

Building Capacity to Innovate

Seven pathways from the Swedish mining ecosystem



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www.swedishmininginnovation.se

Foreword



Innovation is often presented through individual projects, new technologies or successful collaborations. Much less attention is given to what makes these achievements possible in the first place.

This handbook was created to address that gap.

Building Capacity to Innovate brings together practical experience from collaborative innovation in one of the world's most technology-intensive and sustainability-driven industrial sectors. Rather than documenting a programme or presenting a new methodology, it distils recurring patterns that helped strengthen an innovation ecosystem over time. The seven pathways described in these pages are not theoretical models. They are practical lessons drawn from experience and refined through continuous collaboration between industry, academia, public organisations and society.

Although these experiences originate in the Swedish mining and minerals sector, this handbook is not written exclusively for mining, nor only for Sweden. The challenges of accelerating innovation while navigating increasing complexity are shared across industries and regions. Whether the ambition is to strengthen industrial competitiveness, support the green transition, build regional innovation capacity or improve collaboration between public and private actors, many of the underlying questions are remarkably similar.

There is no universal blueprint for innovation. Every ecosystem is shaped by its own history, institutions and culture. The intention of this handbook is therefore not to offer solutions to be copied, but practical perspectives that others can adapt to their own circumstances. We hope it serves as a source of inspiration, a tool for reflection and a starting point for discussion among programme leaders, policymakers, researchers, companies, innovation agencies and regional actors working to strengthen collaborative innovation.

The experiences presented here build on a long tradition of collaboration between industry, research

organisations and public actors. Swedish Mining Innovation built on this foundation by strengthening collaboration, broadening participation and creating new connections across organisational boundaries.

Looking back, many of the programme's most valuable outcomes could not have been planned in advance. New partnerships emerged, priorities and available instruments evolved, failures provided learning and external developments reshaped the innovation agenda. The ability to adapt while maintaining a shared long-term direction proved just as important as any individual project or technology.

That may also be this handbook's most important message. Innovation ecosystems are not built through isolated initiatives. They evolve through sustained collaboration, shared learning and the continuous strengthening of relationships between people, organisations and knowledge.

If the reflections collected here help others accelerate that process in their own context then this handbook will have achieved its purpose.

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How Innovation Systems Learn

A Question Worth Asking

The most valuable outcome of a long-term innovation programme is rarely the individual innovations it supports.

Successful projects, new technologies and industrial applications matter. They are often the most visible achievements, and in many cases the easiest to measure. Yet they represent only part of the legacy. Equally important is what remains after the projects themselves: stronger relationships, new ways of collaborating, shared knowledge and a greater ability to respond to challenges that no single organisation could address alone.

This handbook begins with a simple question: **How do you build an innovation ecosystem that continues to learn and adapt while technologies, industries and society keep changing?**

Every innovation ecosystem develops under its own industrial, political and cultural conditions. Twelve

years of practical experience do, however, offer an unusual opportunity to reflect on how one ecosystem strengthened its collective capacity over time and what others might learn from that experience.

The Mining Innovation Landscape in Sweden

Swedish Mining Innovation was one part of a broader research, development and innovation landscape supporting Sweden's mining and metals industry. This landscape connects industry, academia and research institutes, governmental organisations and civil society with national and international R&I programmes and platforms.

A Platform, Not a Starting Point

Innovation did not begin with strategic innovation programme SIP STRIM established in 2013, later renamed Swedish Mining Innovation. The Swedish mining and mineral ecosystem already possessed many of the characteristics that enable collaborative innovation: internationally recognised research, close cooperation between industry and academia, European partnerships, shared research agendas and decades of experience from joint research programmes. Environmental performance, attractive workplaces, international collaboration and social sustainability were already recognised as important parts of the sector's long-term development.

The programme should therefore not be understood as the beginning of system innovation. It became a long-term platform through which these existing strengths could be connected, expanded and continuously refined.

At the same time, the innovation landscape was changing. Advances in automation, electrification, digitalisation and artificial intelligence opened new technological opportunities, while growing

attention to climate change, critical raw materials, biodiversity, competitiveness and social legitimacy broadened expectations of innovation. Rather than replacing existing priorities, these developments became increasingly intertwined.

The central question became how the ecosystem could identify emerging needs, mobilise the right actors and integrate different forms of knowledge while maintaining a shared strategic direction.

Long-term direction provides stability. Shared agendas and strategic roadmaps help many independent organisations move towards common ambitions over extended periods. But direction alone is not enough. Innovation ecosystems must also be willing to question existing approaches, evaluate their experience and revisit familiar questions as technologies, markets and society evolve.

The questions often remain remarkably consistent. The answers do not.

Swedish Mining Innovation at a Glance

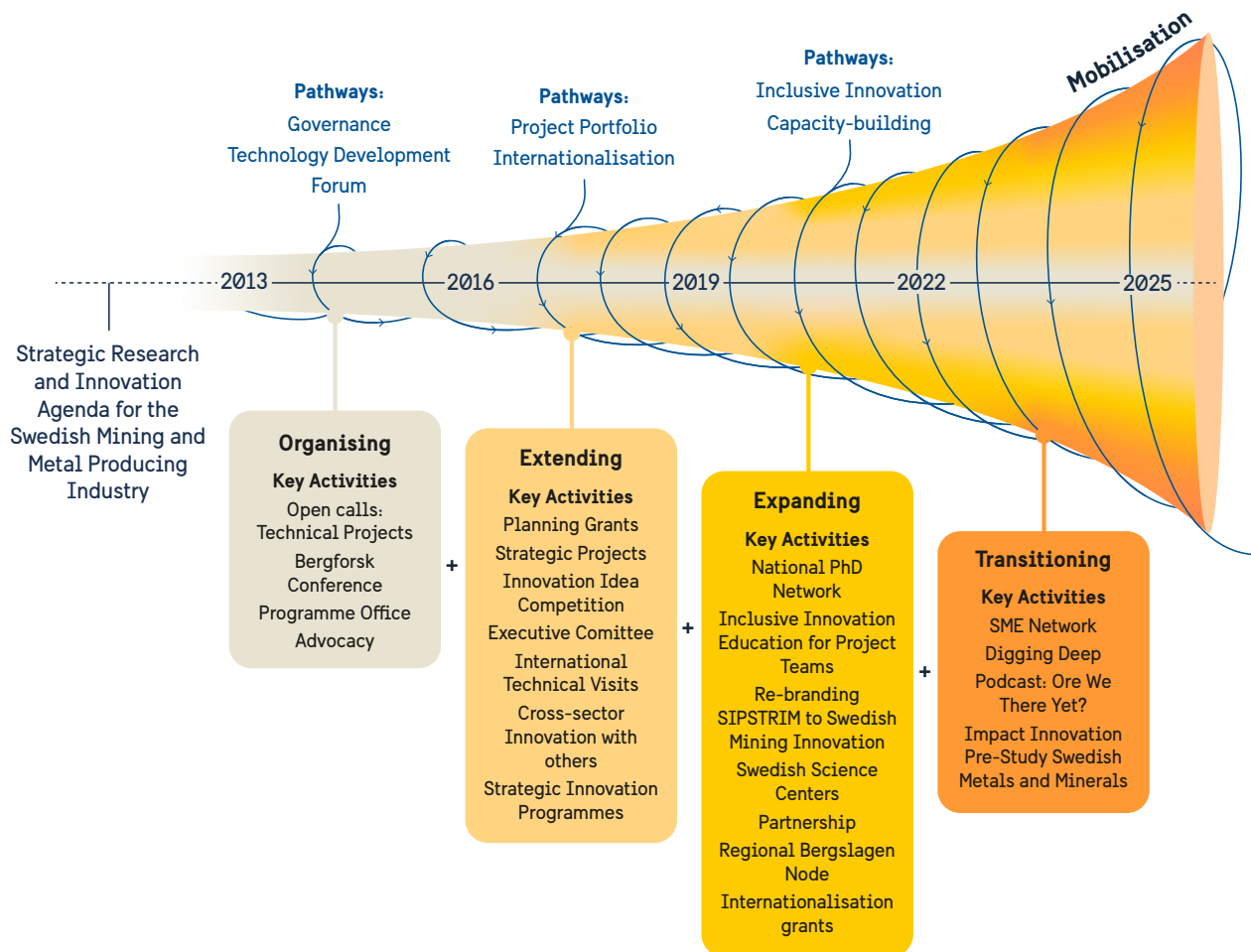
Swedish Mining Innovation was one of Sweden's **Strategic Innovation Programmes (SIPs)**, a national initiative launched by the Swedish Government to strengthen long-term innovation capacity through collaboration between industry, academia and the public sector. The programmes are jointly funded by **Vinnova**, the **Swedish Energy Agency** and **Formas**.

The programme operated 2013 to 2025, beginning as **SIP STRIM (Strategic Innovation Programme for the Swedish Mining and Metal Producing**

Industry) after the Swedish mining and minerals ecosystem successfully secured funding in national competition.

In **2020**, the programme was renamed **Swedish Mining Innovation** to create a clearer and more accessible identity that better reflected its role as a shared platform for the entire mining and minerals innovation ecosystem and to engage a broader range of stakeholders beyond its traditional research community.

Reading the Programme Differently



The figure illustrates more than the development of a programme over time. It shows how activities accumulated and interacted, gradually strengthening the ecosystem's capacity to mobilise knowledge, people, investment and action.

Established forums continued alongside new initiatives in areas such as competence supply, biodiversity and international collaboration; funding instruments were added and refined; governance evolved as participation broadened.

The lasting value of these activities lay not only in their immediate results, but in what accumulated between them: stronger relationships, shared routines, broader participation and experience that could be applied to new challenges. This capacity

was shaped through adjustment as much as success. Independent evaluations exposed weaknesses in governance and portfolio balance, efforts to broaden participation required repeated adaptation, some pre-studies did not progress, and strategic gaps revealed the limits of open calls alone. External events, from the COVID-19 pandemic to a changing geopolitical landscape, further tested established ways of working.

Looking back across twelve years, these accumulated activities and adaptations reveal recurring patterns in how the ecosystem built capacity. We describe these as seven interconnected pathways: governance, project portfolio, technology development, inclusive innovation, capacity-building, internationalisation and forums.

From Activities to Pathways

Individually, these activities were responses to specific challenges. Collectively, they strengthened the ecosystem's ability to learn, coordinate and adapt. It is these recurring patterns that this handbook describes as seven pathways for system innovation.

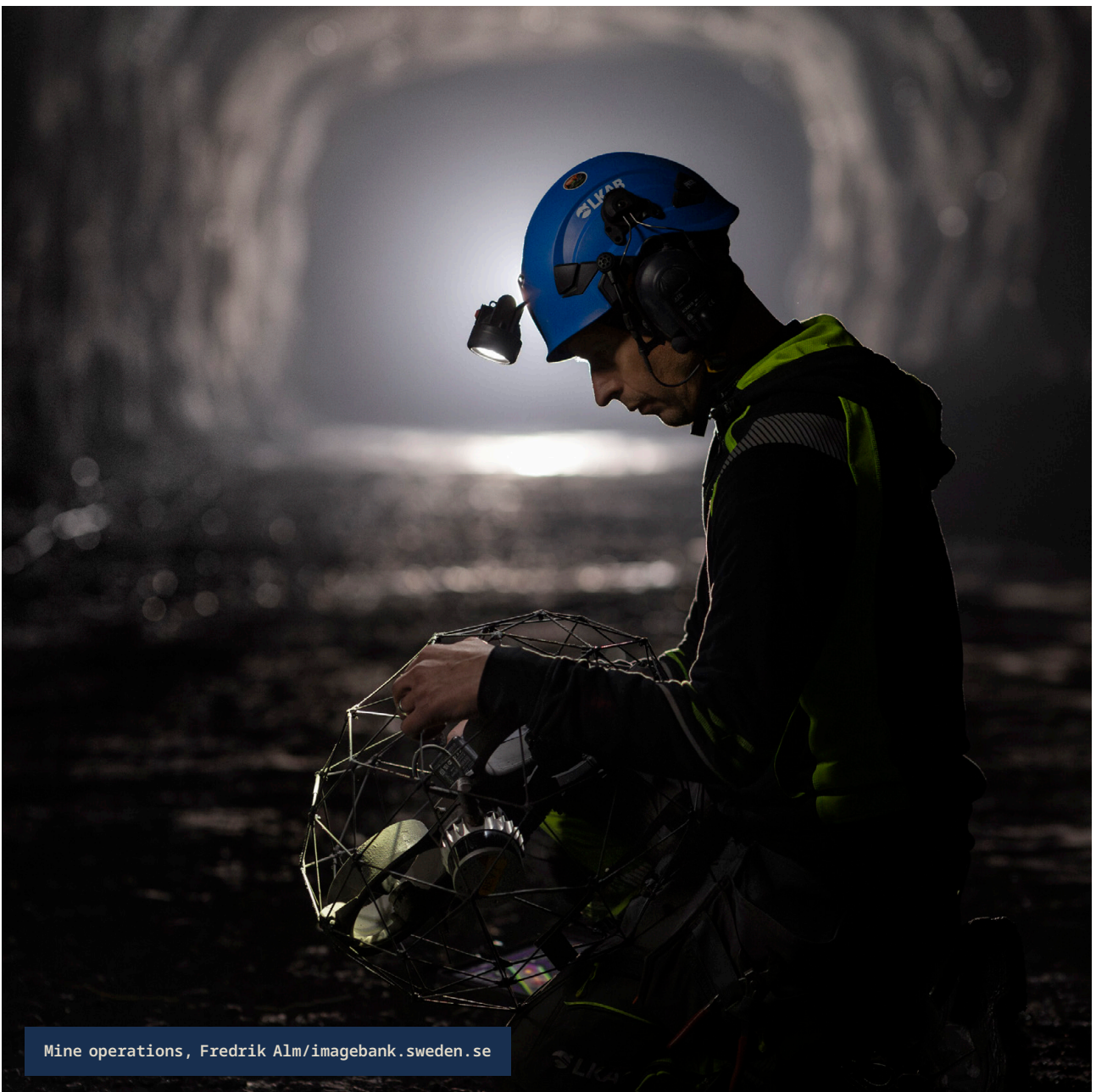
The pathways are neither sequential stages nor a predefined methodology. They are a way of understanding how different interventions, developed and refined over time, collectively strengthened the innovation ecosystem beyond the immediate outcomes of individual projects. Perhaps most importantly, they demonstrate that building an

innovation ecosystem is not about finding the right answers once and for all. It is about creating the capacity to keep asking the right questions—and recognising that while the questions may remain surprisingly consistent, the answers must continue to evolve.

