt per year » Support public infrastructure efficiency upgrades and fuel switching to biofuels with the CleanBC Communities Fund » To help meet increased demand for lower-carbon fuels, B.C. will support the production of 650 million litres of renewable fuels per year » Help remote communities reduce their dependence on diesel
Existing Collaborations	BC Pulp and Paper Bio-Alliance, FP Innovations, BC Bioenergy Network. Forestry Innovation Investment, Cleantech Innovation Strategy for the Forestry Sector



Forestry

Competitive Advantages in the Sector

- Established and highly concentrated chemical pulp industry and infrastructure that can be leveraged.
- Availability of biomass and in particular the long/strong cellulose fibres that are unique to BC that can provide strength and light-weighting advantages for added value products.
- Availability of pulp process by-products (e.g. lignin, tall oil) and waste streams (ash, sludge) to use for creation of added value products.
- Shipping routes and access to Asia Pacific markets.
- Able to build upon the research and development foundation of the BC Pulp & Paper BioAlliance, UBC Bio-Products Institute and Forest Product Innovations.

Gaps in the Sector

- An expanded bioeconomy model for BC and organization that supports coordination of an end-user network in BC, pan Canada and international. Market development and engagement with end-users and buyers of new advanced bioproducts products.
- Transportation and logistics from the forest to the processing facility is a high-cost supply chain.
- Access to capital for commercialization and pre-commercialization of new bioproducts.
- Talent development as new processes and products are brought to market (particularly outside the Lower Mainland) and market development activities.

Opportunities for Cluster Activities to Drive Competitiveness

- Coordinate a network of end-users with the wider BC bioeconomy network. Leverage the BioAlliance network and UBC Bioproducts Centre to share learning and exchange information on bioproduct development and collaborations required to scale.
- Capitalize on existing infrastructure and availability of pulp and paper waste by-product to make bioproducts (e.g. value-added products from mill wastes (ash, sludge), renewable building and packaging materials/bioplastics).
- Share the story that BC is a known centre of excellence in mass timber and value add products to attract interest from end-users and investors to co-develop projects.
- Manufacture value added sustainable materials in BC using available biomaterials (e.g. for markets like textiles, bioplastics etc).

We're looking at how to design a mine for electrification.

Mining

ECONOMIC SIGNIFICANCE:

High. Mining employs 10,000+ across multiple regions.²⁶

EMISSIONS PROFILE:

High. GHG emissions associated with primary mineral and metal production was equivalent to approximately 10% of the total global energy-related greenhouse gas emissions in 2018.²⁷

With a varied type of mining activity taking place in the province, the needs of mines can differ. On sites, large amounts of energy and water are used for extraction and processing and a significant amount of waste is produced at the end of the mining life cycle. Cleantech solutions exist to optimize efficiency, reduce the environmental footprint of energy, water, and waste and improve air quality at mining sites and facilities. There are also products and services that reduce the cost of exploration and development (e.g. geospatial data analytics, visualization, drones).

The demand for cleantech is growing as innovation is now becoming a necessity due to both regulation and cost competitiveness e.g. energy efficient solutions, GHG reductions, watertech (esp. tailings), electronics recycling, exploration tech and ore sorting.

Across industry, we find that risk appetite is low, appetite for innovation is high and companies' internal capacity for innovation is mixed or low. Many mining companies outsource innovation efforts.



MINING INNOVATION ROADMAP A COLLABORATIVE APPROACH

In 2018, the BC Mining Jobs Taskforce recommendations were released with the aim to boost jobs and support a sustainable mining industry.

The recommendations are being enacted and include development of a Mining Innovation Roadmap with input from industry, SMEs, academia and government.²⁸

TABLE 11. SNAPSHOT OF THE MINING ECOSYSTEM

NO. OF CLEANTECH SMES	19
Technology Competencies	H2/Fuel Cells, Battery Storage, Renewable Generation, CCUS. Electrochemical Technologies. Thermal Energy Technologies, IoT Technologies & Platforms Digital Analytics/AI/M, Water-Tech
Associations	Mining Association of BC, Mining Association of Canada, Association for Mineral Exploration, Mining Suppliers Association of BC, Canadian Institute of Mining, Metallurgy & Petroleum, Association of Professional Engineers and Geoscientists of British Columbia, Canada Mining Innovation Council
Industry Customers Types	Mining and oil & gas, governments, construction, manufacturing, transportation
Knowledge Centre Activity	<ul style="list-style-type: none"> » UBC Bradshaw Research Initiative for Minerals & Mining » UBC Keevil Institute of Mining Engineering » BCIT - Mineral Exploration and Mining Technology » NIC - Underground Mining Essentials » British Columbia Geological Survey » Geoscience BC
Alignment With Cleanbc Plan	The CleanBC program for industry will reduce industrial emissions by 2.5 Mt
Existing Collaborations	Tahltan Central Government (working with Newcrest - tndc.ca), BC Mining Innovation Roadmap Project (led by MABC), BC Mining Jobs Task Force



Mining

Competitive Advantages in the Sector

- BC is a hub of human capital and expertise in this space.
- Concentration of mining company headquarters, engineers, suppliers and industry leaders including anchor companies such as Teck.
- High level of employment and successful collaboration projects with First Nations groups
- Availability of mining resources in the Province.
- Competitive at ore sorting, creating better efficiencies (e.g Minesense, Sacre Davey Engineering - design of ore sorting systems).
- Water and wastewater technologies are commonly deployed on sites, due strict regulations in BC for water management in natural resource sectors.

Gaps in the Sector

- Appetite for taking risk in the mining industry is inconsistent and varies greatly between companies because of size and ability to innovate, leading to inconsistent deployment of clean technologies.
- Capacity to take on innovation projects is mixed. Large companies such as Teck have the ability to devote resources to innovation and take chances in a way smaller operators do not.
- Existing regulatory environment is not conducive to emerging companies with new types of technology, and need to go through rigorous assessment processes, leading to long lead customer cycle processes.
- Lack of proving and testing grounds to test clean technologies.

Opportunities for Cluster Activities to Drive Competitiveness

- Expand mining companies capacity for innovation through a) capacity building programs that advance education around cleantech, b) access to testing and demonstration sites and c) targeted large industry innovation challenges and partnerships with mining companies of all sizes.
- Support broader market development activities to bridge relationships with international mining companies and cleantech solutions providers from BC.
- Facilitate knowledge sharing between parallel industries (water management, electrification) to advance rapid uptake of technology and explore collaborative project opportunities such as challenge projects.
- Leverage the BC Mining Innovation Roadmap initiative to share learnings and engage the whole sector in activities that drive adoption and development of the technologies required for the mining industry to advance CleanBC targets.

BC has all the raw ingredients for a leadership position.

4.5 Transportation

ECONOMIC SIGNIFICANCE:

High. Clean Energy Vehicle Sector generates over \$702 million in total direct economic activity.²⁹ Demand for clean transportation infrastructure is growing.

