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CORDIS Results Pack on

sustainable mineral extraction

A thematic collection of innovative EU-funded research results

October 2023

Innovative solutions for sustainable raw materials extraction

Research and Innovation

Contents

Editorial

Modern life and its accompanying devices like mobile phones, flat screen televisions, automobiles, solar panels, space guidance systems, jet engines and pacemakers depend on mineral resources. This Results Pack showcases six Horizon 2020 funded research and innovation projects offering concrete innovative solutions for sustainable minerals extraction.

Critical raw materials (CRMs) are important to Europe's continued economic success, but they are vulnerable to supply chain disruptions such as the COVID-19 pandemic in 2020 and Russia's invasion of Ukraine two years later. Furthermore, CRMs are in growing global demand due to their critical role in the decarbonisation of the world's economies.

CRMs are defined as those materials that are economically and strategically important and have a substantial risk associated with their supply and are difficult to substitute due to their unique properties. The first list of 14 CRMs for the EU was published in 2011 and has been revised every three years since then. After the last update in 2023, the fifth list of critical raw materials for the EU now numbers 34.

These materials, which include rare earths, play a vital role in industry. Hence, improving access to CRMs while optimising their consumption and improving extraction conditions across Europe plays a major role in delivering the European Green Deal, which aims to make Europe the first carbon-neutral continent by 2050.

Reducing negative impacts

The challenge confronting the extractive industry is to scale up promising innovative production technologies and to demonstrate that raw materials can be extracted sustainably from both an environmental and a social standpoint.

Reducing high extraction costs while improving the participation of civil society from the beginning of the production process will help in raising awareness and trust among local communities and other stakeholders. Scaling up the most promising technologies and launching them onto the market will strengthen the competitiveness of European industries.

Six sustainable solutions

The industry- and user-driven multidisciplinary projects presented here have developed solutions with good prospects for ending up on the market and reinforcing the competitiveness of the EU raw materials industry. In addition, each project contributes towards meeting the EU's ambitious energy and climate targets, reducing negative environmental and health and safety impacts and risks, and improving the awareness of the general public across the EU about the need for a secure, sustainable, and responsibly sourced supply of raw materials.

The ROBOMINERS project created a bio-inspired, modular and reconfigurable robot for mining small and difficult-to-access deposits. Goldeneye provides next-generation tools for mining safety, environmental monitoring and mineralogical mapping in real time.

Dig_IT built a smart industrial Internet of things platform to improve the efficiency and sustainability of mining operations by connecting cyber and physical systems. NEXTGEN SIMS developed strategies for the safe introduction of autonomous carbon-neutral (battery-powered) mining machinery and the required infrastructure for a fully digitally connected mine, tested under real-life conditions.

RE-SOURCING advanced the responsible sourcing of raw materials across global mineral value chains to support the green energy transition. SUMEX established a sustainability framework that provides guidance on how extractive industries can achieve sustainability goals while operating within the political framework established by the Green Deal.

Mining goes digital to meet modern demands

An EU-funded project's data-driven technologies connect cyber and physical systems to advance a human-centred, environmentally focused transformation of mining industries.

Rising demand and advances in technology are bringing rapid changes to mineral extraction industries. Mining has been slow to adapt to digitisation opportunities compared to downstream industries, but the Dig_IT project has developed several tools to foster technical development.

Innovative technologies

Project-developed technologies represent numerous innovations. Big data optimisation allowed for early prediction of slope failure in an open pit mine. Other innovations include a sustainable blockchain platform for managing mining data and a support system platform for managing mining decisions.

The project also developed digital twins in the areas of geotechnical monitoring and fluid dynamics. A digital twin is a dynamic copy of a system or physical asset that can use data to replicate processes, thereby enabling predictions concerning the real-world twin.

One of the project's most significant innovations is a smart industrial Internet of things (IoT) platform to optimise mining performance, enhance safety and safeguard the environment. IoT components include a plethora of devices that collect data important to safety and developing predictive models.

