CCES 2025 Session Summary

Maximizing the Supply of Critical Minerals & Metals through Circular Economy Strategies

Critical and strategic minerals (CSMs) like copper, nickel, lithium, and rare earth elements are essential for advanced electronics, medical devices, and renewable energy technologies. With global demand expected to surge, sustainable sourcing and responsible resource management are increasingly urgent. Challenges include limited mining sources, environmental impacts, and geopolitical control over supply.

Circular economy strategies—such as waste reduction, product redesign, and recycling—can help ease supply pressures. Canada, which produces 21 of its 31 critical minerals, has an opportunity to strengthen domestic supply chains, but regional approaches are key to cost-effective implementation.

Shifting North American policies, trade barriers, and tariffs will impact cross-border partnerships, creating both challenges and opportunities. This session will bring together industry and policymakers to explore how circular economy strategies can secure a sustainable CSM supply for Canada, considering regional and geopolitical factors. Discussions will address global competition, innovative sourcing strategies, and circular supply chain design.

Topics to be covered include:

1. Designing for Circularity: One of the most effective ways to maximize the supply of critical minerals and metals is through the design of products that are easier to repair, upgrade, and recycle.
2. Recycling and Reuse of Critical Minerals and Metals: These approaches can not only reduce reliance on primary mining but also help lower costs and improve efficiency in recovering valuable materials from end-of-life products.
3. The Role of Innovation and Technology: Technological innovation is pivotal in realizing circularity in mineral and metal supply chains.
4. Business Models and Policy Frameworks for Circular Supply Chains: In light of evolving geopolitical dynamics in North America, how might business models and circular supply chains be enabled or impacted by evolving trade and policy frameworks.

Date / Location: Tuesday, April 15, 2025 / Montreal, Canada

Speakers

- **Alan Young**, Principal, Materials Efficiency Research Group (MERG) (moderator / host)
- **Geoff McCarney**, Executive Director, Smart Prosperity Institute
- **Bryony Clear Hill**, Director of Innovation, International Council on Mining and Metals (ICMM)
- **John Holm,** Senior Vice President, Partnership Development, Pyxera Global
- **Brian Nicholson**, Director, Government Relations & Lead, Western Battery Hub, Energy Futures Lab
- **Isabel Cyr**, Public Affairs & Communications Director, Lithion Technologies Inc.
- **Paul Steenhof,** Manager, Strategic Initiatives - Environment & Business Excellence, CSA Group

SUMMARY

Introductory Remarks by Alan Young, MERG

Alan Young of the Materials Efficiency Research Group expressed his delight at the significant growth in interest and engagement in circularity since its early days. He acknowledged Quebec's pioneering work in the field and commended the organizers for bringing the discussion full circle.

Despite the current global uncertainties affecting supply chains and international cooperation, Alan highlighted the emerging opportunities within this crisis. He clarified that the focus should be on "optimizing" rather than "maximizing" critical mineral supply, emphasizing the need to reduce overall material consumption as a fundamental aspect of circularity and sustainability. Even with advancements in technologies like EV batteries, simply increasing extraction is not a sustainable path. The emphasis needs to be on optimizing the use of both primary and secondary mineral sources through strategies like transportation and product redesign, reuse, servicing, and regeneration.

Alan underscored the materials-intensive nature of the renewable energy transition, requiring a significant supply of critical minerals. These minerals, defined by their economic importance and supply insecurity, are also in demand across various sectors, including defense, medicine, agriculture, and electronics, creating a competitive landscape. He pointed out Canada's 21 recognized critical minerals and the country's opportunity and responsibility in their optimized use.

The panel aimed to unpack the complexities surrounding critical minerals, moving beyond rhetoric to identify strategic priorities and concrete next steps. Discussions would cover the entire supply chain, from mining to consumer products, and delve into sobering demand and supply realities, emphasizing that recycling alone cannot solve the issue. The goal was to explore how the extractive sector can actively participate in circularity and to highlight the significant untapped potential of secondary sourcing through local and regional strategies, infrastructure development, and capacity building.

Alan called out the significant and rapid transformation within the mining sector's approach to the circular economy, driven by market demand and the recognition that traditional linear mining models are not optimized for long-term value creation. Alan stressed that minerals are inherently circular materials with the potential for infinite reuse, leading to reduced energy, water, and biodiversity impacts when managed correctly.