The chapters that follow explore each of these pathways in greater depth. Together they describe not only the evolution of Swedish Mining Innovation, but the practical experience of how an innovation ecosystem strengthened its collective capacity to innovate together.



Developing Technology Towards Implementation



Mine operations, Fredrik Alm/imagebank.sweden.se

Sweden's position in mining technology was established long before Swedish Mining Innovation. Mining companies, equipment manufacturers, universities and research institutes had developed close working relationships over decades, creating an industrial environment in which research could be tested against operational needs and new solutions applied in demanding production settings. The programme did not create this capability. Its role was to strengthen the conditions through which an already advanced ecosystem could continue to renew itself.

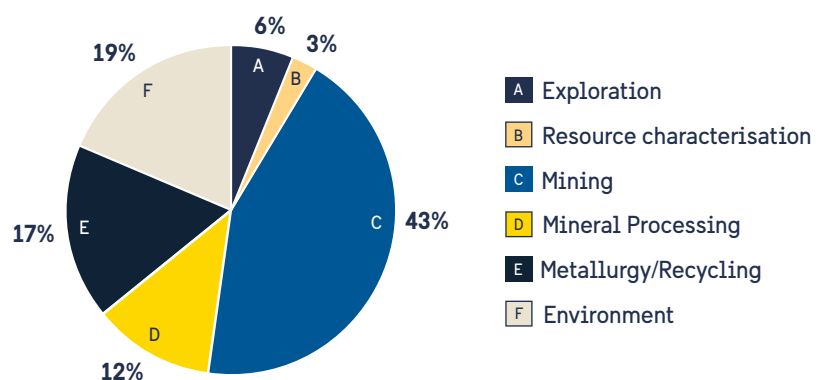


Sustaining Industrial Leadership Through Continuous Renewal

Continuous renewal is essential in mining. Mines are capital-intensive, technically complex and designed around assets with long operating lives. New technology must therefore do more than perform under controlled conditions. It must operate safely and reliably at scale, integrate with existing infrastructure and processes, and justify further investment by industrial partners. Moving from an early concept to implementation can take many years and require successive stages of research, validation and industrial adaptation.

Swedish Mining Innovation supported development across multiple parts of the mining value chain. Within these areas, projects addressed practical challenges such as improved resource characterisation, safer and more productive extraction, higher mineral recovery, lower energy and reagent use, and reduced long-term environmental impact.

Total financing by technical thematic area



Over the programme period, however, some of the most important technology shifts increasingly cut across these categories. Electrification, automation, digitalisation and artificial intelligence affected the whole value chain. An autonomous machine depends on



communication infrastructure, positioning systems, sensors and reliable data. Electrified equipment must function together with charging systems, ventilation, production planning and maintenance. Advanced process control requires not only algorithms, but sufficiently robust measurements and the ability to integrate results into operational decision-making.

This increasing interdependence changed the technical character of innovation. Improvements could no longer always be developed and evaluated as isolated components. Equipment, software, infrastructure and work processes increasingly had to be tested together under realistic conditions. Meanwhile, technology development takes different forms at different stages of an innovation journey. Early ideas may need a small investment to test their technical potential, while more mature solutions require larger collaborative research projects, pilots or industrial-scale validation. Swedish Mining Innovation therefore supported technology development through a range of funding opportunities, allowing different levels of technical maturity, uncertainty and ambition to be addressed.

The programme also created routes for ideas and actors that did not fit easily into established research collaborations. Initiatives such as the Innovation Idea Competition opened opportunities for start-ups and SMEs to test promising concepts and establish connections with the mining sector. Together, these different routes helped technologies move forward without assuming that every innovation would follow the same development path.

Explore the project portfolio

Across twelve years, technology development remained at the industrial core of Swedish Mining Innovation. Companies, researchers and entrepreneurs developed the technologies, while the programme provided continuity, shared risk and routes for ideas to move from research towards industrial application.

On swedishmininginnovation.se you can explore the projects, technologies and collaborations supported by the programme.

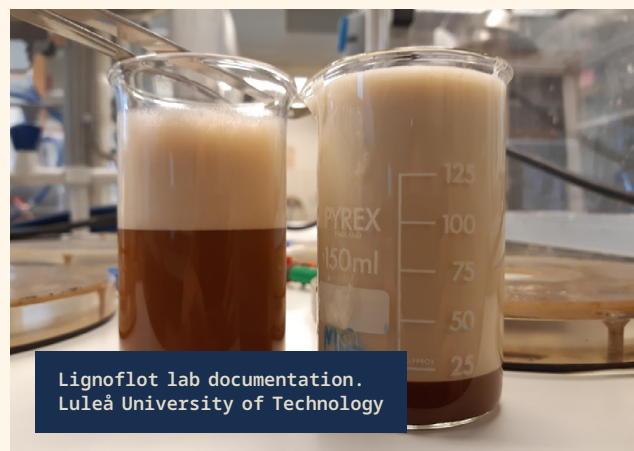
Renewable Reagents for Mineral Processing

Flotation is one of the most widely used processes for separating valuable minerals from unwanted material. In Swedish mineral processing, xanthates have traditionally been used as collectors because they help valuable sulphide minerals attach to air bubbles and separate from the surrounding material. Their effectiveness is well established, but they are petroleum-derived, toxic to aquatic organisms and may degrade into hazardous compounds. Replacing or reducing their use therefore presents both an environmental and an industrial challenge: any alternative must improve sustainability without compromising recovery, selectivity or concentrate quality.

Researchers at Luleå University of Technology and their industrial partners investigated whether particles made from lignin (a renewable material found in wood and other biomass) could function as flotation collectors. The development began with the LIGNOFLOT pre-study, which demonstrated that lignin particles could selectively recover copper and other valuable sulphide minerals while suppressing iron sulphides. The results also indicated that the process

could operate without conventional depressants and provided the basis for a patented flotation method.

The subsequent LIGNOFLOT project moved the concept into more systematic development and validation. Laboratory and semi-pilot trials examined how lignin particles performed in combination with conventional reagents. The project reported that small additions of lignin particles, together with substantially reduced xanthate dosages, could improve copper recovery and selectivity while maintaining concentrate grade. In some test



"The funding scheme has enabled us to explore and demonstrate the industrial feasibility of using biodegradable lignin particles and its potential to increase metal recovery while simultaneously reducing the environmental footprint of the mining sector."

– Ulrika Rova, Professor and Project Manager, Luleå University of Technology.

conditions, xanthate use was reduced by up to 75 per cent. The lignin-based reagent also reduced iron content in the copper concentrate and, under certain conditions, removed the need for lime addition.

Development continued through LIGNOMIN, which broadened the range of renewable raw materials and examined how lignin particles could be adapted to different ore types. Feedstocks included lignins from Nordic biorefineries and agricultural residues such as brewers' spent grain. The work combined flotation performance with questions of biodegradability, environmental impact and continuous operation. The case illustrates why industrial technology development rarely follows a single project from idea to application. The same technical concept progressed through a pre-study, two Swedish research and innovation projects, a planning grant that

supported a successful European proposal, and an internationalisation grant used to engage potential stakeholders and examine questions relevant to a future market strategy. Each instrument addressed a different uncertainty: initial feasibility, technical optimisation, validation, access to larger research resources and the conditions for future adoption. The technology had not reached commercial implementation at the end of the programme. Nevertheless, the sequence created a much stronger technical and industrial basis than any individual project could have provided. It demonstrates the value of maintaining continuity around a promising idea while allowing the scientific hypothesis, industrial requirements and route towards application to develop over time.





Boliden Aitik Mine, Hypex Bio

Spotlight

Accelerating Use of Hydrogen Peroxide Explosives

Blasting is fundamental to mining and tunnelling, but conventional ammonium nitrate explosives generate greenhouse-gas emissions during production and release nitrogen oxides, ammonia and nitrate residues after detonation. Hypex Bio Explosives Technology AB developed an alternative explosive based on hydrogen peroxide, which decomposes into water and oxygen. The objective was to achieve the performance required for industrial blasting while significantly reducing emissions and harmful residues.

The company's hydrogen peroxide emulsion initially entered Swedish Mining Innovation through a research and innovation project in 2020–2021. Testing showed that the underlying technology had potential, but also that modifications were needed to meet the specific requirements of mining. This was an important result. Industrial validation did not simply confirm that the concept worked; it revealed where performance, stability and handling needed to be adapted before the technology could be used in an operating mine.

Hypex Bio subsequently entered the programme's Innovation Idea Competition in 2021 and was selected for further support. Through the Hydrogen Peroxide Emulsion Stability Verification Project, the company continued to address the technical requirements identified during the earlier work. The flexible competition format provided a route for a smaller company whose development needs differed from those of a conventional three-year research consortium.

Progress thereafter was comparatively rapid. A full-scale underground trial was conducted at

Boliden's Kankberg mine, where the technology was evaluated in an industrial setting. In 2022, Hypex Bio received Boliden's Supplier Recognition in Sustainable Innovation and was included by Ny Teknik among Sweden's 33 leading technology start-ups. The first full-size explosives plant was built in 2023, followed by the first commercial application in a Stockholm tunnelling project. In 2024, a full-scale production plant was commissioned at the Kankberg site. The company subsequently entered licensing and distribution agreements in several international markets.

The company reports that its technology can reduce carbon dioxide emissions by up to 90 per cent compared with conventional ammonium nitrate explosives, while producing little or no nitrogen oxides, ammonia or nitrate pollution after detonation. At the time of the programme's documentation, however, the technology's total realised impact had not yet been measured.

This case illustrates a different innovation journey from the lignin-based flotation work. The development cycle was shorter, the principal actor was an entrepreneurial company and the route towards application depended on rapid interaction with an industrial customer and access to a real operating environment. The programme's contribution was not to remove the commercial and technical risks, but to provide flexible support at moments when additional verification and industry contact could materially improve the prospects for implementation.

Rethinking How Mining Landscapes Are Reclaimed

Waste rock is an unavoidable part of mining, and how it is deposited has consequences long after production has ended. Conventional waste rock landforms are often designed primarily around efficient deposition during mine operation. Over time, however, poorly adapted landforms can require continued maintenance and contribute to erosion, biodiversity loss, visual impacts and limitations on how land can be used after mining.

The Waste2Place project approached this as a technology and design challenge. Led by VAST Landscape Architecture together with ten partners from industry, academia and specialist organisations, the project brought an internationally established approach known as geomorphic reclamation into a Swedish mining context.

Rather than treating a waste rock facility simply as material to be covered and stabilised after mining, geomorphic design considers the final landscape from the outset. Landforms are shaped with reference to natural terrain and drainage systems, with the aim of creating long-term physical stability while supporting ecological recovery and future land

use. The approach is recognised as Best Available Technique in the EU, but has not yet been widely adopted in Scandinavia.

Waste2Place therefore focused not on developing a single product, but on assembling the knowledge required for implementation. The project examined reference landscapes, landform design, mine planning, construction, revegetation and long-term performance monitoring. These elements were brought together into a Swedish-oriented reclamation toolkit intended to help mining companies incorporate geomorphic principles into planning and closure.

The case illustrates an important dimension of technology development. Innovation does not always mean inventing a new technology. It can also mean bringing established knowledge into a new industrial context, combining disciplines and adapting methods until they become practically applicable. For mine reclamation, this shifts attention from managing waste rock at the end of operations towards designing post-mining landscapes as part of the mining system itself.

“This far, three former Innovation Idea Competition winners; RockSigma, Flasheye and Hypex Bio; have gone on to make the 33-list, Sweden’s most prestigious ranking of young technology companies. It says something about the innovation capacity within the mining cluster, and we are proud to have supported their journeys.”