EMISSIONS PROFILE:

High. Transportation accounts for 38% of carbon emissions in BC.

Global greenhouse gas (GHG) emissions from the transport sector have more than doubled since 1970.³⁰

In Canada, transportation accounts for 24% of carbon emissions.³¹ Breaking that down even further, in British Columbia, transportation accounts for 38% of all carbon emissions.³²

The vast majority of transport fuels in BC are petroleum based, with only a small proportion met by non-emitting clean fuels such as electricity, biofuels and hydrogen.

To address the challenge of mass adoption of zero carbon transportation, governments, cities and companies are setting ambitious goals providing a mandate for more time and investment spent. The overriding challenge is getting projects off the ground.

Economic development activities undertaken for this sector will be diverse as we already have a number of made-in-BC technologies at different stages of maturity, working on a variety of fuel types targeting different markets e.g. light vehicles, heavy duty vehicles, shipping, aviation and autonomous vehicles/robotics.



BC FERRIES AND CORVUS ENERGY SAILING TOWARD THE ZERO-EMISSION FUTURE

Corvus Energy is supplying the energy storage system (ESS) for four new battery-hybrid ferries for BC Ferries. The ferries are designed with the latest in advanced clean marine technology and are prepared for fully battery-powered, zero-emissions operation in the future.

Until electrical charging systems are in place, the ferries will use a low sulfur diesel generator and battery hybrid system.

TABLE 12. SNAPSHOT OF THE TRANSPORTATION ECOSYSTEM

NO. OF CLEANTECH SMES	27
Technology Competencies	Hydrogen / Fuel Cells, Battery Storage, Renewable Gas, Renewable Liquids, IoT, Digital Analytics
Associations	Canadian Fuels Association, BC Trucking Association, Advanced Biofuels Canada, CHFCA, Electric Mobility Canada
Industry Customers Types	Municipalities, Transportation Authorities (eg. Translink, Ferries, Ports, Airports), Industrial, Consumer, Trucking/Transportation, Rail, Shipping, Vehicle Manufacturers, Utilities, Energy/Oil & Gas, Original Equipment Manufacturers
Knowledge Centre Activity	<ul style="list-style-type: none"> » UBC - Clean Energy Research Centre » University of Victoria - Pacific Institute for Climate Solutions » SFU – START (Sustainable Transportation Action Research Team) » BCIT- Automotive Service Technician/Smart Microgrid) » Trades Training BC
Alignment With Cleanbc Plan	<ul style="list-style-type: none"> » By 2030, 30% of all sales of new light-duty cars and trucks will be zero-emission vehicles, rising to 100% by 2040 » To help meet increased demand for lower-carbon fuels, B.C. will support the production of 650 million litres of renewable fuels per year » The Province will reduce GHG emissions from government vehicles by 40% » Overall, fossil fuel use for transportation will drop by 20%
Existing Collaborations	BC Smart-Fuels Secretariat, Transportation Futures (UBC), Project Greenlight (Vancouver Economic Commission (VEC) & Foresight), Canadian Urban Transit Research & Innovation Consortium (CUTRIC), Shore Power/Port of Vancouver, Plug-in BC (Fraser Basin Council), CleanBC Go Electric Vehicle Program, Advanced Research and Commercialization (ARC) Program



Transportation

Competitive Advantages in the Sector

- Progressive legislation in the form of the low carbon fuel standard, and incentive programs (e.g. CleanBC Go Electric, ARC).
- Mature clean technology companies working on batteries and hydrogen/fuel cell and demonstrating competitive advantages.
- A local refinery is incentivised and provides blended low carbon intensity liquid fuels for the transport sector.
- Vancouver is home to the largest shipping port in Canada and has strong ambitions to be low carbon.
- A hydrogen and fuel cell sector including hydrogen supply and processing, component and systems testing, technology development and commercialization, and standards development.
- High adoption rate of electric vehicles with environmentally-minded consumers.
- Transportation infrastructure and geographic proximity to Western US states with emergent clean transportation and aviation sectors, along with proximity to rail, truck and port facilities.

Gaps in the Sector

- Existing innovation budgets by transportation companies is too minimal to create effective impact, preventing wider technology adoption. Innovative financing models are required.
- Clean technologies for medium-heavy duty vehicles /marine/rail sectors is not commercial nor cost competitive and as a result not widely adopted. These transportation modes contribute significantly to BC's emissions.
- Earlier stage feedstock supply uncertainty for liquid fuels. Aside from lipids, the renewable liquid fuels sector is in the R&D phase and will require significant investment for technologies.
- Permitting delays for transportation infrastructure such as electrical charging, stifling new business models and technology deployment.
- Lack of a model to recycle or repurpose lithium ion batteries for second life. There will be an abundance of lithium ion batteries over time, given that 100% of vehicles in BC will be zero emission by 2040.

Transportation

Opportunities for Cluster Activities to Drive Competitiveness

- Design programs to bring together partners with innovative financing models for roll-out of electric charging infrastructure for different types of fleets.
- Set the stage for BC to have a competitive economic advantage in developing technology solutions for commercial medium and heavy longer range transportation modes - medium-heavy duty vehicles, marine and rail sectors.
- Support market development engagement with transport clusters, international transport companies and transport OEMs to connect with local SMEs and attract foreign investment.
- Establish an engagement strategy and supportive programs focused on low carbon shipping in light of strategic and growing port activity in Vancouver.
- Work with industry to create a model for repurposing of lithium ion batteries for multiple uses.
- Launch and support programs to accelerate early adoption of clean technologies by connecting SMEs to institutional partners including “space to innovate” and platforms to test and prove the commercial viability of new products and services (e.g. Project GreenLight by VEC).

Right now in Canada, there is no umbrella organization to tie together all the pieces in the water sector.

4.6 Water

ECONOMIC SIGNIFICANCE:

High. Growing Global Demand.

EMISSIONS PROFILE:

GHG emission profile varies depending on industrial application.

There is an emerging ecosystem in BC that demonstrates cutting edge innovation in water management, remediation and recovery. This includes a number of progressive SMEs with technology offerings along with leading research institutions with proven capabilities to spin out successful companies. The local market is limited and mostly composed of mining, oil and gas and municipalities. The global market is more extensive, as there is a growing demand for water technologies across the supply chain due to the impact of polluting industry, climate change, natural disasters and population growth.³³

Locally, there are progressive measures undertaken to advance innovation in how wastewater can be used in a circular economy model. For example, Metro Vancouver is responsible for the region's wastewater, operating and monitoring five wastewater treatment plants and maintaining a region wide network. One of their goals is to use wastewater as a resource. In the case study outlined (see box on the right) they established a collaboration that yields benefits for each of the stakeholders involved and uses the Low Carbon Fuel Standard as an incentive to get credits for lower intensity fuel.

There are a number of member associations in BC, and we are home to one of the world's leading water intelligence firms - BlueTech Research. However, the Canadian water management ecosystem currently has a void left behind by the loss of WaterTAP, an Ontario based organization that led network building activities across the country.