The discussion would also address waste reduction, value capture, and regenerative strategies in the context of metals. Finally, the panel aimed to hear from businesses navigating market forces and regulations to find sustainable approaches to mineral use in technologies like lithium-ion batteries, identifying operational challenges and potential solutions. The session was structured into two parts: one setting the context and the other focusing on opportunities and challenges, with the hope of generating insightful discussions and identifying gaps in policy, markets, and technology that need to be addressed.

Presentation by Geoff McCarney, SPI

Geoff McCartney, Executive Director of the Smart Prosperity Institute, presented research on critical mineral demand and waste volumes in Canada's transition to a low-carbon economy. He highlighted projections showing a tripling of nonmetallic mineral demand and a doubling of metallic mineral demand globally by 2050, even with efficiency improvements. Decarbonization efforts will further increase demand for battery metals and minerals used in solar panels and wind turbines.

Geoff's research indicates a 60-fold increase in end-of-life solar panels and a 30-fold increase in wind turbines in Canada by 2050. Installed renewable energy capacity increases faster than waste volumes, creating a lag in secondary supply. He pointed out that achieving economies of scale in solar panel recycling, estimated at 10,000 tonnes per year, won't occur nationally until 2035. Current material recovery rates are low, with potential offsets of primary demand reaching a maximum of 30% even with 100% recovery and reuse.

Regional disparities in waste generation also pose challenges. Ontario, with earlier adoption of solar energy, will produce higher waste volumes sooner than other provinces. For EV batteries, meeting the 2035 target for no new internal combustion engine sales will significantly increase demand for battery materials. Recovery and reuse from EV batteries won't significantly impact primary demand until after 2035 due to vehicle lifecycles. Reusing batteries for other purposes, like standalone storage, may offset demand in other sectors but increase primary demand within the EV sector.

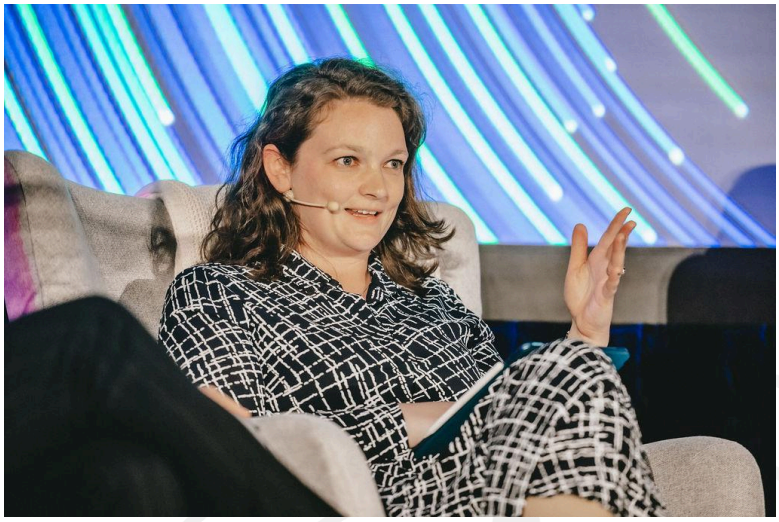
Geoff emphasized that recycling alone cannot meet the increasing demand for critical minerals. A lag exists between demand and the availability of secondary materials, requiring sourcing from other sectors and competing with industries like electronics and defense. Therefore, sustainable mining practices are crucial to meet decarbonization targets until secondary material volumes increase.

Presentation by Bryony Clear Hill, ICMM

Bryony Clear Hill from the International Council on Mining and Metals (ICMM) addressed the critical role of mining in a decarbonized future, acknowledging its often negative public image. She emphasized that a significant number of new mines will be required to meet the growing demand for metals in clean energy technologies, as recycling alone cannot fulfill the immediate need due to locked-up metals in existing infrastructure and the fact that initial generations of these technologies were not designed for easy recovery.

ICMM, an industry association focused on responsible mining, collaborates among its 24 CEO-led member companies to address challenges that individual companies cannot tackle alone. Their approach to circularity in the mining and metals industry is two-fold: process circularity and product circularity.

Process circularity focuses on applying circular economy principles to make the mining process more efficient, reduce environmental impact, and maximize benefits for people. Examples include Vale producing sand from iron ore mining tailings, reducing both waste and the need for primary sand mining. Boliden utilizes excess heat from smelting to generate electricity for the national grid and local industrial parks. While these practices are not yet universal, they demonstrate the business sense of waste reduction, potential revenue generation from byproducts, and improved sustainability and regulatory compliance.