– Lotta Sartz, chair of the jury.

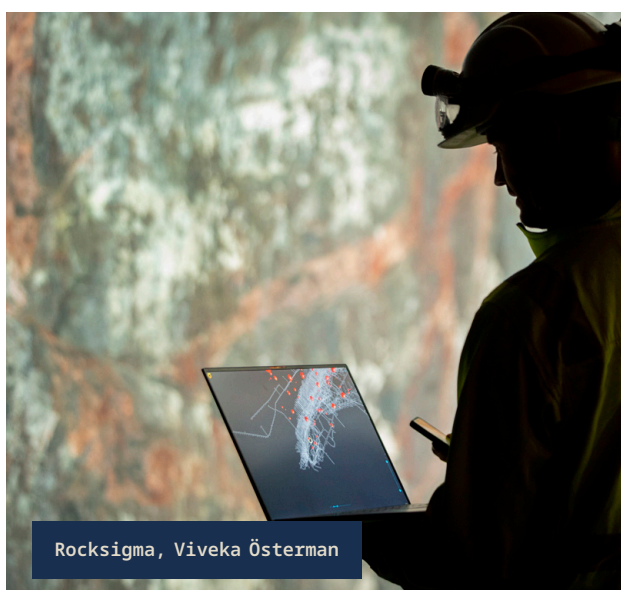
Building a Business Around Safer Mining at Depth

As underground mines become deeper, managing seismic risk becomes increasingly important. Mines already generate large quantities of seismic data to understand changes in the rock mass and identify hazardous conditions. The challenge is turning increasingly complex data into information that can support operational decisions quickly and reliably. RockSigma grew from research addressing precisely this problem. The company first entered Swedish Mining Innovation's Innovation Idea Competition in 2021 as RS Solutions. Its winning technology, BEMIS, was developed to automate processing of mine seismic data, provide information about seismic events, predict activity based on production plans and create tomographic images showing changes in the rock mass. The competition provided funding and industry recognition at an important stage in the company's development.

Support subsequently extended beyond technology development. An internationalisation grant enabled RockSigma to participate in mining innovation activities in Canada and the United States in 2023, supporting the company's efforts to develop

relationships in the North American market. In 2024, RockSigma returned with a new proposal; a next-generation processing solution capable of handling DAS data at mine scale, with the aim of improving how operators identify and manage seismic hazards as mining moves deeper. The proposal was selected as one of the competition's two final winners and received SEK 600,000 for further development. The case demonstrates how an SME-focused instrument can support different needs at different stages of the same company's development. The underlying knowledge originated in industrial research. Early programme support helped turn that expertise into a commercial proposition. Internationalisation support opened opportunities in new markets, while a later competition award enabled the company to pursue a new generation of its technology.

RockSigma's journey therefore illustrates that technology development and company development are often inseparable. For specialised industrial SMEs, progress may depend not only on solving the next technical problem, but on gaining credibility, reaching customers and finding timely resources to pursue emerging opportunities.



The Innovation Idea Competition at a glance

Swedish Mining Innovation's annual Innovation Idea Competition was designed to identify promising ideas that could contribute to a more sustainable mining and metals industry. An international jury with expertise from industry, innovation and business development selected the most promising ideas for a pitch final. Winners received SEK 600,000 to accelerate their innovation. Read more in Pathway 7.

Developing Technology Towards Implementation



Technology Leadership requires continuous renewal.

In technology-intensive industries, innovation programmes are most effective when they build on existing industrial strengths rather than attempt to replace them. Swedish Mining Innovation worked because it complemented companies' own research and development with collaborative projects, shared risk and long-term continuity, allowing industry, academia and public actors to contribute according to their respective strengths.



Implementation requires industrial integration.

Successful technology development depends on continuous collaboration between researchers, suppliers and mining companies. Industry contributes operational knowledge, specialist expertise, equipment, data and access to production environments, ensuring that research addresses real operating conditions from an early stage. As technologies mature, they also need to be integrated with existing equipment, infrastructure, data systems, maintenance routines and ways of working. Demonstration environments therefore become a critical bridge between technical validation and industrial implementation.



Technologies require flexible development routes.

There is no single route from idea to industrial application. Some technologies advance through successive stages of research, testing and demonstration over many years, while others can progress rapidly once a specific technical barrier is overcome. What matters is access to the right resources, expertise and validation opportunities at each stage, with enough flexibility to maintain momentum as the technology matures.



Scooptram ST18 SG in underground mine, Epiroc media gallery

→ **Promising technologies need visibility as well as funding.**

Innovation programmes create value not only through financial support, but also by showcasing promising technologies and connecting innovators with potential users, investors and collaborators. Strategic visibility helps promising ideas gain traction at critical points in their development and can accelerate progress towards implementation.

→ **Technology development does not follow funding boundaries.**

Innovators work across a continuous progression of technology readiness, while public funding is typically organised into separate instruments, projects and programmes. Bridging these boundaries is therefore critical to maintaining momentum from research through testing and demonstration towards industrial use, especially in mining where development and validation cycles are long.

Governing Collective Innovation



Iron ore pellets, Fredric Alm/imagebank.sweden.se

System innovation requires more than technical projects. It depends on structures that can align actors, mobilise resources and maintain a shared direction over time. Throughout Swedish Mining Innovation, governance became one of the programme's core capabilities. By combining actor-driven leadership, public funding, strategic coordination and adaptive decision-making, the programme created conditions for collaboration across a diverse and evolving innovation ecosystem.



The Swedish mining and minerals cluster has a long tradition of collaboration between industry, academia and public actors. Long before Swedish Mining Innovation was established, companies, universities and research organisations were working together to solve common technical challenges and strengthen the sector's international competitiveness. This collaborative culture provided an important foundation when Sweden introduced the strategic innovation programme in 2012.

The SIP model represented a significant shift in innovation policy. Rather than funding predefined research agendas, the programmes were designed as actor-driven platforms where industry, academia, institutes and public actors jointly identified priorities and developed initiatives. For the mining sector, this created an opportunity to expand collaboration further and create a formalised innovation platform.

The cluster's research and innovation agenda became one of the programme's most important governance tools. From the outset, it combined technological priorities with broader social dimensions, including attractive workplaces and gender equality. The agenda preparation process remained deliberately open and participatory, using workshops, consultations and dialogue across the cluster to identify emerging challenges and opportunities and revisit existing priorities as conditions changed. Successive editions broadened and refined this shared direction, with the fourth edition, published in 2022, reflecting an innovation landscape in which technological development, environmental performance, social sustainability, competence and competitiveness had become increasingly interconnected.

As the programme matured, governance structures evolved as well. During the first programme period, a relatively large steering group ensured broad representation but also made decision-making slower and more complex. Over time, responsibilities were clarified and an executive committee was introduced to complement the steering group. This created a more agile governance model while maintaining transparency and stakeholder participation. Equally important was the development of thematic reference groups and expert networks that connected governance

discussions to operational realities. These structures provided specialised knowledge, helped identify emerging gaps and ensured that strategic discussions remained grounded in the needs of the cluster.

The programme office was anchored at Luleå University of Technology (LTU), reflecting the university's long-standing role in Swedish mining research and its broad research base across mining and rock engineering. Programme directors throughout the programme were researchers at LTU, providing continuity between the research environment, industrial stakeholders and programme governance. LTU Business, the university's business development organisation, later became part of the programme management, adding expertise in business development, innovation and portfolio follow-up. The programme office played a central role



Swedish Mining Innovation Project Types

- Open calls allowed companies, researchers and other actors to formulate projects based on their knowledge of industrial needs and technological opportunities. The programme could shape the scope and conditions of these calls, but did not select the individual projects that received funding. Independent assessment was an important safeguard for quality, transparency and impartiality.
- Strategic projects served a different purpose. When portfolio analysis, stakeholder dialogue or emerging developments revealed a critical gap that was unlikely to be addressed through open calls alone, the programme could initiate a targeted intervention. This mechanism was used,

for example, to strengthen regional innovation capacity through Bergslagen Mining Node, develop a shared roadmap for biodiversity, and bring actors together around reducing traffic accidents involving reindeer.

- Planning grants supported participation in international partnerships and European projects.
- Internationalisation grants enabled small and medium enterprises to accelerate in new markets.

Together, these mechanisms allowed the programme to combine openness with strategic agency: leaving substantial room for bottom-up innovation while retaining the capacity to respond deliberately when important system-level needs remained unaddressed.



“Swedish Mining Innovation Bergslagen has enabled specialised competence, such as AI and robotics, to reach the national level. At the same time, collaboration at the national level has also been reflected in the region.”

– Amy Loutfi, Professor Örebro University and Linköping University, WASP Programme Director.

Amy Loutfi, Örebro University, photo from www.thesmartmove.se

in connecting these different layers. Its function extended far beyond administration. Staff combined expertise in research, innovation management, industry development, policy, communication and international collaboration. This mix of capabilities enabled the programme office to act as a neutral coordinating actor capable of translating between different stakeholder perspectives.

Governance also relied heavily on culture that was already established among the key actors. There was a shared belief that collaboration, learning and working towards shared goals would create opportunities that would be beneficial for many and strengthen the sector as a whole – in Sweden and beyond. Throughout the programme, efforts were made to create open and transparent processes where participants could see how their input influenced priorities and activities. Physical and digital meetings were coordinated with other cluster activities whenever possible, reducing barriers to participation and strengthening engagement. As the needs of the cluster evolved, it became evident to the cluster that the culture should as well. Swedish Mining Innovation became a means and arena to accelerate for example diversity and inclusion through initiatives both internally and externally.

Rather than directing the innovation system from above, the programme sought to create conditions where actors themselves could identify opportunities, build partnerships and take ownership of initiatives.

The programme’s budget functioned as more than a source of funding. It became an instrument for shaping relationships, encouraging collaboration and enabling strategic experimentation across the innovation system. Different levels of co-financing further reinforced desired behaviours. Higher-risk early-stage activities could be supported under more favourable conditions, while larger development projects



required stronger commitment from participating organisations. This created incentives for both experimentation and long-term ownership.

Importantly, the programme could shape the conditions for investment, but not select the individual projects funded through open calls. The programme and its stakeholders developed the strategic agenda, designed funding instruments and helped formulate the scope of calls, while project proposals were independently assessed through processes managed by the funding agencies. A distinctive feature was the use of international subject-matter experts as reviewers, deliberately bringing leading expertise from outside Sweden into the assessment process. This strengthened the scientific and technical scrutiny of proposals while maintaining a clear separation between the programme's strategic role and decisions on individual projects. The portfolio that emerged could therefore not be prescribed in advance. Instead, the programme used the research and innovation agenda, portfolio analysis and gap assessments to understand how investments collectively contributed to strategic priorities and where important needs remained unaddressed. Where open calls were unlikely to fill critical gaps, strategic projects provided a complementary route for targeted action.

This governance logic also enabled other pathways to develop. In internationalisation, for example, targeted instruments helped connect Swedish actors with European partners and funding opportunities. Governance and internationalisation were therefore not separate activities, but mutually reinforcing parts of how the programme responded to strategic needs.

Over time, the programme increasingly tracked how initial investments generated follow-on funding from national programmes, European initiatives and industry. This reflected a broader understanding of funding as a catalyst: its value lay not only in the projects supported, but in enabling ideas and collaborations to progress and mobilise further resources.

From a systems perspective, funding could therefore serve several purposes at once: reducing barriers, strengthening networks, testing new approaches and creating opportunities for further development beyond the programme itself.



Spotlight

Shared Stewardship of the Innovation Ecosystem

One of the defining characteristics of the SIP model was the long-term partnership between the programme and its funding agencies Vinnova, the Swedish Energy Agency and Formas. Rather than functioning solely as a funding mechanism, the SIP initiative created a governance arrangement in which agencies and programme organisations shared responsibility for the development of the innovation ecosystem.

The agencies provided a neutral platform, giving legitimacy and accountability. At the same time, the ecosystem encompassing all engaged stakeholders, were given considerable freedom to determine how programme resources should be used to achieve shared objectives. According to the SIP framework, programmes were entrusted with both budget and mandate to develop activities, funding instruments and initiatives aligned with their strategic agendas, while agencies maintained responsibility for transparency, legal compliance and funding decisions.

In practice, this created a continuous dialogue between the programme office and agency representatives. Governance did not occur only through formal reporting or periodic evaluations. It was embedded in ongoing discussions about emerging challenges, new opportunities and the evolving needs of the innovation system. The presence of Vinnova in programme governance structures further strengthened this connection between operational experience and national innovation policy.

This combination of autonomy and accountability became an important enabling factor for system innovation. It allowed the programme to experiment with new funding instruments, adapt priorities over time and respond to emerging gaps, while maintaining the transparency and legitimacy expected of publicly funded initiatives. The result was not a traditional principal-agent relationship, but a form of long-term public-private stewardship focused on building the capabilities of the innovation system itself.



Ore wagons in motion, photo tomalv / Adobe Stock

Spotlight

From Representation to Action

One of the most important lessons from Swedish Mining Innovation concerns the relationship between representation and effectiveness. At the outset, the programme reflected the broad composition of the Swedish mining ecosystem. Large mining companies, equipment suppliers, universities, research institutes and other stakeholders were represented in governance structures. This diversity strengthened legitimacy and ensured that multiple perspectives were included.

