CALGARY REGION'S
GREEN ENERGY ECONOMY

SUMMARY REPORT

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calgary economic development
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Delphi Group
Environmental Strategies. Business Solutions.

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Preface

In the Fall of 2015, the Government of Alberta announced a Climate Leadership Plan charting a course for Alberta to reduce its greenhouse gas (GHG) emissions and create greater opportunities for the growth of a green energy economy. The Climate Leadership Plan describes targets for the phasing out of coal generated electricity in favour of renewable energy and utilizing revenue from a carbon levy to grow the green energy sector.

With this new policy push in mind, Calgary Economic Development engaged The Delphi Group in 2016 to undertake research and analysis designed to better understand the size and scope of the green energy economy in the Calgary region and develop recommendations for an action plan designed to support the needs of local businesses, grow key components of the value chain, and attract new investment and talent.

Secondary research for this study included undertaking a broad sweep of more than 50 relevant reports and articles; a review of major industry trends and growth opportunities; a policy analysis on evolving federal, provincial, and regional priorities; and a review of comparative cities and best practice programs.

Sector profiling work included data collection and analysis of statistical sources in order to estimate green energy sector employment and gross domestic product (GDP); compiling lists of relevant companies, projects, investments, and research activities; and performing a value chain assessment of existing strengths, weaknesses, and gaps.

Extensive consultation was also undertaken through 35 interviews with industry leaders and a focus group that brought together key stakeholders from business and government to discuss the local opportunities and challenges for growing Calgary's green energy economy.

It is hoped that the outcomes from this project will be used to grow Calgary's green energy sub-sectors and related exports, to support local companies with relevant information, and to encourage the development of strategic partnerships that will help position Calgary as a growing green energy economy leader.

Cover Photo: City of Calgary's Southland Leisure Centre solar PV rooftop installation.

Delphi Group

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As a pioneer in sustainability and environmental risk management, The Delphi Group has more than 25 years of experience advancing a greener economy, helping to improve the sustainability of the organizations they work with as well as the local and global communities in which they operate. Delphi's clients benefit from the unique combination of policy expertise, strategic thinking, and technical know-how that Delphi's inter-disciplinary team brings to every project.

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Executive Summary

The uptake of renewable energy generation in power systems globally, accelerated further by policy action and cost reductions in wind and solar, is fundamentally changing the way power markets work, changing the control paradigm for the grid from base-load-and-peak to forecast-and-balance. It is also forcing through an accelerated digitization of all electrical equipment and the grid network and increasing the demand for energy storage solutions. A "smarter" grid, combined with energy storage, is key to supporting renewable energy integration and distributed generation, for improving efficiencies and stabilizing the grid, for smoothing price volatility, and for improving the adequacy of supply.

Buildings and transportation systems are also experiencing rapid overhauls, from 'brick and mortar' and traditional infrastructure investments to more high-performance buildings, connected communities, electrified vehicles, and intelligent transportation systems that are infused with a layer of information and communication technology in order to optimize efficiencies and reduce operational costs.

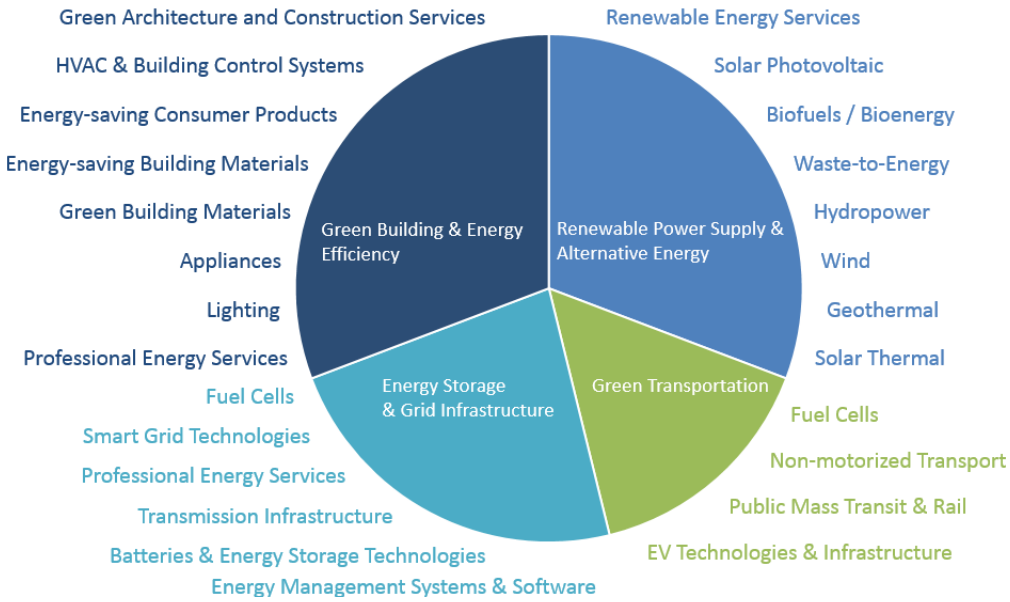
These shifts lie at the heart of the growing green energy economy and present significant opportunities for cities that are positioned to take advantage of the economic benefits, including new investments and job creation potential.

Calgary's interest in exploring a diversification strategy that includes an emphasis on growing the green energy sector is also well aligned with current federal and provincial policy, programs, and funding that include support for renewable energy, high-performance buildings, energy efficiency, green transportation, and clean technology and innovation more generally. Alberta has mandated a broad-based carbon pricing scheme with emission limits on industry, a carbon levy on consumption of fossil fuels (to take effect January 1, 2017), the phase-out of coal-fired electricity by 2030 to be replaced in large part by renewable energy solutions, and significant funding to support energy efficiency programming.

This report provides an overview of the Calgary region's current green energy economy, profiling the size and scope of activities, its key strengths and short-comings, and putting forward recommendations for an action plan designed to support the needs of local businesses, grow key components of the value chain, and attract new investment and talent.

Calgary's Green Energy Economy

Calgary's green energy economy, as defined by this study, consists of four sub-sectors and a number of interrelated segments, as outlined in Figure ES1. These four sub-sectors are connected through technology, services, and inter-related systems and, when applied holistically, can support a resilient, green energy economy that has the potential to power and operate all aspects of society, from day-to-day living to business activities and industrial operations.



Source: The Delphi Group

Figure ES1: Calgary's four green energy economy sub-sectors and related segments profiled in this report.

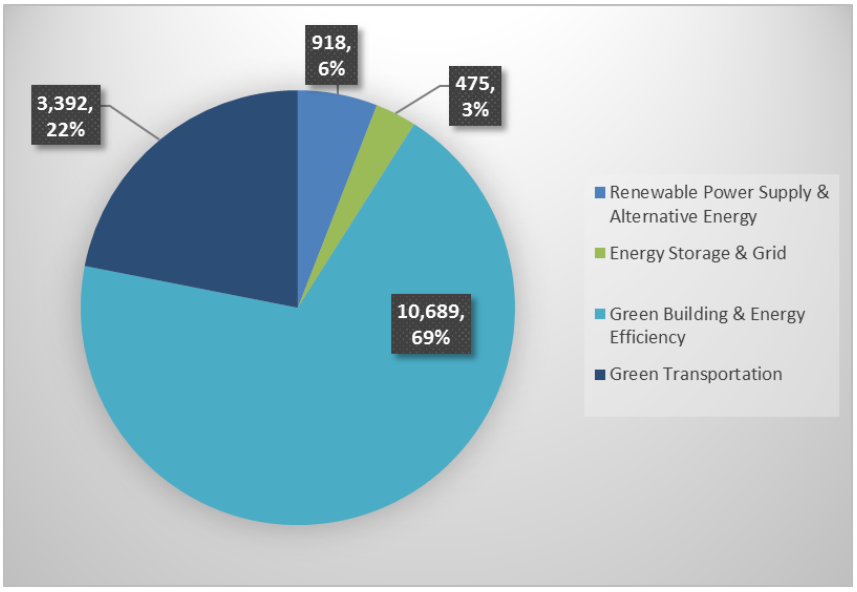
Author's Note on Definition:

The scope as defined for this study focused on renewable energy and related technologies. While Delphi Group recognizes there are non-renewable energy related technologies that could be considered part of the green energy economy given their positive impact on reducing energy demand and/or GHG emissions (e.g., carbon capture and utilization, co-generation, etc.), these technologies were not included in this study.

Calgary is a well-established 'talent hub' of high-value added, service-oriented workers that are experienced in the energy industry. A great deal of baseline expertise exists in Alberta in terms of energy system design, resource maximization, and driving toward cost efficiencies.

In 2015, Calgary's green energy economy was responsible for generating **$3.63 billion** in gross output[1], **$1.78 billion** in gross domestic product (GDP), and employed approximately **15,470 jobs**, equal to 1.8% of all workers in the Calgary Economic Region (see Figure ES2).[2]

Employment and economic output was largest in the green building and energy efficiency sub-sector, due in large part to the extensive value chain and the fact that Calgary has been a leader in green building project design and construction over the last decade, particularly with Class A commercial office buildings.



Source: The Delphi Group

Figure ES2: Direct jobs in the Calgary's region's green energy economy in 2015.

The Calgary region has a wealth of research and development capacity, although the overall levels of investment in the green energy sector as a whole in Alberta have been small. From 2012-2016, 6.1% of all NSERC grants in Alberta have gone to green energy economy sub-sectors, equal to approximately $25.0 million. Of the NSERC grant funding in Alberta allocated to green energy economy sub-sectors since 2012, approximately 60% or $14.9 million has targeted post-secondary institutions in Southern Alberta. Specialized pockets of research expertise have developed in areas that include solar PV, bioenergy, geothermal energy, energy storage and fuel cells, electric vehicles and advanced transportation systems, and green building technology applications.

In terms of later stage investment into the green energy sector in Alberta, the Climate Change and Emissions Management Corporation (recently renamed as Emissions Reductions Alberta or ERA) has contributed approximately $122 million to 18 relevant projects, leveraging nearly $1.5 billion in total project value.

Renewable Power Supply & Alternative Energy

By the end of 2015, Alberta had more than 2,800 MW of installed renewable power capacity (including hydro, wind, biomass, and solar), making up approximately 17% of total installed capacity. In recent years, growth of new utility-scale renewable energy projects has slowed because of decreasing prices for power, driven by slowing demand and what many see as oversupply of power generation on Alberta's competitive market. However, as of September 2016, there were 61 new utility-scale renewable energy generation projects proposed by industry, equal to a total power capacity of approximately 7,460 MW.

In terms of generation, renewable energy sources represented 9.4% of power generated in 2015, due to growing output from wind power generation which was equal to 4.7% of total electricity generation for the province.

With respect to renewable energy project development, a vast amount of project design and engineering expertise exists in Alberta, stemming from a number of leading examples across the range of technology areas, as outlined in the table below.

[1] Gross output measures total economic activity in the production of new goods and services in an accounting period. It is more representative of 'revenues' and is a much broader measure of the economy than GDP, which is limited mainly to final output (finished goods and services).
[2] Note: Estimates are based on a geographic scope equivalent to Calgary's Economic Region (Census Division #6). Total employment for Calgary's Economic Region was estimated to be 850,000 in 2015 (average). Appendix A provides more details on the methodology that was applied for estimating employment and GDP.

Segment	Overview
Bioenergy	• Approximately 30 biomass or biofuel plants in Alberta. • Alberta's bioenergy projects have provided $788 million to provincial GDP and hundreds of jobs • CCEMC (ERA) has supported $191 million worth of bioenergy projects in Alberta
Wind	• Alberta is the 3rd largest producer of wind energy in Canada • 38 projects equal to 1,500 MW installed • 41 proposed projects equal to $14.5B in investment and 6,400 construction jobs
Solar PV	• Alberta's solar resource is 25% greater than Ontario's and 30% greater than Germany's • 1,500 solar PV micro-generation sites in Alberta equal to 11.5 MW installed • 560 MW of solar PV proposed for Alberta through 18 new projects • New AB Govt. goal to procure 55% of power from solar PV starting in 2018
Hydro-electricity	• Hydro power currently makes up 5% of total installed capacity, down from 50% 65 years ago • Recent developments have been mostly micro-hydro and smaller dams • Canadian Hydro Association estimates >11,500 MW of remaining economic hydro potential
Geothermal	• No commercial geothermal power plants operating in Alberta at present • Growing interest due to available related skilled workforce and number of orphaned O&G wells • Research is underway to map high technical potential for geothermal across Western Alberta

Energy Storage & Grid Infrastructure

In Alberta, the planned phase out of coal-fired generation is set to usher in a new era of renewable energy supply in the province that will encourage the uptake of a smarter grid, energy storage solutions, and demand-side management measures such as smart meters and time-of-day and/or peak pricing charges. Energy storage at generation will also be essential to preventing renewable energy curtailment.

Transmission is designated as a monopoly service in Alberta, with the Alberta Electricity Systems Operator (AESO) being responsible for long-term planning. The AESO directly assigns transmission development and operation to transmission facility owners based on their service territory, with the exception of specific projects for which a competitive process is used. In the Calgary region, AltaLink, ATCO, and ENMAX are the three primary companies involved with the bulk of transmission and distribution activities.

Small-scale renewable power and alternative energy generation and uptake into the grid has been encouraged through Alberta's Micro-Generation Regulation, which allows Albertans to generate their own environmentally-friendly electricity and receive credit from any excess electricity they send into the electricity grid for projects with a total capacity of 1 megawatt or less.

Modernizing Alberta's electricity network through grid balancing technologies, energy management applications, and related smart grid support services is essential for increasing renewable energy integration in-line with Alberta's new target to increase renewable power to 30% of the electricity mix by 2030.

AltaLink, ATCO, and ENMAX have installed many devices that are considered to be "smart" transmission technologies, focused on building energy management, residential energy management, data center readiness, system security, and renewable energy optimization. While advanced metering technology (i.e., smart meters) for residential and small commercial users have yet to be rolled-out in most of Southern Alberta, the information and electronic communications infrastructure that does exist has the potential to be further enhanced to accommodate them in the future.

A number of smaller, Calgary-based companies are also involved in the smart grid, power management, and conversion space already. In the energy storage segment, activities exist in the areas of solid-state (lithium-ion), lead-acid, and flow batteries; compressed air energy storage (CAES); pumped hydro; and fuel cells.

In Alberta, the AESO is exploring how best to enable a single energy storage unit to provide a combination of time-shifting, price arbitrage, and ancillary services so long as technical requirements are met. This is an example of "stacking" energy storage services, which is a key advantage in the Albertan market.

Research related to energy storage is also underway at post-secondary institutions in Southern Alberta. As one example, the Calgary Advanced Energy Storage and Conversion Research (CAESR) Group is made up of a group of 15 researchers from the Faculty of Science and the Schulich School of Engineering who have come together to help develop technologies and solutions for clean and efficient energy storage and conversion of electricity, such as batteries, electrolyzers, and fuel cells.

Green Building & Energy Efficiency

The Green Building and Energy Efficiency sub-sector in Alberta has evolved over the last two decades with economic drivers increasingly advancing the market transformation.

Calgary (and Alberta more generally) has been the leader in Canada in recent years with respect to green building projects and related certification. In the commercial and institutional sector, buildings that achieve top ratings with both LEED and BOMA BESt certification programs are high-performers with low energy consumption, best-in-class management, and often combining new technologies with industry leadership.

In addition to having certified more than 190 LEED buildings in Calgary over the last decade, market penetration rates (as a percent of gross new construction floor space) have been growing over the last decade, with new commercial and institutional building construction reaching approximately 32% market in 2015. Alberta, in fact, now has the highest area of certified LEED floor space per capita in Canada.

As a result of the rapid growth in LEED buildings in the province, the Alberta Chapter of the CaGBC now has more than 300 members (including architects, engineers, designers, builders, trades, and suppliers), making it the third largest chapter in Canada after Ontario and Quebec.

International competition is requiring a heightened collaboration between designers and builders throughout the project design and delivery phases. The integration of emerging technologies, such as Building Information Modelling (BIM), automation, and off-site construction or pre-fabrication, as well as new procedures, have had a positive impact on productivity and efficiency by streamlining processes, reducing waste during construction, and resulting in significant cost savings. The expansion of BIM into more visualization software is resulting in the merging of more traditional industrial building design with the gaming industry for example, with Calgary-based companies that have become leaders in this space.

In the construction segment, there is increasingly a shift in procurement that is enabling innovation for green building – moving away from the traditional 'design-bid-build' model toward more 'integrated project delivery' processes. Alberta in general and Calgary more specifically has become a leader in Canada with respect to pre-fabrication and modular construction. Companies in this space are pushing the envelope with respect to standard construction practices and overall quality.

Alberta has also been at the forefront of the net zero energy push in Canada. Building design and construction best practices are approaching the point where achieving net zero energy for new homes is technically viable, although the upfront extra costs for the required features and technologies remain the greatest barrier to widespread market adoption and, as such, it remains relatively niche at present.

In addition, the focus on green building has driven the demand for more sustainable building products and materials, with local and environmentally-friendly products embedded into the various green building certification programs. A range of green building technology, equipment, and material suppliers are found in the Calgary region, including some limited local manufacturing in areas that include windows, structural walls and related components, and insulation products as examples.

Innovation is also changing the landscape and making buildings more efficient through the adoption of 'smart' technology. In particular, the adoption of sophisticated energy management, control, and automation systems in buildings has proven to reduce energy consumption and GHG emissions. The ability of these systems to process and analyze huge volumes of energy-related 'big data' has shifted the way buildings are designed, built, and operated. Calgary also has a software development community with 'apps' being designed to support green buildings and energy efficiency.

Green Transportation

Approximately 90% of the Calgary region's employment in the Green Transportation sub-sector comes from the rail and public transit segments. Canadian National (CN) Railway is Canada's largest freight railroad, providing transportation and intermodal services throughout North America. Canadian Pacific (CP) Railway provides additional freight rail services in Alberta. These two major rail companies are supported by a range of smaller service companies and suppliers.

On the public transit side, Calgary Transit currently enjoys the highest light rail transit (LRT) ridership in North America, with its LRT system being powered by wind energy. Additional investment is underway to further enhance public transit infrastructure, guided by the City of Calgary's 'Investing in Mobility' 10-year plan and supported by provincial programs such as GreenTRIP.

The City of Calgary is currently focused on improving the overall fuel efficiency of its 4,000 vehicle fleet (including nearly 1,000 public buses), implementing new practices and technologies that reduce fuel consumption, including consideration for electric vehicles, hybrids, and natural gas solutions where it makes sense. In 2015, it is estimated that there were more than 500 electric vehicles (EVs) on the road, powered by approximately 20 public charging stations in the Calgary region.

There have also been research efforts focused on green transportation related technology advancement in the Calgary region. Since 2012, NSERC, for example, has funded approximately $900,000 toward EV research in Alberta, with $256,000 (or 28%) flowing to post-secondary institutions in Southern Alberta—predominantly at the University of Calgary.

Calgary's Green Energy Sector Value Chain

The de-regulated energy market, the lack of time-of-use or peak energy pricing, and the lack of a strong demand-side pull for green energy sector products and services in Alberta at present, combined with a dearth of related incentive and funding programs in recent years, has resulted in a value chain that is less well established than in some other jurisdictions.

That being said, with the exception of an extensive manufacturing supply chain, most of the key players involved in supplying green energy sector related products and services exist in the Calgary region in some capacity, although many of them diversify activities on projects outside of the green energy space in order to remain active and/or may work on projects outside of Alberta, focused on geographic regions where the demand for their products or services is higher.

As industry and consumer demand grows and Alberta begins to roll out new policies and programs, there is good potential for existing professionals and suppliers to ramp up activities as well as integrate workers from other sectors to refocus on the green energy economy. This could include collaborative efforts for start-ups and SMEs to work with larger domestic firms and/or global companies with a presence in Alberta.

Green Energy Sector Growth Opportunities

Alberta is expecting up to 5,000 MW of renewable power to be solicited through RFP over the next 15 years, which will require significant investments in new projects. The first 400MW procurement cycle was announced in early November 2016. A large percentage (likely upwards of 90%) of the investment is expected to be focused on wind energy. Diversifying beyond wind projects to include solar PV, geothermal, and hydropower, along with energy storage, will help to balance demand and optimize loads. Calgary has the professional workforce to supply these major renewable energy projects and is well positioned to attract additional businesses active in these areas, which may come in part as a result of Ontario's decision to suspend the procurement of new large-scale renewable energy projects.

In terms of energy efficiency and green building, Alberta's plans to invest approximately $645 million over the next 5 years through Energy Efficiency Alberta puts an immediate emphasis on the opportunities for companies active in this space. Alberta's strengths in off-site, pre-fabrication and modular construction can be further expanded, both for domestic consumption and as an export opportunity.

The Internet and 'big data' focused companies is a fast growing segment and an opportunity area for Alberta's growing energy and ICT sectors. This includes network applications and systems-based support equipment and services, as well wireless technologies, software, controls, and sensors.

A summary of the opportunity areas is provided in the table below.

Sub-sector	High-growth Opportunity Areas
Renewable Power Supply & Alternative Energy	1. Renewable energy project design & planning 2. Digitization & automation technologies 3. Niche manufacturing across the renewable energy value chain 4. Bioenergy / biofuels / biogas capture & utilization
Energy Storage & Grid Infrastructure	1. Energy storage technologies 2. Micro-grid systems & urban energy storage solutions 3. Smart grid technologies 4. Cloud-connected & analytics services
Green Building & Energy Efficiency	1. Net zero energy communities 2. Smart / connected building technologies 3. Cloud-connected & analytics services 4. Building design & project delivery software solutions 5. Energy efficiency retrofits & related professional services 6. Energy efficient prefabrication & modular construction 7. Green building materials
Green Transportation	1. Vehicle electrification 2. EV charging infrastructure 3. Goods movement & logistics 4. Smart transportation technologies

In Conclusion

Calgary has an opportunity to demonstrate leadership by proactively developing a strategy that supports all stakeholders in the transition to a more diversified energy economy and, in doing so, can set up well to realize the economic, social, and environmental benefits that come along with the long-term transition. Calgary will need to establish a unique strategic position that will enable it to differentiate from other global cities that are also looking to grow their green energy economies, and will need to market and promote itself accordingly. There is also a need to work with important local stakeholders to build buy-in and demonstrate the economic potential that exists around the green energy economy transition.