Product circularity centers on ensuring that the metals produced are used and reused effectively. Metals possess the potential for infinite recyclability if the right systems are in place. While specialist metal recyclers exist, major mining companies like Teck (recycling lead batteries) and Glencore (recycling e-waste) are increasingly involved in the recycling and reprocessing of metals, often integrating secondary materials back into their smelting processes for optimization and additional benefits.

Bryony concluded that achieving circularity in the mining and metals industry requires both optimizing mining processes and ensuring the continuous use of the metals produced. While significant progress is being made, much more work is needed to implement these practices globally and realize the full potential of a circular approach in the sector.

- ➔ **Question (Alan to Bryony): How is the mining industry viewing the intersection between the critical minerals rush and the circular economy opportunity?**

Bryony stated that the more progressive mining companies are moving from viewing the circular economy as a **threat** (potentially replacing primary mining) to recognizing it as an **opportunity** and a necessary complement. The understanding is growing that both primary mining and secondary recovery

are needed to meet the increasing demand for critical minerals. Bryony anticipated the emergence of **different business models** within the mining sector, including:

- Continued primary mining with maximum efficiency (net-zero, nature-positive, zero-waste).
- Diversification into resource solution providers, offering both primary and secondary metals.
- More innovative models like "metals as a service" and increased focus on traceability.

Bryony emphasized that primary mining cannot come at any cost to nature and highlighted two key focus areas for the industry:

1. **Standards:** Recognizing the need for strong ESG credentials for primary suppliers, with a focus on voluntary standards and initiatives like the Consolidated Mining Standards Initiative.
2. **Innovation:** Investing in technologies to address challenges like tailings reduction and the electrification of mining equipment.

With respect to secondary materials, Bryony noted the dual challenge of the **existing "urban mine"** (often not designed for recovery, making extraction difficult) and the need to **design new products for recyclability from the outset**. She suggested that mining companies' expertise in metals could contribute to the design for recovery. Ultimately, Bryony concluded that the industry is increasingly seeing circularity as an opportunity, although the specific approach will vary among companies.

Presentation by John Holm, Pyxera Global

John Holm, Senior VP at Pyxera Global, discussed the potential of regional economies to tap into the "above ground resource" of recyclable materials for local and planetary benefit. Pyxera Global, a nonprofit, unites public, private, and social sectors to solve problems, focusing on building coalitions for circular supply chains.

John highlighted the current geopolitical context, including global conflicts, climate change disrupting supply chains, and China's dominance in critical mineral refining and mining. He argued that the focus should shift from subsidizing extractive industries to incentivizing reuse behaviors and onshoring supply chains to prioritize local value.

The Circular Supply Chain Coalition, initially funded by FedEx, aims to establish reverse logistics hubs to efficiently recover and process materials with commoditized value (excluding non-commoditized materials like plastic). This initiative draws on the concept of "urban mining," incentivizing the return of discarded electronics and other waste for deconstruction and material recovery. John emphasized that the issue is not a lack of supply but a lack of incentives and subsidies to drive demand for recycled materials.

The Coalition is working to solve the challenges of overburdened supply chains by facilitating forward material sourcing, pre-competitive collaboration among industries, and an integrated hub-and-spoke model for material collection and processing. This model aims to create economically efficient systems for companies to utilize domestic feedstocks as an economic hedge against global supply chain risks.

John presented a plan to establish initial hubs in North America (including potential locations like Buffalo, Cleveland, Atlanta, Texas, Colorado, and California), Europe, and Singapore, focusing on waste streams from the tech and automotive industries (batteries, semiconductors, and e-waste). The strategy involves leveraging policy subsidies, incentivized procurement, and private sector engagement to create a viable

circular economy. He noted that while Europe is progressing faster due to supportive regulations, Canada has the potential to be more nimble in adopting these models compared to the US.

John concluded by emphasizing that recycling alone is insufficient and urged stakeholders to seize the current geopolitical situation as an opportunity to define new, financially viable reuse and repurpose business models to enhance supply chain security and resilience.

➔ **Question (Alan to John): How can local businesses and governments best create the conditions for maximizing value and supply of critical minerals? What's typically missing in these sorts of conglomerations to build viable capacity?**

John emphasized the need to differentiate between large industry and Small and Medium-sized Enterprises (SMEs) in the e-waste sector. He noted that many existing e-waste providers are struggling for survival and lack the scale and demand to grow. John suggested that **state-level governments** can play a crucial role by creating **net-positive subsidies and incentives** to tether these SMEs together, forming co-ops to achieve the necessary volume, speed, and quality for a hub-and-spoke model.

