



Fuelling Our Future: Talent and Technology in Canada's Mining and Oil & Gas Industries

Signal49
RESEARCH

Land Acknowledgement

As this is a virtual event with people joining from across Canada, or Turtle Island, I acknowledge that we gather from many Indigenous territories. I invite each of us to reflect on the traditional lands where we live, work, and play, and to hold gratitude for the Peoples who have cared for these places since time immemorial.





Meeting Rules of Engagement

Invitation Only & Chatham House Rule: Council sessions are closed-door and follow the Chatham House Rule. Participants may use the information shared, but identities, affiliations, and attributable details must not be disclosed.

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Fuelling Our Future: Talent and Technology in Canada's Mining and Oil & Gas Industries



Amber Hayes

Lead Council Manager,
Innovation & Technology,
Signal49 Research



Stephen Gravel

Manager, Center for Smart
Mining, Cambrian College



Bryan Helfenbaum

Chief Operating Officer,
Clean Resource Innovation
Network (CRIN)



James Lannigan

Senior Research Associate,
Innovation & Technology,
Signal49 Research



Dr. James Lannigan

Dr. James Lannigan brings a unique mixed-methods approach that combines in-depth qualitative research, statistical rigour, and social network analysis to produce actionable insights for informed decision-making. At Signal49 Research, his work focuses on emerging technology adoption in Canada, including C-suite perspectives on artificial intelligence, recent AI developments, and projects examining AI adoption among Canadian firms and innovation trends in the mining and oil and gas sectors.

His role spans the full research lifecycle, including project design, stakeholder engagement, qualitative and quantitative data collection, advanced analysis, and knowledge mobilization. In addition to his core responsibilities, Dr. Lannigan contributes to several internal initiatives at Signal49 Research, including the AI Table, Research Community of Practice, Joint Health and Safety Committee, and the Wellness Committee. Dr. Lannigan's academic research centres on communication and social networks, with topics spanning social media engagement by public institutions, political polarization in digital and print media, and consumer-brand interactions

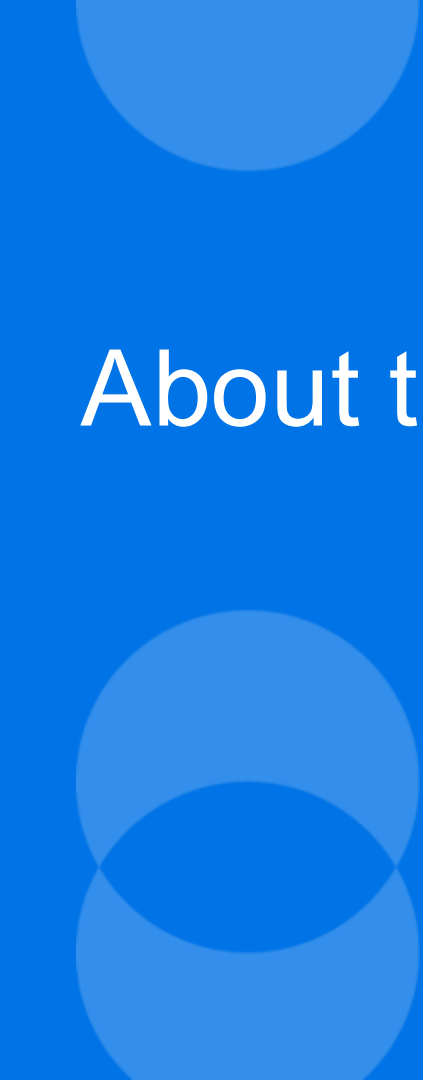


Fuelling our Future:

Talent and Technology in Canada's Mining and Oil & Gas Industries

September 8 2026

James Lannigan, Senior Research Associate, Innovation & Technology



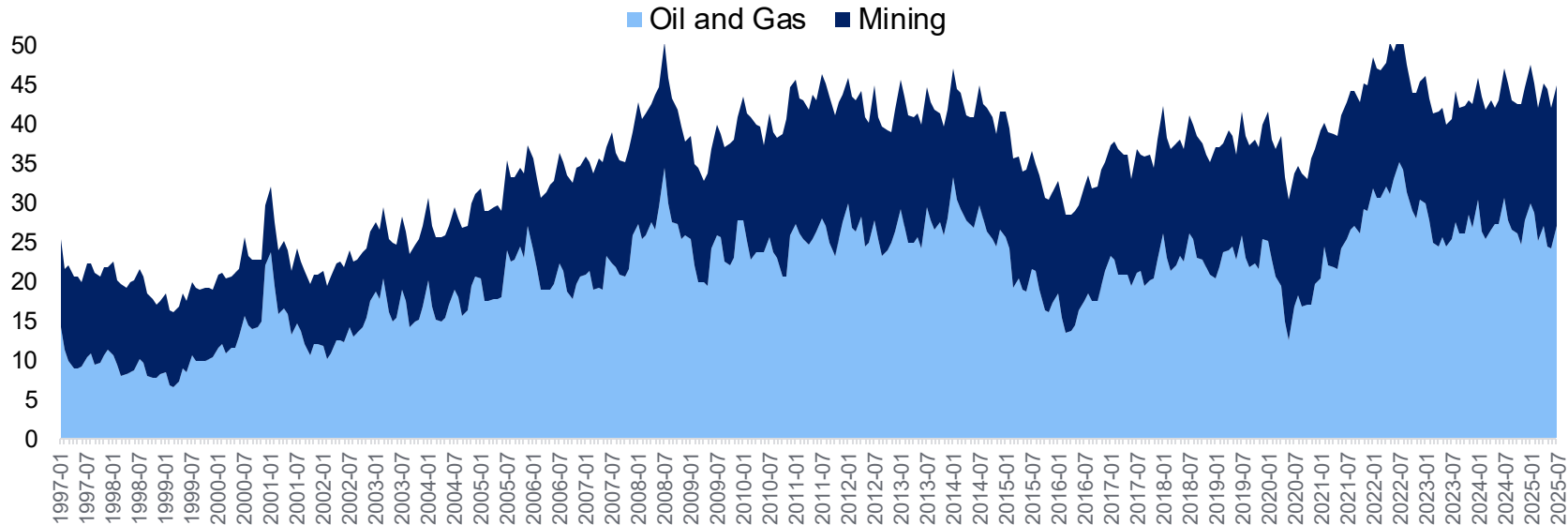
About this Research

Primary industries are an integral part of the Canadian economy

Mining and oil and gas comprised about 5 per cent of Canada's GDP in 2024 and 45 per cent of its exports in 2025.

Primary industries' share of exports increased over time

(the percentage share of energy products and minerals in Canada's total merchandise exports, 1997-2025)



Source: Signal49 Research Analysis of Statistics Canada Data.

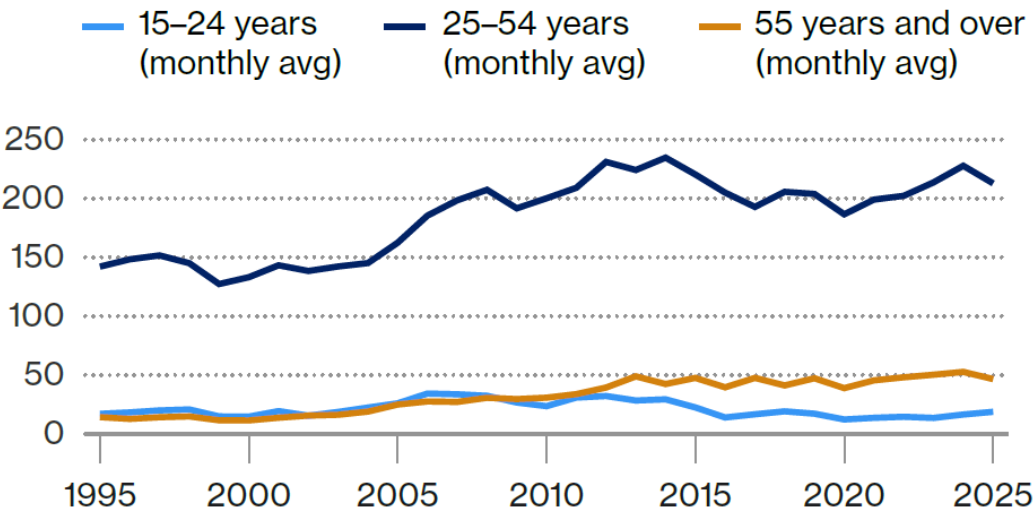
Yet there is a looming labour shortage to support the demand

The age gap for mining and oil & gas reached its peak in 2024, with a ratio of 55+ to 15-24 years nearly double the industry average

Chart 3

Employment in mining and oil & gas (1995–2024)

(employment, 000s)



Public perception paradox

Studies of public perception show that both mining and oil & gas industries have high public support. However, a national survey conducted by the Mining Industry Resources Council in 2020 reported that 42 per cent of young Canadians (ages 15-20) “definitely would not consider” working in mining, and 38 per cent “definitely would not consider” working in oil & gas

Research objective and questions

This research assesses the extent of advanced technology adoption within Canada's mining and oil & gas industries and analyzes workforce skill requirements and gaps.

