MINING TRL FRAMEWORK – PROJECT

CHARTER & SPONSOR INVITATION

November 2025

1. EXECUTIVE SUMMARY

What Is the Project?

The Mining TRL Framework is an industry-first initiative to develop a dedicated, mining-specific Technology Readiness Level standard. It aims to provide a transparent, evidence-based method for assessing technology maturity and deployment readiness—reducing uncertainty, strengthening comparability, and enabling faster, safer adoption across global mining operations.

Why It Matters

Mining is entering a decade of structural change. Demand for critical minerals is increasing, water and tailings constraints are intensifying, and ESG expectations are rising. Yet even proven technologies routinely take 20–40 years to achieve broad deployment. The challenge is not a lack of innovation—it is the absence of a shared, independent benchmark that helps the industry understand readiness, risk, and scalability. A mining-specific TRL framework intends to address this gap.

The Challenge

Existing readiness models imported from other sectors fail to capture mining's unique complexity: geological variability, dynamic mineralogy, water and energy interactions, tailings implications, operational diversity, constructability, and the services required for long-term reliability. The result is repeated pilots, inconsistent data, slow learning cycles, and barriers to scaling technologies that could deliver meaningful ESG impact.

The Solution

The Mining TRL Framework proposes a structured, multi-dimensional approach that reflects the full lifecycle of technology deployment in mining. It spans technical readiness, system integration, mine-to-mill compatibility, environmental and social performance, project delivery, installation, ramp-up, lifecycle services, and technology-transfer maturity. It creates a common language for miners, OEMs, METS companies, EPCMs, researchers, and investors—builds trust, reduces duplication, and accelerates the path from concept to operational value.
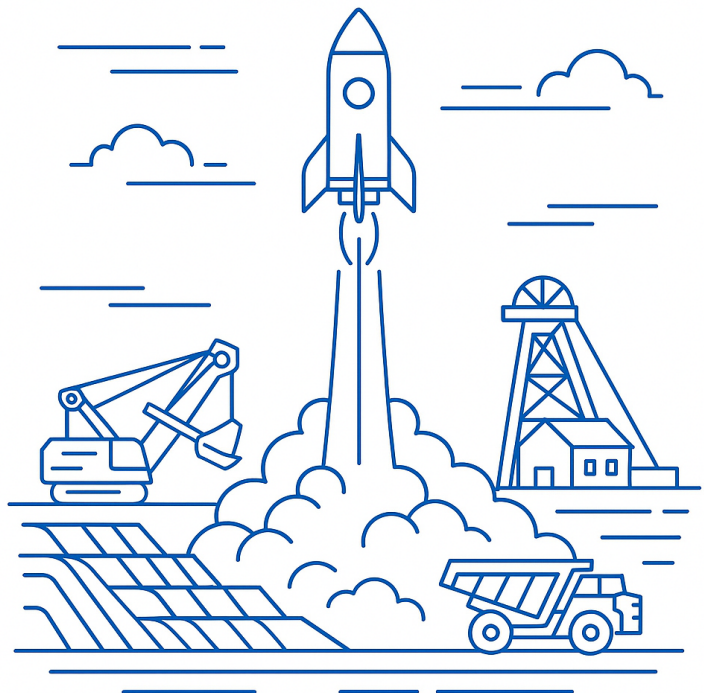
How will it Work

Governance: Independent structure led by CEEC, supported by a Steering Committee, Technical Advisory Board, and Validation Team.

Timeline: 18-month development program, progressing through four phases: Design & Alignment, Consortium Formation, Collaborative Framework Development, Publication & Launch.

Value for Sponsors & Contributors

Founding Sponsors will:

- Help shape a global, industry-wide standard from its formative stage.

- Gain early access to drafts, workshops, and validation processes.

- Influence the methods used to assess technical, operational, and ESG readiness.

- Position their organisation as a leader in innovation and sustainability.

- Reduce deployment risk and shorten technology adoption cycles.

Call to Action

Join CEEC and leading mining companies, OEMs, researchers, and investors in co-developing the Mining TRL Framework. Help create the benchmark that will guide how the industry evaluates, deploys, and scales the technologies essential for future performance in energy, water, emissions, and tailings.