He cited Colorado's policy banning the landfilling of critical minerals as an example, creating a glut of material without a clear marketplace. John also highlighted the changing perspective of **industry**, moving from viewing ESG as a CSR concern to recognizing the **competitive advantage** of local sourcing and investing in hub-and-spoke models. Finally, he stressed the importance of **community ownership** of the waste resource, empowering local communities to benefit from the materials on their land. John summarized the key elements as:

- States creating net-positive investments to attract industry.
- Industry recognizing the competitive advantage of local value chains.
- Communities coming together to leverage the value of their waste resources.

PANEL OPENING REMARKS & DISCUSSION

This segment involved a panel of speakers who provided introductory remarks and led to a discussion that focused on the practical aspects of building capacity for a circular critical minerals economy, focusing on regional development, industry perspectives, and the crucial role of standards.

Brian Nicholson (Energy Futures Lab) provided a Western Canadian perspective on the investments needed to increase Canada's capacity for processing raw critical materials. He highlighted the **regional disparities** across Canada, emphasizing that a one-size-fits-all policy approach wouldn't work. He noted that while Quebec and Ontario have established strategies and attracted investments, the West and North lag behind with less clarity on their integration into national and global supply chains. Brian identified three key challenges:

1. **Outsourcing of Industrial Capacity:** Over the past two decades, Canada has largely outsourced the processing and refining of critical minerals to Asia, creating a "missing middle" in the domestic supply chain.
2. **Lack of Clean Power:** The Prairies and the North lack the abundant, affordable, clean hydropower that is a key criterion for attracting energy-intensive refining companies.
3. **Logistical Difficulties:** The decentralized and distant nature of populations in the West and North makes the aggregation of both primary and secondary materials logistically difficult and expensive, hindering economies of scale.

Brian argued for **targeted government initiatives** to support the development of the midstream processing sector in the West and North. He suggested policy tools like **incentives, infrastructure development (electricity and transportation), regulations (like battery passports), and strategic critical mineral reserves sourced domestically**. He also proposed investing in **retraining programs** for workers from other sectors. Ultimately, he emphasized the need for a **purposeful and coordinated plan**, potentially through a coordinating entity like Quebec's Société du Plan Nord, to integrate the West into the national and global supply chains.

Isabelle Cyr (Lithion Technologies) offered the perspective of a company actively engaged in lithium-ion battery recycling in Quebec. She emphasized that their company emerged from a **market need** driven by the high number of EVs in the province. Isabelle highlighted two primary barriers to scaling up their operations:

1. **Access to Capital:** While initial funding rounds were successful, securing further capital for commercial-scale hydrometallurgical refining has become challenging due to a downturn in the North American and European battery space.
2. **Regulatory Burden:** Existing hazardous materials regulations, put in place before the rise of the EV market, create significant permitting hurdles for the treatment, storage, and transportation of used batteries, hindering recycling efforts compared to regions like the US.

Isabelle stressed that used EV batteries represent a **rich "urban mine"** with higher concentrations of critical minerals than natural ores. She advocated for **regulatory changes** that favor the circular economy, making it easier to recycle and reuse battery metals domestically rather than exporting them. Isabelle outlined the two-step recycling process (mechanical separation to produce "black mass" and hydrometallurgy to refine battery-grade materials), noting that while black mass production exists in North America, **commercial-scale hydrometallurgical refining capacity is lacking**, leading to the export of black mass to Asia. She highlighted the **environmental benefits of battery recycling** compared to

mining (reduced emissions and water usage) and the need to bring the supply chain local, as there is a net export of black mass from North America to Asia.

Paul Steinhoff (CSA Group) discussed the **role of standards** in enabling successful circular strategies for critical minerals. He highlighted key areas where standards are needed, including **sustainability measurements across the value chain, data management for digital product passports, and downstream processing**. Paul pointed out a significant challenge: **China's dominance in international standards development (ISO)** for critical minerals due to their leading role in production. He also noted the increasing **geopolitics within ISO**. While Canada is participating in relevant ISO technical committees, its smaller industrial base presents a challenge in terms of having the critical mass of experts to be heavily involved. Paul emphasized the **opportunity for Canada to step up and lead in standardization for the downstream aspects of circularity**, where gaps exist. He underscored the importance of standards in setting performance expectations, ensuring quality, protecting the public and the environment, and facilitating value transfer through supply chains.