As the programme matured, experience gradually revealed that broad representation alone did not automatically create agility. Through continuous reflection on how decisions were made and how collaboration functioned in practice, governance arrangements evolved to better balance inclusiveness with the ability to act. Rather than following a predefined model, structures were adjusted as new needs emerged and lessons accumulated. Over time, the steering group became more focused, while executive functions and thematic working structures assumed a stronger role in supporting coordination and implementation.

This evolution illustrates a broader challenge facing many innovation ecosystems. Effective

governance requires both inclusiveness and operational capacity. Too much emphasis on representation can slow decision-making, while overly centralised structures risk losing legitimacy and engagement.

Rather than resolving this tension once and for all, the programme learned to manage it through layered governance. Strategic decisions remained anchored in representative structures, while executive committees, programme management and expert groups provided the flexibility needed to respond to emerging opportunities. The balance between these functions continued to evolve throughout the programme.

The same adaptive mindset shaped the programme's response to emerging topics such as biodiversity, competence supply, international collaboration and the social dimensions of mining. Regular dialogue with stakeholders, combined with ongoing reflection on the programme portfolio, revealed where existing initiatives no longer matched the evolving needs of the innovation system. Governance structures enabled targeted responses without requiring major organisational restructuring.

Governing Collective Innovation



Trust, engagement and shared ownership are the foundation of effective governance.

Governance structures create value only when stakeholders see them as legitimate, participate actively and feel a shared responsibility for the programme's direction. Building trust over time creates the conditions for coordinated action across organisational boundaries.



Long-term agency partnerships create adaptive capacity.

By combining sector-specific knowledge with public accountability, the SIP model enabled governance that was both flexible and legitimate.



People and skills matter as much as organisational structures.

A programme office with experience from industry, research, innovation management and stakeholder engagement can act as an effective bridge between actors with different interests and perspectives.



Open and adaptive processes strengthen legitimacy.

Continuous dialogue, transparent decision-making and visible responsiveness to stakeholder input help maintain engagement, reinforce shared ownership and sustain long-term trust.



Funding instruments can shape conditions without determining outcomes.

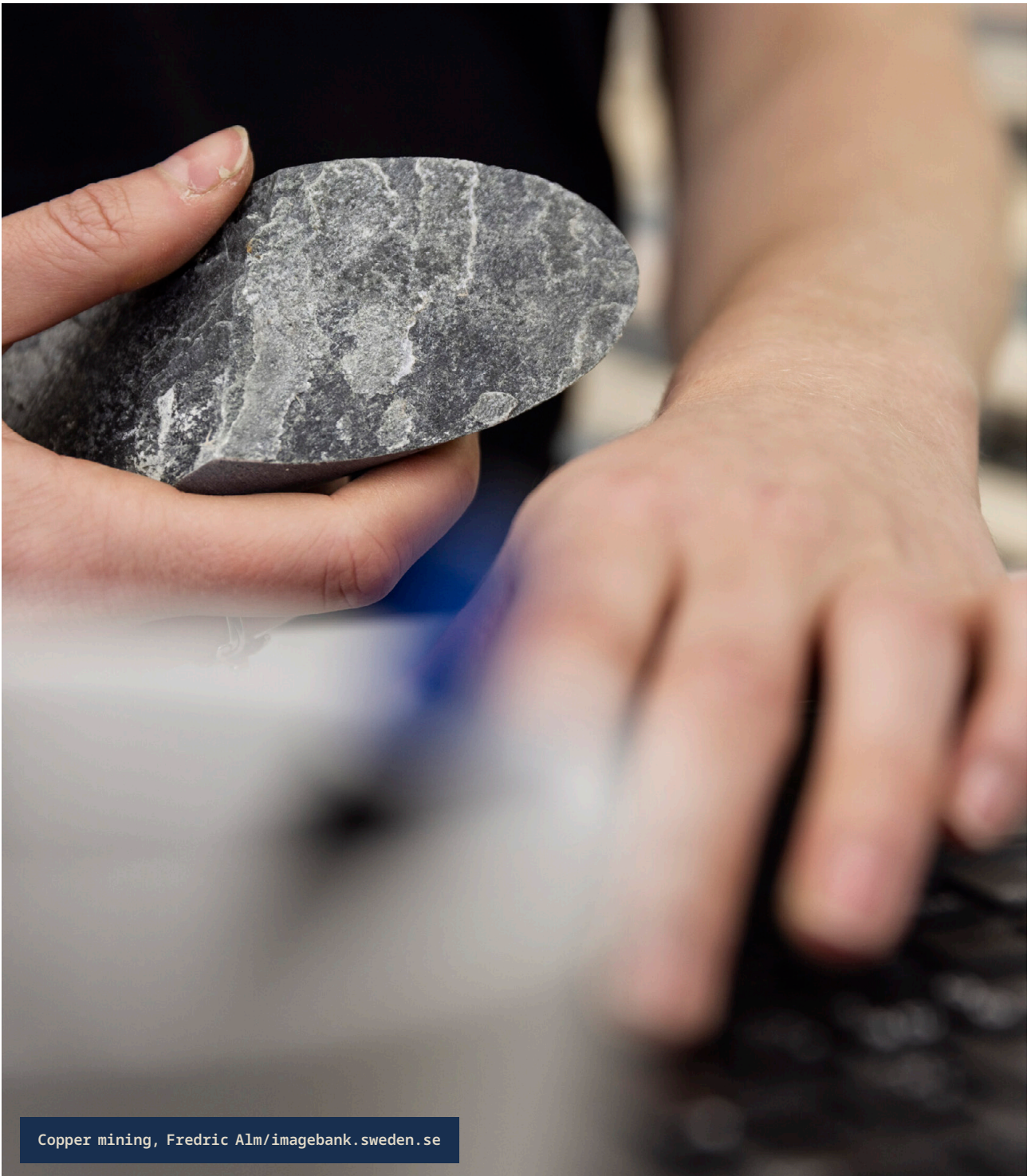
Pre-studies, planning grants, strategic projects, call design and differentiated co-financing can lower barriers, encourage collaboration and direct attention towards shared challenges. In open calls, however, the programme did not select which individual projects received funding. This separation allowed strategic direction to coexist with independent assessment and bottom-up initiative.



Flexibility is essential for long-term relevance.

Innovation systems evolve. Governance models must be capable of identifying emerging gaps, testing new approaches and adapting priorities without losing strategic direction. The willingness to experiment, and occasionally accept failure, can be an important source of learning and renewal.

Steering Through a Project Portfolio



Copper mining, Fredric Alm/imagebank.sweden.se

Technical development creates new possibilities. Governance establishes direction and legitimacy. Project portfolio management connects the two. It enables a programme to support many different innovation journeys while continuously assessing whether their combined development is strengthening the wider system.



How do you create strategic direction when you cannot choose which projects are funded? Portfolio management did not mean selecting the projects needed to construct an ideal portfolio. In open calls, project selection was independent of the programme. The programme could instead influence the conditions around the portfolio: strategic direction, call design, funding instruments, stakeholder mobilisation and, increasingly, the interpretation of the portfolio that emerged.

Project portfolio management therefore developed as a way of maintaining and adapting direction under conditions of uncertainty.

This made portfolio management a learning process as much as an investment process. By analysing where activity concentrated, where gaps persisted and how projects contributed across several dimensions, the programme could decide what question to ask next: whether to adjust a future call, develop a roadmap, mobilise new actors, introduce another instrument or leave an area to other parts of the innovation system.

The approach combined three functions:

- **Openness.** Broad calls enabled ideas and collaborations to emerge from actors closest to the technological and industrial challenges. Individual funding decisions were made through independent assessment rather than by the programme.
- **Interpretation.** Effect logic, portfolio analysis and stakeholder dialogue helped the programme understand what this emerging portfolio was contributing, where activity was concentrated and where important gaps persisted.
- **Strategic intervention.** Where a critical need was unlikely to generate sufficient activity through open calls, strategic projects provided a mechanism for targeted action. Rather than selecting preferred projects within an open call, the programme could mobilise actors around a defined system need and create the conditions for work that might otherwise not have emerged.

Vision: A World Leading Mining and Mineral Producing Industry Contributing to a Sustainable Society

Working Within Four Dimensions:

D1. Innovation Capacity
D2. Innovation and Technology Development
D3. Social Benefit and Social Acceptance
D4. Education and Access to Qualified Personnel

Activities	→	Outputs	→	Direct Effects	→	Long Term Impacts
What type of activities and projects will generate outputs in line with our vision?		What are the results from the activities and projects? What is measured?		What are the impacts that the program will contribute to?		What long-term goals does the program contribute to?
Yearly activity plans		KPIs		Effect to 2030 (8–10 y)		Effect after 2030



The effect logic became the central tool for doing this. It connected the programme's vision; "a world-leading mining and metal-producing industry contributing to a sustainable society" to four dimensions: innovation capacity; innovation and technology development; social benefit and social acceptance; and education and access to qualified personnel.

Over time, the programme made increasingly explicit something already present in how many projects were understood: their value extended beyond their primary objective. A technical project could also build research capacity, establish a testbed, strengthen networks or competence, and contribute to environmental performance. The effect logic helped make these interconnected contributions visible across the portfolio, giving structure to a broader understanding of innovation that would later increasingly be described in terms of system innovation.

This made it possible to move from counting projects to examining patterns. As expected, technology development remained dominant. Mining-related projects represented a particularly large share of the technical portfolio. Exploration and resource characterisation appeared less prominent, prompting discussion within the programme's executive committee and steering group. The conclusion was not necessarily that the area lacked development, but that much of it occurred within companies and was therefore less visible in the collaborative portfolio.

The example illustrates an important point. Portfolio analysis did not provide automatic answers. It enabled better questions. Was a gap evidence of insufficient capability, or did other funding models exist?



Should the programme intervene, convene relevant actors or continue to observe? Was an emerging issue mature enough for an open call, or did the system first need a roadmap, knowledge base or stronger research community?

Over twelve years, repeated analysis of the emerging portfolio helped broaden the programme’s interventions. Its centre of gravity remained industrial research and technical development, while new calls, strategic initiatives, roadmaps and capacity-building activities increasingly addressed internationalisation, competence, inclusion, biodiversity, regional mobilisation and social acceptance. This was not a departure from the programme’s industrial mission. It reflected a growing understanding of the conditions under which technical innovation can progress and create value.

Importantly, this widening was not only achieved through formal funding instruments. It was also reinforced through repeated portfolio-wide interaction arenas. Annual programme days brought project teams together to share results and identify connections, complementarities and gaps across the portfolio. This enabled knowledge and ideas to move between projects, strengthening cross-pollination between otherwise separate initiatives.

Portfolio management thus became more than the allocation of funding. It was the practice of connecting individual initiatives to a larger transformation, learning from the pattern they formed, and strengthening the relational infrastructure, such as programme days, thematic dialogues and shared arenas, that allowed projects to influence and reinforce each other.

Portfolio distribution of SEK 451 million in public investment

Effect logic dimensions	Funding share %	Portfolio status	High funding level Low funding level / Gap
D1 Innovation Capacity	16%	Medium funding	
D2 Innovation and Technology Development	75%	High funding	
D3 Social benefit and Social Acceptance	5%	Identified gap	
D4 Education and Access to qualified personnel	4%	Identified gap	

Acting Where the Portfolio Leaves a Gap

Open calls work well when actors can define a problem, form a consortium and describe a credible project. Some of the most important challenges facing an innovation system do not initially meet these conditions.

Responsibility may be distributed across several industries or public institutions. Knowledge may exist in different organisations without being assembled into a shared picture. The benefits of action may be substantial for the system as a whole, while being too diffuse or long-term to motivate an application from any single actor.

Roadmaps became one way for Swedish Mining Innovation to respond. Rather than developing a specific technology, roadmap projects created a common basis for understanding needs, dependencies and possible directions. During the programme period, this approach was applied to issues including competence supply, biodiversity, fossil-free development and the future research and innovation needs of the mining and minerals sector. The independent nine-year evaluation identified roadmaps, mappings and knowledge bases as important instruments for addressing structural challenges and clarifying development needs.

The roadmap project led by the Royal Swedish Academy of Engineering and Sciences illustrates this type of portfolio intervention. Metals and minerals

are fundamental to electrification, renewable energy systems, digital infrastructure and industrial competitiveness. Yet the associated challenges extend across extraction, processing, recycling, energy, environmental performance, investment and public policy. They cannot be reduced to a single technical problem or assigned to one organisation.

The roadmap created a format in which these relationships could be considered together. Its role was not to select a preferred technology or prescribe a complete course of action. It was to clarify the contribution of metals and minerals to wider societal transitions, identify areas requiring coordinated attention and create a stronger basis for decisions by industry, research organisations and public actors. From a portfolio perspective, roadmaps can make fragmented knowledge accessible, establish shared priorities and connect long-term ambitions with opportunities for research and innovation. This is particularly important in emerging fields, where actors may first need a common understanding of the challenge before strong collaborative projects can form.

