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**Canada Mining Innovation Council
Business Case Executive Summary:
Towards Zero Waste Mining**

August, 2015

The Canadian mining industry is at risk and needs to adapt to a new reality of increasing complexity



Declining Productivity

Structured labour market forces, declining resource quality, and a legacy of inefficient capital allocation have led to declining productivity (i.e., declining labour productivity, increasing capital intensity, and decreasing mining intensity)



Increasing Costs

High energy consumption, elevated input costs (e.g., energy, infrastructure, labour, royalties, permitting fees, and compliance), and **critical shortages in energy and water** have resulted in **increasing energy intensity, decreasing margins** and diminishing economic feasibility of new mine developments



Increasingly Complex License to Operate

Concerns from multiple stakeholders including conservation and the potential environmental impacts of mineral development and mine closure have resulted in **increasing government regulation** and **demand for heightened corporate social responsibility and stakeholder engagement**



Operating With Uncertainty

Volatile commodity prices have resulted in unpredictable margins, forcing companies to plan for the unforeseeable, and decreasing financing capital availability

In order to remain sustainable and profitable, the industry must innovate and collectively challenge existing ways of thinking

- The **sustainability** of the Canadian mining economy **is at risk if current trends continue**
- **Mining business challenges will continue to grow**, resulting in decreased productivity, increased costs, difficulty maintaining a license to operate, and continued short term decision making at the expense of long-term value creation
- As each of the main business challenges ultimately impact mining operation profitability, mining companies will find it increasingly **difficult to remain profitable and continue operations** in Canada

If no action is taken there will be a significant negative impact to the Canadian economy with the resulting factors all declining in the short term



Contribution
to GDP



Fiscal
Contribution



Project Investment
in Next 10 Years



Mineral
Production



Number of
Canadians Employed



Additional Employees
Required over the Next
10 Years

Therefore, the industry requires a collective approach to innovation

In order to make a **significant shift in** improvement to address the greatest mining challenges and maintain the immense contribution that mining provides to the Canadian economy, **the industry must act as a business ecosystem** and **collectively challenge existing ways of thinking**, by revisiting long-standing practices and processes

The Canada Mining Innovation Council provides a forum for change to enhance Canada's position as a global mining leader



National **non-profit** organization comprised of **over 75 members** that includes mineral exploration companies, mining companies, service providers (mining and other), academia, research labs, and provincial and federal government

Why CMIC Was Created?

Formed at the request of the industry and government to provide innovation leadership to the Canadian mining industry

What CMIC Does?

CMIC facilitates an **industry-driven innovation** ecosystem connected through parallel and sequential linkages-towards addressing **Canadian Zero Waste mining challenges**

CMIC's Mission & Goals

To **enhance the competitiveness and sustainability** of the Canadian mining industry by coordinating excellence in research, innovation, and commercialization towards-maintaining Canada's **global leadership** in mining

CMIC's Approach

The staged and phased approach of the technology roadmaps ensures **gradual progression** (Phase 1 – 3) and **adoption of innovative technologies** (Stages 1 – 3) which promote, **more efficient and sustainable operations** and increase **shareholder value**



Definition of "Towards Zero Waste Mining™"

Stimulate technology innovation in Canada to achieve **zero waste** in mining and mineral processing **within 10-20 years**, with a focus on the environment, energy, and productivity

Sources of Inspiration for the CMIC Model¹



Created to develop, facilitate, and manage collaborative research projects for interested parties



Focused on accelerating the pace of improvement in environmental sustainability in Canada's oil sands through collaborative action and innovation



Designed as a collaborative, industry led innovation network to solve key industry issues by helping members combine resources to solve common problems and decrease costs



CMIC's Towards Zero Waste Mining strategy addresses the pressing issues that are keeping executives up at night...

