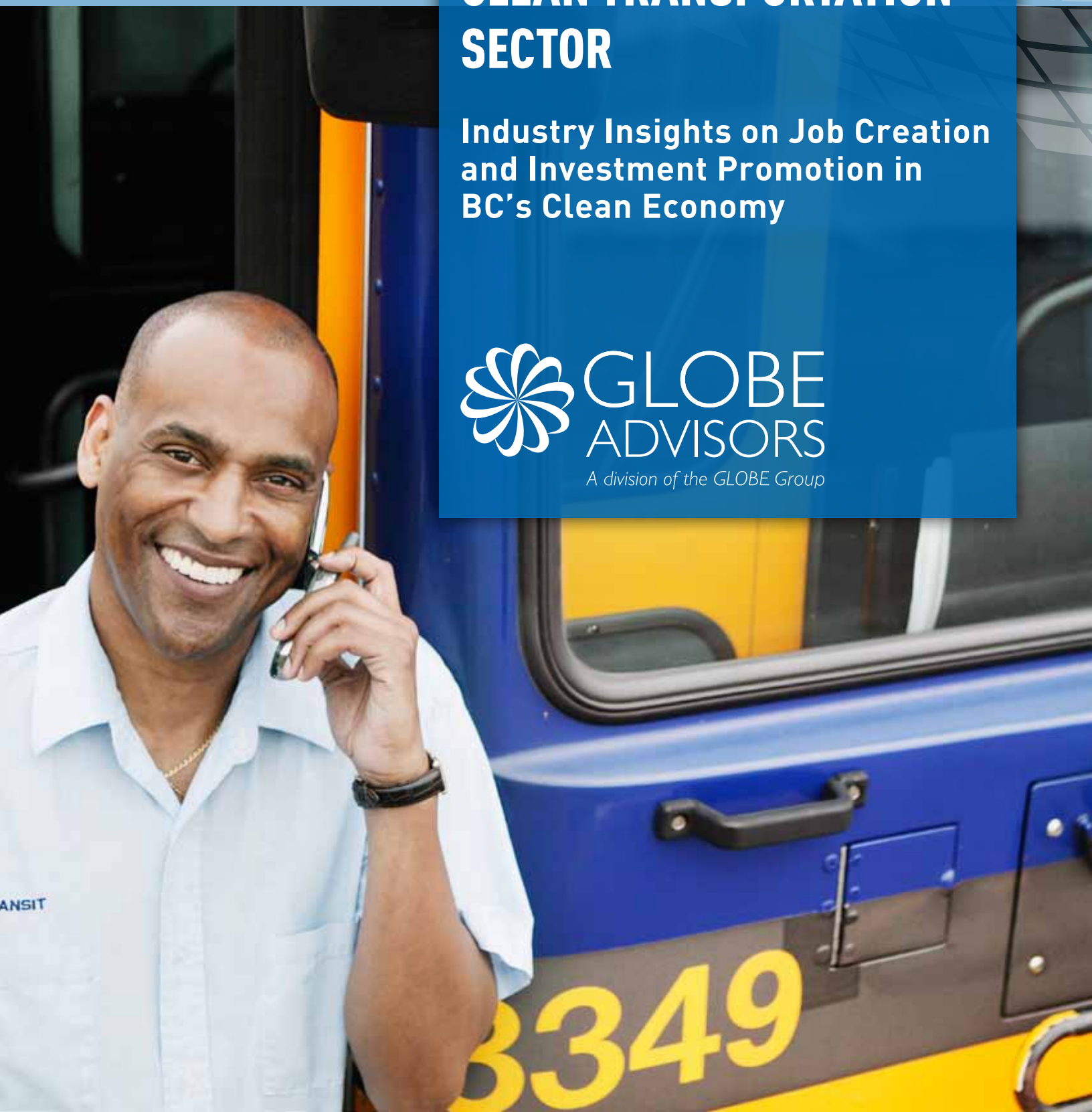
September
2012

MARKET REPORT

British Columbia's CLEAN TRANSPORTATION SECTOR

Industry Insights on Job Creation and Investment Promotion in BC's Clean Economy



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This report is one of a series of three market reports prepared by GLOBE Advisors that examine the "core" sectors of British Columbia's clean economy. To download reports on the **Clean Energy Supply and Storage** and the **Green Building and Energy Efficiency** sectors, please go to **www.globeadvisors.ca**.

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PREFACE

In March of this year, GLOBE Advisors, in collaboration with the Washington, DC-based Centre for Climate Strategies, published a report on the West Coast clean economy that was commissioned by the Pacific Coast Collaborative (PCC) — a formal working group that involves the province of British Columbia and the US states of California, Oregon, Washington, and Alaska.

That report confirmed that opportunities abound for the members of the PCC to act jointly and co-operatively to maximize the benefits of their shared clean economies and to minimize the overlap of efforts in order to address shared priorities and challenges. GLOBE Advisors estimated that through a collective approach to investment attraction and job creation in five clean economy market opportunity areas or "sectors", the region could generate up to an additional $143 billion in gross domestic product (GDP) and an estimated 1.03 million net new full-time equivalent jobs by 2020.

In keeping with that analysis and other earlier work, GLOBE Advisors undertook new research over the last six months to examine three of these interrelated and potentially high-growth sectors in British Columbia's clean economy — specifically clean energy supply and storage, green buildings and energy efficiency, and clean transportation. From this research, GLOBE Advisors has published three market reports — one on each of these three key sectors.

Secondary research and employment estimates for this study were backed up by extensive consultation and outreach activities, including more than 90 in-depth interviews with industry leaders from successful BC companies, as well as academic institutions, government agencies, and non-governmental organizations. The interviews were designed to identify current trends, economic development opportunities and challenges, and employment demand and supply issues.

In addition, GLOBE Advisors was involved in organizing a one-day "Green Workforce Development Symposium" alongside the City of Vancouver, the Vancouver Economic Commission, and six public post-secondary institutions in March 2012 that was designed to explore current and potential future employment opportunities and challenges in BC's clean economy.

This market report looks specifically at British Columbia's Clean Transportation and presents a range of opportunities for creating new jobs, attracting investment, and expanding positive synergies. The job opportunities presented in this report were quantified using updated and proven methodologies that allow for the identification of industries and occupations that are part of this sector in BC.

This report is not an advocacy document. The pages that follow provide a current snapshot of the Clean Transportation sector in British Columbia, a sector that is a driving force behind what will ultimately be this province's single most powerful competitive advantage — a cleaner and more sustainable economy.

ACKNOWLEDGMENTS

GLOBE Advisors would like to thank the following companies, government agencies, and industry organizations. These organizations provided important resources, insights, and/or data in support of this study.

Automotive Fuel Cell Cooperation (AFCC)
Ballard Power Systems
BC Ferries
BC Transit
Big Green Island Transportation
Canadian National (CN) Railway
Car2Go
City of Vancouver
Coast Mountain Bus Company (CMBC)
Corvus Energy
Delta-Q Technologies
FortisBC
IMW Industries
Lignol Energy
Modo – the Car Co-op
National Research Council of Canada
Port of Prince Rupert
Province of British Columbia
Schneider Electric
Southern Railway of British Columbia
TransLink
Vancouver Electric Vehicle Association (VEVA)
Victoria Transport Policy Institute (VTPI)
Webtech Wireless
Westport Innovations

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HIGHLIGHTS

1. For the purposes of this report, the Clean Transportation sector is divided into five key market opportunity segments – namely rail transportation; public transportation (excluding rail); biofuels; vehicles and technology; and other areas such as non-motorized transportation, car share programs, and improvements to transportation systems through applications such as intelligent transportation system (ITS) technology.

2. In 2011, the Clean Transportation sector in British Columbia was estimated to have generated some $1.9 billion in gross domestic product ($1.3 billion direct and $600 million indirect) and 23,290 full-time equivalent jobs (16,730 direct and 6,560 indirect).

3. Higher demand for public transit services, greater vehicle fuel efficiency and fuel switching opportunities, improvements to systems and infrastructure, and the deployment of various clean transportation vehicle technologies are key factors enabling growth in this sector.

4. Significant employment opportunities exist for public transportation-related services; rail and goods movement-related services; clean transportation vehicles, technology, and infrastructure; research and development in biofuels; and other clean transportation-related services, including transportation logistics and information technology (IT) services.

5. Workforce challenges faced by companies in this sector include rising attrition rates for public transportation and railway service companies, as well as the limited available resources for recruitment, retention, and training, particularly for smaller companies involved in the design, development, assembly, and manufacturing of clean transportation vehicles and related technologies.

6. Heavy-duty and transportation mechanics, skilled track maintenance managers, and experienced mechanical, electrical, and power engineers and technicians are some of the most challenging positions to staff in this sector. These positions are especially difficult to staff in northern and more remote locations in the province.

7. While the sector currently is supported by a solid education and training framework, there is a need for more engineering programs related to clean transportation enabling technologies such as power electronics and converters, chargers, and motors. There is also a greater need for graduates to develop "soft" skills as part of their formal training programs to allow them to prosper in small, team-based work environments.

8. Barriers including current market uncertainties related to the roll-out of clean transportation vehicles; the low cost of energy and fuels in BC; the high costs and real and perceived risks involved with new technology adoption; the lack of clean transportation-related infrastructure; limited funding for the expansion of public transit services; and the lack of qualified / skilled labour are some of the key factors limiting the growth of this sector.

9. Accelerating growth in this sector will require government leadership through supportive public policies and regulation; the development of innovative financing models and cost-effective solutions for public transit service expansion; improved awareness for the benefits of clean transportation options; and better access to skilled labour.

10. Collaboration with key players in this sector will be required in order to develop comprehensive labour market strategies that will ensure that the current and future supply of skilled workers in this sector aligns with demand.

EXECUTIVE SUMMARY

The Clean Transportation sector includes land-based clean transportation vehicles, public mass transit, rail and low-carbon marine transport, non-motorized transport, and improvements to transportation systems through new processes and technologies such as intelligent transportation systems (ITS).

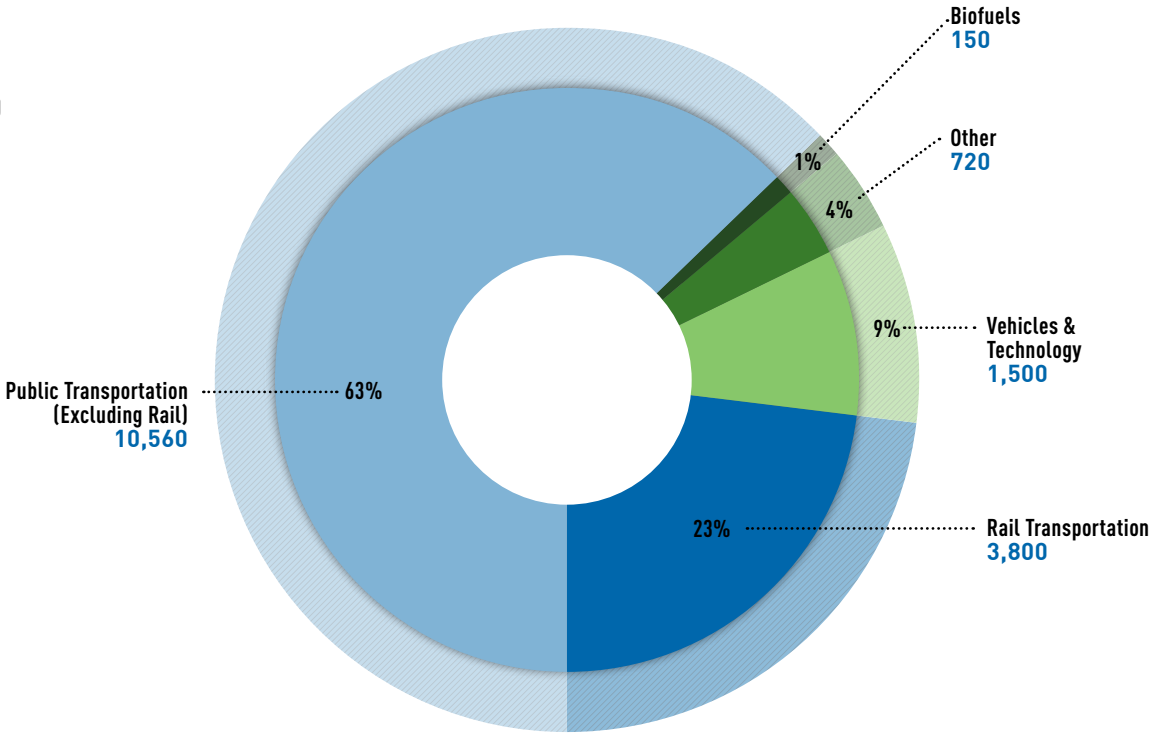
In 2011, the sector in British Columbia was estimated to have generated some $1.9 billion in gross domestic product ($1.3 billion direct and $600 million indirect) and employed approximately 23,290 FTE workers (16,730 direct and 6,560 indirect). As illustrated in Figure 1, companies in the Public Transportation and Rail Transportation segments combined accounted for the vast majority (86%) of total direct employment in this sector, equal to 14,360 direct FTE jobs.

While companies in the Rail Transportation segment are responsible for the highest GDP contributions in this sector (i.e., 56% of all GDP), the Public Transportation segment is more labour intensive and as a result, is responsible for more jobs (i.e., 10,560 direct FTE jobs in total).

The Vehicles and Technology segment – which includes companies involved in the design, manufacturing, and assembly of clean transportation vehicles powered by electric, hydrogen fuel cell, and natural gas engines, as well as related technologies and infrastructure – accounted for approximately 1,500 direct FTE jobs or 9% of total employment in the sector in 2011. It is estimated that the clean transportation technology segment in British Columbia is currently responsible for approximately 18%

Figure 1: Employment (direct full-time equivalent jobs) in British Columbia's Clean Transportation sector by segment, 2011.

Source: GLOBE Advisors



of total clean technology-based employment in the province.

Companies involved in the "Other" segment – which includes non-motorized transportation options such as cycling and related infrastructure, as well as car share programs and system improvements through applications such as intelligent transportation system (ITS) technology – are small contributors at the moment to BC's economy in terms of employment; however, this segment is growing rapidly.

CURRENT TRENDS

As is the case with other clean economy sectors, the Clean Transportation sector in British Columbia finds itself in a constant state of flux. The rising price of high-carbon fossil fuels and energy continues to drive demand for transportation system efficiencies. As such, BC is seeing a trend toward greater use of more efficient modes of transportation for both people and goods, as well as the application of new technologies in the realm of fleet management and Intelligent Transportation System (ITS) improvements.

Demand continues to increase for public transit across the province with a number of new services proposed and under development. Demand is expected to continue rising in the future with demographic changes in BC, which comes with a potential for creating thousands of new jobs. As such, finding creative financing methods for maintaining and expanding public transit services in the province will be essential moving forward.

Transportation plans, such as Vancouver's *Transportation 2040*, are establishing road maps for a future where walking, cycling, and transit are attractive options for getting around. Higher-density, mixed-use developments in urban centres are also enabling new transportation business models in British Columbia such as car and bike share services.

British Columbia is at the forefront in Canada when it comes to market interest for electric vehicles and related infrastructure. BC Hydro research suggests that BC residents are already switching to hybrid vehicles at double the rate of the Canadian average. In addition, recent market and policy developments in British Columbia are opening up new economic and employment opportunities in the province related to natural gas vehicles, particularly for liquefied natural gas (LNG) powered heavy-duty trucking and ferry fleets, as well as the potential for rail in the future.

JOB CREATION OPPORTUNITIES

The Clean Transportation sector includes a number of employment opportunities for British Columbia, particularly related to:

- Public transportation services;
- Improvements to the systems for the movement of people and goods, including intelligent transportation systems (ITS);
- The design and development of components for electric vehicles such as batteries, chargers, converters, and controls;
- The research, development, design, and assembly of natural gas and hydrogen fuel cell-powered vehicles;
- The design, manufacturing, installation, and maintenance of infrastructure for alternative fuelling and charging stations; and
- The development of low carbon fuels and biofuels;

LABOUR DEMAND AND SUPPLY

BC Transit has set ambitious targets to double its ridership by 2020 according to the *Provincial Transit Plan*, which will have a considerable impact on jobs in British Columbia. Construction of major transportation infrastructure projects, such as the Evergreen Line in the Lower Mainland and Victoria's proposed light rapid transit (LRT) system, also have the potential to significantly influence labour demand in the province.

Demand for skilled and qualified workers in the rail and goods movement segment is also expected to increase as expansion of the province's ports and resource-based industries grow over the next several years. A significant demand exists for train crews (e.g., locomotive engineers, conductors, and brake people), particularly in northern parts of the province. Heavy-duty, rail car, and track mechanics, electricians, and related apprentices are also in demand across the province.

For companies operating in the clean transportation technology space in BC, maintaining a global competitive advantage in many ways comes down to whether these firms can attract the skilled and experienced workers and specialized professionals they need (e.g., design and power engineers, specialized technicians / technologists, research and computer scientists).

Companies that develop battery systems and related components (e.g., chargers, inverters, power conversion and management equipment, etc.) look for talent in three key areas of engineering: electrical, mechanical, and firmware and software development. In addition, as EVs penetrate the marketplace, there will be a growing need for certified electricians qualified to install and maintain EV charging stations.

» Attrition will be a major issue for larger companies active in this sector in the near future as hundreds of employees are set to retire over the next five to ten years.

Attrition will be a major issue for larger companies active in this sector in the near future as hundreds of employees are set to retire over the next five to ten years. Companies will be challenged to find qualified skilled trades people such as electricians, power-line technicians, welders, pipe-fitters, and mechanics to replace those entering retirement. The problem is expected to worsen as demand for these occupations by higher-paying industries in Northern BC and other province's in Canada continues to grow.

The immigration process for bringing in skilled foreign workers can also be a challenge. Companies will at times have to wait long periods of three months or more for a permit before foreign hires can begin work. This can be detrimental to companies who may lose competitive positioning in their industries while their design and engineering processes are stalled.

Companies in this sector offer significant on-the-job training. Regardless of the skill set, there is always a need to bring new employees up-to-speed with a company's business practices and / or on the details of a specific project or technology.

However, the limited available resources for recruitment, retention, and training, particularly for smaller companies involved in the design, development, assembly, and manufacturing of clean transportation vehicles and related technologies were cited as considerable challenges.

To overcome some of the workforce challenges, companies have forged relationships with post-secondary institutions such as UBC, SFU, UVic, BCIT, Douglas College, and other engineering and technology-focused schools to bring on co-operative education students.

Companies will also make use of federal programs such as the National Research Council's Industrial Research Assistance Program (NRC-IRAP), Natural Sciences and Engineering Research Council (NSERC) program, and MITACS to find and fund research and post-doctoral candidates.

While companies will usually try to recruit locally, many end up having to search across Canada, North America, and often internationally for more specialized and experienced staff and the individuals required for strategic business planning and operations, which takes a great deal of resources (both in terms of time and money).

Companies did indicate that by marketing themselves as sustainable businesses and positioning themselves as active players in the clean economy, they have been better able to attract and retain educated young professionals looking to work for progressive organizations.

While companies interviewed in this sector were overall very positive about the available education and training in the province, some pointed to a greater need for more specific engineering programs focused on power electronics and related enabling technologies such as converters, chargers, and motors, as well as geospatial technologies and telematics, which have applications in multiple industries in addition to the Clean Transportation sector.

However, most technology-focused companies interviewed recognized that it would be impractical for post-secondary institutions to meet the highly-specialized needs of this sector. As such, it is important that graduates leave post-secondary institutions with holistic, technical skill sets in a variety of areas and that programs integrate "soft" skills into technical programs – such as conflict negotiation, communications, and facilitation – particularly for technology-focused companies where team-based work is essential.

BARRIERS TO GROWTH

Many issues affecting job growth were identified by business leaders active in the Clean Transportation sector. On the policy side, regulatory issues are often a challenge for technology companies. Jurisdictional boundaries also create issues for public transit service providers and for sourcing related funding.

From an economic perspective, low-cost fossil fuels serve as barriers to innovation and the deployment of some alternative forms of clean transportation such as electric and fuel cell-powered vehicles. The hard realities and risks associated with commercializing and deploying new transportation technologies contribute to increased costs for vehicles and associated infrastructure.