Contact CEEC to explore participation as a Founding Sponsor.

2. PURPOSE

The Mining TRL Initiative seeks to establish the first independent, mining-specific Technology Readiness Level (TRL) Framework — a common language that allows the sector to objectively evaluate the maturity of new technologies, reduce implementation risk, and accelerate their safe and effective adoption across operations worldwide.

Today, mining faces a paradox. Technologies with proven potential to reduce energy use, water consumption, and emissions — from High-Pressure Grinding Rolls (HPGRs) and Ore Sorting to Coarse Particle Flotation and hybrid comminution circuits — have taken 20 to 40 years to achieve broad industrial adoption. This long diffusion cycle is not caused by lack of innovation, but by a persistent absence of shared, transparent, and independent criteria to assess when a technology is truly ready for implementation.

In most cases, every company applies its own internal criteria, influenced by risk tolerance, local experience, or supplier assurances. The result is fragmented validation, repeated pilot programs, inconsistent data, and delayed scaling — even for technologies that have already demonstrated viability elsewhere. This lack of a common standard has created one of the greatest hidden inefficiencies in mining's innovation system: a structural lag between invention and adoption.

The Mining TRL Framework directly addresses this challenge. It will provide measurable and independently verified readiness levels — defining what must be proven, in which environment, and with what quality of evidence before a technology can credibly move forward. By doing so, it enables mining companies, OEMs, EPCMs, and research institutions to speak the same language, align expectations, and focus resources where they will have the greatest impact.

Ultimately, the initiative's goal is to shorten the time between idea and impact, transforming technology adoption from a decades-long endeavor into a predictable, transparent, and collaborative process that supports the transition toward low-energy, low-water, and low-emission mining.

3. WHY IT MATTERS

Mining is entering one of the most transformative decades in its history. Global demand for critical minerals is rising sharply, while societal expectations for sustainability, transparency, and environmental performance are higher than ever. To meet these challenges, the industry must adopt new technologies that enable step-changes in efficiency, circularity, and emissions reduction.

However, history shows that even when new technologies are proven, their adoption in mining is painfully slow. The introduction of HPGRs, for example, took more than two decades to move from early pilot plants to mainstream use; sensor-based ore sorting and coarse particle flotation are following similar trajectories. The consequences are substantial: valuable innovations remain trapped in demonstration, slowing the sector's ability to decarbonize, optimize resources, and deliver on ESG commitments.

The main barrier is not the absence of innovation — it is the absence of trust and shared understanding. Each company, supplier, or research group assesses "readiness" differently. One miner's "field-proven solution" may still be viewed as "experimental" by another. Without independent and consistent criteria, adoption becomes a series of fragmented, duplicative efforts, increasing cost, risk, and uncertainty for everyone involved.

The Mining TRL Framework will change that dynamic. By introducing a transparent, evidence-based system to evaluate technology readiness, it will:

- Provide miners and OEMs with a common reference for evaluating implementation risk.

- Enable EPCMs and project developers to integrate emerging technologies into design stages with confidence.

- Allow investors and financiers to differentiate between technologies that are promising and those that are proven.

- Create a credible pathway for innovators to demonstrate progress and attract partnerships faster.

In doing so, the Mining TRL Framework will become a catalyst for accelerated, low-risk innovation, ensuring that critical solutions for energy efficiency, water management, and emissions reduction reach the field in years — not decades.

4. LEADERSHIP AND GOVERNANCE

The Mining TRL Initiative is led by CEEC International (Coalition for Eco-Efficient Comminution) — a globally recognized, independent not-for-profit organization with over 15 years of experience driving collaboration, benchmarking, and innovation across the mining value chain.

CEEC acts as a neutral convener, bringing together mining companies, OEMs, METS providers, researchers, and investors to share knowledge and accelerate the adoption of eco-efficient practices. Through initiatives such as the Energy Curves, Water Curves, and the Global Water Initiative (GWI), CEEC has established a proven model for delivering technical credibility, global reach, and industry alignment without commercial or regional bias.