Research question 1

To what extent are businesses in mining and oil and gas in Canada adopting and innovating with emerging technologies, and what barriers, if any, are affecting their ability to fully integrate these technologies?

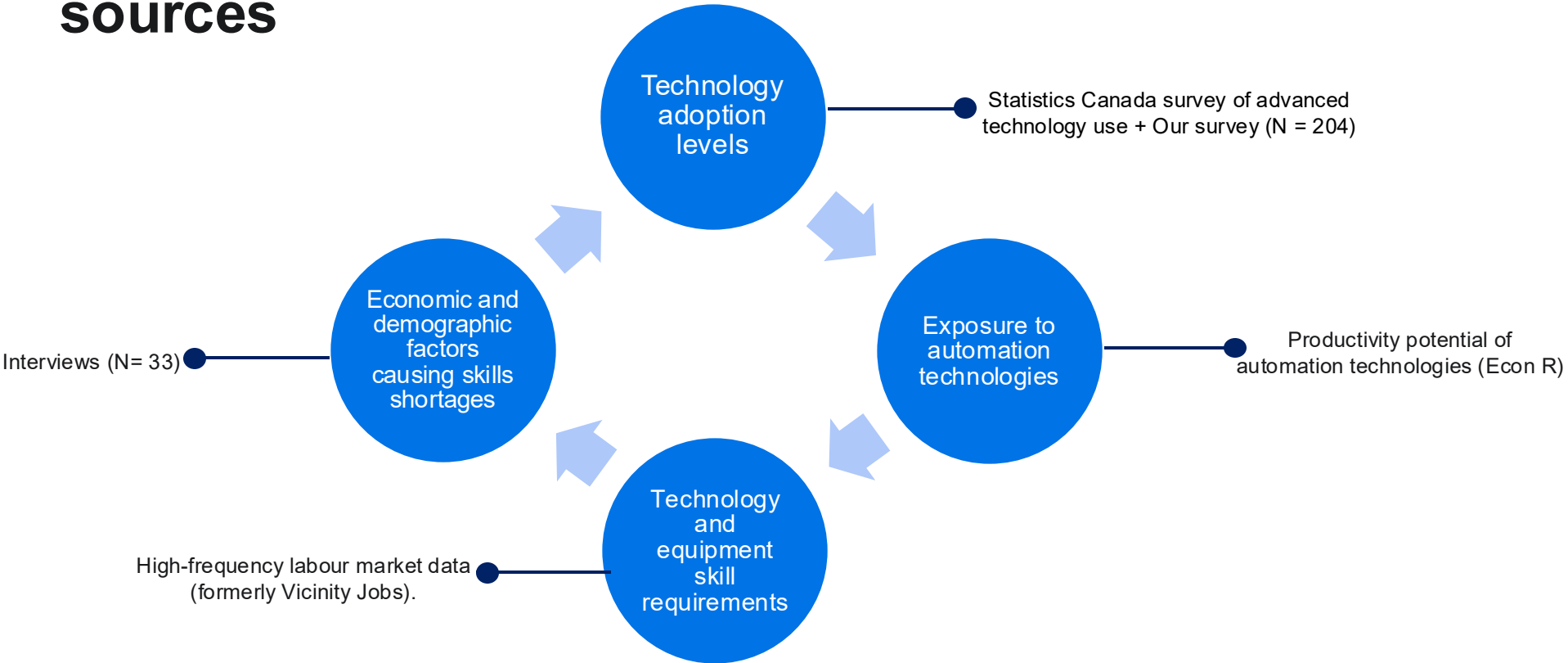
Research question 2

What skills do employers in Mining and Oil & Gas need to support technology adoption and innovation, and what are the gaps between current workforce skills and emerging skill needs?

Research question 3

What are the cross-cutting factors (economic, demographic, institutional) causing skill shortages in Mining and Oil & Gas?

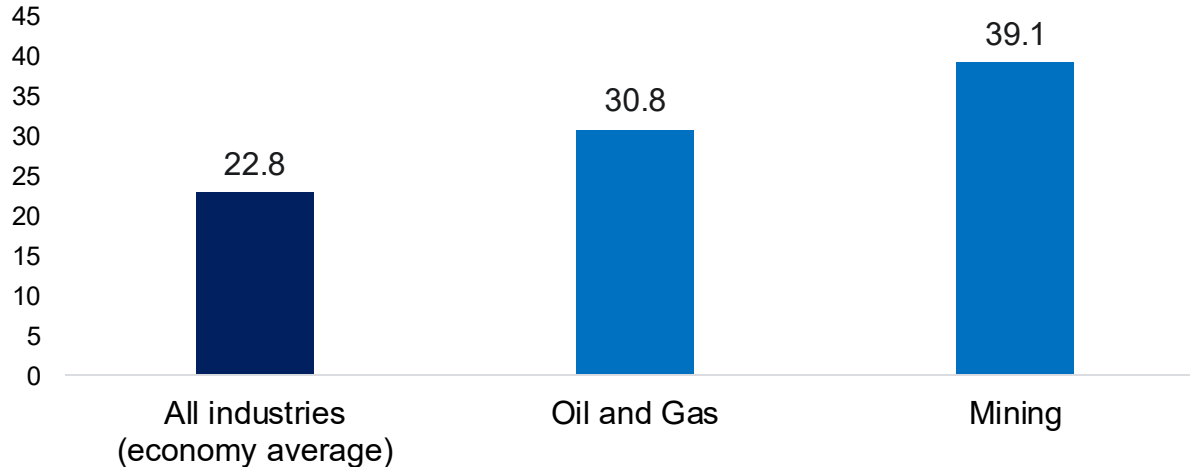
Research had four main components, multiple data sources



Exposure of employment to automation technologies

Primary industries are more exposed to automation technologies than the economy average

Automation Exposure Scores weighted by occupational employment in 2024
(the percentage of job-specific tasks that are exposed to automation technologies)



Occupations in Canada's oil and gas and mining sectors face substantially higher exposure to automation technologies than the economy-wide average. With scores of 30.8 for oil and gas and 39.1 for mining—compared to the 22.8 average—these industries are more susceptible to technological disruption and transformation.

Mining occupations have higher exposure to automation technologies

Automation exposure by occupations and employment in primary industries

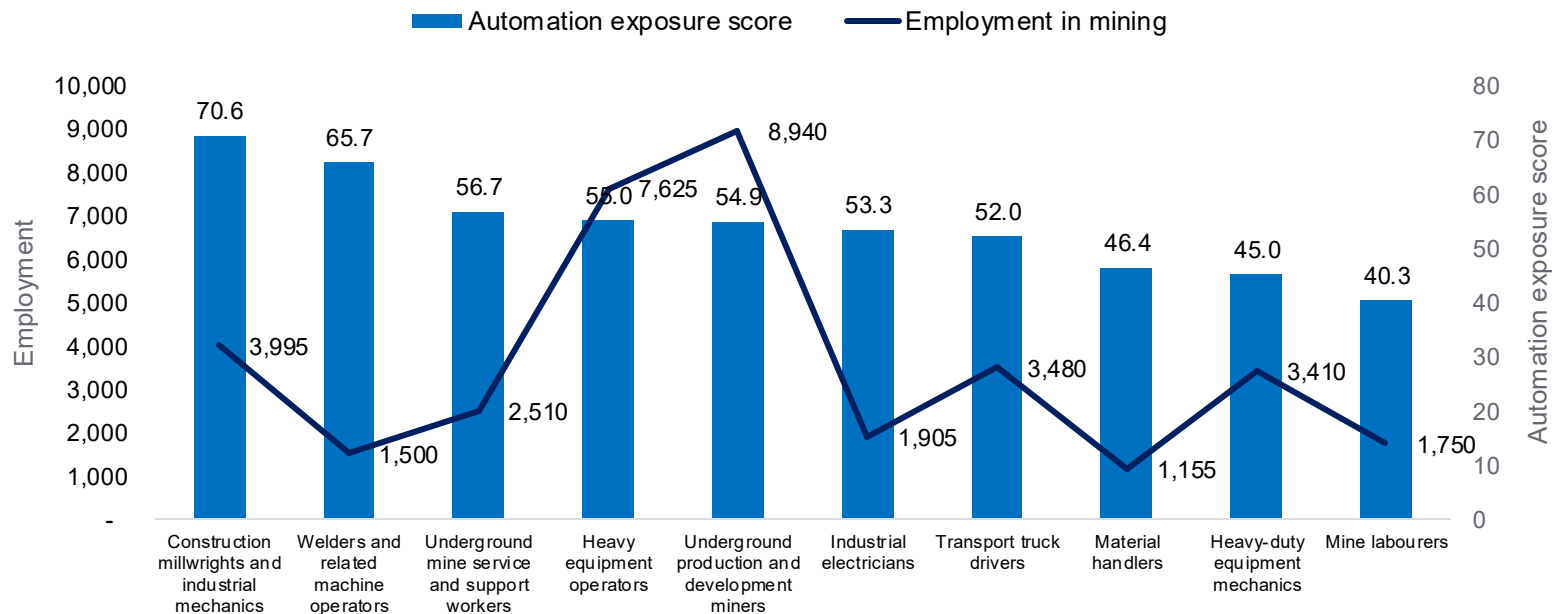
Mining				
Automation Exposure	Number of occupations	Share (%)	Employment	Share (%)
High Exposure (>50)	27	10.1	30,965	40.2
Medium Exposure (25 - 49)	105	39.3	25,545	33.2
Low Exposure (<25)	135	50.6	20,520	26.6
Total	267	100.0	77,030	100.0

Oil and Gas				
Automation Exposure	Number of occupations	Share (%)	Employment	Share (%)
High Exposure (>50)	24	9.8	12,615	17.5
Medium Exposure (25 - 49)	87	35.4	23,325	32.4
Low Exposure (<25)	135	54.9	35,990	50.0
Total	246	100.0	71,930	100.0

In both oil and gas and mining, a notable share of employment is concentrated in occupations with high exposure to automation—17.5 per cent in oil and gas and 40.2 per cent in mining. This suggests that technological disruption is likely to impact a substantial portion of the workforce in these sectors.

