Corporación Instituto de Tecnologías Limpias (ITL)
Antofagasta
Carrera #1615

CHALLENGE TITLE

Development of national capabilities and solutions for modeling, testing, validation, certification, and scaling of technologies associated with batteries, hybrid systems, retrofitting, green hydrogen (H2V), and electromobility in mining.

CHALLENGE DESCRIPTION

The decarbonization of mining requires accelerating the adoption of low-emission propulsion and energy supply technologies, including hybrid systems, retrofitting of existing equipment, green hydrogen (H2V), and electromobility. However, there is a national gap in capabilities to model, test, validate, certify, and scale these solutions under the extreme operating conditions of mining (altitude, dust, vibration, temperatures, heavy load cycles, and operational safety). The challenge seeks to mature technologies (≥ TRL 4) and consolidate national capabilities through the development of modeling methodologies, test benches, validation protocols, and certification pathways, along with scaling pilots in relevant and semi-industrial environments. Priority is given to interoperability, safety (electrical and hydrogen), energy performance, reliability, and techno-economic feasibility to accelerate adoption in mining operations.

GENERAL OBJECTIVE

Develop and validate comprehensive national capabilities and solutions for modeling, testing, validation, certification, and scaling of hybrid systems, retrofitting, H2V, and electromobility technologies applied to mining, reducing adoption time and costs while ensuring performance, safety, and interoperability.

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SPECIFIC OBJECTIVES

1. Execute multiscale models (vehicle–system–operation) for performance, safety, and total cost of hybrid, retrofitting, H2V, and/or electric solutions in mining cycles.
2. Design and implement test benches, functional, environmental, and safety test protocols, and pilots in relevant/semi-industrial environments.
3. Define certification and homologation pathways aligned with international standards; establish verification methodologies for interoperability between components and systems.
4. Execute scaling pilots with industrial partners, generate engineering guides and business models, and develop training and technology transfer programs.

EXPECTED RESULTS

- Validated simulation models and tools for sizing, control, and optimization of hybrid systems, retrofitting, H2V, and EV in mining.
- Test and validation protocols (environmental, functional, safety, interoperability) and test benches (e.g., HIL for powertrain, battery cycling, H2 combustion/use, hybrid powertrain).
- Documented certification/homologation pathways and pre-agreements with relevant bodies; regulatory compliance matrices.
- Semi-industrial demonstration pilots (≥ TRL 6) with performance, safety, and cost indicators in mining operations.
- Test data repositories and models (curated datasets) and manuals/guides for scaling and safe operation.
- National capabilities plan addressing gaps, test infrastructure roadmap, and sustainability plan.

SCOPE

Includes:

- Demonstrations in controlled relevant environments, semi-industrial and operational pilot testing and validation.
- Execution of models, test benches, and protocols for testing, validation, and interoperability verification.
- Definition of certification pathways and pre-validation with certifying bodies and/or accreditable laboratories.
- Pilots with mining fleets/equipment (retrofitting, hybrids, H2V, BEV) and technical, economic, and environmental evaluation.
- Safety strategies (electrical and hydrogen) and emergency response plans in pilots.

Does not include:

- Proof-of-concept and/or laboratory-scale tests.
- Technologies with TRL equal to 9.
- Solutions that pose risks to worker, equipment, or environmental safety.
- Technologies that increase consumption of strategic resources such as water or energy.
- Interventions that alter or interfere with continuity of the production process.
- Commercial manufacturing of vehicles, battery packs, or cell stacks at industrial scale.
- Construction of commercial-scale H2 production plants (pilot production or supplied H2 is allowed).
- Final commercial homologation (pre-audits and pre-compliance tests are included).
- Acquisition of complete commercial fleets (except for demonstration/pilot units).

KEY PERFORMANCE INDICATORS (KPIs)

5. Reduction in validation and pre-certification time (% vs. baseline) per technology.

6. Verified interoperability percentage between components/systems (%).
7. Improvement in energy performance and operational availability in pilots (%).
8. Scaled technologies and maturity level achieved (number of solutions advancing ≥ 1–2 TRL levels) and number of formalized protocols.

DESIRABLE CONTRIBUTION TO ITL CAPACITY BUILDING

- Validation, verification, and interoperability protocols and methodologies reusable by the national industry.
- Accreditation pathway (e.g., applicable ISO/IEC) and partnerships with certifying bodies, universities, and R&D centers.
- Specialized training in H2 safety, high power, advanced diagnostics, data analysis, and modeling.
- Data governance and digital infrastructure for traceability, digital twins, and test result repositories.