Roadmaps do not substitute for implementation. Their value lies in creating a basis for subsequent decisions, investments and partnerships, providing a bridge between strategic ambition and investable activity.



The Royal Swedish Academy of Engineering Sciences' (IVA) roadmap is one of several examples where Swedish Mining Innovation enabled shared priorities and direction in strategically important areas.



Karin Byman, Project Manager, Royal Swedish Academy of Engineering Sciences (IVA)

Different Projects Move Innovation Forward in Different Ways

Industrial innovation rarely proceeds directly from funded project to implemented solution. Early ideas are tested and sometimes abandoned. Promising results generate several continuation projects. Technologies move between national programmes, European funding and company-led development. Networks and research capabilities may remain valuable even where commercial implementation is still distant.

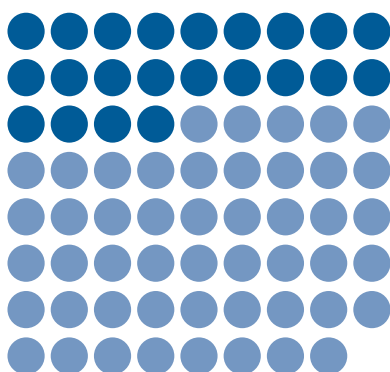
Swedish Mining Innovation's follow-up surveys and interviews with project leaders provide a view of this longer journey. The figures show why pre-studies were an important portfolio instrument. Their purpose was not to ensure that every idea advanced. They provided an efficient way to test early assumptions,

conduct initial trials and determine whether a larger investment was justified. Common reasons for not continuing included the absence of an industrial interest or results that did not support the original hypothesis. In such cases, discontinuation could represent a useful outcome: uncertainty had been reduced before significantly more resources were committed.

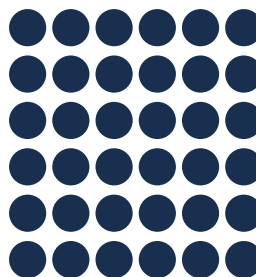
For larger research, full-scale and pilot projects, continuation rather than completion was the dominant pattern. Of 50 project leaders surveyed,

5
ave.no of
scientific
publications per
project

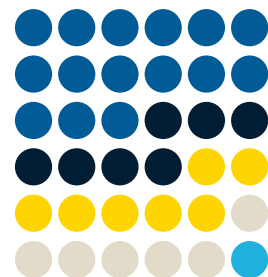
Pre-studies continuation



22 out of 71 pre-studies led to...



...a total of 36 continuation projects.



The 36 projects progressed to SMI R&I (15), other Swedish programmes (7), EU grants (7), direct industry (6), and other sources (1).

40 reported further research, together generating 51 continuation projects. Continuation funding provides one indication of momentum, but it does not capture the full range of results.

These results show a portfolio producing several forms of value at once. Publications strengthened the knowledge base. Networks increased the system's ability to form future collaborations. Testbeds created infrastructure for subsequent development. Patents, prototypes and new methods indicated movement towards application. Continuation projects mobilised further resources and extended innovation journeys beyond the programme's direct funding.

Implementation remained more difficult to document. Out of the 50 full-scale and pilot projects surveyed, 12 reported that their results had been implemented, but only one could provide a quantified operational effect: a production increase of between five and ten per cent in a process. This does not necessarily mean that other projects lacked impact. Implementation may take place several years

after a project ends, and its effects may be difficult to isolate from other operational changes. Relevant data may also remain inside participating companies rather than returning to the original project organisation.

This gap between project results and measurable industrial impact is itself a portfolio lesson. Final reports provide information about completed activities, but they cannot fully capture long innovation journeys. Programmes seeking system effects need mechanisms for following projects across time - several years after project completion - to assess development, implementation and impact.

The portfolio's significance therefore lies not only in how many projects reached implementation during the programme period. It lies in the capabilities and pathways created: ideas tested before major investment, research made more industrially relevant, consortia able to attract further funding, infrastructure established and knowledge carried into new projects and organisations.

Project outcomes overview	Pre-studies (2013-2021)	Full-scale/Pilot (2013-2025)
Projects interviewed	71	50
Non-commercial outcomes	Not analysed	81
Commercial outcomes	13	36
- New products and methods	5	16
- Patent applications	5	10
- Test beds created	-	7
- Prototypes	-	2
- Company founded	3	1
Scientific publications	48	261
New or improved networks	27	69

Steering Through a Project Portfolio



Manage the portfolio as a whole.

Individual project quality is necessary but insufficient. Effect logic and portfolio analysis can help reveal how investments collectively contribute to long-term goals through technology, knowledge, networks, competence and infrastructure, while making concentrations, gaps and dependencies more visible. These tools support strategic judgement rather than replace it.



Maintain direction without over-prescribing solutions.

Broad calls allowed companies and researchers to respond to emerging needs and opportunities. Strategic direction came from combining this bottom-up activity with agendas, portfolio analysis, stakeholder dialogue and targeted intervention where the system was not generating sufficient activity itself.



Match instruments to the uncertainty being addressed.

Pre-studies tested feasibility. Larger collaborative projects developed and validated solutions. Pilots addressed industrial integration. Roadmaps and strategic projects created direction around distributed challenges. Strong portfolios require complementary instruments rather than a single standard project model.



Treat discontinuation as part of innovation.

Not every idea should progress. A pre-study that disproves a hypothesis or reveals insufficient industrial ownership can prevent larger misdirected investments. Portfolio management must support informed selection as well as continuity.



Follow journeys beyond individual projects.

Many projects generated follow-on research, external investment, publications, networks and infrastructure. Measuring only outputs at project completion underestimates this cumulative value. Longer-term follow-up is required to understand eventual effects on productivity, environmental performance, safety and competitiveness.



Swedish Mining Research & Innovation Days 2025, Elin Emborg/LTU Business

Connecting the Ecosystem Through Forums



Photo Elin Emborg/LTU Business

Over the course of the programme, Swedish Mining Innovation has used forums as a central mechanism to build, connect and evolve the innovation system. In total, close to 300 forums have been organised or attended, ranging from field trips and workshops to conferences, peer groups and digital communities. Collectively, these have created thousands of links between actors across the mining and metals value chain. More than individual events, they form an infrastructure for knowledge diffusion, network effects and shared sensemaking.



The role of forums has shifted over time. Early on, they primarily served as channels for information sharing and visibility. As the programme developed, they increasingly became spaces for interaction, alignment and joint problem formulation. This includes matching actors across disciplines and sectors, enabling dialogue between industry and policy, and creating arenas where technical and societal perspectives can meet. In this sense, forums have contributed to building not only knowledge, but also relational and collaborative capital within the system.

A deliberate effort has been made to combine formats and perspectives. Physical meetings in mining regions have been complemented by digital platforms, allowing both depth and continuity. At the same time, forums have been used to highlight not only technological advances, but also tensions, trade-offs and broader societal implications linked to mining and metals.

“Within the Mining Municipalities Network, you can gain new experiences and competencies that are difficult for a smaller municipality to acquire in other ways.”

– Anna Kumpula, Georange.

→

By bringing in voices from across the system — including authorities, municipalities, SMEs and international actors — the programme has sought to create more inclusive and forward-looking discussions.

At the same time, forums are not ends in themselves. Their value depends on how clearly their purpose is defined and how well they are connected to the wider system. Within Swedish Mining Innovation, they have functioned as tools for coordination, alignment and system-building, supporting the gradual development of a more connected, resilient and adaptive innovation ecosystem.

The following cases illustrate how different types of forums have contributed to this process in practice.



National PhD Network as a System Innovation Forum

A national PhD network was established in 2019 to connect early-career researchers across Sweden's mining and metals ecosystem. Running throughout 2019–2025, the network functioned as a structured forum for interdisciplinary exchange and national coordination, spanning the entire value chain; from geology and engineering to social sciences.

Coordinated by Luleå University of Technology, the network brought together PhD candidates from 15 universities across Sweden, creating a rare platform that combined broad geographic reach with cross-disciplinary integration. Its core purpose was to strengthen long-term competence supply while enabling early collaboration between academia, industry, authorities and other stakeholders.

A defining feature of the network was its format. Activities centred on a series of in-person workshops

hosted in key mining regions such as Bergslagen, the Skellefteå district and Norrbotten. These combined site visits, expert lectures, panel discussions and structured networking. By on-site learning in real industrial and regional contexts, participants gained a system-level understanding of the sector — linking technical challenges to issues such as sustainability, governance, policy and social acceptance. Over time, the network became a national meeting infrastructure for PhD-level knowledge exchange.

The network also connected to national and European arenas, including participation in Swedish Mining Research & Innovation Days, AI in Mining, and Raw Materials Week in Brussels (2023), where a delegation of PhD students represented Swedish research in a high-level EU context.

149

PhD members

15

Universities



A National Forum for Research and Innovation



Swedish Mining Research & Innovation Days has grown into a key forum for bringing together actors across Sweden's mining and metal-producing system. Each year, it gathers participants from industry, academia, research institutes and public authorities and civil society, creating a shared space focused on ongoing research, innovation and sector development.

The format is deliberately mixed. Alongside presentations of funded projects, the programme includes panels, thematic sessions, informal networking and exhibition space for small and medium enterprises and NGOs. This combination makes it possible to move between technical depth and broader system questions—linking, for example, developments in automation or electrification to issues such as regulation, competence supply and social acceptance.

A defining feature is the breadth of participation. Attendees come from across Sweden's main mining regions — Norrbotten, Västerbotten and Bergslagen — as well as national-, European- and international-level actors. This gives the conference a practical function as a meeting point between regional initiatives and national priorities, rather

than a purely academic or industry-specific event. The conference is also used to situate individual projects in a wider context. Research results are not presented in isolation, but as part of a larger system, often organised around shared themes such as digitalisation, circularity or sustainable production. This helps participants understand how different efforts connect and where there are gaps or overlaps.

In practice, much of the value lies in the interactions around the formal programme. The conference creates opportunities for people who rarely meet in their day-to-day work to exchange perspectives across disciplines, organisations and roles. It is often in these settings that new collaborations take shape or existing ones are strengthened.

Over time, Swedish Mining Research & Innovation Days has come to function as a recurring coordination point in the system. It provides a moment to take stock of progress, surface new questions and align ongoing work. As such, it illustrates the role of structured, recurring forums in supporting knowledge exchange, system integration and continued development within an innovation programme.

Forums for Different Audiences and Purposes

→ Mining Innovation Summer

Students are paired with an experienced mentor and business case from industry or academia. As a paid summer internship their role is to assess the market potential of the innovation and present to the case owners at the end of the programme.

→ Mining Safari Find your future

Field trip open to bachelor and master students designed to showcase career opportunities with or without helmet.

→ Tech tour

International field trips combining site visits with networking and representation at key events. Open for key stakeholders in the Swedish cluster.

→ Mining @ORU

First launched in 2020, Mining @ORU has become an annual mining innovation meeting

place in Bergslagen, connecting social and technical, academia and society, local and national.

→ Mining municipalities network

Peer network, knowledge sharing and collaborative platform for public sector officials in mining municipalities.

→ SME network

A joint innovation arena and structured process connecting small and medium enterprises with industry to solve specific technical challenges.

→ Social media and digital platforms

Newsletters, LinkedIn, podcasts and webcasts have been instrumental to retain and engage with a broader international community over a long period of time and have ensured robustness of the cluster during challenging episodes like the Covid-19 pandemic.





Connecting the Ecosystem Through Forums



Tailoring forums for different needs.

Across the programme, forums have proven to be a critical intervention for enabling system-level change. Not primarily through content alone, but through how that content is structured, packaged and opened up. Well-designed formats that lower barriers for participation and “open doors” to new actors have been central in broadening the system and creating new connections.



Mix of participants.

Bringing together decision-makers, operational actors, researchers and SMEs in the same setting has enabled more grounded and actionable exchanges. This combination allows strategic perspectives to meet practical constraints, and research to connect more directly to industry needs.



Providing an international springboard.

Dedicated tracks or participation in European arenas have helped position Swedish actors and bring in external perspectives, even if a clear one-to-one counterpart to the programme has been difficult to identify.



Create arenas for cross-pollination, not only funding.

Programme-wide gatherings such as annual programme days were not peripheral activities. They were central to portfolio value creation. By bringing all projects together, the programme enabled learning across boundaries, surfaced synergies, and allowed ideas, methods and results to circulate. This strengthened the portfolio as a connected innovation system rather than a set of parallel projects.

Scaling Through Internationalisation



Anna Öhrwall Rönnbäck, Luleå University of Technology and Daniel Pacurar, Boreal Orchards, Sweden Canada Innovation Days, Toronto 2024

The mining and minerals sector operates across borders by default. Supply chains, technology development, investment flows, talent and regulatory frameworks increasingly span multiple countries and governance levels. For Swedish Mining Innovation, internationalisation evolved into a strategic mechanism for mobilising resources, building capabilities and connecting the Swedish mining ecosystem to wider European and global developments.



The transition towards a more sustainable and resilient economy has elevated the strategic importance of minerals and metals.