More broadly on the societal front, the current lack of public knowledge and awareness around the benefits of clean transportation vehicles is a challenge to industry growth and market penetration. Uncertainty about the timing and extent of clean transportation vehicle roll-outs by manufacturers also has negative implications for the entire industry, particularly when combined with the shortage of experienced and qualified engineers and technicians with respect to the design, manufacturing, assembly, maintenance, and repair of clean transportation vehicles and related infrastructure.

From a technology viewpoint, the fact that very little infrastructure exists in BC for clean transportation vehicle fueling and charging is a serious constraint. As a consequence, fleet operators and major transportation service providers are hesitant about making major investment commitments.

In addition, a challenge for many EV technology companies in BC is finding customers for their products – which has led to the demise of several companies active in this space over the last few years. Without an automotive industry in BC, a key challenge is a lack of plant capacity and quality engineering expertise specific to the industry.

ENABLERS TO GROWTH

Government use of its purchasing power to add clean transportation vehicles to public fleets and to put in place related infrastructure would serve as a major stimulus to the sector in BC. Regulations governing natural gas conversions of ferries could serve the same end and would play a key role in expanding natural gas use for the BC Ferries fleet. By-laws and building code policies have been exemplary for encouraging EV adoption, car sharing, and other clean transportation alternatives and greater harmonization of by-laws could help with vehicle and infrastructure roll-out.

Incentive programs that are competitive with other jurisdictions in order to reduce the upfront costs for the adoption of EVs and infrastructure (particularly for the commercial fleet owners / operators) or heavy-duty vehicles, buses, and ferries to use natural gas are helping to accelerate the deployment of clean energy technologies. In addition, exploring new sources of funding for public transit would help with expansion of services.

More targeted public education programs are needed to build awareness and trust for the benefits of adopting electric or natural gas-powered vehicles, as well as ITS technologies. Providing more support for training related to clean transportation vehicles and technologies and wider use of subsidized co-operative education programs with modular learning units which would allow students to move more effortlessly between education

» Opportunities exist to strategically focus BC's ICT sector on transportation solutions that would benefit government and industry.

and employment could help to facilitate access to skilled workers in the sector.

On the technology front, more demonstration projects are essential for companies looking to sell their clean transportation vehicle technologies. The establishment of multi-stakeholder working groups, such as "Plug-In BC" and the collaborative team that developed the City of Vancouver's "Project Get Ready", can help to accelerate the roll-out and adoption of clean transportation technologies.

Opportunities also exist to strategically focus BC's ICT sector on transportation solutions that would benefit government and industry by increasing fleet efficiencies, maximizing asset utilization, saving costs, and reducing GHG emissions.

Further research and more intense collaboration with key players in this sector will be required in order to design a comprehensive labour market strategy that will ensure the current and future supply of skilled workers in this sector aligns with demand.

IN SUMMARY

This latest research by GLOBE Advisors confirms that a solid basis exists that will allow British Columbia to capitalize on the economic and employment benefits of the Clean Transportation sector. However, work must continue to develop a consistent, clear, and strategic policy framework that encourages investment and market-driven growth.

The following is list of elements that would help to accelerate growth in British Columbia's Clean Transportation sector.

1. Clear and stable policy frameworks;
2. Support for creative financing models;
3. Improvements to public education and outreach;
4. A focus on increasing productivity;
5. Facilitating knowledge transfer; and
6. Increasing partnerships and collaboration.

1. INTRODUCTION:
A Background on the Clean Economy

WHAT IS THE CLEAN ECONOMY?

A "clean economy" is neither an abstract concept nor a separate component of the larger economy. It is in fact an end-state that is achieved following a transition or dynamic process of change within the entire economy toward more energy- and resource-efficient solutions and longer-term sustainability planning and programming.

A cleaner economy is one that promotes enhanced economic performance, strengthens global competitiveness through energy and environmental security, and promotes sustainable investment.

It is not dissimilar from how companies in the private sector are continually improving their operating efficiencies to reduce wastes and to conserve energy, thereby enhancing their bottom lines. And while the payoff for a corporation is improved profitability and shareholder benefit, the payoff of a cleaner economy is measured in terms of creating better jobs and promoting more public and private sector investment.

As noted by the Brookings Institution, "the clean economy matters because its emergence responds to critical global and national environmental, security, and economic trends and associated challenges, most notably the growing demand for global environmental sustainability, the sharpening need for resource security, and the aspiration everywhere toward economic transformation."[1]

By definition, at the centre of the clean economy are specific industry sectors that are directly responsible for supplying technologies, products, and services with measurable benefits for reducing greenhouse gas (GHG) emissions and for improving both energy and resource efficiency throughout the economy as a whole.

In broad terms, the transition toward a cleaner economy is about creating and retaining wealth and jobs, reducing the carbon footprint of societies, restoring the natural environmental balance of critical ecosystems, and implementing improvements in energy and industrial efficiency, all of which contribute to enhanced economic competitiveness.

The concept of a clean economy supports enhanced local manufacturing and employment opportunities, and utilizing recycled or locally-sourced raw materials. It also promotes the export of value-added, processed materials and advanced products with lower embodied energy. By reducing the need for imported energy, materials, goods, and services, the goal is to keep capital circulating longer through local sourcing and supply chains.

Many economies around the world are developing progressive strategies to position themselves in order to exploit the potential benefits from the transition to a cleaner economy, which has been described by some as the greatest opportunity for economic growth over the next decade. In 2010, HSBC Global Research estimated that worldwide

revenues for clean energy-related sectors alone could grow to $2.3 trillion by 2020.

Investment and developments in clean technology sectors such as solar and biofuels in countries such as China and Brazil underscore the importance of what truly has become a global race to seize the market opportunities.

While clean and renewable energy sources and technologies figure largely in the substance of a cleaner economy, the opportunities for job creation and investment promotion range far wider and find expression in all areas of public policy and private enterprise.

British Columbia is in reality well-positioned for realizing the opportunities. In its 2012 Green Provincial Report Card, Corporate Knights ranked British Columbia first in Canada in the areas of Energy and Buildings, Transportation, and Innovation – good news by all accounts.[2]

As a gateway to Asia-Pacific nations, British Columbia is well-situated to exploit the expanding global clean economy opportunities. The province also continues to enjoy strong ties with the United States, the province's largest trading partner and one of the world's largest markets for clean economy-related products and services.

WHERE ARE THE MARKET OPPORTUNITIES IN BC'S CLEAN ECONOMY?

Five market "sectors" present the highest potential in terms of new investment and job growth, as were identified in the March 2012 West Coast Clean Economy report by GLOBE Advisors (see box below).[3] These sectors exist at the "core" of the clean economy and interface with the larger economy as a whole by supplying the products, technologies, and services that are helping to accelerate the transition to a lower-carbon future in British Columbia (as illustrated in Figure 1.1).

The five market opportunities at the core of British Columbia's clean economy are:

- **Clean Energy Supply and Storage** – In particular, supporting distributed energy systems, smart grid infrastructure and transmission, and enhanced integration of energy from clean and other renewable sources.
- **Clean Transportation** – In particular, enhancing public transit infrastructure, promoting cleaner-powered vehicles, and fuel switching to lower-carbon alternatives (e.g., biofuels, electricity, natural gas, etc).
- **Green Building and Energy Efficiency** – In particular, related to whole building retrofitting, renovation, and new, high-performance building and home construction.
- **Environmental Protection and Resource Management** – In particular, shifting towards greater recycling and reuse of materials and products, the advancement of sustainable, energy-efficient infrastructure, and enhanced measures to promote conservation of natural resources and restore critical ecosystems.
- **Knowledge and Support** – In particular, engaging educational institutions for workforce skills development and strengthening centers of excellence that build on the knowledge base of the clean economy.

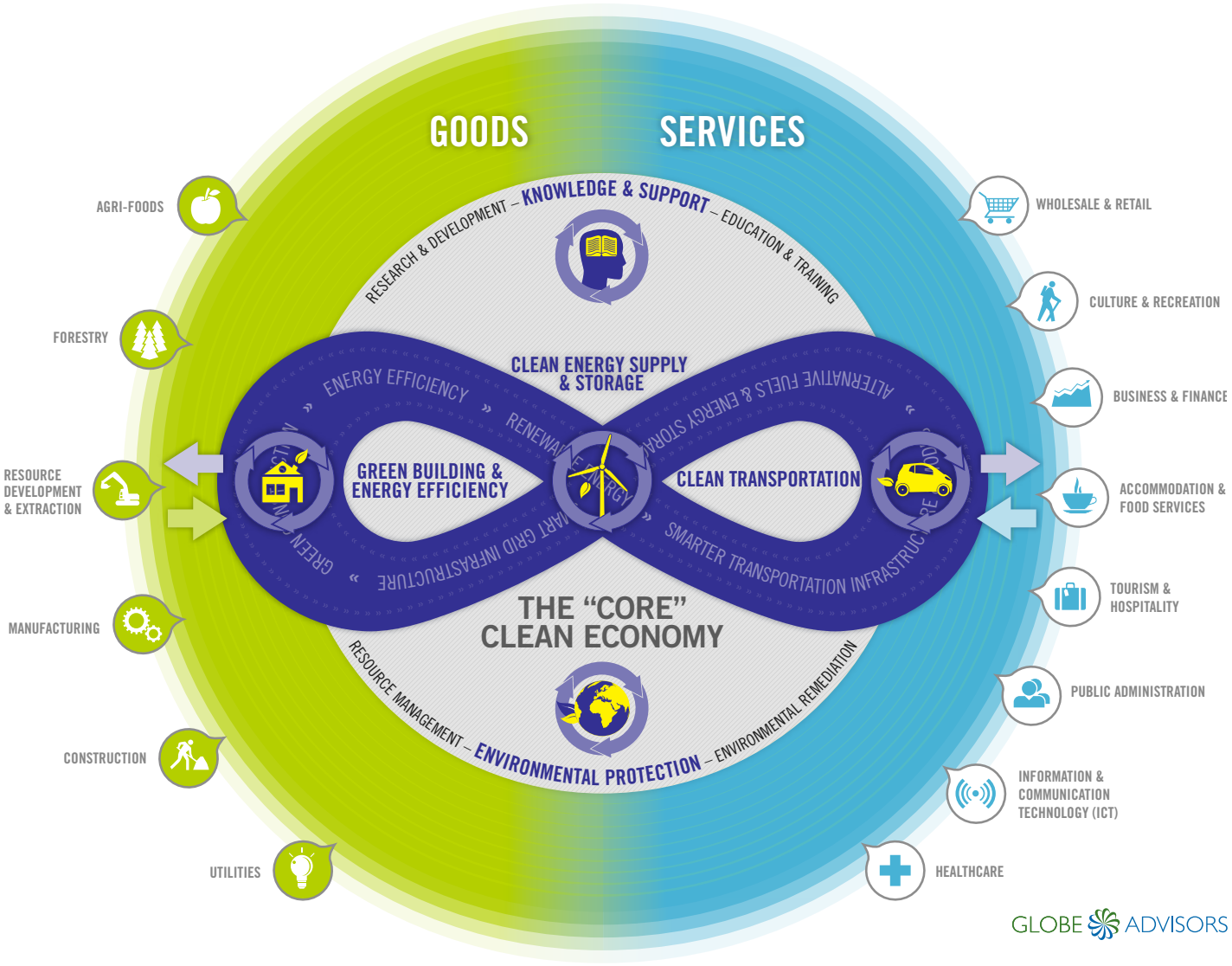


Figure 1.1: ↗
The "core" sectors of BC's clean economy supply important products, technologies, and services to help accelerate the transition to a more energy and resource-efficient economy as a whole.

Source:
GLOBE Advisors

Three of these core clean economy sectors exist in an interrelated relationship as part of an "endless energy" loop. These are the Clean Energy Supply and Storage, the Clean Transportation, and the Green Building and Energy Efficiency sectors.

The three interrelated sectors at the core of BC's clean economy are also responsible for a considerable level of investment, employment, and economic activity in the province at the present time.

As illustrated in Figure 1.2, the total market value of BC-based public companies listed on the TSX and TSX-Venture exchanges and active in the three key market sectors of BC's clean economy was approximately $2.56 billion at the end of June 2012.

But public companies in these sectors represent only a fraction of the total employment and economic activity in these sectors in BC. Collectively, the three interrelated sectors in British Columbia were estimated to be responsible for 123,350 full-time equivalent (FTE) jobs (75,170 direct and 48,180 indirect) and $15.1 billion in gross domestic product ($10.7 billion direct and $4.4 billion indirect) in 2011.[4]

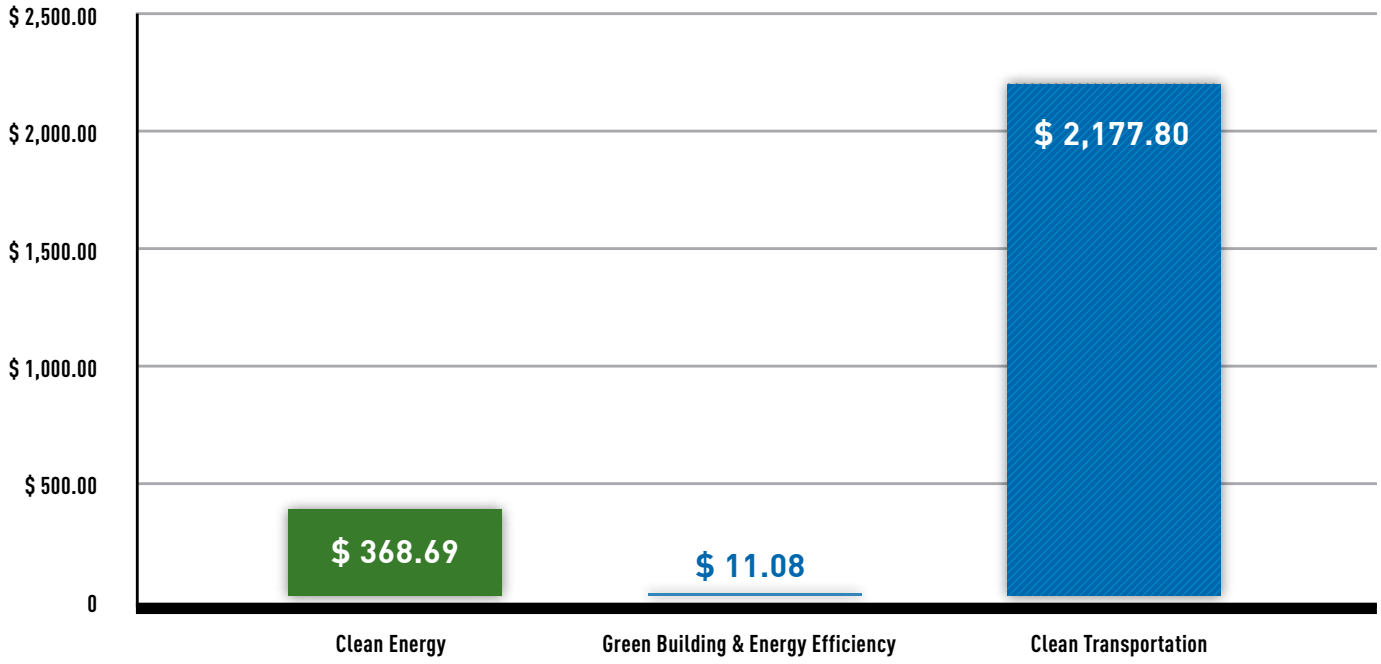


Figure 1.2: ↗
Market capitalization of BC public companies listed on the TSX and TSX-Venture Exchanges by clean economy sector (as of June 30, 2012), $ millions.[5]

Source:
TMX Group and GLOBE Advisors

LOOKING AHEAD IN THIS REPORT

This report looks specifically at the Clean Transportation sector in British Columbia. The sections that follow provide:

- The latest estimates of economic activity (in terms of GDP) and current employment for the sector;
- A detailed overview of the current status of activities in this sector;
- An examination of the current trends affecting job growth;
- An overview of labour market demand and supply issues, including key occupations and skill sets;
- A summary of the barriers and enablers to sector growth; and
- A list of policy, program, and financial drivers.

To download reports on the **Clean Energy Supply and Storage** and the **Green Building and Energy Efficiency** sectors, please go to **www.globeadvisors.ca**.

2. CLEAN TRANSPORTATION: Jobs and GDP

The Clean Transportation sector includes land-based clean transportation vehicles, public mass transit, rail and low-carbon marine transport, non-motorized transport, and improvements to transportation systems through new processes and technologies such as intelligent transportation systems (ITS).

In 2011, the sector was estimated to have generated some $1.9 billion in GDP ($1.3 billion direct and $600 million indirect) and employed approximately 23,290 full-time equivalent workers (16,730 direct and 6,560 indirect).[6] For the purposes of this report, the sector has been divided into five segments, as illustrated in Figure 2.1 below.

Companies in the Public Transportation and Rail Transportation segments combined accounted for approximately $1.12 billion or 84% of total provincial GDP from the sector in 2011. The Vehicles and Technology segment, which includes companies involved in the design, manufacturing, and assembly of clean transportation vehicles powered by electric, hydrogen fuel-cell, and natural gas engines, as well as related technologies and infrastructure, accounts for approximately $110 million or 8% of total provincial GDP generated in the sector.

The segment entitled "Other" includes companies involved in non-motorized transportation options such as cycling and related infrastructure, as well as car share programs and system improvements through applications such as intelligent transportation system (ITS) technology.

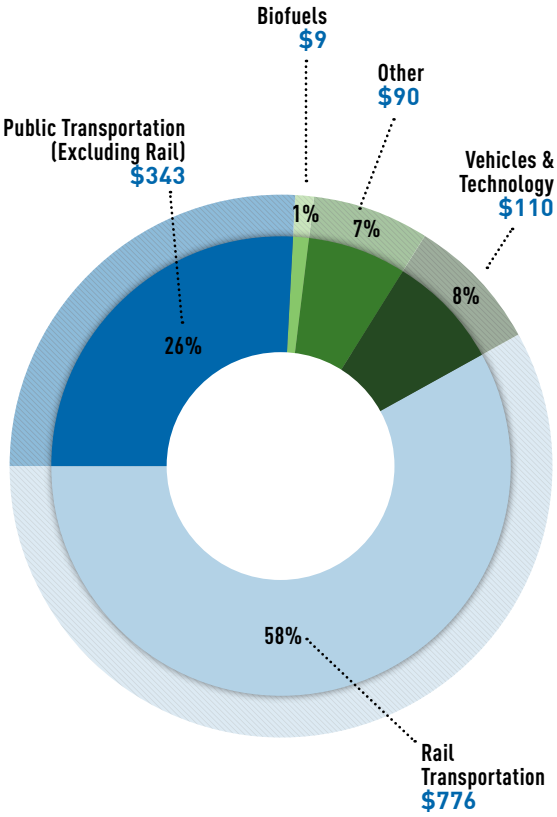


Figure 2.1: ↗
Direct GDP by segment generated by firms active in British Columbia's Clean Transportation sector, 2011 ($ million).