The Mining TRL Framework builds upon this foundation, introducing a structured, pre-competitive platform to align the industry around a shared understanding of technology readiness and adoption risk. CEEC's role is to ensure that the framework is developed through independent governance, transparent processes, and balanced participation — enabling broad industry trust and long-term credibility.

The governance structure for the program includes:

- Steering Committee (SteerCo) – Composed of nine members: six nominated by sponsors and three appointed independently by CEEC. The SteerCo provides strategic oversight, approves budgets, and ensures alignment with CEEC's mission and the initiative's public-good objectives.

- Technical Advisory Board (TAB) – A multidisciplinary group of experts in mineral processing, energy efficiency, water stewardship, ESG, and digital innovation. The TAB ensures scientific and technical integrity, mobilizes Subject-Matter Experts (SMEs) and Independent Validators, and authorizes the publication of validated outputs.

- Delivery Team – The operational engine of the program. This team coordinates workshops, integrates stakeholder input, and drafts the framework and guidance materials. It acts under the supervision of the SteerCo and in close collaboration with the TAB.

Together, these governance bodies create a balanced and transparent leadership model that safeguards the neutrality of the Mining TRL program. By combining CEEC's independence with sponsor participation and expert oversight, the initiative is positioned to deliver a framework that the industry can trust — one that reflects the collective intelligence and integrity of the global mining community.

5. PROGRAM OVERVIEW

The Mining TRL Initiative will be delivered through a structured, multi-phase program designed to balance technical rigor, stakeholder participation, and practical outcomes. The goal is to move efficiently from concept definition to a validated, industry-ready framework that can be broadly adopted across commodities, geographies, and company types.

The program is planned over an estimated 18-month period, organized into four main phases. Each phase is designed to build progressively — ensuring that the framework is not only technically sound, but also shaped, reviewed, and endorsed by the industry that will use it.

Phase 1 – Design & Alignment

This initial stage establishes the foundation of the initiative. It includes finalizing the Info Memo, Prospectus, and Governance Charter, setting out the project's purpose, objectives, structure, and participation model. It also involves identifying key stakeholders, refining the communications plan, and confirming the scope boundaries (TRL 4–9 focus, excluding early R&D).

Output: Approved governance framework, communication package, and sponsor onboarding materials.

Phase 2 – Consortium Formation

In this phase, CEEC formalizes participation through the establishment of the Steering Committee (SteerCo) and Technical Advisory Board (TAB). Founding sponsors join the consortium, and the Delivery Team is mobilized. This stage ensures that governance, accountability, and technical leadership are in place before framework development begins.

Output: Confirmed consortium membership, operational launch, and approved Charter v1.0.

Phase 3 – Collaborative Framework Development

This is the technical and consultative core of the program.

Under TAB supervision, the Delivery Team coordinates four global workshops that bring together miners, OEMs, METS, EPCMs, and researchers to co-develop and test the TRL structure. Each workshop targets a critical building block of the framework:

1. Defining Battery Limits – Clarifying what constitutes a "technology" for TRL assessment and what lies beyond its scope.

2. Identifying Mining Archetypes – Developing representative operational contexts (e.g., hard rock, bulk, tailings reprocessing) to anchor readiness evaluation.

3. Defining TRL Dimensions – Establishing the key axes of readiness (technical, operational, ESG, scalability, integration).

4. Setting Exit Criteria and Evidence Protocols – Defining what constitutes sufficient proof to progress between TRL levels.

Each session combines technical co-design with peer review, ensuring that the framework is both methodologically sound and operationally relevant.

Output: Draft Mining TRL Framework, validation protocols, and archetype taxonomy.

Phase 4 – Publication & Dissemination

The final phase focuses on validation, publication, and industry adoption.

Independent Validators, coordinated through the TAB, review the draft framework, ensuring quality and reproducibility. Once approved, the Mining TRL Framework v1.0 is published as an open reference under CEEC

governance. A tailored Guidance Kit and Communication Package will accompany the release, supporting sponsors, adopters, and regional associations in implementation and training.

