

VANCOUVER

Vancouver Economic Development Commission | British Columbia, Canada

GREEN TECHNOLOGY

IN VANCOUVER: DEMONSTRATED STRENGTHS & INDUSTRY CHALLENGES



GREEN TECHNOLOGY IN VANCOUVER: DEMONSTRATED STRENGTHS & INDUSTRY CHALLENGES

June 2009

By Jeetesh Rup (B.A., J.D., M.B.A.)

Report produced for the Vancouver Economic Development Commission

Project Supervisors: Jonathan Kassian, Vancouver Economic Development Commission, and Dr. James Tansey, Centre for Sustainability and Social Innovation, Sauder School of Business, University of British Columbia.

Contents

I. INTRODUCTION/OVERALL PROJECT BACKGROUND	3
The VEDC & an Economic Development Strategy for the City of Vancouver	3
Project Background	3
Purpose of the Study	3
Spatial Map.....	3
II. METHODOLOGY AND CHALLENGES	4
Methodology.....	4
Challenges	4
III. GREEN TECHNOLOGY IN THE LOWER MAINLAND	5
Hydrogen & Fuel Cells	6
Renewable Energy: Wind and Water Energy Conversion	7
Battery Storage Technologies	8
Biomass Conversion	8
Green Buildings	9
Sustainable Urban Planning	10
Energy Management & Conservation Technologies	11
Green Roofs	12
Environmental Technologies	12
IV. SUMMARY OF FINDINGS	13



This project was undertaken in conjunction with the Centre for Sustainability and Social Innovation, Sauder School of Business, University of British Columbia.



We acknowledge the financial support of the Province of British Columbia through the Ministry of Small Business, Technology and Economic Development and the NCE Program and NSERC provided via the Industrial Research & Development Internship Program Fund.

VEDC
Suite 1620 - 1075 West Georgia Street
Vancouver, BC Canada
Toll Free: 1 866 632 9668
www.vancouvereconomic.com

I. INTRODUCTION/OVERALL PROJECT BACKGROUND

The VEDC & an Economic Development Strategy for the City of Vancouver

The Vancouver Economic Development Commission is currently in the process of developing an Economic Development Strategy (EDS) for the City of Vancouver. This report has been commissioned as background research as part of the EDS project. Further information is available at <http://www.vancouvereconomic.com/page/economic-development-strategy>.

Project Background

The City of Vancouver is known as an environmentally progressive municipality. However, Vancouver's strongly-held environmental beliefs have not yet translated into the 'take-off' of our green technology industry (see **Appendix A** for discussion on defining "Green Technology"). Environmental technology, green buildings, clean energy technology and power management technology are all small but growing sectors globally. Vancouver has a large number of innovative firms in a variety of sectors, many of which are world leaders in their field.

It has been recognized that the city's small domestic market creates an added challenge for firms in an industry that already faces an uphill battle. Building the local market for these technologies could benefit firms trying to get a foothold in an emerging global market, particularly in demonstrating and/or marketing the effectiveness of individual components or entire suites of solutions. While there is no clear evidence that Vancouver's green technology industry is any more regulated than in other regions, it is still very important that, in our small market, we overcome any barriers that do exist so that our companies can demonstrate their technology. Building the local Vancouver market for green technology will require several steps, including bringing the industry together to articulate a long-term strategy, fostering cooperation in a competitive environment, and possibly modifying by-laws, building codes and standards.

However, in order to bring about such changes, it is first necessary to have an understanding of the strengths and weaknesses of the industry. Unfortunately, such a full understanding does not exist. While there are companies and projects that are active in the Vancouver market, there is no master list that can provide such information. Further, there is no clear understanding of what the actual barriers, gaps or opportunities relating to the sector are.

Purpose of the Study

The purpose of this study is to provide the foundations for understanding what role Vancouver's municipal government can play in building a local market for green technology.

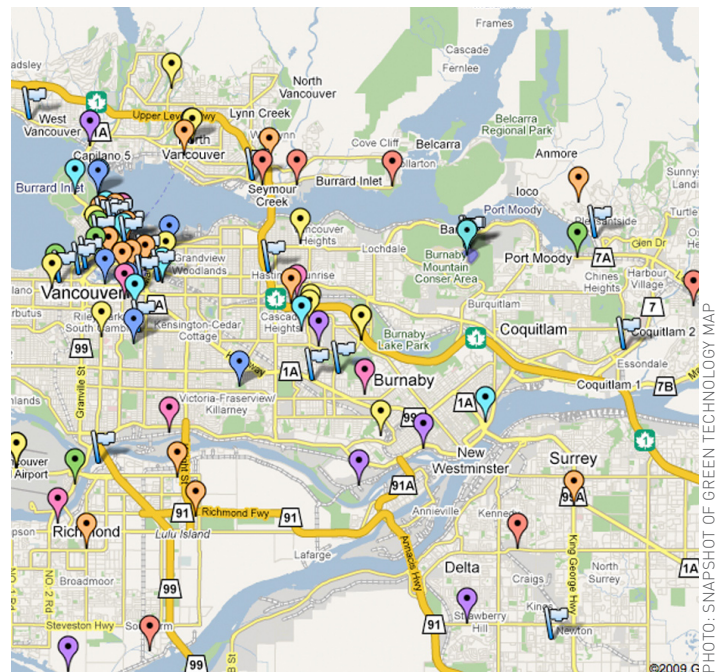
This study attempts to establish the foundations of that understanding by identifying:

1. the industry: the companies and the technologies they have deployed
2. the strengths of and areas that need improvement in the industry, and
3. the municipal and regulatory barriers that industry sectors face in deploying technology

Spatial Map

Accompanying this report are two spatial maps:

- A map of green technology projects in and near the Lower Mainland that provides the user with an easily-accessible interface to obtain details about technologies and technology providers that have projects in the region, including links to the projects and firms where applicable
- A map of green technology companies in and near the Lower Mainland that allows the user to quickly locate relevant providers, with links to the companies where applicable



Additions to either list are welcome, inquiries and additions can be made by contacting info@vancouvereconomic.com with the subject line "Green Technology Map".

II. METHODOLOGY AND CHALLENGES

Methodology

The first step was to compile a list of companies from available industry and sector reports and association membership lists.¹ The compiled list of companies can be found in **Appendix B**. These companies were then solicited for information regarding deployment of their technology locally. The second step was to identify green projects and buildings through research. Then, an effort was made to determine the type of technology installed in those projects or buildings from building operators, architects, engineers, and any other relevant resources. A list of all projects and deployed technologies can be found in **Appendix C**. The companies and the projects of deployed technology were then each mapped separately. These two maps are companion pieces to this report.

At all times the focus was on local companies deploying technologies locally. While there was a focus on the dense Metro core area of the City of Vancouver, where many high-profile demonstration projects and green buildings are located, projects across the Lower Mainland and a select few beyond were also included. This made the most sense for the Vancouver region, which despite having a large number of individual municipalities is a regional economy.

The exploration of municipal and regulatory barriers proceeded in two phases. The first phase involved a desk-based review of barriers that have been identified by other studies. This included an analysis of academic, industry, and sector based reports as well as newspaper articles. The second phase involved contacting companies with known deployed technologies within the sector and asking them to identify the barriers they faced. The next logical step in this study is to establish a series of roundtable events with the industry.

Challenges

Identifying the Companies

A significant challenge in identifying the companies (and their technologies) was the expansive scope and compressed time frame for the project. Because of the large number of emerging companies, shifting business models (more providers “going green”), rapidly-changing industry, and quick push to deploy technologies before the 2010 Olympics, there may be some projects or companies that were missed. Also, with the rapid arrival of the Olympics in the region, companies are much more focused on delivery than on networking and communications, which meant that opportunities for in-depth contact with many companies was limited.



PHOTO: BALLARD

Identifying Deployed Technology

The goal of identifying technologies that have been deployed posed a greater challenge. Technology companies were generally very eager to provide information about their technology and where it had been deployed, as the showcase opportunity of the map provided an incentive. Those deploying their technology for the first time or still in the process of finding a demonstration project were even more eager to provide their time and information. However, not all companies who were contacted made an effort to respond.

Working backwards from green buildings and green projects to identify local companies and technology deployed proved very difficult. The most readily available documentation focuses on efficiency factors and/or results, but such documentation neither provided information with regard to the actual type of technology nor identified which companies provided the technology. Contacting building operators directly was problematic, as they generally did not know where to find the specific information. In the process, one would get passed onto several different people until someone either recommended contacting the architect or engaged in various stall tactics to get out of having to find the information. Finally, the engineers and architects were contacted. While they appeared to possess the information or knew how to access it, it became apparent that it would be too taxing to produce this information without revenue in return.

The challenges faced in the process of working backwards from projects to technology and companies reveal that information must be gathered either during the construction or implementation of technology. While companies whose technology was implemented are willing to provide the information, the actual names of the companies are often the missing link. Once a building or project is completed, the memory of the specific project details disappears.

Identifying Municipal & Regulatory Barriers

The research on barriers was significantly constrained by time. The challenges in identifying the companies and

¹ Including: BC Technology Industry Association, the Biodiesel Association of Canada, Canadian Wind Energy Association, Hydrogen & Fuel Cells Canada, GeoExchange BC, Independent Power Producers of BC, National Research Council of Canada, Ocean Renewable Energy Group, Sustainable Technology Development Canada, and Vancouver Fuel Cell Vehicle Program.

technology deployed meant that more time was spent on creating those inventories. Unfortunately this meant that truly comprehensive research on the barriers could not be completed within the project period. Another challenge was that while many companies were quick to provide general barriers, very few were capable of providing the specific information sought. The best example is that some would identify 'zoning bylaws' as a problem. However, when called upon to provide exactly what the barrier or obstacle was, a specific answer was rarely provided. The inability to elicit specifics from companies may be revealing in itself in that it is possible that various barriers may not even exist. They may instead be perceptual or may not actually be a code or regulatory barrier at all.