Data collection on multiple levels

To create the IoT platform, Dig_IT gathered data on human, environmental and asset levels. On the human level, the project developed a smart garment (consisting of a wristband, vest and headset) that can be worn by mining personnel that will collect data relevant to the individual's health.

According to María García Camprubí, project coordinator: "The smart garment is capable of enduring the harsh conditions of the mines, with embedded miniaturised sensing devices assessing occupational health, safety and environment (OHSE) parameters (e.g. temperature, humidity, gases and noise), as well as measuring biometrics data (e.g. heart rate and body temperature)."

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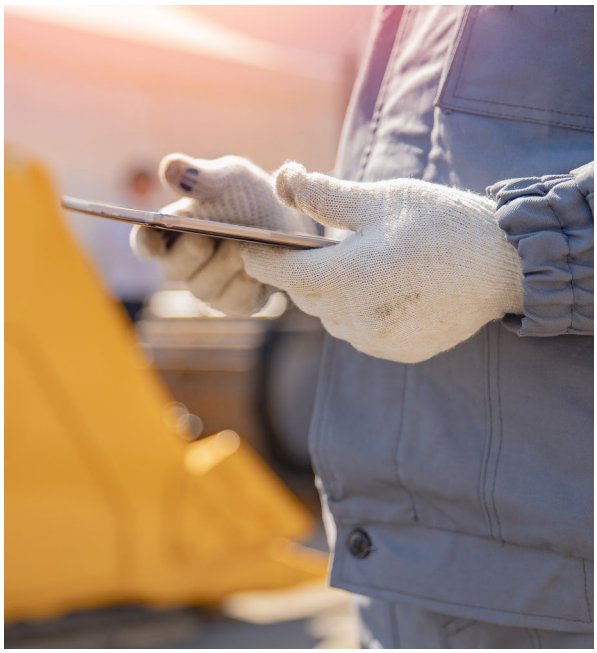
On the environmental level, Dig_IT developed sensors to be used in mines that monitor air and water quality. With respect to air quality, the sensors collected data on dust, diesel exhaust, temperature and humidity. Sensors also measured the turbidity, or relative clarity, of water.

There are many types of machines among mining assets, and the IoT platform includes several monitoring devices. These devices measure such things as location, speed, fuel rate and coolant temperature. Data collected is used to develop predictive maintenance models for optimising performance.

Next steps and use cases

All of the technologies developed by Dig_IT are ready for deployment. They will be tested in five use case mines located in Finland, Italy, Norway and Spain to raise the technology readiness level of the IoT platform.

The COVID-19 pandemic and the war between Russia and Ukraine presented challenges to the project. Travel bans during the pandemic made it difficult to coordinate with the use case mines.



One use case mine was closed due to its reliance on natural gas, and activities had to be moved to another mine. A second use case was lost due to a subcontract termination, but fortunately a very similar mine was found to replace it.

When the testing stage is completed, Dig_IT will focus on disseminating results. The project's innovations are driven by societal needs, and these go far beyond a straightforward demand for extracted minerals. Dig_IT delivers smart solutions that address the health and well-being of humans and the environment while simultaneously optimising the economic contributions of mining industries

PROJECT

Dig_IT - A Human-centred Internet of Things Platform for the Sustainable Digital Mine of the Future

COORDINATED BY

Technological Institute of Aragon in Spain

FUNDED UNDER

H2020-EU.3.5., H2020-EU.3.5.3.

CORDIS FACTSHEET

cordis.europa.eu/project/id/869529

PROJECT WEBSITE

digit-h2020.eu/

Data fusion unlocks the potential of geo-intelligence in mining

A new platform leverages satellites, drones and direct-contact sensors to collect high-resolution data from all areas of a mine. Turning raw data into actionable intelligence, this novel system improves monitoring, safety and productivity of mining operations.