Leveraging partnerships and expanding existing programs where possible to include a green energy economy focus—such as with the YYC Innovation Lab, GE's Innovation Centre, and the Energy Venture Competition—could increase the overall impact. Working with Alberta Innovates and ERA, for example, to encourage further investments in project areas such as energy storage, renewable power integration, micro-grids, high-performance buildings, and transportation logistics, could benefit local entrepreneurs and the innovation value chain. There are also a number of 'best practice' programs and initiatives that have been developed by green energy sector municipal leaders from around the world that could be replicated and modified for the local context.

Embracing a holistic and systems-based approach will help to maximize the opportunities and benefits, which will require looking beyond the renewable energy sub-sector to explore synergies that may come from complementary energy technologies and skills sets in the more conventional energy sector, as well as the green building, energy efficiency, and transportation sub-sectors.

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1. Introduction

The Green Energy Economy: A Growing Global Imperative

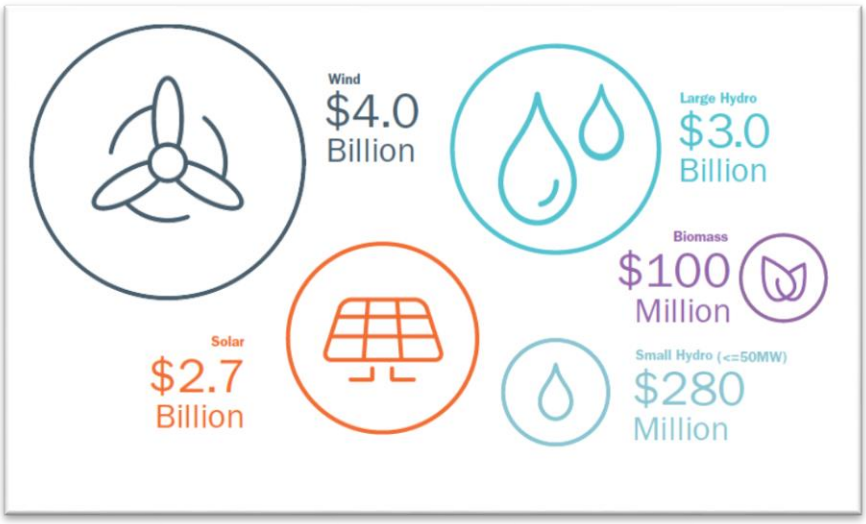
A rapidly growing global population, the trend toward urbanization, a new emphasis on international climate change policy, and the evolving business case for sustainable energy solutions and clean technology[3] is spurring a movement toward a green energy economy around the world. This movement includes an increasing focus on renewable energy and distributed generation that is revolutionizing the way energy is produced, managed, and consumed, as well as efforts to improve energy efficiency (particularly within the built environment and transportation sectors) and minimize the environmental impacts of conventional energy extraction and utilization.

New business models are emerging and advancements in and scale up of technologies are driving down costs and improving performance in areas such as solar photovoltaic (PV) panels and energy storage solutions. Renewables are now considered to be cost competitive with fossil fuels in many markets and are established around the world as mainstream sources of energy.[4] According to a 2015 report by Deutsche Bank[5], electricity produced from solar PV is currently at 30-40% below the retail price of electricity in many markets globally, and it is expected to continue to drop, potentially on par with the price of coal by end of 2016. Battery costs have also been dropping at similar rates to the solar industry, down 65% in the past five years. Small-scale battery storage is now considered to be a $250 billion global market.

In fact, some 500,000 solar panels were installed every day in 2015 alone as a record-shattering surge saw renewables overtake coal as the world's largest source of installed power capacity.[6] In countries including China, two wind turbines went up every hour last year. As a result, the International Energy Agency (IEA) has sharply upgraded its forecast for how quickly renewable energy sources will continue to grow over the next decade and beyond. The IEA now sees global renewable electricity capacity jumping by 42% by 2021, up 13% from its 2015 forecast.[7]

In Canada, 2015 was the second biggest year in history after 2014 for new renewable energy development, with just over $10 billion invested (see Figure 1).[8]

Cities, communities, and companies (including companies such as GM, Coca Cola, Walmart, Apple, and Google) are also adopting "100% renewable" goals and playing a vital role in advancing the global green energy economy transition.[9]



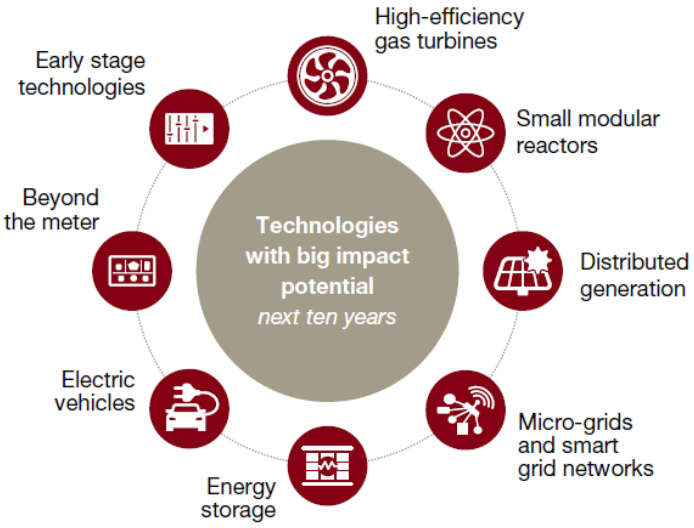
Source: Clean Energy Canada, 2016

Figure 1: 2015 spending on renewable energy in Canada by technology type.

Looking forward, wind and solar costs are expected to continue to fall sharply. The levelised costs of generation per MWh for onshore wind will fall 41% by 2040, and solar photovoltaics by 60%, making these two technologies the cheapest ways of producing electricity in many countries during the 2020s and in most of the world in the 2030s.[10]

[3] By definition, cleantech is a term used to describe products or services that improve operational performance, productivity, or efficiency while reducing costs, inputs, energy consumption, waste, or environmental pollution.
[4] See: http://www.ren21.net/status-of-renewables/global-status-report/
[5] See: https://www.db.com/cr/en/concrete-deutsche-bank-report-solar-grid-parity-in-a-low-oil-price-era.htm
[6] Financial Times article (Oct. 25, 2016) "Renewables overtake coal as world's largest source of power capacity". https://www.ft.com/content/09a1f984-9a1d-11e6-8f9b-70e3cabccfae
[7] International Energy Agency Medium-term Renewable Energy Market Report 2016. See: https://www.iea.org/Textbase/npsum/MTrenew2016sum.pdf
[8] Clean Energy Canada report "Tracking the Energy Revolution in Canada 2016". http://cleanenergycanada.org/wp-content/uploads/2016/06/Tracking-Canada-June-2016.pdf
[9] See: www.there100.org
[10] See: https://www.bloomberg.com/company/new-energy-outlook/

This rapid growth trajectory is not confined to the renewable energy sector but is also impacting on transportation and buildings. While plug-in cars make up only one-tenth of 1% of the global car market today, a major shift is under way that is expected to lead to widespread adoption of electric vehicles (EVs) in the next decade. Bloomberg New Energy Finance estimates that 35%-50% of new cars worldwide will have a plug by 2040. The smart cities market with a growing push toward net-zero energy buildings and communities is projected to more than double between 2015 and 2020, from USD 312 billion in 2015 to USD 758 billion by 2020, equal to a Compound Annual Growth Rate (CAGR) of 19.4%.[11]



Source: PwC Capturing Value from Disruption Report, 2016

Figure 2: Technologies with big impact potential – next ten years.

The rapid growth of green energy technology and the focus on reducing GHG emissions is moving hand-in-hand with a trend toward the digitalization of the energy, building, and transportation sectors.[12] Managing the intermittency of renewable energy generation from wind and solar, for example, requires more sophisticated or 'smart' electricity grids that include demand-response backed by energy storage solutions and ICT-infused networks. The growing demand for EVs is requiring the systems and infrastructure to support their charging. Connected buildings are increasingly being operated through high-tech, data-driven management systems allowing them to 'communicate' and respond to their occupants.

New technologies and a range of advanced applications are increasingly helping to optimize processes and operations in urban settings (i.e., the emerging 'smart' city concept), as well as impacting on more traditional industries including oil and gas, mining, transportation, and manufacturing—improving productivity, reducing costs, diversifying revenue streams, and increasing profitability as benefits.

One of the key characteristics of complex systems, such as the world's energy and transport sectors, is that when they change, it tends not to be a linear process. Disruptive technologies (as shown in Figure 2) are expected to have a large impact on the energy sector over the next decade. With this rapid change comes new business, job creation, and investment opportunities for leaders involved in the design, operation, and maintenance of these advanced 'cyber-physical' systems, as well as risks for those who do not adapt quickly enough to the transition that is underway.

The Role of Policy as a Driver

Despite the rapidly dropping prices for green energy technologies and systems, these solutions are still challenged economically in terms of competing directly with coal, natural gas, and oil in Alberta given the relative abundance and low pricing at present of more conventional energy sources in the province. As such, policy, incentives, and the regulatory environment are key to driving the green energy sector in Alberta at the present time.

At the international level, 194 countries coalesced around the Paris Agreement at the UN Climate Conference (COP21) in December 2015, coming to a consensus that carbon must be contained. Carbon pricing, which was already accelerating, will likely become even more prevalent as a result, including a federal plan to mandate carbon pricing in Canada starting in 2018. In turn, this will increase the costs of fossil fuels and make renewables more competitive.

[11] See: http://www.marketsandmarkets.com/Market-Reports/smart-cities-market-542.html
[12] Bloomberg New Energy Finance article (Aug. 22, 2016) "Electric Vehicles – it's not just about the car". https://about.bnef.com/blog/liebreich-mccrone-electric-vehicles-not-just-car

In March 2016, Canada's Prime Minister and Premiers signed the Vancouver Declaration, putting a new emphasis on climate change policy, including the establishment of Federal-Provincial-Territorial Working Groups on (1) Mitigation, (2) Adaptation, (3) Carbon Pricing, and (4) Clean Technology, Innovation, and Jobs. The 2016 Federal budget proposes providing more than $1 billion over four years to support clean technology development and deployment in Canada.[13] In addition, approximately $2.65 billion will be invested in international commitments to help developing countries with the transition to lower-carbon economies—an opportunity for Alberta-based firms to export their green energy sector solutions in-line with these efforts.

In November 2015, the Government of Alberta (GoA) released its Climate Leadership Plan (CLP), based on four pillars:

- Economy-wide carbon pricing;
- Phasing out coal and increasing renewable power generation;
- Capping oil sands emissions; and,
- Reducing methane from oil and gas operations.

On April 14, 2016, the GoA announced investments in clean technology as part of its 2016-17 budget, including $3.4 billion for large-scale renewable energy projects, transformative innovation and technology development, bioenergy initiatives, and CLP implementation.

On May 24, 2016, the GoA introduced the *Climate Leadership Implementation Act* in the Alberta legislature, detailing the applicability, rates, and rebates for a new carbon levy that will take effect on fossil fuels purchased and used in the province starting January 1, 2017. The carbon levy is designed to cover 90% of GHG emissions with a commitment to reinvest all revenues into Alberta's economy, including $645 million earmarked for energy efficiency over the next five years.

The CLP also outlines the phase out of coal-fired power by 2030, replacing at least 50-75% of retired coal generation with renewable power and increasing the overall share of renewables to 30%[14] The GoA has mandated the Alberta Electric System Operator (AESO) provide recommendations on the Renewable Electricity Program, the anticipated competitive process to procure large scale renewable electricity generation. The GoA has also directed the AESO to develop and implement a renewable electricity incentive program for adding the required additional renewable generation capacity into Alberta's electricity system.[15]

To help achieve the GoA's 30% target by 2030, the provincial government is planning to support 5,000 MW of additional renewable energy capacity[16], estimated to roll out through a series of 200-400 MW calls for power every couple of years. The first 400MW call for bids was announced at the start of November 2016.

In addition, the Provincial Government has set a goal to acquire 55% of its annual demand for power (equal to approximately 250,000 MWh / year) from solar PV beginning in 2018, equal to an additional 100MW of procurement to meet the annual demand.[17] The Province also recently announced $2.5 million in green energy programs for Alberta's indigenous communities.[18]

At the municipal level, Calgary was an early leader in publicly committing to energy efficiency and climate action, with the Sustainable Building Policy in 2004, the Climate Change Accord in 2009, the Calgary Community GHG Reduction Plan in 2011, and a renewed commitment in June 2015 alongside Canada's big city mayors through a united call for climate action, leading up to COP21 in Paris. The City of Calgary has committed to developing policies, plans, and operations that reduce GHG emissions by 20% by 2020 and 80% by 2050, based on 2005 levels.

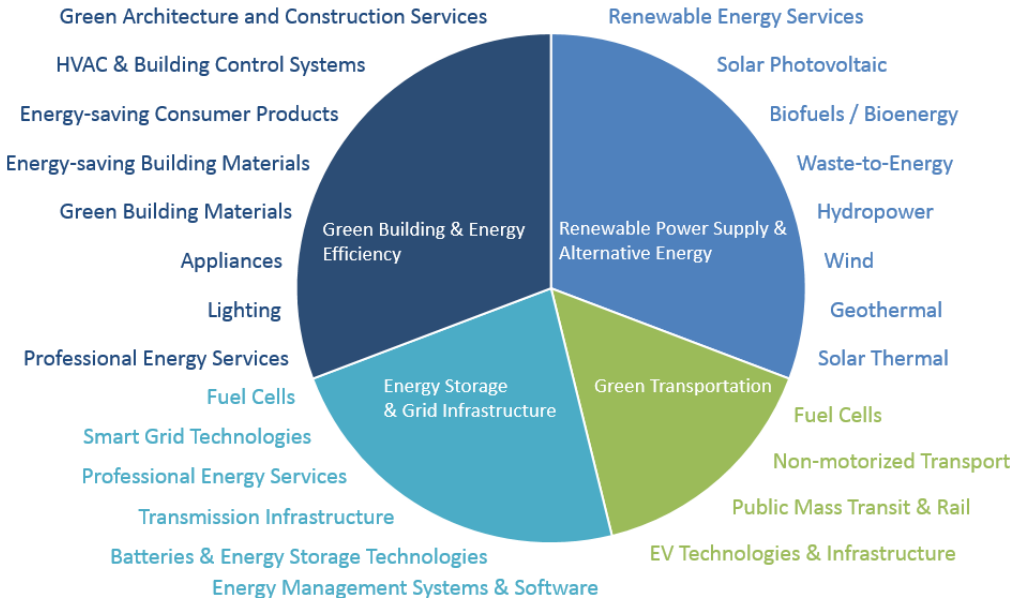
[13] See: http://www.budget.gc.ca/2016/docs/plan/ch4-en.html
[14] See: http://www.alberta.ca/documents /climate/climate-leadership-report-to-minister.pdf
[15] See: http://www.aeso.ca/downloads/Renewable_energy_to_play_key_role_in_Albertas_electricity_future.pdf
[16] See: http://www.alberta.ca/release.cfm?xID=434069BDC1E17-D70A-8BEE-63FDAE67F6CC37EA
[17] See: http://edmontonjournal.com/news/politics/here-comes-the-sun-alberta-plans-to-establish-first-solar-farms
[18] See: http://edmontonjournal.com/news/politics/province-announces-2-5-million-in-green-energy-programs-for-alberta-indigenous-communities

Profiling Calgary's Green Energy Economy

Cities are, in fact, strong engines for economic growth and have a major role to play in creating vibrant ecosystems that foster green energy sector investment, innovation, and entrepreneurship. The global transition to a green energy economy outlined above, combined with national, provincial, and municipal policies, aligns well with the innovation and diversification strategy being explored by the City of Calgary that builds on existing energy sector expertise, as well as with Calgary Economic Development's renewed Economic Strategy that has sustainable development as one of three elements of its vision statement.

Mayor Naheed Nenshi has commented that Calgary can work towards being a hub of excellence for clean and renewable energy technology: "There is no reason that Calgary should not be the centre of clean tech [since] we remain one of the best-educated places on Earth; so if we cannot figure this out, nobody can figure it out".[19]

The sections that follow in this report provide detailed information on Calgary's green energy economy and its four related sub-sectors, as outlined in Figure 3. The sections that follow highlight some of the key players, projects, and activities; identify Calgary's potential opportunities for growth and further investment based on existing value chain strengths and gaps; and provide options for consideration moving forward with respect to how Calgary may position strategically in order to maximize the opportunities and minimize the risks.



Author's Note on Definition:

The scope as defined for this study focused on renewable energy and related technologies. While Delphi Group recognizes there are non-renewable energy related technologies that could be considered part of the green energy economy given their positive impact on reducing energy demand and/or GHG emissions (e.g., carbon capture and utilization, co-generation, etc.), these technologies were not included in this study.

Source: The Delphi Group

Figure 3: Calgary's four green energy economy sub-sectors and related segments profiled in this report.

[19] http://www.bnn.ca/News/2016/6/16/Calgary-Mayor-Nenshi-envisions-city-as-clean-tech-hub-when-we-grow-up.aspx

2. Calgary's Green Energy Economy

By definition, Calgary's green energy economy includes the following four sub-sectors:

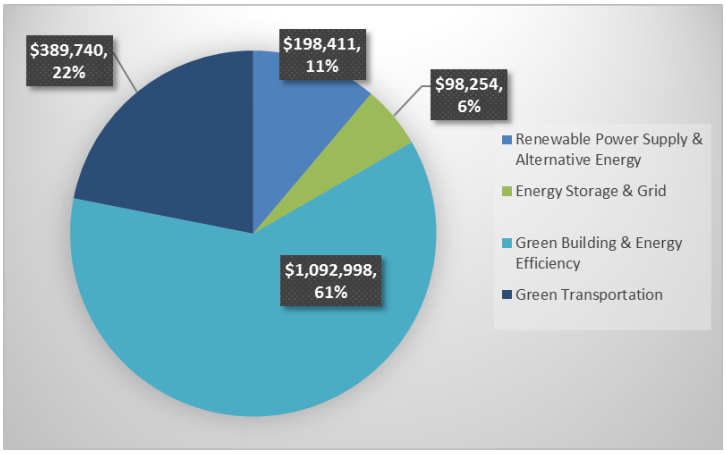
- Renewable power generation & alternative energy;
- Energy storage & grid infrastructure;
- Green building & energy efficiency; and
- Green transportation.

These four sub-sectors are connected through technology, services and inter-related systems and, when applied holistically, can support a resilient, green energy economy that has the potential to power and operate all aspects of society, from day-to-day living to business activities and industrial operations.

The province of Alberta, and Calgary more specifically, have considerable strengths in the green energy economy. In fact, Alberta was an early leader in Canada with respect to utility-scale renewable energy project development and deployment, having installed the country's first wind farm in 1993 at Cowley Ridge in Southern Alberta.

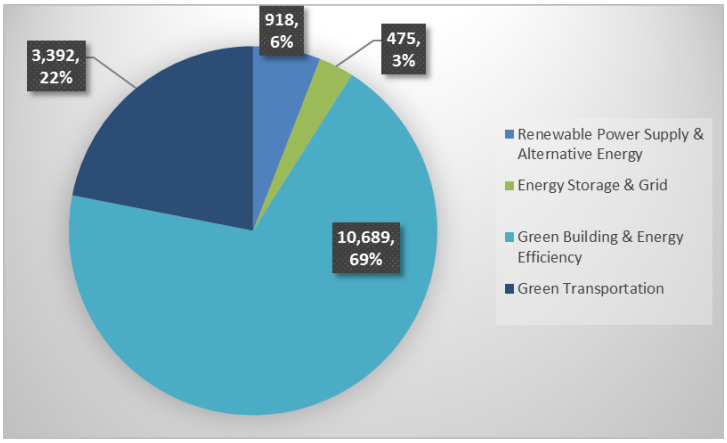
Today, Calgary-based companies are developing a range of leading renewable energy projects, including in the areas of wind, solar photovoltaic (PV), and bioenergy—in their home province, across Canada, and internationally. In the green building space, Alberta currently has the highest LEED certified floor space per capita in Canada, with more than 190 LEED certified projects in Calgary alone. On the green transportation side, Calgary also currently enjoys the highest light rail transit (LRT) ridership in North America, a system which is powered entirely by wind energy.

As show in Figures 4 and 5, in 2015, Calgary's green energy economy was responsible for generating **$3.63 billion** in gross output [20], **$1.78 billion** in gross domestic product (GDP), and employed approximately **15,470 jobs**, equal to 1.8% of all workers in the Calgary Economic Region.[21]



Source: The Delphi Group

Figure 4: Direct GDP generated from the Calgary's region's green energy economy in 2015 ($ thousands).



Source: The Delphi Group

Figure 5: Direct jobs in the Calgary's region's green energy economy in 2015.

Value Chain Strengths

Calgary is an established 'talent hub' of high-value added, service-oriented workers that are experienced in the energy industry. A great deal of baseline expertise exists in Alberta in terms of energy system design, resource maximization, and driving toward cost efficiencies.

There are also significant transferrable skills and occupations that could be refocused on project development for energy systems in the green energy economy.

[20] Gross output measures total economic activity in the production of new goods and services in an accounting period. It is more representative of 'revenues' and is a much broader measure of the economy than GDP, which is limited mainly to final output (finished goods and services).
[21] Note: Estimates are based on a geographic scope equivalent to Calgary's Economic Region (Census Division #6). Total employment for Calgary's Economic Region was estimated to be 850,000 in 2015 (average). Appendix A provides more details on the methodology that was applied for estimating employment and GDP.