III. GREEN TECHNOLOGY IN THE LOWER MAINLAND

Vancouver's reputation as a green city on the global stage has helped make it a centre for research and innovation across the broad spectrum of the green technology industry. British Columbia's vast resources also create a strong foundation for this kind of activity within the province, from site remediation to bioenergy. Vancouver also acts as a business hub for head offices of companies that carry out their activities elsewhere in the province. Numerous academic institutions, industry associations, and government programs within the Lower Mainland provide further support for the industry. While the region is the natural breeding ground for green technology companies, the province was not a major location for technology installations until very recently.

The surge in deployed projects within the region is a result of several factors including government policy, the economic environment, and general awareness of the importance of the industry. Many of the deployed technologies occur in areas where there are few bylaws that address those types of technologies specifically. These first-time projects therefore face municipal and regulatory barriers because of the lack of familiarity and experience at the various government levels. Companies implementing these projects bear the burden of 'proof of concept' and the added costs associated with delays in the approval process. While the lack of familiarity with these technologies at the governmental levels has slowed deployment, governmental bodies will gain experience that will speed the process for future projects.

Another common barrier for the deployment of green technology is the notion of risk and liability. Municipalities especially are averse to the adoption of new technologies or make requirements that may hinder deployment for fear of liabilities that may result from any risks taken. Public opposition to some types of technology, especially in urban settings, can become politically charged topics that sometimes hinder the adoption or deployment of technology. The politicization in some sectors is so pronounced that



PHOTO: VANCOUVER CONVENTION CENTRE

companies start by looking elsewhere to deploy their first projects.

An overarching issue is that a great number of the municipal and regulatory codes and by-laws identified are prescriptive and structural. While they are in place to reach a certain level of performance, the actual codes and bylaws are not performance-based. This means that industry is restricted from innovating to reach the same goals. However, local authorities have consistently indicated a willingness to exempt industry from code violations to accommodate technologies that achieve mandated performance goals. This means that the barriers identified may only be a matter of perception. Companies facing barriers, if they go far enough along in the process, will in most part find municipalities like the City of Vancouver to be flexible in adapting codes and bylaws to accommodate new technologies. But from an industry perspective, years of obstacles to projects at the municipal level has led firms to look to other jurisdictions that are perceived as more "business friendly" to implement their projects. Some respondents indicated that the biggest code barriers concerned not implementing technology, but basic permitting that would be faced in the course of any development.

Market and economic barriers remain the biggest obstacles for companies in the deployment of green technology. Different sectors have discrete market issues, but one common challenge that permeates them all is the lack of incentives for developers and the general public to adopt and implement technology. The relatively low cost of energy in British Columbia makes alternative energy sources and more efficient technologies relatively less competitive. While companies do face municipal and regulatory barriers, the general consensus is that if one wants to adopt technology, one can in most circumstances do so. However, the relatively low cost of energy in British Columbia provides little incentive for companies to expend the additional effort necessary to overcome the barriers that do exist. The greatest challenge therefore is the lack of incentive.

In recent years there has been recognition that the deployment of technologies provides a crucial demonstration function. Since the Lower Mainland's market is too small to support the widespread commercial sales necessary to sustain companies, these companies need opportunities to prove the viability of their technologies to potential clients or investors. This identification of the Lower Mainland's role as a demonstration zone, combined with the global showcase opportunity provided by the 2010 Olympic and Paralympic Games, has created an incentive and an impetus for companies to overcome barriers to limited-scale deployment within the region.

Hydrogen & Fuel Cells

Hydrogen & Fuel Cells refers to the conversion of natural gas, methanol or hydrogen into electricity. Much of the development in this sector focuses on efforts by the automobile industry to replace dependency on oil, especially in the context of declining conventional oil supplies, climate change and local air pollution. The BC Hydrogen Highway represents British Columbia's first significant set of deployed technology in this sector in vehicles, refuelling facilities and hydrogen collection and production facilities. The Integrated Waste Hydrogen Utilization Project makes use of captured hydrogen from a vented waste stream in North Vancouver while hydrogen is produced by electrolysis in Surrey.

Despite the heavy focus on the automobile sector, fuel cells also have stationary applications for producing energy. The EasyWash Car Wash (see text box) in North Vancouver is a novel example of the use of fuel cells and waste hydrogen in such a stationary application.

While deployment of hydrogen and fuel cell technology is increasing, demonstration projects in this sector are a relatively recent phenomenon. Historically, the sector's strength in the Lower Mainland and Vancouver has been

PROJECT HIGHLIGHT: EASYWASH CAR WASH (NORTH VANCOUVER)



The EasyWash Car Wash demonstrates the use of hydrogen and fuel cell technology in an application outside vehicles and fuelling. In an attempt to reduce water consumption, the car wash treats and filters water sourced from 180 foot water well and uses this water to wash cars. A 150KW combined heat and power fuel cell produces enough electricity to power the site and heat the water that is used to wash car. Any extra energy produced is sent to the BC Hydro power grid. This is currently one of the largest net metering projects. The type of fuel cell installed at EasyWash is modular and space efficient and can be used for residential, commercial, and other applications. EasyWash is part of the Integrated Waste Hydrogen Utilization Project (IWHUP) and uses waste hydrogen from North Vancouver.

UN-MAPPED PROJECTS

Not all applications of fuel cell technology are map-friendly. The following is a list of projects within this sector that do not appear on the map that accompanies this report.

- Ballard Power Systems has teamed up with BC Transit, the provincial government and others to champion the world's first hydrogen hybrid fuel cell bus fleet for urban mass transit in revenue service. This project will operate a fleet of twenty buses to demonstrate the integration of fuel cell buses into the regular operational services of an urban transit system.
- Westport Innovations and Sacre-Davey have a similar project in Port Coquitlam with Heavy-Duty Hydrogen and Compressed Natural Gas (HCNG) transit buses.
- In North Vancouver, Sacre-Davey is working with Powertech Labs to convert eight light-duty GMC Sierra Trucks to run on HCNG in modified combustion engines.
- The Vancouver Fuel Cell Vehicle Program with Ford Motor Company will use state-of-the-art Ford Focus Fuel Cell Vehicles for real daily driving conditions as part of a three-year hydrogen fuel technology demonstration program.

research expertise, making Vancouver the global research hub for fuel cell technology. Led by Ballard Power Systems, British Columbia is home to several world-leading research organizations and companies in fuel cell and related technologies.² Fuel Cells Canada is a BC-based cluster that combines corporate research and development and government programming with respect to fuel cells. Both the National Research Council Institute for Fuel Cell Innovation and the Clean Energy Research Centre are based out of the University of British Columbia's Point Grey campus. The Lower Mainland also boasts upwards of twenty local companies that have leading technologies including micro hydrogen and proton exchange membrane fuel cells, hydrogen supply, humidification products for fuel cell systems, hydrogen fuelling, and magnesium-air fuel cells.

This sector faces relatively few municipal or regulatory barriers. The most significant barriers facing the fuel-cell sector remain market and infrastructure barriers. There is a considerable cost disadvantage of fuel cells and hydrogen storage and distribution against established alternatives in the market. Cost issues include materials, hydrogen transport, storage and compression, and volume manufacturing, as well as the cost of implementing fuelling infrastructure along a transportation route. However, the BC Hydrogen Highway will be an important for finding solutions to the various infrastructure and market barriers that permeate this sector.

The BC Hydrogen Highway has set the stage for fuel cell demonstration within the Lower Mainland and the world. BC's Hydrogen and Fuel Cell Strategy envisions BC as the world's pre-eminent hydrogen economy by 2020. Moving into the future, British Columbia's Lower Mainland could become

² <http://www.wd-deo.gc.ca/eng/4838.asp>

a global centre for fuel-cell development, demonstration, and commercialization as fuel cells move from an emerging technology to a commercial electrical power product.

Renewable Energy: Solar Technology

Solar Technology refers to the capture and use of energy from the sun, usually in the form of photovoltaic panels or solar tubes. Solar technologies are probably the most widely-deployed green technology within the Lower Mainland. The main applications have been for non-electricity passive solar applications for space and water heating. However, the British Columbia Institute of Technology has several projects that demonstrate the possibility for the use of solar beyond this narrow scope (see text box).

Local companies engage in the production and sale of solar modules, controls, specialized water pumps, and solar lighting systems. Because of the highly commercialized nature of this sector, there are a string of companies that focus on innovation, research and development, while a separate group of companies specialize in the sales of solar technology of both local and foreign companies. Xantrex Technology and Day4 Energy are good examples of local solar product manufacturers while Vancouver Renewable Energy Co-Op and Taylor Munro Energy Systems are prominent sales and installation companies. Vancouver's solar sector is characterized by more sales and installation companies than research, development, and manufacturing companies.

The municipal and regulatory barriers for the deployment of solar technologies are minimal. Solar panels and systems can generally be installed on demand. The most significant technical barrier identified by the industry relates to inconsistent engineering standards and interconnection guidelines. Nonetheless, solar technologies have yet to be installed in a significant percentage of homes, largely due to cost barriers. While the low cost of energy in BC is a barrier, local companies, such as Day4Energy, are innovating to reduce the costs associated with solar panel production.