Modern society relies heavily on significant quantities of mineral resources essential to machinery, vehicles, electronics, smartphones and computers. As mineral demand is expected to rise owing to renewable energy, electric vehicles and advanced electronics, the mining industry will face significant challenges. Mining operations must prioritise workers' safety and environmental protection despite challenges posed by the scarcity of high-grade deposits often located in remote or densely populated areas.

Marko Paavola, coordinator of the EU-funded Goldeneye project, states: "Increased automation and Earth observation will greatly change the future of mining. The monitoring of mining activities such as employee location, mine slope stability, asset management and environmental control will see significant advancements." Paavola highlights that the key to this evolution lies in harnessing multiple data sources – satellite imagery, drone and aerial surveys – and in situ sensors or instruments.

Intelligent, easy-to-use platform automating the mining industry

The Goldeneye consortium is developing an AI platform that enables novel uses of Earth observation data in the mining industry. "The Golden AI platform fuses satellite, drone and in situ sensor data with automated data pre-processing and state-of-the-art visualisation tools. The end result will be analytical maps that are easily accessible to mining site operators, eliminating the need for in-depth knowledge of data collection and processing," notes Paavola.

Data fusion integrates data from two or more sources over the same area with comparable resolutions, significantly improving data quality. The process can also be beneficial for data with different spatial or temporal resolutions. "For instance, the temporal resolution of low-resolution, low-frequency satellite data can be enhanced by integrating data from higher-resolution yet higher-frequency sources," explains Paavola.

The Golden AI platform also allows combining geophysical data from drone missions and in situ Raman spectroscopy measurements or active hyperspectral imaging. The resulting data fusion products are added to a stack of generated analysis ready data in the European Space Agency Data Cube facility for reuse.

The groundbreaking platform automates the recognition of known patterns in the fused data by creating specific AI knowledge packs (AKPs) developed for different use cases. These AKPs are independent of language and development tools, meaning any AI tool compatible with the Golden AI platform can be utilised.

Successful technology demonstrations

Goldeneye has conducted successful field campaigns in various European countries. Its use cases cover mineral detection, safety monitoring, operational management, geohazard monitoring and environmental monitoring.

© Andreas Knobloch

"Our automated environmental monitoring solutions have been instrumental in overseeing large water bodies like lakes and tailing ponds and detecting ground displacement in large areas reducing human effort by at least 50 %," remarks Paavola.

The Golden AI platform provides next-generation tools for mining safety, environmental monitoring and mineralogical mapping. Its high-level architecture serves as the foundation for a cost-efficient, scalable and commercially viable solution

State-of-the-art technologies like drone-based 3D mapping and electromagnetic sensing help reduce human effort in exploration targeting by over 80 % when combined with best exploration practices. Such methods can significantly mitigate the environmental impact of exploration activities by reducing drilling volumes by over 60 %.

As for mining operations, Goldeneye's technology has improved planning that has led to a 40 % decrease in energy use for blasting and drilling.

"Combining different data sources, the Golden AI platform provides next-generation tools for mining safety, environmental monitoring and mineralogical mapping. Its high-level architecture serves as the foundation for a cost-efficient, scalable and commercially viable solution. The design is flexible and updatable, ready to incorporate novel technologies in the future," concludes Paavola.

PROJECT
Goldeneye – Earth observation and Earth GNSS data acquisition and processing platform for safe, sustainable and cost-efficient mining operations

COORDINATED BY
VTT Technical Research Centre of Finland in Finland

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.3.

CORDIS FACTSHEET
cordis.europa.eu/project/id/869398

PROJECT WEBSITE
goldeneye-project.eu/

The green and digital transformation of mining

European mining is on the verge of an evolutionary leap with completely autonomous battery-powered vehicles in a 5G interconnected mining environment.