Source: GLOBE Advisors

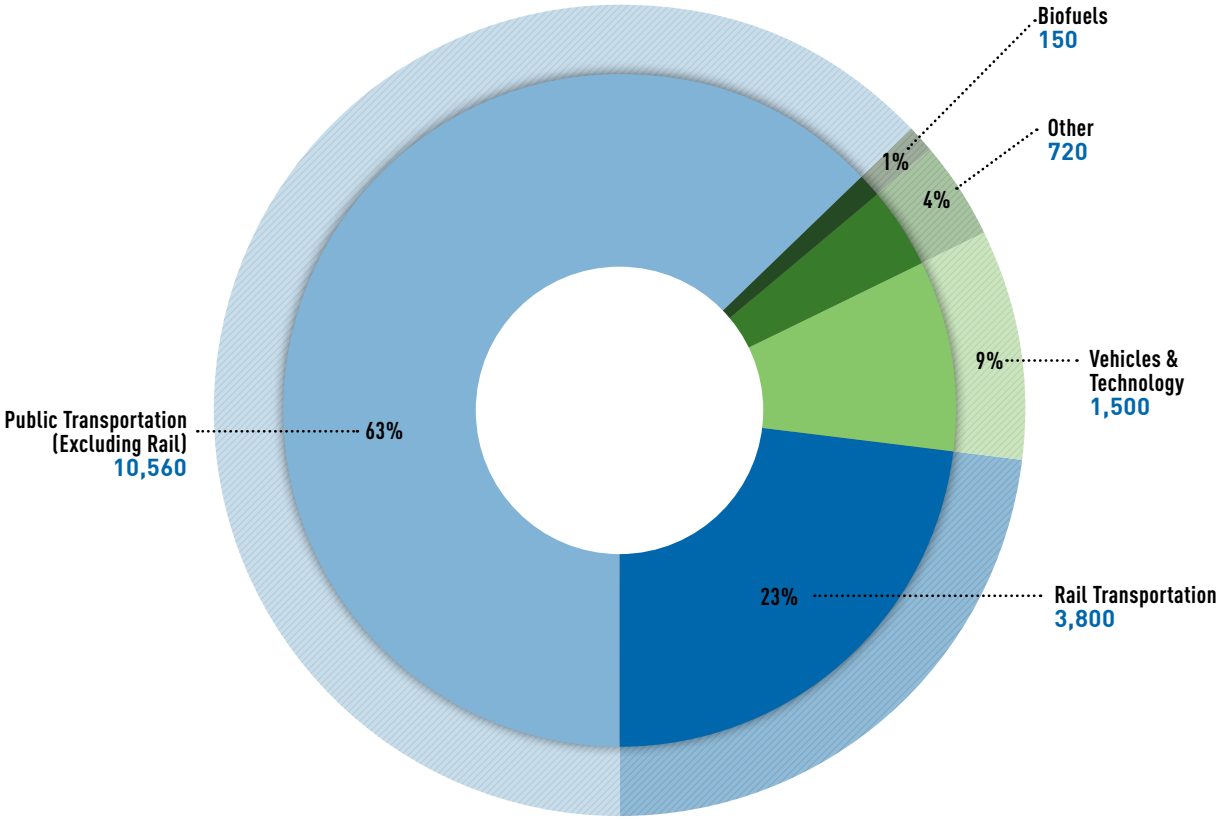
» In 2011, the sector was estimated to have generated some $1.9 billion in GDP and employed approximately 23,290 full-time equivalent workers.

In terms of jobs in the sector, companies in the Public Transportation and Rail Transportation segments combined account for the vast majority (86%) of total direct employment in the sector, equal to 14,360 direct FTE jobs (see Figure 2.2). While companies in the Rail Transportation segment are responsible for the highest GDP contributions to this sector (i.e., 56% of total GDP), the Public Transportation segment is more labour intensive and as a result, is responsible for more jobs (i.e., 10,560 direct FTE jobs in total).

The Vehicles and Technology segment accounts for approximately 1,500 direct FTE jobs or 9% of total employment in the sector. It is estimated that the clean transportation technology segment in British Columbia is currently responsible for approximately 18% of total clean technology sector employment in the province.[7]

Figure 2.2: ↓
Employment (direct full-time equivalent jobs) in British Columbia's Clean Transportation sector by segment, 2011.

Source: GLOBE Advisors



3. SECTOR PROFILE

The Clean Transportation sector includes a number of employment opportunities for British Columbia, particularly related to:

- Public transportation services;
- Improvements to the systems for the movement of people and goods, including intelligent transportation systems (ITS);
- The design and development of components for electric vehicles (EVs) such as batteries, chargers, converters, and controls;
- The research, development, design, and assembly of natural gas and hydrogen fuel cell-powered vehicles;
- The design, manufacturing, installation, and maintenance of infrastructure for alternative fuelling and charging stations; and
- The development of low carbon fuels and biofuels.

The following sub-sections describe these market opportunity areas in more detail.

PUBLIC TRANSPORTATION

Investment in public transport and related infrastructure can add considerable value to British Columbia's economy. The Economic Development Research Group (2009) and the Surface Transportation Policy Project (2004) suggest that $1 billion spent on public transport generates in the range of 36,000 jobs (averaging between operations and capital projects), which is 9% and 19% higher than the job-creation potential of road maintenance and new road projects respectively.[8] Public transit is already the largest Clean Transportation segment in terms of existing local jobs in British Columbia, and there is room for further growth.

BC Transit is the provincial Crown agency charged with coordinating the delivery of public transportation in more than 150 communities across British Columbia (outside of the Metro Vancouver region).[9]

The transit agency's mandate is set out in the *British Columbia Transit* Act, driven by the *Climate Change Action Plan*. Its 83 transit systems are operated by 18 private operating companies, 5 public operating organizations, and 15 non-profit agencies.

In most municipalities, the provincial government contributes 47% of funding for conventional transit services. Ridership fares and contributions from local governments (i.e., through property and gas taxes) make up the remainder.

The agency currently serves over 1.5 million people through a fleet of approximately 1,100 buses, mini-buses, and vans and has a total of 870 mostly full-time employees (not including the employees of the third-party agencies).

The agency has ambitious targets to double its ridership by 2020 as per the *Provincial Transit Plan* by increasing travel choice for

» British Columbia has been actively working to integrate regional land-use planning, housing, and transportation.

people around the province through new fleets, green technology, new rapid transit lines, and new innovative services.[10]

BC Transit has a strong interest in natural gas and battery EV technology. In the next three to five years, the company anticipates launching small numbers of these vehicles within its fleets. The new technologies however do come with increased costs for both buses and for infrastructure upgrades with respect to garages, as well as fuel handling and storage.

BC Transit fleets also have widespread use of biodiesel (with experience up to B20) and the transit agency is in year three of a five-year study of its hydrogen fuel cell-powered bus fleet network in Whistler. Despite having to truck hydrogen from Quebec twice weekly, the full lifecycle of the imported hydrogen versus diesel go from 45% to 65% lower greenhouse gas (GHG) emissions. The industry is currently investigating the potential for local supplies of hydrogen coming from North Vancouver which could lower lifecycle emissions by up to 92% over diesel.[11]

The other major public transit agency in British Columbia is TransLink, Metro Vancouver's regional transportation authority, which plans and manages the region's transportation network (see Profile Box 1). As a multi-modal agency, TransLink is the first in North America to have responsibility for planning, financing, and managing all public transit.

Translink delivers services through their operating companies, subsidiaries, and contractors, including Coast Mountain Bus Company, which includes SeaBus and HandyDart services; BC Rapid Transit Company, which operates SkyTrain and West Coast Express; Transit Police services; AirCare (to be retired at the end of 2014); and Intelligent Transportation Systems programs.

TransLink also owns and maintains the Major Road Network, which comprises most major regional arteries not owned by the Provincial Government (including a number of bridges such as the Knight Street, Pattullo, and Golden Ears). The company has some 7,200 employees (of which 50% are operators) and a fleet of approximately 1,400 buses – including an extensive fleet of hybrid and electric trolley buses.

Expanding public transit services is an ongoing challenge from a cost perspective for municipalities and operators in British Columbia. This is due in part to historically low-density community development which results in issues for transit agenices in being able to provide cost-effective services throughout their territories, with the exception of higher-density corridors.

British Columbia has been actively working to integrate regional land-use planning, housing, and transportation along with incentives for developers to pursue projects consistent with regional and community sustainability plans. By continuing to embrace higher-density urban planning throughout the province, the success rate of public transit initiatives increases, and in turn, so do the employment benefits.

Transit service providers are also exploring innovative financing tools but finding stable funding for network expansion continues to be a challenge. TransLink for example continues to experience impressive annual ridership growth as more people in the region make public transit their choice for sustainable transportation. In fact, TransLink carries about 85% of all transit rides in BC. While funding is secured for its next major transit infrastructure project (i.e., the Evergreen Line with project completion expected in 2016),

PROFILE BOX 1
TRANSLINK: DRIVING EXCELLENCE IN SUSTAINABILITY

Photo Credit: TransLink

TransLink aims to enhance the Metro Vancouver region's livability by providing a sustainable transportation network embraced by its communities and people. TransLink has a dual role in offering sustainable transportation choices while also reducing its own corporate footprint. In addition to encouraging people to make smarter transportation choices, TransLink's environmental and emissions policies recognize the influence that TransLink's own operations have on the region.

By adopting sustainability as a core value, TransLink has made progress toward its vision of a better place to live, built on transportation excellence. Over the past few years, TransLink has significantly decreased its fleet GHG emissions and criteria air contaminants, all while achieving record ridership levels year over year for the last decade. Between 2009 and 2011, TransLink cut its fleet GHG emissions by 9,174 tonnes. TransLink has also curbed energy use in its facilities through efficiency measures, including energy retrofits in bus maintenance facilities and some administrative offices.

TransLink has replaced an aging diesel fleet with cleaner running technologies, reducing diesel fuel use. One of its most successful programs is its "Idle-Free" program at depots and transit exchanges. The program has drivers turning off buses when not in use or when stopped for longer than three minutes. In 2011, the program avoided the use of an estimated 500,000 litres of diesel fuel.

TransLink has continued to achieve fuel efficiencies by redeploying diesel buses from urban routes to routes with fewer stops where they achieve better fuel efficiency and investing in technologies that use other sources of energy such as hydro-electricity. One example is the Canada Line, which is considered part of the SkyTrain network and is operated by InTransit BC (a TransLink contractor) under a 35-year concession agreement with TransLink. As of 2011, more than a quarter (26%) of fleet energy was derived from renewable sources.

TransLink was recognized for its sustainability performance in 2011, becoming the first-ever North American transportation authority to achieve gold under the American Public Transportation Association's (APTA) Sustainability Commitment. Among the Commitment's 77 transit authorities, including organizations in New York, Montréal, Toronto, Seattle, Los Angeles, and Portland, TransLink is a recognized leader in sustainability amongst its peers.

To learn more, see: **www.translink.ca**

» Modal shifts from truck and car to rail and ship have enormous potential for reducing fuel consumption and related GHG emissions.

TransLink is now revising its long-term "Transport 2040" strategy and will work with all levels of government and the public to determine the role public transportation will play in the future. BC Transit continues to work with the BC Ministry of Transportation and Infrastructure, and with local government partners to explore improved funding and governance arrangements to help meet the requirements set out in the *Provincial Transit Plan*.

BC's Transportation Minister recently ordered a review of transit operators and their assets in order to search for potential opportunities for cutting costs and improving operational efficiencies.

In addition to urban and rural transit systems in BC, inter-city transportation companies such as Greyhound Lines and Pacific Coach Lines offer important transportation services. The Passenger Transportation Board makes decisions relating to passenger transportation applications to operate inter-city buses in BC. While the Board promotes the use of eco-friendly vehicles, it currently has no environmental policies or requirements in place that directly influence inter-city bus applications in the province.[12]

RAIL AND GOODS MOVEMENT

From a clean economy perspective, the movement of goods is about increasing efficiencies. Modal shifts from truck and car to rail and ship, for example, have enormous potential for reducing fuel consumption and related GHG emissions. As an example, a single train can move one tonne of freight 180 kilometers on a single litre of fuel.[13] Increasing rail capacity will enable some freight to shift from trucks to rail. Moving freight from highways to rail can also relieve congestion on highways, improving the fuel economy of the remaining vehicles on the road.

Canadian National (CN) Railway is Canada's largest freight railroad, providing transportation and intermodal services throughout North America. The company currently employs some 2,800 workers in British Columbia (approximately 1,000 in Northern BC and 1,800 in Southern BC) and has aggressive plans to increase rail traffic in the province, including doubling its northern line traffic between Edmonton and Prince Rupert by 2015.[14] VIA Rail and the Rocky Mountaineer also operate on CN's rail lines.

Canadian Pacific (CP) Railway provides additional freight rail services in BC with direct links to Port Metro Vancouver, an intermodal terminal located in Pitt Meadows, and a number of load transfer terminals in BC.

The Southern Railway of British Columbia (SRY) is a short-line railway offering freight services in the province – in the Lower Mainland and on Vancouver Island (through an arrangement with the Southern Railway of Vancouver Island). SRY has 26 full-time employees and has plans to expand its freight rail services and add a new passenger service on Vancouver Island.

Growth for the freight rail industry in BC is entirely based on customer growth – linked closely with BC's natural resource-based sectors. As such, traffic expansion of BC's two main ports (i.e., Port of Prince Rupert and Port Metro Vancouver) means simultaneous growth for the rail industry.

The relationship between BC's rail network and its port systems are critical and efforts to improve efficiencies are ongoing. In May 2010 for example, Port Metro Vancouver and CN announced a supply chain collaboration agreement to drive further efficiencies at the port and recognize the importance of shared accountability.[15] The $307 million Roberts Bank Rail Corridor project is also designed

to improve rail efficiency of goods movement in the BC, with the number of trains on this route expected to increase from 18 per day in 2011 to up to 38 by 2021.[16]

Rail projects underway tied to port expansion plans in the province include the $300 million Prince Rupert Road Rail Utility Corridor. As part of the "BC Jobs Plan", the provincial government committed $15 million to this project – along with additional funding from federal government, CN, and the Prince Rupert Port Authority.

In addition, the "Pacific Gateway Transportation Strategy, 2012-2020" outlines plans to invest $2.8 billion by 2015 to meet CN and CP rail mainline growth.[17]

British Columbia's ports support a large number of jobs in the province. The Port Metro Vancouver's on-going operations support more than 47,000 direct jobs in BC (although only a small percentage are clean economy-related jobs at the present time).[18] The Port of Prince Rupert employs some 2,300 direct jobs based on the products it ships annually. The Port of Prince Rupert has generated approximately 900 jobs in the last three years, which have been filled largely by local workers.

There is considerable capacity in Prince Rupert for additional expansion of port activities in order to assist North American shippers in meeting Asian demand for clean economy resources. Over $30 million in investment is planned in the North to develop port terminal capacity to handle forest products including wood pellets. Locally, a number of industry players are looking at land issues in and around Prince Rupert for the purposes of expansion.

» British Columbia's major port authorities are actively pursuing environmental protection initiatives with respect to air, water, and land.

With respect to Port Metro Vancouver, expansion plans are expected to generate a 50% increase in traffic over the next 15 years to 185 million tonnes of cargo and nearly 1 million passengers. As part of these expansion plans, the Port has developed a $717 Gateway Infrastructure Program (GIP) to invest in 17 separate projects in supply chain improvements beyond traditional port activities and lands.[19]

British Columbia's major port authorities are actively pursuing environmental protection initiatives with respect to air, water, and land. As the first North American port to employ a dedicated team of specialists to address issues concerning the environment, Port Metro Vancouver works with Transportation Canada, Environment Canada, Department of Fisheries and Oceans, Metro Vancouver, and other local organizations on a number of initiatives.

As one example, the Northwest Ports Clean Air Strategy was developed by Port Metro Vancouver, in collaboration with the Port of Seattle and Port of Tacoma, and with support from Environment Canada, the US Environmental Protection Agency, BC Ministry of Environment, the Puget Sound Clean Air Agency, and the Washington State Department of Ecology. The strategy includes GHG emission reduction performance goals for port-related sources, and represents a co-operative effort amongst the three ports to improve air quality and reduce contributions to climate change in the shared Georgia Basin-Puget Sound air shed.

In addition, by partnering with Princess and Holland America Cruise Lines, the provincial and federal governments, and BC Hydro, Port Metro Vancouver has implemented infrastructure to provide shore power for vessels at Canada Place to reduce GHG emissions when vessels are docked.

Similar to concerns raised around port expansion plans in Seattle (Washington) and Long Beach (California), the growth of urban centres around Port Metro Vancouver is resulting in some push back from local residents and municipalities. As such, everything that is done at this terminal is subject to extra layers of scrutiny.

Port authorities are working with environmental agencies and various levels of government to identify potential risks to the environment that are associated with their operations. Where environmental risks are identified, action is taken to eliminate or mitigate those impacts.

The proposed $4.1 billion expansion of Kinder Morgan's Trans Mountain pipeline from Edmonton, Alberta, to its Westridge Marine Terminal in Burnaby is one such concern with respect to oil spill risks. Should the project be approved, it could see throughput capacity raised from the current number of 300,000 barrels per day (bpd) to 750,000 bpd by 2017, and would have a significant impact on vessel traffic in and around Metro Vancouver waterways, increasing the number of oil tankers in BC waterways to 300 per year, or approximately 10% of Port Metro Vancouver's vessel traffic.[20]

An additional interesting development in the area of goods movement concerns an initiative that looks to improve fuel efficiency for owners / operators of long- and short-haul trucks in BC. The Carbon Offset Aggregation Cooperative has developed a first-of-its-kind in the world methodology for converting diesel savings into verified carbon offsets through the addition of technology, the modification of equipment, and driver training (see Profile Box 2).[21]

PROFILE BOX 2

CO-OP INNOVATES WORLD'S FIRST TRANSPORTATION CARBON OFFSET PROGRAM IN NORTHERN BC

Photo Credit:
Northern Development Initiative Trust

As awareness of the impact of greenhouse gas emissions has reached global levels, a new business concept based in northern BC is showing that individual companies can make a difference by reducing their fuel consumption which in turn, reduces the harmful emissions.

Created in 2011, the Carbon Offset Aggregation Cooperative of BC is the first of its kind in the world, providing the framework for owners of heavy equipment and trucks to create, aggregate and sell carbon offsets. Equipment modification and operator awareness training are used to reduce fuel emissions from vehicles and equipment. The fuel savings are measured in the form of carbon offsets which are aggregated and sold by the cooperative on the world market. Proceeds of the sale are returned to co-op members as dividends, less a percentage which remains with cooperative to cover administration costs.

What began as an idea and gathering of potential stakeholders quickly progressed to the development of a formal protocol for converting fuel savings into carbon offsets. Recognizing the tremendous short- and long-term economic benefits to the forestry and transportation firms that employ thousands of people in central and northern BC, Northern Development Initiative Trust provided funding toward the protocol development. It was developed by Dr. Jurg Grutter of Switzerland, a world expert on transportation protocols, and accepted by the Ministry of Environment's Climate Action Secretariat in July, 2011.

Pilot studies were conducted and by September, 2011, a five year agreement was established between the Carbon Offset Aggregation Cooperative of BC and the provincial government to sell carbon offsets through the Pacific Carbon Trust.

Source: **www.northerndevelopment.bc.ca**

CLEAN TRANSPORTATION VEHICLES AND RELATED TECHNOLOGIES

The clean transportation vehicle and technology segment can be divided into three main categories: electric vehicles (EVs), technologies, and related infrastructure; natural gas vehicles and infrastructure; and hydrogen fuel cell-powered vehicles and technologies.

Transportation in British Columbia currently accounts for over 30% of the province's greenhouse gas (GHG) emissions. In 2008, BC passed the GHG Reduction (Vehicle Emissions Standards) Act (see Appendix B on policy and program drivers) to set emission standards equivalent to California's 2004 Low-Emission Vehicle II regulations. The provincial standards are projected to cut GHG emissions by 30% relative to current vehicle models, which would result in a reduction of approximately 600,000 tonnes of GHG emissions by 2016. In addition, BC's high gasoline prices and its carbon tax create favourable conditions in the marketplace for more fuel-efficient vehicles.

While BC's Vehicle Emissions Standards Act legislation has yet to be brought into force, the province may be deferring to the federal government to avoid any policy overlap and would be based on the recently announced fuel efficiency standards for cars and light trucks in the United States.

Electric Vehicles, Infrastructure and Components

When battery EVs are fuelled by renewable or hydro electricity, these vehicles present the lowest GHG emission scenario of all transportation vehicles and have the added benefit of being available for roll-out in the immediate term.

British Columbia has been active in the electrification of the light-duty transportation sector since 2007 with the formation of a multi-stakeholder working group "Plug-In BC", responsible for market transformation in this sector, the conversion of a small number of hybrid vehicles to plug-in electric, and studies on grid impacts and GHG emissions benefits. In addition, Plug-In BC has designed a proposed Charging Infrastructure Project that would see the deployment of up to 1,000 charging points in residential and commercial locations across the province.

High market interest for EVs and efforts by government have resulted in the provincial government establishing Memorandums of Understanding (MoUs) with major auto manufacturers – including Mitsubishi, Nissan, Toyota, and GM – to be the initial province in Canada to deploy their first EVs.

British Columbia currently offers point-of-sale incentives for EVs through its Clean Energy Vehicle (CEV) Program, which provides up to $5,000 per eligible vehicle and rebates of up to $500 per eligible EV charging station to residents who own or lease eligible vehicles (see Appendix B on policy and program drivers for more details). The provincial government is also investing $2.74 million for 570 charging stations across the province through its BC LiveSmart "Community Charging Infrastructure Fund", administered by the Fraser Basin Council.