Transferrable occupations that exist in high capacity in Alberta include: engineers (mechanical, electrical, civil, chemical, structural, systems, and environmental), geologists and geotechnical specialists, biologists, computer and ICT specialists, construction specialists, land management specialists, lawyers, and contract administrators.

With respect to renewable energy project development, a vast amount of project design and engineering expertise exists in Alberta. In the energy storage sub-sector, a number of demonstration and pilot projects have provided local experience in areas such as lithium-ion and flow batteries.

In the green building and energy efficiency sub-sector, the more northerly climate and rapid growth of Calgary's commercial office sector over the last decade has resulted in a considerable number of professionals active in the architecture, design, and engineering of high-performance buildings, as well as residential and non-residential building construction and repair. Alberta has become a leader in Canada with respect to net-zero energy home construction.

In terms of manufacturing, while it is fair to say that no true 'clusters' and no large scale manufacturing currently exist in Alberta related to the green energy sector value chain, a number of niche manufacturers of specialty components do exist (such as for inverters, power electronics, anti-islanding technologies, energy storage solutions, and a range of niche green building materials and equipment).

Pre-fabrication and modular construction is also a relative strength for Alberta—perhaps having evolved from the demand for work camps in remote locations across the province. Modular construction expertise in the Calgary region is growing and changing the dynamics of the industry, bringing down costs and improving both the quality and energy performance of new homes. Mandatory warranty requirements for quality have also raised the bar in this space.

Major global firms including GE, Siemens, Schneider Electric, Cisco, Johnson Controls, and ABB are present in Alberta and have the potential to do more in this space as market demand grows.

Research, Innovation & Investment

The Calgary region has a wealth of research and development capacity, although the overall levels of investment in the green energy sector to date in Alberta as a whole have been small. Federal and provincial support for research exists through organizations including the National Research Council of Canada (NRC), the Natural Sciences and Engineering Research Council of Canada (NSERC), and Alberta Innovates. These agencies work to support a variety of start-up companies, as well as innovative research initiatives and projects with a green energy economy focus in collaboration with the private sector and various post-secondary institutions in Southern Alberta.

In terms of investment into green energy economy related research in Alberta, the academic community is funded in large part through NSERC. From 2012-2016, 6.1% of all NSERC grants in Alberta have gone to green energy economy sub-sectors, equal to approximately $25.0 million. Of the NSERC grant funding in Alberta allocated to green energy economy sub-sectors since 2012, approximately 60% or $14.9 million has targeted post-secondary institutions in Southern Alberta.

Specialized pockets of research expertise have developed in areas that include solar PV, bioenergy, geothermal energy, energy storage and fuel cells, electric vehicles and advanced transportation systems, and green building technology applications (as outlined in Table 1). At present, Alberta has three Industrial Research Chairs focused on renewable energy technology areas, predominantly wind and solar (two at the University of Calgary and one at the University of Alberta).

However, there is a need to build capacity from the bottom up in order to fill out the value chain. Strong policy direction, public sector support, and a growing market demand for green energy solutions and technologies could mobilize a material part of the Calgary region's scientific research and engineering community in this direction. The loss of employment in the oil and gas sector is freeing up some of the highly skilled professionals whose expertise could be harnessed in this space.

Table 1: Green Energy Economy Related Research & Innovation Initiatives underway at Calgary Post-secondary Institutions

Initiative / Institution	Sub-sector(s)	Description
Centre for Advanced Solar Materials (CASM) [22] ➔ University of Calgary	Renewable Energy & Energy Storage	CASM is dedicated to solving issues that are central to solar energy conversion and storage. Building on existing expertise in chemistry and materials science, CASM is designing novel ways of converting sunlight to electricity and high-density fuels such as hydrogen. Solutions under development take an interdisciplinary approach that includes materials design and synthesis, nanotechnology, spectroscopy, and electrochemistry. The combined, comprehensive focus on conversion and storage sets CASM apart from other Canadian sustainable energy research centres.
Solar Lab[23] ➔ Southern Alberta Institute of Technology (SAIT)	Renewable Energy & Energy Storage	The Solar Lab is used for training, research, and demonstration purposes in areas related to solar technology. The Lab features over seven building-integrated, rack-mounted, and actuating solar-thermal systems, photovoltaic (PV) systems, seasonal heat storage, integrated mechanics, and grid and battery storage. Complementing the lab is a solar timber carport.
Green Building Technologies (GBT) Research Division ➔ Southern Alberta Institute of Technology (SAIT)	Renewable Energy, Green Building & Energy Efficiency	The GBT research division got its start within SAIT's Applied Research and Innovation Services (ARIS) department in 2008. ARIS has brought SAIT and GBT researchers together with industry partners to identify and develop environmentally-friendly technologies, processes, programs, systems, and services that will fundamentally change the way buildings are constructed, education is delivered, and skills are developed. In 2012, SAIT received an $800,000 federal grant to support the research lab and an additional $1.75 million in 2014 to support green building technology development.
Fuel Cell Research Team[24] ➔ University of Calgary	Energy Storage	The University of Calgary's Fuel Cell Research Team has been working on projects with the oil and gas industry, including a Molten Carbonate Fuel Cell project that captures carbon-dioxide from natural gas-fired processing units while also generating electricity.
Calgary Advanced Energy Storage and Conversion Research (CAESR) Group [25] ➔ University of Calgary	Energy Storage	A group of 15 researchers from the Faculty of Science and the Schulich School of Engineering who have come together to help develop technologies and solutions for clean and efficient energy storage and conversion of electricity, such as batteries, electrolyzers, and fuel cells.
Electric Transit Bus Research Project[26] ➔ University of Calgary	Energy Storage & Green Transportation	In September 2016, the world's largest producer of battery-electric buses, China-based BYD, announced a new partnership with Alberta to develop transit buses. BYD's proprietary iron-phosphate (or "Fe") Battery is currently the safest and longest lasting electric bus battery available on the market. Initial program details will be set in the Fall of 2016 between BYD, a number of Alberta technology companies, the Alberta Centre for Advanced MNT Products, the University of Alberta, and the University of Calgary.
Smart Multimodal Transportation System Integration Project ➔ University of Calgary	Green Transportation	Two UofC researchers have received a $650,000 grant over five years from Alberta Innovates to lead a team of 20 engineering graduate students to create an information and communication technology (ICT) platform to support more dynamic transportation systems of the future.[80] The team's "Smart Multimodal Transportation System Integration" project focuses on the impacts to traffic stability, capacity, and safety required for when autonomous (self-driving) and conventional vehicles share the road.

[22] See: http://www.solar.ucalgary.ca/
[23] See: http://www.sait.ca/research-and-innovation/about-aris/our-facilities.php
[24] See: http://www.cosia.ca/molten-carbonate-fuel-cells
[25] See: http://www.ucalgary.ca/energy/major-initiatives/matching-funds-research-projects/electricity-storage-calgary-advanced-energy
[26] See: http://www.masstransitmag.com/press_release/12253370/global-electric-vehicle-leader-byd-and-canadian-province-of-alberta-announce-research-and-innovation-agreement-to-develop-smarter-safer-transportation-technology

In terms of later stage investment into the green energy economy in Alberta, Emissions Reduction Alberta or ERA (formerly Climate Change and Emissions Management Corporation) has contributed approximately $122 million to 18 relevant projects, leveraging nearly $1.5 billion in total project value. This amount is equal to approximately 39% of all the funding that has been invested by ERA over the last decade. Major ERA funded initiatives relevant to the green energy economy include:

- ENMAX's Micro Renewable Energy Program for Solar PV Deployment (ERA contribution: $14.5 M);
- TransAlta's Wind Energy & Storage Project with Tesla Energy (ERA contribution: $11.1 M);
- Enbridge's Alberta Solar One 10 MW Solar PV Power Plant (ERA contribution: $10 M);
- EDF EN's Blackspring Ridge 1 Wind Project (ERA contribution: $10 M);
- Weyerhaeuser's Pulp Mill Plant High-efficiency Evaporator System (ERA contribution: $5 M);
- Grow-TEC 633 kW anaerobic digester (ERA contribution: $3.7 M);
- Medicine Hat Power Plant Solar Thermal Project (ERA contribution: $3 M);
- Landmark Group's Large Scale Building Integrated Solar PV Demonstration in Production Housing (ERA contribution: $2.3 M); and
- Enerkem Greening Biofuel Production & CO_2 Utilization Pilot Plant (ERA contribution: $1.8 M).

Additional details on each of the four sub-sectors is provided in the section that follows, including information on employment and economic impact, as well as relevant companies, projects, and activities.

3. Green Energy Sub-sector Profiles

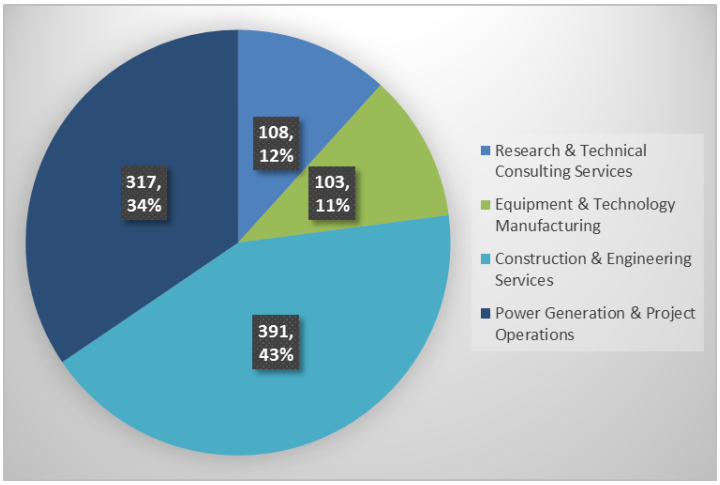
Renewable Power Supply & Alternative Energy

Jobs & GDP

In 2015, Calgary's Renewable Power Supply & Alternative Energy sub-sector was responsible for approximately **918 direct jobs** and **$198 million** in direct GDP across the value chain.[27]

As illustrated in Figure 6, employment was highest in the construction and engineering services segment, equal to 391 jobs or approximately one-third (43%) of employment. The next largest segments included power generation and project operations (317 jobs); research and technical consulting services (108 jobs); and equipment and technology manufacturing (103 jobs), respectively.

In terms of direct GDP from the sub-sector in 2015, approximately one-third (63%) was generated from the power generation and project operations segment, equal to $125 million (see Figure 7).



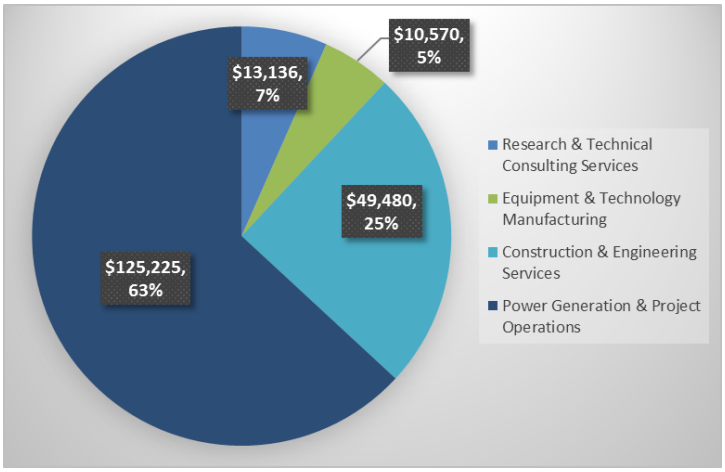
Source: The Delphi Group

Figure 6: Direct jobs in Calgary's Renewable Power & Alternative Energy sub-sector in 2015.

Projects & Activities

By the end of 2015, Alberta had more than 2,800 MW of installed renewable power capacity (including hydro, wind, biomass, and solar), making up approximately 17% of total installed capacity.

In recent years, growth of new utility-scale renewable energy projects has slowed because of decreasing prices for power on Alberta's competitive market. In total, the installed capacity of renewables in 2015 was up 401 MW over 2013. As illustrated in Table 2 below, the largest growth area since 2013 has been in wind power, up 378 MW in 2015 from 1,113 MW in 2013. Hydropower and biogas / biomass installed capacity has stayed more or less constant.



Source: The Delphi Group

Figure 7: Direct GDP from Calgary's Renewable Power & Alternative Energy sub-sector in 2015 ($ thousands).

In terms of actual generation, renewable energy sources were responsible for 9.4% of electricity supply in 2015. Hydropower and biogas / biomass generation were down in terms of GWh of production between 2013 and 2015. Wind generation increased by 709 GWh in 2015 from 3,107 GWh in 2013, equal to 4.7% of total electricity generation in the province.

[27] Note: Appendix A provides a more detailed breakdown of these job and GDP figures by industry NAICS code.

Table 2: Total installed capacity in Alberta by year and technology type (MW / %).

Year	2013		2014		2015	
Coal	6,258	42.9%	6,258	40.9%	6,267	38.8%
Natural Gas	5,811	39.8%	6,161	40.2%	6,953	43.1%
Hydro	900	6.2%	900	5.9%	902	5.6%
Wind	1,113	7.6%	1,459	9.5%	1,491	9.2%
Biogas & Biomass	417	2.9%	438	2.9%	424	2.6%
*Others	98	0.7%	98	0.6%	97	0.6%
Total	**14,597**		**15,314**		**16,133**	

** Others include oil, diesel, and waste heat*

Source: Alberta Utilities Commission[28]

In terms of new potential projects, as of September 2016, there were 61 utility-scale renewable energy generation projects proposed by industry[29], with a total power capacity of approximately 7,460 MW.[30] Table 3 provides a breakdown of these proposed projects by technology type and total megawatts.

Table 3: Proposed renewable energy projects in Alberta as of September 2016.

Project Type	Number of Proposed Projects	Total Generation Potential (MW)
Biomass	1	42 MW
Hydropower	1	N/A
Solar	18	560 MW
Wind	41	6,862 MW
Total	**61**	**7,464 MW**

Source: Alberta Electric Systems Operator

Bioenergy

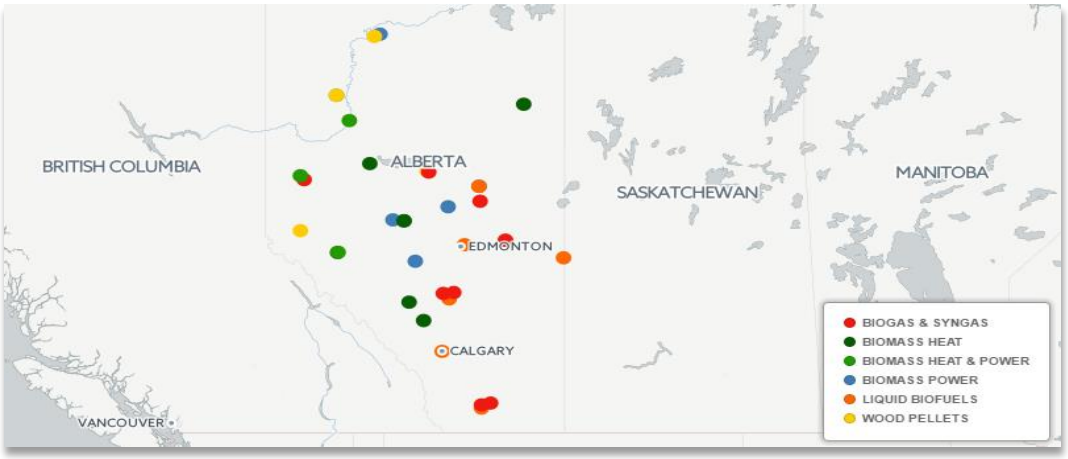
Alberta is looking to convert the province's biomass resources beyond traditional commodities into higher value products such as bioenergy, which can help to increase the economic returns from Alberta's natural resources. According to Alberta Energy, the province has 20 million tonnes of annual waste in potential biomass feedstocks which can be converted to bioenergy.[31]

There are approximately 30 biomass or biofuel plants in Alberta (see Figure 8). An assessment of the province's Bioenergy Producer Credit Program (BPCP) estimates that the bioenergy industry in Alberta is worth approximately $2 billion.[32] Between 2007 and 2014, Alberta's bioenergy projects have provided $788 million to provincial GDP and supported hundreds of jobs, including providing some $300 million in labour income.

The **Lethbridge BioGas** plant is a full scale biogas co-generation project fueled by organics comprised of agricultural manures and food processing wastes. It is able to obtain all of its required amounts of organic fuel within 15 km of the site. This facility is the first to incorporate patented thermal hydrolysis technology approved by the Canadian Food Inspection Agency for the destruction of prions that cause BSE in cattle. Generating electrical and thermal energy through the anaerobic digestion of organics reduces greenhouse gas (GHG) emissions significantly.

For more information, see: http://www.lethbridgebiogas.ca/

[28] See: http://www.auc.ab.ca/market-oversight/Annual-Electricity-Data-Collection/Pages/default.aspx
[29] Proposed projects are ones under active construction; projects with regulatory approval; projects that have been announced; and projects that have been deferred.
[30] See: http://www.aeso.ca/downloads/Final_September_2016_Project_List.xls
[31] See: http://www.energy.alberta.ca/BioEnergy/bioenergy.asp
[32] See: http://www.virescosolutions.com/wp-content/uploads/2015/10/Bioenergy-Producer-Report-Card-FINAL_20150901.pdf



Source: Alberta Bioenergy Producer Report Card (2015). Western Canada Biodiesel Association.

Figure 8: Map of Alberta bioenergy production plants by location.

Alberta is currently undertaking a third-party, comprehensive review of the BPCP in order to develop a long-term policy that will work towards a self-sustaining industry.[33] In the meantime, the Alberta Government has provided an additional $60 million in funding over 1.5 years for the BPCP, which will run retroactively from April 2016 to September 2017. In addition to the BPCP, ERA has levered approximately $46 million of seed money investments into $191 million worth of bioenergy projects in Alberta.

The **300 MW Blackspring Ridge Wind Project**, located in Vulcan County, Alberta (50 km north of Lethbridge), is comprised of 166 Vestas V100-1.8 MW wind turbines. EDF EN Canada managed the construction of the project under a fixed price engineering, procurement, and construction contract with Mortenson Construction. Construction began in May 2013, and was completed in May 2014. As a result of the partnership agreements concluded in 2013, EDF EN Canada and Enbridge became co-owners of Blackspring Ridge. Enbridge now holds 50% interest in the project while EDF EN Canada maintains a 50% ownership position.

With an investment of about $600 million, the project represents the largest investment in wind energy in Western Canada. More than 350 jobs were created during the construction phase with 20 permanent operations and maintenance jobs. Renewable Energy Credits (RECs) generated from the project are contracted to Pacific Gas and Electric under 20-year purchase agreement. The electricity is sold into the Alberta power pool with pricing substantially fixed through mid- and long-term contracts.

For more information, see: http://www.edf-en.ca/projects/project_display/blackspring-ridge-wind-project

Wind

Alberta is currently Canada's third largest producer of wind energy (following Ontario and Quebec), with the third highest amount of installed capacity for wind energy as of December 31, 2015.[34] A total of 38 projects exist in Alberta with a combined installed capacity of 1,500 MW.[35]

Major project developers, owners, and operators include Enbridge, Suncor, TransCanada, TransAlta, and ENMAX. Additional smaller project developers based in Alberta include BluEarth Renewables, Northern Power, and GreenGate. In addition to projects in Alberta, the Canadian Wind Energy Association (CanWEA) estimates that, as of December 31, 2015, Calgary-based companies have developed approximately 32% of Canada's total installed wind capacity of 11,205 MW (see Table 4).

[33] See: http://www.alberta.ca/release.cfm?xID=43684E807969B-BBD6-DC1F-545C0DC2CC7829C4
[34] See: http://canwea.ca/wind-energy-continues-rapid-growth-in-canada-in-2015/
[35] See: http://canwea.ca/wind-energy/alberta/

According to the CanWEA, every 150 MW of new wind capacity developed in Alberta represents:

- $316 million in investment;
- 140 full-time equivalent (FTE) jobs in construction;
- 10 permanent jobs in operations and maintenance;
- $17 million in lease payments to landowners over 20 years; and
- $31 million in property tax payments to municipalities over 20 years.

Table 4: Calgary-based companies with Canadian wind operations

Company	Total Installed Wind Capacity in Canada (MW)
AltaGas	102
BluEarth Renewables	29
Enbridge/Enbridge Income Fund	1,303
ENMAX	219
Suncor	287
TransCanada	365
TransAlta	1,329
Total	**3,634**

Source: CanWEA

In terms of future potential, it is estimated that only 1% of Alberta's total potential wind energy resources are currently being utilized[36] and over one-third of Alberta's land base has wind energy sources suitable for wind energy production.[37] Industry experts consulted for this project suggest that approximately 90% or more of the new utility-scale renewable energy capacity to be installed in Alberta over the next decade will be wind projects. It is estimated that the total number of proposed wind projects in Alberta (as of September 2016) are worth $14.5 billion of investment and 6,400 FTE jobs in construction.

Solar Photovoltaic (PV)

As of September 2016, there were approximately 1,500 solar PV micro-generation sites in Alberta, with a total installed capacity of more than 11.5 MW.[38] Based on estimates by the Canadian Solar Industries Association (CanSIA), 11.5 MW represents approximately $34.5 million in investment and 150 direct full-time equivalent (FTE) construction jobs.[39]

The Solar Energy Society of Alberta lists more than 100 solar providers in Alberta, 22 of which are based in Calgary.[40] Key commercial-scale developers at present include ENMAX, SkyFire, Suncor, and EDF EN. Suppliers include companies such as Calgary-based Invensun (a designer and manufacturer of solar PV panels) as well as a wide range of installers including EECOL Electric, ESL Electric, Greenergy Renewable Energy, Green Light Power, KCP Energy, Kustom Projects, Momentum Solar, SolarPanel.ca, and Sunmade Solar Energy Group.

Source: www.skyfireenergy.com

Calgary-based SkyFire Energy's 2 MW Green Acres Solar Farm in Bassano is the largest solar farm in Western Canada.