Solar is a variable-energy resource, providing electricity only when the sun shines. The low level of sun the Lower Mainland receives compared to regions in the United States down south is another barrier. This increases the length of time it takes to recover initial capital costs, but also means that the weather requires grid-tied solar electric systems as opposed to off-grid systems, having the grid as a back-up when there is insufficient solar-produced electricity. Advancement in battery storage technologies and capabilities would significantly reduce the need for grid-tied systems. Despite these limitations, solar power is a strong area in terms of technology deployment in the Lower Mainland.

Renewable Energy: Wind and Water Energy Conversion

Wind and water energy conversion refers to the capture of energy from oceans, rivers, and wind. British Columbia's

BCIT'S APPLICATIONS OF SOLAR TECHNOLOGY

The British Columbia Institute of Technology is a leading researcher and installer of solar technologies. The deployed technology is different from conventional uses of solar technology for heat and water purposes. There are four grid-tied PV systems on the BCIT Burnaby campus. Three are grid-connected Building Integrated Photovoltaic (BIPV) systems that act as mini power plants. There is a 2 kW array on the Home 2000, a 3 kW array on the Discovery Parks – Technology Place building, and 1kW array on the Institute's Technology Centre (NE25). The fourth System is a 15-meter tall Power Tower with two kilowatts of rainbow-coloured solar cells that provides an ideal base for research and training. BCIT also has a Solar Canopy System that brings daylight inside multi-floor buildings, slashing electricity needs and green house gas emissions.

geographic make-up of mountains, rivers, strong tidal currents, offshore waves, and rich wind corridors provides the natural environmental for companies within this sector to both deploy and test their technologies. Despite the general strength of demonstration projects in this sector throughout BC, much of the deployment of wind and water technologies has occurred outside the Lower Mainland. This is hardly surprising because these types of technologies are generally located outside of urban centres. There are a number of deployed run-of-the-river projects outside the Lower Mainland, while wind turbine deployment has yet to find an operational industrial-scale project in the Province. Those wind projects that are under construction are stand-alone turbines. While these projects represent useful demonstrations, it would take large-scale wind-farms to generate any significant amount of power.

Even so, the sector has a strong business presence within the Lower Mainland. Vancouver is increasingly becoming the business centre for the renewable energy sector. The region boasts upwards of 35 companies, all of whom only have projects outside the Lower Mainland. The hydroelectric energy sub-sector is stronger than the wind energy sub-sector in terms of number of both local companies and

PROJECT HIGHLIGHT: WIND TURBINE INSTALLATION AT GROUSE



The construction of a single wind turbine on Grouse Mountain is slated to be complete in August 2009. The turbine will reach 65 meters high and consist of 37.5 meter blades with the final result being an operating power generator producing 2,000,000kw. The wind turbine will generate 20 percent of Grouse Mountain's electricity needs. The turbine represents British Columbia's first viable wind energy solution. The project was approved in October 2008, after Grouse Mountain conducted three years of study and followed the prescribed application process set out by the North Vancouver District. None of the components for the wind turbine were sourced locally.

projects deployed. More than 25 companies specialize in hydroelectric energy technologies while more than ten specialize in wind energy technologies.

Wind- and water-based renewable energy technologies face a multitude of regulatory barriers. Projects are often located on remote Crown lands, requiring the use of rivers or waters that entails extensive Environmental Assessment processes. Recently, the BC government published a Guidebook on the extensive permitting and public consultation process for wind and water projects. The guidebook highlights the technical, commercial, and permitting requirements that these types of projects must meet to successfully deploy technology within the sector.

The barriers for this sector are even higher in urban settings. While wind projects are somewhat better suited for urban settings than water projects, restrictions on height and size of collectors and sounds of spinning blades are all obstacles to wind-turbine projects. Further, the revenue stream does not exist in most circumstances to justify the costs for the adoption of these technologies at a large scale because of the cheap cost of electricity in BC. The use of wind and especially water energy within the province is also a significant political issue because most large-scale projects require a connection to the publicly-owned and regulated grid and distribution system. Wind and water energy producers have one truly viable client: the provincial utility, BC Hydro. Therefore it is the political environment that will shape the future of this sector.

Battery Storage Technologies

Battery Storage Technologies refers to the ability to convert electricity from various sources into a storable form for later reconversion and use. Battery storage technologies are closely linked with other sub sectors in the green technology industry. They are seen as significant enablers to more effective use of clean energy by being able to store solar, tidal, and wind energy in electrical form. Battery storage technologies also expand the reach of clean energy to the automobile industry.

British Columbia has a 30 year history of advanced battery development, and has built up a solid core of expertise, development, and commercial activities in this area. Maple Ridge houses E-Moki Energy, North America's only manufacturer of cylindrical Li-ion rechargeable batteries which were developed locally. Cadex Electronics has a long history of innovative development in batteries, specialized battery packs, battery analyzers, charges, and rapid testers. While the sector continues to focus on research and development for greater energy storage capabilities, various projects have been deployed around the lower mainland. However, these projects mostly relate to transportation applications. E-Moli Energy is making use of batteries to run Electric Scooters and Bikes while Delta-Q's batteries are being used in various hybrid cars.

The deployment of battery technologies is not directly hindered by any significant municipal or regulatory barriers.

TECHNOLOGY HIGHLIGHT:

NEXTERRA GASIFICATION SYSTEM (NEW WESTMINSTER)

Nexterra Energy Corporation will be installing a Gasification System – Direct Fired Boiler Application at Kruger Products Tissue Mill in New Westminster. Nexterra will supply the complete gasification system from fuel metering bins to the existing ESP. The system will convert wood residue into clean burning “syngas” that will be fired directly into a boiler in place of natural gas. The process will produce steam for multiple uses at the Kruger mill. The existing ESP further cleans flue gas before releasing it out the stacks. The Kruger installation will produce 40,000 lbs/hour of process steam and displace approximately 445,000 GJs of natural gas annually. The entire system is estimated to reduce both greenhouse gases by approximately 22,000 tonnes per year and costs by millions of dollars per year. Kruger, Nexterra and FPIInnovations have formed a consortium to build the new system. The project received support from Natural Resources Canada, the BC Innovative Clean Energy Fund and Ethanol BC. The Kruger project will be the first commercial demonstration of Nexterra's direct fired gasification solution.

Barriers, if they exist, generally result from the way in which batteries are deployed. Batteries used for harnessing and storing solar energy, for example, face few challenges.

The actual challenges are associated with the deployment of the solar panels themselves. Batteries used for electric vehicles however face significant challenges. For example, the City of Vancouver does not allow low speed cars – cars that usually run on battery technology – to travel on major municipal roads. Though this may change as a result of pilot projects currently underway with electric car manufacturers. Further the cars that these batteries are used in are frequently designed in a way that cannot be crash tested. The deployment and adoption of battery technology therefore is hindered by these indirect barriers.

Biomass Conversion

Biomass Conversion refers to green hydrocarbons that can be combusted or gasified to produce heat or converted into liquid fuels, derived from wood and other forms of solid or liquid waste. While British Columbia has a rich history of deriving energy from biomass sources, the sector only recently deployed advanced technologies in areas of gasification and waste-to-energy conversion. Several projects, both within and outside the lower mainland, are in the planning process, breaking ground or nearing completion. Paradigm Environmental Technologies' Lulu Island Waste Water Treatment Facility in Richmond will produce electricity from wastewater sludge. Nexterra Energy Corporation has installed a direct-fired boiler biomass gasification system in New Westminster.

Some examples of this technology deployed in the province are not of local origin although they have been installed by local companies.

For example, Catalyst Power's anaerobic digester, which is being installed in Abbotsford, is of European origin. While there were options to install Canadian technology, Catalyst Power chose a European model because of the advanced level of European technology in this sector due to Europe's long history of advanced biomass applications.

Despite the potential technology gap, British Columbia has a strong and growing bio energy sector. Nexterra is a good example of a local company with significant expertise and local projects. There are more than twenty local companies within the Lower Mainland involved in the research, development and manufacture of various components and technologies within the sector. Local wood-pellet companies are the furthest along in terms of commercialization, though most of the markets for their products remain overseas. British Columbia has yet to provide a true wood-pellet market for these companies, although the province has significant capacity in pellet production and research, development and testing of biomass systems. Several local companies in BC are also converting organic waste products such as vegetable oils, fisheries by-products and rendered animal fats into biodiesel.

This sector faces significant barriers at the municipal and regulatory levels. While zoning and fire code restrictions are two areas that were consistently identified as barriers, the main challenges seem to stem from that the fact that there are usually very few regulations or bylaws that speak directly to the industry. Therefore, the greatest obstacle appears to be the lack of knowledge and/or experience in the approval process placing an enormous burden on local companies.

The increasing number of projects in this sector indicates the growing application potential within the province. Indeed, a high proportion of the projects approved by BC's Innovative Clean Energy Fund have been bio-energy projects, and in its second call for proposals, the ICE Fund put out a separate call for projects relating to liquid fuels from biomass. This trend is indicative of the positive outlook for the bio-energy sector.

Green Buildings

Green Buildings refers to those parts of the real estate development industry that specialize in construction of buildings that leave a smaller environmental footprint through reduced energy and/or water consumption. These performance improvements come as a result of both design features and integration of relevant green technology within buildings. 'Green' features of a building can range from the type of paints used to state-of-the-art energy systems and technologies. Various rating systems are used to label buildings 'green,' – LEED and GoGreen being some of the most prominent – but not all buildings go through a formal certification process because certification can be burdensome and expensive.