Ability to **reach ore bodies** that are further away faster and in a safe manner

Environmental footprint reduction and more effective operations

Making **continuous mining** more economical and efficient

Comminution energy reduction

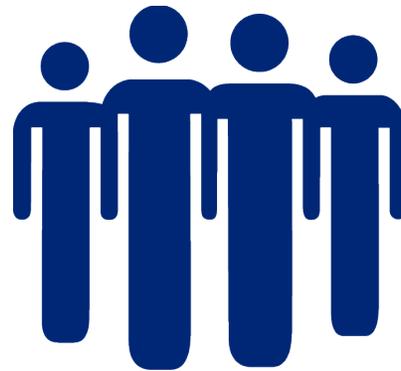
Water usage, availability, and efficiency is a challenge

Energy management and efficiency

Improvements in **safety** to benefit employees

Access to real time data – strong drive to improve the ability to make decisions and monitor operations from large data sets in real time

Mine planning and **better understanding of ore bodies** to allow for efficient mining



...by addressing the five most pertinent Towards Zero Waste Mining issues through implementable portfolio roadmaps

From Zero Waste mining issues...

...to actionable Portfolio Roadmaps

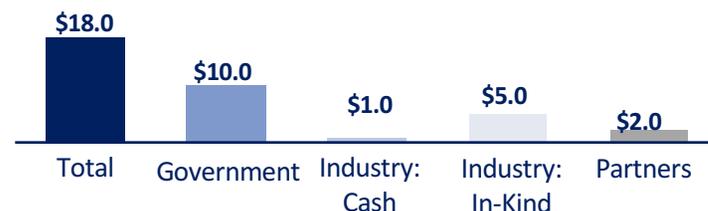
Priority Projects

Required Investment*

Exploration



- Accelerated targeting undercover
- Near-time data retrieval, analysis, and modeling



Continuous Underground Mining



- Real-time continuous underground mining



Processing (Comminution Efficiency)
Energy Efficiency



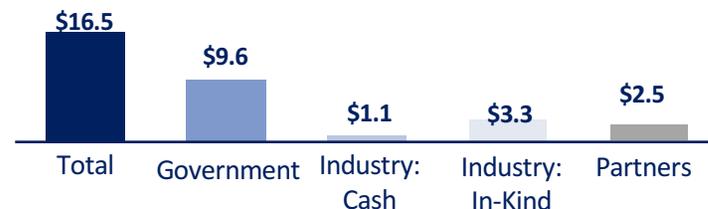
- Energy efficient comminution through new technology demonstration and waste energy recovery



Environmental Management



- Closure criteria
- Tailings management
- Mining industry knowledge hub & sensors
- Data management



* The split between government and industry investment across portfolios is based on anticipated investment level by industry, given their stated priorities

CMIC incorporates multiple, agile project delivery models that leverage knowledge, facilities and investments...

1. **CMIC managed research consortia:** Our current exploration project is the largest geoscience consortia in North America, addressing explicit research needs for the industry.
2. **Project integration/coordination:** This clusters existing new mining projects, adds potential new project elements and accounts for multi-million investments being made by companies. This will be one component of our underground mining program.
3. **Technology Demonstration:** This accounts for new technology that is not developed far enough and is typically too costly for a single company to test. In the case of energy efficient processing we are examining 3-5 new technologies in this genre.
4. **CMIC Directed, Partner Delivered:** These projects typically occur on the initial stages of larger, consortia-based project to prove an idea or provide a baseline of data, information and models on which we need to proceed.
5. **CMIC Instigated with “Ecosystem” Participation:** These are either very difficult technical challenges that have broad applicability and interest or where there are significant groups working on elements yet need to be stimulated to move in the right direction. environmental monitoring technologies. Low grade waste energy recovery is one example.
6. **Mini-Consortia:** Evolve around needs of a select group of companies and include two nascent projects in genomic based sensors for environmental monitoring and hybrid air vehicles for alternative transportation.