Against this backdrop, internationalisation has been a central component of Swedish Mining Innovation's efforts to scale impact and return on public-private investment in the strategic innovation programme. The objective was not simply to increase participation in international activities, but to shape broader innovation ecosystems. In practice, this means a combination of funding instruments to support research and innovation aligned with industry needs and the strategic innovation agenda, e.g. the planning and internationalisation grants.

“For a small company, entering a new mining market is about much more than finding potential customers. You need the right introductions, credibility and an understanding of how the market works. Being part of an established delegation gave us access to conversations that would have taken much longer to establish on our own.”

– Daniel Pacurar, Founder, Boreal Orchards.



"What strikes us is your unity around sustainability in the future of mining. There is not the same polarisation, whether you are right or left politically. Everyone in this sector is working towards the goal, to build a future where we live within the limits of the planet. We can learn a lot from you."

– David Welsh, Sun Corridor Inc. Executive Vice President, Arizona.

Foreign organisations were able to participate in Swedish Mining Innovation projects throughout the programme, typically without receiving programme funding. In total, 22 international organisations participated in projects, representing ten countries including Canada, Australia, Norway and Finland. The programme office also worked with Business Sweden to facilitate targeted knowledge exchange between Swedish and international mining actors. Workshops were organised around technical priorities identified jointly by LKAB, Boliden and the Chilean mining company Codelco, creating opportunities to explore shared challenges and potential areas for collaboration.

This multi-faceted role became increasingly important as European industrial policy began placing greater emphasis on critical raw materials, traceability, strategic autonomy and resilient value chains. The priorities outlined in Sweden's innovation agenda increasingly intersected with broader European ambitions regarding sustainable mineral supply, digitalisation and climate transition. Over time, Swedish Mining Innovation also became a recognised contact point for international stakeholders seeking to understand, partner or take inspiration from the Swedish mining innovation ecosystem. This position was not without challenges. Unlike industry associations or trade organisations, the programme did not have a formal mandate to represent the sector. Nevertheless, international interest often centred precisely on the collaborative relationships between industry, academia, government agencies and research organisations that characterise the Swedish innovation system.

This created an important opportunity to communicate how innovation emerges through cooperation across institutional boundaries rather than through individual actors alone.



By linking domestic capabilities to international networks, the programme helped strengthen both the visibility and competitiveness of Swedish actors while simultaneously bringing external knowledge and perspectives back into the national innovation portfolio.

“Internationalisation was never only about bringing European funding and knowledge back to Sweden. We also took a leading role in shaping the European research agenda, contributing to the first ERA-MIN agenda and to the establishment of EIT RawMaterials. It was a two-way exchange.”

– Pär Weihed, Professor and Pro Vice-Chancellor,
Luleå University of Technology and first Programme Director,
Swedish Mining Innovation.

Internationalisation at a Glance

Internationalisation generated impact through both resource mobilisation and network development. These figures illustrate an important principle; internationalisation was not pursued as a separate objective, but as a means of strengthening the innovation capacity of the ecosystem as a whole. Examples include:

- Approximately 33 per cent success rate in European funding applications (planning grants).
- SEK 518 million secured for Swedish organisations through subsequent international funding – equivalent to 69 times the programme’s initial investment.
- 22 international partners*
- Participation in major European research and innovation projects involving companies, universities and public organisations.
- Growth in recurring international partnerships and long-term consortium relationships.
- Support for SMEs and researchers to create or expand their international networks through internationalisation grants (38 grants).
- Increased participation in European policy processes, partnerships and stakeholder networks.
- Contributions to consultations, strategic agendas and discussions related to European raw materials and innovation policy.

*Canada (6), Australia (4), Norway (4), Finland (2), France (1), UK (1), Switzerland (1), Spain (1), Germany (1), Brazil (1).

Planning Grants as a Gateway to Industrial-Scale Innovation

Many of the challenges facing the mining and metals sector cannot be solved through small, isolated research projects alone. Developing new technologies for mining environments often requires testing and demonstration under real industrial conditions, integration across complex value chains, and collaboration between companies, research organisations, equipment suppliers and public actors. Such efforts typically unfold over many years and require investments that extend well beyond the scope of most national innovation programmes.

This is particularly true for technologies linked to automation, electrification, digitalisation and sustainable production. While early-stage research may generate promising concepts, moving from laboratory results to operational implementation

often requires large-scale pilot facilities, international partnerships and substantial financial resources. In this context, access to international funding programmes becomes a critical part of the innovation system.

Recognising this challenge, Swedish Mining Innovation introduced planning grants to help Swedish actors prepare competitive applications for major international funding opportunities, particularly within European programmes such as Horizon 2020 and Horizon Europe. The grants could be used to build consortia, strengthen project proposals and establish collaborations with international partners. Rather than funding the innovation itself, the instrument was designed to unlock access to

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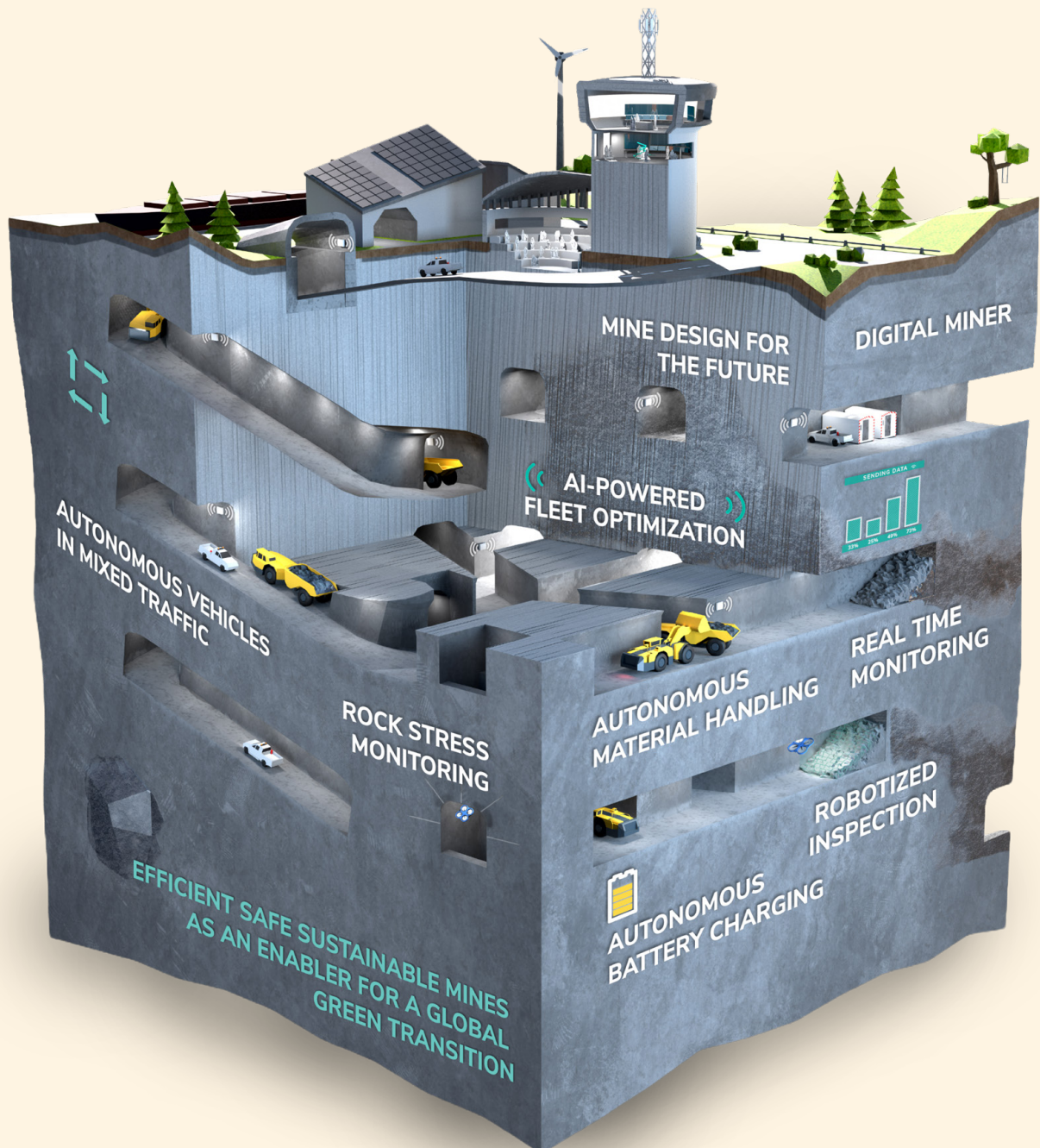
leverage via international funding million SEK to Swedish organisations

larger innovation ecosystems and funding streams.

Beyond the financial leverage, the grants helped position Swedish organisations within European innovation networks and enabled participation in projects of a scale that would otherwise have been difficult to access.

This includes the mission-oriented design and proposal of system demonstrator Horizon projects SIMS (2017-2020) and NEXGEN SIMS (2021-2024)

which focused on developing and demonstrating technologies for sustainable, intelligent mining. Widely regarded in the cluster and international community as an innovation milestone, the projects were early adopters of combining focus areas ranging from battery-electric mining equipment, underground 5G connectivity, autonomous systems, integrated process control, with education, digitalization, talent management and job creation.



Building Visibility Beyond Borders

International collaboration depends not only on technical excellence, but also on visibility, trust and continuity. Partnerships are rarely created through individual projects alone. They emerge through repeated interactions, shared narratives and sustained engagement over time.

Recognising this, Swedish Mining Innovation treated communication as an enabling component of internationalisation rather than a separate activity. As the programme evolved, communication became increasingly important in making the ecosystem visible and accessible to audiences beyond its traditional core stakeholders.

The transition from SIP STRIM to Swedish Mining Innovation reflected a broader ambition to engage actors beyond the mining sector and present innovation as a collaborative endeavour across industry, academia, government and society. The new identity also provided a more accessible entry

point for international partners seeking to understand and engage with the Swedish mining innovation ecosystem.

English became the programme's primary communication language, helping make research results, innovation projects and strategic discussions accessible to international audiences. A growing portfolio of digital channels, events and publications created opportunities to maintain relationships between projects and strengthen connections between organisations operating across different countries and sectors.

The Ore We There Yet? podcast became one example of this approach. Through conversations with researchers, industry leaders, entrepreneurs and policymakers, the podcast explored topics ranging from critical raw materials and technological development to sustainability, competitiveness and





Technical trip 2017, Mine visit at El Teniente

Jenny Greberg, LKAB and Darja Isaksson, Vinnova, Mining Innovation mini series in partnership with the Swedish Innovation Podcast 2022



societal acceptance. Rather than focusing solely on project outcomes, it provided a platform for discussing broader developments shaping the future of mining and minerals.

Over time, these efforts contributed to a substantial international audience. By 2025, more than one-third of Swedish Mining Innovation's online community was located outside Sweden, with particularly strong engagement from established mining regions such as Chile, Australia, Finland and South Africa. The audience extended beyond academia to include engineers, business developers, operational specialists and senior industry decision-makers.

From a system perspective, this visibility served a purpose beyond dissemination. Innovation networks require ongoing interaction to remain active and

productive. By creating channels through which actors could continue to follow developments, identify opportunities and remain connected to the Swedish mining ecosystem, communication became part of the infrastructure that supported international collaboration.

Internationalisation grants further strengthened this dynamic by enabling SMEs, researchers and emerging actors to participate in conferences, trade fairs and strategic meetings. Regional initiatives such as Bergslagen Mining Node similarly helped connect local capabilities with national and international networks. Together, these efforts broadened participation in international arenas and ensured that a wider diversity of actors could contribute to and benefit from international collaboration.

Scaling Through Internationalisation



Internationalisation is most effective when linked to domestic capability-building.

International collaboration creates the greatest value when national projects, partnerships and research activities prepare organisations to participate in larger international initiatives. Becoming "EU-ready" is often the result of long-term ecosystem development rather than individual project preparation.



Small interventions can unlock substantial resources.

Planning grants and internationalisation grants demonstrated how relatively modest investments can generate significant leverage by enabling consortium building, relationship development and proposal preparation.



Innovation ecosystems benefit from trusted intermediaries.

International stakeholders often seek a point of contact that can explain not only technologies and projects, but also how innovation is organised across the wider ecosystem. Over time, Swedish Mining Innovation increasingly played this role, connecting industry, academia, SMEs, public actors and international partners. The experience highlights the value of trusted intermediaries that can convene diverse stakeholders and communicate a shared ecosystem narrative, even when they do not hold a formal representative mandate.



Technology and policy should be developed in parallel.

Successful international engagement often requires connecting technological innovation with policy discussions, regulatory developments and strategic agendas. Participation in both arenas strengthens the relevance and influence of innovation activities.



→ **Strong research and innovation are necessary but not sufficient.**

Effective communication, international presence and the ability to articulate shared ambitions play an important role in attracting partners, opportunities and investment.

→ **Internationalisation must create feedback loops.**

The value of international engagement depends on how knowledge, networks and opportunities are brought back into the domestic ecosystem. Internationalisation becomes a system function when external insights continuously inform national priorities, projects and collaborations.