At the present time, approximately 50 charging stations exist province-wide, almost entirely in the Lower Mainland and on Southern Vancouver Island.[22] Companies including Powertec Labs, Victoria-based PowerUp Systems, and Vancouver-based Big Green Island (BGI) Transportation have been involved in charging infrastructure design, installation, and servicing. BGI goes beyond standard installation and maintenance to include comprehensive, full-service infrastructure design solutions such as cafes integrated with charging stations.

For the last five years, BCIT has been conducting research on an Intelligent Micro-grid System, which localizes loads, electricity generation, and energy storage. Technology solutions to address long-term smart grid issues, such as managing the power demands of EVs are just some initiatives being pursued at the BCIT lab. For example, vehicle-to-home (V2H) and vehicle-to-grid (V2G) systems allowing EVs to have electricity flow from the car back to the grid is being researched as a means of back-up power when natural disasters strike.

At the municipal level, the City of Vancouver has shown leadership by becoming the first jurisdiction in North America in 2008 / 9 to integrate charging station requirements as part of its residential building code. The City is currently revisiting the code to upgrade the electrical capacity of charging infrastructure requirements from 120V circuit to 220V, as well as rolling the requirements out for the commercial code in parking lots.[23]

As such, the City has developed an EV Level 2 charging infrastructure pilot program in partnership with BC Hydro, which will offer a number of vendors the chance to demonstrate their products and services at several EasyPark public parking lots.

The City of Vancouver currently has a fleet of cost-saving EVs, including three Mitsubishi i-Mievs and a Nissan Leaf. The local car co-op Modo also offers a Nissan Leaf as part of its car share network, which is used by City staff

» The "West Coast Electric Highway" initiative has been developed to connect the major cities of Vancouver, Seattle, Portland, San Francisco, and Los Angeles with fast charging for EVs.

Photo Credit:
Government of Washington State

during the week. The City recently released a request-for-proposal (RFP) for an additional 30 EVs as replacements for outgoing vehicles.

The City of Vancouver is also developing and testing an EV charging network trial for homes, workplaces, and public spaces including fuel stations, community centres, and parking lots, in partnership with the Federation of Canadian Municipalities, BC Hydro, the provincial government, the Vancouver Electric Vehicle Association (VEVA), and other key stakeholders.

Through "Project Get Ready" in 2010 / 11, the City of Vancouver worked with the Colorado-based Rocky Mountain Institute, BCIT, and other key stakeholders to develop a "Menu of Actions" that set the overall strategic direction with respect to roll-out of EVs in the City.[24] Targets include 150 public EV charging stations by the end of 2013 and 275 by the end of 2016.

Outside of the City of Vancouver, BCIT is testing Level 2 chargers within its smart grid demonstration project in Burnaby and Colwood developer permit approvals now require EV-ready infrastructure.

The "West Coast Electric Highway" initiative has also been developed to connect the major cities of Vancouver, Seattle, Portland, San Francisco, and Los Angeles with fast charging for EVs. This effort could enable green-conscious travellers and early EV adopters to visit the province – a potential boost for the local tourism industry. British Columbia is also evaluating joint procurement opportunities with US states along the West coast in order to accelerate the adoption of EVs and lower the per-unit costs.

Future Vehicle Technologies is a local success story with its three-wheeled eVaro high-performance electric sports car featured in Popular Science magazine. The company specializes in BMS and drive motors and has developed an extremely lightweight genset.

Rapid Electric Vehicles (REV) has focused its development on vehicle technologies that allow for the two-way exchange of electricity with the power grid, enabling electric cars to become a versatile storage resource for renewable power. The company is now re-focusing its attention on telematics.

Azure Dynamics was a leading company headquartered in Burnaby developing and producing hybrid electric and electric components and power train systems for commercial vehicles. Although the company recently filed for bankruptcy protection, the human resource capacity remains in the province with many of the experienced workers moving to other companies in the Clean Transportation sector.

In terms of the actual manufacturing of EVs, however, British Columbia is unlikely to ever become a global leader. But the province does have significant expertise in the EV technology space, particularly in battery technology and battery management systems (BMS), which comes somewhat as an indirect result of the expertise developed in the local hydrogen fuel cell sector.

Recognized BC companies in this space include Blue Star Battery (acquired by Eagle-Picher), E-One Moli Energy (whose founder is considered the local father of the rechargeable lithium-ion battery), and Advanced Lithium (no longer in business).

Schneider Electric, a company specializing in the manufacturing of energy management solutions and equipment with offices in both Victoria and the Lower Mainland, acquired Xantrex in 2008 – a BC-based company that designs and manufactures a variety of AC and DC mobile power products for vehicles.

Delta-Q Technologies supplies vehicle manufacturers with power conversion and power management products for battery-based electric drive systems. The company is focused locally on research and development (R&D) and manufactures in China, with some 70 employees based in BC. Nelson-based Pacific Insight Electronics is involved with the design, manufacturing, and supply of LED lighting, controls, and electrical harnesses for the automotive and commercial vehicle market.

Outside of the automotive industry, Analytic Systems is involved in developing power conversion technologies for marine and rail / transit uses, as well as a number of other applications in military, telecommunications, commercial / industrial, alternative energy, and oil / gas. Analytic Systems does all of its manufacturing in BC.

Corvus Energy, based in Richmond with some 50 employees, is a growing start-up involved in high-power industrial lithium-ion battery solutions and management systems used in marine transportation, airport ground support equipment, trucking, and a number of other non-transportation related applications such as grid storage (see Profile Box 3).

The largest challenge for many EV technology companies in BC is finding customers for their products – which has led to the demise of several companies active in this space over the last few years. Without an automotive industry in BC, a key challenge is a lack of plant capacity and quality engineering expertise specific to the industry.

While energy storage companies in BC have focused mainly on export markets, pursuing domestic applications of these technologies has the potential to create additional value chain job opportunities in areas such as business development, battery assembly and installation, and equipment maintenance.

PROFILE BOX 3

CORVUS ENERGY: THE FUTURE OF ENERGY STORAGE

Photo Credit:
Corvus Energy

Corvus Energy is emerging as a global leader in state-of-the-art, high-powered, lithium-ion battery systems for heavy duty and industrial applications. Founded in 2009, the company designs and manufactures all of its products in-house at its facility in Richmond, BC.

The company currently employs some 50 staff and has experienced rapid growth over the past 3 years. Corvus is looking to add another 100 staff over the next 12 months. The majority of company employees are located in the Lower Mainland, but operations are expanding around the world as Corvus looks to set-up close to their customers in order to improve product design and cost efficiencies.

While the largest market for Corvus' batteries is currently found in the marine sector for powering diesel-hybrid tugboats, the company has experienced growth in demand for its products by other key segments including airport materials handling, for backup power systems and electricity grid storage, and for auxiliary power units (APUs) in the trucking industry, solutions which significantly reduce diesel fuel consumption and related GHG emissions through conversion to electrical power.

To ensure that the company is able to find the highly-specialized workers with expertise in electronics (firmware and software) and mechanical engineering required for its ongoing expansion, Corvus has worked closely with various government agencies, including the National Research Council's Industrial Research Assistance Program (IRAP), Sustainable Development Technology Canada (STDC), and the Natural Sciences & Engineering Research Council (NSERC).

To learn more, see: **www.corvus-energy.com**

Natural Gas Vehicles and Infrastructure

The promotion of natural gas technologies and liquefied natural gas (LNG) as a fuel alternative, particularly for large urban vehicle fleets, long-haul intercity trucking, and ferry fleets, shows particular promise for British Columbia – both as a job generator and for reducing GHG emissions. As the "cleanest burning" fossil fuel, current well-to-wheels estimates for the GHG emissions reduction savings for switching from gasoline to natural gas range from 18-30%.

Companies active in this space feel strongly that this is a high-growth area, both in BC and internationally, with the dominant industry players Westport Innovations and IMW Industries having hired a total of more than 200 people in BC over the last year alone. The cost and environmental benefits of natural gas as a fuel for transportation continue to be key drivers for this segment's growth. The fuel cost savings today for natural gas over diesel are in the range of 40-60%.

The natural gas vehicle technology segment in BC has historically been entirely export focused. However, recent market and policy developments in BC are opening up new economic and employment opportunities in the province.

At the February 2012 meeting between the Governor of Washington and the Premier of British Columbia, a comprehensive suite of joint undertakings related to natural gas, renewable fuels, and clean transportation were announced. These ranged from sharing information on the possible use of LNG for use in coastal ferries and in the heavy-duty vehicle sector, to joint reviews of regulatory oversight and information disclosure on the environmental impacts of shale gas recovery and natural gas storage to enable firming of intermittent electric generators.

The provincial government recently announced regulations allowing utility companies in the province to deliver natural gas transportation programs, including opportunities to:

- Offer incentives to transportation fleets that would use natural gas, such as buses, trucks, or ferries;
- Build, own, and operate compressed natural gas (CNG) fuelling stations or LNG fuelling stations; and
- Provide training and upgrades to maintenance facilities to safely maintain natural gas-powered vehicles.[25]

The regulation permits a utility to spend up to $62 million on vehicle and ferry incentives, up to $12 million on compressed natural gas fuelling stations and up to $30.5 million on liquefied natural gas stations, for a total of $104.5 million.

FortisBC is also currently developing and implementing a $60 million, ratepayer-funded Natural Gas Vehicle program to support a transition to natural gas use for medium- and heavy-duty vehicles, buses, and ferries. The program includes:

- Utility ownership of fueling infrastructure assets under a regulated rate offering (including third-party fueling);
- Utility incentives for fleet operators; and
- Utility education and safety incentives for industry transition to natural gas.

FortisBC's Natural Gas Vehicle program has been successful to date, having supported three projects including:

- 20 CNG waste haulage trucks, resulting in an estimated 468,000 liters of diesel displaced per year and fuel savings of approximately 50%;
- 50 LNG vehicles, resulting in an estimated 3.6 million liters of diesel displaced per year and fuel savings of approximately 50%; and
- 13 school buses.

Westport Innovations (TSE:WPT), with a market capitalization of $2.07 billion at the end of July 2012, is a company that was born from a UBC research project spin-off and has grown to become a global pure-play leader for gaseous fuel storage, delivery, and combustion technologies (see Profile Box 4). The company is focused on the assembly of engines and fuel systems at its Annacis Island facility, and converts conventional engines in the light-, medium-, and heavy-duty transportation markets to natural gas. The company is also involved in converting marine and rail power applications to natural gas.

Infrastructure and fuel partnerships with key transportation and energy industry players have been important for BC companies in this space. Westport Innovations for example has developed a number of important partnerships with companies including Cummins, General Motors, Ford, Hyundai, Peterbilt, Cat, Mack, Kenworth, and Weichai Power.

The successful roll-out of natural gas vehicles in BC depends largely on developing the fueling infrastructure corridors throughout the province. At the moment, infrastructure is being rolled-out on a project-by-project basis in collaboration with FortisBC, with only a handful of sites so far in the Lower Mainland. This infrastructure investment makes since when a cluster of vehicles exist, as has been the case for commercial vehicle fleets operated by companies including TransLink, Waste Management, Vedder Transport, and BFI.

In BC, the key player in the infrastructure space is IMW Industries, with approximately 10% of the global market share. The company specializes in the design and manufacturing of compressors for LNG fueling stations at its plant in Chilliwack.

BC Ferries is also pursuing a strategy over the next decade to replace existing engines in some ships with LNG and to replace older ships with new ones powered by LNG. With fuel as the BC Ferries' second largest cost after labour, the company expects to realize significant operational cost savings through this initiative. Unfortunately, the capacity for manufacturing new, large-scale natural gas engines (in the 1,000-1,500 horsepower range) does not exist in the province at the present time so new engines will most likely be imported, at least in the near-term.

The real economic and employment opportunities in this area are in the conversion of existing diesel ferry engines to LNG. At the moment, 15 vessels are primed for conversion, with retrofits of the two Spirit Class vessels that would providing significant cost-saving benefits (these vessels currently account for 25% of the company's total fuel consumption).

The Queen of Capilano, which runs from Horseshoe Bay to Bowen Island, has already undergone a conversion to LNG as part of a $20 million pilot project that will see a 10-year payback period.

PROFILE BOX 4

WESTPORT INNOVATIONS: POWERING FLEETS WITH NATURAL GAS

Photo Credit:
Westport Innovations

From modest beginnings in 1995 as a spin-off from a University of British Columbia research project, Westport Innovations has established itself as a global leader in alternative fuel, low-emissions technologies that allow engines to operate on cleaner burning fuels such as compressed natural gas (CNG), liquefied natural gas (LNG), and renewable natural gas (RNG) from organic feedstock sources like landfill gas.

Westport currently has operations in nine countries, and employs close to 1,000 staff, up from 200 in 2009. Strategic partnerships with the world's top engine and vehicle manufacturers have been critical to rapid growth at Westport.

Finding the qualified workforce to realize this growth has been a challenge as Westport seeks skilled mechanics, senior engineers, technicians and business support staff from around the globe. Westport has also developed a relationship with post-secondary institutions in BC to provide work placement and co-operative education employment opportunities for local students who, upon graduation, become valuable additions to the company's workforce.

While on-road vehicles have historically been the company's main focus, companies from around the world have expressed interest in Westport technologies for high horsepower applications such as marine and rail transportation.

To learn more, see: **www.westport.com**

» By introducing natural gas vehicles to commercial fleets province-wide, job retention benefits could be realized.

Conversion work would be done in BC, but companies from Europe are the top prospects for doing the work because they are the current industry leaders in this space. Opportunities also exist for other marine shipping companies and fleets (i.e., tugs, ferries, in-land freighters) to convert to LNG.

While not a huge employment generator province-wide, pursuing the natural gas vehicle opportunities at a faster rate could result in more jobs. At up to $2 million per fueling station, 50 stations province-wide could result in $100 million in economic and employment benefits to the province. In addition, the investment in natural gas engines and truck sales would have a local economic spin-off and could drive demand for an additional LNG terminal in the province – a total potential investment in the range of $400-$500 million over the next six to seven years. By introducing natural gas vehicles to commercial fleets province-wide, job retention benefits could be realized as a result of making local businesses and trade gateways more cost competitive.

It is important to note, however, that the overall market size in BC is relatively small and exports remain of critical importance to the industry.

Hydrogen Fuel Cell Vehicles

British Columbia continues to be a world-class centre for hydrogen and fuel cell technology research and development. Companies in this space are actively working on creating new technologies and materials (such as catalysts, membranes, and plates) and on reducing the costs of technology from the prototype stage to commercialization.

A cluster of approximately 40 companies and more than 800 direct jobs exist in BC, supported by industry associations, government agencies, universities, and research facilities such as the National Research Council that is involved in modeling / simulation, prototyping, and technology assessment.

Burnaby-based Ballard Power Systems (TSE:BLD), with a market capitalization of $88.8 million at the end of July 2012, was at the original centre of BC's fuel cell research and industry cluster development. The company is currently focused on fuel cell systems for buses, as well as for backup power systems, distributed generation, and the materials handling industry. Ballard's flagship transportation project in BC was the development of the world's largest fleet of 20 hydrogen fuel cell buses which was showcased during the 2010 Winter Olympic and Paralympic Games and continues to operate in Whistler. Ballard is now focused on moving beyond demonstration projects to building volume sales in the bus market in order to develop economies of scale and drive down overall costs.

Ballard sold much of its intellectual property for its automotive fuel cells in 2008 to Daimler and Ford, which formed one of the largest companies currently active in this space, the Burnaby-based Automotive Fuel Cell Cooperation or AFCC (see Profile Box 5). The company has doubled in size in the last four years, currently employing some 230 people full-time.

Daimler (i.e., Mercedes-Benz Canada) has also recently invested in a new $50 million manufacturing facility for fuel cell stacks for its hydrogen-powered vehicles that will employ some 50 people. The company hopes to grow its fleet from approximately 200 vehicles to 10,000 by 2015 by building on the existing AFCC joint venture.

While hydrogen fuel cell vehicles present a low GHG emissions scenario, fuel cell system technology for the automotive segment is still under development, with the anticipated roll-out of commercial vehicles in the 2015-2017 timeframe.

In terms of infrastructure, British Columbia currently has six active hydrogen fuelling stations, plus one mobile station that is expected to be located permanently in the Metro Vancouver area and be the first publically accessible station.

PROFILE BOX 5

AUTOMOTIVE FUEL CELL COOPERATION (AFCC): NEXT GENERATION MOBILITY

Photo Credit:
Automotive Fuel Cell Cooperation

The Automotive Fuel Cell Cooperation Corp. (AFCC), located in Burnaby, British Columbia, is the center of excellence for Daimler and Ford Motor Company's fuel cell technology. AFCC is responsible for the research and product development of automotive fuel cell modules with the goal of developing cost competitive and reliable technology solutions for commercial introduction in the 2015 timeframe.

A focus at AFCC is to increase the cost competitiveness of today's technology compared to incumbent technologies. A key factor in achieving this goal is developing an intimate relationship between manufacturing and development. This need was identified and addressed by AFCC's largest shareholder, Daimler, who further increased its investment in Canada by establishing a production facility neighbouring AFCC's location. This production facility demonstrates the continued commitment of its partners in fuel cell technology and their confidence in Canadian technical capabilities that exist today. This facility will serve to expedite the company's primary goal: the development of world-leading, commercial fuel cell technology.

Since its inception in 2008, AFCC has grown from 112 to more than 200 employees and has invested over $120 million in fuel cell development activities. To meet this growing need for highly-qualified employees, AFCC invests externally in academia to facilitate the development of domestic core competencies in fuel cell technology. Internally, AFCC invests in training programs that provide continued learning and growth opportunities essential for the recruitment and retention of today's top talent. These investments also serve to indirectly support non-automotive fuel cell activities by developing and stimulating a wider market demand for the industry's domestic supply chain.

To learn more, see: **www.afcc-auto.com**

Low Carbon Transportation Fuels

Provincial targets for reduced GHG emissions from the transportation sector, as well as policies such as the low-carbon fuel standard which requires a minimum 10% cut in GHG emissions intensity by 2020, are driving improvements in fuel efficiency and alternative fuel usage (see Appendix B on policy and program drivers for more details).

BC has committed to working with neighbouring Washington State to share information related to low-carbon and renewable transportation fuels, including legislation and regulations to encourage the use and development of low-carbon fuels, with a particular focus on creating a uniform market for biodiesel products across Washington and British Columbia. Information sharing on the development of advanced aviation fuels, including developing new markets for these fuels, was also part of the joint undertakings announced by the Governor of Washington State and the Premier of BC in 2012.

In addition, some municipal governments in BC have set their own targets above the Provincial one. The City of Vancouver for example requires a higher biofuel blend of B20 for its heavy-duty fleet. Vancouver currently sources its canola-based biofuel from Manitoba and Saskatchewan and is looking to ensure that increasing its targets further will not carry a negative impact on the food supply chain.

Companies in BC such as Lignol own patented technology for bio-refining ethanol and other co-products from readily available biomass in the province. British Columbia is also the largest market in Canada for biodiesel and fuel can be purchased through bulk distribution suppliers and a retail card lock network in Metro Vancouver, Kelowna, Prince George, and on Vancouver Island.

Two biodiesel plants based in Delta are currently operational in BC. City-Farm Biofuel is the province's first biodiesel producer, with an annual output of approximately 50 million litres sourced from recycled oil and tallow. Consolidated Biofuels produces approximately 11 million litres per year also from second generation feedstock.

In addition, a number of smaller biodiesel suppliers and co-operatives exist throughout the province in locations including Vancouver Island, the Lower Mainland, the Cariboo, and the Kootenay regions. These organizations tend to produce their own biodiesel by recycling oil from restaurant deep fryers and then selling it to their members.

Photo Credit: Lignol Energy

» Car sharing has been shown to significantly reduce the number of cars on the road and overall usage, and therefore reduces fuel consumption and GHG emissions.

Car Share Programs

Car sharing involves a service where people can rent cars for short periods of time – by the hour or minute. The model provides access to vehicles for those who either cannot afford one or choose not to own one, with the aim of contributing significantly to sustainable mobility patterns using a variety of transport options rather than single vehicle ownership. This, in turn, generates jobs related to the operation of these service models and maintenance of the vehicles.

The social and environmental benefits of car sharing are considerable.[26] Car sharing has been shown to significantly reduce the number of cars on the road and overall usage, and therefore reduces fuel consumption and GHG emissions. In addition, the cost savings that car sharing programs offer their customers puts money back into customers' pockets to be invested elsewhere in the economy.