Exploration



Underground
Mining



Processing

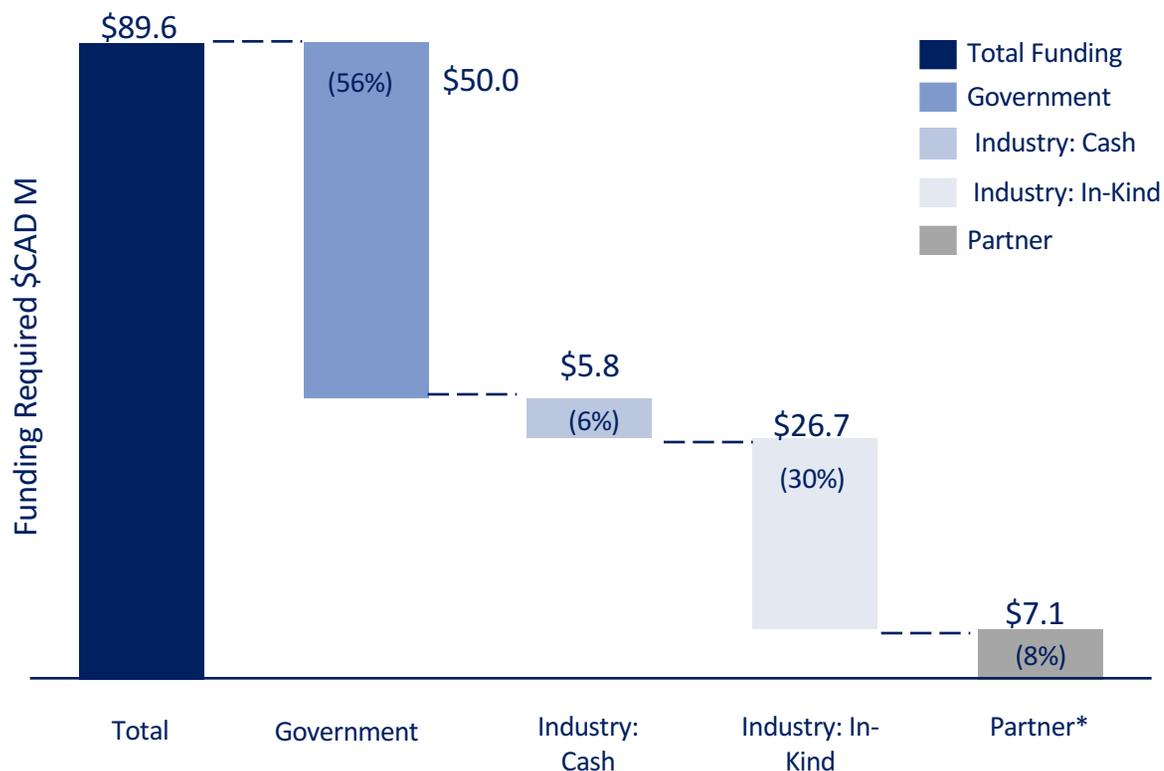


Environmental
Stewardship

In order to implement these roadmaps, government and industry investment is required

In order to **facilitate the collaborative innovation agenda** within the mining industry, **CMIC and its industry members have identified a total of \$89.6M in funding requirements over the first 5 years**. CMIC, together with industry participants, will then prioritize projects based on actual funds received. Further funding details and breakdowns are provided in the following slides

Funding Breakdown



*In addition to industry and government funding contributions, CMIC is leveraging cash and in-kind funding input from other groups (approximately 15-20, including public sector organizations, private industry, and service providers). It is expected that additional funding from these groups will be identified when projects are further defined

The possible savings from investment in the portfolios can be quantified based on industry expenditures

CMIC evaluated the 2014 financial statements of 13 mining companies and **applied the expected outcomes** to the relevant expenditure items to calculate the possible 10-year long-term ROI figures

