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.

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.

- **Stage 3**
  - All new: Net Zero Waste

- **Stage 2**
  - Optimized and advanced: Industry cost-drivers

- **Stage 1**
  - Safe and reliable: Environmental impact reduction

**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 Model**

- **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**

Source: (1) Details sourced from the websites of COSIA, Eclipse, and AMIRA Monitor Deloitte.
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
- Comminution energy reduction
- Energy management and efficiency
- 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
- Environmental footprint reduction and more effective operations
- Making continuous mining more economical and efficient
- Water usage, availability, and efficiency is a challenge
- Improvements in safety to benefit employees

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

**From Zero Waste mining issues...**

**Exploration**

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

**Continuous Underground Mining**

- Real-time continuous underground mining

**Processing (Comminution Efficiency)**

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

**Energy Efficiency**

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

**Environmental Stewardship**

<table>
<thead>
<tr>
<th>Priority Projects</th>
<th>Required Investment*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Exploration</td>
<td>$18.0</td>
</tr>
<tr>
<td>Underground Mining</td>
<td>$31.1</td>
</tr>
<tr>
<td>Energy / Processing</td>
<td>$16.5</td>
</tr>
</tbody>
</table>

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

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.
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.

*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.

### Exploration Outcomes

#### Portfolio

- **Short-term:** Average exploration value per dollar spent increased by 10-15%
- **Long-term:** Average exploration value per dollar spent increased by 25-30%

#### Possible Savings*

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>Possible Savings*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration</td>
<td>Annual Exploration Expenditure Range</td>
<td>Annual Short-term Savings</td>
</tr>
<tr>
<td>Low spenders: $3-8M</td>
<td>$0.5-1M</td>
<td>$1-2M</td>
</tr>
<tr>
<td>Medium spenders: $41-80M</td>
<td>$6-12M</td>
<td>$12-24M</td>
</tr>
<tr>
<td>High spenders: $245-392M</td>
<td>$37-59M</td>
<td>$74-118M</td>
</tr>
</tbody>
</table>

**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**

#### Underground Mining Costs Range

<table>
<thead>
<tr>
<th>Underground Mining Unit Costs Range</th>
<th>Short-term Mining Unit Cost Savings</th>
<th>Long-term Mining Unit Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base metals: $55-89 / t</td>
<td>$11-18 / t</td>
<td>$18 – 30 / t</td>
</tr>
<tr>
<td>Gold: $800 – 1,000 / oz</td>
<td>$160-200 / oz</td>
<td>$270 – 330 / oz</td>
</tr>
<tr>
<td>Uranium: $28 / lb</td>
<td>$6 / lb</td>
<td>$9 / lb</td>
</tr>
</tbody>
</table>

**Energy / Processing**

- **20% energy reduction in comminution**
- **45% energy reduction in comminution**

#### Daily Mine Energy Use

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Mill Capacity: 11 MWh</td>
<td>2 MWh</td>
<td>5 MWh</td>
</tr>
<tr>
<td>Medium Mill Capacity: 93 MWh</td>
<td>19 MWh</td>
<td>42 MWh</td>
</tr>
<tr>
<td>High Mill Capacity: 2,300 MWh</td>
<td>460 MWh</td>
<td>1,035 MWh</td>
</tr>
</tbody>
</table>

**Environmental Stewardship**

- **20% cost reduction in cost and liabilities for environmental management and regulatory compliance**

#### Annual Environmental Cost Range

<table>
<thead>
<tr>
<th>Annual Environmental Cost Range</th>
<th>Annual Long-term Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remediation: $5-20M</td>
<td>$1-4M</td>
</tr>
<tr>
<td>Rehabilitation: $50-80M</td>
<td>$10-16M</td>
</tr>
<tr>
<td>Reclamation: $30-200M</td>
<td>$6-40M</td>
</tr>
</tbody>
</table>

*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**

- **Project Directorate**
  - Nominated by project investors
- **Project Management Office**
  - Project leaders and support staff
- **Project Test Site Leaders**
  - Manage and report on project execution
- **Technical Expert Groups**
  - Provide industry and non-industry subject matter experts

**Intellectual Property Framework**

- **Background Intellectual Property**
  - *Owned by a Project Sponsor who has developed or licensed it*
- **CMIC Project**
  - *Sponsors (who provide financial or In-Kind support) get exclusive access to generated IP for 12 months, after which it is circulated to the rest of CMIC’s members*
- **Project Intellectual Property**
  - *Created by a project participant(s) as a direct result of a Project and remains owned by creator(s) unless otherwise transferred.*

---

*Monitor Deloitte.*

*Canada Mining Innovation Council.*
### Creating long term value through collaboration on common issues

<table>
<thead>
<tr>
<th>Investment Options</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Invest in Property, Plant, and Equipment (PPE) | - 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) | - 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 | - 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 | - 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 | - 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 | - 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

<table>
<thead>
<tr>
<th>Direct Impact</th>
<th>Indirect Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Confidence in the Mining Industry</td>
<td>Effects on Industry, the Economy, and Job Creation</td>
</tr>
<tr>
<td>More Investment by Firms</td>
<td>License to operate</td>
</tr>
</tbody>
</table>

- Perception that government sees the value of investing in the Canadian mining sector
- Industry investment will have greater investment incentive if not matched by governments
- Solved mining challenges result in positive impact to the economy and enable further growth of tech and clean tech economy
- Addressed environmental and community concerns will enable further growth of the resource economy

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

1. **Budgetary Submission (By Q1 2016):** Submit budget request for the Towards Zero Waste strategy to Parliament

2. **Approval of Funds (By Q1 2016):** Approval of funds by Treasury for 2016 expenditure

3. **Transfer of Funds (By Q2 2016):** Transfer of funds from Treasury to CMIC for investment in the Towards Zero Waste strategy
Workflow for the CMIC Towards Zero Waste Mining strategy implementation

**Industry Next Steps**

1. **Commit to 5 year Investment (Q1 2016):**
   Review detailed business case, align with CMIC’s Towards Zero Waste™ strategy, confirm five year funding commitment

2. **Allot Funding (Q3 2016):**
   Align with one or more Portfolios and allot yearly budgets across Portfolio projects

3. **Establish Individual Project Consortia:**
   Technical Working Groups determine Project Test Sites, and leadership and subject matter expert roles by consortium members

4. **Commit to “In-Kind” Investment (Prior to Project Start):**
   Technical Working Groups to determine what in kind resources required from consortium members and pursue individual commitments

5. **Execute Projects:**
   Initiate projects in accordance with Business Case roadmaps and signed IP policies

6. **Commence Next Planning Cycle:**
   Compile industry insights from current projects and begin plans for second generation programs

**CMIC Next Steps**

1. **Present Business Case (Q3 2015):**
   Share the Business Case with industry and government stakeholders to solicit buy-in and investment commitment

2. **Obtain Funding (Before Q1 2016):**
   Finalize investment allocations with industry participants and other stakeholders

3. **Finalize Roadmaps (Before Q2/Q3 2016):**
   Obtain outstanding funding and resources required in order to finalize technical working group project plans

4. **Budget Approval (by Q1 2016):**
   Finalize government budgeting process and keep both industry and government informed regarding project executions

5. **Execute Projects:**
   Initiate projects in accordance with CMIC Roadmap and Project Governance Structure and any partnership agreements

6. **Canas as a Global Mining Leader**

---

**Monitor Deloitte**