A GENOMICS STRATEGY FOR BRITISH COLUMBIA'S

EXTRACTIVE INDUSTRIES SECTOR

Genome BritishColumbia
Leading ▸ Investing ▸ Connecting

2019

Contents

1. Importance of the extractive industries sector to the BC Economy

The mining and energy industries provide the raw materials needed to build and power our modern economy and infrastructure. Collectively, these industries are referred to here as the "Extractive Sector". Canada is rich in natural resources and has invested heavily in developing these resources, becoming global leaders in extracting, processing and getting these products to market. Both the private and public sectors in Canada maximize these resources and economic opportunities through research, development and the application of novel technologies, developing robust geological databases for mineral and energy deposits and creating a globally competitive and highly qualified workforce.

In British Columbia the extractive sectors employ over 67,000 people and is the largest employer of First Nations people in the province.[1] Direct incomes for these sector employees are nearly double that of the provincial average. Over the next ten years, the mining industry is projected to hire an additional ninety-seven thousand workers in the province.[2] The automation of mining sites, conversion to electric vehicles and adoption of genomic tools for environmental monitoring and remediation will require a highly qualified workforce, driving higher wages in the resource sector.[2] Furthermore, the transportation, processing and refining of metals, minerals and fuels, as well as other industries that support the extractive sector will grow providing the services needed to get BC's natural resources to consumers.

To remain globally competitive, companies are continually exploring ways to improve operating efficiency, reduce input costs and produce higher value products. Innovations such as autonomous trucks, centralized computer controlled equipment, digital modeling/mapping and predictive maintenance have supported the extractive sector's efficiency pursuits. Other sector innovations include the implementation of genomics tools to optimize microbes through biological engineering enhancing bioleaching and bioreactor effectiveness. Genomics tools can provide solutions to many of the challenges faced by the extractive industries in Canada.

2. Current state of the extractive industry sectors

British Columbia is home to the largest concentration of exploration companies in the world.[3] This clustering of companies might be linked to BC's advanced transportation infrastructure networks, access to capital, as well as its proximity to markets. In addition, the Canadian extraction sector strives to develop advanced industrial health and safety practices, identify novel technologies and optimize innovation across the sector, internationally.

Key statistics for extractive industries in Canada

Mining Production in Canada[1]

- $97 Billion to Canada GDP (2017)
- Directly employs 426,000 and indirectly supports 206,000 in Canada
- $1.5 Billion on exploration in 2017

Canadian Mining Production[4]

- Metals = $24 Billion
- Non-metals = $13.6 Billion
- Coal = $6.4 Billion
- Total = $43.9 Billion

Top Canadian Resources[1]

- 1st Gold ($8.7 Billion)
- 2nd Coal ($6.2 Billion)
- 3rd Copper ($4.7 Billion)
- 4th Potash ($4.6 Billion)
- 5th Iron ore ($3.8 Billion)

Mining Production in British Columbia[1]

- $8.8 Billion in 2017
- $258 Million on exploration in 2017

Top BC Resources[5]

- 1st Coal (mostly metallurgical) ($5.96 Billion) [6]
- 2nd Copper ($2.3 Billion)
- 3rd Gold ($700 Million)
- 4th Molybdenum ($112 Million)
- 5th Silver ($41 Million)

Energy Production in Canada[7]

- $230 Billion to the Canadian GDP (2018)
- Directly employs 269,019 and indirectly supports 550,588 in Canada
- Canadian Governments spent over $799 Million on energy R&D between 2017–2018

Top Global Energy Stats for Canada[8]

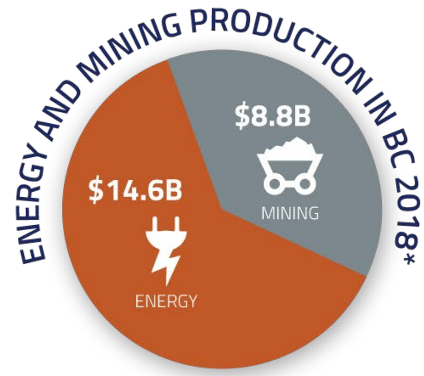
- 6th largest energy producer globally
- 5th largest energy exporter globally
- 2nd largest producer of hydropower globally
- 2nd largest producer of uranium globally
- 3rd largest crude oil reserves (proven)
- 6th largest producer of biofuels globally