[36] See: https://www.pembina.org/reports/greeningthegrid-report.pdf
[37] See: http://www.alberta.ca/climate-leadership-plan.aspx
[38] See: https://solaralberta.ca/
[39] See: http://solaralberta.ca/sites/default/files/canwea_-_cansia_final_submission_sept_30.pdf
[40] See: https://solaralberta.ca/directory/alberta-solar-providers

Several commercial and community scale projects have successfully been developed in Alberta, including the 2 MW Green Acres Solar Farm in Bassano (the largest solar farm in Western Canada)[41], Drake's Landing Solar Community in the Town of Okotoks[42], the Southland Leisure Centre project in Calgary, and the 1.14 MW system located on the Leduc Recreation Centre, Canada's largest rooftop solar system[43].

Despite the economic barrier at present, the interest for developing larger, utility-scale solar projects in Alberta is high. As of September 2016, approximately 560 MW of solar PV generation has been proposed for Alberta through 18 projects.

Hydroelectricity

Currently, hydro capacity is about 5% of total installed capacity down from approximately half of the total capacity in the early 1950s. Most of the recent developments in this segment have been micro-hydro projects or smaller dams whose contribution to the overall provincial power output has been fairly minimal.

While many of the province's best hydro locations have already been developed, the Canadian Hydro Association estimates that Alberta still has more than 11,500 MW of remaining economic hydro potential, including both reservoir and run-of-the-river projects. [44] Approximately 25% of this ultimate potential is contained in the Red Deer River basin and the North and South Saskatchewan River basins in Alberta.

Source: www.atco.com

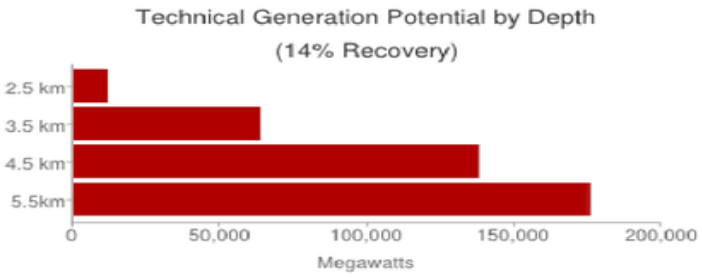
The 32 MW Oldman River Hydroelectric Plant in Southern AB is ATCO Power's first hydro project.

Geothermal Energy (Power & Heating)

Geothermal power plants turn hot water into electricity. Companies drill underground for water or steam similar to the process of drilling for oil. The heat (via water or steam) is brought to the surface and used to spin turbines and is then returned underground.

Due to the high capital expenses, there are no commercial geothermal power plants currently operating in Alberta. However, there is growing interest in geothermal in the province, particularly due to the existing and available related skilled workforce (oil and gas drilling has very transferrable skills to geothermal drilling), the number of orphaned oil and gas wells that may provide a suitable venue for geothermal, and the growing demand for renewable power.[45] [46]

Research is currently underway at the University of Alberta in order to map the potential for geothermal power across the western part of Alberta, in a partnership with Alberta Innovates. [47] The work includes mapping water reservoirs several kilometres underground that could be hot enough to convert into electricity using a turbine mechanism. Existing research suggests that the technical potential for geothermal in Alberta is fairly significant. [48] At 14% recovery, the generation potential is upwards of 60,000 MW at a depth of 3.5 kilometres (see Figure 9).



Source: Alberta Geothermal Favourability Maps, CanGEA

Figure 9: Technical potential for geothermal electricity production in Alberta.

[41] See: http://www.skyfireenergy.com/case-study-business/2-mw-solar-farm-bassano-alberta/
[42] See: http://www.dlsc.ca/
[43] See: https://www.leduc.ca/news/canada%E2%80%99s-largest-rooftop-solar-system-unveiled
[44] See: http://history.alberta.ca/energyheritage/energy/hydro-power/hydroelectricity-in-alberta-today.aspx
[45] See: http://www.cbc.ca/news/business/geothermal-pitched-as-alberta-s-next-big-energy-source-1.3132416
[46] See: http://www.huffingtonpost.ca/carol-linnitt/geothermal-energy-alberta-workers_b_9997332.html
[47] See: http://www.cbc.ca/news/canada/calgary/geothermal-research-alberta-1.3616014
[48] The technical potential is essentially the fraction of the theoretical potential that can be used under the existing structural and ecological restrictions, as well as legal and regulatory allowances.

The industry in Alberta is represented by the Canadian Geothermal Energy Association (CanGEA) and a number of active companies, although most are currently focused outside of the province. Calgary-based Borealis GeoPower is pursuing two geothermal projects in British Columbia because of the existing program available in that province for companies to develop electricity from geothermal technology. Additional companies include Turkana and FlashPoint Resources Management.

In addition to geothermal power, geothermal energy is used to heat or cool homes by drilling to much shallower depths and using heat pumps to circulate warm or cool air or water depending on the season. A number of companies and specialty contractors are focused on the installation of this 'geoexchange' technology in the Calgary region, including Thermal Creek, Calgary Geothermal Inc., and GeoTility. Others are actively manufacturing heat exchangers and related hydronics equipment.[49]

[49] See NRCan backgrounder on heat pumps:
http://www.nrcan.gc.ca/energy/publications/efficiency/residential/heating-heat-pump/6823

Energy Storage & Grid Infrastructure

Jobs & GDP

In 2015, Calgary's Energy Storage & Grid Infrastructure sub-sector was responsible for approximately **475 direct jobs** and **$98 million in direct GDP** across the value chain.[50] As illustrated in Figure 10, employment was highest in the "clean" transmission system construction and engineering segment (which includes only projects related to renewable energy interconnections), equal to 155 jobs or one-third (33%) of all employment. The next largest segments included transmission system operations and maintenance (143 jobs); equipment and technology manufacturing (124 jobs); and research and technical consulting services (53 jobs), respectively.

In terms of direct GDP from the sub-sector in 2015, 60% was generated from the transmission system operations and maintenance segment, equal to $59 million (see Figure 11).

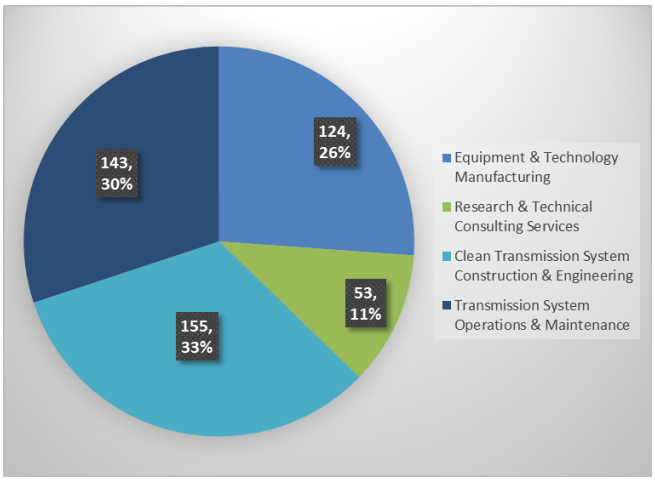
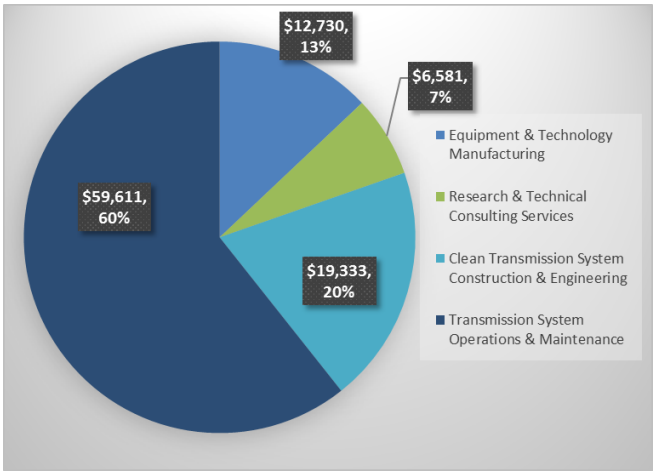


Figure 10: Direct jobs in Calgary's Energy Storage & Grid Infrastructure sub-sector sub-sector in 2015.

Projects & Activities

In Alberta, the planned phase out of coal-fired generation is set to usher in a new era of renewable energy supply in the province that will encourage the uptake of a smarter grid, energy storage solutions, and demand-side management measures such as smart meters and time-of-day and/or peak pricing charges. Energy storage at generation will also be essential to preventing renewable energy curtailment.[51]



Source: The Delphi Group

Figure 11: Direct GDP from Calgary's Energy Storage & Grid Infrastructure sub-sector in 2015 ($ thousands).

Transmission & Distribution

At present, Alberta's electricity grid system includes 26,000 kilometers of transmission lines, connecting approximately 235 generating units and 170 participants to the open market. Transmission is designated as a monopoly service in Alberta, with the Alberta Electricity Systems Operator (AESO) being responsible for long-term planning. The AESO directly assigns transmission development and operation to transmission facility owners based on their service territory, with the exception of specific projects for which a competitive process is used.

In the Calgary region, three primary companies are involved with the bulk of transmission and distribution activities, although in different capacities:

- **AltaLink** is Alberta's largest regulated electricity transmission company, delivering energy to approximately 85% of Albertans, including in the Calgary region.
- **ATCO** is a transmission and distribution company also active in Alberta, with a number of transmission projects in Southern Alberta and the Calgary Region.
- **ENMAX** is a vertically integrated utility that generates and distributes electricity, natural gas, and renewable energy to customers in Calgary and is a wholly-owned subsidiary of the City of Calgary.

[50] Note: Appendix A provides a more detailed breakdown of these job and GDP figures by industry NAICS code.
[51] GE Energy's August 2016 Pan-Canadian Wind Integration study estimated under a 35% integration target for wind power into Alberta's grid would result in 11% curtailment due primarily to transmission congestion, making energy storage solutions essential. See: http://canwea.ca/wp-content/uploads/2016/07/pcwis-section01-summaryreport.pdf

Covering Calgary and surrounding areas, ENMAX Power's transmission system consists of approximately 300 kilometers of transmission wires and 7,600 kilometers of distribution lines in Calgary and surrounding areas, with 37 substations powering residences and businesses.

The AESO's 2015 Long-term Transmission Plan anticipates 17 new transmission projects to 2020 under its Main Long-term Outlook, worth approximately $2.5 billion in investment.[52] Under a lower growth scenario, the AESO estimates 11 projects will be required by 2020 at an investment of $800 million.[53]

Small-scale renewable power and alternative energy generation and uptake into the grid has been encouraged through Alberta's Micro-Generation Regulation, which was adopted in 2008.[54] The regulation allows Albertans, using renewable resources or alternative energy, to generate their own environmentally-friendly electricity and receive credit from any excess electricity they send into the electricity grid.[55]

Source: www.enmax.com

Photo caption: ENMAX is vertically integrated utility and a wholly-owned subsidiary of the City of Calgary.

In Alberta, micro-generation is currently defined as being the generation of electrical energy from a generating unit with a total capacity of 1 megawatt (MW) or less which is connected to the distribution system and exclusively uses sources of renewable or alternative energy (such as solar photovoltaic, small-scale hydro, wind, biomass, geothermal, and fuel cells). The electrical energy output is intended to meet all or a portion of the customer's electricity needs and owners of electrical distribution systems are expected to provide connection services for micro-generators.

Smart Grid Applications & Energy Management Solutions

Modernizing Alberta's electricity network through grid balancing technologies, energy management applications, and related smart grid support services will be essential for increasing renewable energy integration in-line with Alberta's new target to increase renewable power to 30% of the electricity mix by 2030. The implementation of smart distribution technologies for advanced communications, monitoring, and control will also enable more micro-generation and distributed generation resources into the system.

Smart grid and information and communication technologies (ICT) can provide a more resilient power grid, improving energy efficiency, enhancing reliability, cutting costs, and reducing GHG emissions.[56]

AltaLink, ATCO, and ENMAX have installed many devices that are considered to be "smart" transmission technologies such as phasor measurement units (PMUs), dynamic thermal line ratings (DTLR) technology, and Flexible AC Transmission (FACTS) on transmission projects.[57] AltaLink has also upgraded the telecommunications systems in its substations to enhance protection, controls, automation, and monitoring systems.

ENMAX has been working with companies such as Cisco[58], GE, and others to develop its next-generation utility model to support Calgary's energy management and efficiency goals. Project efforts to date have focused on building energy management, residential energy management, data center readiness, system security, and renewable energy optimization.

[52] See: http://www.aeso.ca/downloads/2015_Long-termTransmissionPlan_WEB.pdf
[53] It should be noted that these projects still require regulatory approval. In addition, distributed generation and energy storage projects may reduce the need for and required investment in traditional transmission projects.
[54] See: http://www.qp.alberta.ca/documents/Regs/2008_027.pdf
[55] See: http://www.auc.ab.ca/involving-albertans/micro-generation/Pages/default.aspx
[56] QUEST Canada "Resilient Pipes and Wires" report (2015). See: http://www.questcanada.org/events-projects/research/rpw
[57] Alberta Utilities Commission "Alberta Smart Grid Inquiry" (2011). See: http://www.energy.alberta.ca/electricity/pdfs/smartgrid.pdf
[58] See: https://newsroom.cisco.com/press-release-content?type=webcontent&articleId=5409264

The presence of a large industrial and commercial customer base in Alberta that responds to changes in the Alberta power pool price, as well as the development of the billing and settlement systems to make the competitive generation and retail markets function smoothly, has required the development of an information and electronic communications infrastructure between the distribution companies, the AESO, and competitive retailers. This infrastructure has enabled the deployment of smart meters which have been widely adopted by industrial and large commercial customers who consume the highest percentage of electricity in the province.

While smart meters for residential and small commercial users have yet to be rolled-out in most of Southern Alberta, the information and electronic communications infrastructure that does exist has the potential to be further enhanced to accommodate the introduction of smart meters for these customers.[59] Of note, Edmonton's local utility-company Epcor is in the process of replacing 385,000 meters with smart meters.[60]

A number of Alberta-based companies are involved in the smart grid, power management, and conversion space already. Calgary-based Eguana Technologies is developing and installing inverters that allow the conversion of AC power to DC power and back again, used for a range of renewable energy and storage applications.[61]

Calgary-based Grid Software is developing utility automation software for transmission and distribution customers with services that include substation automation design, configuration of protection and control IEDs, HMI/MMI solutions, product verification, commissioning, and installation.[62] Edmonton-based DX3 Enterprises has developed an 'anti-islanding' protection system, which allows for the interconnection of Distributed Generators (DGs) to the utility power grid.[63]

Source: www.eguanatech.com

Eguana Technologies is a Calgary-based manufacturer and supplier of power control solutions (inverters) for residential and commercial energy storage systems. Its distributed energy storage systems technology enables higher levels of renewable energy supply and better utilization of the existing grid infrastructure.

The company first commercialized its inverter technology 15 years ago in order to connect hydrogen fuel cells to the grid for combined heat and power (CHP) systems. The now publicly traded company (TSX-V: EGT) has since focused on the solar PV and more recently the energy storage markets.

With a Calgary team of approximately 12 employees, the company is currently exporting most of its product to markets in Europe, the United States, and Australia.

Energy Storage Technologies

Energy storage is relevant across the energy value chain including generation, transmission, distribution, and consumption. There are opportunities for Alberta-based companies in all of these areas. For example, wind generation facilities whose electricity output varies considerably day-to-day may benefit from installing energy storage capacity behind-the-fence of the wind facility.[64]

Many different energy storage technologies exist, including:

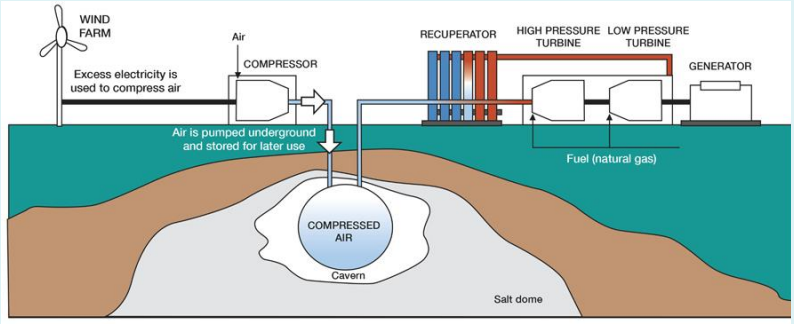
- Flywheels
- Solid state batteries (electrochemical capacitators, lithium-ion, nickel-cadmium, sodium sulfur)
- Lead acid batteries
- Flow batteries

[59] See: https://newsroom.cisco.com/press-release-content?type=webcontent&articleId=5409264
[60] See: http://www.epcor.com/meters/advanced-metering/Pages/technology.aspx
[61] See: http://www.eguanatech.com/
[62] See: http://www.gridsoftware.com/
[63] See: http://www.dx3ltd.com/
[64] Alberta Innovates Technology Futures "Techno-economics of Energy Storage" report (Mar. 2014). See: http://www.albertatechfutures.ca/Portals/0/documents/Energy%20Storage/Energy%20Storage%20Technoecon%20Final%20Report_Revised%20March%202014.pdf

- Compressed air energy storage (CAES)
- Pumped hydro
- Thermal energy
- Fuel production (e.g., hydrogen, methanol, etc.)

Importantly, energy storage technologies are in various stages of commercial readiness. In addition, not every type of storage is suitable for every type of application, requiring the need for a portfolio strategy for energy storage technology. [65] In terms of specific companies and projects in Alberta, activities exist in the areas of solid-state (lithium-ion), lead-acid, and flow batteries; compressed air energy storage (CAES); pumped hydro; and fuel cells.

In terms of applications, NextEra has two battery energy storage projects proposed for its Red Deer and Ghost Pine wind farm sites (40MW and 30MW projects respectively). AltaLink and TransAlta have been exploring flow battery potential on specific projects. TransAlta is working with Tesla to develop a wind energy integration project backed up by Tesla's Powerpack storage solution. TransAlta has also been exploring pumped-hydro storage as an option at existing hydro sites. Turning Point Generation is another small developer working on pumped-hydro projects in Alberta, including its proposed Canyon Creek project.[66]



Source: http://rockymountainpower.ca/ASISt.html

Rocky Mountain Power's proposed Alberta-Saskatchewan Intertie Storage (ASISt) facility will combine existing Compressed Air Energy Storage (CAES) technology with an interconnection between the Saskatchewan and Alberta power grids.

The project will be the first of its kind in Canada, able to offer customers cheaper electricity since energy can be removed from the grid and stored when the prices are low and then returned with a savings. ASISt is also the first facility in the world proposed to combine CAES technology with an interconnection between grids.

Located near Lloydminster on the Saskatchewan-Alberta border, the ASISt project will have an initial capacity of 160 MW generating capacity with the possibility of future expansion.

With respect to CAES, motor compressors pump air underground to be released at a later date through a generation system in order to create electricity. The technology is well suited to Alberta given the geological salt deposits that have formed large, potential storage caverns. Calgary-based project developer Rocky Mountain Power has a proposed 160MW CAES facility – making it a unique example with only a handful of CAES storage projects currently in operation around the world.

The AESO has been investigating the value of energy storage since 2012 in order to examine the effectiveness and applicability of existing market rules and technical standards with regards to energy storage technologies.[67] The AESO has released a number of discussion and recommendation papers since that time and has a dedicated Energy Storage Work Group focused on identifying and prioritizing possible solutions.[68]

In Alberta, there is potential for a single energy storage unit to provide a combination of time-shifting, price arbitrage, and ancillary services so long as technical requirements are met. This is an example of "stacking" energy storage services and, according to research by Alberta's Department of Economic Development and Trade, is the strongest opportunity available for energy storage in Alberta given stacking is a key advantage in the Albertan market.[69]

Alberta has recently seen the formation of the Alberta Storage Alliance (ASA), a consortium of experts from across the energy industry who have come together as an advocate for the energy storage industry with the goal of advancing the opportunities in the Alberta market.[70] A relatively nascent group, the ASA is made up of approximately 40 individuals,

[65] U.S. Department of Energy "Grid Energy Storage" report (Dec. 2013). See: http://energy.gov/oe/downloads/grid-energy-storage-december-2013
[66] See: http://www.turningpointgeneration.ca/
[67] Alberta Storage Alliance, "Energy Storage: Unlocking the Value for Alberta's Grid" report (2016). See: http://albertastoragealliance.com/white-paper
[68] See: http://www.aeso.ca/gridoperations/28793.html
[69] Invest Alberta, Ministry of Economic Development & Trade "Energy Storage Markets in Alberta: Opportunities & Challenges" report (Aug. 2016).
[70] See: http://albertastoragealliance.com/

including a number of technology and project developers, utilities, research groups, energy consultants, and power generators—some of whom are based in Alberta and others from outside the province.

In June 2015, Alberta Innovates announced $1.5 million in funding for six energy storage projects ($250,000 each), two of which are based in Calgary:[71]

- University of Calgary: Redox Flow Battery Innovation for Large Scale Electrical Energy Storage
- Eguana Technologies: Distributed Lithium-Ion Storage for Demand Charge Reduction

Most of the research work in electro-chemistry is happening at the University of Calgary (focused on solid oxide fuel cells, lithium-ion, and flow batteries), with a smaller amount of activity at the University of Alberta (on lithium-ion batteries and carbon-based super-capacitators).

Innovative academic spin-off companies, such as Geometric Energy, are demonstrating themselves as successful ventures in this space. In addition, Connecticut-based FuelCell Energy has a solid oxide fuel cell research center in Calgary, which was purchased from Versa Power Systems in 2013. The Calgary facility was originally established in 1997.[72]

The **Calgary Advanced Energy Storage & Conversion Research (CAESR)** Group at the University of Calgary is a group of close to 15 researchers that are collaborating to develop advanced storage technologies that involve the inter-conversion of fuels, CO2, and electricity, as well as electricity management. These storage technologies will make reliance on renewable energy more feasible, and reduce the environmental impact of traditional energy production.