A simultaneous green and digital transition will increase sustainability, mitigate the impact of climate change and move us towards a carbon-neutral EU by 2050. While the conversation often centres on topics like transport, buildings and factories, tremendous opportunity exists virtually everywhere, including places and sectors not often targeted.

The ambitious and pioneering NEXGEN-SIMS project is paving the way for safe, sustainable, digitised and autonomous mining and mineral extraction leveraging battery-powered autonomous vehicles with AI-powered fleet optimisation in an interconnected environment.

Battery-powered autonomous machines: faster, safer access

Mining is essential to the provision of the mineral and metal commodities we use to produce myriad goods that strengthen our economies and improve our quality of life. Historically, mining has required humans to drill and blast, to build new shafts and air vents, to extract ore and load it onto carriers, and to operate heavy, often diesel-powered machinery and equipment needed for these tasks. Considerable progress has been made in supporting workers with machines that are partially or totally automated – but this is just the tip of the iceberg of what is possible.

NEXGEN-SIMS is catapulting mining into a green and digital future. "Our machines are battery-powered and driven completely autonomously with no human interaction, allowing us to keep humans away from potentially dangerous mine zones. Further, these machines can navigate and access more rugged areas sooner after blasting. Utilising drones to assess gases and the distribution of muck pile (the pile of mineral or rock obtained after blasting) further supports safety and faster access," explains project coordinator Jan Gustafsson of Epiroc Rock Drills.

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Mining blasts its way into the future: 5G and human-machine collaboration

The machines and infrastructure will be equipped with devices operating with 5G wireless cellular technology, creating an Internet of things in tomorrow's modernised and sustainable mines. The project will also research and verify machines' operation in defined mixed-traffic scenarios, specifically when an autonomous vehicle meets a manually driven one in two-way traffic. This collaboration will require communication via uninterrupted connectivity and will be an enabler of future human-machine collaborative systems, given that humans will have increasingly critical roles in an era of increasing technological sophistication.

Green and digital augment sustainability and reduce costs

Rolling out 5G in the depths of the Earth and running an autonomous factory down there is no small task and could have raised stakeholder concerns about costs. NEXGEN-SIMS has laid these potential concerns to rest. Gustafsson explains:

© NEXGEN-SIMS

"Keeping mines well ventilated for the humans working in them accounts for the largest share of operating costs due to the energy needed to do so. The ventilation requirement is further increased using diesel-powered machinery. By substituting autonomous battery-powered vehicles for humans and diesel, NEXGEN-SIMS has reduced tremendously ventilation needs and costs while simultaneously decreasing energy consumption and emissions."

Autonomously driven machines also enable increased machine utilisation and thus lower material handling costs.

NEXGEN-SIMS is developing strategies for the safe introduction of autonomous carbon-neutral (battery-powered) mining machinery and the required infrastructure for a fully digitally connected mine. These will be tested in a real mining environment (mining pilots) at Agnico Eagle in northern Finland. With added focus on reducing investment risk and increasing stakeholder confidence, the project is paving the way for mining's green and digital transformation.

PROJECT

NEXGEN-SIMS – NEXT GENERATION CARBON NEUTRAL PILOTS FOR SMART INTELLIGENT MINING SYSTEMS

COORDINATED BY

Epiroc Rock Drills in Sweden

FUNDED UNDER

H2020-EU.3.5., H2020-EU.3.5.3.

CORDIS FACTSHEET

cordis.europa.eu/project/id/101003591

PROJECT WEBSITE

nexgensims.eu/

Responsible sourcing reaches new advances with European platform

The EU-funded project RE-SOURCING connected experts and stakeholders to promote the development of responsible sourcing of raw materials, key to achieve energy transition even earlier than expected.

Responsible sourcing of raw materials is crucial for a more sustainable world. Only through sourcing that is socially responsible, environmentally sensitive and economically viable can environmental targets such as the ones in the European Green Deal be achieved.