Energy Production in British Columbia[9]

- The energy sector generated $14.6 Billion towards the GDP in 2018[7]
- Energy sector provided 22,000 jobs in 2017 in the province[1]
- 75,500 barrels a day of crude, 1.4% of national total (2017) [10]
- 4.5 Billion cubic feet per day (Bcf/d), 29% of 2017 Canadian Production[11]
- 11 Mb/d of Natural Gas Liquids (NGL) production represents about 12% of total Canadian production

Top Energy Production Stats for British Columbia[7]

- 2nd largest producer of hydroelectricity in Canada (by installed capacity)
- 2nd largest Natural Gas Producer, 29% of 2017 Canadian Production[10]
- 4th largest Oil production in the country producing
- 4th largest wind energy producer



MINING AND ENERGY DIRECTLY SUPPORTS **695,000** JOBS IN CANADA*

BC PRODUCED **4.5B** CUBIC FEET OF NATURAL GAS PER DAY 29% OF 2017 CANADIAN PRODUCTION †

TOP BC RESOURCES*
1) COAL ($5.96B)
2) COPPER ($2.3B)
3) GOLD ($700M)
4) MOLYBDENUM ($112M)
5) SILVER ($41M)

SOURCE: NATURAL RESOURCES CANADA*
NATIONAL ENERGY BOARD †

3. Sector challenges and opportunities

The development and operation of oil and gas wells, mines, refineries, hydro-electric dams and other large-scale operations can provide jobs, create new products and energy, spur the development of technology and provide the foundation modern economies rely on. They can also generate greenhouse gases, contaminate water sources, displace wildlife and communities, and create hazardous chemicals. These projects can take decades to build and operate, leaving behind legacy structures such as tailings facilities, massive earth dams that are expected to contain waste for hundreds of years. Until viable alternatives are found, we need to balance the benefits the extractive industries provide, with impacts to the natural world ensuring we do not pass on today's costs to future generations.

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In the development of new projects, industry must demonstrate to the public, government, First Nations and regulatory agencies that they can operate cleaner, more efficient projects that have a net positive impact on society and the economy. All project partners, including First Nations, must be engaged fully to address the challenges many resource development projects face such as water use and contamination, land use and reclamation, energy consumption, habitat loss and destruction, decreasing ore grades and the storage and treatment of waste products. Proactive engagement of First Nations is paramount to ensuring the continuation of responsible exploration and this is dependent upon transparency, open dialogue, trust, and co-development.

Water use and treatment

Water use and environmental stewardship are essential to the mineral and energy processing cycle; the effort to optimize or minimize water use while striving to prevent contaminants and toxic elements such as metals, solvents and hydrocarbons from entering waterways are critical for extractive projects. Regulatory requirements for projects in British Columbia are highly stringent, further driving the need for the development of protocols and innovative technologies. Currently industry uses several means to treat mine influenced water; one example is bioreactors, which are contained environments designed to support bacteria and drive chemical reactions to end points such as the removal of selenium, nitrates and other unwanted chemicals.

Microbiology

While biologically engineered bacteria can be deployed to drive chemical reactions towards positive outcomes, they can also do the opposite; microbes can accelerate the generation and release of heavy metals on mine sites, resulting in Acid Rock Drainage (ARD). Deep underground, in oil and gas wells, bacteria can produce hydrogen sulfide, a process referred to as souring. Hydrogen sulfide is toxic, corrosive and a significant cost to industry. Microbes are also capable of forming biofilms in pumps, pipes, on ship hulls and many other surfaces where they corrode these materials. Known as Microbially Induced Corrosion (MIC), this has been estimated to cost the extractive industry between $4–$30 Billion annually,[12] as well as result in health and safety issues due to equipment failures and leaks.

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Climate change and energy consumption

Energy for operations is the largest expense for extractive companies and a primary target for improved efficiency. To advance, companies are turning to digitization, seeking out new technologies such as sensors, ore-sorting machines, predictive maintenance and a host of data driven practices that provide a more accurate assessment of extractive operations. These changes have also seen the adoption of cost saving technologies, like automated and electric vehicles that not only decrease hydrocarbon use, but also improve safety by removing people from dangerous site operations.