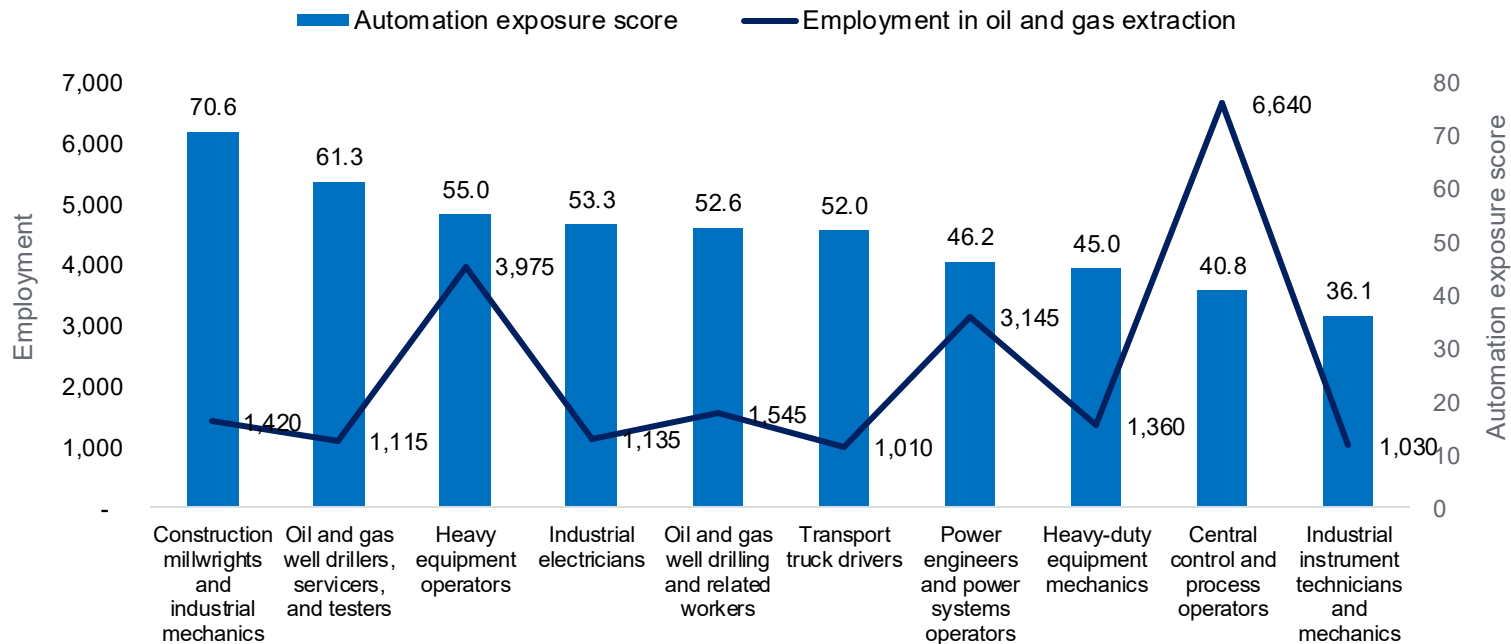
Top 10 occupations with the highest automation exposure in mining industry

Left axis: Employment (2021 Census), right axis: Automation exposure score. Automation exposure score. Occupations with at least 1000 employment



Top 10 occupations with the highest automation exposure in oil and gas industry

Left axis: Employment (2021 Census), right axis: Automation exposure score. Occupations with at least 1000 employment



Technology adoption

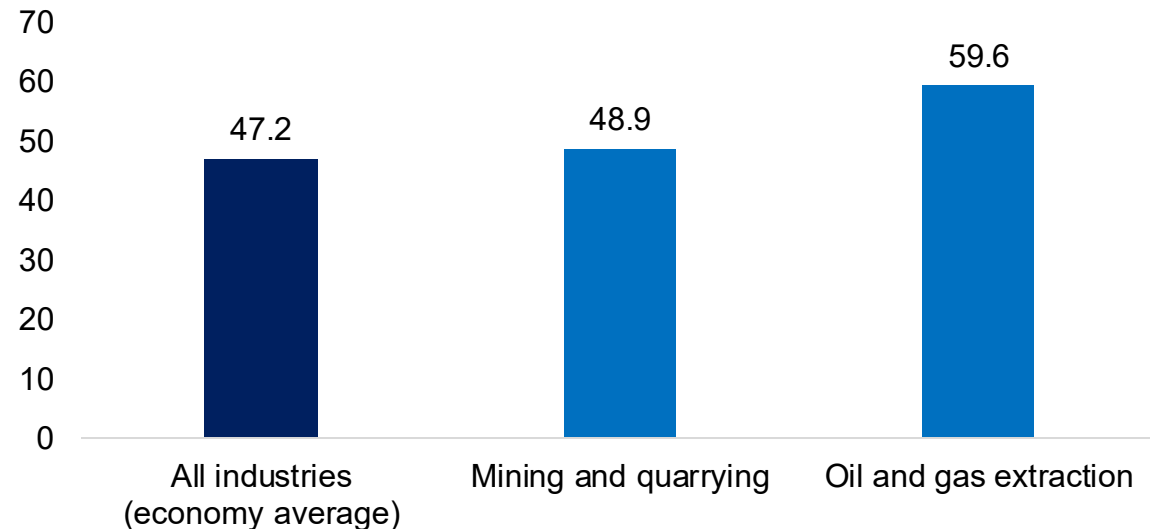
Advanced technologies

An advanced technology is one that “performs a new function or significantly improves an existing function performed by a more commonly used technology.” 15 advanced technologies are:

- Advanced material handling, supply chain and logistics technologies
- Advanced business intelligence technologies
- Advanced design and information control technologies
- Advanced processing and fabrication technologies
- Clean technologies
- Additional advanced technologies
- Geomatic or geospatial technologies
- Nanotechnologies
- Biotechnologies
- Artificial Intelligence technologies
- Blockchain or distributed ledger technologies
- Internet of Things
- Robotics
- Virtual reality, augmented reality, or mixed reality technologies
- Advanced medical devices

Technology adoption rates vary by industries

Percentage share of firms that use at least one advanced technology, 2022

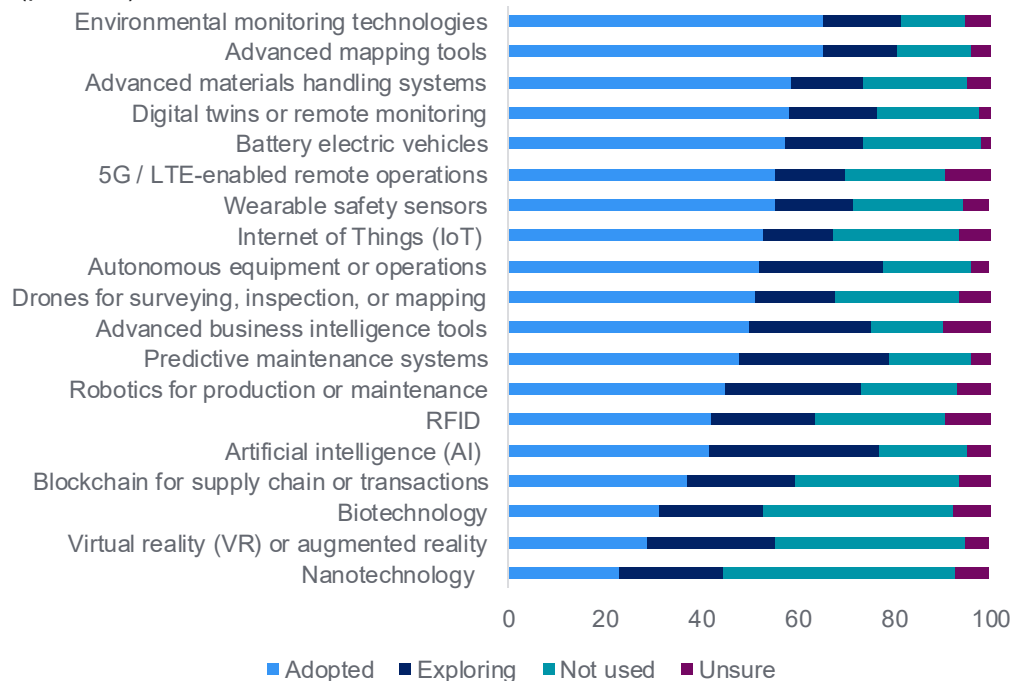


Nearly 60 per cent of oil and gas extraction firms used advanced technologies—well above the economy average of 47 per cent. Mining firms (48.9 per cent adoption) and support service firms for mining and oil and gas (44.8 per cent adoption) lag.