The theme has gained momentum in recent years, but the adoption of responsible sourcing in Europe and internationally is still lacking. To help tackle this challenge, the RE-SOURCING project was launched to advance the responsible sourcing of raw materials across global mineral value chains.

Getting closer to a sustainable future

"Responsible sourcing would help protect local communities and ecosystems by minimising negative impacts such as habitat destruction, water pollution and human rights abuses," explains Alexander Graf, RE-SOURCING project coordinator from the Vienna University of Economics and Business.

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The project created a platform that connects experts and stakeholders through physical and digital activities, such as workshops, site visits and digital conferences, allowing them to exchange information that facilitates responsible sourcing initiatives.

The most exciting thing about our project is that we can project that the green energy transition is not only possible through a collaborative and strong effort by 2050 but could be achieved even earlier.

Graf was surprised by the progress the platform achieved. Through its multi-stakeholder approach, RE-SOURCING was able to identify actors in business, politics and civil society that can achieve today what current EU policies and visions have established for the near and distant future. "The most exciting thing about our project is that we can project that the green energy transition is not only possible through a collaborative and strong effort by 2050 but could be achieved even earlier."

The path to achieve responsible sourcing

Focused on the sectors of renewable energy, mobility, and electric and electronic equipment, the project developed roadmaps for each one. The RE-SOURCING output materials provide short-, medium- and long-term milestones with recommendations for EU policymakers, international industry and civil society organisations.

In the electronics sector, one of the world's largest and fastest growing industries, three main targets were identified: respect for human rights, circular economy and decreased resource consumption, and responsible production. "The electronics industry needs to shift its business model away from profit maximisation driven by shareholders and move towards meeting human well-being needs within planetary boundaries," states Graf.

While renewable energy is growing exponentially, there are significant environmental and social impact concerns regarding the production of raw materials and equipment used to build wind and photovoltaic systems. The renewable energy roadmap addresses three raw materials (copper, rare earth elements and silicon), wind and solar power technologies, and the supply chain stages of mining, manufacturing and recycling. The project coordinator notes that to advance responsible sourcing more easily in this sector, NGOs should help governments to make due diligence laws feasible and effective.

For the mobility roadmap, the RE-SOURCING team focused on lithium-ion batteries, since battery electric vehicles will have a major contribution in achieving sustainability goals. The publication addresses lithium, cobalt, nickel and graphite, which are four relevant raw materials used in lithium-ion batteries, and considers the supply chain stages of mining, cell manufacturing and original equipment manufacturing, and recycling. "It is crucial that policy and industry consider recycling at the battery design stage," says Graf.

Besides the guidance documents, the project involved stakeholders in over 60 events, webinars, consultations, workshops, peer learning labs, videos and conferences.

PROJECT
RE-SOURCING - Global Stakeholder Platform for Responsible Sourcing

COORDINATED BY
Vienna University of Economics and Business in Austria

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.3.

CORDIS FACTSHEET
cordis.europa.eu/project/id/869276

PROJECT WEBSITE
re-sourcing.eu/

Mining robots designed for selective extraction

An EU-funded initiative equips robots with novel locomotive capacities, sensors and tools able to identify and mine targeted ores, making mining a more eco-friendly industry.

Rare minerals are essential to many critical industries, including energy, electronics and defence. Most such minerals are imported, as European deposits tend to be small and in areas difficult to access. The EU-funded project ROBOMINERS investigated ways to develop cost-effective and environmentally friendly methods for extraction of crucial minerals.

Mining robot prototype

ROBOMINERS set out to develop a robust and versatile modular robotic prototype capable of moving in difficult environments, including underwater. Inspired by biology, the team used the movement patterns of insects, worms and fish to design propulsive strategies for the robot. They also designed a locomotive technique based on Archimedes' screw, which proved viable in a number of test environments.