Electro-chemistry is core to the Group's research. CAESR is headed up by Dr. Viola Birss, Professor in the Department of Chemistry and former Director of the NSERC Solid Oxide Fuel Cells Canada Strategic Research Network. Additional academic / research leads at CAESR include: Ted Roberts (focused on large-scale flow batteries); Kunal Karan (solid-oxide fule cells); and VT Thangadurai (lithium batteries and solid-oxide fuel cells. A wider group of 10+ professors are involved with CAESR and support the research through materials, systems analysis, electricity systems modelling.

See: https://schulich.ucalgary.ca/keywords/calgary-advanced-energy-storage-and-conversion-research

[71] See: http://www.marketwired.com/press-release/ai-ees-invests-15-million-in-game-changing-energy-storage-technology-projects-2034412.htm
[72] See: http://www.chfca.ca/resources/chfca-blog/versa-power-systems---a-canadian-success-story-you-may-not-have-heard and http://www.forbes.com/sites/peterdetwiler/2016/03/11/fuelcell-energy-continues-to-position-itself-for-future-growth/#6f3bc5571b68

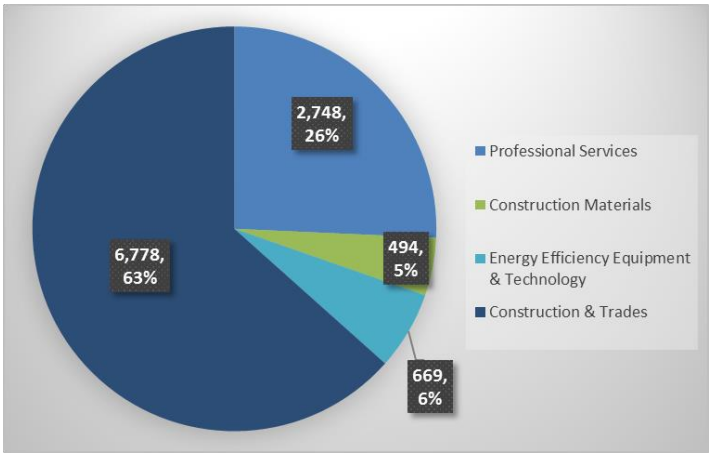
Green Building & Energy Efficiency

Jobs & GDP

The Green Building and Energy Efficiency sub-sector is the largest employer and revenue generator for Calgary's green energy economy.

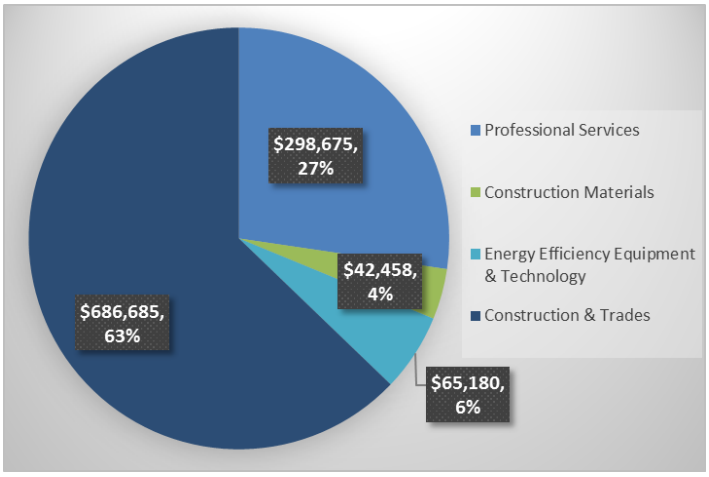
In 2015, Calgary's Green Building and Energy Efficiency sub-sector was responsible for approximately **10,690 direct jobs** and **$1.09 billion in direct GDP** across the extensive value chain.[73] As illustrated in Figure 12, employment was highest in the construction and trades segment (which includes work on green building related projects only), equal to 6,780 jobs or approximately two-thirds (63%) of all employment in this sub-sector. The next largest segment was in green building and energy efficiency related professional services (which include jobs in architecture, design, and engineering, as well as property management, equipment repair and maintenance, research, and technical services), equal to 2,750 jobs (or 26% of all employment in this sub-sector).

In terms of direct GDP from the sub-sector, 63% was generated from the construction and trades segment, equal to $687 million in 2015 (see Figure 13).



Source: The Delphi Group

Figure 12: Direct jobs in Calgary's Green Building & Energy Efficiency sub-sector in 2015.



Source: The Delphi Group

Figure 13: Direct GDP from Calgary's Green Building & Energy Efficiency sub-sector in 2015 ($ thousands).

Projects & Activities

The Green Building and Energy Efficiency sub-sector in Alberta has evolved over the last two decades. Motivations for embracing green building and energy efficiency have expanded beyond their original energy and environmental focus which were driven primarily by policy and regulation. Now economic drivers are increasingly advancing market transformation.[74] This shift is also encompassing aspects of social sustainability, with health and wellness benefits a key focus and of growing importance.

In Calgary, residential energy use represented just under one-third (31%) of community energy consumption and greenhouse gas (GHG) emissions in 2011.[75] According to the Alberta Chapter of the Canadian Home Builders Association, improvements in energy efficiency have been made across Calgary's residential sector, with new homes now achieving an EnerGuide rating equivalent of 78 to 80 on average (which is essentially a new house built to building code standards containing energy requirements), despite not being mandated in the Provincial building code.[76] That being said, based on an assessment of single-family detached houses in Calgary carried out between 2006 and 2013, the energy efficiency of homes from this period prior to retrofits put them in the middle of the pack with respect to energy efficiency compared with other mid-sized Canadian cities for which data was available.[77]

Despite Calgary region's overall residential building stock being more or less average in terms of energy performance, Calgary (and Alberta more generally) has been the leader in Canada in recent years with respect to R-2000 and the

[73] Note: Appendix A provides a more detailed breakdown of these job and GDP figures by industry NAICS code.
[74] The Delphi Group & Canada Green Building Council (2016), "Green Building in Canada: Assessing the Market Impacts & Opportunities"
[75] See: http://www.aeea.ca/pdf/calgary-advancing-energy-efficiency.pdf
[76] See: http://www.nrcan.gc.ca/energy/efficiency/housing/new-homes/18702
[77] See: http://www.aeea.ca/pdf/calgary-advancing-energy-efficiency.pdf

Built Green certification.[78] Calgary currently has 17 Built Green homebuilder firms with another four based in Southern Alberta.

ENERGY STAR, LEED for Homes, and Passive House are additional residential-focused green building certifications that have had some uptake in the Calgary region, although with relatively low numbers to date due in part to the currently depressed housing market and the fact that they are relatively new programs to Alberta.

In the non-residential sector, commercial buildings in Calgary consume less than residential buildings in terms of overall community energy demand (13% versus 31%), however they still contributed to almost one-quarter (24%) of the city's total GHG emissions in 2011.[79]

In the commercial and institutional sector, the dominant green building related certifications include the Canada Green Building Council's LEED program (for both new construction and existing buildings) and the Building Owners and Managers Association (BOMA) Building Environmental Standards (BESt) program for existing buildings.

What are Green Buildings?

Green buildings are buildings that are designed, constructed, and operated to achieve clearly defined environmental, economic, and social performance objectives that are measurably above and beyond the norm. Today, the definition of green building is largely tied to standardized metrics defined by the leading rating systems and certification programs such as Built Green, Leadership in Energy and Environmental Design (LEED), and BOMA BESt.

In Alberta, energy performance is benchmarked against the National Energy Code for Buildings (NECB) or American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) standards. The degree of focus on performance, however, relies largely on where the line that denotes "green" is set and is a constantly moving target.

Buildings that achieve top ratings within these programs are high-performers with low energy consumption, best-in-class management, and often combining new technologies with industry leadership.

With respect to LEED, at the end of July 2016, there were 192 certified projects in Calgary, making up approximately half (51%) of the 373 LEED certified projects in Alberta. An additional 179 LEED projects were registered in Calgary as of the end of July 2016.

Furthermore, LEED certified building market penetration rates (as a percent of gross new construction floor space) have been growing over the last decade. As shown in Table 5 below, the market penetration for new commercial and institutional building construction is approximately 32%. Alberta now has the highest area of certified LEED floor space per capita in Canada. [80]

Within the institutional and commercial sectors, longer-term property holders tend to appreciate the added benefits of green buildings and are prepared to make the additional capital investments. This was in part the reason that, in 2010, Alberta Infrastructure met its goal to have its 90 large, public, government-owned buildings BOMA BESt certified. Green building development in Calgary's commercial sector has seen some of the highest growth in Canada, partly because of the number of new Class A office buildings that have been constructed over the last decade.

Table 5: Market penetration of certified LEED floor space as a percentage of total new commercial and institutional floor space by year.

	2011	2012	2013	2014	2015
Total Commercial / Institutional Floor Space - Alberta (million m2)	106.9	108.5	110.9	113.1	115.4
Year on Year % Change - new construction	1.4	1.6	2.4	2.2	2.3
3 Year Rolling Average % Change - new construction	2.3	1.8	1.8	2.1	2.3
LEED Certified Floorspace (million m2)	0.29	0.40	0.86	0.74	0.64
3 Year Rolling Average % Change - LEED Certification			0.52	0.67	0.75
LEED as % of Total Commercial/Institutional (3 year rolling average)			**28.7%**	**32.2%**	**32.6%**

Source: The Delphi Group using data from CaGBC and Natural Resources Canada

[78] Established in 2003, Built Green is a third-party certification program for homes that are environmentally responsible offered in B.C., Alberta, Saskatchewan, Manitoba, and Ontario. See: www.builtgreencanada.ca
[79] See: http://www.aeea.ca/pdf/calgary-advancing-energy-efficiency.pdf
[80] Canada Green Building Council 2015 Annual Report. See: http://www.cagbc.org/cagbcdocs/aboutcagbc/CaGBC_Annual2015_EN_FINAL_WEB.pdf

The movement has been largely voluntary, driven by building owners and institutional investors who see better rental potential and returns on buildings that have a green building certification. Industry adoption has been driven by both corporate sustainability policies and the growing business case that demonstrates positive return on investment (ROI) over the life of green buildings. In the institutional sector, policy, building code, and bylaw requirements have been the primary driver.

As a result of the rapid growth in LEED buildings in the province, the Alberta Chapter of the CaGBC now has more than 300 members (including architects, engineers, designers, builders, trades, and suppliers), making it the third largest chapter in Canada after Ontario and Quebec.

Professional Services

The professional services segment includes firms involved in architecture and design, engineering, property management, equipment maintenance and repair, and a range of more technical services such as energy auditors and modelers.

As a result of innovative and often collaborative projects between the design, engineering, construction, and building operator communities, Alberta has been able to showcase a number of high-performance building projects that have achieved LEED Platinum certification (see Table 6). Oxford Properties Group's Centennial Place is an excellent example, having achieved LEED Gold certification in 2010 and more recently LEED Platinum certification for Existing Buildings: Operations and Maintenance.

International competition is requiring a heightened collaboration between designers and builders throughout the project design and delivery phases. The integration of emerging technologies, such as Building Information Modelling (BIM), automation, and off-site construction or pre-fabrication, as well as new procedures, have had a positive impact on productivity and efficiency by streamlining processes, reducing waste during construction, and resulting in significant cost savings. There is increasingly a shift in procurement that is enabling innovation for green building – moving away from the traditional 'design-bid-build' model toward more 'integrated project delivery' processes.

Source: www.oxfordproperties.com

Centennial Place is a two tower complex located in downtown Calgary, managed by Oxford Properties Group. Construction was completed in 2010 and the project achieved LEED Gold certification for Core and Shell Development. Oxford is dedicated to innovation and environmentally responsible management and strives to provide a safe and healthy work environment for its tenants. To reflect this commitment, the building team has successfully implemented and maintained operational policies and green building features to achieve LEED Platinum certification for Existing Buildings: Operations and Maintenance (EB:OM).

Highlights include:

- Eight best-in class Sustainable Operations Policies
- Proximity to transit - 72% of occupants use alternative transportation daily
- Reflective white roof / green roof areas to reduce the urban heat island effect
- Water-efficient fixtures
- Landscape vegetation which requires no potable water use for irrigation
- Fine-tuned operation of building systems to achieve industry-leading energy efficiency
- Extensive energy sub-metering to better understand opportunities for further improvement
- Combined heat and power generation system on site Zero Waste Program to divert 75% of waste from landfills
- Demand controlled ventilation to optimize outdoor air delivery
- Active engagement of tenants to understand and contribute to green building initiatives

Table 6: LEED Platinum certified projects in Alberta as of September 2016.

Project Name	City	Project Type
Avalon Discovery III	Red Deer	Single family, duplex, triplex or townhome
Calgary Public Building - Floors 7 & 8	Calgary	Office building
Centennial Place	Calgary	Office building
Cuku Residence	Parkland County	Single family, duplex, triplex or townhome
Discovery 5 House	Calgary	Single family, duplex, triplex or townhome
Eighth Avenue Place - Phase I	Calgary	Retail
Enermodal Engineering Ltd. - Calgary Office	Calgary	Office building
Habitat Net Zero Precast Concrete Home	Edmonton	Single family, duplex, triplex or townhome
University of Calgary - Child Development Centre	Calgary	Office building
University of Calgary - Energy Environment Experiential Learning Building	Calgary	Laboratory
Vento Residences	Calgary	Mixed-use

Source: CaGBC

BIM platforms such as Autodesk's 'Revit', integrated project delivery software such as 'Last Planner', and other related software technologies are important enablers that are increasingly allowing the entire supply chain to collaborate throughout a project's lifetime and explore creative new solutions to old problems. The expansion of BIM into more visualization software is resulting in the merging of more traditional industrial building design with the gaming industry for example. Calgary-based DIRTT's ICE software is an excellent example, which, when combined with DIRTT's pre-fabrication facilities, acts similar to a giant 3-D printer of sorts.

In the commercial and institutional sectors, full-service, integrated architecture, design, and engineering firms such as Stantec, Omicron, B+H Architects, HOK Architects, and Kasian Architecture, as well as engineering and technical firms such as WSP, Morrison Hershfield, MCW Consultants, and Williams Engineering, have been successfully developing high-performance buildings in the Ca lgary region.

Companies such as Enermodal Engineering, 3D Energy, Smith+Andersen, and the Integral Group offer energy efficiency services including energy and water audits, energy management and planning, operator training, and mechanical and electrical system upgrades.

Source: www.dirtt.net

DIRTT Environmental Solutions is a Calgary-based company that uses proprietary software to streamline interior design and office spaces and develop customized, pre-fabricated interiors. The company has nearly 1,000 employees spread across its four production facilities; two in Calgary and two in the United States (in Arizona and Georgia).

DIRTT has been involved in a number of innovative projects, including Suncor building in Calgary, and a large number of hospitals, universities, and other institutional buildings across Canada, the United States, and the Middle East.

In 2015, the company won CaGBC's Product of the Year award for its prefabricated modular building interior wall system called "Enzo", due to its ingenuity and application, particularly as a benefit to healthcare facilities. The product's modular and flexible nature allows for a reduction of waste and related costs that are normally associated with the reconstructing healthcare facility interiors. DIRTT completed a life-cycle assessment (LCA) for the product, created a global Product Category Rule (PCR) and had a third-party verified Environmental Product Declaration (EPD) completed. This information provides consumers with an extended degree of comfort that sustainable design claims are realistic and accurate.

DIRTT has also developed a proprietary 3-D visualization software, called ICE, which is currently being used by 50 design firms around the world to service their clients. This java script software has been referred to as 'BIM with brains'.

Companies including Johnson Controls, Schneider Electric, Trane, ESC Automation, and Honeywell Controls provide technical support and service for the maintenance of high-performance buildings and related HVAC and control systems.

Within the commercial, institutional, and high-rise residential sectors in the Calgary region, large property owners and managers such as Ivanhoe Cambridge, Bentall Kennedy, Oxford Properties, Morguard, Colliers International, and Cadillac Fairview are leading the investment in energy efficient buildings, including on deep retrofits and with day-to-day operations. These companies undertake various retrofit and recommissioning initiatives on their portfolios in order to maintain the value of their properties, reduce operating costs through improved efficiencies, and attract and retain tenants by positioning their properties as green building performers.

Construction & Trades

This construction and trades segment includes general contractors, builders, and relevant trades such as foundational and structural contractors (e.g., carpenters), building equipment contractors (e.g., electricians, heating, and plumbing contractors), finishing contractors (e.g., drywallers, floor installers, and painters), and other specialty trades (e.g., solar PV installers).

At present, the focus for Alberta's construction industry is on productivity and performance improvements with a push to build more affordable buildings and homes at a faster pace while increasing overall efficiency and, in turn, profitability. While energy efficiency can be a co-benefit of these efforts, it is not the main focus for the average firm.

Leading design-build and construction management companies such as PCL, Graham, Ledcor, Ellis Don, Stuart Olson, and Scott Construction have developed internal policies and programs in order to minimize on-site waste production and improve recycling, as well as adding environmental criteria to their purchasing decisions. For these companies, consideration is given to suppliers that provide reduced packaging, as well as locally-sourced, recycled, and environmentally-friendly products.

Companies in this space are supported by industry bodies such as the Calgary Construction Association, the Construction Owners Association of Alberta, the Alberta Chapter of the Canadian Home Builders Association (CHBA), the Thermal Insulation Association of Alberta, the Mechanical Contractors Association of Alberta, and the Electrical Contractors Association of Alberta.

Source: www.landmarkgroup.ca

For the last 14 years, the Landmark Group of Builders has pushed the envelope of standard residential construction practices in Alberta, having achieved construction efficiencies and energy savings by building the major components of its homes in its Edmonton-based manufacturing plant instead of on-site. The current pre-fabrication facility is approximately 150,000 square feet and employs 170 people at present time. The plant has the capacity to build approximately 3.5 energy efficient homes per day, selling on average 700 homes per year (approximately 150-250 homes per year in the Calgary region).

Landmark homes have achieved an EnerGuide baseline rating of 82 and have achieved up to 86 a townhouse project. The company set a goal to achieve net zero construction and is hoping to achieve this on a large scale by 2018. Landmark's net zero energy community projects are focused on the Calgary, Edmonton, and Red Deer regions and have received $500,000 in funding support from ERA.

Landmark is looking to achieve net zero status by focusing on three elements: making the house "envelope" as energy-efficient as possible (such as using triple-glazed, low-e windows); using the most energy-efficient equipment and appliances (including high-efficiency furnaces and heat recovery ventilators); and generating energy through the use of solar PV systems combined with energy storage solutions.

Companies such as Albi Homes, Alloy Homes, Avalon Master Builder, Battistella Developments, Brookfield Residential, Crystal Creek Homes, Homes By US, and Lifestyle Homes are industry leaders, developing and constructing energy and resource-efficient single-family homes and/or multi-unit residential buildings (MURBs). These green building experts are focused on tight building envelopes and good air flow properties to create more comfortable, quieter, healthier, and sustainable living environments.

Alberta in general and Calgary more specifically has become a leader in Canada with respect to pre-fabrication and modular construction. Companies such as DIRTT, Horizon North, and Landmark Group have pushed the envelope with respect to standard construction practices and overall quality. Landmark Group's base model home for example is now exceeding EnerGuide 82 with a townhouse development that has reached EnerGuide 86.

Alberta has also been at the forefront of the net zero energy push in Canada, with builders such as Avalon Master Builder, Mattamy Homes, Brookfield Residential, and Landmark Group. According the US Department of Energy, a Zero Energy Ready Home, or "net zero" building, is a high performance building that has reached peak energy efficiency, allowing a renewable energy system to offset all or most of its annual energy consumption. In designing with the goal of net zero, buildings are dramatically changing in shape and form, underpinned by a greater focus on passive design features and building envelopes (including increased insulation, reduced glazing surfaces, and triple-paned glass).

In Alberta, building design and construction best practices are approaching the point where achieving net zero energy for new homes is technically viable, although the upfront extra costs for the required features and technologies remain the greatest barrier to widespread market adoption and, as such, it remains relatively niche at present.

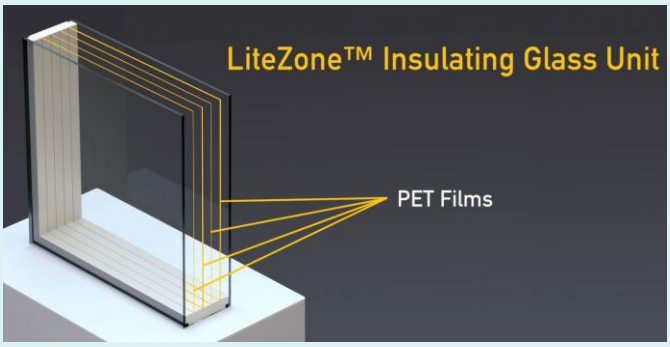
At the same time, decreasing costs for technology and improvements in process over the last several years have taken net zero closer to larger-scale commercialization. As an example, Landmark Group's pre-fabrication facility in Edmonton is drastically moving the science forward at an accelerated pace, with expectations that net zero will be widely achievable within the next few years. In addition, the rapidly decreasing cost for solar photovoltaics (PV) technology over the last several years means many homes in the Calgary region are exploring this as an option. The evolving intersection between solar PV, home energy storage (batteries), and plug-in electric vehicles is one to watch as consumers are increasingly able to seek sustainable energy options along the pathway to net zero.

Green Building Materials, Equipment & Energy Efficient Technologies

Green building products and materials are diverse and include all aspects of the construction value chain, from wood-based products, to concrete, drywall, paint, and carpeting / textiles. Energy efficient equipment and technologies include heating, ventilation, and air conditioning (HVAC), lighting (e.g., LEDs), plumbing (e.g., geoexchange), appliances, and a range of building management systems, controls, and software solutions.

The focus on green building has driven the demand for more sustainable building products and materials, with local and environmentally-friendly products embedded into the various green building certification programs. A range of green building product and material suppliers are found in the Calgary region, including some limited local manufacturing in areas that include windows, structural walls and related components, and insulation products as examples.