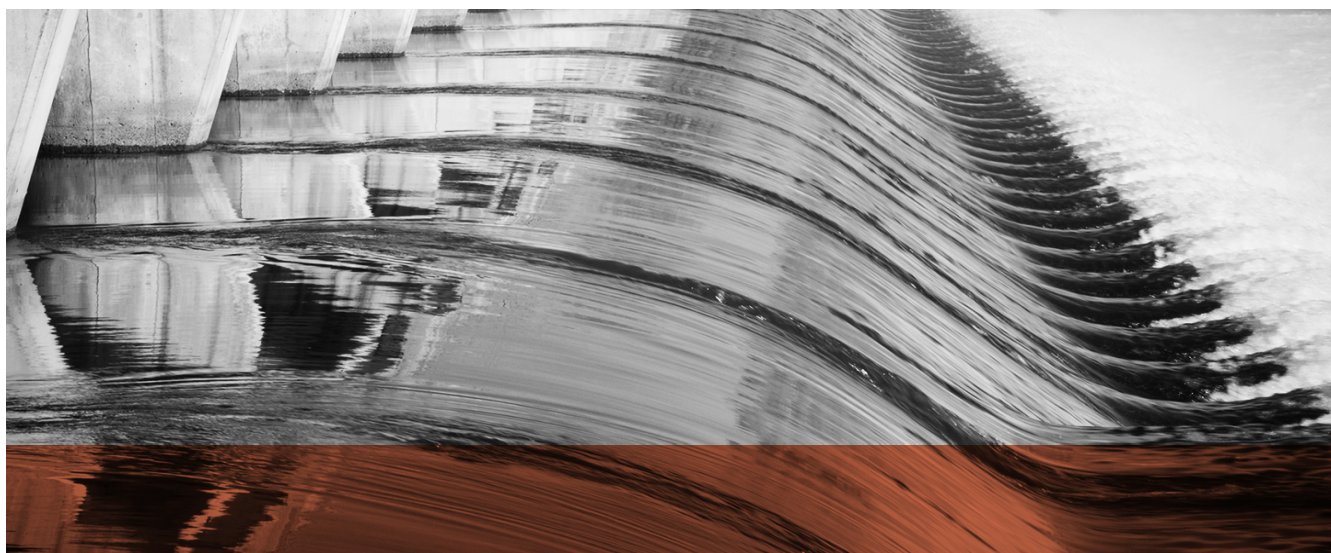
A WORLD'S FIRST IN METRO VANCOUVER: UTILIZING WASTEWATER BIOMASS FOR FUEL

A hydrothermal processing pilot project converts wastewater biomass from Annacis Island wastewater treatment plant (run by Metro Vancouver) into biocrude oil that can be refined to a low carbon transportation fuel. The byproduct of this treatment is seen as waste, but a hydrothermal process results a refined low carbon transportation fuel product.

This a progressive partnership between Parklands Refinery and Metro Vancouver, they have been conceptualizing the project since 2016, with the refinery supporting the idea and now working with the regional district as a biofuel partner on a technical basis. The project is in its preliminary design stage with detailed design to follow. Parkland hopes to be commissioning wastewater biocrude as another of its biofeedstock sources by 2022.³⁴

TABLE 13. SNAPSHOT OF THE WATER ECOSYSTEM

NO. OF CLEANTECH SMES	37
Technology Competencies	Renewable Generation, Electrochemical Technologies (seperation), Thermal Energy Technologies, IoT Technologies & Platform, Digital Analytics/AI/ML, Biomaterials/Biocomposites
Associations	BC Water & WasteWater Association, BC Ground Water Association, Canadian Water Resources Association, Partnership for Water Sustainability in BC (PWSBC), Bluetech Research
Industry Customers Types	Municipalities, Utilities, Mining, Oil and Gas, Industrial, Agriculture, Pulp & Paper
Knowledge Centre Activity	<ul style="list-style-type: none"> » SFU - Pacific Water Research Centre » SFU - School of Resource and Environmental Management » UVic - Water & Climate Research Centre/Pacific Institute for Climate Solutions » VIU - Coastal Hydrology and Climate Change Research Lab » UBC - Institute for Resources, Environment and Sustainability
Alignment With Cleanbc Plan	<ul style="list-style-type: none"> » Protect B.C.'s unique environment to guarantee clean air, land and water for future generations » Supports electrification through hydroelectricity, increases resilience in the agriculture sector and supports water recycling and remediation in industrial processes. » By 2020, the Province will develop an Adaptation Strategy based on a province-wide climate risk assessment
Existing Collaborations	Okanagan Water Supply & Demand Project, BC Water Funders Collaborative



Water

Competitive Advantages in the Sector

- Extensive research and development facilities at universities.
- Majority of companies operate in wastewater management. This is a large and growing global market due to the needs for water security and remediation, particularly industrial.
- Strict regulations in BC for water management in natural resource sectors have a global 'seal of approval'.

Gaps in the Sector

- Growth financing for later stage companies is hard to find. Typically water tech companies need to look outside of Canada as there is only one dedicated fund for water tech in Canada.
- Domestic market is limited to oil, gas, mining and municipal needs, which are small. Seeking opportunities abroad with multinational corporations, utilities and municipalities is optimal to scale, but often it is costly for SMEs to enter new markets and verticals.

"Developing international markets is key for water and wastewater SMEs"

- A coordinated network. A void has been left in the Canadian ecosystem since WaterTAP ceased operations in 2019. Its role was to promote and foster the growth of innovative water technology companies.
- There is a gap in leadership talent with skills in international business and technology. SMEs spent a significant amount of time looking for senior leadership.
- There is a lack of sector-level marketing that communicates the core strengths of water technology in BC, including the high-level of technology competencies and impact of this sector. This is essential for global market positioning and customer acquisition.

Water



Opportunities for Cluster Activities to Drive Competitiveness

- Hire a water sector ecosystem manager to drive innovation and build a supportive network dedicated to the water management sector.
- Support local and provincial market activities for the sector through connecting industry needs to technology companies (within BC & Canada) and engaging with the Province on the connection between water technology and regulations and policies.
- Support the export market through marketing and communication of technology capabilities for the overall sector, and through direct support of cleantech companies through events and engagement activities focused on export-markets (including municipalities, utilities, and multinational companies from resource, industrial and manufacturing sectors). This will help to lessen the initial cost of doing business in global markets.
- Utilizing the CORE Cleantech Cluster brand and voice to tell the story of BC's water technology companies and promote BC as a place to purchase, invest in, and build water technology companies.

BC is a leader in food safety,
and we should share that story.