Green buildings are establishing a strong presence within the Lower Mainland, with a large cluster of them in or near the downtown Vancouver core. While the Lower



Mainland boasts strengths in all areas of the sector, design appears to be Vancouver's particular area of green building expertise. The technologies in a majority of these buildings seem to extend largely to heat recovery and storm-water runoff systems. The Lower Mainland has a large number of individuals and organizations skilled in energy-efficient design, engineering, and architecture. Stantec, Bunting Coady Architects, Busby Perkins + Will, Bing Thom Architects, and Omicron have significant experience in this area. Supporting organizations such as Light House Sustainable Building Centre and the Cascadia Green Building Council also provide local support in terms of both resources and education. Much of the success of the green buildings sector within the region can be attributed to municipal leadership, exemplified by Vancouver's globally-recognized planning and recent greening of its building code.

Gaps, however, still remain on several levels. Industry consistently identified three in particular. First, little allowance is made in terms of the large amounts of space that mechanical equipment and systems – such as recovery heat ventilators – take up. This is space that developers are generally reluctant to give up in terms of saleable space. Currently, those involved in the architectural and engineering design process are not necessarily the same people who actually build and operate buildings. This disconnect is in some cases being overcome by an integrated design process that seamlessly incorporates low profile systems into a largely passive building and therefore reduces the need for large mechanical equipment.

Second, mandatory costs such as development cost charges (DCCs) have to be paid despite the fact that technology installed may limit or even eliminate the use of infrastructure such as sewage systems. Third, it is difficult to secure approval for the design and implementation of storm water/grey water reuse systems since there is little guidance in Vancouver's building code that speaks directly to whether the systems can be used, even for non-potable purposes.

This requires a case-by-case approval process that can be cumbersome and delay the approval process. Industry indicated that while these municipal barriers exist, they are not too difficult to overcome. More important than these regulatory barriers are the lack of incentives in place for developers or homeowners to build green.

Despite these specific references and other barriers that may exist at the municipal or regulatory level, the current Mayor of Vancouver has set a goal of making Vancouver the Greenest City in the world. While this bodes well for all sectors, it is especially significant for the green buildings because the City of Vancouver has direct control over the laws that govern green buildings. The future outlook for green buildings in Vancouver is therefore positive in all fronts.

Sustainable Urban Planning

Sustainable Urban Planning refers to settlements that integrate the principles of density, mixed use with supportive resources, human-scale transportation, diverse open spaces, healthy environments and ecosystems, and efficient use of energy and resources. There are numerous examples of sustainable urban planning throughout the Lower Mainland including the South East False Creek development in Vancouver, UniverCity at Simon Fraser University in Burnaby, and the Northeast Coquitlam Area plan in Coquitlam.

PROJECT HIGHLIGHT: SOUTH EAST FALSE CREEK



The transformation of South East False Creek (SEFC) is a prime example of sustainable urban planning in North America, incorporating forward-thinking infrastructure, strategic energy reduction, high-performance buildings and easy transit access. SEFC will be a mixed-use community with a focus on residential use, developed at the highest density possible while meeting liveability and sustainability objectives. The SEFC development is built on the last remaining large tract of undeveloped waterfront land near downtown Vancouver. It will be the future site of the Olympic Village, and, after the 2010 Winter Games, SEFC will become home to 16,000 people in the form of more than 5,000 residential units. The SEFC development will have a 30,000 square foot community centre, several child care centres, an elementary school, community garden, public plaza, mid-size grocery store and community serving retail/services, interfaith spiritual centre, restoration of five heritage buildings, and 10 hectares of park land, including habitat, playgrounds and opportunities for urban agriculture. The SEFC development will also make use of a community energy system – the Neighbourhood Energy Utility waste heat recovery system. SEFC will be home to the Athletes Village and will be showcased to the world during the 2010 Olympics.

Projects Outside the Lower Mainland

Lower Mainland firms are increasingly exporting their expertise to other jurisdictions. In some cases, such as Dockside Green in Victoria or Northern BC “smart” street lighting project, these projects are occurring around the Province. Others involve projects as far away as Dubai.



PROJECT HIGHLIGHT: DOCKSIDE GREEN

Dockside Green is one of the most famous developments in the western hemisphere. Dockside combined many sustainable features in an entire neighbourhood: green roof, recycled building materials, renewable energy, energy efficiency, low-VOC finishes, day lighting, natural ventilation and more. Dockside green is also the first example of district waste treatment and energy in Canada, incorporating a Nexterra gasification system. This is the major accomplishment at Dockside. This project is of even more significance because of the way the development sits within its urban context with attention to land use, density, transportation and the like. The residential units at Dockside sold at a premium and the project set the world record for LEED Platinum points.

Sustainable planning, like green buildings, incorporates green technologies in order to meet its objectives. Building codes, zoning and neighbourhood planning and design standards have the possibility of restricting the ability of private developers to provide higher-density and more pedestrian-friendly forms of development that could support efficient transit service and pedestrian based interaction. As urban centres become home to more and more residents and the focus of the world shifts towards sustainability, sustainable urban planning will become increasingly important to municipal governments, with urban centres like Vancouver becoming a model for progressive planning principles. The City of Vancouver has made significant progress in “greening” its bylaws, including the relaxation of density restrictions and required parking-to-building ratios. Metro Vancouver adopted the Liveable Region Strategic Plan in 1996 as its framework for decision-making at the regional level, and municipal governments are increasingly making sustainable development the focus of their planning, especially in the light of the region’s focus on sustainability.

Energy Management & Conservation Technologies

Energy Management & Conservation Technologies or Power Electronics Technologies refers to a set of hardware, software, and power electronics that serve to improve the way electricity is generated, transported, and used. Enhanced grid and delivery technologies make systems smarter, cost effective and more reliable. End-use technologies make buildings, transportation, and equipment more efficient and provide tools to manage energy use. Energy management and conservation technologies have been widely deployed throughout British Columbia, especially as a result of various incentives and programs by BC Hydro. Energy Aware’s PowerTab at the Millennium Water Development in the Athletes village will provide

residents with real time energy usage data. Projects on a larger scale include the City of Vancouver's Neighbourhood Energy Utility and Port Metro Vancouver's shore power for cruise ships at Canada Place. Shore power will help reduce marine diesel air emissions by enabling ships to shut down their engines and connect to BC Hydro's electrical grid in order to provide necessary power while docked.

The energy management and conservation technology sector is another area of significant commercial advancement in the region. The region possesses expertise embedded both in local firms and academic and research institutions. Local companies such as Legend Power Systems and Tantalus Systems Corp pioneered power technology globally and continue to be a leader in the field. This sector has a number of local companies that are very active in terms of technologies both demonstrated and sold. This sector faces struggles that other technology sectors have yet to face. Despite having reached commercial viability, British Columbia's small market poses a challenge as it does not represent the volume of sales that is required for these companies to remain profitable. In order to earn sufficient revenue to succeed, local companies in this sector need access to export markets. Further, the province is not best suited for low-cost manufacturing for large volume sales. Therefore while the expertise and actual technology are home-grown, outsourcing manufacturing may occur at the commercialization stage.

Generally, energy management and conservation technologies do not face significant municipal or regulatory barriers in terms of the ability to deploy their technologies. Technologies in this sub sector face little in the way of proof of concept, risks or liabilities, or even resistance from governments or neighbourhoods. In fact, programs are in

TECHNOLOGY HIGHLIGHT: ENERGY AWARE'S POWERTAB

Energy Aware's patented PowerTab is being installed at the Millennium Water Development in the Athlete's Village at the SEFC development. The PowerTab is an in-home display designed to help the utilities industry meet their need for increased communication and feedback to their customers. The PowerTab receives real time consumption data on electricity, heating & cooling, and water consumption wirelessly from a residential smart meter. The display indicates electricity use in monetary or kWh units and text message alerts from the service provider. The PowerTab is slated to be installed in two phases. In the first phase, the technology will be installed in public buildings. After testing in these units and troubleshooting any problems identified during initial deployment, the PowerTab will then be installed in private buildings. The proposal for and installation of the PowerTab technology faced few obstacles municipally. The real challenge was demonstrating value relative to competing technologies.

PROJECT HIGHLIGHT: NEIGHBOURHOOD ENERGY UTILITY AT SEFC



Among the many innovative green features of the SEFC development is the Neighbourhood Energy Utility (NEU), a community energy system that will provide space heating and domestic hot water to all buildings within SEFC. NEU makes use of sewage waste heat recovery technology, a renewable and locally available source of energy. Thermal energy is captured using a heat exchange process integrated with a new municipal sewage pump station. Heat pumps transfer thermal energy for residential space heating and domestic hot water. Heat will also be utilized from solar modules on the rooftops of several SEFC buildings that will return solar energy to the NEU distribution system. High efficiency natural gas boilers will provide backup and supplemental heat on the coldest days of the year. A network of pipes and heat exchangers will share thermal energy amongst buildings. The centralization of energy production will result in significant efficiency benefits.

place to incentivize the use of these technologies generally. The most significant challenges in this area are potentially the lack of market awareness of the benefits of technologies and the lack of capital for local companies.

The outlook for the sector is promising. It is expected that there will be a five-fold increase in revenues and jobs within the sectors in the next decade. The Premier's Technology Council and the Alternative Energy and Power Technology Task Force have recommended four strategies in leadership, commercialization, growth, and innovation to make British Columbia a world leader in power technology.