Adoption of advanced technologies

Over the past five years, to what extent has your organization used the following technologies?

(per cent)



Source: Signal49 Research, N=204

Environmental monitoring

“We developed a process that has a zero-waste footprint. There are no legacy materials that must be left on the site after we’re done. Everything that we bring in becomes a product for sale going out.” Mining industry professional

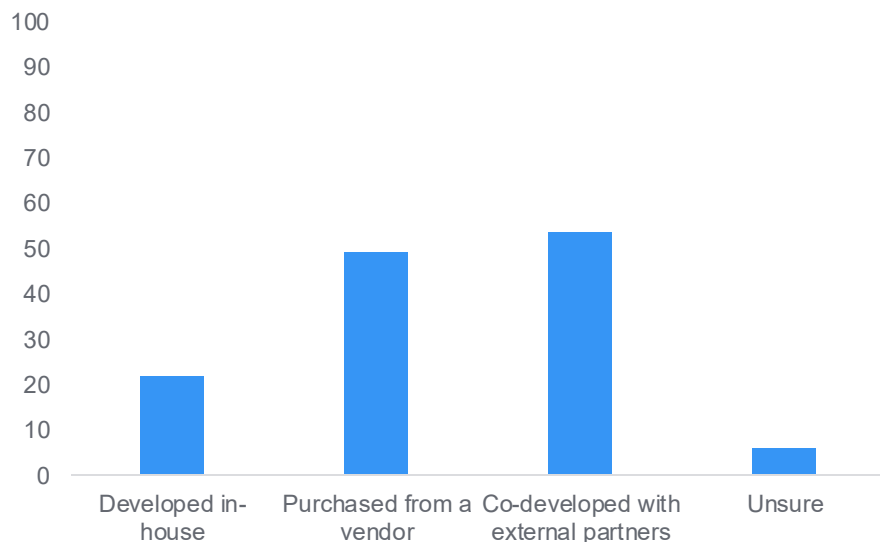
Digital twins

“We’ve used digital twins for years and now have digital triplets with AR/VR added for training. They let us do virtual walkthroughs, design work, and problem-solving. I can even climb virtual towers. AR/VR has been a great addition. Digital tools boost productivity, but they need disciplined implementation.” Oil & gas industry professional

Tech adoption is a collaborative endeavor

How has your organization accessed or developed new technologies?
Select all that apply.

(per cent)



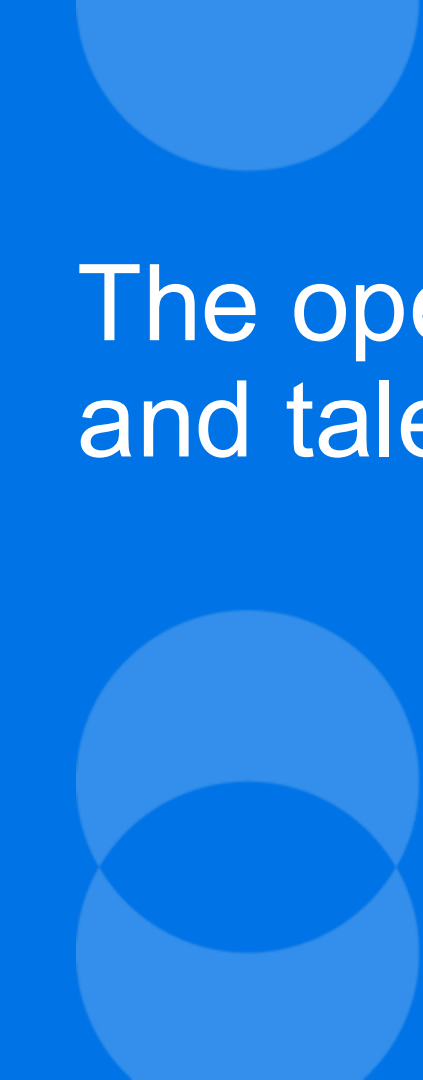
Source: Signal49 Research, N=204

“When developing or testing new tech, we start small and use trials to build confidence. For automation, operations decide what they need. We often work with other mining companies and test outside current operations to prepare. We start with smaller projects and mines.”

Mining industry professional

“Oil & gas companies collaborate on tech development through joint partnerships like COSIA [Canada’s Oil Sands Innovation Alliance]. They share pilot sites, such as one at Suncor, where all participants could test chemicals.”

Oil & gas industry professional



The operating environment and talent

Operating setbacks and a culture of caution

Permitting

“Delays happen because mine development is hard. Regulatory and environmental requirements, plus ESG obligations, make investors hesitant to fund new mines.” Mining industry professional

Variable lifecycles

“Most of our decisions depend on mine life, usually 5–10 years or less. If we consider innovation, we ask if it will pay off within that timeframe. Often it doesn’t, so we delay. The problem is that ‘five years’ keeps getting extended every year, so the short-term mindset never ends.” Mining industry professional

Unique geographic operations

“When I started working in the industry, technology was standardized across sites so employees could move easily and use the same tools everywhere. That was great for efficiency. Today, it’s more decentralized, each site does its own thing instead of following a central standard.” Mining industry professional

First second

“Clients want new tech but refuse to be first adopters. They’d rather wait until two others have successfully used it before buying.” Support industry professional

Legacy industry

“Mining is a legacy industry driven by quarterly returns. It sticks to proven methods and remains conservative.” Mining industry professional

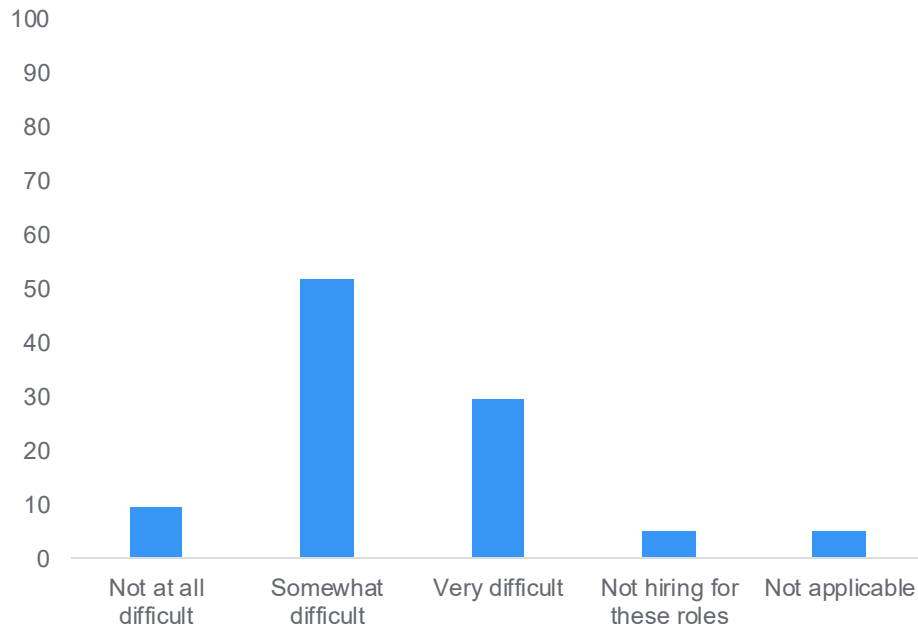
Risk-averse

“Energy companies are slow and conservative. They avoid risk, which is natural for the industry.” Oil & gas industry professional

Securing and retaining talent

Over the last year, how difficult has it been for your organization to find workers with the skills required for roles related to advanced technology adoption?

(per cent)



Source: Signal49 Research, N=204

Keeping them

“We see a lot of turnover. For example, someone left today who was very talented. If your employee is strong in process work and then gains AI/ML experience, they become highly marketable and hard to keep. Retaining top talent is tough, especially those who combine engineering skills with a willingness to learn AI. These people end up with exceptional skill sets, strong networks, and entrepreneurial drive. We don’t have great systems to keep them, and it’s hard to compete.”
Oil & gas industry professional



Actionable insights

Federal policy makers who are interested in enhancing the opportunities for the mining and oil & gas industries can consider the following:

- Modernize incentives to accelerate technology adoption
- Reform permitting systems to reduce delays
- Strengthen the talent pipeline
- Support Indigenous workforce development and partnerships



Actionable insights

For industry:

Build deeper partnerships with polytechnics; applied research centres such as NORCAT, CEMI, and CRIN; and technology vendors to pilot and scale innovations

Invest in clear reskilling pathways, especially for medium-exposure roles that will evolve rather than disappear

Strengthen retention strategies for workers with technical skills, including career paths in AI, automation, and digital operations

For universities and colleges:

Align curricula with industry needs through direct collaboration with polytechnics and industry leaders

Invite industry ambassadors into classrooms to address perception challenges and highlight the sector's transformation



Where knowledge
inspires action



Bryan Helfenbaum

Chief Operating Officer, Clean Resource Innovation Network (CRIN)

Bryan has spent 27 years working across the energy industry with an emphasis on innovation & collaboration. He served for almost two decades at Imperial Oil and Devon Energy across a variety of technical, business, and leadership roles, and then moved to Alberta Innovates, rising to the position of Vice President of Energy, Aerospace, Defence, and Advanced Materials.