4.7 Agriculture & Food

ECONOMIC SIGNIFICANCE:

High. BC's agriculture, food and seafood (including primary production in agriculture, aquaculture, commercial fisheries and the processing of food and beverages) is a \$14.95 billion industry.³⁵

EMISSIONS PROFILE:

Food production is responsible for one-quarter of the world's greenhouse gas emissions.³⁶

The agri-food system is a complex and tightly-integrated production chain ranging from primary agriculture to the food and beverage services sector. As outlined in the recent Food Security Taskforce report, B.C. produces high-value diversified crops, quality fruit and seafood, and a range of cereal based products and canola. B.C. contributes to over one-third (35 per cent) of Canada's total revenues for fruit. The food processing industry alone employs over 30,000 British Columbians and produces over \$10 billion in sales per year.³⁷

The agri-food innovation landscape in BC varies across the value chain in a number of technological sub-categories, including 'smart farming' (big data, AI, analytics, sensors, IoT, platforms), processes for conversion of bio-waste (waste to energy, waste to bioproduct), soil science (plant feed/ fertilizers/ pesticides), or plant genomics/novel food production and processing science.



TERRAMERA: A GROWING ANCHOR COMPANY

Terramera, a privately owned company headquartered in Vancouver, started as a one-person operation in 2010, and has since grown to a \$200+ million company with a couple hundred employees.

As innovators in the field of food production and green chemistry technology, they have the ambitious agenda to reduce synthetic chemical loads in agriculture by 80 per cent while increasing global yields by 20 per cent by 2030.

Terramera's Actigate technology platform significantly improves the performance and uptake of the active ingredients used in crop protection products. The excessive build-up from the chemicals sprayed on crops can be damaging to human health and the environment, including soils, waterways, beneficial organisms and wildlife.

Terramera, (recently named a World Changing Idea from Fast Company), is leading a collaborative project with universities, government labs and innovative companies from across Canada to target crop disease management as part of the Digital Technology Supercluster.

TABLE 14. SNAPSHOT OF THE AGRICULTURE AND FOOD ECOSYSTEM

NO. OF CLEANTECH SMES	99
Technology Competencies	Battery Storage, Biogas, Biofuels, Biomaterials/Biocomposites CCUS, Electrochemical Technologies, Robotics, IoT Technologies & Platforms Digital Analytics/AI/ML, Water-Tech
Associations	BC Agriculture Council, BC Food Processors Association, BC Blueberry Council, BC Cattlemen's Association, Farmland-Riparian Interface Stewardship Program, BC Cherry Association, BC Dairy Association, Dairy Industry Research and Education Committee, BC Forage Council, BC Fruit Growers Association, BC Grain Producers Association, BC Grape Growers Association, BC Potato and Vegetable Growers' Association, BC Poultry Association, BC Tree Fruits Cooperative, BC Wine Grape Council, Beef Cattle Industry Development Fund, Canadian Seed Growers' Association (BC Branch), Cariboo Cattlemen's Association, Cowichan Agricultural Society, Delta Farmers' Institute, District H Farmers' Institute, Kersley Farmers' Institute, Lower Mainland Horticultural Improvement Association, FARMED – North Cariboo, Nechako Regional Cattlemen, Pacific Field Corn Association, Peace Region Forage Seed Association, Peace River Forage Association of BC, Peace River Regional Cattlemen's Association, Peace River Soil Conservation Association, Potato Industry Development Trust, Raspberry Industry Development Council, Tranquille Livestock Association, Southern Interior Stockmen's Association, Seafood Producers Association of BC, BC Seafood Alliance
Industry Customers Types	Commercial farming operations, wholesale distributors, food processing industry, horticulture operations/greenhouses
Knowledge Centre Activity	<ul style="list-style-type: none"> » Okanagan College - Viticulture and Wine Studies » Thompson Rivers University - Applied Sustainable Ranching » University of British Columbia - Centre for Sustainable Food Systems at UBC Farm, Faculty of Land and Food Systems and UBC Okanagan) » University of Northern British Columbia - Wildlife & Fisheries » University of Fraser Valley - Agriculture » North Island College - Aquaculture/Small Scale Sustainable Farming » Vancouver Island University - Fisheries & Aquaculture » Kwantlen Polytechnic University - Plant Health, Sustainable Agriculture, Brewing and Brewery Operations) » North Island College » Camosun College » Simon Fraser University - Resource & Environmental Management » Agriculture and Agri-Food Canada Abbotsford, Agassiz and Summerland

NO. OF CLEANTECH SMES

99

Alignment With Cleanbc Plan

- » Help communities to achieve 95% organic waste diversion for agricultural, industrial, and municipal waste – including systems in place to capture 75% of landfill gas
- » Renewal of the B.C. Bioenergy Strategy and building out the bioenergy and biofuels cluster
- » CleanBC targets for reduced GHG emissions: (40% by 2030, 60% by 2040, 80% by 2050)
- » Aligning food security goals with CleanBC goals (BC Food Security Task Force). Agriculture and agrifoods can also play a role in mitigating climate change and reducing emissions – opportunities to reduce emissions in this sector could contribute to CleanBC’s targets
- » CleanBC natural gas target of 15% renewable content

Existing Collaborations

BC Food Hub Network, Food Innovation Centres, Natural Products Canada, the Protein Supercluster, Agriculture Venture Acceleration Program with Foresight & Innovate BC, Agritech Innovation Challenge, UBC Food and Beverage Innovation Centre, Food Network Hub, Food Innovation Centres, Natural Products Canada, the Protein Supercluster, Digital Supercluster, Agritech Innovation Challenge, BC Agriculture and Seafood Research, Education and Extension Network, Food Security Task Force recommendations implementation, BC Agriculture & Food Climate Action Initiative



Terramera Rooftop Greenhouse that enables rapid experimentation located downtown Vancouver, BC.
Photo courtesy of TERRAMERA.

Agriculture & Food

Competitive Advantages in the Sector

- In BC, there is an array of regional commodity diversity including high value crops and niche products ranging from fruit to dairy to horticulture to seafood.
- A very supportive research ecosystem evidenced by the number of courses available across Universities and Colleges.
- BC is a leading jurisdiction in food processing, with almost 3,000 food processing companies based here and as a result have unique food processing expertise and domain knowledge.
- Global leader in food safety and processing practices.
- Geographic proximity to Asia Pacific markets and established position in a number of ongoing relationships and strategic alliances that have been set up along the Cascadia Corridor.
- Government recognition of agriculture and food security as a key economic driver (as shown by the work of the Food Security Task Force).

Gaps in the Sector

- For global markets, it was highlighted that we could take further advantage of our proximity to the Asia Pacific markets, and trade/export missions in Europe (particularly the Netherlands).
- Lack of sufficient Canadian capital to scale up SMEs with unique offerings that could enhance sustainability in the agriculture sector. Most companies are small and not export ready.
- There is a gap in technology adoption by farmers and producers.
- The ecosystem is extensive, but also fragmented and could be better connected to each other and to other Canadian clusters and sectors. Particularly in the context of the bioeconomy - there are information sharing gaps between sectors.
- Significant talent and labour market pressures due to seasonality.
- In the BC market, there is a lack of large corporations (anchor companies) to drive innovation.
- Distinct need for land for pilot projects and testing at a commercial scale.
- Lack of processing manufacturing and lab space in urban areas.