The current trend for clean and green is most promising for this sector because unlike many other sectors, the energy conservation and management sector does not face significant regulatory and municipal barriers and there is little or no opposition from the public.

Green Roofs

Green Roofs are an extension of the existing roof which involves a high quality water proofing and root repellent system, a drainage system, filter cloth, and a lightweight growing medium and plants. Green roofs reduce storm water runoff, energy consumption, and greenhouse gas emissions. They also represent opportunities for significant social, economic and environmental benefits, particularly in urban settings.

Until recently, applications of green roofs had been limited in North America. While green roofs are slowly gaining traction in the Lower Mainland, applications within the region are mainly limited to industrial, commercial and institutional buildings. Most of these applications have occurred in urban settings, with Vancouver setting the standard with the green roof atop the Vancouver Convention Centre. This green roof has been billed the largest in Canada and brings a new level of ecology and habitat to the urban landscape.

The expertise of the sector generally falls to the architects and engineers who design custom green roof systems on a building-by-building basis. Many of the large firms have built expertise around this area, but a good number of small local firms have also developed significant experience with green roofs. The Lower Mainland generally boasts expertise in terms of the number of both experienced companies and support institutions. The British Columbia Institute of Technology is leading the way with its Centre for the Advancement of Green Roof Technology and the Centre for Architectural Ecology – Collaborations in Green Roofs and Living Walls.

Significant municipal and regulatory barriers exist in the implementation of green roofs. These include structural concerns, insufficient standards, and lack of information, skills, and experience in the approval process. Provincially, the Homeowner Protection Office has been identified as an obstacle because of the legacy of the leaky condos in BC's past. Green roof developments may not qualify for the warranty, though the industry has seen indications that the province may consider a more accommodating policy in the future. Currently the HPO will not insure green roofs atop condo-strata buildings because of issues around maintenance.

Also significant are the economic and market barriers that pose challenges in the deployment of green roofs. Lack of market understanding of the benefits of green roofs – particularly the energy savings that accrue from the natural insulating and cooling properties of the roofs – is the primary challenge. Further, much deployment in the private sector is occurring on commercial buildings. Developers often do not consider the extra expense of green roofs to be justified as the benefits flow to future occupants not the developer.

As the market begins to understand the benefits of green roof technology, people may be willing to pay premiums for buildings with green roofs. Indeed, local governments are very interested in green roofs and this interest is growing due to the perceived benefits of green roofs for municipal infrastructure in reducing storm water flows, especially in Vancouver where there is not a city wide storm water system. The City of Vancouver is working towards modifying its by-laws and building code to accommodate green roof construction. Therefore, with greater awareness, government support, and significant incentives, green roofs have the potential for success within Vancouver and the Lower Mainland.

Environmental Technologies

Environmental Technologies refers to those technologies that measure, prevent, limit or correct environmental damage to water, air, and soil, and which deal with problems of waste, noise reduction and ecosystem protection. The sector does not just focus on end-of-pipe solutions to treat pollutants. Technologies that reduce material inputs and energy consumption or recover useful by-products are also

TECHNOLOGY HIGHLIGHT: VANCOUVER CONVENTION CENTRE GREEN ROOF

The custom six-acre green roof atop the Vancouver Convention Centre is the largest of its kind in Canada. In fact, it is the biggest non-industrial living roof in North America. The six-acre roof is covered with more than 400,000 indigenous plants and grasses from the Gulf Islands, providing natural habitat to birds, insects and small mammals. The roof is designed to act as an insulator and is projected to reduce summer heat gains by up to 95 percent and winter heat losses by up to 26 percent. The vegetated roof is only one of many environmental innovations included in the project. The Convention Centre will serve as the international broadcast and media centre for the 2010 Olympic and Paralympic Winter games. The environmental features of the centre, including the living roof, will be given a global showcase and will add to Vancouver's brand as an environmentally progressive city.

considered environmental sector offerings. This sector therefore greatly overlaps with others including green building, sustainable urban planning, and energy (and water) management and conservation. Paradigm Environmental's installation at the Lulu Island Waste Water Facility to convert waste into energy is a prime example of how environmental technologies overlap with the bio energy sector.

Deployed projects include water and wastewater treatment systems, storm water management, soil and groundwater remediation and water reuse applications. Generally though, demonstration projects involving large scale, real-world urban demonstration sites (within the Lower Mainland) where environmental technologies, products and services can be tested and showcased in order to attract international customers have been lacking until recently.

The broad breadth of environmental technologies within BC is indicative of the sector's strength within the Lower Mainland and the province generally.

PROJECT HIGHLIGHT: LULU ISLAND WASTEWATER TREATMENT FACILITY



Paradigm Environmental Technologies has installed MicroSludge™ at the Lulu Island Waste Water Treatment Facility in Richmond, British Columbia. MicroSludge™ is the company's patented technology for waste water treatment plants that significantly enhances the anaerobic digestion process. The technology can reduce the total quantity of biosolids for disposal by an additional 60% and enables anaerobic digesters to generate increased volumes of methane gas, which will then readily be converted into electricity and heat with the co-generation equipment at Lulu Island to turn wastewater sludge into a clean, renewable source of electricity. This enhancement also reduces operating costs and increases plant capacity.



PHOTO: PORT OF VANCOUVER

The industry is predominantly characterized by small to medium-sized firms. Bioteq Environmental Technologies and Air Phaser are examples of strong local companies within the sector. The largest and strongest sub sectors within the Lower Mainland include environmental construction, recycling, water and wastewater technologies including solid waste management, co-generation systems, and environmental instrumentation technologies. There are also a number of larger organizations with expertise in site remediation, including the Port of Vancouver which has developed capacity in this area by undertaking restoration projects on its significant land holdings around the region.

A major weakness for the sector is the absence of a strong cluster and an industry-based environmental business association which can influence the sector with respect to shaping regulatory regimes and government practices. This is in part due to a number of firms with very different practices, from enzyme-based remediation to air pollution control. However, as with other sectors covered in this report, the lack of a strong unified cluster impedes the international recognition of the full breadth of BC's environmental excellence.

The industry generally identified the need for the removal of regulatory and municipal barriers created by rigid adherence to standards. Indeed, the regulatory constraints are the reasons cited for why environmental technologies have not been readily deployed throughout the Lower Mainland. The core of the problem seems to be the risk aversion tendencies of regulators prompting the use of traditional old technologies for urban environmental application. While provincial legislation does permit the use of innovative technologies for water reuse, these technologies are often met with apprehension at the municipal level. Adoption of innovative solutions for water and waste water treatment are

often avoided because of the direct impact of infrastructure on human health.

While comments relating to the regulatory barriers are well founded, the success of current projects underway at Lulu Island and Lions Gate Wastewater facilities will facilitate the implementation of more technologies within this area. Further, because of the large breadth of the sector there are several emerging opportunities including contaminated sites and brownfield site reclamation, green building design, technologies, and products, sustainable communities and integrated environmental solutions, and water and wastewater technologies, services, and solutions.

IV. SUMMARY OF FINDINGS

The Vancouver region has demonstrated strengths in a wide variety of green technology sectors and types. While specific barriers do exist in a number of these sectors, market barriers remain the single greatest obstacle to the deployment of these technologies around the region. While widespread deployment of certain technology suites like passive solar applications or green roofs is possible, for many of the advanced technologies successful commercialization will require accessing markets beyond the Lower Mainland. This creates an impetus for local companies to demonstrate their technologies locally, making the region a demonstration zone for the region's wide swath of innovative offerings.

Where this involves overcoming regulatory barriers, it is important that municipalities take proactive steps overcome these barriers. Numerous barriers were identified by industry as regulatory and/or municipal. These include permit applications to approval of new types of technology. However, a number of these barriers identified do not seem to be actual barriers. Local authorities have consistently indicated a willingness to exempt industry from code violations to accommodate technologies that achieve mandated performance goals. This means that the barriers identified may only be a matter of perception. Market and economic barriers remain the biggest obstacles for companies in the deployment of green technology. The broader issue therefore will be creating the right set of incentives that overcome the market barrier to initial deployment.