The high cost of housing in Vancouver is helping to drive growth of car sharing programs as people look to save money in other areas such as by cutting their transportation costs. As such, three car sharing businesses have emerged in the Metro Vancouver region over the last decade.

Modo (the Car Co-op) is the original company in BC, having started with two cars in 1997. The company has since grown to operate a fleet of more than 270 vehicles (including some 20 hybrid and electric vehicles) with a full-time staff of approximately 20 people.

Location is everything in the car sharing industry. Some expansion has occurred into New Westminster, Burnaby, Richmond, and Surrey around transit hubs. Modo also has partnerships with car share organizations in Victoria and the Kootenays and is working on a partnership in Kelowna. The company projects a sustainable growth rate of 12-15% going forward, although the expansion into suburban markets is more difficult in terms of the viability of the business case.

The newest company to start operations in BC is Car2Go provides a fleet of free-floating, low-emission, self-service Mercedez-Benz Smart For-Two cars distributed throughout the City of Vancouver for on-demand access (see Profile Box 6). Member demand, municipal regulations, and population density are key factors for expansion to adjacent municipalities such as North Vancouver, Richmond, and Surrey. The company recently added 100 new cars in May 2012 and is considering adding a small number of EVs to their Vancouver fleet as part of a pilot project. The company currently employs 10 full-time staff in Vancouver and contracts out a local cleaning crew.

Other car share programs in BC include Zipcar in the Metro Vancouver region, which leases some 150 vehicles in Metro Vancouver that are available for rent to members on an hourly basis. The company has calculated that every Zipcar takes at least 20 personally-owned vehicles off the road.

PROFILE BOX 6
CAR2GO: CAR SHARE INNOVATION

Photo Credit:
Car2Go

Car2Go is one of the newest and most exciting additions to the emerging car-share market in British Columbia. While other car-sharing companies in the province have been instrumental in pioneering the market, Car2Go has introduced a new and dynamic free-floating concept which is touted as a personal and flexible mobility option that compliments existing public transportation, biking, and walking.

Members of the service can pick up a car anywhere in the operating area (City of Vancouver), and drop it off anywhere, whenever they want. Refueling, cleaning, roadside assistance, GPS mapping, insurance, parking, and maintenance are all included in the very reasonable rate that is calculated by the minute.

The company is a wholly-owned subsidiary of the Daimler North America Corporation and is a new business that focuses on providing a mobility service. Launched in Vancouver with a pilot project of 15 vehicles in April 2010, the company completed a full roll-out of its service in June 2011.

The company now has 320 fuel-efficient, low-emission vehicles in its Vancouver fleet and has registered more than 15,000 members within its first year of operations. In the coming months, Car2Go will introduce three new smart for-two electric drive vehicles to its car-sharing network, as it has in other cities throughout the world. In February 2012, Car2Go was named the "Best Car-share in Vancouver" by the readers of The Vancouver Courier.

With operations in 7 countries and 13 cities, Car2Go sees plenty of expansion opportunities throughout Canada, in the Lower Mainland, and potentially other parts of British Columbia. In June 2012, Car2Go launched in Toronto and in July the company launched in Calgary.

To learn more, see:
www.car2go.com/vancouver/en

Non-motorized Transport

Research indicates that shifts from driving to non-motorized transportation can provide significant economic development benefits by reducing overall transport costs (traffic and parking congestion, as well as road and parking facility costs), shifting consumer expenditures from vehicles and fuels to goods with more regional input, and by supporting more efficient land development. These shifts are likely to increase indirect employment and productivity within a region.

Several studies published by the Victoria Transport Policy Institute have evaluated the benefits and costs of non-motorized transportation in BC, as well as the economic value of "walkability".[27] Retail sales of bicycles and equipment, as well as their maintenance and repair, is just one example of an industry that is responsible for hundreds of jobs in BC.[28] Infrastructure projects that promote walking and cycling such as designated bike lanes and pedestrian walk ways, provide additional local employment benefits.

Similar to public transit, urban density is a key success factor for the widespread adoption of non-motorized transport, as is public safety, convenience, and comfort. To address the issue of convenience, the City of Vancouver is in the process of rolling out a bike share program. Bixi, a Montreal-based bike share manufacturer will be providing the two-wheeled transport for Vancouver's bike share program, with operations managed by the Alta Company based out of Portland, Oregon.

Photo:
City of Vancouver bike lane

Credit: Stephen Wu

» Major opportunities to maximize asset utilization and fleet efficiencies through ITS technologies exist for both public and private sector fleets.

Intelligent Transportation Systems

Intelligent Transport Systems (ITS) involve advanced appli¬cations of wireless, geospatial, telematics, and other information and communication technologies (ICT) which can be applied to transportation infrastructure, vehicles and users, and related interfaces with the aim of providing innovative services relating to different modes of transport and traffic management.[29] ITS can be considered a disruptive technology that enables various users to be better informed and make safer, more coordinated, and "smarter" use of transport networks.

British Columbia has well-established capacity in the ICT sector, and in 2002, the Province along with a number of key partners established a vision and strategic plan related to ITS.[30]

WebTech Wireless (TSE:WEW), with a market capitalization of $25.3 million at the end of July 2012, is the largest provider of ITS technology in Canada, employing some 120 people at its Burnaby development centre.[31] The company provides end-to-end wireless GPS fleet management solutions that help organizations mitigate risk, improve regulatory compliance, streamline intermodal operations, and lower operating costs. The company has also developed new applications that allow fleet management and tracking through mobile devices such as smart phones and iPads.

RFind Systems of Kelowna combines Radio-Frequency Identification (RFID) and Real-Time Location System (RTLS) location techniques into a single wireless solution for tracking vehicle fleets. The company was recently acquired by the Trapeze Group, an international subsidiary of Toronto-based Constellation Software Inc. that provides advanced software, ITS, and mobile technologies to the transportation sector.

Major opportunities to maximize asset utilization and fleet efficiencies through ITS technologies exist, for both public and private sector fleets. In addition, room exists to further capitalize on the global opportunities by strategically leveraging BC's ICT cluster and the related expertise of companies in the province in order to develop new ITS applications.

4. CURRENT TRENDS

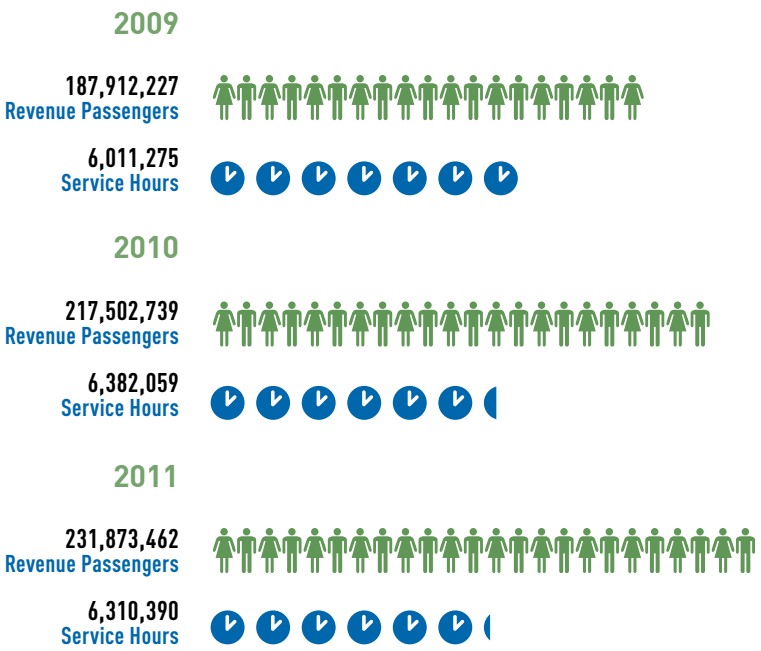
The Clean Transportation sector in British Columbia finds itself in a constant state of flux. The public policy landscape, technology pricing and performance, social acceptance, and other broader market and economic conditions are critical factors influencing developments in this sector. The following section touches on some of the key trends affecting this sector in BC, based on the insights of industry leaders interviewed as part of this analysis.

Transit service providers financially challenged despite growing demand for services

Demand continues to increase for public transit across British Columbia with a number of new services proposed and under development (e.g., the Evergreen Line Rapid Transit Project). In 2011, BC Transit ridership throughout the province increased by 5.0% over the year before to 51.2 million.[32] TransLink's new ridership increased by 14 million (6.6% increase) to a record of nearly 232 million (see Figure 4.1).[33]

Figure 4.1: ↘
TransLink ridership and service hours, 2009-2011.

Source: TransLink, 2011



With limited funding to expand however, transit providers across the province are forced to find ways to improve efficiency and effectiveness in order to avoid cutting back services. Despite these efforts, there is no other option but to discontinue services in some cases.

Demand is expected to continue rising in the future with demographic changes in BC. For example, the "baby boomer" generation will increasingly need public transit services as they age and discontinue driving. As such, finding creative financing methods for maintaining and expanding public transit services in the province will be essential moving forward.

Rising fuel costs driving efficiencies in transportation systems and logistics

The rising price of high-carbon fossil fuels and energy continues to drive demand for transportation system efficiencies. As such, BC is seeing a trend toward greater use of more efficient modes of transportation for both people and goods, such as toward public transit and rail.

In addition, new applications using information and communications technology (ICT) for intelligent transportation systems (ITS) are on the rise to better support fleet and transportation logistics. The ITS industry is predicted to grow by 40% over 2009 to $73

» British Columbia could be home to some 1.3 million electric vehicles by 2030.

billion in North America by 2015, employing an estimated 203,000 people.[34] Limited public funding encourages ITS initiatives that reduce congestion without the need for expensive infrastructure upgrades.

The biggest investment is projected to be in the area of intelligent traffic management, such as real-time transit and traffic information, synchronized traffic lights, multi-modal traffic and parking management centres, transit vehicle priority systems, congestion charging, and "smart" EV charging infrastructure.[35] This requires innovative ICT solutions, including sensors, data storage, user interfaces, and wireless applications for gathering, transmitting, and analyzing data.

Additional opportunities exist for resource industries (e.g., mining, oil / gas, and forestry) looking to maximize their asset utilization through initiatives such as reduced idling times. An example is an innovative forestry company in California that has developed a number of worker incentives to improve safety, efficiency, and output of their systems by applying WebTech Wireless technology.

The new technology is also opening up opportunities for smaller companies and independent contractors to compete with larger firms such as UPS and FedEx in terms of providing real-time tracking and logistical support services to customers.

Increasing urban density enabling new transportation business models

Transportation plans, such as Vancouver's *Transportation 2040*, are establishing road maps for a future where walking, cycling, and transit are attractive options for getting around. The City of Vancouver's goal is that at least half of all commuter trips in the City are made on foot, by bike, or on transit by 2020.[36] To achieve this target, higher-density, mixed-use developments are essential. This trend toward developing higher-density urban centres in BC is also enabling new transportation options in the province.

For example, the last several years have seen a proliferation of car sharing programs in the Lower Mainland. This new business model is a fundamental shift away from cars as "products" to a service offering by companies such as Car2Go (owned by Daimler / Mercedes Benz). In terms of employment, this fundamental shift opens up new jobs on the "service" side of the clean transportation sector.

Non-motorized transportation options are also growing in urban settings across the province. The development of separated bike lanes in the City of Vancouver and the City's recent commitment to roll-out a bike share program – similar to those offered in other major cities around the world – are two examples.[37]

A challenge for some of the "transportation sharing" companies continues to be the high upfront capital requirements and rapid equipment depreciation which make it costly for these businesses to thrive and survive.

» Local expertise in battery technologies and battery management systems (BMS), as well as natural gas engines and infrastructure, show particular promise moving forward.

BC set to lead Canada in the roll-out of electric vehicles

British Columbia is at the forefront in Canada when it comes to market interest for early adoption of electric vehicles and related infrastructure. BC Hydro research suggests that BC residents are already switching to hybrid vehicles at double the rate of the Canadian average.

With leadership at both the provincial and municipal government levels in BC (e.g., point-of-sale and charging infrastructure incentives, building code modifications, and efforts by working groups on projects such as "Plug-in BC" and "Project Get Ready"), major vehicle manufacturers are choosing BC as the initial province in Canada to deploy their first EVs.

The Pembina Institute estimates that in 20 years time, one in every three vehicles on BC's roads could be electric. British Columbia could be home to some 1.3 million EVs by 2030—one of the highest EV adoption rates in North America.[38]

Deploying sufficient EV charging infrastructure remains a significant barrier to widespread adoption. Relative to other jurisdictions with more established EV markets (e.g., the United States and Norway), BC has a long way to go.

That being said, innovative wireless charging technology now being tested on a fleet of EVs run by Building Operations at the University of British Columbia (UBC) may see the province benefit from not having overly invested in existing infrastructure technology.[39] By operating at a low frequency, the UBC technology could further encourage wireless charging adoption and the use of electric vehicles, as it does not have any of the perceived health risks of competing high-frequency wireless technologies.

Natural gas poised to transform trucking and ferry fleets in BC

Recent market and policy developments in British Columbia are opening up new economic and employment opportunities in the province related to natural gas vehicles, particularly for liquefied natural gas (LNG) powered heavy-duty trucking and ferry fleets, as well as the potential for rail in the future.

In its 2012 Natural Gas Strategy [40] and Liquefied Natural Gas Strategy documents, the provincial government confirmed its commitment to developing the sector in BC and laid out three critical priorities for LNG development.

The low price of natural gas compared with diesel and other high-carbon fossil fuels, combined with more than $200 million in incentives for natural gas powered vehicles, ferries, and related infrastructure, has the potential to significantly alter the landscape for fleet-based operations in BC.

Technology micro-clusters continue to tap into global markets

British Columbia's strength in clean transportation industry research and development continues to evolve, bolstered by close partnerships with university-based research facilities and centers of excellence.

While BC remains a global leader in hydrogen fuel cell technology research and development, local expertise in battery technologies and battery management systems (BMS), as well as natural gas engines and infrastructure, show particular promise moving forward.

Companies that form part of the supply chain for key players such as Westport, Ballard, WebTech Wireless, Schneider Electric, Corvus Energy, and AFCC will benefit as these micro-clusters continue to tap into the global market opportunities.

5. LABOUR DEMAND AND SUPPLY

INDUSTRY WORKFORCE NEEDS

Public Transportation Related Services

British Columbia's two largest public transportation service companies (i.e., TransLink and BC Transit) collectively employ more than 8,000 people – not including workers employed by BC Transit's private, public, and non-profit agency operating companies.

BC Transit has set ambitious targets to double its ridership by 2020 according to the *Provincial Transit Plan*, which will have a considerable impact on jobs in BC. Construction of major transportation infrastructure projects, such as the Evergreen Line in the Lower Mainland and Victoria's proposed light rapid transit system, also have the potential to significantly influence labour demand in BC.

Transit operators / drivers are the largest category of public transit employees at more than 50% of the total workers. While TransLink has plans to hire and train some 200 new operators in order to expand services and replace drivers entering retirement, these efforts have been placed on hold due to funding challenges.[41]

Skilled trades account for another significant component of the public transportation workforce in BC. Commercial and heavy-duty mechanics that can ensure the efficient operation of traditional diesel bus engines, as well as those experienced with working on natural gas engines and battery drive systems, are in demand. Charging infrastructure technicians are also in demand, particularly in the City of Vancouver which has a large fleet of electric trolley buses.

Transportation planners and engineers have also been hired by the province's public transportation companies over the last several years, as well as information technology (IT) experts tasked with implementing intelligent transportation system (ITS) improvements such as real-time transit information (RTTI) and new technologies such as TransLink's Compass Card, a reloadable electronic fare card that will work everywhere on transit in Metro Vancouver.[42]

Other important occupations related to public transportation services are marketing and communications professionals, graphic designers, data analysts, and management staff (including asset managers).

In addition to technical skills, companies look for employable qualities such as strategic planning capabilities, strong communication skills, and customer service skills.

Transferrable industries include workers from other large unionized organizations such as municipal workers, airline companies (also involved in transportation and customer service), and the trucking industry for mechanics.

» A significant demand exists for train crews, particularly in northern parts of the province.

Rail and Goods Movement Related Services

Rail is not only one of the cleanest forms of transportation for the movement of goods but also a considerable job generator in British Columbia, with more than 3,500 people employed in this segment province-wide. Demand is expected to increase as expansion of the province's ports and resource-based industries grow over the next several years.

A significant demand exists for train crews (e.g., locomotive engineers, conductors, and brake people), particularly in northern parts of the province. Heavy-duty, rail car, and track mechanics, electricians, and related apprentices are also in demand across the province.

Due to the nature of the work, companies look for employees who are comfortable with shift-work, with working outdoors in all weather conditions, and with working in unsupervised settings. Experience working in heavy industry and operating equipment (such as welders and small hand tools) is important. Workers must also be safety-oriented.

Transferrable industries include other transportation-based businesses (such as courier companies) and hard labour-related industries such as forestry and tree planting.

Individuals who have worked under collective agreements are also beneficial as they understand the dynamics of working in unionized environments.

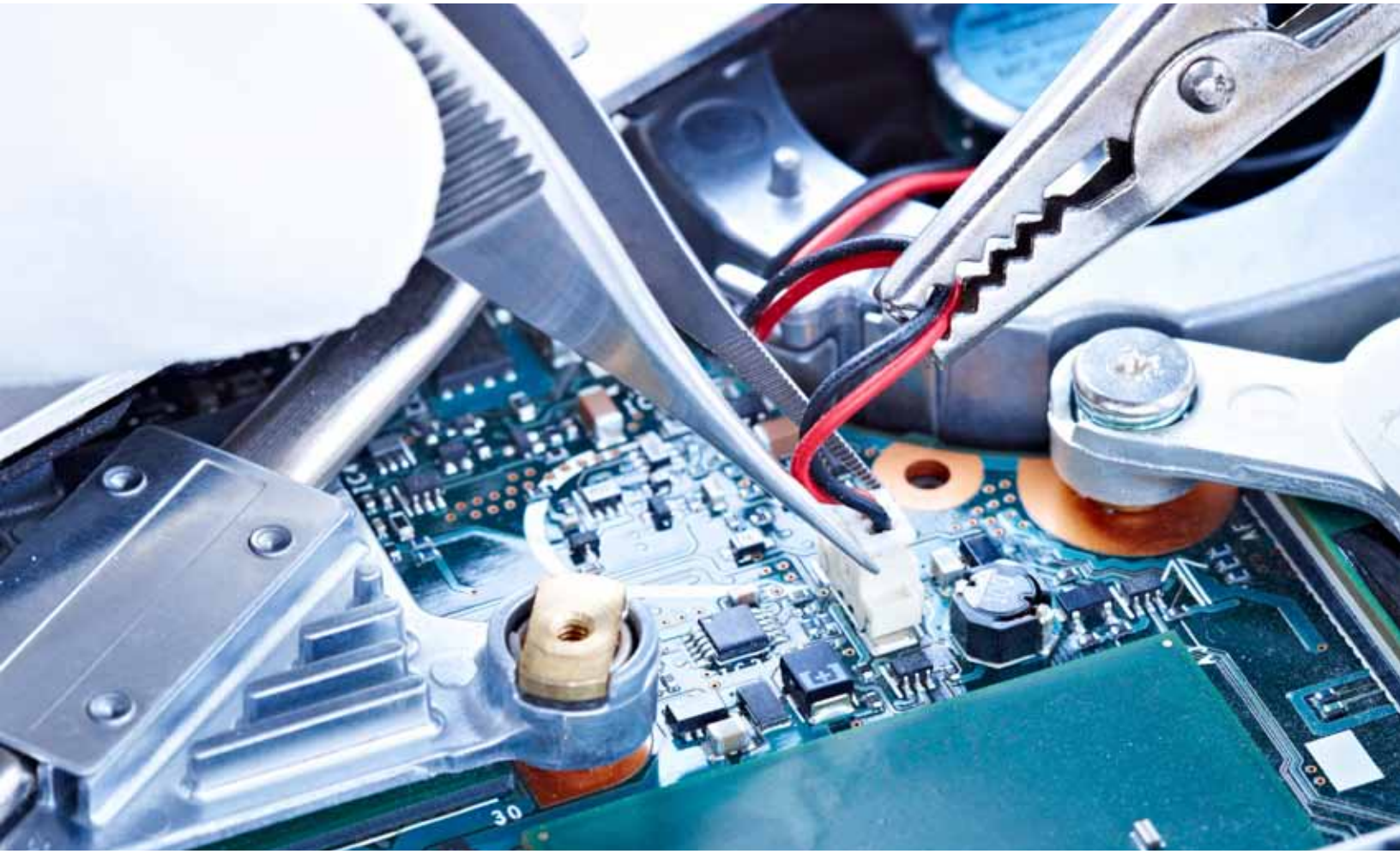
Clean Transportation Vehicles, Technology, and Infrastructure

For companies operating in the clean transportation technology space in British Columbia, maintaining a global competitive advantage in many ways comes down to whether these firms can attract the skilled, experienced labour and the specialized professionals (e.g., design engineers and specialized technicians / technologists).