Agriculture & Food

Opportunities for Cluster Activities to Drive Competitiveness

→ Expand the existing Agriculture Venture Acceleration Program to focus on four areas:

- 1) Core Agtech
- 2) Agrifood & Production
- 3) Farmers with Innovation and Farmers
- 4) Producers Being Tech Enabled.

The latter two areas would focus on both education/skills training as well as capacity building for farmers and producers to 1) better understand how cleantech innovation can help them be more competitive, locally and globally, and 2) gain practical, hands-on training in how these technologies will change operations and practices and support technology adoption overall.

- Curate overseas targeted missions to 2-3 strategic regions (including the Netherlands) that are interested in buying and investing in advanced technology products for their agriculture and food sectors.
- Encourage cross-sector dialogue and collaborative project building between sectors. Create value through utilizing agriculture waste and regenerative farming and creating linkages with bioeconomy approaches in other sectors (eg. forestry, energy) and regions.
- Support removing fragmentation in the innovation ecosystem by connecting into Digital and Protein superclusters and Natural Products Canada programs and services.

Conclusion

British Columbia's opportunity to launch a cleantech cluster is now. It's clear that clean technology is solving the hardest problems faced by industry today - decoupling growth from emissions, repurposing used materials, and adopting new products and processes that sustainably maximize efficiency and minimize waste.

Once formalized, the CORE Cleantech Cluster will add significant value to the ecosystem through projects, programs and activities. All of these opportunities involve identifying and supporting business and technology gaps, facilitating collaboration between stakeholders and sectors, and implementing programs and projects that maximize the benefits of efficiency and scale. The result is more jobs, capital and production of value-added products.

Implementing this strategy will fast-track our transition to a clean economy, help achieve CleanBC goals and position BC as a global cleantech leader. Join us in connecting the dots and collaborate to energize and unlock opportunities for BC's clean economic prosperity.



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Appendices

APPENDIX A Methodology

METHODOLOGY

The research for this project was framed by the following core questions:

1. Is there an emerging cluster of economic activities?
2. Are these activities significant enough to have the desired impact on the economy?
3. What are the characteristics, challenges and opportunities of the emerging cluster?
4. What more needs to happen to help this take off?

To answer these questions, the team conducted an extensive combination of secondary and primary research to identify:

1. Successful cleantech cluster models that exist globally
2. Cleantech clustering opportunities in BC, including areas of expertise and specialization
3. Requirements of industry to scale up technologies and access talent, markets and capital
4. Projects and programs that will accelerate and support a growing sector

SECONDARY RESEARCH

For secondary research, the team conducted an analysis and review of key reports and studies to help leverage best practice in cluster development and create a cluster strategy that is unique to BC. The reports studied centered on:

- » Global cluster best practice analysis and economics
- » Cleantech sector in BC and Canada
- » Market adoption of cleantech in BC, Canada and International
- » Best practice on policy measures and incentives
- » Finance and Investment options for scaling cleantech
- » Cluster Case Studies - A number of global clusters in regions with economic similarities to British Columbia were identified through the International Cleantech Network³⁸ (of which Foresight is a member) and through the European Cluster Collaboration platform website.³⁹

The team listed the 250+ cleantech SMEs in British Columbia and based on internet research mapped them to markets where their solutions apply to. These assumptions on markets were then tested and validated through roundtables and 1:1 interviews.

The team also worked with Invest in Canada who shared data relating to investments into BC cleantech SMEs from the period 2016-2019.



PRIMARY RESEARCH

Our primary research activities consisted of:

- » Conducting a survey and face to face meetings with our Advisory Group. These 15 industry leaders provided steer on the project and the recent history of BC Cleantech and lessons learned
- » 45 x one-to-one interviews with SMEs, Industry, Cluster Managers and Associations. The purpose of this was to better understand industry needs in BC and what is best practice in cluster management. These interviews were conducted over the phone or at external events.
- » Conducting survey in partnership with MaRS to have a better characterization of cleantech SMEs in BC.
- » 25 x Roundtables were organized with key partners that centred on:

Sectors

These sessions brought together experts from SMEs, academia, nonprofits and large industry working in specific technology sectors of interest including Hydrogen, Water, CCUS, Bioproducts, Liquid Fuels, Gaseous Fuels, Green Buildings and Agriculture and Food. The purpose was to understand strengths and opportunities to support commercialization and go-to-market strategies for scaling BC cleantech.

Stakeholders

These sessions brought together experts from different stakeholder groups including Finance, Academia, Industry, Indigenous Leadership and Government. The purpose was to understand areas of interest and similarities/differences in how each group engages with cleantech - to where there is overlap and collaboration and where they see opportunities for future programs and projects.

Regional

These sessions brought together diverse stakeholder groups in different areas of BC, including Squamish, Kelowna, Campbell River and Vancouver to better understand regional strengths and priorities

The Foresight team also attended 24 external events during this period, where they met leaders and key stakeholders from industry to let them know about the project, ask key questions and invite them to participate further in the project.

Workshops/Roundtables & Advisory Board Meetings:

STAKEHOLDER MEETINGS	DATE
Universities	September 19, 2019
Industry	October 10, 2019
Finance	October 16, 2019
International Partners/Cluster	November 15, 2019
SME (webinar)	January 15, 2020
Government - Victoria	January 17, 2020
Government - Vancouver	January 20, 2020
First Nations Leadership	March 11, 2020

SUB-SECTOR	DATE
Built Environment #1	September 20, 2019
CCUS	October 10, 2019
Water	November 4, 2019
Ag-Food Innovation	November 6, 2019
Gaseous fuels	November 12, 2019
Liquid fuels	November 13, 2019
Hydrogen/Fuel Cell	November 20, 2019
Forestry - Bioproducts	November 26, 2019
Built Environment #2	December 9, 2019

REGIONAL	DATE
Prince George	September 13, 2019
Kelowna	September 25, 2019
Campbell River / Vancouver Island	October 8, 2019
Squamish	October 11, 2019

SPECIALIST GROUPS	DATE
Rocketbuilders	October 3, 2019
Foresight EIRS	October 14, 2019
Vancity	November 13, 2019
Food Security Task Force	November 28, 2019
BC Cleantech CEO Alliance	November 28, 2019
NRC-IRAP (ITA Network)	December 12, 2019

Advisory Board Meetings

DESCRIPTION	DATE
Meeting 1	August 15, 2019
Meeting 2	September 13, 2019
Meeting 3	October 17, 2019
Meeting 4	November 14, 2019
Meeting 5	January 24, 2020
Meeting 6	March 25, 2020
Meeting 7	June 18, 2020

Marketing & Communications

BLOG POST/FEATURE ARTICLES
23

NEWSLETTER/EMAIL ENGAGEMENT
5 Newsletters (total 2750 subscribers)