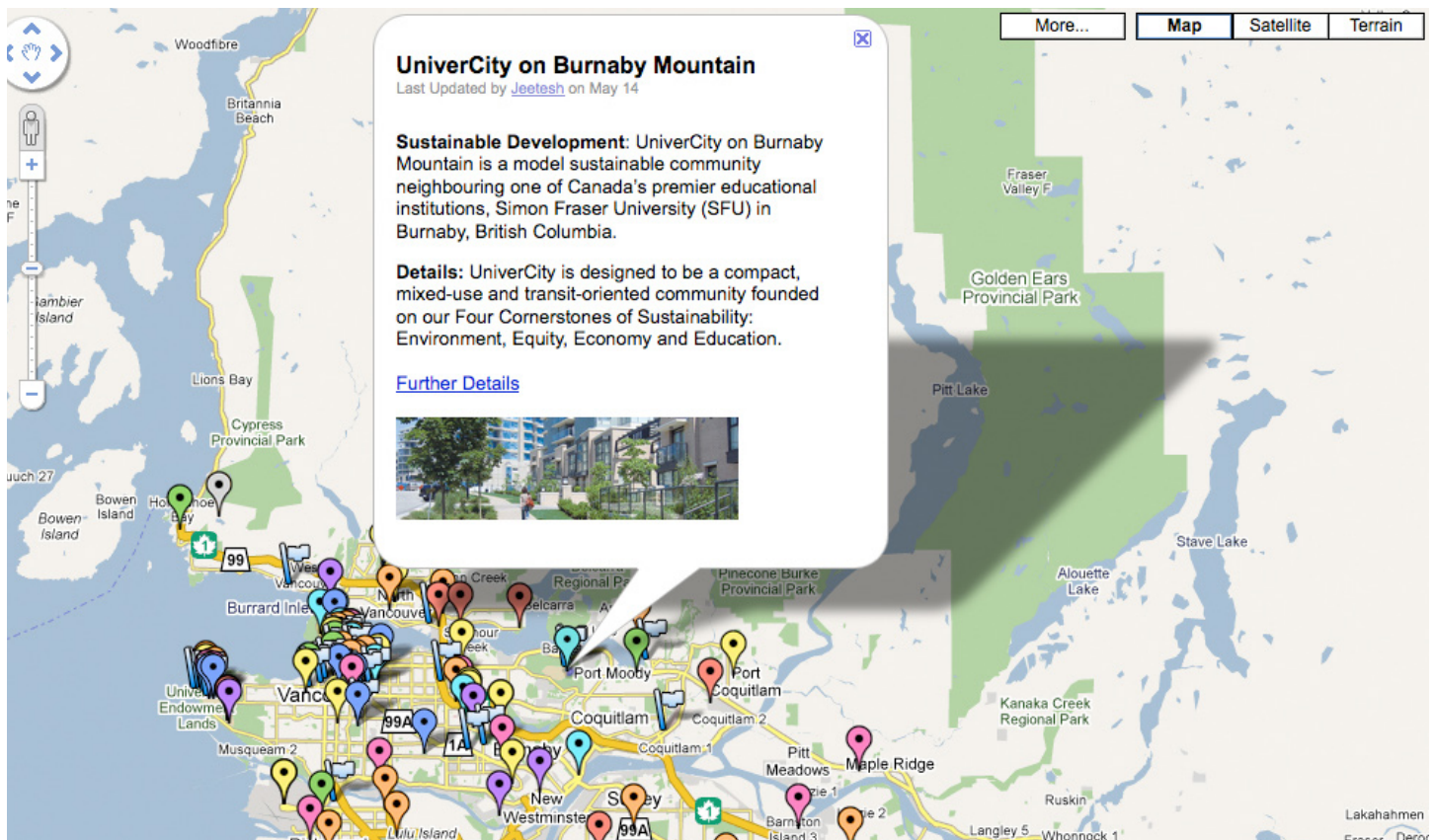
APPENDIX A: DEFINING GREEN TECHNOLOGY

A significant determining factor for the success of any study is its scope. In the current context, this means defining what 'green technology' encapsulates. Research indicates that 'green technology' has narrow to broad definitions that could include methods, materials, and techniques for generating energy to producing non-toxic cleaning products.³ The expansive definition that includes cleaning products is impractical given the purpose and objective of the project. As a result, green technology should be defined within the context of its application in British Columbia.

The British Columbia Technology Industry Association (BCTIA) uses the term "Clean Technology" instead of Green Technology. The BCTIA identifies "Clean Technology" as one of the major industry sectors in British Columbia. BCTIA includes the following areas as "clean technology:"⁴ Hydrogen, Fuel Cells, Power Electronics, Energy Storage, Wind, Ocean and Solar Power, and, Environmental Technologies. This is also the definition used by the British Columbia Ministry of Small Business, Trade and Economic Development to describe the "Sustainable Technology Sector."⁵

Also of significance is what is excluded. None of these definitions include the Green Building sector. The following areas fall within the Green Building sector: Architecture and Urban Planning, Engineering, Development Management, Landscape Architecture, Finance, and Green Building Material Supply. Generally speaking, the great majority of green technology is installed in buildings. Therefore, projects in the green building sector have been included in this project.

There is no one single definition of green technology. While this project's focus was 'green technology' in name, the actual objectives were broader. Second, few want to leave any category or sector out of studies and reports by narrowing scope. Because the industry is so fragmented, few really understand the scope of the sector. The industry only recently gained prominence and therefore there is a tendency towards flexibility in terms of definitions. Third, the majority of green technology is deployed in buildings. Therefore, to locate technology and identify deployment barriers, one must also look to green buildings.



³ <http://www.green-technology.org/what.htm>

⁴ http://www.bctia.org/files/White_Paper/BCTIA_SRED_Consultation_Paper_-_Nov_30_07.pdf (page 21)

⁵ http://investbc.com/Documents/AssetMaps/SectorProfile_SusTech.pdf The Ministry identified 20 of the largest BC companies in this sector to include companies spanning all the categories of the BCTIA definition of "Clean Technology."

APPENDIX B: COMPILED LIST OF LOCAL COMPANIES

<i>Company Name</i>	<i>City</i>	<i>Sector</i>	<i>Website</i>
Armstrong Pellets	Armstrong	Biomass Conversion	www.armstrongpellets.com
Canada U-Grow	Chilliwack	Biomass Conversion	
Canadian Bioenergy Corp	North Vancouver	Biomass Conversion	www.canadianbioenergy.com/
Cascade International Sales Corp	White Rock	Biomass Conversion	
City Farm Biofuel	Delta	Biomass Conversion	www.cityfarmbiofuel.com/
Dynamotive	Vancouver	Biomass Conversion	www.dynamotive.com
EnEco Industries Ltd.	Vancouver	Biomass Conversion	www.eneco.ca/
Entropic Energy Corp	White Rock	Biomass Conversion	www.entropicenergy.com/
Enviro 2000 Pelletizer Ltd	Surrey	Biomass Conversion	
Gaian Bioenergy	Mission	Biomass Conversion	www.gaianbioenergy.com/
Green Island Energy	Vancouver	Biomass Conversion	www.greenislandenergy.com
Green Machine Biofuels	Delta	Biomass Conversion	www.greenmachine-biofuels.com
JF Bioenergy	Abbotsford	Biomass Conversion	www.jfwasteenergysystems.com
Lignol Energy Corp	Burnaby	Biomass Conversion	www.lignol.ca
Linnaeus Plant Science	Vancouver	Biomass Conversion	www.linnaeus.net/
Nexterra Energy Corporation	Vancouver	Biomass Conversion	www.nexterra.ca
Pacific BioEnergy Corporation	Vancouver	Biomass Conversion	www.pacificbioenergy.ca
Paradigm Environmental Technologies	Vancouver	Biomass Conversion	www.paradigmenvironmental.com/
Pinnacle Pellet Inc	Quesnel	Biomass Conversion	www.pinnaclepellet.com/
Premium Pellet Ltd	Vanderhoof	Biomass Conversion	www.premiumpellet.com/
Princeton Co-Generation	Princeton	Biomass Conversion	www.eaglevalleyabm.com/
QuestAir Technologies Inc.	Burnaby	Biomass Conversion	www.questairinc.com
Syntec Biofuel	Vancouver	Biomass Conversion	www.syntecbiofuel.com/
Alpha Technologies	Burnaby	Energy Conservation & Management	www.alpha.com
Analytical Systems	Delta	Energy Conservation & Management	www.analyticsystems.com
Argus Technologies	Burnaby	Energy Conservation & Management	www.argusdcpower.com
Carmanah Technologies Corp	Victoria	Energy Conservation & Management	www.carmanah.com
Coda Research Corp	West Vancouver	Energy Conservation & Management	www.codaresearch.com
Energex Inc	Richmond	Energy Conservation & Management	www.energexinc.com/
Energy Aware Technology	Vancouver	Energy Conservation & Management	www.energy-aware.com
Enviromech Industries	West Vancouver	Energy Conservation & Management	www.exro.com
Gas Protection Systems Inc	Maple Ridge	Energy Conservation & Management	
IFD Corporation	Vancouver	Energy Conservation & Management	www.ifdcorporation.com
Innovative Circuit Technology	Langley	Energy Conservation & Management	www.ictcorporate.com/
Legend Power System	Burnaby	Energy Conservation & Management	www.legendpower.com
Leister Blake Enterprises	Port Coquitlam	Energy Conservation & Management	www.lbe.ca
MP2 Mobile Power Corp	Port Moody	Energy Conservation & Management	www.mp2inc.com
NxtPhase T&D Corporation	Burnaby	Energy Conservation & Management	www.nxtphase.com
Power Measurement (Sneider Electric)	Saanichton	Energy Conservation & Management	www.pwrm.com
Rainforest Automation	Vancouver	Energy Conservation & Management	www.rainforestautomation.com
Reliable Controls	Victoria	Energy Conservation & Management	www.reliablecontrols.com
Small Energy Group Inc	West Vancouver	Energy Conservation & Management	www.smallenergygroup.com
Tantalus Systems Corp.	Burnaby	Energy Conservation & Management	www.tantalus.com
Thompson Technology	Langley	Energy Conservation & Management	www.tti.bc.ca

Appendix B continued...