Bryan is now the Chief Operating Officer at Clean Resource Innovation Network, the “network or networks” that seeks to enable the development, commercialization, and adoption of clean technology solutions for the oil & gas industry. He is also a Senior Advisor at Exergy Solutions, an innovative engineering & advisory firm. Finally, he serves as fractional Chief Operating Officer at Jade Sunrise Law, the largest fully bilingual English/Chinese law firm in Alberta.



CRIN

Clean Resource Innovation Network

Fueling Our Future

Bryan Helfenbaum – Chief Operating Officer
September 8 2026

CRIN

A NETWORK OF NETWORKS



FEWER SILOS | MORE SOLUTIONS

CRIN AT-A-GLANCE



MISSION

Enable development, commercialization and adoption of innovative clean technology solutions in oil and gas that are applied across Canadian hard-to-abate industries and globally reduce emissions.

FREE TO
JOIN



MEMBERS

4,900+

ACROSS CANADA +
GLOBALLY



FEDERALLY FUNDED

\$110,000,000

STRATEGIC INNOVATION
FUND (SIF)

TOTAL FUNDED PROJECTS



66

FIVE SECTORS



FUNDERS



ADOPTERS



INNOVATORS



SUPPORT
SERVICES



TALENT
DEVELOPMENT

SEVEN TECHNOLOGY THEMES



CARBON CAPTURE
VALUE ADDED PRODUCTS



CLEANER FUELS - REDUCING
CARBON INTENSITY



DIGITAL OIL & GAS
TECHNOLOGY



METHANE MONITORING,
QUANTIFICATION &
ABATEMENT



NOVEL HYDROCARBON
EXTRACTION (NHE)



NOVEL LAND & WELLSITE
RECLAMATION



WATER TECHNOLOGY
DEVELOPMENT

Signal49
RESEARCH

In partnership with



**Future
Skills
Centre**

**Centre des
Compétences
futures**

Fuelling Our Future

Talent and Technology in Canada's Mining and Oil & Gas Industries





Global primary energy use by source

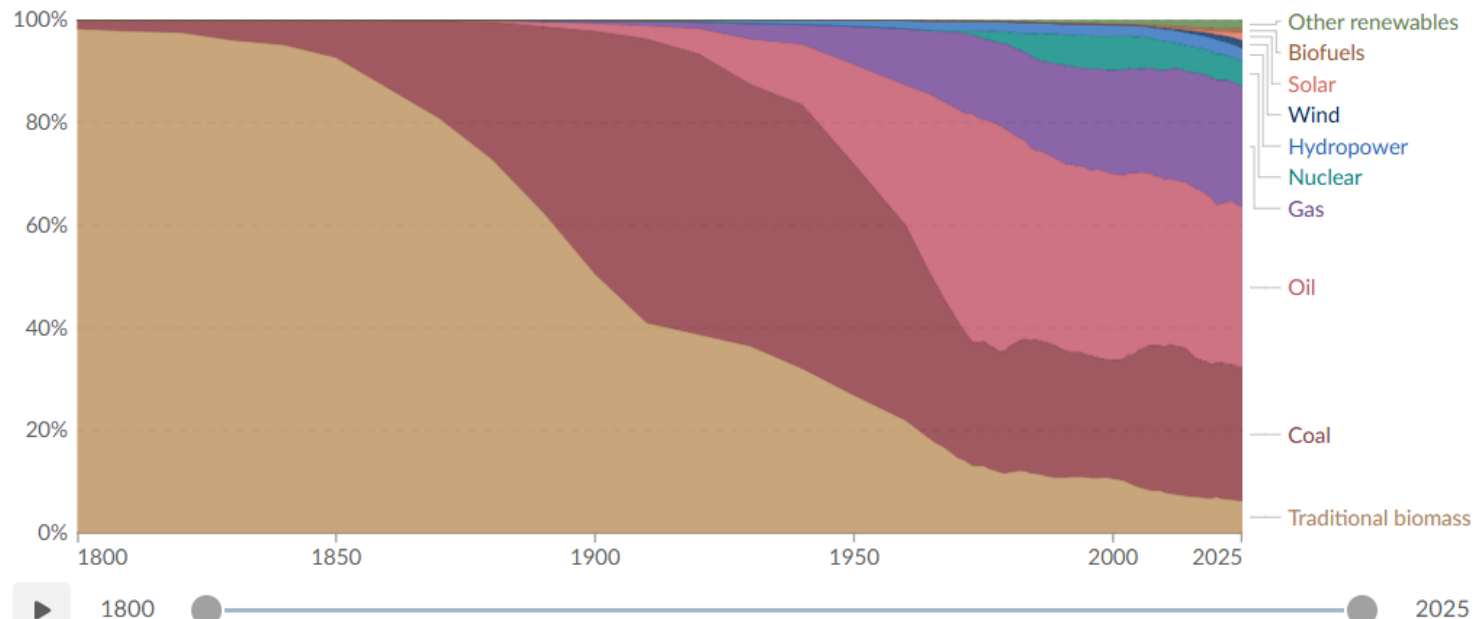
Measured in terawatt-hours of total energy supply.

Our World
in Data

Table

Area

Settings



Data source: Energy Institute - Statistical Review of World Energy (2026); Smil (2017) - [Learn more about this data](#)

Global primary energy use by source

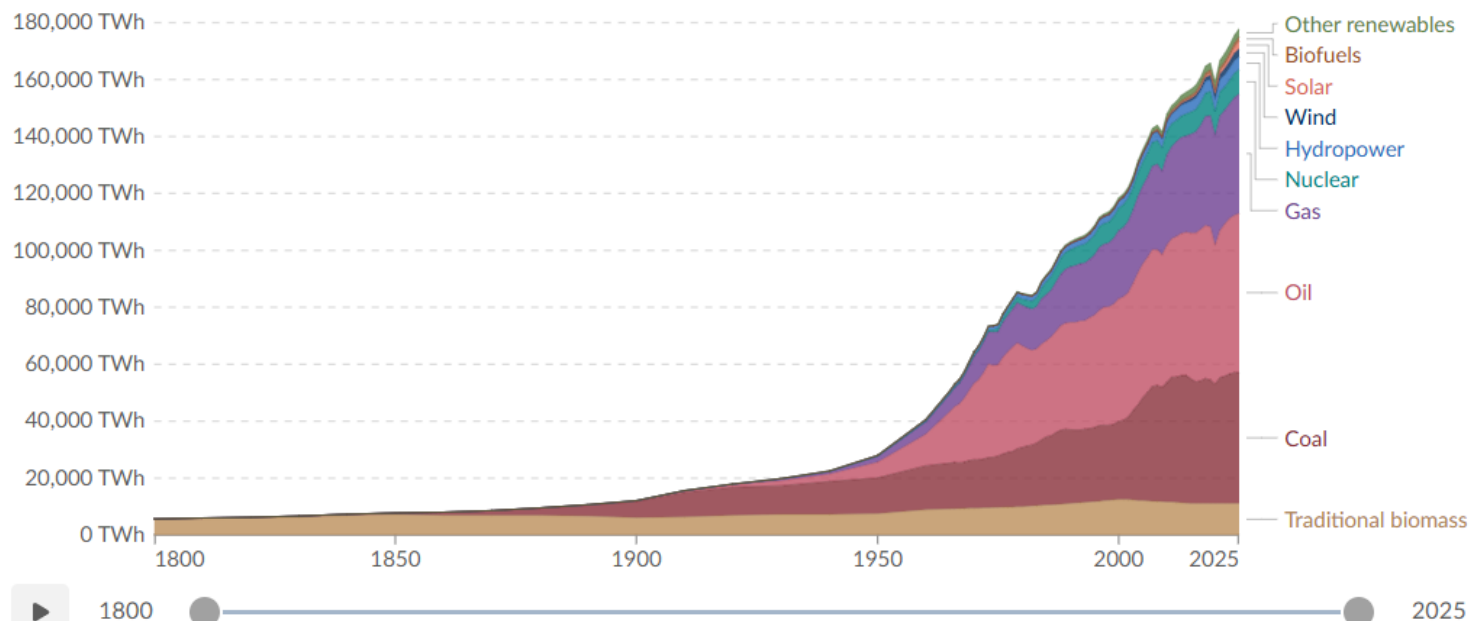
Measured in terawatt-hours of total energy supply.