PUBLIC SPEAKING EVENTS
5



External Events

DESCRIPTION	DATE
Bioenergy Guild (Monthly Meetings X 2)	August 14 & November 13, 2019
Inspiring Climate Action: Learning from TopSector in the Netherlands	August 26, 2019
World of Walas - Marketplace for Disruptive Ideas in Urban Sustainability	August 27, 2019
Canadian Electricity Association, Electrification Debate in BC	September 16, 2019
WEFTEC (Water Environment Federation's Technical Exhibition and Conference)	September 23-25, 2019
MistyWest - Technology for Conservation	September 26, 2019
NISP Circular Economy Workshop	September 16, 2019
Advantage BC - Sustainable Finance Session	October 10, 2019
EcoCity World Summit	October 7-11, 2019
Green Economy Tour in Squamish	October 21, 2019
Low Carbon Shipping Meeting	October 30, 2019
Export Development Canada Cleantech Export Forum	November 4, 2019
Conference Board of Canada - Regional Input on Clean Energy Growth Economy Indicators	November 6, 2019
Rural Islands Economic Forum	November 7-8, 2019
Generate BC	November 8, 2019
Energy Leadership Summit	November 19, 2019
Plug and Play Mining Event with Worley Parsons	November 21, 2019
Kamloops Emergency Management Innovation Centre Meeting	November 28, 2019
PEIA Breakfast Meeting	December 3, 2019
MABC Mining Ecosystem Development Event	December 10, 2019
NGen Supercluster Project Funding Webinar	December 11, 2019
MABC Mining Regulation Event	December 11, 2019
2020 Value of Biogas West	January 14, 2020
Embodied Carbon: The Blind Spot of the Building Industry (Buildex)	February 12, 2020
PEIA Breakfast Meeting	March 26, 2020

APPENDIX B Advisory Group

A diverse group of business and industry leaders helped guide the project:



Steven Slater

Dr. Steven Slater is Vice President for Strategic Initiatives at Terramera. He earned his Ph.D. in Molecular Microbiology from Case Western Reserve University and was an NIH Postdoctoral Fellow in Biochemistry at Harvard University. He joined Monsanto in 1996 and held a variety of senior science positions, being appointed as a Monsanto Fellow in 2002. In 2004 he left Monsanto for a tenured faculty position at Arizona State University in Tempe, AZ. After nearly five years at ASU, he moved to the University of Wisconsin – Madison where he led scientific programs for six years at the Great Lakes Bioenergy Research Center, a \$25M/year DOE-funded program focused on production of cellulosic biofuels.

In 2013, he joined Midwestern BioAg as Vice President for Research and Development, and in 2017 he joined Terramera. He is an Adjunct Professor in the Faculty of Land and Food Systems at the University of British Columbia, serves on the Board of Canada's Digital Technology Supercluster, and remains a scientific advisor to Midwestern BioAg and several other agriculturally focused companies. Dr. Slater has over 40 scientific publications and 20 patents in the fields of genetics, genomics and biochemistry.



Anna Stukas

Anna Stukas is a VP of Business Development at Carbon Engineering Ltd. (CE), a Canadian-based clean energy company. CE is leading the commercialization of groundbreaking technology that captures carbon dioxide directly from the atmosphere, and a second technology that synthesizes it into clean, affordable transportation fuels.

Anna is a professional engineer with more than 15 years experience bridging the gap between technology and business to overcome barriers to cleantech commercialization. Anna previously worked with Angstrom Power and BIC developing hydrogen and fuel cell technologies, and has led a variety of CE initiatives from strategic projects to government programs. Anna is also a Past President of the Society for Canadian Women in Science and Technology, and a firm believer that diversity is a critical component to driving innovation.



Raghwa Gopal

Ragwa Gopal is the President and CEO of Innovate BC, and a serial entrepreneur who has extensive experience starting, growing and selling numerous businesses, Gopal joined Innovate BC from Accelerate Okanagan (AO), where he was Chief Executive Officer. At AO, Gopal was instrumental in the creation and management of successful programs for technology companies at all stages of growth, and he has been a driving force in the development of the Okanagan's tech sector into a \$1.6 billion economic contributor. A graduate of New Zealand's Central Institute of Technology in information technology, Raghwa has also received degrees in computer science from Australia's Collier MacMillan School and the University of the South Pacific.

In addition to his corporate experience, Gopal has lectured in the Faculty of Management (Business) at UBC Okanagan and the School of Arts and Sciences (Computer Science); has been an Entrepreneur-in-Residence at Okanagan College School of Business; and serves on the boards of multiple organizations including the University of British Columbia, India Canada Innovation Council, Women's Enterprise Centre and Central Okanagan Economic Development.



Stephen Brydon

Stephen Brydon is the Director, Innovative Clean Energy (ICE) Fund, Electricity and Alternative Energy Division, BC Ministry of Energy, Mines and Petroleum Resources.

Stephen returned to the BC Ministry of Energy, Mines and Petroleum Resources in May 2016 as the Director of the Innovative Clean Energy Fund. Prior to his return, Stephen was with BC Transit for nine years where he was Manager, Environment & Climate Action responsible for environmental risk management and compliance. He also oversaw the Crown Agency's carbon neutral obligations.

Stephen has worked for over 25 years in the BC Public Service in a number of provincial government ministries and crown agencies (including both BC Transit and BC Hydro) with a focus on clean energy innovation, clean transportation technologies, economic development, trade and investment.



Mark Warren

Mark Warren is Director, Business Innovation for FortisBC. In his current role, he leads corporate data analytics, gas and electric advanced metering, electric vehicle charging and a variety of corporate and employee innovative initiatives. He was previously in various operational and customer service roles within FortisBC. Mr. Warren is a registered professional engineer in British Columbia. He received a B.A.Sc. in Engineering Physics from the University of British Columbia and a Master's in Business Administration from Queen's University.



Janice Larson

Janice Larson is a policy, planning and partnerships consultant, with over 22 years of experience in public policy development and implementation, focused on strategic planning, regulatory and economic development, community and international relations.

Janice was from 2014-2017 the Executive Director, Regional Innovation Initiatives with the BC Ministry of Technology, Innovation and Citizens' Services, based in Kelowna at UBC's Okanagan campus, and focused on building academic/ community/industry connections to enhance innovation throughout the province.

Previously Janice was with the BC Ministry of Advanced Education, leading the development and implementation of BC's International Education Strategy, and working to advance policies and initiatives that support BC's higher education objectives and opportunities at home and abroad.

Janice also worked on the Pacific Gateway Strategy with the BC Ministry of Transportation, and from 2001-2011 she was the Director of Renewable Energy Development with the BC Ministry of Energy, working on the 2002 and 2007 Energy Plans, the BC Bioenergy Strategy, and other initiatives to advance clean technology, renewable energy, energy efficiency, low-carbon transportation and related energy/ environmental objectives. She cycled across Canada in 2008 (fueled by carbohydrates, not hydrocarbons :-), and as her heart keeps a green beat, she and her husband built and live in a zero-net energy passive house in Lake Country, BC.