Company Name	City	Sector	Website
Busby, Perkins + Will	Vancouver	Energy Planning & Sustainable Design	www.busby.ca
Cobalt Engineering	Vancouver	Energy Planning & Sustainable Design	www.cobaltengineering.com
Energovironment Consulting Ltd	West Vancouver	Energy Planning & Sustainable Design	
Hammera Envirochem Inc.	Vancouver	Energy Planning & Sustainable Design	www.hemmera.com
Philips Lighting	Burnaby	Energy Planning & Sustainable Design	www.tirsys.com
Powertech Labs Inc.	Surrey	Energy Planning & Sustainable Design	www.powertechlabs.com
Stantec Inc	Vancouver	Energy Planning & Sustainable Design	www.stantec.com
Streetlight Intelligence Inc	Victoria	Energy Planning & Sustainable Design	www.streetlightiq.com
Switch Materials Inc.	Burnaby	Energy Planning & Sustainable Design	www.switchmaterials.com
The Sheltair Group	Vancouver	Energy Planning & Sustainable Design	www.sheltair.com
Azure Dynamics	Detriot/Burnaby	Engines & Automotives	www.azuredynamics.com
Dynasty Electric Car Corp	Delta	Engines & Automotives	www.itiselectric.com
ECO Fuel Systems Inc.	Langley	Engines & Automotives	www.ecofuel.com
Enviromech Industries	Kelowna	Engines & Automotives	www.enviromech.net
NxtGen Emissions Controls Inc	Burnaby	Engines & Automotives	www.nxtgen.com
Technocarb Equipment Ltd.	Abbotsford	Engines & Automotives	www.technocarb.com
Westport Innovations	Vancouver	Engines & Automotives	www.westport.com
ACDEG International	West Vancouver	Environmental Technologies	
Air Phaser	Surrey	Environmental Technologies	www.airphaser.com
Aquavive Technologies	Vancouver	Environmental Technologies	www.aquavivetechnologies.com
Aqua-Guard Spill Responses	North Vancouver	Environmental Technologies	www.aquaguard.com/
EPI Environmental Technologies	Vancouver	Environmental Technologies	www.epi-global.com
HAZCO Environmental Services	Richmond	Environmental Technologies	www.hazcoenv.com/
International Bio Recovery	North Vancouver	Environmental Technologies	www.ibrcorp.com/
Positive Results Environmental Management	Delta	Environmental Technologies	
Richway Environmental Technologies	Richmond	Environmental Technologies	www.richway.ca/
Sonic Environmental Solutions	Vancouver	Environmental Technologies	www.sonictsi.com/
Smartcool Systems Inc.	Vancouver	Environmental Technologies	www.smartcool.net/
Transform Compost Systems	Abbotsford	Environmental Technologies	www.transformcompost.com/
Tri-Arrow Industrial Recovery	Surrey	Environmental Technologies	www.tri-arrow.com/
Bioteq Environemtnal Technologies	Vancouver	Environmental Technologies	www.bioteq.ca
EcoTECH Waste Management Systems Inc.	Vancouver	Environmental Technologies	www.etwm.ca/
Hoskin Scientific Ltd	Vancouver	Environmental Technologies	www.hoskin.ca
Angstrom	North Vancouver	Fuel Cell Technology	www.angstrompower.com
Ballard Power Systems	Burnaby	Fuel Cell Technology	www.ballard.com
Cellex Power Products	Richmond	Fuel Cell Technology	
D-Point Technologies	Vancouver	Fuel Cell Technology	www.dpoint.ca
Gen-X Power Corp (subsidiary)	Vancouver	Fuel Cell Technology	/www.whitefox.com
General Fusion Inc.	Burnaby	Fuel Cell Technology	www.generalfusion.com/
Green Light Innovation Corp	Burnaby	Fuel Cell Technology	www.greenlightinnovation.com
H3 Energy Ltd.	Vancouver	Fuel Cell Technology	
Heuristic Engineering Inc.	Vancouver	Fuel Cell Technology	www.heuristicengineering.com/
Hydrogenics Test Systems	Burnaby	Fuel Cell Technology	www.hydrogenics.com
MagPower Systems	White Rock	Fuel Cell Technology	www.magpowersystems.com

Appendix B continued...

Company Name	City	Sector	Website
Palcan Power Systems Inc.	Vancouver	Fuel Cell Technology	www.palcan.com
Power Air Corp	Vancouver	Fuel Cell Technology	www.poweraircorp.com
PowerDisc Development Corp	Richmond	Fuel Cell Technology	www.powerdisc.ca
Sweet Power Inc	Victoria	Fuel Cell Technology	www.sweetpower.com
Tekion Solutions	Burnaby	Fuel Cell Technology	www.tekion.com
General Hydrogen	Richmond	Fuel Cell Technology	
Zongshen PEM Power Systems Inc	Vancouver	Fuel Cell Technology	www.zongshenpem.com
Adnavance Technologies	Vancouver	Hydrogen Supply Technologies	www.adnavance.com
Global Hydrofuel Technologies Inc.	Richmond	Hydrogen Supply Technologies	
HTEC	Vancouver	Hydrogen Supply Technologies	www.htec.ca
Membrane Reactor Technology	Vancouver	Hydrogen Supply Technologies	www.membranereactor.com
Methanex	Vancouver	Hydrogen Supply Technologies	www.methanex.com
Plug Power	Richmond	Hydrogen Supply Technologies	www.plugpower.com/
Sacre-Davey Innovations	North Vancouver	Hydrogen Supply Technologies	www.sacre-davey.com
Accelerate Power Systems	Vancouver	Power Storage & Conversion Systems	www.accelrate.com
Advanced Lithium Power Inc	Vancouver	Power Storage & Conversion Systems	www.advancedlithium.com
Alten Energy Solutions	Surrey	Power Storage & Conversion Systems	www.altenes.com
Cadex Electronics	Richmond	Power Storage & Conversion Systems	www.cadex.com
Delaware Power Systems	Richmond	Power Storage & Conversion Systems	www.delpowersys.com
Delta Q Technologies	Burnaby	Power Storage & Conversion Systems	www.delta-q.com
Eagle Picher Energy Products Corp	Surrey	Power Storage & Conversion Systems	www.eaglepicher.com
E-One Moli Energy	Maple Ridge	Power Storage & Conversion Systems	www.molienergy.com
VRB Power Systems	Richmond	Power Storage & Conversion Systems	www.vrbpower.com
Xantrex Technology Inc	Burnaby	Power Storage & Conversion Systems	www.xantrex.com
Advanced Energy Systems Ltd.	Maple Ridge	Renewable Energy Conversion	
Airsource Power	West Vancouver	Renewable Energy Conversion	
Alta Energy	Vancouver	Renewable Energy Conversion	www.atlaenergy.com
Altaqua Renewable Energy Corp	Vancouver	Renewable Energy Conversion	
Blue Energy	Vancouver	Renewable Energy Conversion	www.blueenergy.com/
Canadian Solar Technologies	Delta	Renewable Energy Conversion	www.canadiansolartechnologies.ca/
Chinook Power Corp	North Vancouver	Renewable Energy Conversion	www.chinookpower.com
Clean Current Power Systems Inc.	Vancouver	Renewable Energy Conversion	www.cleancurrent.com
Cloudworks Energy Inc	Vancouver	Renewable Energy Conversion	www.cloudworksenergy.com
Day4 Energy	Burnaby	Renewable Energy Conversion	www.day4energy.com
earthRight Solar - Solareagle	Vancouver	Renewable Energy Conversion	www.solareagle.com
Elemental Energy Inc.	Vancouver	Renewable Energy Conversion	
Energy Alternatives Ltd	Victoria	Renewable Energy Conversion	www.energyalternatives.ca
English Bay Energy Inc.	West Vancouver	Renewable Energy Conversion	www.englishbayenergy.com/
Finavera Renewables	Vancouver	Renewable Energy Conversion	www.finavera.com
Fosthall Creek Power Ltd.	Vancouver	Renewable Energy Conversion	
Fred Olsen Renewables (Canada)	Vancouver	Renewable Energy Conversion	www.fredolsen-renewables.com
Green Wing Energy	Vancouver	Renewable Energy Conversion	www.greenwingenergy.com
Holbert Wind Energy GP Inc.	West Vancouver	Renewable Energy Conversion	
Hydromax Energy Ltd	Vancouver	Renewable Energy Conversion	www.hydromaxenergy.com/

Appendix B continued...

Company Name	City	Sector	Website
INNERGEX Renewable Energy	North Vancouver	Renewable Energy Conversion	www.innergex.com
Innovative Air Solutions	Vancouver	Renewable Energy Conversion	www.evergreentechnologies.ca
Island Energy	Victoria	Renewable Energy Conversion	www.islandenergyinc.com
Katabatic Power Corp	Vancouver	Renewable Energy Conversion	www.katabaticpower.com
MSR Innovations	Burnaby	Renewable Energy Conversion	www.msrinnovations.com
NaiKun Wind Development Inc	Vancouver	Renewable Energy Conversion	www.naikun.ca/
Nevada Geothermal Power Inc.	Vancouver	Renewable Energy Conversion	www.nevadageothermal.com
Pemberton Power	Vancouver	Renewable Energy Conversion	www.pembertonpower.com
Plutonic Power Corp Inc.	Vancouver	Renewable Energy Conversion	www.plutonic.ca
Quantum Wind Power Corporation	Peachland	Renewable Energy Conversion	www.quantumwind.com/
Resolution Electric	Kelowna	Renewable Energy Conversion	www.resolutionelectric.ca/
Run of River Power Inc	Delta	Renewable Energy Conversion	www.runofriverpower.com/
Rupert Peace Power Corp	Vancouver	Renewable Energy Conversion	www.rupertpeacepowercorp.com
Rutherford Creek Power Ltd.	Vancouver	Renewable Energy Conversion	
Sea Breeze Power Corp	Vancouver	Renewable Energy Conversion	www.seabreezepower.com/
Sierra Geothermal Power Corp	Vancouver	Renewable Energy Conversion	www.sierrageopower.com
Summit Power Corp.	Vancouver	Renewable Energy Conversion	
SunCentral Inc.	Vancouver	Renewable Energy Conversion	www.suncentralinc.com/
Swift Power Corp.	Vancouver	Renewable Energy Conversion	www.swiftpower.ca
Swiss Solar Tech Ltd	Summerland	Renewable Energy Conversion	www.swissolartech.com
SyncWave Energy	Pemberton	Renewable Energy Conversion	www.syncwaveenergy.com/
Synex Energy Resources Ltd.	Vancouver	Renewable Energy Conversion	www.synex.com
Syntaris Power	Vancouver	Renewable Energy Conversion	www.syntaris.com
Taylor Munro Energy Systems	Delta	Renewable Energy Conversion	www.taylormunro.com/
Vancouver Renewable Energy	Vancouver	Renewable Energy Conversion	www.recov.org
Welwind Energy International	Maple Ridge	Renewable Energy Conversion	www.welwind.com