Companies that are looking to sell their technology and components into the vehicle industry market (often through original equipment manufacturers or OEMs) must be able to produce highly-reliable technology at low cost. Companies in BC are working toward this goal at the moment by becoming more efficient and automating as much as possible from a manufacturing perspective.

The largest employee categories for BC-based companies in this space are engineers, technicians, and related research and development (R&D) specialists. Key workforce qualities, regardless of the specialization, include initiative and motivation, an ability to learn quickly, to innovate, and to think critically and creatively.

In addition, team-based skills are important as workers must co-operate to address specific industry problems in order to find solutions. These include communication and language skills; facilitation, negotiation, and conflict management skills; and an ability to deal with stress and heavy workloads.



Electric Vehicles and Charging Infrastructure

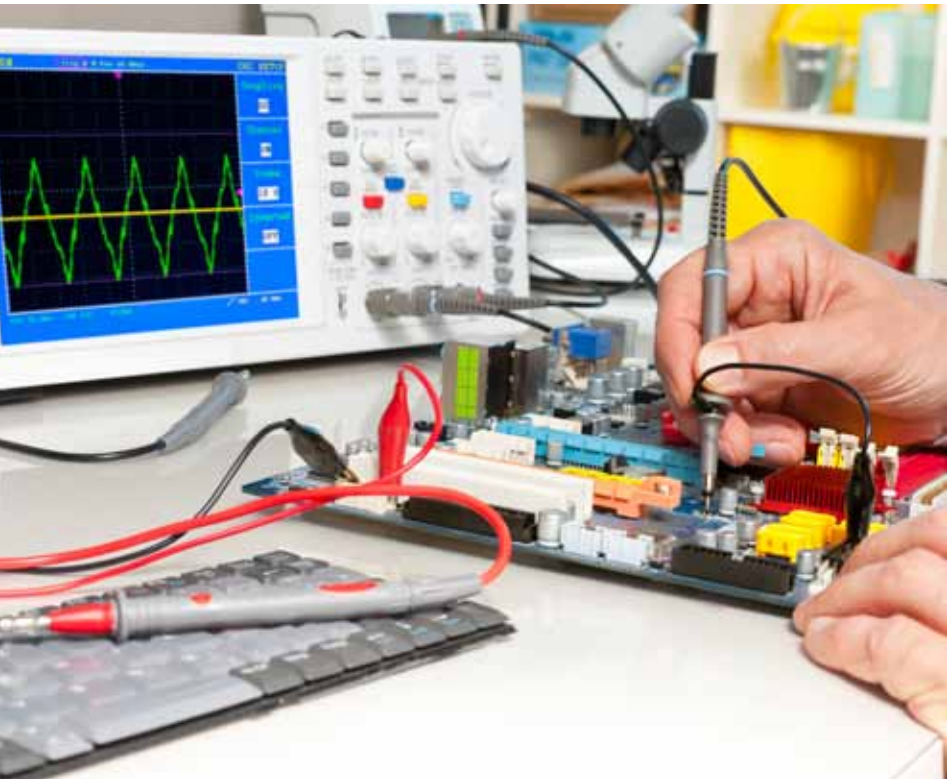
In the electric vehicle space, companies perform most of the research and development here in BC, along with some prototype testing and field trials. Manufacturing happens almost entirely abroad, mostly in Asia. As operations in the electronics industry become increasingly automated, which decreases the demand for labour and related costs, there is an opportunity for some low-cost manufacturers to return to North America. Some could possibly move to British Columbia, but more likely they will shift closer to the OEMs and customers in central Canada and the United States.

While BC-based companies have very little expertise producing the vehicles themselves, employment opportunities do exist with respect to the design and development of vehicle components and equipment, particularly the battery technologies, the battery management systems (BMS), and the related chemistry.

Companies that develop battery systems and related components (e.g., chargers, inverters, power conversion and management equipment, etc.) look for talent in three key areas of engineering: electrical, mechanical, and firmware and software development (i.e. digital power, onboard diagnostics, and communications with other vehicle parts and components). This expertise is often sourced from the automotive industry.

With respect to EV infrastructure, while charging stations are manufactured abroad, installation and maintenance of these stations is expected to create a handful of jobs in the province. As EVs penetrate the marketplace, there will be a growing need for certified electricians qualified to install and maintain EV charging stations. Non-certified electricians doing this work are a considerable risk as faulty installations and maintenance could result in accidents and / or fires with negative implications for the entire industry.

In addition, the installation of EV charging stations can go beyond the equipment itself to include the design and construction of surrounding infrastructure (e.g., buildings, rest stops and shelters, etc.). As such, knowledge of green building practices and urban planning is helpful for those companies looking to offer integrated solutions for the design and installation of EV charging stations and infrastructure.



Natural Gas Vehicles and Infrastructure

Leading companies in this segment have experienced tremendous growth in demand for their products and services over the last several years. In 2011 for example, Westport Innovations alone hired over 200 people. Approximately 90% of these hires were based in BC, 85% of which were on the engineering side. From an R&D perspective, leading companies look for staff with mechanical and electrical engineering backgrounds, often from the automotive, clean technology, and / or natural gas industry sectors.

There is also a potential demand for qualified workers with respect to existing fleet conversions. BC Ferries for example has plans over the next several years to convert the diesel engines of up to 15 existing vessels to liquefied natural gas during the mid-life overhaul process, which may in-turn create a number of jobs in BC's ship yards.

From an infrastructure perspective, companies look for experienced design engineers and experts in customized manufacturing, such as experienced welders.

Hydrogen Fuel Cell Vehicles

Despite the reality that hydrogen fuel cell technologies for transportation are still largely pre-commercial, British Columbia has an established cluster of expertise in related research and development.

Companies in this space tend to look for engineers with materials and mechanical backgrounds, combined with a good understanding of electro-chemistry. In addition, power and electrical engineers who can approach product cost reductions from a development perspective are highly sought after. Power engineers must be comfortable working with electrical controllers, high voltage motors, and have a good understanding of power electronics in order to match power ranges, voltages, and current windows.

» Research scientists with chemistry and physics backgrounds are important, particularly those with experience on fuel cell specific components such as catalysts and membranes.

Research scientists with chemistry and physics backgrounds are important, particularly those with experience on fuel cell specific components such as catalysts and membranes. Design experts familiar with programs such as AutoCAD are also relevant and individuals with cross-disciplinary experience are considered valuable by industry.

Transferrable industries include academia (for research scientists), as well as automotive and / or automotive supply, particularly those with experience in product development.

Biofuels Research and Development

Because the technology is new and constantly developing, there are very few experts in the field of biofuels and so many companies are focused on building internal capacity. For growing companies in this space, critical and core skills are developed in-house or hired on a permanent basis.

Companies tend not to look for specific types of skills as they are rather specialized. Depending on a project's stage of development (i.e., feasibility, construction, or operation), the talent sourced by companies varies. As the majority of companies in BC are in the pre-commercial stage, most firms look for staff with scientific and engineering expertise, which requires advanced levels of post-secondary education and previous experience.

As larger bio-refineries are established in the province, they will require operators and technicians for ongoing operations and maintenance.

Communities close to feedstock sources that have traditional economies built around chemical processing, pulp and paper, and / or forestry may be well-positioned for taping into the opportunities as their existing labour force will have transferable skill sets that can be dedicated to supporting bio-refinery operations. These services may range from engineering and millwrights, to operations, maintenance, and other support services.

Car Share Companies

The proliferation of car share companies in BC is creating a handful of new employment opportunities, particularly in urban locations. At the moment, some 50 people are employed province-wide by car share companies.

Key positions include transportation and logistics managers (i.e., fleet managers involved in cleaning, checking, and moving vehicles); information technology (IT) experts; customer service associates (preferably with foreign language skills such as Chinese); and marketing and sales professionals with an understanding of sustainability.

Companies tend to hire people with multi-disciplinary backgrounds as the organizations are small in size and staff members carry multiple responsibilities. Individuals with a range of educational backgrounds have been hired, from business professionals, to accountants, automobile mechanics, and mechanical and electrical engineers. Transportation and logistics people have come from jobs working for car dealerships for example. Companies have also hired people with a background in developing mobile phone software due to the reliance on mobile phone applications by some of these companies.

Companies tend to look for individuals who are culturally aligned with their organizations and are dedicated to the car sharing cause.

Intelligent Transportation System Developers

The bulk of demand for workforce expertise in the ITS realm lies in the areas of advanced computer sciences and engineering. Companies tend to look for people with a transportation background combined with the technical computer science or engineering experience, which is often a challenge. Developers of mobile applications are also critical for this industry as wireless solutions enable monitoring of data and information with respect to fleet management. Software testing and quality assurance (QA) experts are also in high demand. From a business development perspective, companies seek product managers with engineering backgrounds and advanced, solution-based sales skills in order to address the complicated and technical issues that arise during the sales process.

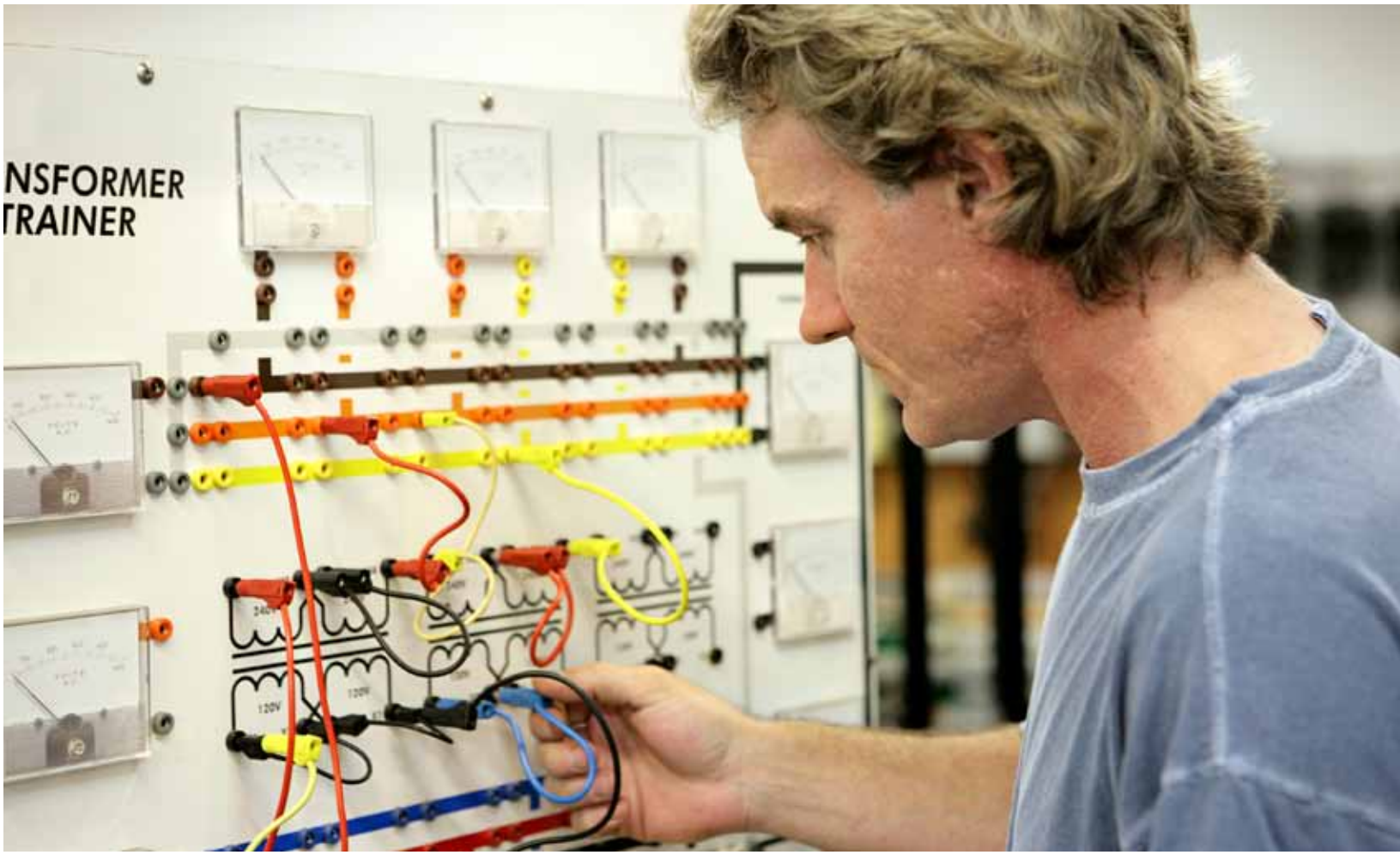
WORKFORCE RECRUITMENT AND RETENTION

For public transportation service companies, hiring is done locally for operators and other relatively easy to fill positions using on-line postings, word-of-mouth, and through internal referral programs. For more specific employment opportunities such as accountants, positions are often posted on-line using industry association websites.

With respect to rail operations, companies have been very aggressive with employee recruitment, particularly in Northern parts of the province where there is a shortage of skilled workers and it is difficult to attract and retain qualified employees. Unionized companies will often use job security and the available long-term employment benefits as a selling benefit to attract qualified workers.

In more remote communities or with harder to fill positions such as heavy-duty mechanics, companies will invest more effort and use targeted methods including traditional media sources such as print and radio advertisements.

For many technology companies active in BC's Clean Transportation sector, the highly-specific nature of the technology can make



» Companies seek product managers with engineering backgrounds and advanced, solution-based sales skills in order to address the complicated and technical issues that arise during the sales process.

finding the skilled and qualified engineers and technicians / technologists locally a challenge. Companies will post openings on their corporate websites and on-line using industry job boards such as T-Net [43] and the Association of Professional Engineers and Geoscientists of BC (APEG-BC). Word-of-mouth and social media platforms such as Twitter and LinkedIn are also essential tools. For some firms, hosting information sessions and participating in trade and career fairs have been found to be worthwhile.

In addition, companies will forge relationships with local schools and universities such as UBC, SFU, UVic, BCIT, Douglas College, and other engineering and technology-focused post-secondary institutions to bring on co-operative education students. The Mitchell Odyssey Foundation programs, designed to enrich the learning experience of high-school students in the areas of science, technology, and math, were identified as important by some industry players.[44]

Companies will also make use of federal programs such as the National Research Council's Industrial Research Assistance Program (NRC-IRAP), Natural Sciences and Engineering Research Council (NSERC) program, and MITACS to find and fund research and post-doctoral candidates (see Appendix B on policy and program drivers for more details).

While companies will usually try to recruit locally, many end up having to work with recruitment agencies (with mixed results) in order to search across Canada, North America, and often internationally for more specialized and experienced staff and the individuals required for strategic business planning and operations. These efforts involve a great deal of resources (in both time and money). Others have outsourced manufacturing and some of the more technical work (such as computer programming and coding) to countries including China, India, and Russia with mixed results in terms of quality.

The Labour Market Opinion (LMO) program, and to a lesser extent the Provincial Nominee Program, were identified as important avenues for bringing in foreign workers. The recent changes to the LMO are expected to assist in expediting workers for difficult to fill positions.[45] Transit service providers also make use of NAFTA agreements for urban planners coming out of the United States. Programs for new immigrants run by organizations such as S.U.C.C.E.S.S. have been helpful and companies will often use British Columbia's good lifestyle as a draw for attracting top talent.

Companies also identified that by marketing and positioning themselves as sustainable business and active players in the clean economy, they are able to attract and better retain educated young professionals looking to work for progressive organizations.

For more information on education and training related to the Clean Transportation sector in British Columbia, download GLOBE's Reference Guide to Green Education and Training:

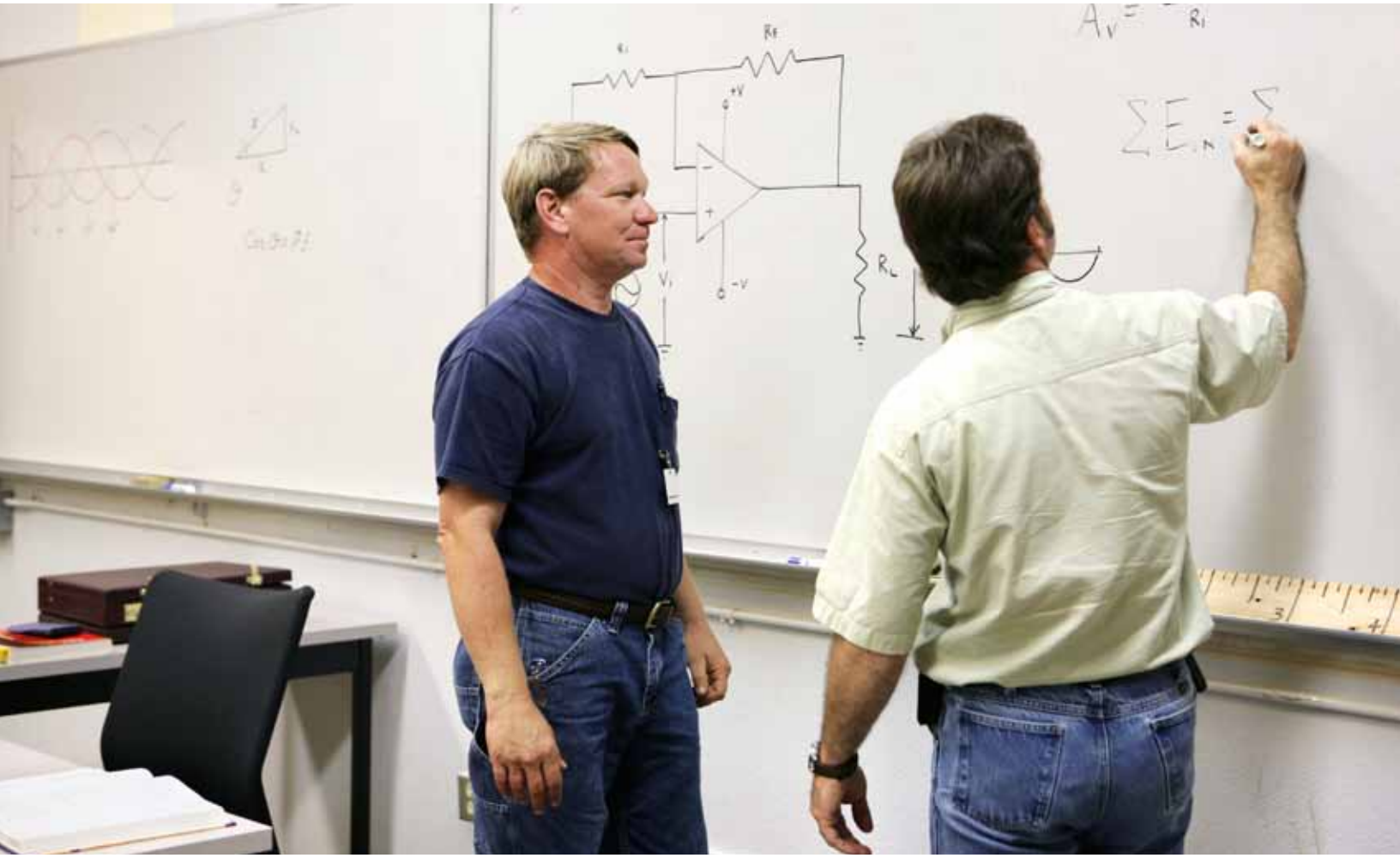
Skilled, Qualified and Sustainable: A Reference Guide to Green Education and Training in BC

EDUCATION, TRAINING, AND PROFESSIONAL DEVELOPMENT

External Education, Training, and Experience Factors

BC's post-secondary institutions were consistently identified by industry as offering excellent programs, particularly co-operative education programs for engineers offered at universities such as UBC, SFU, and UVic. While practicum programs are also beneficial for companies, they tend to be less effective due in part to the fact that these positions are unpaid and therefore less responsibility and training is given to students.