PANEL DISCUSSION & AUDIENCE Q&A

Panelists underscored the need for regionally tailored strategies, highlighted the practical challenges and opportunities faced by a battery recycling company, and emphasized the crucial role of standards in building a robust and trustworthy circular economy for critical minerals. The speakers collectively pointed to the necessity of government support, private investment, regulatory reform, and collaborative efforts to realize a more sustainable and secure critical mineral supply chain in Canada.

The final segment of the panel discussion on critical minerals involved questions from audience to the panel and focused on practical strategies for maximizing value and supply at the local level and explored the mining industry's evolving perspective on circularity.

Question 1: Where are the opportunities for smaller scale investors and entrepreneurs in the circular economy around critical minerals? Where do you see the gaps and richest opportunities to position yourself?

- **John Holm (Pyxera Global)** pointed to emerging startups in **robotics and AI for product disassembly**. He also highlighted **gaps in the efficiency of the external supply chain** connecting smelters, OEMs, refurbishers, and manufacturers, suggesting opportunities for solutions that improve economic viability. He advised identifying gaps and needs, especially as regulations evolve.
- **Isabelle Cyr (Lithion Technologies)** noted that **battery recycling itself is less capital intensive** than other parts of the battery value chain. She identified opportunities in **storage and transportation of used batteries**, **local-level battery health diagnosis** at auto recyclers and dealerships, and **lab support for qualifying recycled materials** (black mass, lithium, cobalt, nickel). She also cited market intelligence suggesting a significant increase in investment needed in battery recycling between 2030 and 2040.

Question 2: Given the parallels with the oil and gas industry's past hesitancy to transition, is there a risk that the mining industry might similarly revert to solely focusing on primary extraction if secondary recovery proves too complex? Is there something fundamentally different about metals versus energy sources?

- **Bryony Clear Hill (ICMM)** argued that it is **fundamentally different** due to **declining ore grades** in primary mining, meaning more waste for the same amount of metal. She also noted the **long lead times for mining permits**, requiring current action for future supply. While some companies will remain primary miners, she believes the trend of **diversification into secondary processing** by larger companies is likely to continue and grow overall metal supply.
- **Alan Young** added that applying circular economy principles to **mining processes themselves offers significant optimization opportunities** (reduced waste and liability, increased revenue) regardless of secondary market developments. He also noted the increasing awareness of waste inventories at mine sites and the breakdown of silos between processes and products, driven by potential shareholder interest in efficiency and revenue gains.

Question 3: How should Canada collaborate with other countries, for example, with the planned EU Critical Minerals Act, to control materials flow and assets?

- **Brian Nicholson (Energy Futures Lab)** advocated for **learning from leading countries** that have piloted relevant initiatives to expedite Canada's progress and avoid past mistakes.
- **Alan Young** highlighted the **EU Critical Raw Materials Act** as a comprehensive and thoughtful piece of public policy, recommending the circular economy analysis by Sitra.
- **John Holm (Pyxera Global)** suggested leveraging the **EU's circular economy policies** as a benchmark for the US and Canada. He also pointed to the **opportunity for strategic collaboration between Canada and the US** on critical minerals, especially given recent import restrictions in the US.

Question 4: Given the focus on metals and minerals, what about the significant amount of plastic waste in electronics, for which there isn't a strong market? Is anyone working on this, and should design for disassembly be a key consideration?

- **Paul Steinhoff (CSA Group)** mentioned that CSA has done significant work on plastics recycling, suggesting a separate discussion with colleagues in that area.
- **Isabelle Cyr (Lithion Technologies)** acknowledged the **struggle with light plastics** in battery recycling, noting that current revitalization options are limited to energy recovery. She highlighted the economic factors favoring plastics in EVs but emphasized the importance of **design for recycling** and questioned societal norms around frequent car replacement. She also pointed to research suggesting EV batteries can last significantly longer with proper use, potentially reducing waste.
- **John Holm (Pyxera Global)** emphasized the need to **reformat subsidies** to incentivize longer-lasting products and a shift away from the single-use, throwaway model for plastics, aligning with planetary boundaries.
- **Alan Young** linked this back to the initial question about entrepreneurial opportunities, suggesting that a more systematic approach to understanding the **values and niches within regionalized material flows** could create opportunities for addressing plastic waste and other under-utilized resources. He pointed to existing mining hubs with diverse small businesses thriving on niche needs.

The panel concluded by emphasizing the importance of precise conversations about values, impacts, and business priorities to unlock entrepreneurial opportunities in the circular economy of critical minerals and related materials like plastics.