APPENDIX C: COMPILED LIST OF DEPLOYED PROJECTS

<i>Project Name</i>	<i>City</i>
Catalyst 1 Agricultural Project	Abbotsford
Greenhouse Wood-Fired Heat and CO2 Recovery Plant	Aldergrove
BCIT - Solar Canopy Illumination System Demonstration Project	Burnaby
Adera Green Ltd. Bldg #1	Burnaby
Adera Green Ltd. Bldg #2	Burnaby
Cranberry Commons Grounds	Burnaby
Taylor Park Elementary School	Burnaby
BCIT PV Power Tower	Burnaby
The Cornerstone	Burnaby
BCIT Cellulosic Ethanol Pilot Plant	Burnaby
GVRD Waste-to-Energy Facility	Burnaby
Metrotown, Metropolis	Burnaby
SFU - The Verdant	Burnaby
Oaklands Development Condos	Burnaby
Green Roof at Electronics Art Motion Capture Studio	Burnaby
Burnaby Mountain Secondary School	Burnaby
Kerr Wood Leidal Associates Office	Burnaby
UniverCity	Burnaby
Brentwood Skytrain Station	Burnaby
APEG BC Headquarters	Burnaby
Cottonwood Lodge	Coquitlum
Hyde Creek Integrated Watershed management Plan	Coquitlum
Corporation of Delta City Hall	Delta
Vancouver Landfill Cogeneration Project	Delta
Tilbury Eco-Industrial Partnership	Delta
Princess and the Pea B&B	Langley
Walnut Grove Community Ctr	Langley
Envision Financial Services Willoughby Branch	Langley
FH - CareLife Maple Ridge	Maple Ridge
All Saints Anglican Church	Mission
Kruger Gasification System	New Westminster
Green Roof at Woodlands Assisted Living Development	New Westminster
Northeast Coquitlam Area Plan	North East Coquitlam
East Clayton	North Surrey
The Brook Development	North Vancouver
North Vancouver Library	North Vancouver
Holiday Inn North Vancouver	North Vancouver
Quayside Village Cohousing	North Vancouver
Lonsdale Energy Corporation	North Vancouver
Vancity Lynn Creek Community Branch	North Vancouver
IWHUP - North Vancouver HTEC H2 Recovery Project	North Vancouver
IWHUP - EasyWash Car Wash Fuel Cell Installation	North Vancouver

Appendix C continued...

Project Name	City
IWHUP - Light Duty Hydrogen Fuelling Station	North Vancouver
The Silva	North Vancouver
IWHUP - Compressed Hydrogen Distribution	North Vancouver
Light Duty Hydrogen Vehicles	North Vancouver
Heavy-Duty HCNG Transit Buses	Port Coquitlam
Hyde Creek Community Centre	Port Coquitlam
Translink Bus Depot: Heavy Duty Fuelling Station	Port Coquitlam
Gleneagles Public Safety Building	Port Moody
Port Moody Recreation Centre	Port Moody
Heritage Woods Secondary School	Port Moody
Garry Point Park Solar/Wind Powered LED Lights	Richmond
YVR Domestic Terminal Solar Hot Water System	Richmond
YVR International Terminal Solar Hot Water System	Richmond
IKEA - Electrical Harmonizer	Richmond
Crestwood Corporate Centre - Building 8	Richmond
Richmond City Hall	Richmond
BCIT Aerospace Tech Geo-Exchange System	Richmond
Lulu Island Wastewater Facility	Richmond
River Rock Casino Resort	Richmond
PEM Fuel Cell Stacks with patented PowerWedge(TM)	Richmond
VANOC - Richmond Olympic Oval	Richmond
YVR International Terminal Carbon Dioxide Sensors	Richmond
Revenue Canada Building	Surrey
Terasen Gas Coastal Facility	Surrey
Kwantlen University College Trades & Tech Centre	Surrey
Gabrielle Roy K-12 School	Surrey
HH - Surrey Hydrogen Fuelling Station	Surrey
Semiahmoo Library & RCMP District Office	Surrey
Surrey Transfer Station	Surrey
HH - Electrolysis of Water for Hydrogen Production	Surrey
Oliva	Tsawwassen
Children's Hospital Solar/Wind Powered LED Lights	Vancouver
Solar Canopy Illuminations System Demonstration Project	Vancouver
Strata Corporation VR 1397	Vancouver
City of Vancouver National Works Yard	Vancouver
Kitsun Co-op	Vancouver
VANOC - Millennium Water Development (Athlete's Village)	Vancouver
UBC Hospital	Vancouver
VANOC - Vancouver Convention & Exhibition Centre Expansion Project	Vancouver
Mole Hill	Vancouver
Pomaria	Vancouver
Capers Multi-Use Development	Vancouver
Vancouver Aquarium	Vancouver

Appendix C continued...

<i>Project Name</i>	<i>City</i>
BC Cancer Research Centre	Vancouver
Koo's Korner	Vancouver
Ardencraig	Vancouver
VANOC - Killarney Centre	Vancouver
UBC Thunderbird Arena	Vancouver
VANOC - Vancouver Olympic/Paralympic Centre	Vancouver
ICICS/CS Expansion	Vancouver
In-Vessel Composter at UBC	Vancouver
Sustainable Building Centre	Vancouver
Liu Institute for the Study of Global Issues	Vancouver
1 Kingsway Community Facility	Vancouver
Centre for Interactive Research on Sustainability	Vancouver
Technology Enterprise Facility III	Vancouver
Hughes Condon Marler: Architects Office Renovation	Vancouver
Michael Smith Laboratories	Vancouver
VANOC 2010 Offices	Vancouver
Vancity Centre	Vancouver
Five	Vancouver
The Federal Building	Vancouver
Canada Green Building Council - Pender Street Office	Vancouver
MCW Consultant Ltd	Vancouver
St. Paul's Hospital 9A Mental Health Unit	Vancouver
National Research Council Canada Institute	Vancouver
Novel Gas Reformer	Vancouver
Membrane Electrode Assembly (MEA), Fuel Cell Stacks, Hydrogen Storage	Vancouver
Aquaquest - The Marilyn Blusson Learning Centre	Vancouver
Centre for the Advancement of Green Roof Technology	Vancouver
Green Roof at Vancouver Public Library	Vancouver
Evergreen Building	Vancouver
Stanley Park Popcorn Stand	Vancouver
Aquatic Ecosystems Research Laboratory	Vancouver
Life Sciences Centre	Vancouver
Materials Testing Facility	Vancouver
Spanish Bank Creek Daylighting	Vancouver
Urban Search and Rescue Emergency Lighting High-Powered Head Lamps	Vancouver
Hydrogen Fuel Cell Powered PDA's @ Hospitals	Vancouver
Merchant Hydrogen Supply Using Tube Trailer Delivery	Vancouver
Vancouver Fuel Cell Vehicle Program	Vancouver
Neighbourhood Energy Utility - Olympic Village	Vancouver
Net-Zero Energy Building pilot project - Olympic Village	Vancouver
Granville Island	Vancouver
University Town	Vancouver
Country Lanes	Vancouver

Appendix C continued...

<i>Project Name</i>	<i>City</i>
Country Lanes	Vancouver
Sustainability Street Project	Vancouver
Stormwater Management	Vancouver
Fred Kaiser Building	Vancouver
HH/ Pacific Spirit Hydrogen Fuelling Station @ NRC	Vancouver
Hotels Solution - Pan Pacific Hotel	Vancouver
Electrical Harmonizer @ BC Hydro	Vancouver
Electrical Harmonizer at Science World	Vancouver
Guinness Tower	Vancouver
Buchanan Towers (UBC)	Vancouver
Busby Perkins + Will Head Office	Vancouver
Listen Hotel Downtown Vancouver Solar & Heat Recovery System	Vancouver
SEFC Energy Centre & Sewage Pump Station	Vancouver
City Farmer's Vancouver Compost Demonstration Garden	Vancouver
Stantec Vancouver Office	Vancouver
Omicron Head Office	Vancouver
C.K. Choi Institute for Asian Research	Vancouver
AIBC Headquarters	Vancouver
Vancouver Port Authority Office	Vancouver
Dockside Green Development	Victoria
BC Transit Victoria Hydrogen Fuelling Station	Victoria
UVic Hydrogen Flashlight Project	Victoria
Gleneagles Community Centre	West Vancouver
Lions Gate Wastewater Treatment Plant Biomethane project	West Vancouver
West Vancouver Aquatic Ctr.	West Vancouver
Eagle Lake Micro Hydro Facility	West Vancouver
City of White Rock Green Operations Buildings	White Rock
Magnesium Air Fuel Cell	White Rock