Technical colleges are providing quality graduates with examples cited by industry that include Camosun College's program for mechanics and BCIT's electrician and railway conductor programs. In order to provide input on curriculum development, members from industry will often work with relevant sector councils, associations, and Industry Training Organizations (ITOs) such as the Canadian Urban Transit Association, and sit on program advisory committees at the various post-secondary institutions. In addition, instructors have been brought into the workplace through partnerships with post-secondary institutions in order to ensure alignment of industry needs with various program curricula.



Most technology companies, however, recognize that it would be impractical for post-secondary institutions to meet the highly-specialized needs of the province's Clean Transportation sector. As such, it is important that graduates leave post-secondary institutions with holistic, technical skill sets and a strong educational foundation.

Internal On-the-Job Training, Mentorship, and Professional Development

Similar to many industries, companies in the Clean Transportation sector offer significant on-the-job training. Regardless of the skill set, there is always a need to bring new employees up-to-speed with a company's business practices and / or on the details of a specific project.

Public Transportation and Railway
Transit operators and drivers are all trained in-house. Apprenticeship programs are offered for most trades, particularly mechanics. Additional training is offered to dispatch staff and logistics crews, as well as customer service agents. Professional development training programs are offered for core management staff.

Given that the railway business is so specialized, most training is done in-house. Training is offered for the operation of small machines, as well as for safety and situational awareness (i.e., operating rules).

Railway conductors are hired from post-secondary institutions all over the country (e.g., BCIT, Confederation College, etc.) and are given approximately two months of in-class training, followed by 4-6 months hands-on training before they qualify to operate the trains.

Specialized in-house training programs for First Nations have been developed by some companies and larger companies offer specialized programs for senior management.

Clean Transportation Vehicles and Technology
Engineering and technology-focused mentorship programs are offered by many companies active in this segment as knowledge transfer and shared learning are extremely important for success. A great deal of the training is project and team-based. Senior members of the team mentor and provide support to more junior staff which allows for practical learning on the job. In some areas of technology such as hydrogen fuel cell research and development, the field is so unique that companies must train internally. Companies recognize that there is a very steep learning curve for their industry and therefore expect new hires to come in and "hit the ground running".

Some product manufacturers provide training support and companies will often pay for various professional development opportunities for staff, including association-based workshops, conferences, and accreditation programs. Companies will also hire graduates from post-secondary programs such as inspection as well as health and safety and train them internally through quality control programs.

» There is a greater need for more specific engineering programs focused on power electronics and related enabling technologies such as converters, chargers, and motors.

STAFFING CHALLENGES AND KNOWLEDGE, EDUCATION AND TRAINING GAPS

Key Staffing Challenges

Public Transportation and Railway Services
Attrition will be a major issue for these larger companies in the near future as hundreds of employees are set to retire over the next five to ten years. Companies will be challenged to find other qualified, skilled trades people such as electricians, power-line technicians, welders, pipe-fitters, and mechanics. The problem is expected to worsen as demand for these occupations by higher-paying industries in Northern BC and other province's in Canada continues to grow.

Mechanics (commercial and heavy-duty) continue to be the most difficult position to source and retain. This includes both traditional mechanics as well as those able to service emerging clean transportation technologies such as natural gas engines, fuel cells, and battery electric drive systems, as well as the related infrastructure.

Skilled track maintenance managers are very difficult to source for railway companies, often taking several months to hire the qualified staff. This is not a BC-specific problem however. Companies have struggled to find these people in other jurisdictions as well.

Companies find it difficult to attract people to more remote, northern locations in the province. As such, sourcing highly skilled trades people, technicians, conductors, and engineers is always a challenge.

Clean Transportation Vehicles and Technology
Companies, such as Schneider Electric and Delta-Q Technologies, which are two of only a handful of power electronics specialists in the province, have indicated that it is often difficult to source qualified individuals for their business needs and also difficult to attract them from other jurisdictions due to the fact that the cluster in BC is so small.

A second challenge relates to the limited resources available to smaller companies active in this segment. As such, most lack full-time human resources staff and the duties are internalized by other business unit functions which can make recruitment, retention, and training difficult.

Finding the time for on-the-job training can be difficult as it takes people off of their normal work and affects productivity levels. Companies do make extensive use of co-op and other research, training, and experience programs, but for smaller companies, it can be a challenge to dedicate time to train the students, especially for shorter 4-6 month work terms. There are further opportunities for government to help facilitate this process.

In addition, as described above, finding senior and experienced specialized engineers and technicians in the province can be a challenge at times. The skill sets are often not available locally so companies must seek experts from abroad.

This is the case for companies working in the electrical engineering and power electronics space (which includes electric, hybrid, and fuel cell vehicle technologies). While recent growth of the global renewable energy sector (i.e., solar) is resulting in a "rebirth" of the power engineer, there are additional opportunities for skill development and employment in this area for British Columbia.

The immigration process for bringing in skilled foreign workers can also be a challenge. Companies will at times have to wait long periods of three months or more for a permit before foreign hires can begin working. This can be detrimental to companies who may lose competitive positioning in their industries while their design and engineering processes are stalled.

At the moment, the immigration process is federal but the province may take on an increasing role in identifying key areas. As such streamlining will be beneficial and important. Companies have suggested that if the Canadian system is too cumbersome, they will consider moving to other jurisdictions to set up their operations.

Intelligent Transportation Systems Technology

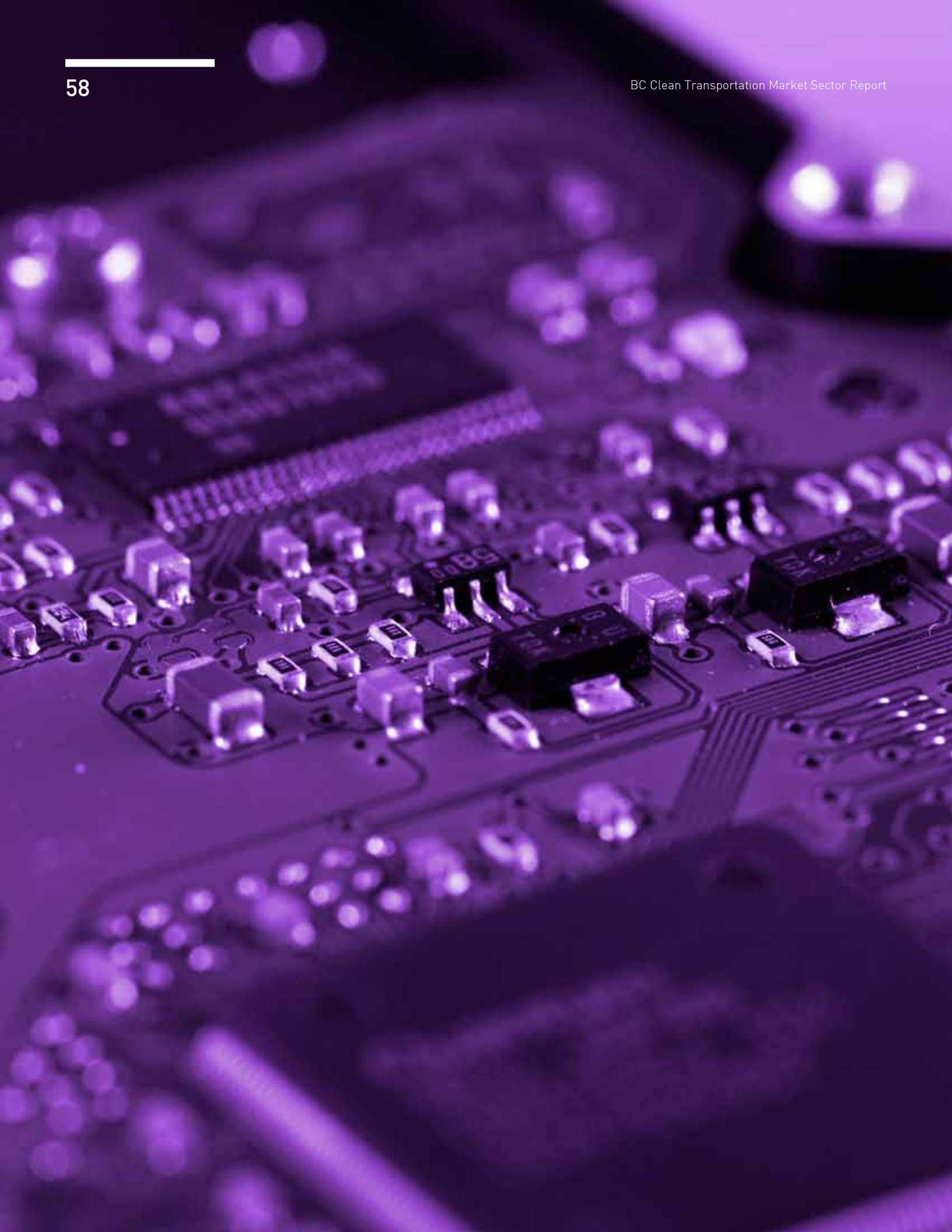
Companies involved in telematics, geospatial technology, and related data management are challenged to find the qualified experts they need, partly because the area is so leading edge and few programs exist at the post-secondary level. Finding experienced staff with a background in transportation combined with computer science and / or engineering is also a challenge. From a software development perspective, workers with experience in testing and quality assurance are difficult to recruit, as are mobile application developers, due in part to intense competition with other larger players in the ICT industry, both in BC and internationally.

Gaps in Education and Training

While companies interviewed in this sector were overall very positive about the available education and training in the province, some pointed to a greater need for more specific engineering programs focused on power electronics and related enabling technologies such as converters, chargers, and motors, which have applications in multiple industries in addition to the Clean Transportation sector.

In terms of ITS technologies, the lack of geospatial engineering programs in BC that combine computer science in the areas of telematics and wireless technology to explore applications for industry needs provides an area of opportunity.

Several companies indicated that there is a greater need for graduates to have aptitudes in a variety of areas and that programs that teach in relative silos are not effective for the needs of industry today. In addition, there is a growing demand for integrating "soft" skills into technical programs (such as conflict negotiation, communications, and facilitation), particularly for technology-focused companies where team-based work is essential.




Natural Gas
for Vehicles
1

6. BARRIERS AND ENABLERS FOR SECTOR GROWTH

Many issues affecting job growth were identified by business leaders active in the Clean Transportation sector. This section also highlights the enablers that could possibly guide efforts to mitigate the challenges facing the sector or to put in place measures that would promote job growth.

Barriers and enablers are grouped into four broad areas: Policy, Economic, Societal, and Technological. Understandably there are overlapping issues involved in many of the barriers and enablers cited. Efforts have been made to minimize these overlaps as much as possible.

POLICY

BARRIERS

Regulatory Challenges

- Regulatory issues are often a challenge for technology companies active in the Clean Transportation sector. An example is the current EV infrastructure permitting process that requires electricians to carry permits for each municipality where they operate. A harmonized and more efficient system would help to bring down costs.
- Jurisdictional boundaries (federal, provincial, municipal) and resulting limitations create challenges for the integrated delivery of public transit services and for the sourcing of related funding.

POLICY

ENABLERS

Government Leadership

- Government use of its purchasing power to add clean transportation vehicles to their public fleets and to put in place related infrastructure serves as a major stimulus to the advancement of this sector. An investment model could be used by municipalities and communities such as First Nations on under-utilized sites to this end that would minimize the upfront costs.
- Government can also play an important role in changing land use and zoning to encourage greater density around mass transit stations. As an example, the provincial government worked with TransLink and local governments on land use planning for the development of SkyTrain and Canada Line stations.

Supportive Public Policy and Regulation

- Low-carbon fuel requirement regulations to support biofuel blending have helped BC Transit reach its environmental targets. Regulations governing natural gas conversions of ferries could serve the same end and would play a key role in expanding natural gas use for the BC Ferries fleet.
- The City of Vancouver and other municipal by-laws and building code policies have been exemplary for encouraging EV adoption, car sharing, and other clean transportation alternatives. Upgrades to 220V capacity and commercial code requirements for parking lots could add more weight to this transition, as would streamlining permitting for EV charging infrastructure for single-family homes, multi-unit residential, and commercial properties.
- Government policy that encourages broader public accessibility for EV charging infrastructure instead of private use will only encourage adaptability and adoption of EVs in general.
- Government could work with agencies such as the Passenger Transportation Board to ensure that all passenger transportation services in the province (including inter-city buses) have in place policies that encourage the use of eco-friendly vehicles.

ECONOMIC

BARRIERS

Low Energy and Fuel Costs

- Low-cost fossil fuels and relatively inexpensive electricity serve as barriers to innovation and the deployment of alternative forms of clean transportation technology. New shale gas discoveries and softening of prices for natural gas have also impacted the economics of alternative fuel sources.

High Cost for New Technologies

- The hard realities and risks of commercializing and deploying new transportation technologies are increased costs for vehicles and associated infrastructure. These increased costs affect public transit systems, long-haul trucking, privately-owned vehicles, and even car share companies. Technology companies active in this space are all working to increase the reliability of their products while simultaneously reducing costs but these seemingly competing dichotomies often present challenges.

Limited Funding for Public Transit and Passenger Rail Infrastructure

- Financial constraints of public transit and rail services force transit authorities to demand more productivity from existing assets while limiting expansion plans and potential for added services that would add jobs and help to reduce GHG emissions.

ENABLERS

Develop Effective Incentives

- Incentive programs that are competitive with other jurisdictions in order to reduce the upfront costs for the adoption of EVs and infrastructure (particularly for commercial fleet owners / operators) and heavy-duty vehicles, buses, and ferries to use natural gas would accelerate the deployment of newer clean transportation technologies.
- Relaxing and modifying urban parking requirements and using related taxes to promote car sharing and / or the use of EVs could be a practical, low-cost incentive for changing consumer behavior. Partnering with organizations such as "Air Miles for Social Change" has helped FortisBC customers to transition to natural gas in the past and similar innovative incentive programs could be developed by industry.

Develop Innovative Financing Models and Cost-Effective Solutions

- Exploring new sources of funding for public transit and passenger rail services (e.g., bridge tolls, parking taxes, property taxes, gas taxes, green bonds, or the re-allocation of carbon tax revenues) could facilitate investments in infrastructure and accelerate the transition to cleaner forms of transportation.
- As an example, TransLink successfully completed a bond issue in 2011 to bring in $200 million in 30-year bonds at 4.7% interest.[46] Smoothing BC Transit's funding cycle to move away from an annual budget to a 3-year cycle was also suggested as a better way to manage service and expansion plans.

SOCIETAL

BARRIERS

Lack of Knowledge and Awareness

- The current lack of public knowledge and awareness around the benefits of clean transportation vehicles is a challenge to industry growth and market penetration. As an example, a major deterrent to the adoption of EVs is the tendency of consumers to focus on the upfront capital costs of the vehicle and not the long-term, lower operating costs.

Industry and Market Uncertainties

- Uncertainty about the timing and extent of clean transportation vehicle roll-outs by major manufacturers and the lack of coordination with other private or public incentives is a lingering deterrent to widespread adoption of clean transportation vehicle technologies.

Lack of Qualified and Skilled Labour

- The shortage of experienced and qualified engineers and technicians with respect to the design, manufacturing, assembly, maintenance, and repair of clean transportation vehicles and related infrastructure has negative implications for the entire industry. Sourcing talent from abroad continues to be a challenge for some companies where immigration visa delays can be a barrier to growth and competitiveness.
- The shortage of heavy-duty mechanics, railroad conductors / engineers, and track maintenance workers (particularly in northern and more remote regions in the province) creates real challenges for expansion plans.

ENABLERS

Improve Opportunities for Education and Outreach

- More targeted public education programs are needed to build awareness and trust of the benefits of adopting clean transportation vehicles. These could be tied to building awareness for the cost and environmental benefits of adopting clean transportation vehicles, reducing real and perceived risks to technology adoption, and linked to the installation of supportive infrastructure improvements.

Improve Access to Skilled Labour

- Providing more support for training related to cleaner modes of transportation and wider use of subsidized co-operative education programs with modular learning units which would allow students to move more effortlessly between education and employment could help to ease the entry of skilled workers in this sector.
- More opportunities for faculty to work in industry on specific projects would help ensure that the incoming supply of graduates effectively meets industry demand. Government could play a larger role in financing this type of professional development.
- Further streamlining of the immigration processes for workers with important skill sets would benefit this sector, along with the needed support related to this process.

TECHNOLOGICAL

BARRIERS

Lack of Infrastructure and Capacity

- At the present time, very little infrastructure exists in the province for clean transportation vehicle fueling / charging. The lack of well-established clean transportation-related technology clusters in BC also makes it a challenge for BC companies to find customers, attract capital, and source talent. As such, BC companies have limited capacity for tapping into the full range of global market opportunities, such as in the rail and marine technology related sub-sectors.

Technological Risks

- Fleet operators and major transportation service providers (i.e., rail, marine, and utility vehicle customers) are reluctant to adopt new technologies or products if there is no demonstration of its use in practice as the risk factors are too high. This creates challenges for local companies looking to sell their products in the global marketplace with no examples to showcase closer to home.

ENABLERS

Demonstration Projects

- Demonstration projects are essential for companies looking to sell their clean transportation vehicle technologies. For example, FortisBC's demonstration program has been successful in showcasing the fuel saving benefits of waste haulage trucks and is resulting in prompting conversions for commercial heavy-duty trucking fleets. The 2010 Winter Olympics helped to showcase the world's largest fleet of hydrogen fuel cell buses which has resulted in further success for Ballard in the global marketplace.

Partnership Development

- The establishment of multi-stakeholder working groups, such as "Plug-In BC" and the collaborative team that developed the City of Vancouver's "Menu of Actions" for EVs as part of "Project Get Ready", can help to accelerate the roll-out and adoption of clean transportation vehicles in the province by addressing specific barriers to growth. Additional collaborative efforts between public and private sector players in the clean transportation space can enable further opportunities.
- Opportunities exist for government to work with the province's ICT industry in order to put a strategic focus on ITS and other transportation-related solutions that would benefit government and industry by increasing fleet efficiencies, maximizing asset utilization, saving costs, and reducing GHG emissions.

7. CONCLUSIONS

Becoming a world leader in clean transportation requires strong leadership, a clear vision, and a well-articulated plan. British Columbia has already demonstrated this type of leadership, having implemented progressive environmental and technological innovation policies, programs, and standards that serve as an example for other jurisdictions across North America and around the world.

The Clean Transportation sector profiled in the foregoing sections is already a significant generator of well-paying jobs in British Columbia, employing an estimated 23,290 full-time equivalent workers (16,730 direct and 6,560 indirect) in 2011 in a variety of occupations. This sector is also estimated to have generated some $1.9 billion in GDP ($1.3 billion direct and $600 million indirect) last year.

This latest research by GLOBE Advisors confirms that a solid basis exists that will allow British Columbia capitalize on the economic and employment benefits from clean transportation. However, work must continue to develop a consistent, clear, and strategic policy framework that encourages investment and market-driven growth.

Based on the foregoing commentary, the following conclusions are put forward to help accelerate investment and employment growth in British Columbia's Clean Transportation sector.

1. **Clear and stable policy frameworks** – Having clear and stable policy frameworks that encourage private sector investment and that foster competitive market-based platforms for clean transportation-related goods and services are crucial to the creation of more jobs and the deployment of innovative transportation technologies across the province.
2. **Support for creative financing models** – Government financial support and related incentives are important for reducing technology risk and accelerating market adoption of clean transportation technologies. However, creative market-based financing models must be developed, particularly in support of public transportation service expansion plans across the province.
3. **Improve education and outreach** – More targeted public education programs are needed to build awareness and trust for the benefits of adopting clean transportation vehicles. These could be tied to building awareness for the cost-saving and environmental benefits of adopting clean transportation vehicles, reducing real and perceived risks to technology adoption, and linked to the installation of supportive infrastructure improvements.
4. **Focus on increasing productivity** – Increasing productivity is critical for realizing the opportunities in the Clean Transportation sector. This will require a combination of investment and technology innovation, as well as training for workforce development. Investing more in skills-based learning will be critical for boosting productivity levels.
5. **Facilitate knowledge transfer** – Promoting knowledge transfer across the Clean Transportation sector is critical to accelerating its market penetration. More cross-training and systems-based approaches to problem solving are required. Demonstration projects are also important, not only as a means for proving new technologies and solutions to potential buyers, but also as tools for education and skill development.
6. **Increase partnerships and collaboration** – Collaboration between governments and also between companies can help identify and exploit synergies to grow the clean transportation sector. The research conducted for this project has revealed numerous instances where collaboration and strategic partnerships have resulted in industry success.