In the window space for example, Calgary-based companies such as GlasCurtain and LiteZone have been developing energy efficiency options for high-performance buildings. LiteZone was in fact awarded CaGBC's Product of the Year Award in 2016.



Source: www.litezone.ca

LiteZone™ Glass Inc. is a company that is primarily in the business of manufacturing its innovative insulating glass product. LiteZone's air filled proprietary system allows air pressure between the inside and outside of the glass unit to equalize with changing temperatures and atmospheric pressure, while keeping water vapour from entering the unit. The expected life of LiteZone™ is more than 60 years.

LiteZone™ only uses two glass lites and therefore weighs less than triple pane. With its weight and performance, LiteZone™ allows large windows and generous glass areas in buildings designed to be highly energy efficient.

In the lighting space, many suppliers are increasingly providing LED solutions for residential and non-residential customers. The City of Calgary as one example is working with GE and others to retrofit its entire street lighting to LEDs, which will result in large operational savings over time with less than a three-year payback. The street lighting will include adaptive controls for dimming and wireless monitoring through sensors, with the potential to add video-on-demand to improve security / safety in the future.

Product and equipment suppliers in Calgary are represented by a broad range of industry associations, including the North American Insulation Manufacturers Association (NAIMA Canada), the Canadian Institute of Plumbing and Heating, and the Provincial Glaziers Association of Alberta.

In terms of household appliances, there has been a marked increase in appliance efficiency over the past decade with many appliance categories achieving a high percentage of ENERGY STAR ratings.

Innovation is also changing the landscape and making buildings more efficient through the adoption of 'smart' technology. In particular, the adoption of sophisticated energy management, control, and automation systems in buildings has proven to reduce energy consumption and GHG emissions. The ability of these systems to process and analyze huge volumes of energy-related 'big data' has shifted the way buildings are designed, built, and operated. However, this shift has brought with it challenges for the individuals involved with operating buildings that have not received proper training on these advanced ICT-based systems.

In Calgary, multi-national companies such as Siemens, Johnson Controls, and Schneider Electric dominate the market. One locally based example is Spartan Controls, an industrial equipment supplier providing a wide range of controls and energy management technologies. Calgary also has a strong software development community with 'apps' being designed to support green buildings and energy efficiency. As one example, a Calgary-based firm has 'gamified' its software as a way to encourage consumers to unplug their appliances.

Green building related products and materials from successful companies in Alberta tend to differentiate from the global competition based on their higher quality, performance, aesthetics, and operational attributes. The service element is also a distinguishing factor for many companies, who often provide ongoing customer support for clients.

The Green Building Technologies (GBT) research division got its start within SAIT's Applied Research and Innovation Services (ARIS) department in 2008. ARIS has brought SAIT and GBT researchers together with industry partners to identify and develop environmentally-friendly technologies, processes, programs, systems, and services that will fundamentally change the way buildings are constructed, education is delivered, and skills are developed. In 2012, SAIT received an $800,000 federal grant to support the research lab and an additional $1.75 million in 2014 to support green building technology development.

Research themes include:

- Net-Zero Energy and Energy-Positive Design
- Building Integrated Renewable Energy
- Architectural Ecology
- Energy Management and Monitoring
- Education and Industry Transformation
- Materials and Advanced Component Assembly

Services offered by GBT include:

- Early-Stage Business Development
- Design and Engineering Services
- Construction Innovation
- Fabrication, Prototyping and Installation Services
- Performance Monitoring and Management
- Testing Services
- Education, Workshops, and Seminars

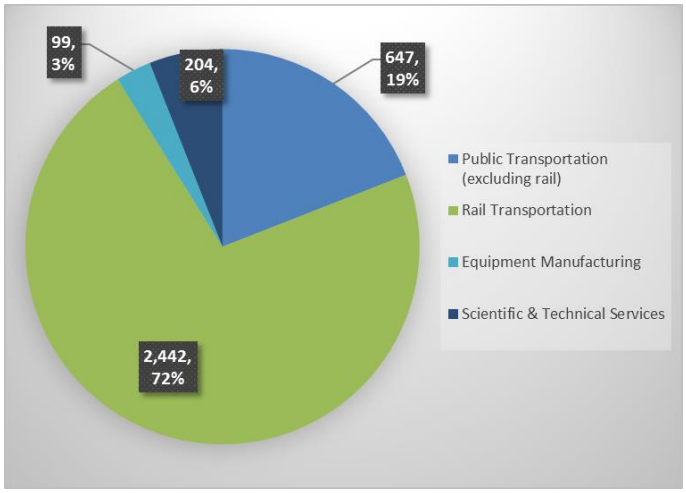
See: http://www.sait.ca/research-and-innovation/green-building-technologies.php

Green Transportation

Jobs & GDP

In 2015, Calgary's Green Transportation sub-sector was responsible for approximately **3,390 direct jobs** and **$390 million in direct GDP** across the value chain.[81] As illustrated in Figure 14, employment was highest in the rail transportation segment, equal to 2,440 jobs or approximately three-quarters (72%) of all employment in this sub-sector. The next largest segment was in public transportation (excluding rail), equal to 647 jobs (or 19% of all employment in this sub-sector).

In terms of direct GDP from the sub-sector, 79% was generated from the rail transportation segment, equal to $307 million in 2015 (see Figure 15).



Source: The Delphi Group

Figure 14: Direct jobs in Calgary's Green Transportation sub-sector in 2015.

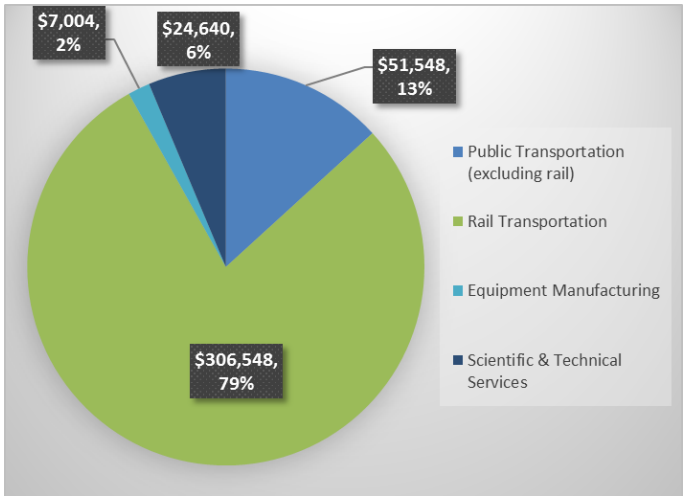
Projects & Activities

Rail & Public Transit

Approximately 92% of the Calgary region's employment in the Green Transportation sub-sector comes from the rail and public transit segments.

Calgary currently serves as an inland port and a hub for goods movement, located at the junction between the TransCanada and CANAMEX highways. From a green transportation perspective, rail movement of goods as opposed to current on-road vehicles (trucks and cars) has a large positive impact in terms of reducing fuel consumption and related greenhouse gas emissions. As an example, a single train can move one tonne of freight 180 kilometers on a single litre of fuel.[82]

Canadian National (CN) Railway is Canada's largest freight railroad, providing transportation and intermodal services throughout North America. Canadian Pacific (CP) Railway provides additional freight rail services in Alberta. These two major rail companies are supported by a range of smaller service companies and suppliers.



Source: The Delphi Group

Figure 15: Direct GDP from Calgary's Green Transportation sub-sector in 2015 ($ thousands).

On the public transit side, Calgary Transit currently enjoys the highest light rail transit (LRT) ridership in North America, with its LRT system being powered by wind energy. Additional investment is underway to further enhance public transit infrastructure in the Calgary region. This includes a number of major public transit projects that are currently under construction or proposed for Calgary, including:

- **Under construction** (equal to $33.8 million): Spring Gardens Bus Maintenance / storage facilities
- **Proposed** (equal to $412 million): Green Line LRT, North / South Crosstown BRT, Southwest and Southeast transit ways, Stoney CNG Transit bus garage

[81] Note: Appendix A provides a more detailed breakdown of these job and GDP figures by industry NAICS code.
[82] See: http://www.ottawalife.com/2012/11/canadian-railways-assisting-canadas-environmental-performance/

The City of Calgary's 'Investing in Mobility' 10-year Plan (2015-2024) forms the basis of the City's strategic plan for capital transportation infrastructure projects. It defines the priority and timing of projects, and helps inform Council's capital budget decisions as part of Action Plan 2015-2018. The Investing in Mobility Plan includes a focus on:

- Mobility hubs and transit corridors;
- Goods movement and traffic growth;
- Transportation network optimization; and
- Life-cycle and asset management.

Provincial and federal funding sources currently account for 61% of Calgary's transportation capital funding. The provincial Green Transit Incentives Program (GreenTRIP)[83] is one initiative that has been critical to supporting new transit infrastructure projects in Calgary.

Source: www.calgarytransit.com

Photo caption: Calgary Transit's Light Rapid Transit system has the highest LRT ridership in North America.

However, in order to implement all of its proposed transportation infrastructure projects, the City of Calgary estimates that it will require $5.6 billion over the next 10 years. As many provincial and federal funding programs expire over the coming years, the City of Calgary is projecting a $1.9 billion funding gap over the next decade. This means some priority transportation infrastructure projects will remain unfunded until new funding becomes available.

Green Transportation Technologies, Equipment & Innovation

The City of Calgary is currently focused on improving the overall fuel efficiency of its 4,000 vehicle fleet, implementing new practices and technologies that reduce fuel consumption, including consideration for electric vehicles, hybrids, and natural gas solutions where it makes sense.

As part of its asset renewal, the City of Calgary's bus fleet of approximately 1,000 buses needs replacement on a 20-year lifecycle. The City is exploring new buses running on both electric and compressed natural gas (CNG), as well as the transit facility infrastructure to support refueling. In September 2016, the world's largest producer of battery-electric buses, China-based BYD, announced a new partnership with Alberta to develop transit buses. BYD's proprietary iron-phosphate (or "Fe") Battery is currently the safest and longest lasting electric bus battery available on the market. Initial program details will be set in late 2016 between BYD, a number of Alberta technology companies, the Alberta Centre for Advanced MNT Products, the University of Alberta, and the University of Calgary.[84]

As illustrated in Table 7, the number of battery electric vehicles (BEVs) on the roads in Alberta has been increasing in the last five years as the technology becomes more accepted and charging infrastructure is deployed, although as a percent of total passenger vehicles registered, the number remains at less than 0.01%.

Table 7: Electric vehicle charging stations in Alberta.

	2012	2013	2014	2015
Total BEV Purchases in Alberta	67	74	64	149
Total Motor Vehicle Sales in Alberta	247,785	263,224	277,191	241,918
Total Passenger Car Sales in Alberta	59,383	62,568	59,892	51,845
Total Vehicle Registrations	4,569,980	4,764,093	4,952,037	5,098,281

Source: GreenCarReports & Statistics Canada

[83] See: http://www.transportation.alberta.ca/5409.htm
[84] See: http://www.masstransitmag.com/press_release/12253370/global-electric-vehicle-leader-byd-and-canadian-province-of-alberta-announce-research-and-innovation-agreement-to-develop-smarter-safer-transportation-technology

In 2015, it is estimated that there were more than 500 BEVs on the road. In terms of Tesla cars alone, however, there are approximately 300 in Alberta today and 160 orders pending for the Model S. In addition, more than 100 Model 3s were pre-ordered in Alberta on opening day. With respect to EV infrastructure, there are just under 20 Level 2 public charging stations in Calgary, making up approximately 20% of the total in Alberta (see Table 8).

Table 8: Electric vehicle charging stations in Alberta.

EV Charging Stations in Alberta	Level 2	Level 3	Total
Calgary	17		17
Southern Alberta (Outside Calgary, South of Red Deer)	19	1	20
Central Alberta (Between Red Deer and Edmonton)	13	1	14
Greater Edmonton	17		17
Northern Alberta	10		10
Total	**76**	**2**	**78**

Source: www.caa.ca/evstations

There have also been research efforts focused on green transportation related technology advancement in the Calgary region. Since 2012, NSERC has funded approximately $900,000 toward EV research in Alberta, with $256,000 (or 28%) flowing to post-secondary institutions in Southern Alberta—predominantly at the University of Calgary (UofC).

Since 2004, the UoC has been competing in 7 races around the world with its Solar Car.[85] In addition, a professor at UofC has begun a new 5-year research program focused on EVs, including battery technologies and refueling infrastructure.

Source: www.calgarysolarcar.ca

Photo caption: University of Calgary's Solar Car Team.

Two UofC researchers also recently received a $650,000 grant over five years from Alberta Innovates to lead a team of 20 engineering graduate students to create an ICT platform to support more dynamic transportation systems of the future.[86] The team's "Smart Multimodal Transportation System Integration" project focuses on the impacts to traffic stability, capacity, and safety required for when autonomous (self-driving) and conventional vehicles share the road.

[85] See: http://www.calgarysolarcar.ca/
[86] See: http://albertatechfutures.ca/NewsRoom/NewsBlog/TabId/1211/ArtMID/1769/ArticleID/1357/Transport-integration-necessary-for-roads-ahead.aspx

4. Calgary's Green Energy Economy Value Chain Gaps

The energy only electricity market, the lack of time-of-use or peak energy pricing, low average electricity prices, a dearth of related incentive and funding programs in recent years, and the lack of a strong demand-side pull for green energy sector products and services in Alberta at present, has resulted in a value chain that is less well established than in some other jurisdictions around the world. In some locations, including many European countries and parts of the United States such as California as examples, higher energy costs makes renewables more competitive and drives the need for efficiency and/or supportive programming and incentives.

The primary value chain gaps identified for Calgary's green energy sector at present include:

1. Large-scale / commercial manufacturing of technologies and components related to the renewable energy, energy storage, buildings, and transportation sectors.
    - Note: Some of the product / technology is available from Canada (mostly coming from Ontario) or imported internationally. As an example, wind turbine towers were imported from Saskatchewan for an earlier project in Alberta. Renewable energy technologies and specialized systems such as wind turbines, solar panel, invertors, batteries, power train and vehicle technologies, HVAC equipment, and LED lighting as examples are usually imported internationally (in particular, from the United States, Europe, and Asia).
2. Large and specialized EPCs focused on the renewable energy sub-sector with international experience.
3. Experienced project developers and system integrators specialized in the smart grid and energy storage sub-sector.
4. Global distribution networks for growing the export potential of Alberta green energy sector focused companies.
5. Commercial financing and investment firms focused on the green energy sector projects across all sub-sectors.
6. Builders (primarily residential) and construction trades who have experience working with energy efficient products / technologies and processes (e.g., house-as-a-system).
    - Note: This is not a value chain gap as much as it is an industry education / training issue that is motivated by consumer / customer demand.
7. Building operations staff experienced with high-performance buildings and related technology.
    - Note: This is a fundamental issue across Canada due to the current lack of relevant education and training programs for modern day buildings that are seeing an increasing high technology / ICT component.

With respect to large-scale manufacturing, issues include Alberta's rising corporate tax rates, a relatively high minimum wage, and the limited domestic market at present. However, opportunities do exist for more niche equipment and component manufacturing across the green energy sector value chain (as described in the next section), with advanced manufacturing presenting a particular area of opportunity for Calgary.

That being said, with the exception of an extensive manufacturing supply chain, most of the key players involved in supplying green energy sector related products and services exist in the Calgary region in some capacity, although many of them diversify activities on projects outside of the green energy space in order to remain in business and/or may work on projects outside of Alberta, focused on geographic regions where the demand for their products or services is higher.

As industry and consumer demand grows and Alberta begins to roll out new policies and programs, there is good potential for existing professionals and suppliers to ramp up activities as well as integrate workers from other sectors to refocus on the green energy economy. This could include collaborative efforts for start-ups and SMEs to work with existing firms such as Siemens, GE, Schneider Electric, ABB, Lockheed Martin, Hatch, Cisco, IBM, and Accenture.

5. Calgary's Green Energy Economy Opportunities

Alberta is expecting up to 5,000 MW of renewable power to be solicited through RFP over the next 15 years, which will require significant investments in new projects. The first 400MW procurement cycle was announced in early November 2016. A large percentage (likely upwards of 90%) of the investment is expected to be focused on wind energy.[87]

Diversifying beyond wind projects to include solar PV, geothermal, and hydropower, along with energy storage, will help to balance demand and optimize loads. According to a recent report by Alberta's Ministry of Economic Development and Trade, the two energy storage technologies that have proven especially fit for the relevant market applications and have advantages unique to Alberta are: Lithium-ion (and Lithium advanced chemistries) and Compressed Air Energy Storage (CAES). Flow batteries present a third promising option.[88]

Calgary has the professional workforce to supply these major renewable energy projects and is well positioned to attract additional businesses active in these areas, which may come in part as a result of Ontario's decision to suspend the procurement of new large-scale renewable energy projects.[89]

In terms of energy efficiency and green building, Alberta's plans to invest approximately $645 million over the next 5 years through Energy Efficiency Alberta puts an immediate emphasis on the opportunities for companies active in this space. Alberta's strengths in off-site, pre-fabrication and modular construction can be further expanded, both for domestic consumption and as an export opportunity. As one example, the rebuild of Fort McMurray provides an opportunity to integrate energy efficiency modular construction and related design elements, although current compressed timelines and insurance industry requirements may present challenges here for large scale adoption.

The shift toward more advanced manufacturing technologies and emerging solutions such as multi-dimensional or 3-D printing in large formats using products such as concrete and cellulose resin is an area to watch. Resilient building materials is an additional area that is evolving through innovation and a fusion with nanotechnology, including smart materials (e.g., shape memory alloys) that allow buildings and/or infrastructure (such as bridges) to restore their original shape following an earthquake for example.[90]

The Internet and 'big data' focused companies are a fast growing segment and an opportunity area for Alberta's growing energy and ICT sectors. This includes network applications and grid support equipment and services, as well wireless technologies such as controls and sensors. There is also a growing focus on delivering 'cleantech as a service'—not just software or big data management as a service but lighting 'as a service' and energy storage 'as a service'. This includes intelligent software, analytics that synchronize to the "cloud" and mobile devices, as well as Internet of Things (hardware and software combined).

As a general trend, the increasing digitalization of buildings and energy systems is resulting in an infusion of conventional buildings with new technology that is impacting on how buildings are designed, constructed, and operated —a realm more commonly associated with the emerging 'smart city' concept and practice. Software-enabled solutions in this area are being applied to building design and visualization software, BIM and integrated project delivery solutions, building management and automation systems, energy efficiency focused software and apps, and 'smart' products (e.g., smart windows) and appliances. The same applies in the smart mobility space where digital technology and sensors are being overlaid to new and existing infrastructure to improve transportation systems, optimize logistics, and manage traffic flows as examples.

Opportunities also exist for small-and-medium sized enterprises (SMEs) and entrepreneurs for helping to fill gaps in the market that larger players are not addressing. As a side note, Alberta's technology sector saw a 48% increase in companies headquartered in the province over the last four years, including significant growth of the cleantech and energy technology segments.[91]

[87] Based on consultation for this project with AESO.
[88] Invest Alberta, Ministry of Economic Development & Trade "Energy Storage Markets in Alberta: Opportunities & Challenges" report (Aug. 2016).
[89] See: https://news.ontario.ca/mei/en/2016/09/ontario-suspends-large-renewable-energy-procurement.html
[90] See: https://en.wikipedia.org/wiki/Shape-memory_alloy and http://www.livescience.com/22317-smart-materials-earthquake-safe-bridges-nsf-bts.html
[91] See: http://www.newswire.ca/news-releases/alberta-technology-sector-sees-48-increase-in-companies-headquartered-in-the-province-595120551.html

Calgary's green energy economy opportunities are summarized by sub-sector below.

Renewable Power Supply & Alternative Energy

1. **Renewable energy project design & planning**
   - Largely focused on wind and solar PV, as well as some geothermal potential at orphaned oil well sites
   - Applications related to geomatics, mapping, and GIS

2. **Digitization & automation technologies**
   - Heavy emphasis on ICT, mechatronics, controls / sensors, software
   - Potential for operation and management centres for wind and/or solar, as well as remote sensing of renewable energy resources and monitoring / optimization of assets
   - Big data / predictive analytics

3. **Niche manufacturing across the renewable energy value chain**
   - Wind turbine towers and turbine components
   - Solar racking
   - Balancing systems (inverters, combiner boxes, collection systems)
   - Controls and energy management systems

4. **Bioenergy / biofuels / biogas capture & utilization**
   - Focusing on the waste-to-energy, anaerobic digestion, biofuels from agriculture, forestry, construction wastes, landfill biogas capture to be used for alternative fuels and/or electricity generation.

Energy Storage & Grid Infrastructure

1. **Energy storage technologies**
   - Key technology areas include: lithium-ion batteries; compressed air energy storage (CAES); and flow batteries
   - Fuel-cells for industrial applications (e.g., for oil and gas, mining, and agriculture industries)
   - Real time pricing in Alberta provides technical opportunities for energy storage (i.e., the stacking of services and price arbitrage)

2. **Micro-grid systems & urban energy storage solutions**
   - Alongside solar PV / thermal, district energy (where relevant)
   - More resilient in the face of natural disasters
   - Cushions from price volatilities and transmission infrastructure challenges, and could allow for locational pricing

3. **Smart grid technologies**
   - Advanced metering infrastructure (smart meters) in the residential and small commercial sectors
   - Demand response / energy management systems (community and building level)
   - Reactive power control systems
   - Inverters and anti-islanding technology
   - Software solutions to support energy storage and renewable energy integration

4. **Cloud-connected & analytics services**
   - Power management apps
   - Cleanweb services (e.g., energy storage as a service)
   - Big data / predictive analytics

Green Building & Energy Efficiency

1. **Net zero energy communities**
   - Consider integration of renewable energy, onsite co-generation, and storage systems

2. **Smart / connected building technologies**
   - Examples (non-residential): Demand response, building energy monitoring, management, optimization, and automation systems, and other ICT-based solutions (reactive controls, sensors, software)
   - Examples (residential): Advanced metering infrastructure (i.e., smart meters) and demand-side management (DSM) technologies

3. **Cloud-connected & analytics services**
   - Examples: Power management apps, 'cleanweb' services (e.g., lighting as a service), and big data / predictive analytics

4. **Building design & project delivery software solutions**
   - Examples: BIM, 3-D design / visualization, and integration software

5. **Energy efficiency retrofits & related professional services**
   - Existing buildings need to consider all the changes over time and be flexible with re-design and repurposing
   - Retrofits are a large job generator for the trades (i.e., 30:1 ratio of contractors to engineers on commercial retrofits).
   - Energy auditors / evaluators, energy modelers, and related service providers for buildings.