Janice has a Bachelor of Arts degree from the University of Lethbridge, degrees in Education and Law from the University of British Columbia, and she is a non-practising member of the Law Society of British Columbia.

Janice is keen to advance ways to use waste as a resource, boost regional energy efficiency and renewable energy, expand regional cycling infrastructure and care for the Okanagan watershed.



Wal Van Lierop

Dr. Wal Van Lierop is the Executive Chairman & Founding Partner, Chrysalix Venture Capital. Wal is an award-winning business leader and visionary in innovation, sustainability and cleantech, with unique industry insights gained through deep operational experience as a venture capitalist, corporate executive, international consultant and university professor.

Wal founded Chrysalix Venture Capital, one of the earliest and most recognised private equity firms focused on industrial innovation, where he has helped raise more than \$250M and participated in more than \$1B in venture capital funding. He has sourced, invested in and advised numerous startups, assisting them in building breakthrough solutions for the new world economy while working hand-in-hand with large multinational companies on their innovation strategies. Currently Wal is a member of the Board of Directors at Chrysalix portfolio companies General Fusion, Svante and Axine Water Technologies.

Wal is a longstanding contributor to the tech community in British Columbia and abroad as the founder of New Ventures BC, a founding member of the BC CEO Alliance and Evok Innovations, contributor to various Vancouver greenest city projects, Advisory Board member of the Cleantech Group and judge of the Cleantech 100. He has been an adjunct professor at both SFU's Beedie School and UBC's Sauder School of Business, and is a frequent speaker at events like GLOBE Series, Disrupt Mining, Oil & Money, the BCTECH Summit, Energy for Tomorrow, and the Cleantech Forum.



Mischa Steiner

Mischa Steiner is the founder and CEO of Awesense, a digital energy company in Vancouver, BC. founded in 2010 focused on the future of decarbonized and decentralized energy. Mischa's product development and management experience in cleantech, and software industries was honed at organizations such as ECO Fuel Systems, Newpoint Thermal and the Okanagan Research & Innovation Centre.

Mischa is a frequent speaker and panelist at industry conferences, university programs and government events on the future of energy as it relates to climate and the innovation potential of technology to have impact for our collective future. He is a member of the Institute of Electrical and Electronics Engineers (IEEE) and an active volunteer at Science World to encourage school children to pursue careers in math, science, and engineering. Mischa previously held a Board Director position with the Vancouver Economic Commission, and currently is a Board Director at Proxixi Technologies Inc.

Mischa started his education with a Mathematics scholarship at Simon Fraser University ultimately leaving to obtain a degree in Electrical Engineering from the University of Victoria and Wireless, Electronics, Engineering Technology from the British Columbia Institute of Technology.



John McPherson

John McPherson is the Sector Development Manager, Cleantech for the Vancouver Economic Commission (VEC). The longest-serving member of VEC, John McPherson works as a Sector Development Manager for VEC and is responsible for supporting cleantech innovators and strengthening Vancouver's cleantech ecosystem. Part of his role involves organizing strategic events and managing initiatives that address company-related challenges – a large proportion of John's time is spent managing the Green and Digital Demonstration Program (GDDP). GDDP gives entrepreneurs access to municipal assets and infrastructure for testing and showcasing emerging green and digital technologies. The City then provides GDDP participants a reference and testimonials for companies to use in their marketing and sales efforts – allowing them to attract new investors, partners, and clients both locally and around the world.

John is currently scaling up the GDDP into a regional initiative and is working with regional asset owners including YVR, the Port, and Translink. The initiative, called the Tech Deployment Network (TDN), will also be used as a platform to attract investment and business to the region.

John has previously held senior marketing and sales roles in the private sector and started his career in Hong Kong as an Assistant Trade Commissioner.



Walter Mérida

Dr. Walter Mérida is Associate Dean, Research and Industrial Partnerships at the University of British Columbia. Walter grew up in Guatemala, attended high school in Italy, and obtained his PhD at the University of Victoria in Canada. He began his career collaborating with Ballard Power Systems, British Gas Investments Canada and universities in 1996. He worked at Canada's National Research Council, and at the Fraunhofer Institute for Solar Energy Systems in Germany. He was a founder and Board member for General Hydrogen Corporation, and the Institute for Breakthrough Energy Technologies.

At UBC, Walter's research focuses on integrated energy systems, hydrogen and fuel cell technologies. He leads the Natural Gas Futures consortium, and the Transportation Futures Group at the Pacific Institute for Climate Solutions. Walter is the former director for the Clean Energy Research Centre, and the Master of Engineering Leadership Program. Currently, he is the Associate Dean of Research and Industrial Partnerships in the Faculty of Applied Science, and a Senior Advisor to the President and Vice-Chancellor.

Walter serves on the Board of Directors for the Canadian Hydrogen and Fuel Cell Association, the Academic Council for the Global Alliance on Powerfuels, and the Climate Change Advisory Board for Toronto Dominion Insurance.



Mark Kirby

Mark Kirby is the President and CEO of Canadian Hydrogen and Fuel Cell Association. Mr. Kirby joined CHFCA as President and CEO in August, 2019. A mechanical engineer with an honours degree from the University of British Columbia, he has led the commercialization of many clean technologies, including hydrogen energy technologies.

Mr Kirby was a founder and CEO of S2G BioChemicals Inc., a Vancouver-based industrial biotech company 2nd -generation technology for sustainable bioproducts. Over a 10-year period, Mr. Kirby secured investment and strategic partnerships that enabled it to develop into a leading bioproducts company. In 2018, S2G was acquired by Fortress Global Industries, a Canadian forest products company, becoming Fortress Advanced Bioproducts.

Prior to starting S2G, Mark led business and technology development, operations and commercialization in the food, industrial gases, fuel cell and forest products industries with fuel cell leader Ballard Power, Canadian hydrogen technology start-up QuestAir Technologies and global industrial gases company Praxair.



Rose Klukas

Rose Klukas, EC.D. is the City of Campbell River's Economic Development Officer. As EDO, Rose provides leadership and strategic direction, collaborates with key stakeholders to make Campbell River a compelling choice for businesses.

Rose manages industrial and commercial inquiries, creates innovative initiatives that support existing businesses and promotes Campbell River as an investment friendly community. As president of Vancouver Island Coast Economic Development Association, Rose works with regional communities to encourage investment in the technology sector.

Developing excellent working relationships with all levels of government, community and business groups is a priority for Rose and key to creating sustainable economic development opportunities. Rose Klukas, EC.D. is the City of Campbell River's Economic Development Officer. As EDO, Rose provides leadership and strategic direction, collaborates with key stakeholders to make Campbell River a compelling choice for businesses.

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Melissa Barcellos

Melissa Barcellos is the Manager of Economic Development, City of Prince George. As the Manager of Economic Development for the City of Prince George, Melissa's role is to facilitate and promote economic growth and diversification in order to increase the population and tax base by providing support for business growth and attraction.