Our World
in Data

Table

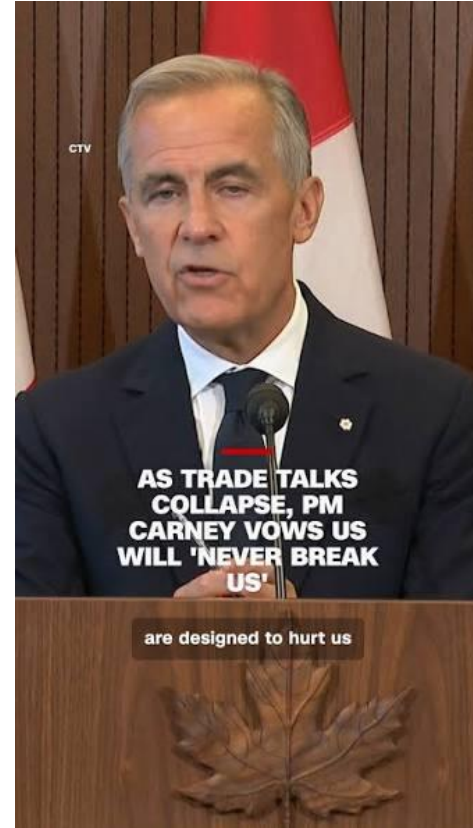
Area

Settings



Data source: Energy Institute - Statistical Review of World Energy (2026); Smil (2017) - [Learn more about this data](#)

“We are realizing Canada’s full potential as an energy superpower, in nuclear, LNG, renewables, and **low-carbon oil and gas**” – Aug 22 2026



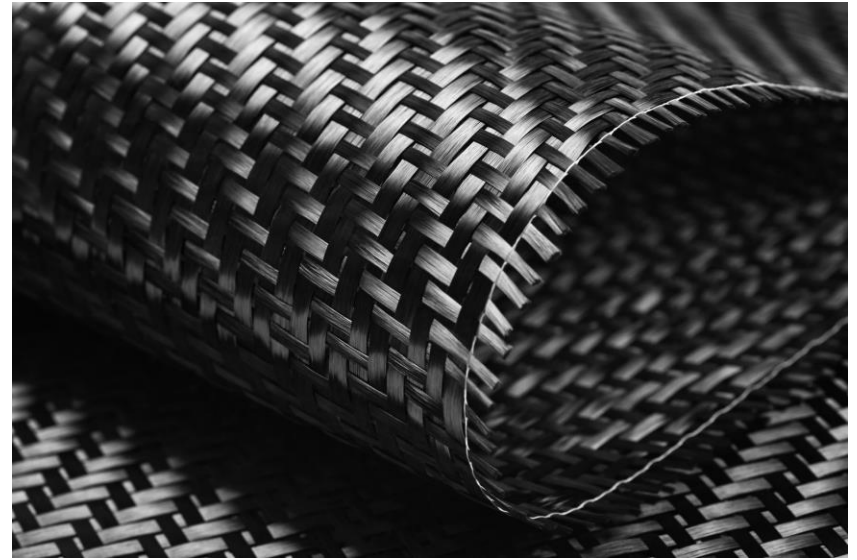
Calgary

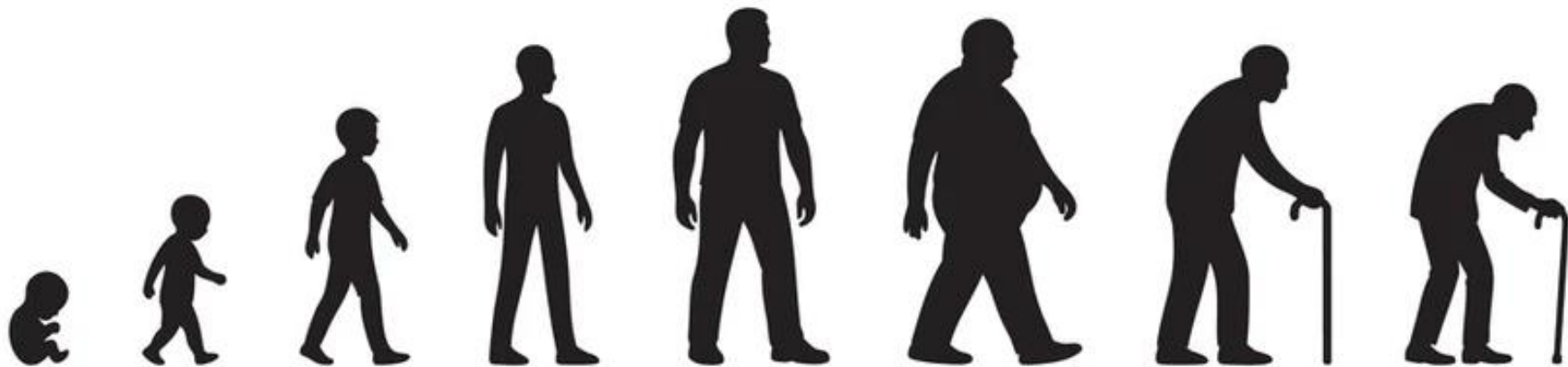
University of Calgary hits pause on bachelor's program in oil and gas engineering

Enrolment in undergrad program fades after long oilpatch downturn and with energy landscape changing

[Tony Seskus](#) · CBC News · Posted: Jul 08, 2021 2:00 AM MDT | Last Updated: July 8, 2021