6. **Energy efficient prefabrication & modular construction**

7. **Green building materials**
   - Examples: Engineered wood, recycled content materials, intelligent reinforced concrete, insulated concrete forms, and carbon-capture and utilization into value-added products like cement

Green Transportation

1. **Vehicle electrification**
   - Fleets & trucking industry

2. **EV charging infrastructure**
   - In-line with potential for building retrofits

3. **Goods movement & logistics**
   - Calgary has a large logistics sector and well-positioned at Trans Canada and CANAMEX Highway junction
   - Opportunity for piloting new technologies (e.g., autonomous vehicles, electrification of long-haul trucking sector, etc.)

4. **Smart transportation technologies**
   - Traffic and parking management solutions
   - Real-time traffic monitoring and pricing
   - Connected and autonomous vehicles (commercial & industrial applications)
   - Big data / predictive analytics

6. Conclusions

Global megatrends suggest that the green energy sector is not a 'fad' but, rather, will continue to grow at an accelerated pace over the next several decades. These shifts lie at the heart of the growing green energy economy and present significant opportunities for cities that are positioned to take advantage of the economic benefits, including new investments and job creation potential.

As profiled in this report, Calgary already has a stake in the sub-sectors that make up the green energy economy, including established strengths in renewable power project development and green building design and construction. In 2015, Calgary's green energy economy was responsible for generating $1.78 billion in GDP and nearly 15,500 jobs, equal to 1.8% of all workers in the Calgary region.

However, Calgary needs to step out in front and further demonstrate leadership in order to fully maximize the benefits, building on the business case for industrial renewal that positions the City for long-term, economic prosperity. At the same time, it will be essential to engage with the entire energy sector and its major incumbents in order to exploit the synergies that come from collaboration and to ensure buy-in, which will require Calgary to focus on building greater awareness around the opportunities and act as a green energy economy 'champion' of sorts. The City of Calgary and Calgary Economic Development will need to look at both the policy levers and options under their control, as well as ways to work with industry partners and other levels of government, in order to:

- Drive demand for green energy sector products and solutions;
- Encourage the adoption and demonstration of green energy technologies to address local challenges;
- Convene important players across the value chain to move projects forward;
- Serve as educators of the public and advocates for action and investment; and
- Help level the playing field for green energy sector technologies and solutions.

As mentioned above, Calgary is not starting from zero. In fact, with the exception of an extensive manufacturing supply chain, most of the key players involved in supplying green energy sector related products and services exist in the Calgary region in some capacity. As Alberta begins to roll out new policies and programs, there is good potential for existing professionals and suppliers to ramp up activities, as well as integrate under-employed workers from other sectors to refocus on the green energy economy. This could include collaborative efforts for start-ups and SMEs to work with existing firms such as Siemens, GE, Schneider Electric, ABB, Lockheed Martin, Hatch, Cisco, IBM, and Accenture.

Leveraging partnerships and making minor adjustments to existing programs where possible to provide a green energy economy focus—such as with the YYC Innovation Lab, GE's Innovation Centre, and the Energy Venture Competition—could increase the overall impact. Working with ERA, for example, to encourage further investments in project areas such as energy storage, micro-grids, high-performance buildings, and transportation logistics, could benefit local entrepreneurs and the innovation value chain. There are also a number of 'best practice' programs and initiatives that have been developed by green energy sector leaders from around the world that could be replicated and modified for the local context. Programs such as Vancouver's Green and Digital Demonstration program, San Francisco's Start-up in Residence Program, and Montreal's InnoCité are but a few examples.

Finally, where possible, 'expanding the pie' through holistic and systems-based thinking will help to maximize the opportunities and benefits. Looking beyond the renewable energy sub-sector to explore synergies that may come from complementary energy technologies and skills sets in the more conventional energy sector (e.g., co-generation), as well as from the green building, energy efficiency, and transportation sub-sectors, may help Calgary become a 'future energy' leader while simultaneously developing a resilience to energy pricing shocks, extreme weather events, and economic downturns.

Appendix A: Project Methodology

This Appendix summarizes the methodology for all secondary and primary research activities carried out by the Delphi Group in 2016 as part of the Calgary Region Green Energy Economy study. This work involved:

1. **Developing a 'green energy economy' statistical framework** to support sub-sector profiling**;**
2. **Undertaking secondary research to profile the four green energy sub-sectors** in terms of key projects, companies, investments, and research activities;
3. **Developing estimates of employment and GDP** within the four green energy sub-sectors under investigation;
4. **Developing a green energy company database**;
5. **Undertaking a comparative analysis with global cities;**
6. **Undertaking SWOT, value chain mapping, and gap analyses**;
7. **Conducting in-depth interviews with industry leaders** involved in Alberta's green energy economy; and
8. **Organizing a green energy economy focus group** focused on Calgary's potential opportunities and positioning in line with its current strengths and value chain gaps.

The research methodologies used to address each of the points listed above are discussed in detail in the following sub-sections.

1. Developing the 'green energy' economy statistical framework

Delphi began by establishing a clear and common definition and overarching framework for Calgary's green energy economy. For the purposes of this research, the project team focused on the following four (4) sub-sectors[92]:

- **Renewable power supply & alternative energy** – including wind, solar, geothermal, hydro, biomass, waste heat to power.
- **Energy storage & grid infrastructure** – including batteries, battery management systems, smart meters, fuel cells, energy management software, and other smart grid applications.
- **Green buildings & energy efficiency** – including products, services, and materials related to energy efficient building design, construction, renovation, and operations such as HVAC, windows, lighting, and control systems.
- **Green transportation** – including electric vehicles, e-bikes, public transit, rail, as well as related technologies and infrastructure.

Delphi finalized a list of statistical codes using NAICS[93] that encompass the proposed green energy economy definition and relevant sub-sectors above. There has already been extensive work undertaken in this space by the Delphi Group and others, which served as the foundation and cross-reference for this study. Delphi used the best available sources and standards for this effort.

2. Undertaking secondary research to profile the four green energy sub-sectors

Delphi undertook secondary research, reviewing existing reports, websites, articles, and other available information on the various green energy sub-sectors, including information on key companies, research initiatives, demonstration / pilot projects, investment activities, important stakeholder groups, policy and program drivers, and other details to map out current activities and cluster strengths.

Delphi also tabulated the number of establishments by employment size group for each of the relevant green energy industry NAICS codes from the Statistics Canada Business Patterns database for the City of Calgary and surrounding region.

[92] **Please Note:** The relevant value chain manufacturing will be considered as part of the analysis on all of the four green economy sub-sectors and included in those individual sub-sector profiles.
[93] NAICS = North American Industry Classification System

In addition to the Industry Canada Company Capabilities and Hoover's databases, Delphi analyzed:

- Information from key trade or industry association organizations, such as databases of member or known companies;
- Data drawn from surveys delivered by Calgary Economic Development and other agencies specific to Alberta; and
- National, regional, and city-level research studies on the core green economy sector or relevant sub-sectors.

3. Developing estimates of employment and GDP

The Delphi Group used a bottom up approach in order to develop estimates of employment and GDP, utilizing data published by Statistics Canada, which was then validated and verified through a range of other sources (including Hoover's company data, industry association membership lists, indicator data from green certification programs, NSERC and ERA funding, and key informant interviews) to estimate the amount of activity within relevant key industries. Below is a more fulsome overview of the methodology that was applied:

1. Total jobs for the industries (4-digit NAICS) identified for the four green energy sub-sectors were prepared based on both labour force and employment data from the Statistics Canada National Household Survey (NHS) for Calgary Economic Region and job estimates derived from the Statistics Canada Business Patterns database.
2. The jobs based on both sources were compared and through similar results it was concluded that the Canada Business Patterns was a legitimate source by which to estimate detailed employment at the 4-digit NAICS level for the Calgary Region.
3. The next step was to estimate 'green' intensity ratios for each industry (4-digit NAICS) in the four groups. Intensity ratios are essentially the amount of 'green energy' sub-sector activity happening within a given industry, expressed as a % or number from 0 to 1.00.
4. The intensity ratios were derived through examining Alberta's and Calgary's related 'market penetration' of activities related to the green energy economy in each of the relevant industries at the 4-digit and 6-digit NAICS code level.
5. Key indicators that were used to estimate market penetration include, as examples, the amount of renewable electricity as a percentage of total generation, the amount of new renewable energy capacity built over the last year as a % of total capacity added, the number of buildings and homes certified under a recognized third-party program as a percentage of total new construction, and the amount of research grants flowing to green energy sector technologies areas as a percentage of total research grant funding. Third-party certification programs considered in the analysis included LEED (for both new construction and existing buildings), BOMA BESt (for existing buildings in AB), Built Green (for new home construction), and ENERGY STAR (for homes, and equipment / appliance manufacturing and repairs).
6. In some cases, where estimating market penetration was not possible due to limited data, we used intensity ratios developed by the Delphi on other studies and/or research from other sources such as the US DOE (for ENERGY STAR equipment and appliances) and US Bureau of Labor Statistics as the benchmark and adjusted based on our understanding of the AB market.
7. Relevant 'green energy' jobs were then estimated by applying these intensity ratios to each of the total jobs that had been derived from the Canada Business Patterns for the Calgary Region at the 4-digit NAICS code level and validated through job counts from the Statistics Canada National Household Survey.
8. Green jobs were subsequently converted to green energy economy output and GDP through multipliers for Alberta that were provided to the project team by the Statistics Canada National Accounts (Input Output) Division.

The method applied in this study mirrors approaches that have been developed and applied in other jurisdictions by organizations such as the Vancouver Economic Commission[94] for the City of Vancouver and the US Bureau of Labor Statistics[95] in their green job estimates.

However, one fundamental difference with this study as opposed to the other two referenced above is that no industry survey to companies in each of the relevant industries (at the 6-digit NAICS code level) in order to further refine intensity ratios. Instead, the work has relied on available data, market penetration estimates, and qualitative information from

[94] Vancouver's Green Jobs estimate and 2014 update: http://www.vancouvereconomic.com/wp-content/uploads/2015/04/VEC_GreenJobsReport_2014_web.pdf

[95] See US BLS's Green Goods and Services 2010-2012 study: http://www.bls.gov/ggs/home.htm and http://www.bls.gov/news.release/pdf/ggqcew.pdf

stakeholder interviews to refine the intensity ratios as best as possible. Future updates to job and GDP estimates following this methodology could consider including an industry survey for further accuracy.

The final employment and GDP estimates by sub-sector, including intensity ratios, can be found in the tables at the end of Appendix A.

4. Developing a green energy company database

Delphi worked with both publicly and privately available business directories and databases to compile a list of relevant companies by green economy sub-sector. Companies were identified through secondary business data, trade / membership body databases, and the research team's knowledge of key businesses and networks in Alberta. Directories included:

- Calgary Economic Development's Renewable Energy company list;
- GLOBE Series Conference and Expo database;
- Industry Canada Company Capabilities database;
- Hoover's database;
- Relevant sector-specific reports;
- Various industry association membership lists; and
- Various corporate directories including Scotts, Yellow Pages, and directories either published by or linked to by the Provincial Government.

5. Undertaking a comparative analysis with global cities

The comparative city analysis involved a multi-stage process. First, Delphi identified a short-list of cities that mirrored Calgary by one or more of the following factors: size, key industries, innovation clusters, and/or relevant geographic location. In total, Delphi reviewed 35 cities in detail, including:

- World Energy Cities Partnership participants
- Leading 'green cities' and innovation hubs
    - **North America:** 16 cities (in Canada, USA – AK, CA, CO, HI, IL, MA, NY, OR, TX)
    - **Europe:** 9 cities (in Austria, Denmark, Finland, Germany, Norway, Scotland)
    - **Asia:** 7+ cities (in China, South Korea, Japan, Singapore)

Each city was scanned for research institutions, evidence of cluster development, building code and energy efficiency regulations, climate plans, economic development plans, green energy sector and smart city related programs and initiatives, and other innovative initiatives that could support Calgary's interest in potentially growing the green energy economy.

Delphi then selectively sourced information from various international studies and reports on municipal economic development best practices published by organizations such as the Urban Sustainability Directors' Network (USDN), ICLEI Local Governments for Sustainability, C40 Cities Climate Leadership Group, the New Climate Economy, CDP, the International Institute for Sustainable Development, the Rockefeller Foundation's 100 Resilient Cities, Siemens Green City Index, the United Nations Environment Programme (UNEP), the Organization for Economic Co-operation and Development (OECD), and others.

6. Undertaking SWOT, value chain mapping, and gap analyses;

Delphi conducted an analysis of the strengths, weaknesses, opportunities, and threats (SWOT) associated with the green energy economy and related sub-sectors for Calgary and surrounding area. The SWOT analysis was based on the extensive research carried out for this project and validated through strategic and targeted industry outreach as described below.

Delphi highlighted key observations as it relates to the green energy economy sub-sectors in Calgary and surrounding area, including how current federal and provincial priorities related to green economy and climate change policy and investments, as well as global megatrends, may impact on existing or potential future business and investment attraction opportunities, create inherent risks, and/or generate export development possibilities for local businesses. The SWOT also highlights how Calgary Economic Development and other key stakeholders in Alberta may consider positioning in order to capitalize on the opportunities and mitigate potential threats by addressing existing weaknesses.

In addition to the SWOT analysis, value chain mapping was conducted based on examining input-output related sources and by examining Alberta based international trade for "green" commodity exports.

Delphi (and previously GLOBE Advisors) have developed a detailed list of green HS commodity codes by which Canada and other World Trade Organization (WTO) countries classify the movement of international trade. This list of green HS commodity codes was initially developed by the United States International Trade Administration (ITA) for environmental goods and services including renewable energy technologies. This list has been modified and new commodities added by Delphi over the past few years through several international trade related consulting assignments.

Green energy sector exports and imports were tabulated from this amended HS commodity code list for Alberta. Subsequently, the total Alberta production for these commodities were estimated through export intensity multipliers that are included in the Input Output multipliers that Statistics Canada provided to us. Production data for these green commodities were converted to 4-digit NAICS codes and an Input Output shock was prepared in order to derive a value chain of the upstream industries associated with this green output.

The resultant set of green energy value chains for the four sub-sectors were then compared with highly relevant value chains developed for two other Input Output related work that the consultants had been working with. These included an Input Output shock for electricity production that showed the detailed upstream industries that were involved; another on green buildings that showed the relevant upstream industries and another value chain derived for green transportation components from the Statistics Canada Input Output Accounts.

In addition to the development of Input Output derived value chains for the four green groups, the consultants worked with an economic impact model developed by the United States National Laboratory for Renewable Energy (NREL) that more specifically shows the upstream components for solar power, wind power, geothermal, run-of-river hydro, large hydro, cellulose ethanol and pyrolysis (bio-crude oil / syn gas). The NREL model provided more specific component industries for each of these renewable energy technologies.

A value chain gap analysis was then undertaken. The gap analysis was estimated by showing the number of business counts for each industry component of the value chains that were identified through both the Statistics Canada Input Output modeling and the upstream renewable energy technologies identified through the NREL model.

Based on this work, it was shown that the Calgary Region has minimal capacity based on business counts for the manufacturing components of these green value chains. However, Calgary Region has a strong capacity based on business counts for many of the high value added professional services including engineering and scientific services.

The Input Output modeling also showed data on inter-provincial and international trade at the provincial level. Many of the green "manufacturing" components were either imported from other provinces or internationally. Alberta (and Calgary Region) though has a strong capacity in professional services that are included in these green value chain components.

7. Conducting in-depth interviews with industry leaders

Delphi developed a prioritized list of industry leaders, experts, and key stakeholders for key informant interviews. The Delphi project team interviewed 35 key industry stakeholders in order to build on existing knowledge, fill-in research gaps, review the relevant industry and market trends, test potential investment attraction strategies, and validate the preliminary SWOT and value chain gap assessments.

Delphi interviewed a diverse number of players across the value-chain including:

- Relevant industry associations and non-profit organizations (e.g., CanWEA, CanSIA, CanGEA, Pembina Institute, etc.)
- Government bodies, research agencies, and post-secondary institutions (E.g., City of Calgary, Calgary Economic Development, Alberta Innovates, SAIT, etc.)
- Corporate buyers and/or technology adopters (Suncor, Enbridge, ENMAX, GE, etc.)
- Equipment and technology suppliers (firms of different sizes and from the relevant sub-sectors)
- Firms supplying green energy related services (architecture, design, consulting, etc.)
- Financial players (e.g., VC firms, etc.)

Delphi used an interview questionnaire and conducted the interviews both in person and by telephone, allowing for contact with respondents in geographically dispersed locations. Delphi then summarized the interviews and integrated the key findings into the study.

8. Organizing the Green Energy Economy focus group

Delphi organized a green energy economy focus group on October 20, 2016, hosted in Calgary Economic Development's Global Business Centre. The focus group was designed to seek additional feedback and input from stakeholders on the research and key findings, including the investment attraction opportunities, key barriers and risks, and the initial SWOT and value chain gap analysis.

The Delphi project team ensured that focus group participants provided a cross-section of individuals representing businesses, R&D agencies, educational institutions and training bodies, government, and other key stakeholder groups.

Approximately 4 hours in length, the focus group session was attended by approximately 25 industry stakeholders and consisted of two 40-minute presentations that were followed immediately by focus group discussions at breakout tables facilitated by Delphi Group staff.

Intensity Ratio	Renewable Power Supply & Alternative Energy	Total Jobs	Green Jobs	Green Gross Output ($ Thousands)	Gross Output per Job ($ Thousands)	Green GDP ($ Thousands)
0.060	2211 - Electric power generation, transmission and distribution	4,757	285	$185,208	$648.89	$119,222
0.006	2379 - Other heavy and civil engineering construction	2,124	13	$3,220	$252.66	$1,417
0.008	2389 - Other specialty trade contractors	8,341	63	$15,113	$241.57	$6,372
0.000	3336 - Engine, turbine and power transmission equipment manufacturing	12	0	$0	N/A	$0
0.250	3344 - Semiconductor and other electronic component manufacturing	204	51	$7,897	$154.71	$3,464
0.100	3353 - Electrical equipment manufacturing	518	52	$17,037	$328.73	$7,106
0.008	5413 - Architectural, engineering and related services	37,586	316	$68,963	$218.43	$41,690
0.001	5414 - Specialized design services	2,235	2	$137	$76.78	$65
0.003	5416 - Management, scientific and technical consulting services	19,094	53	$10,640	$199.00	$6,445
0.040	5417 - Scientific research and development services	1,310	52	$9,134	$174.26	$6,626
0.040	5622 - Waste treatment and disposal	779	31	$7,579	$243.32	$6,003
	TOTAL	**76,962**	**918**	**$324,927**	**$353.90**	**$198,411**

Intensity Ratio	Energy Storage & Grid Infrastructure	Total Jobs	Green Jobs	Green Gross Output ($ Thousands)	Gross Output per Job ($ Thousands)	Green GDP ($ Thousands)
0.030	2211 - Electric power generation, transmission and distribution	4,757	143	$92,604	$648.89	$59,611
0.004	2371 - Utility system construction	12,112	48	$12,241	$252.66	$5,387
0.000	3336 - Engine, turbine and power transmission equipment manufacturing	12	0	$0	N/A	$0
0.040	3345 - Navigational, measuring, medical and control instruments manufacturing	1,141	46	$7,063	$154.71	$3,099
0.100	3353 - Electrical equipment manufacturing	518	52	$17,037	$328.73	$7,106
0.050	3359 - Other electrical equipment and component manufacturing	532	27	$8,183	$307.65	$2,526
0.003	5413 - Architectural, engineering and related services	37,586	105	$22,988	$218.43	$13,897
0.001	5414 - Specialized design services	2,235	1	$103	$76.78	$49
0.001	5416 - Management, scientific and technical consulting services	19,094	13	$2,660	$199.00	$1,611
0.030	5417 - Scientific research and development services	1,310	39	$6,851	$174.26	$4,970
	TOTAL	**79,299**	**475**	**$169,729**	**$357.70**	**$98,254**