Mitigating greenhouse gas emissions can be accomplished by preventing emissions, such as those released at oil and gas operations, increasing the conversion of biosolids to methane in wastewater treatment plants to be used as an energy source, and the conversion of industry CO_2 emissions into biofuels and valuable hydrocarbons using algae farms.

New resource discoveries

Exploration for new resources is becoming increasingly more expensive, as companies search deep underground or in oceans for new deposits.[3] Furthermore, the mining industry is seeing decreasing ore grades, increasing the overall amount they need to mine to obtain the same amount of material.[13] The energy sector has been driven by new technologies, such as fracking, that have made access to existing economically infeasible deposits, cost effective. While both industries are subject to price fluctuations of their respective products (oil, gas, gold, copper, iron, etc.), these price shifts can result in economic super cycles, which dictate when companies invest in new operations, research, or decide to temporarily halt or permanently shut down operations.

Genomic tools such as environmental DNA (eDNA) and long-term monitoring programs are essential to understand habitats, species distributions and ecosystem functions that are necessary to restoring functional ecosystems.

Reclamation and environmental monitoring

When extractive operations are completed, companies must restore the land impacted by development to its pre-development state. Rebuilding productive and self-sustaining habitats on sites that have been heavily impacted by industry requires significant information about the local ecosystem, watershed and indigenous species. Genomic tools such as environmental DNA (eDNA) and long-term monitoring programs are essential to understand habitats, species distributions and ecosystem functions that are necessary to restoring functional ecosystems.[14]

Canadian mining and energy companies are working to decrease their impact on the environment and develop energy efficient and clean operations. Gaining public trust is needed for the approval of new projects, and maintenance of their social license for existing operations. In order to make meaningful change and gain public trust, solutions must often operate effectively for decades at a minimum.

4. The role of genomics in addressing sector challenges

Success stories:

Genome BC's extractive project portfolio consists of 15 projects, with a total co-investment of $37.7 Million spanning discovery and applied research. This has supported the development of BC researchers, industrial partners and generation of highly qualified professionals needed to operationalize genomics technologies in this sector. Genome BC's project portfolio in the extractive sector has focused on understanding the environmental impact of development projects, the diversity and utility of microflora in mine sites, gas wells and watersheds and is needed to actively benefit from genomics at the operational level. Since 2007, Genome BC has supported major successes in the advancement of genomics, enabling our industry partners to improve their operations, and benefit from their research collaborations.

Mining companies in BC have advanced the use of genomics and have moved their research from the bench to larger scale application. Their research has supported the development of a biological water treatment facility that processes 7,500 m^3 daily, to reduce selenium (96%) and nitrate (99%) concentrations in water before releasing it to back into the watershed.[15] Oil and Gas company investments into water treatment have created new enterprises that are developing bacteria to clean up the oil sands' water tailings, remediating over 1 Billion m^3 of contaminated water with the potential to address other contaminated sites around the world.


PHOTO: ©ALEX MACLEAN

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Genome BC has supported several mining companies to work with BC academics to advance reclamation techniques using genomics to better understand how the bacteria metabolize and sequester heavy metals and how this can benefit future mine permitting operations. Similarly, Genome BC has supported research into hydrocarbon and fracking fluid degradation by bacteria and plants, allowing energy companies more options when it comes to operating oil and gas operations. Our ever growing portfolio of reclamation work supports clean operations today, while ensuring future projects can exceed environmental standard thresholds of tomorrow.

More information about environmental conditions, the location and health of species and ecosystem functions (soil microbiome, nitrogen fixation, decomposition, etc.) are of increasing importance to model ecosystems and understanding our impact on the environment. BC municipalities have used environmental DNA (eDNA) to map water conditions in their communities, track contaminations and make urban planning decisions to inform their budget decisions, improve the health of British Columbians and reduce negative impact on the environment.