Portfolio	Outcomes		Possible Savings*		
	Short-term	Long-term	Annual Exploration Expenditure Range	Annual Short-term Savings	Annual Long-term Savings
 Exploration	Average exploration value per dollar spent increased by 10-15%	Average exploration value per dollar spent increased by 25-30%	Low spenders: \$3-8M	\$0.5-1M	\$1-2M
			Medium spenders: \$41-80M	\$6-12M	\$12-24M
			High spenders: \$245-392M	\$37-59M	\$74-118M
 Underground Mining	20% unit cost reduction through a 200% increase in labour productivity and 20% increase in mining intensity	33% unit cost reduction through further increases in mining intensity	Base metals: \$55-89 / t	\$11-18 / t	\$18 - 30 / t
			Gold: \$800 - 1,000 / oz	\$160-200 / oz	\$270 -330 / oz
			Uranium: \$28 / lb	\$6 / lb	\$9 / lb
 Energy / Processing	20% energy reduction in comminution	45% energy reduction in comminution	Small Mill Capacity: 11 MWh	2 MWh	5 MWh
			Medium Mill Capacity: 93 MWh	19 MWh	42 MWh
			High Mill Capacity: 2,300 MWh	460 MWh	1,035 MWh
 Environmental Stewardship	20% cost reduction in cost and liabilities for environmental management and regulatory compliance		Remediation: \$5-20M	\$1-4M	
			Rehabilitation: \$50-80M	\$10-16M	
			Reclamation: \$30-200M	\$6-40M	

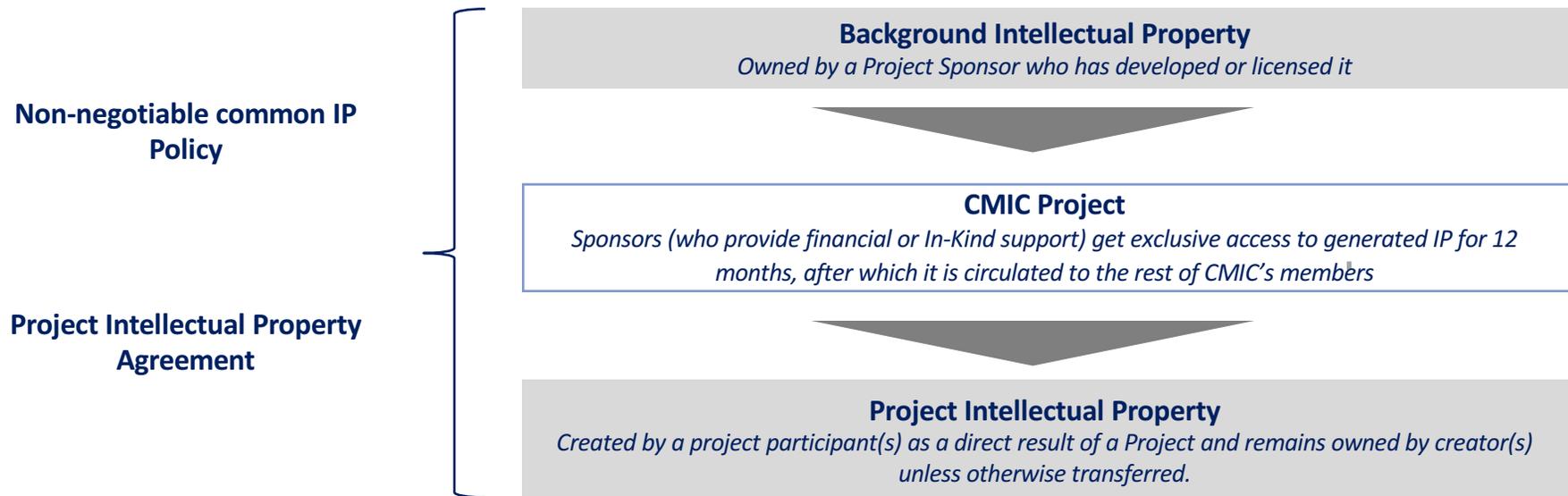
*Assumptions and qualifications for the possible savings targets have been identified in the detailed Business Case document

Project governance and management by internationally recognized subject matter experts