Fusion

**SMNR
DAC
BAM**

**Hydrogen
Biofuels
Lithium
Geothermal**

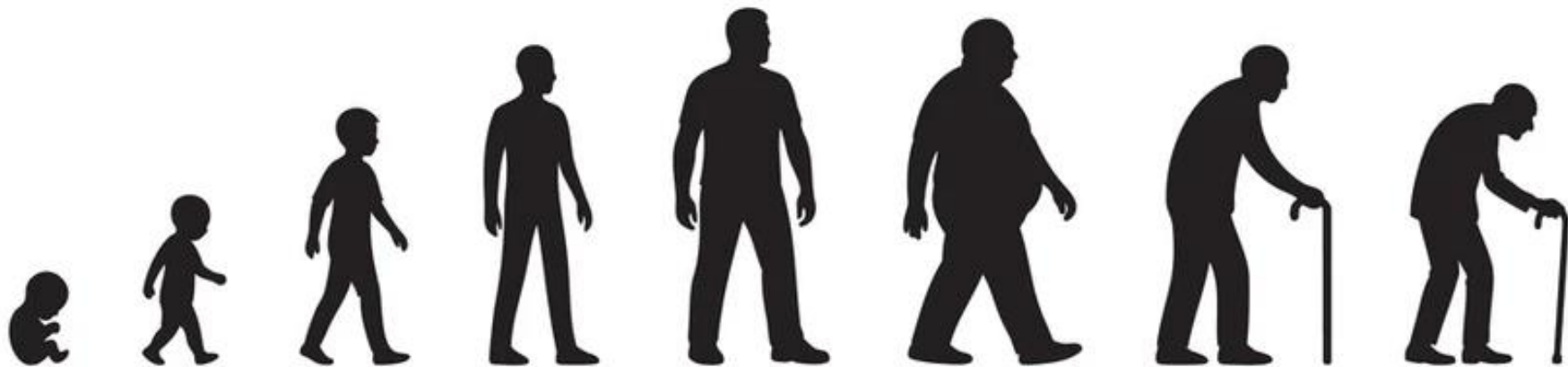
**Digital
CCUS**

**Wind
Solar**

**Oil
Nat Gas**

Coal

Wood



Fusion

SMNR

Hydrogen

Digital

Wind

Oil

Coal

Wood

DAC

Biofuels

CCUS

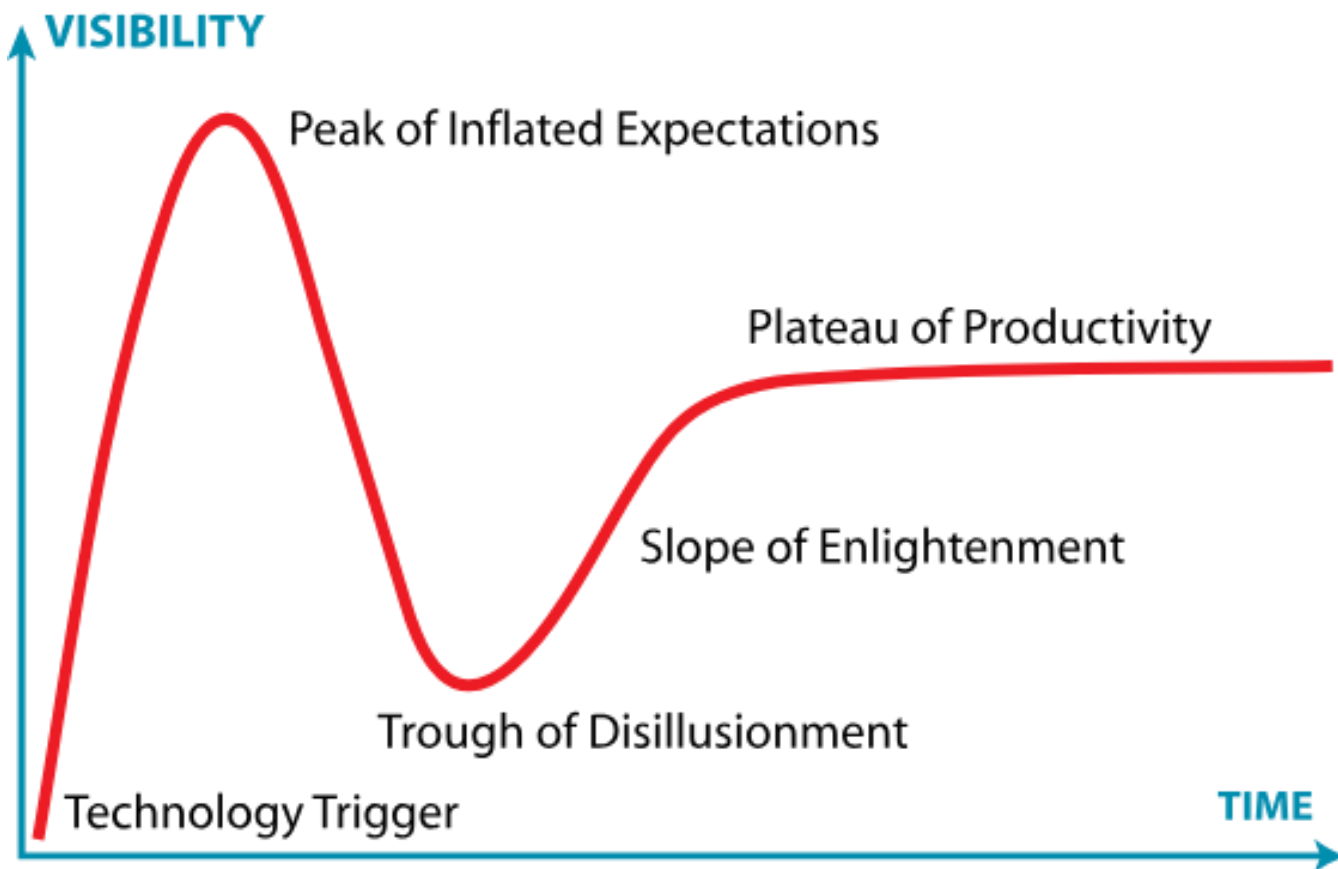
Solar

Nat Gas

BAM

Lithium

Geothermal





What can Industry do better
to promote jobs in oil & gas?

1) Highlight innovation & sustainability, shift culture from “first to be second”



ArmorFoam is using nanoparticle-based foam technology to improve the efficiency of CO2 Enhanced Oil Recovery (EOR) and CO2 storage.

CRIN funding \$0.9M | Project cost \$2.1M | TRL 8

ArmorFoam is a nanoparticle surfactant-based foam that enhances CO2 storage, pressure maintenance, and resource recovery in CO2 EOR processes. ArmorFoam can reduce GHG emissions, maximize underground CO2 storage, and reduce the carbon intensity of hydrocarbon extraction.

“CRIN funding...was the catalyst that allowed us to bring our technology into the real world.” - Ali Telmadarrie, CEO



Mannville Syngas Extraction Project with Integrated Carbon Sequestration: Enhanced hydrogen recovery for low-cost hydrogen from stranded hydrocarbons.

CRIN funding \$10M | Project cost \$44M | TRL 9

Cvictus is targeting commercial operation of its first ‘small’ plant that will produce clean hydrogen. This is a globally scalable solution that enables lower cost hydrogen than that from dominant steam methane reforming from natural gas, and lower emissions than electrolysis of fresh water with hydro-power, with onsite CO2 sequestration.

“...[CRIN’s] funding has been instrumental in commercial development of an emerging technology here in Canada that will be a game-changer in hydrogen extraction.”

- W. Robert Sturgess, VP

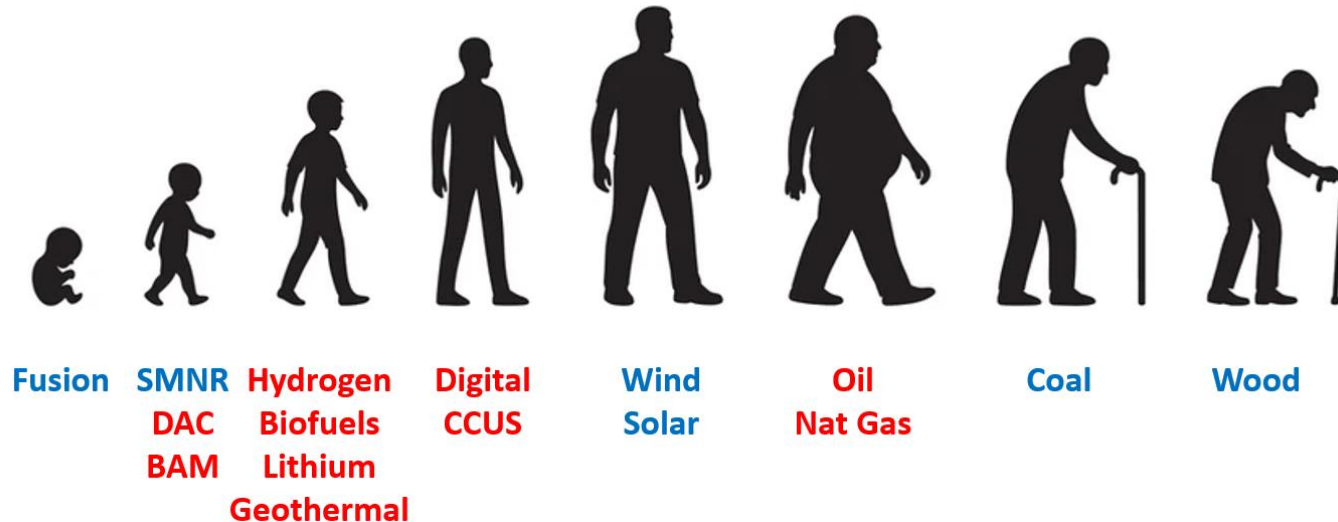


Pulsed Methane Pyrolysis technology converts natural gas into hydrogen and solid carbon at costs comparable to incumbent steam methane reformers.

Ekona developed methane pyrolysis technology to convert natural gas into hydrogen and carbon, proven with a small batch reactor and a 200kg-H2/day system. They're now testing a 1TPD-H2 PMP pilot plant with a Canadian gas producer.

“The funding that we have received from CRIN has significantly accelerated our technology development. This investment has also allowed us to foster a culture

2) Identify broad skill set & transferability



3) Work closely with post-secondaries and other partners



4) Identify AI-proof careers

LEADERSHIP LAB

Jagged little skill: How AI is changing where the next generation of careers will be built

TONY FROST AND CHRISTIAN DIPPEL

SPECIAL TO THE GLOBE AND MAIL

PUBLISHED AUGUST 21, 2026

5) Highlight financial resiliency and importance to Canada







Steve Gravel

Steve Gravel is the Manager of the Centre for Smart Mining, a federally funded research centre that focuses on facilitating new technology adoption in the mining sector by providing mining technology companies with technical services and training. In previous roles, Steve has studied the Ontario mining supply and services cluster in depth and understands its uniqueness and strategic value. Steve also co-hosts a weekly podcast called The Unlikely Innovators which highlights stories of unlikely sources of innovation from thought leaders to start-ups and SMEs and a variety of industrial sectors. Most recently he was the winner of the 2026 CIM-Bedford Canadian Young Mining Leaders Award.

Bridging the Skills Gap

How Cambrian College
Empowers Upskilling in
Mining

Steve Gravel



Context

Aging Workforce: A significant portion of the mining workforce is nearing retirement, leading to potential shortages of experienced workers.

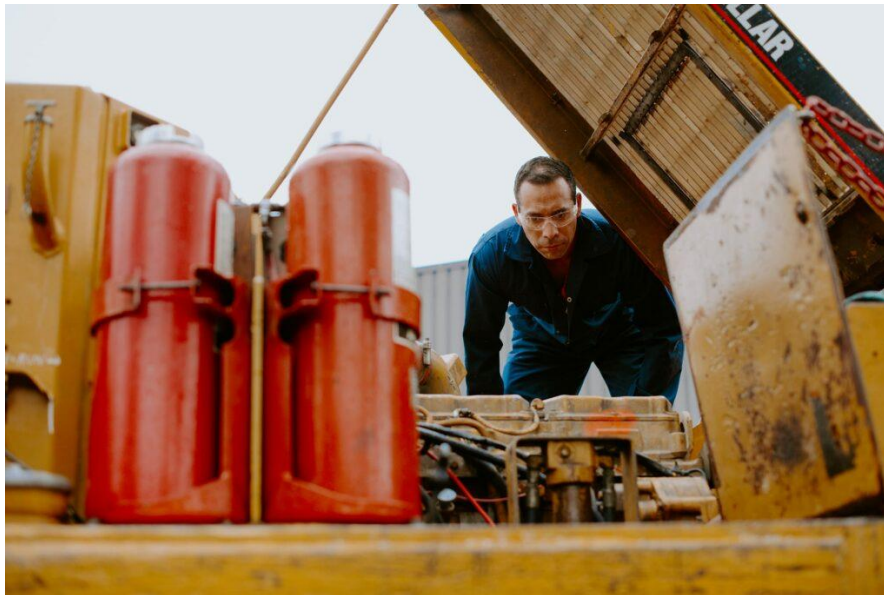
Underrepresentation of Key Demographics:

Women: Despite comprising 48% of the Canadian labour force, women account for only 15% of the mining and quarrying workforce.