APPENDIX A: TECHNICAL NOTE

Estimates of employment and economic activity (measured as contributions to gross domestic product) in British Columbia's Clean Transportation sector were developed through a series of steps that included:

- Identifying relevant industries important for the sector and related NAICS codes;
- Developing intensity ratios that consider the amount of clean economy activity within each industry; and
- Estimating current employment and GDP based on Industry Canada and Statistics Canada data and economic models.

The process that was applied is described in more detail below.

IDENTIFYING INDUSTRY NAICS CODES

A list of North American Industry Classification System (NAICS) codes at the six-digit level that best describe the activities within the Clean Transportation sector was developed and the codes were examined in detail. This list represents considerable research and dialogue over the past three years by GLOBE Advisors. The list of NAICS codes was also aligned with the US Bureau of Labor Statistics (US BLS) list of six-digit industry NAICS codes that are used to classify clean economy goods and services in the United States.[47]

The identified NAICS codes were verified by cross-checking the primary NAICS codes of identified companies in the Clean Transportation sector using both the Hoover's Company database for British Columbia and Industry Canada's Canadian Company Capabilities database to ensure they aligned with the sectors which they were assigned to as part of this study.

DEVELOPING INTENSITY RATIOS

Previous work conducted by GLOBE Advisors in BC and elsewhere in North America, combined with information obtained through industry research, key informant interviews, and through recent work by the US BLS to identify intensity ratios within green industries in the United States as part of their Green Goods and Services survey [48], resulted in a hybrid methodological approach to calculating industry intensity ratios for BC's Clean Transportation sector.

In order to estimate the volume of "clean economy activity" within the sector in BC, the proportion of clean economy-related activity within each industry was estimated. These intensity ratios were calculated by comparing the revenue associated to clean economy-related activity to total industry revenues wherever possible. In the case of certain industries where clean economy-related revenues were not available, estimates were generated based on research.

ESTIMATING CURRENT EMPLOYMENT AND GDP

Total direct employment for each six-digit industry NAICS code were estimated based on Industry Canada's Canadian Business Patterns publication (Catalogue 61F0040XCB). The data published in Canadian Business Patterns represents the current number of locations or establishments for a specific reference period, which is taken from the Statistics Canada Business Register Database.

In terms of indirect employment and direct and indirect gross domestic product (GDP) impacts for the Clean Transportation sector, estimates were based on industry multipliers published by Statistics Canada, derived from the British Columbia Input-Output (I-O) model (Catalogue number 15F0046XDB).

An I-O model is a way of understanding and estimating how economic changes in one industry can affect other industries. For example, changes in ethanol sales will have immediate (direct) effects on the blended retail gasoline industry, but also less immediate (indirect) effects on the agriculture industry, the transportation industry, and on any other industries which provide inputs to the production of ethanol.

Input-Output tables cover all economic activities conducted in the market economies of each province and territory, encompassing persons, businesses, government, and non-government organizations (NGOs), and entities outside its jurisdiction that give rise to imports or exports (inter-provincially or internationally).

The I-O tables represent the most detailed accounting of the Canadian economy available and thus serve as benchmarks to the Canadian System of National Accounts. These tables are the most comprehensive and detailed statistics on transactions involving production activity, as well as intermediate and final consumption of goods and services in the economy.

The simplest application of the I-O model is to estimate the economic impacts of a change in the final demand for some commodity produced by the economy. For example, suppose that there is an increase in exports of lithium-ion batteries. The industry that makes these products will increase its production accordingly. To do this, it will each purchase more of the inputs it requires. Industries which make those inputs will increase production accordingly. To do so they will need to buy more of their inputs, and so on. The model does all of these calculations simultaneously and provides estimates of the increased outputs for each industry affected by the change. In addition, it is able to provide estimates of the changes in GDP, employment, and taxes paid for each affected industry.

For the more detailed methodology – including a list of the NAICS codes and intensity ratios, as well as the direct and indirect full-time equivalent jobs and GDP for the Clean Transportation sector – contact GLOBE Advisors by email at **info@globeadvisors.ca**.

APPENDIX B: PUBLIC POLICY, PROGRAMS, AND FINANCIAL DRIVERS

Governments at all levels (federal, provincial, and municipal) in BC have pursued a number of key policies and programs that have helped to drive growth in the Clean Transportation sector over the last decade. Below is a select number of important policy, program, and financial drivers identified by industry as important for growth of this sector.

NOTE THAT POLICY AND PROGRAM TITLES ARE HYPERLINKED TO MORE INFORMATION.

OVERARCHING PUBLIC POLICIES

Bill 44 – BC Greenhouse Gas Reduction Targets Act (2007)

The *BC GHG Reduction Targets Act* committed that BC reduce greenhouse gas (GHG) pollution in line with internationally agreed-to targets (33 per cent by 2020 and 80 per cent by 2050). This North America first legislation requires all public sector organizations by law to become carbon neutral by 2010. Public sector organizations that fail to reduce to these levels are obligated to purchase carbon offsets from the Pacific Carbon Trust.

BC Energy Plan (2008)

The Energy Plan highlights the BC Government's commitment to clean energy leadership and position the province as a global leader in this sector. This plan saw the development of a suite of programs and initiatives that have supported pre-commercial, and commercial clean energy companies develop their products to help advance the province's conservation, energy efficiency and clean energy objectives.

BC Carbon Tax (2008)

In 2008, BC was the first province to implement a carbon tax on fuels such as gasoline, diesel, natural gas, heating fuel, and propane. This tax is designed to be revenue-neutral where the tax revenue is legally required to be transferred back to the taxpayer as a reduction. This tax aims to reduce the amount of greenhouse gas emissions while helping to reduce the switching costs for cleaner alternative fuels.

Since the carbon tax took effect in 2008, British Columbians' use of petroleum fuels (subject to the tax) has dropped by 15.1% - and by 16.4% compared to the rest of Canada. BC's GHG emissions have shown a similarly substantial decline. BC's GDP growth has outpaced the rest of Canada's (by a small amount) since the carbon tax came into effect – suggesting that it has not adversely affected the province's economy, as some had predicted. To date, the carbon tax has returned far more in tax cuts (by over $400 million) than it has received in carbon tax revenue – resulting in a net benefit for taxpayers. BC's personal and corporate income tax rates are now the lowest in Canada, due to the carbon tax shift. The carbon tax is currently under review by the provincial government.

Photo Credit:
Stephen Wu

BC Climate Action Charter

Out of 188 municipalities, 180 have signed the Climate Action Charter. The charter commits these progressive municipalities to measuring and reporting their community's GHG emissions. At the same time, they will commit to achieving carbon neutrality by 2012. As a result of this initiative, many communities are investigating clean energy solutions to help them reduce their GHG emissions and meet their own community energy needs.

Bill 17 – BC Clean Energy Act (2010)

The *Clean Energy Act* builds upon the strong commitment in the Energy Plan for clean energy development and deployment across the province. The Act advances 16 specific energy objectives with three identified priority areas including:

- Ensuring electricity self-sufficiency at low rates;
- Harnessing BC's clean power potential to create jobs in every region; and
- Strengthening environmental stewardship and reducing greenhouse gas emissions.

SECTOR-SPECIFIC PUBLIC POLICIES

Bill 39 – BC Greenhouse Gas Reduction (Vehicle Emissions Standards) Act (2008)

Based on California's regulations, this legislation is aimed to reduce greenhouse gas (GHG) emissions from vehicle tailpipes. This law establishes pre-determined GHG emissions standards for automakers whereby they would be required to produce lower-emission vehicles for their fleets. As a result of this legislation, 600,000 tonnes of GHG emissions will be reduced annually by 2016.

BC Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirement) Act (2007)

The renewable and low carbon fuel requirements are aimed to reduce BC's reliance on non-renewable fuels and reduce the province's GHG emissions by 33% by 2020. The regulation enables the Province to set benchmarks for the amount of renewable fuel in BC's transportation fuels and reduce the carbon intensity of transportation.

British Columbia Transit Act

The BC Transit Act sets the guidelines and regulations with respect to the planning and construction of public passenger transportation systems and rail transit systems in the province that support regional growth strategies, official community plans, and the economic development of the transit service areas and to provide for the maintenance and operation of those systems.

Provincial Transit Plan

Established in 2008 and with a budget of $14 billion, it is a strategy to double transit ridership with new fleets, deployment of green technologies, establishing new rapid transit lines, and other innovative transportation solutions. This investment by government is expected to further support British Columbians to live nearer to transit-oriented communities which would lead to lower energy use, increased energy efficiency, and a lower carbon future. This plan is expected to cumulatively reduce GHG emissions by 4.7 million tonnes by 2020.

Vancouver Transportation Plan 2040

The City of Vancouver is developing *Transportation 2040*, a plan that supports an inclusive, healthy, prosperous, and livable future for Vancouver. The plan will provide a vision for the next 30 years and will guide transportation decisions for how people and goods will move in and around Vancouver for the next 15 years. It also provides a roadmap for increasing the number of trips taken on foot, by bicycle, and on transit by City residents.

Municipal Building Codes

To facilitate greater adoption of electric vehicles, some municipalities such as the cities of Vancouver, Surrey, Colwood, Qualicum Beach, and Colwood have installed public charging stations. The City of Vancouver has also amended its building code standards to require dedicated circuits for EV charging stations in single family and multi-family dwellings.

INCENTIVE-BASED FUNDING PROGRAMS

Building Canada Fund

The $8.8 billion Building Canada Fund is expected to fund provincial and municipal projects through cost sharing between 2007-2014. This fund supports projects in three distinct categories to build:

- A stronger economy;
- A cleaner environment; and
- Strong and prosperous communities.

As such, this fund has funded public transit infrastructure projects throughout the province including upgrades to TransLink's Expo Line, and installing fare gates at Skytrain stations.

Canada Strategic Infrastructure Fund

This federal $4.3 billion fund provides funding for large-scale infrastructure projects across the nation. The fund provides financial assistance to provinces and municipalities for up to 50% of the total project cost. Public transportation and infrastructure development projects such as Metro Vancouver's Canada Line received funding from this program.

ecoENERGY Efficiency for Vehicles

Natural Resources Canada's ecoENERGY Efficiency for Vehicles program aims to reduce energy use and emissions from transportation in Canada. The program offers fuel efficient driver training, provides energy information to vehicle consumers, and encourages freight companies to make their operations as energy efficient as possible.

ecoENERGY for Biofuels

The initiative will provide operating incentives to producers of renewable alternatives to gasoline and diesel based on production levels and other factors. It will make investment in production facilities more attractive by partially offsetting the risk associated with fluctuating feedstock and fuel prices.

Freight Technology Incentive Program

A Transport Canada program that provides cost-shared funding to companies and non-profit organizations in freight transportation to help them to purchase and install proven emission-reducing technologies.

Freight Technology Demonstration Fund

A Transport Canada program that focuses on establishing cost-shared demonstrations to test and measure new and underused freight transportation technologies in real-world conditions.

Tax Credit for Public Transit Passes

Beginning in 2006, the Federal government launched a non-refundable tax credit program for Canadians to help cover the cost of public transit. This program is aimed to encourage Canadians to consider public transit as a means of regular transportation as it helps reduce traffic congestion and reduce GHG emissions.

LiveSmart BC Clean Transportation Programs

The BC Government's hugely successful LiveSmart Program provides incentives for consumers wishing to purchase clean energy vehicles as described below.

The Clean Energy Vehicle (CEV) Program

- **Point of Sale Incentives for Clean Energy Vehicles** – Incentives of up to $5,000 per eligible clean energy vehicle will be available to B.C. residents, businesses, non-profit organisations, and local government organisations. Incentives will be available until March 31, 2013 or until available funding is depleted (whichever comes first). Enough funding should be available to meet the expected demand (approximately 1370 vehicle incentives). Overall program management and administration for this LiveSmart Program is through the New Car Dealers Association of BC.
- **Residential Rebates for Purchase of Qualifying Electric Vehicle Charging Equipment** – Rebates of up to $500 per eligible electric vehicle charging station will be available to B.C. residents who own or lease a battery electric or plug in hybrid electric vehicle that is eligible for the Clean Energy Vehicle Program point-of-sale vehicle incentives.
- **Plug-in BC Community Charging Infrastructure Fund** – $2.74 million in funding is available through the provincial Community Charging Infrastructure (CCI) Fund to help support communities, businesses and other organisations in expanding the network of electric vehicle charging stations across B.C. This fund, being administered by the Fraser Basin Council, is targeting the deployment of up to 570 Level 2 EV Charging stations across BC communities by March 31, 2013.

The Scrap-It Program

The Scrap-It Program is working to reduce greenhouse gas emissions and improve air quality by getting older vehicles off the road. The program offers qualifying vehicle owners incentives to scrap their older vehicles. The incentive values are based on the greenhouse gas reduction that occurs when an old vehicle is scrapped and an incentive is used as a replacement. Incentives are offered to support the purchase of a low emission vehicle, transit passes, credit with a car sharing organization or a new bicycle.

FortisBC Vehicle Incentive Programs

Light-duty Vehicle Incentive Program

FortisBC's Light-duty vehicle incentive program provides financial assistance to customers considering purchasing new factory built compressed natural gas vehicles or converting existing vehicles to support such technology. The amount of incentive that is eligible cannot exceed $10 per gigajoule based on annual average consumption.

Heavy-duty Vehicle Incentive Program

FortisBC recently announced a $104.5 million program that helps support qualifying heavy-duty fleet operators purchase natural gas vehicles. Eligible vehicles include heavy-duty trucks, buses, vocational vehicles, and marine vessels. This program will also support the development of more compressed and liquefied natural gas fuelling stations across the province. The program initially will provide incentives of up to 80% of the incremental costs between natural gas and its diesel equivalent with the incentive decreasing gradually over time as result of expected wider spread adoption of natural gas engines.

RESEARCH, DEVELOPMENT, AND INNOVATION FUNDING PROGRAMS

Natural Sciences and Engineering Research Council (NSERC) of Canada

NSERC provides support to universities and researchers as well as encouraging Canadian companies to also embark on scientific quests to continue Canada's research and innovation excellence. Companies such as the Automotive Fuel Cell Coop which is performing fuel cell industrial research and development has collaborated with NSERC in the past to accelerate development of this technology.

Canadian Innovation Commercialization Program (CICP)

CICP is a federal program designed to help kick start businesses and allow innovative products including those related to clean energy and energy efficiency to move from a lab to the marketplace. This program awards contracts to companies with promising pre-commercial innovations and provides valuable feedback on the technology and how to access the larger Canadian marketplace.

Scientific Research and Experimental Development (SR&ED) Program

The SR&ED program is a federal tax incentive program that encourages Canadian businesses to conduct research and development activities in the country. This program constitutes as the largest single source of funding for industrial RandD activities by the federal government. Activities including experiment development, applied research, basic research, and support work are all eligible for this tax incentive.

SDTC Sustainable Development Tech Fund

This federally administered $590 million fund supports clean technology projects pass through critical stages of technology development and demonstration. The fund supports innovators without taking an equity stake and without requiring ownership of intellectual property. The fund also does not obligate supported projects to repay any financial contributions.

SDTC NextGen Biofuels Fund

This $500 million fund provides financial assistance to ready-to-commercialize biofuel companies. The financing provided from this fund helps reduce the risk of borrowing for the debt financing communities (banks, credit unions, etc). This assistance to reduce technology risk can bring new biofuels into the markets more quickly.

NRC Industrial Research Assistance Program (IRAP)

The IRAP program administered by the National Research Council (NRC) provides a wide variety of services to businesses conducting industrial research. Through this program the following services are provided to its program participants:

- Technical and advisory services;
- Financial assistance programs;
- Networking and linkage services; and
- Youth employment programs.

ecoENERGY Innovation Initiative

The ecoENERGY Innovation Initiative (ecoEII) is a new program that received $97 million in funding in Budget 2011, the Next Phase of Canada's Economic Action Plan, for a comprehensive suite of research and development (R&D) and demonstration projects. The program's objective is to support energy technology innovation to produce and use energy in a more clean and efficient way. This Initiative is a key component of the Government of Canada's actions to achieve real emissions reductions, while maintaining Canada's economic advantage and its ability to create jobs for Canadians. Activities funded under ecoEII will be in four strategic clean energy priority areas:

- Energy efficiency;
- Clean electricity and renewable;
- Bioenergy; and
- Electrification of transportation.

The Initiative consists of two separate funding streams: one for R&D projects, and one for demonstration projects.

BC Commercialization Voucher Program

The new $7-million "Commercialization Voucher" program will connect small- and medium-sized companies from a variety of key sectors and regions throughout the province with cutting-edge researchers in B.C.'s post-secondary system. Those collaborations will help get the most innovative products to market faster.

MITACS Programs

In partnership with governments, academia, and businesses, MITACS provides research and training programs to next generation researchers and innovators. The organization provides five key programs including:

- **MITACS Accelerate** – A research internship program connecting companies with graduate students from over 50 research-based Canadian universities.
- **Elevate** – A postdoctoral fellowship that allows recent PhD graduates to work on joint industry-academic projects for two years.
- **Globalink** – Provides access for undergraduate students from India, China, Brazil and Mexico to take on research projects in Canada supervised by a Canadian university faculty member.
- **Step** – A comprehensive program providing business-ready skills to up and coming researchers.
- **Outreach** – Provides outreach programs to engage children in science and mathematics.

OTHER PROGRAMS

ecoTRANSPORT

The ecoTRANSPORT program was an ambitious federal program aimed to protect the environment and health of Canadians through its three themed programs including:

- **ecoFREIGHT** program which works with the freight transportation industry to move forward and adopt new technologies and practices that reduce fuel consumptions, criteria air contaminants, and GHG emissions.
- **ecoMOBILITY** program helps municipalities encourage residents to adopt less polluting forms of transportation.
- **ecoTECHNOLOGY** for Vehicles ensures that technologies that help reduce the environmental impact of passenger vehicles are accessible to Canadians safely and quickly.

ENDNOTES

1. See: http://www.brookings.edu/~/media/Series/resources/0713_clean_economy.pdf
2. See: http://www.corporateknights.com/report/green-provincial-report-card-2012
3. For more details on this study, see: http://www.globeadvisors.ca/market-research/west-coast-clean-economy-study.aspx
4. Employment and GDP estimates are based on the latest work by GLOBE Advisors. For more information, see the "Technical Note" section in Appendix A.
5. Most BC clean economy companies are privately owned. Of the companies that are publicly listed, 15 Clean Energy, 5 Green Building and Energy Efficiency, and 3 Clean Transportation companies are listed on the TSX and TSX Venture stock exchanges.
6. See Technical Note in Appendix A for more details on how GDP and employment for this sector was estimated.
7. This estimate is based on KPMG's Cleantech Report Card for BC that estimates a total of 8,400 clean technology employees in BC in 2011. See: http://www.kpmg.com/Ca/en/IssuesAndInsights/ArticlesPublications/Documents/Cleantech%20Report%20Card%20for%20BC.pdf
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12. See: http://www.ptboard.bc.ca/
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22. See Plug Share website at: http://www.plugshare.com/
23. See: http://www.easypark.ca/about-easypark/parking-programs/go-green.aspx
24. See: http://vancouver.ca/sustainability/documents/PGRMenuofActions.pdf
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26. Firnkorn, Jörg and Martin Müller. "What will be the environmental effects of new free-floating car-sharing systems? The case of car2go in Ulm". Ecological Economics, 2011, vol. 70, issue 8, pages 1519-1528. See also: http://www.toolkit.bc.ca/tool/community-car-share-program and http://onlinepubs.trb.org/Onlinepubs/tcrp/tcrp_rpt_108.pdf

27. See: www.vtpi.org

28. Direct employment related to the bicycle industry in the states of Wisconsin and Colorado tied to cycling have been estimated in the range of 2,500 per state. The City of Portland has between 600 and 800 jobs tied to cycling. (Source: Portland State University (2008), A Review of Literature: The Economic Benefits of Bicycling).

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31. See: http://www.webtechwireless.com/

32. See: http://www.transitbc.com/corporate/general_info/pdf/BC_Transit_201011_Annual_Report_Final_WEB.pdf

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