Current initiatives

Water and environment — Water is a critical resource for the extractive sector, and it can carry metals and contaminants far from their source into other watersheds, aquifers, lakes and oceans. Tools such as eDNA can be used in a non-destructive fashion informing the presence/absence of a species, particularly rare species or those in remote areas. In addition, it can help monitor biodiversity of regions and gauge the overall health of ecosystems through disturbances and project operations and thus, be highly effective in monitoring and informing the scope of protective measures for the hydrosphere, as well as the flora and fauna that live within it. Building potentially cost effective biological monitoring programs, which include tools such as eDNA, could allow field crews to collect samples and using genomic technologies simultaneously, determine the presence or absence of multiple indicator species year round compared to other traditional tools which are highly expensive and cost prohibitive to the private sector, as well as being seasonal in scope.

A GBC supported collaboration between the Gitanyow Fisheries Authority (GFA) and researchers from Simon Fraser University are using eDNA to assess the health of a specific salmon type in a watershed downstream of a mine site. This tool will non-destructively assess the health of their fishery and the surrounding environment as the mine site construction begins.

Remediation — Genomic tools such as metabolomics and proteomics can be used to assess the functions of key species in an ecosystem and help guide reclamation efforts when restoring disturbed environments. Using genomic tools to elucidate the metabolic processes of bacteria in tailings facilities could reduce, or even prevent the generation of acid rock drainage, decreasing the long-term costs and environmental impacts of such facilities. Understanding the composition of bacteria in oil and gas wells and careful manipulation of the bacterial community, could reduce the generation of hydrogen sulfide (H_2S), a corrosive and dangerous substance that destroys steel in pipes and pumps. Under controlled conditions, using genomic knowledge, biologically engineered, microbes in bioreactors can process chemicals, remove pollutants and break down organic waste. Bioreactors, when scaled up, have the potential to remediate contaminated lakes, mines and tailings facilities such as those in Fort McMurray. Using synthetic biology derived or biologically engineered microbes could be an economically compelling and feasible way to treat the nearly 1.3 trillion liters of oil sands waste located in Northern Alberta containing naphthenic acid.


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Understanding the composition of bacteria in oil and gas wells and careful manipulation of the bacterial community, genomics could reduce the generation of hydrogen sulfide (H_2S), a corrosive and dangerous substance that destroys steel in pipes and pumps.

Energy — Overall, the adoption of specific genomics technologies can potentially help to (i) increase cost effectiveness and therefore, competitiveness, such as by using eDNA to improve the outcomes of environmental monitoring and lower the cost of ongoing programs, (ii) reduce environmental liabilities such as selenium recovery in bioreactors and use engineered microbes to catabolize naphthenic acid, and (iii) support the reclamation of industry sites, increasing the efficiency of restoration of affected sites to a natural, self-supporting state.

Future exploration and new resources — Genomics may not directly impact the cost of energy and commodity prices but can play a significant role in improving cost effectiveness and mitigate risks pertaining to securing permits, environment, operations and environmental monitoring. While genomics can have positive outcomes for the extractive sector, the two industries approach it differently; in general, technology enabled changes to mining operations can take decades to develop and start, compared to energy projects which can adopt practices, sometimes within months. Operational risks and genomics technology adoption in the mining sector is viewed quite differently to the energy sector and new ideas need to be proven before they are incorporated into future operations.

5. Approach

Building capacity in the extractive sector and expanding the development and availability of genomics tools requires collaborations on several levels. For the mining and energy sectors to remain internationally competitive and environmentally sustainable in the long term, it is imperative to diversify and adopt innovative technologies. Genome BC will continue to support innovation by transferring genomics knowledge in a timely fashion, catalyzing partnerships to increase sector sustainability and competitiveness and exploit new business opportunities. Genome BC has consulted with stakeholders not only in BC’s extractive sector, but across the rest of Canada as well as with international experts to understand how genomics might continue to be applied to maximize economic and social benefits arising from the mining and energy sectors. With the support of sector experts, strategic programs, and user partners, Genome BC will continue to promote innovation to advance genomic applications critical to user partners including sector associations and public and private sector partners.

6. Conclusions

Genome BC is committed to leading the development, integration, and adoption of genomic technologies in the extractive industries sector. To do so, Genome BC will support research that helps in the development and adoption of genomics tools and other enabling technologies. The result will be a stronger and more competitive extractive sector, healthier communities and environment, and reduced legacy issues plaguing future generations.

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