Output: Mining TRL Framework v1.0, Guidance Kit, and Dissemination Plan.

6. INDUSTRY BENEFITS

The Mining TRL Framework is being developed as a public-good standard that benefits the entire mining innovation ecosystem — from technology developers and operators to investors and regulators. It provides a shared foundation of trust that transforms fragmented innovation efforts into coordinated progress, enabling all participants to speak a common language of readiness, risk, and value. By establishing transparent, independent, and consistent criteria for technology maturity, the framework will accelerate the industry's transition toward safer, more efficient, and lower-impact mining.

By introducing a consistent, independent, and transparent method to assess technology maturity, the framework will help every participant make better decisions, reduce risk, and accelerate impact.

For Mining Companies

Mining companies will gain a trusted reference to evaluate the maturity and risk of emerging technologies before investing in pilots or site deployment.

- Enables faster and more confident decision-making on new technologies.

- Reduces duplication of pilots and testing programs by building on verified, shared evidence.

- Supports strategic planning and ESG commitments, linking technology adoption to energy, water, and emissions performance.

- Strengthens collaboration between operations, R&D, and corporate innovation teams under a common readiness language.

The result: shorter implementation cycles, lower uncertainty, and higher return on innovation investment.

For OEMs and METS Providers

Original Equipment Manufacturers and METS companies will benefit from a credible, industry-endorsed standard that demonstrates the real readiness of their technologies to potential clients and investors.

- Provides an independent validation pathway to prove technology readiness and performance.

- Builds market confidence by showing transparent, third-party evidence of results.

- Enables clearer communication with mining companies about risks, requirements, and support needs at each TRL stage.

- Reduces commercial friction by creating common expectations for deployment, commissioning, and service readiness.

This transparency helps OEMs shorten sales cycles, de-risk scale-up, and focus resources on technologies closest to adoption.

For EPCMs and Engineering Firms

EPCMs and design consultants will be able to integrate emerging technologies into projects with clear technical and operational readiness criteria.

- Improves design integration by knowing which technologies have been independently validated and at what level of maturity.

- Reduces rework and design changes by aligning project specifications with TRL-defined thresholds.

- Strengthens early-stage project planning and constructability studies.

Ultimately, the framework allows EPCMs to act as bridges between innovation and execution, enabling safer, more predictable implementation of novel systems.

For Research Institutions and Universities

Researchers will have access to a structured, industry-recognized framework to evaluate progress from laboratory work to industrial readiness.

- Aligns research objectives with industry adoption pathways.

- Enables clearer demonstration of progress to funding agencies and partners.

- Promotes collaboration across institutions by providing a common readiness metric.

This alignment helps close the gap between innovation creation and real-world application, accelerating the impact of academic and applied research.

For Investors, Financiers, and Policy Makers

The Mining TRL provides investors and policy-makers with transparent, evidence-based insight into where technologies stand along their development journey.

- Facilitates better capital allocation by identifying technologies closest to commercial viability.

- Reduces perceived risk and enhances confidence in sustainable technology portfolios.

- Supports policy frameworks, grants, and funding mechanisms tied to demonstrable readiness levels.

With a shared global benchmark, decision-makers can invest and legislate with clarity, knowing which technologies are ready to deliver measurable environmental and economic benefits.

7. WAYS TO PARTICIPATE

CEEC invites organizations to participate as sponsors or technical collaborators:

- Founding Sponsors: Full participation in governance (SteerCo seat), strategic influence, visibility in all communications, and early access to drafts and workshops.

- General Sponsors: Participation in workshops, consultation rounds, and access to pre-publication drafts.

- Technical Partners: Provide subject-matter expertise and participate in peer-review and validation discussions.

- Independent Validators: Universities or technical bodies contributing to verification of evidence and ensuring impartiality.

8. NEXT STEPS

CEEC is now inviting expressions of interest from companies, institutions, and research bodies wishing to join the Founding Sponsor Consortium.

An initial information session will be held in **December 16th 2025**, where the CEEC team will present the project charter, governance model, sponsorship tiers, and next steps.