Project Governance



Intellectual Property Framework

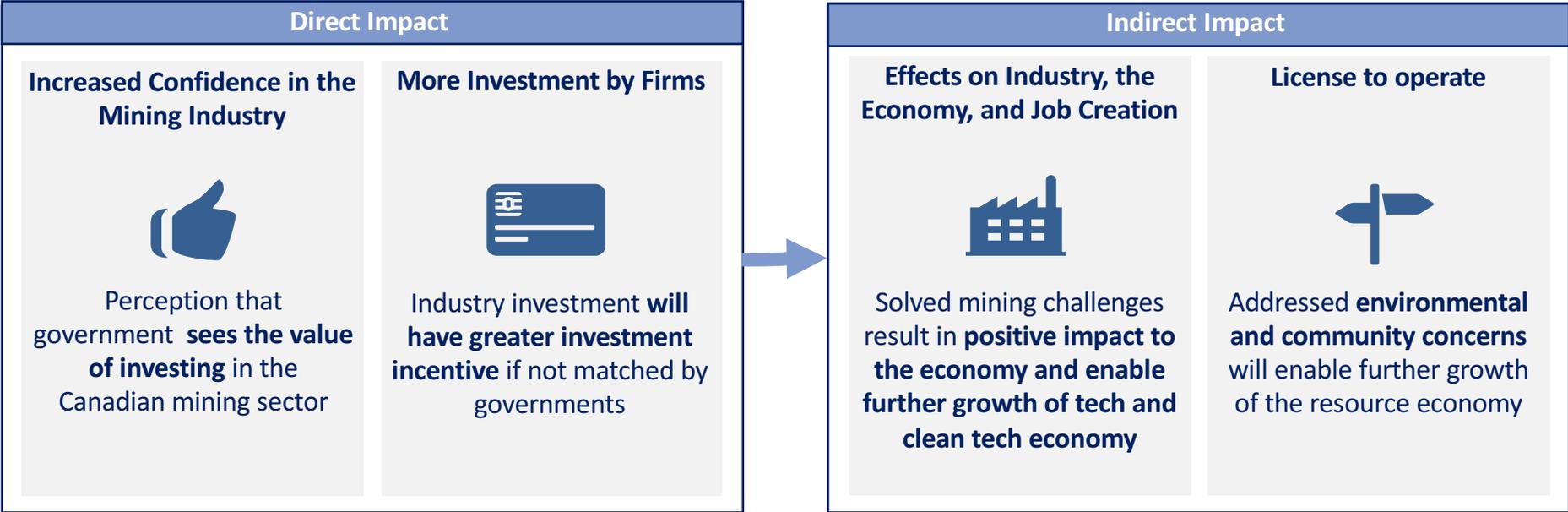


Creating long term value through collaboration on common issues

Investment Options	Advantages	Disadvantages
Invest in Property, Plant, and Equipment (PPE)	<ul style="list-style-type: none">• Addresses current challenges in PPE designed to target specific issues (e.g., poor productivity)• Generates additional revenue or increased margins (i.e., mining intensity through continuous extraction)	<ul style="list-style-type: none">• Only addresses specific issues which have already been solved by PPE suppliers, or other sectors• Addresses the decrease in margins for the short-term, but ignores long-term systematic challenges• Investment depreciates
Independently Invest in Innovation Research and Development	<ul style="list-style-type: none">• Addresses industry challenges, through internal (e.g., existing staff) or external (e.g., research facilities, product / service providers, and specialty mining consultants) resources with a focus on long-term value• Provides sole access to any IP / patents developed, providing a possible competitive advantage	<ul style="list-style-type: none">• Requires substantial financial investment with no sharing of costs with other mining firms• Requires extensive resource and time commitment, taking away from mining production activities• Provides access to limited talent pool (i.e., internal or hired experts)• Imposes significant risk for the time and money invested
Address Operational Expenditure Pressure Points	<ul style="list-style-type: none">• Improves liquidity and cash flow in the short-term, helps fund other priority investments, and provides additional security in case of a drop in commodity price• Reduces debt and / or meets key financial ratios	<ul style="list-style-type: none">• Addresses short-term challenges at the expense of business growth and long-term value creation• Does not provide direct return on investment

Government can prioritize mining investment through CMIC

Government investment will address common mining challenges, increase technology development and adoption, address climate change and environmental impacts



Prompt action is required by government representatives to allocate funding for the 2016 budget



Workflow for the CMIC Towards Zero Waste Mining strategy implementation