Intensity Ratio	Green Building & Energy Efficiency	Total Jobs	Green Jobs	Green Gross Output ($ Thousands)	Gross Output per Job ($ Thousands)	Green GDP ($ Thousands)
0.032	2361 Residential building construction	15,242	488	$109,887	$225.30	$46,777
0.215	2362 Non-residential building construction	10,511	2,260	$588,093	$260.25	$220,608
0.096	2372 Land subdivision	3,927	377	$95,292	$252.66	$41,936
0.020	2379 Other heavy and civil engineering construction	2,137	43	$10,799	$252.66	$4,752
0.072	2381 Foundation, structure, and building exterior contractors	12,468	898	$226,927	$252.66	$99,866
0.072	2382 Building equipment contractors	20,324	1,464	$353,690	$241.57	$149,135
0.072	2383 Building finishing contractors	13,970	1,006	$243,117	$241.57	$102,512
0.072	2389 Other specialty trade contractors	8,590	619	$149,491	$241.57	$63,034
0.072	3141 Textile furnishings mills	48	3	$586	$170.46	$233
0.072	3149 Other textile product mills	131	9	$1,611	$170.46	$641
0.900	3219 Other wood product manufacturing	128	115	$18,870	$163.80	$7,019
0.096	3255 Paint, coating and adhesive manufacturing	143	14	$5,117	$372.35	$1,824
0.096	3273 Cement and concrete product manufacturing	1,045	100	$35,031	$349.06	$15,606
0.096	3274 Lime and gypsum product manufacturing	6	1	$175	$304.47	$83
0.096	3323 Architectural and structural manufacturing	138	13	$3,113	$234.82	$1,137
0.300	3334 Ventilation, heating, air-conditioning and commercial refrigeration equipment manufacturing	889	267	$62,794	$235.35	$28,920
0.165	3345 Navigational, measuring, medical and control instruments manufacturing	1,142	188	$29,161	$154.71	$12,793
0.250	3351 Electric lighting equipment manufacturing	40	10	$2,370	$234.81	$1,068
0.150	3352 Household appliance manufacturing	305	46	$13,934	$304.09	$4,135
0.150	3353 Electrical equipment manufacturing	518	78	$25,555	$328.73	$10,659
0.150	3359 Other electrical equipment and component manufacturing	534	80	$24,641	$307.65	$7,605
0.215	3372 Office furniture (including fixtures) manufacturing	975	210	$31,557	$150.51	$14,013
0.096	3379 Other furniture-related product manufacturing	295	28	$8,058	$284.70	$1,900
0.035	5413 Architectural, engineering and related services	37,882	1,326	$289,611	$218.43	$175,078
0.035	5414 Specialized design services	2,288	80	$6,150	$76.78	$2,904
0.010	5415 Computer systems design and related services	16,873	169	$31,070	$184.14	$18,109
0.010	5416 Management, scientific and technical consulting services	19,750	198	$39,304	$199.00	$23,807
0.015	5417 Scientific research and development services	1,318	20	$3,446	$174.26	$2,500
0.096	5617 Services to buildings and dwellings	3,219	309	$25,048	$81.01	$13,109
0.50	8112 Electronic and precision equipment repair and maintenance	887	44	$6,256	$141.12	$3,873
0.050	8113 Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	3,400	170	$23,987	$141.12	$14,850
0.050	8114 Personal and household goods repair and maintenance	1,106	55	$3,674	$66.46	$2,509
	TOTAL	**181,457**	**10,689**	**$2,468,415**	**$230.94**	**$1,092,998**

Intensity Ratio	Green Transportation	Total Jobs	Green Jobs	Green Gross Output ($ Thousands)	Gross Output per Job ($ Thousands)	Green GDP ($ Thousands)
0.000	3336 Engine, turbine and power transmission equipment manufacturing	13	0	$0	N/A	$0
0.000	3353 Electrical equipment manufacturing	518	0	$0	N/A	$0
0.000	3359 Other electrical equipment and component manufacturing	534	0	$0	N/A	$0
0.000	3361 Motor vehicle manufacturing	5	0	$0	N/A	$0
0.000	3363 Motor vehicle parts manufacturing	115	0	$0	N/A	$0
1.000	3365 Railroad rolling stock manufacturing	1	1	$328	$328.28	$130
0.500	3369 Other transportation equipment manufacturing	51	25	$13,536	$533.51	$3,358
0.650	4821 Rail transportation	1,755	1,141	$277,337	$243.15	$175,120
0.850	4851 Urban transit systems	694	590	$35,356	$59.92	$47,123
0.100	4859 Other transit and ground passenger transportation	572	57	$6,755	$118.11	$4,426
0.650	4882 Support activities for rail transportation	2,001	1,301	$286,432	$220.17	$131,428
0.010	5416 Management, scientific and technical consulting services	19,750	198	$39,304	$199.00	$23,807
0.005	5417 Scientific research and development services	1,318	7	$1,149	$174.26	$833
0.003	8111 Automotive repair and maintenance	5,684	17	$1,615	$94.69	$1,007
0.050	8114 Personal and household goods repair and maintenance	1,106	55	$3,674	$66.46	$2,509
	TOTAL	**34,118**	**3,392**	**$665,483**	**$196.22**	**$389,740**

Appendix B: SWOT Analysis

The list below is a summary of a strengths, weaknesses, opportunities, and threats (SWOT) analysis designed to help better understand the current state of Calgary's Green Energy Economy and related sub-sectors. This list was created based on secondary research, feedback obtained from industry stakeholders during consultation, as well as a review of current federal and provincial policy and investment priorities.

STRENGTHS

- Highly competitive, de-regulated energy sector allows for renewable energy projects to be brought forward at least cost to the market.
- Low energy prices combined with low tax environment and U.S. currency exchange rate at present can serve to attract manufacturing.
- Emerging supportive policy landscape (both federally and provincially), including renewable energy targets, the retirement of coal-fired electricity, and a broad-based price on carbon.
- Considerable federal and provincial investments in renewable energy, storage, energy efficiency, green building, clean transportation, and clean technology provide opportunities for Calgary to tap into funding for these sectors to support joint projects / initiatives – including $120 billion in federal infrastructure funding, $1 billion for federal cleantech funding, $3.4 billion for green energy economy projects in Alberta, and $645 million in energy efficiency over next five years from Province of Alberta.
- ERA serves as an established funding vehicle for investing in green energy economy projects and solutions.
- The Calgary region and Alberta more generally currently has an abundance of entrepreneurial 'knowledge' workers with experience in the energy sector (primarily oil and gas) with transferrable skill sets, including professional engineers, trades, and related services such as ICT specialists.
- Considerable experience exists in Alberta for developing a broad range of renewable energy projects (including utility-scale wind, solar, and hydro, as well as district energy, bioenergy, and commercial scale and residential solar PV projects), as well as transferrable expertise in geomatics, mapping, GIS, and sensors.
- Some expertise exists at the University of Calgary around electro-chemistry (i.e., CAESR), including fuel cells and flow batteries relevant for industrial applications and/or utility-scale energy storage.
- Calgary has relatively strong expertise in energy efficient modular construction and pre-fabrication, as well as expertise in the design of net zero homes and communities.
- Many service providers in the industrial energy efficiency space exists in Alberta – a strength that could be transferred to other sectors / industries.
- A growing segment of technology startups in Alberta, some focused on cleantech and the energy sector.

WEAKNESSES

- Current low energy prices (based on natural gas and coal-fired electricity) combined with the lack of peak and time-of-use pricing makes it a challenge for renewable energy options to compete without a strong policy mandate.
- Weak economy in Alberta with dampened government royalties and revenues from corporate and personal income taxes make funding green energy economy incentive programs challenging.
- The Calgary region has a small / niche manufacturing base with most products, equipment, and technology imported from outside the province of Alberta.
- Alberta is a relatively small market from a global perspective making 'economies of scale' a challenge in terms of large-scale manufacturing of renewable energy equipment and technologies.
- Alberta has relatively high labour costs compared to global manufacturing centres, making manufacturing a further challenge from a cost competitiveness perspective.
- Research and development activities in the energy sector are largely focused on oil and gas (42 Research Chairs in O&G vs. 3 in renewable energy).
- Low public awareness of the potential benefits of renewable energy in Alberta and with respect to broader energy literacy which creates real and perceived barriers.
- There is a lack of market demand or 'receptor' capacity for local technology – lots of research and interest in innovation but need support downstream with commercialization, procurement, and industry adoption.
- There is a low level of risk tolerance for renewable energy technologies in Alberta, with a mindset largely focused on the O&G sector – funding for R&D / innovation often goes to proven technologies or what has worked in the past.

- Considerable investment in fossil fuel energy based infrastructure in Alberta makes the transition to new sources structurally challenging and costly.
- Lack of smart meters installed in the Calgary region limits the amount of demand side management technologies.
- Current policy double charges energy storage companies (T&D) as both a producer and a consumer.

OPPORTUNITIES

- Potential to position for the global megatrend toward the 'digitalization' and automation of the energy, building, and transportation sectors by investing in and developing programs to support companies and partnerships in this space.
- Application of geomatics, GIS, and sensors-based expertise to renewable energy sub-sector, including remote sensing and real-time monitoring, asset optimization, etc.
- Developing local expertise in energy storage 'services stacking' combined with renewable energy technology grid integration.
- Geothermal presents an opportunity given the number of orphaned oil wells in Alberta and the number under-employed workers with transferrable skills from the oil and gas industry.
- Opportunities for closing loops on organic waste streams to create bioenergy opportunities (e.g., biogas capture for energy production, anaerobic digestion for fueling municipal fleets, etc.)
- Distributed generation, micro-grid, and energy storage solutions could enable Calgary to become more resilient to extreme weather events, energy price spikes, etc.
- Energy efficiency building retrofits and related services.
- Cloud-connected services, software development, and predictive data analytics to support energy, buildings, and transportation system optimization and efficiencies (e.g., wind monitoring centre).
- Smaller-scale, niche manufacturing opportunities to support the existing green energy economy value chain, particularly in smart grid, energy efficiency, and green building.
- Green building materials design and development for the local and export market such as carbon-capture and utilization into value-added products like cement.
- Explore expanded partnerships with other levels of government, academia, and private sector, including multi-nationals active in the green energy economy (e.g., Siemens, GE, ABB, Schneider Electric, etc.), to bring forward new projects and collaborative initiatives in the energy efficiency, smart grid / smart cities, and energy storage space.
- Work with ENMAX, City of Calgary, and others to create specific City-focused challenges (in areas such as smart buildings, micro generation, biofuels for fleets, etc.) with Calgary as a 'living lab' and invite solution providers to address the challenges through demonstration and/or an accelerated procurement process with an acceptable risk tolerance (e.g., Montreal's InnoCite or San Francisco's StartUp In Residence programs).
- Educate local residents / public, investors, private sector, and City officials on the green energy economy megatrends, opportunities for sector growth and local businesses, alignment with existing energy sector, etc.

THREATS

- Integration of renewables could impact on grid reliability without effective smart grid and energy storage infrastructure in place.
- Future changes to provincial or federal government could change the policy landscape in Alberta, removing some of the drivers and/or incentives for developing more green energy economy projects.
- Push-back from the public and/or lack of public support for renewable energy projects may create challenges with 'NIMBYism'.
- Fears that investment capital tied up in conventional energy sector could be stranded in the province because of policy changes resulting in push-back from certain sectors.
- The evolution of technology and/or breakthrough products or processes could render current investments in today's technology obsolete and/or more costly in the long-run.
- Climate change impacts may affect certain technologies more than others (e.g., changes to hydrological cycles could impact on the availability of water for hydroelectricity generation).

Appendix C: Comparative Cities Analysis

Research on green energy economy leaders from across Canada, the United States, Europe, and Asia identified more than a dozen common areas of economic development activity being pursued by these urban centres in order to attract investment, encourage entrepreneurship and innovation, grow local businesses, and create jobs while simultaneously leveraging a variety of environmental and community benefits, as outlined in the table below.

Economic Development Initiative	Example Cities
Building Code Requirements	Copenhagen, Stockholm, Oslo, Zurich, Seattle, San Francisco, Washington (DC), Toronto, Vancouver, Singapore
Building Retrofit Programs	Copenhagen, Berlin, Boston, New York, Portland, Seattle
Business / Tax Incentives	Amsterdam, Glasgow, Philadelphia, Denver, Halifax, Atlanta
Business Incubator & Accelerator Programs	Amsterdam, Helsinki, London, Boston, Chicago, New York, Calgary, Toronto, Vancouver, Montreal
Business Hub / Cluster Development	Copenhagen, Glasgow, Helsinki, Boston, Chicago, New York, Portland, San Francisco, San Jose, Vancouver
Climate Adaptation & Green Infrastructure	Copenhagen, Rotterdam, Denver, Portland, Philadelphia, Vancouver
District Energy	Copenhangen, Helsinki, Vaxjo, Dubai (cooling), Paris (cooling), Vienna
Eco-districts / Net-zero Energy Neighbourhoods	Copenhagen, Munich, Denver, Portland, Vancouver
Green Public Procurement	Amsterdam, Copenhagen, Helsinki, Rotterdam, Philadelphia, Portland, San Jose, San Francisco, Vancouver, Montreal
Loan & Financing Programs (e.g., green bonds)	Amsterdam, Copenhagen, Helsinki, Denver, San Francisco, San Jose, Portland, New York, Toronto
Smart City Initiatives & Technology Demonstration	Amsterdam, Bristol, Copenhagen, Glasgow, London, Oslo, New York, Seattle, Columbus, Surrey, Toronto, Montreal, Singapore, Taipei
Solar Deployment (PV & thermal)	Dezhou, California (state), Hawaii (state), New Jersey (state), Chandigarh, Vienna
Transit & Cycling Infrastructure	Amsterdam, Copenhagen, Chicago, New York, Portland, San Francisco, Washington (DC), Vancouver

Overarching Insights

A few of the key from this take-aways review include:

- Most cities with vibrant green energy sectors are ‘all in’ including:
    - Government support exists at multiple levels, from national to regional and local, including progressive regulation, policies, and supporting incentives.
    - Research and innovation partnerships are embraced between public-private-academic institutions and creative programs have been developed to encourage piloting and demonstration of local and/or imported green energy technologies through projects that serve as a learning opportunity for both the public and private sector entities.
    - The private sector, often also supported by government, provides a range of business supports for the technology developers and solution providers in terms of incubator and accelerator programs, financing programs, and other relevant ecosystem support.

- Some cities are stronger in one specific aspect of the green energy economy (e.g., green building, solar PV, etc.) and will position themselves accordingly. Strong local market demand and/or manufacturing cluster strengths favour the positioning in certain areas.
- Some cities are embracing the green energy sector and related 'systems-based' approach as a 'resiliency' strategy. As one example, Greensburg, Kansas, was a coal town flattened by a tornado in 2007. The town has since rebuilt going nearly 100% renewable, becoming a leader in the United States in terms of the number of LEED certified buildings and homes and now being nearly fully powered by wind.[96]

Program Examples

Out of the data collected, Delphi developed a short list of case studies that could serve as templates and inspiration for programs in Calgary. These case studies were narrowed into three categories: (1) 'challenge' focused programs, (2) demonstration / commercialization programs, and (3) smart grid / smart city focused programs. A sample of best-in-class examples are provided below.

Challenge Programs

- **World2NYC[97]** - Through a competitive selection process, the World2NYC Global Industry Challenge program brings the most innovative later-stage companies and established start-ups from around the globe to NYC. While they are in New York, each company gets an inside look into the city's ecosystem as they build partnerships with local and national firms, as well as relevant community and business groups.

  In 2014, the NYC Economic Development Corporation (NYCEDC) began running a theme-based program focused on local activities and challenges. The reason for switching formats was to make the program more focused and cohesive. The first in the spring of 2014 focused on "new manufacturing" (e.g., rapid prototyping and 3D-printing) and involved 10 international organizations (from Spain, Netherlands, Japan, and Italy), 55 local organizations, and over 300 participants. In the fall of 2014, the program focused on "smart sustainable cities", as well as State-wide opportunities for smart energy projects. The fall agenda included 15 participating companies from 10 countries.
- **RISE NYC[98]** – RISE NYC is a Superstorm Sandy business recovery and resiliency program that helps New York small businesses adapt to and mitigate the impacts of climate change through the use of innovative technologies. The competition funds projects at Sandy-impacted small businesses to prepare their buildings, energy systems, and telecom networks for extreme weather. RISE: NYC launched in January 2014 and received over 200 applications from over 20 countries around the world. 11 winning projects will share $30 million to implement their innovative projects at small businesses that were impacted by Superstorm Sandy.
- **San Francisco's StartUp in Residence (STIR)[99]** – The San Francisco Mayor's Office of Civic Innovation in partnership with San Fran Dept. of Technology. STIR connects government agencies with innovative startups to develop technology products that address civic challenges. A 16-week program during which startups volunteer their time to work with government partners to get to the root of civic challenges through user-testing, skills-sharing, data analysis, and prototyping a solution. In 2016 the program was expanded to address civic challenges across thirteen departments across four cities (San Fran, Oakland, San Leandro, West Sacramento).
- **Helsinki's Nordic Innovation Accelerator[100]** – Its goal is to accelerate SME growth by networking and cooperation. The NIA program hosts challenges that various partners will post and members are then invited to provide relevant solutions. The first challenge was posted by Veolia Environment to NIA members, inviting them to submit solutions related to moisture measurement. Additional challenges have related to innovation around waste logistics and stormwater management.

Demonstration / Commercialization

[96] See: http://energy.gov/sites/prod/files/2013/11/f5/48300.pdf and http://www.usatoday.com/story/news/greenhouse/2013/04/13/greensburg-kansas/2078901
[97] See: http://www.nycedc.com/program/world-nyc
[98] See: http://rise-nyc.com/
[99] See: https://startupinresidence.org/
[100] See: https://www.nordicinnovationaccelerator.com/

- **Prospect SV**[101] – Provide a full spectrum of commercialization support including market and technical insight, connections to partners and investors, pilot opportunities as well as access to a $12 million, 23,000 sq. ft. Technology Demonstration Center with working industrial space, lab facilities, and specialized equipment. In partnership with state and local governments, Prospect SV demonstrates and scales leading edge solutions. Now have projects in over 50 cities, leveraging over $50 million in funding and financing, and more than 25 corporate sponsors.
- **Austin's Pecan Street Research Institute**[102] - Since Pecan Street's founding, its demonstration-based approach to research has become an international model for how to develop and operate real-world smart community projects that advance university education, and community and industry preparedness. Its flagship effort is the Pecan Street Demonstration, a smart grid research project that began in Austin's Mueller community and has since expanded across Texas and into California and Colorado.

  Pecan Street is focused on advancing university research and accelerating innovation in water and energy. Based at University of Texas, technology companies and university researchers are able to access the world's best data on consumer energy and water consumption behavior, testing, and verification of technology solutions, as well as commercialization services to help them bring their innovations to market faster.

  The institute helps prepare technically-focused students for careers with industry, and helps them conduct research that will change the world. Pike Powers Commercialization Lab (offering developing, testing, validating space for smart consumer electronics / applications). Large and small companies and researchers will be able to test consumer products and new technologies that will be found in tomorrow's homes and businesses.
- **Waterfront Toronto**[103] - Waterfront Toronto, is an organization administering revitalization projects. Formed as a partnership of three levels of Canadian government in 2001, the organization is directed to support the following policy objectives of the three levels of government that are involved: Reducing urban sprawl; Developing sustainable communities particularly in the area of energy efficiency; Redeveloping brownfields & cleaning up contaminated land; Building more affordable housing; Increasing economic competitiveness; Creating more parks and public spaces. Waterfront Toronto was the 2014 winner of Intelligent Communities Forum international smart cities competition.
- **Vancouver's Green & Digital Demonstration Program**[104] – The GDDP provides access to City of Vancouver resources (i.e., buildings, streets, vehicles, digital infrastructure) for product testing and showcase opportunities, as well as critical follow-on connections and support from VEC and City of Vancouver staff. GDDP is jointly delivered by the Vancouver Economic Commission (VEC) and the City of Vancouver. The VEC and City lend staff time to support the launch and implementation of each pilot project and the benefits go well beyond the provision of physical assets for temporary trials. As the agency responsible for managing GDDP, the VEC collects and screens applications, guides successful candidates through the demonstration process, and promotes successful projects. The City is responsible for providing in-kind support and staff time to manage the installation and operation of the pilot on available assets. These could be physical installations on city assets, or the implementation and testing of digital programs by city staff.

Smart Cities

- **Future City Glasgow**[105] – Glasgow uses open data from a wide range of sources across the city and pools it to allow users to create or update their own Open Dashboard from a range of digital widgets. Over 4 weekends, 240 members of the public joined forces to hack the future of their city, they created 33 products and service ideas to improve transport, health, energy and public safety in Glasgow. Glasgow City Energy Model will map in 2D & 3D the energy consumption of residents and businesses across Glasgow.
- **Amsterdam Smart City Initiative**[106] – ASC initiative is a unique partnership between business, government, research institutions, and the public to develop the Amsterdam Metropolitan Area into a smart city through open platforms, testing, and an urban "living lab". There are 700 projects within five core themes (Mobility, Living, Society, Economy, Big and Open Data) that are often inter-connected and used to create the living labs.
- **Fredericton's Siemens COE in Smart Grid**[107] – Started as a project w/ NB Power, then with University NB and became a global COE for smart grid technology development – Siemens has 50 R&D focused on smart grid. Officially launched

[101] See: http://prospectsv.org/
[102] See: http://www.pecanstreet.org/what-is-pecan-street-inc/
[103] See: http://www.waterfrontoronto.ca/
[104] See: http://www.vancouvereconomic.com/gddp
[105] See: http://futurecity.glasgow.gov.uk/
[106] See: https://amsterdamsmartcity.com/
[107] See: https://www.nbpower.com/en/about-us/news-media-centre/news/2016/nb-power-siemens-and-unb-launch-network-to-spur-innovation/

the ‘Smart Grid Innovation Network’ in January 2016. Now smaller companies with R&D problems can access the facilities to benefit their solutions.

- **Montreal’s InnoCité MTL**[108] – “Canada’s 1st Smart City Accelerator Program”. A startup accelerator that directly addresses the needs of city dwellers. The private sector, mainly formed by startups, will implement solutions to urban issues focusing on the areas prioritized by the Montréal Smart and Digital City Action Plan 2015-2017. It brings startups and cities together to make cities smarter. Cities from all around the world are looking for solutions to accelerate their shift to the 21st century. This is a huge market opportunity and we want to help startups to leverage this opportunity. The program includes 3 steps:
    - Step 1 – SELECTION: Five startups were selected for the first cohort and they began on March 14, 2016. Currently looking for startups for our next cohort which will begin in September 2016.
    - Step 2 – ACCELERATION: The 12-week acceleration program focuses on product market fit and includes: A catalog of training and practical workshops; Diverse mentors ecosystem including entrepreneurs, corporate executives as well as municipal representatives; Individual coaching throughout the program for selected startups; and the possibility to test products with the City of Montreal or other InnoCité partners. The acceleration will be divided into three phases: (1) Defining value proposition (weeks 1 to 4); (2) Achieving and demonstrating scalability of the product/business (weeks 5 to 8); (3) Establishing go-to-market strategy (weeks 9 to 12)
    - Step 3 – TEST: Personalized coaching for startups that run a pilot project with the City of Montreal or another partner of InnoCité.

[108] See: http://innocitemtl.ca/en/le-programme/?lang=en