Born and raised in Prince George, Melissa left the city to work internationally as a professional auctioneer and operated art galleries on several cruise lines prior to returning to Prince George where she graduated from the University of Northern British Columbia with a Commerce Degree. She also holds a Certificate in Economic Development from the University of Waterloo and a designation in economic development through the Economic Development Association of Canada. Melissa began her economic development career in 2011 and has managed the Economic Development Division for the City of Prince George since 2015.

Melissa loves to travel in her free time and has visited over 40 countries. She is a passionate advocate for animal welfare and volunteers as the President of the Board of Directors for the BC SPCA. She also operates her business as a Benefit Auctioneer at events across British Columbia.



Jonathan Rhone

Jonathan is an award-winning, serial cleantech entrepreneur. In his current role as CEO of Axine Water Technologies, he's scaling-up the company to revolutionize industrial wastewater treatment and address a global environmental problem. He's also a founder and director of Evok Innovations, a \$100 million cleantech venture fund with a mission to transform the energy value chain. Jonathan is the founder and former CEO of Nexterra Systems, a global supplier of waste-to-energy systems. Prior to Nexterra, he held leadership positions with a NASDAQ-listed cleantech company, and the Delphi Group, an international consultancy. He began his career in oil and gas with Amoco Canada (now BP).

Jonathan chairs the BC Cleantech CEO Alliance. He is a past board member of Vancity Capital, the venture financing subsidiary of Vancity. He is a past member of the BC Premier's Technology Council and has sat on a number of private and public sector advisory boards. In 2009, he was recognized as Technology Industry Person of the Year by the BC Technology Industry Association. In 2020, he was recognized as Industry Icon by the BC Cleantech Industry.

APPENDIX C Roundtable Organizing Partners

Many of our sector, regional, and stakeholder engagement sessions and roundtables were held in partnership with organizations and consultants who provided sector and regional expertise, logistical support and access to their local and industry-specific networks and contacts.

Their assistance was instrumental in generating the grassroots, responsive engagement process and resulting insights that form the foundation of this report. Thank you to the following:

- » Vancouver Economic Commission
- » City of Prince George
- » City of Campbell River
- » CMC Research Institute
- » Bluetech Research
- » Vantec Angel Network
- » British Columbia Bioenergy Network
- » Canadian Hydrogen & Fuel Cell Association
- » Zen Energy Solutions
- » FP Innovations
- » UBC Bioproducts Institute
- » BioAlliance
- » Fasken
- » University of British Columbia Okanagan
- » City of Squamish
- » City of Campbell River
- » Four Our Future Indigenous Economics Ltd.
- » Temixw Planning
- » SpiritWolfe Consulting & Associates
- » BC Cleantech CEO Alliance
- » BC Government: Food Security Task Force
- » Natural Products Canada
- » Vancity Savings & Credit Union

APPENDIX D Interviewee List

Research interviews were conducted with a number of leaders and innovators covering stakeholders across the Helix 5, and with Cluster Managers and Business Associations in Canada

and globally. Our thanks to the following for helping us better understand industry needs in BC and what is best practice in cluster management.

ORGANIZATIONS	
C3 Alliance Corp	GreenCape Cluster South Africa
Metal Tech Alley	Greentech Cluster Austria
Schneider Electric	CLEAN Cluster Denmark
FP Innovations	Foresight EIR, and previous PowerTech cluster manager
Fortis BC	Food Security Taskforce
YVR Airport Authority	BC Sustainable Energy Association
Pangea Ventures	NEIA Newfoundland
Lafarge Canada	Centre for Excellence in Mining Innovation
Atco Group	Hydra Energy
Air Products	BC Ferries
HSBC Canada	BC Hydro
BioDesign	UBC- Norman B. Keevil Institute of Mining Engineering University of British Columbia
NanoOne	
Hydrogen & Fuel Cell Joint Undertaking, European Commission	LNG Canada
Ecotech Quebec	BQE Water
Northern Development Initiative Trust	Metro Vancouver
Clean Energy BC	Teck Resources
Bluetech Research	UBC Bioproducts Institute
Digital Technology Supercluster	Sustainable Development Technology Canada
Canadian Green Building Council	Catalyst Agri-Innovations Society
Natural Products Canada	Portable Electric
NISP Canada	Svante
Ontario Agri-Food Technologies	Forestry Innovation Investment

APPENDIX E Secondary Research Sources (By Topic)

Cluster Theory & Economics

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- [A Framework for Improving British Columbians' Standard of Living. Economic Plan 2019-2020](#), 2019, Province of British Columbia
- Key Aspects of Developing a Cluster: Case study of Sarnia-Lambton's Hybrid Chemistry Cluster and Saskatoon's Agriculture Biotechnology Cluster (in [Canada's Bioeconomy Strategy Leveraging our Strengths for a Sustainable Future](#), Bioindustrial Innovation Canada, 2018)
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- [Unleashing the Growth Potential of Key Sectors](#), Advisory Council on Economic Growth, February 6, 2017
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- Regulatory Efficiency Indicators for Clean Technology Deployment, An Exploratory Study – Final Report, Prepared for [Innovation, Science and Economic Development Canada](#), April 2019
- [Grow West | Western Canada Growth Strategy](#), Western Economic Diversification Canada, Nov 2019
- [Accelerating Canada's Clean Growth Economy: Cleantech Adoption Strategies for a Low Carbon World](#), Centre for Digital Entrepreneurship + Economic Performance (DEEP Centre), Sept 2016
- [Clean Technology Adoption in Canada: 2019 Survey and Executive Consultation](#), Centre for Digital Entrepreneurship and Economic Performance (DEEP Centre), March 2019
- [Economic Strategy Tables: Clean Technology](#), Prepared for Innovation, Science and Economic Development Canada and Natural Resources Canada, Sept 2018
- KPMG/BC Cleantech Alliance. [British Columbia Cleantech: 2019 Status Report](#). February 2020

Finance

- [Strategies for Integrating the Canadian Financial Sector into Financing the Transition to a Low-carbon Economy](#), Centre for International Governance Innovation, June 2019
- [Invest in Canada's Competitive Advantages: Clean Technology](#), Global Affairs Canada, Spring 2018
- [Growing Clean: Investment Flows in Low-Carbon Technology to 2030](#), Smart Prosperity Institute, June 2019
- [Advancing the Landscape of Clean Energy Innovation](#), Breakthrough Energy Coalition February, 2018
- [Final Report of the Expert Panel on Sustainable Finance: Mobilizing Finance for Sustainable Growth](#), Environment & Climate Change Canada, 2019
- [Flowing Investment to Scale Clean Technology: The Scaling Cleantech Workshop at Globe Capital 2019](#), Globe Capital/Delphi Group, 2019
- [British Columbia Cleantech Status Report 2019](#), KPMG, February 2020

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- [CleanBC Plan: Full Report](#), Province of British Columbia, March 2019
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