→ **Importance of clearly articulating and communicating the programme's role.**

Over time, Swedish Mining Innovation has come to function as a shared voice for the cluster, both nationally and in international contexts. At the same time, as an innovation programme, it does not hold formal ownership or mandate to represent individual actors. This creates an inherent balance: to enable coordination and visibility at system level, while maintaining neutrality and legitimacy across a diverse set of stakeholders. In parallel, it has proven difficult to identify actors with a similar role as Swedish Mining Innovation in other markets.

Broadening Participation Through Inclusive Innovation



A modern mine, Kristineberg, Fredric Alm/Imagebank.sweden.se

The transition towards a more sustainable and resilient mining and metals sector requires new forms of collaboration, broader participation and stronger societal legitimacy. In this context, inclusive innovation has increasingly become a strategic capability rather than a peripheral concern.



During the programme's early years, the focus was largely on gender equality, attractive workplaces and safety—issues already recognised as important to the sector's long-term development. As mining became more knowledge-intensive, digitalised and dependent on interdisciplinary collaboration, however, inclusion increasingly became a question not only of conditions within the industry, but of participation in innovation itself: who accessed funding opportunities, who took part in projects and whose knowledge shaped priorities and solutions. This shift developed through practical experience. The Innovation Idea Competition, created to engage start-ups and SMEs, revealed uneven participation, particularly in the gender balance among applicants and project leaders. Portfolio follow-up provided further insight into where representation remained uneven. Rather than treating these patterns as isolated issues, the programme used them to reconsider how innovation activities were designed, communicated and opened to different participants.

“Up- and re-skilling will become a natural part of work. Demand for creativity, flexibility and teamwork [...] will increase in the future.”

– Lena Abrahamsson, Professor Human Work Sciences, Luleå University of Technology.



Inclusive innovation and gender equality perspectives were subsequently introduced for participants in innovation competitions and later integrated into broader open calls. The programme initiated and funded national roadmaps addressing skills supply and workplace gender equality, safety and digitalisation. New competencies were brought into the programme office, while external expertise supported the development of methods and learning activities. Communication, visual material and outreach were also adapted, and collaboration expanded to networks and communities beyond the programme's established participants, including women in technology, science centres and entrepreneurship.

Over time, the perspective widened further. Technological and industrial development increasingly intersected with questions of land use, local development, environmental performance and societal legitimacy. This placed greater emphasis on knowledge and experience from beyond established industry and research networks. Municipalities, civil society organisations and other societal actors were increasingly engaged through projects, dialogues, conferences and other programme arenas, bringing additional perspectives into how innovation challenges were understood and addressed.

Inclusion thus developed along several connected dimensions: from equality and working conditions, to participation in innovation, and towards a broader recognition that industrial transformation depends on whose knowledge, experience and perspectives are present when challenges and solutions are defined.

“In addition to the good results, it has been very fun and educational to cooperate with all project partners. It is new to us but very important that we find ways to co-exist and solve common challenges together.”

– Johanna Finnholm, Sattajärvi Sameby.

Gender Equality in the Industry

Insights | Perspectives | Actions



Melinda From, RISE

Spotlight

Building Capability Through Inclusive Innovation Training

“Inclusion and gender equality aren’t soft issues – they’re core business.”

– Melinda From, Transformation Lead, RISE Research Institutes of Sweden.

To address gender imbalances in outreach and portfolio teams, Swedish Mining Innovation engaged experts from RISE Research Institutes of Sweden to support the programme steering group and management in developing competence around inclusive innovation. The work focused not only on awareness, but also on operational methods: how calls were formulated, how innovation was communicated and how assessment processes could better support broader participation.

One concrete outcome was the development of a digital training programme on gender equality and inclusive innovation. Initially targeted at participants in the innovation competition, the training was later expanded to applicants in broader open calls. The purpose was partly educational, but also strategic: to strengthen the quality and long-term relevance of innovation projects by encouraging more reflective approaches to team composition, leadership and societal impact.

These measures did not immediately solve participation imbalances. However, they contributed

to gradual change and, perhaps more importantly, to a deeper institutional understanding of inclusion as a capability-building process from the steering group of directors down to the project teams.

This learning also influenced later initiatives. Rather than abandoning innovation competitions when participation goals proved difficult to achieve, the programme chose to complement them with additional formats targeting different audiences and competencies. One example was Metallparadoxen, a concept built on design-thinking methodology, designed to broaden engagement around metals, mining and societal transition. Across several editions, the initiative attracted a significantly higher proportion of women participants than traditional mining innovation activities.

This development also aligned with broader priorities within Swedish industrial policy and research collaboration, where diversity, competence renewal and attractive workplaces were increasingly recognised as prerequisites for long-term competitiveness.

Metals4U and the Next Generation of Industrial Competence

Inclusive innovation also concerns how future generations understand and engage with industrial transformation.

The Metals4U and continuation project Metals4U+ initiative emerged within this context. Rather than focusing directly on technology development, the project aimed to strengthen understanding of mineral raw materials among young people and educators. The initiative connected mining and metals to broader societal challenges including climate transition, electrification and digital infrastructure, while also addressing questions related to sustainability and circular resource use.

– We started Metals4U because it is important for children to understand their role in society and how they use metals and minerals in their daily life, says Stefan Sädbom, project manager Bergskraft.

This represented a broader shift in how the innovation ecosystem approached public engagement. Historically, communication about mining often focused on industrial production or technical expertise. Metals4U instead framed minerals and metals as part of everyday life and future societal development. By doing so, the initiative sought to create a more informed and nuanced public conversation around raw materials and industrial transition.

An important aspect of the project was its effort to reach groups traditionally underrepresented in engineering and mining-related education pathways. Educational material, workshops and

outreach activities were designed to lower barriers to participation and broaden identification with the sector. This reflected a growing recognition that future competence supply depends not only on university programmes and recruitment strategies, but also on how industries are perceived by younger generations.

Such initiatives became increasingly important as mining and mineral extraction attracted greater political and societal attention across Europe. Strategic autonomy, resilience and secure raw material supply are now central policy priorities within the European Union. At the same time, public debates around land use, environmental protection and local impacts continue to intensify.

For Swedish Mining Innovation, this reinforced the importance of long-term dialogue and knowledge-building across society. Industrial transformation requires technological capability, but also public understanding and institutional trust. Programmes such as Metals4U therefore served a dual purpose: strengthening future competence supply while also contributing to broader societal literacy around industrial transition and resource systems.

The initiative further demonstrated how inclusive innovation can extend beyond organisational diversity alone. It also concerns who gains access to knowledge, who feels invited into industrial futures and how innovation ecosystems relate to society at large.



The artwork Fallen Rocks
by Veronika Geiger, photo
Lindesbergs kommun



Lotta Sartz, Project Manager for Swedish Mining Innovation's Bergslagen node

Broadening Participation Through Inclusive Innovation



Building inclusion into programme structures.

One of the most important shifts was moving from inclusion as an ambition to inclusion as an integrated part of programme practice. Over time, Swedish Mining Innovation embedded inclusive innovation into training activities, communication formats, calls and assessment processes. This gradually influenced who participated in projects, who took on leadership roles and how innovation challenges were framed. Clearly defined, measurable team goals, internal follow-up, roles and responsibilities were instrumental in operational management of the programme office.



Capacity-building creates institutional change.

The programme's experience showed that inclusive innovation requires knowledge and organisational capability, not only policy statements. Training activities for programme management, steering group members, executive committee and project participants contributed to a broader understanding of how inclusion affects innovation quality, collaboration and long-term implementation capacity. As competence increased within the system, so did the ability to integrate these perspectives into ordinary programme operations.



Broadening participation strengthens innovation capacity.

A wider mix of experiences, competencies and perspectives contributed to stronger collaboration environments and more robust innovation processes. This became particularly important in projects connected to sustainability transition, where technical, environmental and societal dimensions increasingly intersected. Inclusion therefore became linked not only to representation, but also to problem-solving capacity and system resilience.



“The real value comes from exchanging ideas with people from such different backgrounds. Every discussion gives you a new perspective.”

– Gabriela Budenberg, PhD Student Network participant.

Communication and outreach influence who enters the system.

Adapted communication formats, broader representation in public forums and targeted outreach activities helped lower participation barriers for actors not traditionally connected to the mining innovation ecosystem. The programme also learned that different formats attract different groups, and that broadening participation often requires parallel initiatives designed for different audiences and contexts.

Industrial transition depends on societal legitimacy.

Mining and mineral extraction are deeply connected to local communities, environmental concerns and regional development. As questions related to critical raw materials, climate transition and strategic autonomy gained importance, the programme increasingly recognised that technological innovation alone is insufficient. Long-term transformation also requires trust, dialogue and broader societal understanding of the role of minerals and metals in the transition.

Inclusive innovation is an evolving practice rather than a fixed model.

The programme's work evolved gradually from a relatively narrow focus on workplace equality towards a broader systems perspective on participation, access and societal engagement. This development reflected both changing societal expectations and the increasing complexity of industrial transition. Rather than treating inclusion as a separate agenda, Swedish Mining Innovation increasingly approached it as part of building a more adaptive, collaborative and resilient innovation system.

Building Capacity Beyond Projects



Ukasz_kochanek, stock.adobe.com

Capacity for innovation does not emerge automatically. It depends on the ability of actors to find one another, form new collaborations and move ideas towards implementation. Over time, Swedish Mining Innovation developed structures that helped connect fragmented capabilities across the mining ecosystem and strengthen collective innovation capacity.



The work was closely connected to the programme's forum activities described in the previous chapter. If forums created opportunities for interaction and exchange, capacity-building initiatives created pathways through which those interactions could develop into collaborations, projects and implemented innovations. Together, these functions helped strengthen the connective tissue of the ecosystem.

For the mining and metal producing sector, valuable knowledge, ideas and resources exist across mining companies, equipment suppliers, SMEs, universities, municipalities, public agencies and civil society organisations. Yet the presence of capable actors does not automatically result in innovation nor collaboration. Opportunities are often missed because organisations lack access to the right partners, test environments, funding mechanisms or pathways into existing innovation networks. Building trust among actors is essential to achieving system engagement across a broad set of stakeholders with little, none or even negative experiences of working together towards a shared goal.

For Swedish Mining Innovation, this challenge became increasingly visible over time. While the Swedish mining ecosystem contained substantial technical expertise and strong industrial capabilities, many actors remained disconnected from one another. New entrants struggled to identify points of access, promising ideas lacked routes towards implementation and potential collaborations often failed to materialise. Strengthening the system therefore required more than supporting individual projects. It required deliberate efforts to build the structures, relationships and processes that enable innovation capacity to be mobilised and translated into action.

This perspective gradually broadened the programme's role. Alongside funding research and innovation projects, Swedish Mining Innovation increasingly invested in mechanisms that could strengthen the ecosystem itself. Innovation competitions, challenge-driven collaboration formats, regional initiatives, student programmes and strategic networks were developed not as standalone activities, but as



tools for expanding participation, connecting actors and creating new pathways for innovation.

Some initiatives focused primarily on creating entry points into the system. The annual Innovation Idea Competition, Mining Summer and Mining Safari introduced entrepreneurs, students and emerging innovators to the challenges and opportunities within the mining sector. Other initiatives focused on strengthening collaboration between actors already operating within the ecosystem. The SME Network, Bergslagen Mining Node and Mining Municipalities Network created structures for coordination, knowledge exchange and joint problem-solving. Strategic projects such as Safe Transports in Reindeer Husbandry Areas demonstrated how innovation capacity could also be mobilised around environmental and societal challenges that extended beyond traditional technology development.

An important lesson was that much of this work remained largely invisible. The public-facing activities, a competition, study visit, workshop or networking event, represented only a small part of a broader process and long-term commitment. Behind them lay continuous efforts to identify needs, formulate challenges, connect actors, support project development and maintain relationships across organisational boundaries. These activities required time, trust and a deep understanding of both the sector and the wider innovation system.

Over time, these activities contributed to a broader and more connected innovation community. New actors entered the system, collaborations became more diverse and innovation opportunities emerged across organisational, disciplinary and geographical boundaries. In this sense, building capacity for innovation and collaboration became a practical pathway for strengthening the adaptability, resilience and long-term effectiveness of the Swedish mining innovation ecosystem.

From Industrial Challenges to New Innovation Pathways

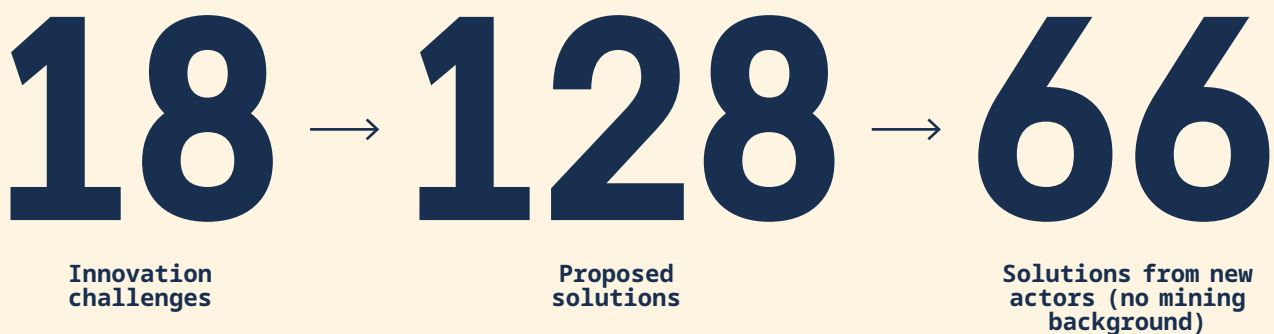
The barriers are well known. Smaller companies may struggle to identify relevant entry points into complex industrial environments, while larger organisations often lack efficient mechanisms for identifying and evaluating emerging solutions. As a result, promising innovations risk remaining disconnected from the problems they are capable of solving.