Immigrants: While immigrants make up 23% of Canada's workforce, they represent just 13% in the mining sector.

Educational Disparities: There is a disconnect between labour demand trends and post-secondary education trends in key occupations, such as geoscientists, leading to potential skills shortages.

Cap on International Students: limits the number of potential future employees getting trained in mining trades and occupations,



Sources: Mining Industry Human Resource Council

Technology Advancements and Workforce Transformation

Automation and Digitalization: The integration of automation, data analytics, and robotics is transforming mining operations.

35% of mining roles may need redesign, and 42% could be enhanced due to technological adoption*

Emerging Skill Requirements: There's a growing demand for competencies in data analysis, digital literacy, and change management. These skills are essential for effectively implementing and managing new technologies within mining operations

*Sources: EY Canada and International Women in Mining



Cambrian College & Centre for Smart Mining

A Leader in Mining Innovation & Workforce Development

Cambrian College: **50+ years in mining education**

6000 full-time students in over **90 programs**

The **Centre for Smart Mining**: Advancing mining tech, automation, and data-driven solutions

Corporate Training: Customized, industry-focused programs

500 corporate training students per year



Centre for Smart Mining

In-demand skills/roles

Heavy Duty Equipment Mechanic

Industrial Electricians



Mining Engineers

Mineral Processing Specialists



Automation and Robotics



General Labour Crunch

Production Miners/ Drill Blast

?

Heavy Equipment Operators

?

General Labourers

?

Mill/plant Operators

?



Market Tightness

The Baseline Need: **246,400** new mining workers by 2035 just to sustain normal operations and replace exiting staff.

The Expansion Need: **329,000** workers.

The math: unfilled hiring gap of **65,700** workers



Industry-Driven Training

Solving Real Mining Workforce Challenges

Gaps occur when demographics, regulations and technology change.

Pathways for non-mining industrial workers

Co-develop programs **with industry** to meet specific needs



Key Training Programs



BEV Industrial Maintenance Program- Upskilling HD Mechanics for underground EV maintenance

Data Analytics for Mining Professionals – Teaching data literacy for operational decision-making

Underground Mining Tech Service Transition Training – Helping industrial workers adapt to underground operations

Underground Construction Miner Program - Primarily focused on contract mining companies

BEV Industrial Maintenance

Targeted at Heavy Duty Equipment Mechanics
at Mining Companies

Focused on safety, components and
troubleshooting

Over 150 technicians trained



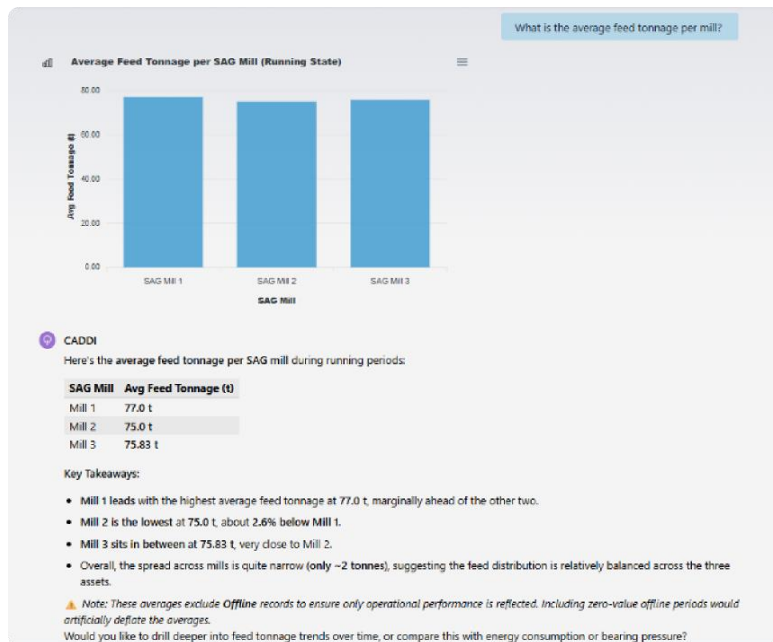
Data Analytics for Mining Professionals

Mining the Power of Data

Why it matters: Mines generate massive amounts of data

Skills taught: data interpretation, predictive maintenance, cost optimization

Impact: Increased efficiency, reduced downtime, improved safety



Surface-Underground Transition

Preparing Open-Pit Miners for Success Underground

Why its needed: mines transition to underground operations, avoid layoffs

Training includes: safety protocols, underground logistics, tech services (surveying, ground control etc.)

Benefits: Reduced onboarding time, improved workforce retention



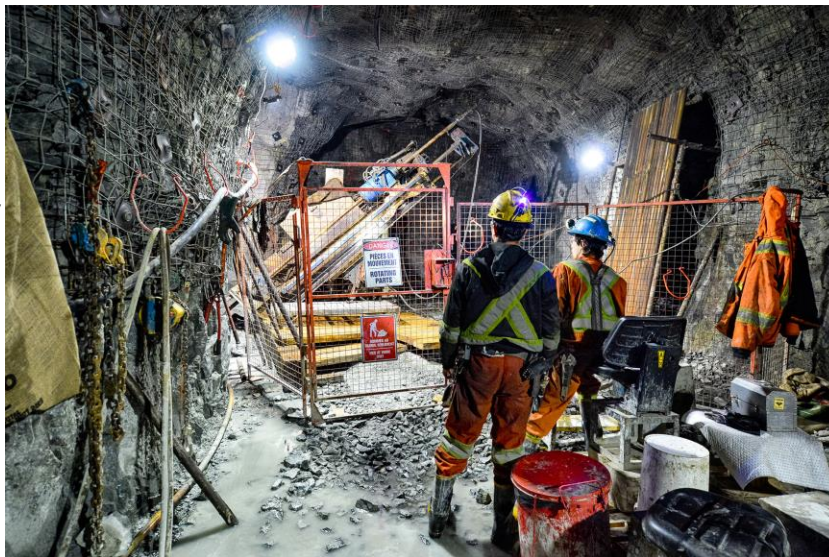
Underground Construction Miner

Real-world, task-based training centered on underground construction projects.

Technical, safety, and trade skills learned together within authentic work scenarios.

Extensive hands-on experience in simulated environments and training tunnel.

Produces **job-ready** graduates aligned with industry needs and operational workflows.



English for Mining & ESL program

The Online English for Mining & ESL program is a **strategic initiative** to provide students with **specialized language skills** and **enhance their technical mining knowledge**.

This partnership prepares students for academic success and professional opportunities with international mining companies.



Indigenous Engagement Program

- **Understand** Indigenous history and worldviews
- **Learn** cultural safety, humility, and allyship
- Explore the TRC's Calls to Action and create action plans
- Gain practical tips for **respectful** engagement
- Strengthen Indigenous outreach and relationships

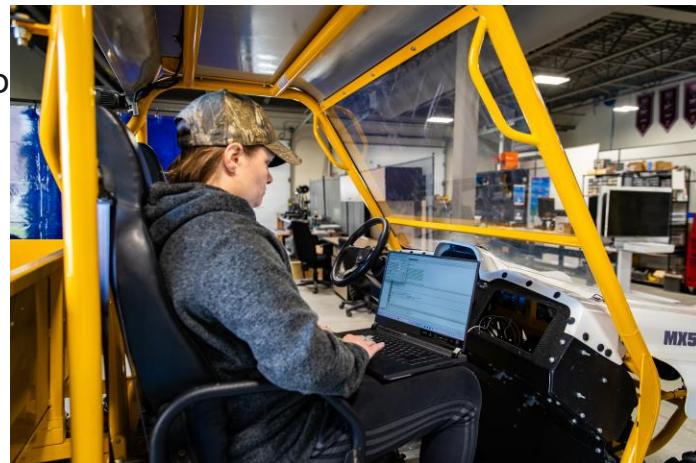


Learn and Stay

Call to Action: Launch a Mining Learn & Stay Program

A Mining Learn & Stay Program would provide financial support for students in mining-related programs in exchange for a commitment to work in Northern Ontario's mining sector after graduation.

- Create a direct pathway from education to employment in mining and mining supply companies.
- Address critical workforce shortages across mining, maintenance, trades, engineering, environmental, and technology occupations.
- Positioning for Sectoral Workforce Innovation Program
- We are seeking OMA's support and industry participation to help build and sustain this talent pipeline for Ontario's mining future.



Centre for Smart Mining

Our Happy Partners



AGNICO EAGLE



GLENCORE



Technica Mining

NewmontTM



ALAMOS GOLD INC.



FLSMIDTH



Nordmin
Engineering



Centre for Smart Mining

Upcoming INNOTECH Events

September 15th - Virtual Webinar | Economic Forecast Update: Navigating Canada's Outlook in an Era of AI (calendar invite has been sent)

November 3rd - Virtual Member Discussion | What Separates Innovations That Scale from Those That Stall (calendar invite to be sent)

November 19th - Virtual Workshop | Strategic AI Workshop: Identifying High-Value Opportunities in Your Organization (calendar invite has been sent)

December 9th - Virtual Webinar | Digital Sovereignty (calendar invite has been sent)

The Signal49 INNOTECH Councils

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