To address this challenge, Swedish Mining Innovation established a strategic initiative to strengthen challenge-driven innovation across the Swedish mining ecosystem. Rather than functioning as a traditional business network, the SME Network was designed as a structured process that connected industrial needs with external innovation capacity.



Erik Hagenrud, SME Network Coordinator

SME Network results



Source: Swedish Mining Innovation

"LKAB is facing a major transition in a relatively short time. At the same time, technological development is exploding. Close collaboration with innovative suppliers will be necessary to solve that equation."

– Markus Odevall, LKAB.

Needs owners included major actors such as LKAB, Boliden, Epiroc, ABB, Sandvik and Zinkgruvan Mining, reflecting a broad commitment from across the mining and minerals value chain. Participating companies were supported in formulating concrete operational and strategic challenges. These challenges were then presented to a growing network of innovative SMEs and technology providers, creating a clear pathway for solution providers to engage with the sector.

Between 2022 and 2025, the SME Network facilitated eighteen innovation challenges that attracted a total of 128 proposed solutions. Of these, 66 came from actors with no previous connection to the mining sector. More than half of all submitted innovations therefore represented new competencies, technologies or perspectives entering the ecosystem for the first time.

These figures highlight an important systems perspective. The value of the initiative was not limited to solving individual industrial challenges. Equally significant was its contribution to broadening the innovation base of the sector itself. By lowering barriers for participation and creating structured pathways into the industry, the initiative helped connect mining companies with expertise that might otherwise have remained outside the ecosystem.

The SME Network also became a foundation for several international initiatives involving small and medium-sized enterprises. Participants gained opportunities to engage with innovation ecosystems in other mining regions, establish new relationships and explore collaborations beyond Sweden. In this way, the network contributed not only to stronger national collaboration, but also to the long-term development of the sector's innovation capacity.

Innovation Competitions as an Entry Point to the Ecosystem

Swedish Mining Innovation launched its annual Innovation Idea Competition in 2015. The competition was designed to attract innovative SMEs and start-ups to the mining and metals ecosystem while creating a platform where new ideas could be interact with industry needs and opportunities. Each year, between eight and sixteen companies pitched their ideas, with two winners receiving funding to further develop their concepts.

The competition quickly became much more than a funding instrument. For participating companies, it provided visibility, access to industry representatives and opportunities to engage directly with actors

from across the mining innovation ecosystem. For the programme, it created a valuable mechanism for identifying emerging technologies, new competencies and entrepreneurial talent.

Equally important were the conversations that took place around the competition itself. Through discussions with participants, the programme gained insight into the practical barriers faced by SMEs seeking to innovate within the sector. Many highlighted difficulties in accessing industrial environments, understanding procurement processes, identifying partners or finding opportunities to test and demonstrate new solutions.

These insights helped shape subsequent



Matt Baida and Frida Holst, VAST Landscape Architecture, one of the two winning entries during the Innovation Idea Competition 2023

programme initiatives. The need for stronger connections between SMEs and industrial challenge owners contributed directly to the establishment of the SME Network. Requests for broader exposure and international opportunities informed later internationalisation activities, including travel grants and collaborative initiatives with innovation ecosystems in other mining regions.

The competition also helped broaden participation in the innovation system. It introduced new actors

to the sector, encouraged engagement with industry challenges and provided a visible entry point into a community that can otherwise be difficult to navigate from the outside. Viewed from a systems perspective, the competition functioned as more than an annual event. It became a mechanism for ecosystem renewal. By continuously attracting new participants and creating opportunities for engagement, it strengthened the sector's ability to identify, absorb and develop innovation capacity over time.

"Winning this competition gave us legitimacy and recognition – hugely important when you are a completely unknown company with new technology and new ideas. The recognition in the mining industry also helped the marketing efforts in other markets we work with as there are high demands for robustness and reliability in the mining industry. "

– Ida Rehnström, Flasheye.



Building Capacity Beyond Projects



Creating entry points matters.

Innovation systems depend on a continuous inflow of new actors, competencies and perspectives. Initiatives such as the Innovation Idea Competition, Gruvsommar and Mining Safari helped lower barriers to participation and created pathways into the mining innovation ecosystem for entrepreneurs, students and emerging innovators.



Collaboration requires structures, not only ambition.

Partnerships rarely emerge automatically. The SME Network, Bergslagen Mining Node, Safe Transports in Reindeer Husbandry Areas and Mining Municipalities Network demonstrated the value of structured approaches that help actors identify common challenges, build trust and develop collaborations over time.



Capacity-building happens between projects.

Much of the work required to strengthen an innovation ecosystem takes place outside formal research and innovation projects. Challenge formulation, matchmaking, relationship-building and project development all play important roles in transforming innovation potential into innovation activity.



Regional and societal perspectives strengthen innovation.

Innovation capacity is not limited to companies and research organisations. Strategic initiatives such as Safe Transports in Reindeer Husbandry Areas illustrate how municipalities, regional actors and civil society perspectives can contribute to more resilient and broadly anchored innovation processes.



Building capacity and building excellence go hand in hand.

Broad participation alone is insufficient. Long-term impact depends on combining ecosystem breadth with strong pathways towards testing, implementation and industrial application. Successful innovation systems require both a wider community of actors and mechanisms that help promising ideas progress towards real-world use.

Appendix

Project Portfolio

Explore the projects, technologies and collaborations supported by the programme: www.swedishmininginnovation.se

The Effect Logic

Vision: A World Leading Mining and Mineral Producing Industry Contributing to a Sustainable Society

Working Within Four Dimensions:

D1. Innovation Capacity
D2. Innovation and Technology Development
D3. Social Benefit and Social Acceptance
D4. Education and Access to Qualified Personnel

Activities	→	Outputs	→	Direct Effects	→	Long Term Impacts
What type of activities and projects will generate outputs in line with our vision? Yearly activity plans		What are the results from the activities and projects? What is measured? KPIs		What are the impacts that the program will contribute to? Effect to 2030 (8–10 y)		What long-term goals does the program contribute to? Effect after 2030

D1. Innovation Capacity

Activities	→	Outputs	→	Direct Effects	→	Long Term Impacts
Mustering, outreach, networking – Thematic & other workshops – External presentations – Media interviews – PhD network Communication channels – Website – Social media – Newsletters – Published articles Project & calls – Open calls – Strategic projects – Idea competition Cooperation & consultation – Top management meeting – Cross-SIP – Executive committee & board Internationalisation & monitoring – Planning projects – International outreach, participation EU & international programs	→	KPIs – Participants in events – Number of participants in platforms/networks; diversity of participants – Joint activities and projects with other SIPS, EIT RM etc. – Of publications – External presentations International cooperation: – Foreign participants in WS, other activities – Foreign organisations in projects – Projects, #partners, diversity of partner types, #SMEs engaged in projects Communication KPIs: – Organisations taking part in call information tour – Newsletters – Press release – Participants in Swedish Mining Innovation Award	→	D1.1. Broad national and international participation, including SMEs in projects and activities D1.2. Established platforms for strategic dialogue with relevant actors D1.3. Branch-wide multidisciplinary projects and initiatives incl. updated Research and Innovation Roadmap D1.4. Swedish Mining Innovation and its projects are visible in national and international settings D1.5. Improved access to international funding, including EU D1.6. Innovation support system is effective and competence in place D1.7. Clarified and communicated needs and enablers for mining innovation (legislation, permitting, funding, competence etc) D1.8. Strengthening existing networks, developing new ones	→	World-leading innovation capability and collaboration partner with global impact (meeting future challenges) Strengthened collaboration among industries (and across industries), academia and society Effective innovation system (organisations and networks, testbeds, competence, society, education and funding) with successful implementation of innovations into commercial use

D2. Innovation and Technology Development

Activities	→	Outputs	→	Direct Effects	→	Long Term Impacts
Mustering, outreach, networking – Thematic & other workshops – External presentations – Media interviews – PhD network Communication channels – Website – Social media – Newsletters – Published articles Project & calls – Open calls – Strategic projects – Idea competition Cooperation & consultation – Top management meeting – Cross-SIP – Executive committee & board Internationalisation & monitoring – Planning projects – International outreach, participation EU & international programs	→	KPIs – Scientific publications – New products, processes, services developed (to TRL 7+) – Patent & patent applications, new intellectual property developed – Projects that support creation of new or develops existing testbeds – Projects, #partners, diversity of partner types, #SMEs engaged in projects – Projects moving to next stages – PhD and Lic. thesis where project results are used – Projects followed up	→	D2.1. Improved production efficiency D2.2. Improved energy efficiency D2.3. Improved resource efficiency D2.4. Improved cost effectiveness D2.5. Increased circularity & recycling metals and wastes D2.6. Lowering environmental impact D2.7. Emissions: lower impact to air, water, land D2.8. Climate neutrality/fossil-free operations D2.9. Safer workplaces D2.10. Developed technology to facilitate a more inclusive & flexible working environment	→	Increased contribution to global sustainable metal production, services and equipment with recognised global leadership and economic competitiveness Meet mining industry commitments and regulations for climate, fossil-free and reduced negative environmental impact Greater access to domestically and sustainably produced metals and minerals (incl. strategic) with established sustainable value-chains Increased economic resource base Diverse and competent people attracted to the mining sector Improved sustainability and global transparency in sourcing and environmental impact Securing long-term mining activities in Sweden

D3. Social Benefit and Social Acceptance

Activities	→	Outputs	→	Direct Effects	→	Long Term Impacts
Mustering, outreach, networking – Thematic & other workshops – External presentations – Media interviews – PhD network Communication channels – Website – Social media – Newsletters – Published articles Project & calls – Open calls – Strategic projects – Idea competition Cooperation & consultation – Top management meeting – Cross-SIP – Executive committee & board Internationalisation & monitoring – Planning projects – International outreach, participation EU & international programs	→	KPIs – Projects and activities that support industry's development of CSR, social acceptance, social benefit – Projects and activities that facilitate dialogue amongst broad range of stakeholders & experts – Projects and activities that support integration of non-technical disciplines in mining and metals industry	→	D3.1 Generation and effective dissemination of environmental and socio-economic impacts of mining and metals industry to all stakeholders incl. policy makers & general public D3.2. Improved open and transparent dialogue between all stakeholders D3.3. Societal awareness and an increased responsibility for supply and use of raw materials actively owning the issue (active ownership) D3.4. The industry and individual companies improve their knowledge of how to contribute to societal development D3.5. Swedish Mining Innovation program attracts researchers from outside of traditional technical areas (e.g. from social sciences, law, finance, ethics, gender studies)	→	Better mutual understanding of issues from all stakeholders points of view Increased benefit to society through economic and social development in mining regions and nationally including mining's role in the green transformation Society recognises the mining industry as increasingly sustainable and as a key enabler for a sustainable society Appropriate permitting processes leading to more stable and good investment climate

D4. Education and Access to Qualified Personnel

Activities	→	Outputs	→	Direct Effects	→	Long Term Impacts
Mustering, outreach, networking – Thematic & other workshops – External presentations – Media interviews – PhD network Communication channels – Website – Social media – Newsletters – Published articles Project & calls – Open calls – Strategic projects – Idea competition Cooperation & consultation – Top management meeting – Cross-SIP – Executive committee & board Internationalisation & monitoring – Planning projects – International outreach, participation EU & international programs	→	KPIs – Participants in doctoral network – Universities in doctoral network – Activities / projects to attract students to the branch – Activities/projects to develop the education system to meet future needs – Students engaged in activities (gymnasium & younger) – Number of female/male project leaders – Amount of funding to females/males	→	D4.1. Up to date information and demonstrations to schools/young people about the mining and metals industry as modern, sustainable, safe and offering interesting careers D4.2. Strategic dialogue with decision makers and stakeholders about the needs for future skills and competencies D4.3. Training & education programs/tools to suit the industry's future needs D4.4. Organisations & workplaces are more progressive and attractive with continual learning D4.5. New contacts/ interaction between students and industry; student's increased understanding of the industry's challenges	→	Increase in number of students applying for education in mining and metals and multi-disciplinary related fields The industry is known as a workplace that respects ethics, ecology, gender equality and diversity Diversity and gender aspects are anchored and prioritised in organisations, developments, management People from diverse and atypical backgrounds will want to work and stay in the branch Industry integrated clearly in education and research fields. The mining industry/ academy /research institutes attract and have access to talented qualified personnel Workforce in mining is further diversified