Locomotion isn't the robot's only bio-inspired feature. Based on the concept of whiskers, the prototype has sensors attached that help to provide 3D modelling of the area being mined. Additionally, spectrometers, mineralogical sensors and geophysical sensors attached to the robot allow it to identify desired minerals for extraction.

The project team worked on development of the prototype to attain a technology readiness level of 4. Tests of the prototype were conducted in the laboratory as well as in simulated settings, and the project made great strides in robotic design and selective mining. Field tests have also been carried out to test the main components of the system in a real mine environment. Additionally, input from sensors enhanced geologic modelling, and the information obtained can be integrated with prior knowledge from established prospection methods.

© Kaloyan Nikolov

While research is not yet market-ready, the vision of ROBOMINERS is likely to be a game changer in the mining industry. Project manager Claudio Rossi states: "We envision a colony of robotic miners working underground, similar to a small ant colony. This approach enhances the resilience and productivity of the mining system, as the swarm-like behaviour enables coordinated and collaborative operations among robots with different functions."

Eco-friendly mining solutions

Public opinion regarding mining has long been negative. This is understandable, given the ecological damage associated with the industry and the highly visible destruction evident in open-faced mines. ROBOMINERS offers solutions that can change that.

Because the project-designed robot is meant to operate underground, only a small opening is necessary, eliminating the unsightly evidence presented by an open mine. Furthermore, because the mining robot can operate in water, there is no need to pump out liquid from flooded mines, which can be costly and introduce environmental damage.

The entire concept of the project addresses environmental concerns through its focus on low-impact mining. The emphasis on selective and precision mining is meant to reduce both waste and the need for high-impact surface infrastructure.

When operating underwater, the robot would pump mineral-rich slurry to the surface for processing. Once desired ores are removed, the remaining slurry can be returned to the mined-out area for backfill, again minimising the environmental damage.

Environmental concerns were forefront in the project. According to Rossi: "The entire concept of the project addresses environmental concerns through its focus on low-impact mining. The emphasis on selective and precision mining is meant to reduce both waste and the need for high-impact surface infrastructure."

The work of ROBOMINERS leverages modern technology in the best of ways. Not only will the autonomous, AI-driven robots provide the raw materials needed for critical industries, teams of mining robots will also meet those needs in ways that minimise impact on the natural environment.

PROJECT
ROBOMINERS - Resilient Bio-inspired Modular Robotic Miners

COORDINATED BY
The Technical University of Madrid in Spain

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.3.

CORDIS FACTSHEET
cordis.europa.eu/project/id/820971

PROJECT WEBSITE
robominers.eu/

A roadmap for sustainable extraction

A collection of guidance resources supports extraction industries to meet sustainability and production goals within the European political framework.

European nations agreed to the Green Deal to meet the challenges of the climate crisis. This vision for the future, which includes a commitment to no net emissions of greenhouse gases by 2050, will have a significant impact on mining. To help companies and other stakeholders prepare, the EU-funded SUMEX project gathered resources to support extraction industries as they evolve to meet new environmental and societal standards.

Sustainability framework

A major resource developed by SUMEX is the sustainability framework. This document provides guidance for how industries can achieve sustainability goals while operating within the political framework established by the Green Deal. To create this resource, the project solicited input from multiple stakeholders throughout Europe.

There are many guidelines related to sustainable extraction already in place, such as the EU principles for sustainable raw materials, but the SUMEX team envisioned a product that would go further. According to project coordinator Michael Tost: "We decided to take a future-oriented, roadmap-based approach and describe various sustainability conditions that have to be met as milestones on the way. Many of these conditions go well beyond what we currently see and therefore this framework should be used as a guide into the future."

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SUMEX repository

Another important resource developed by the team was the SUMEX repository. This is a digital platform that contains a variety of European best practices, handbooks and guidance documents. The repository is intended for industry players and government officials as well as the public, so that citizens can see what industry and policy initiatives are already in place for advancing sustainability goals.

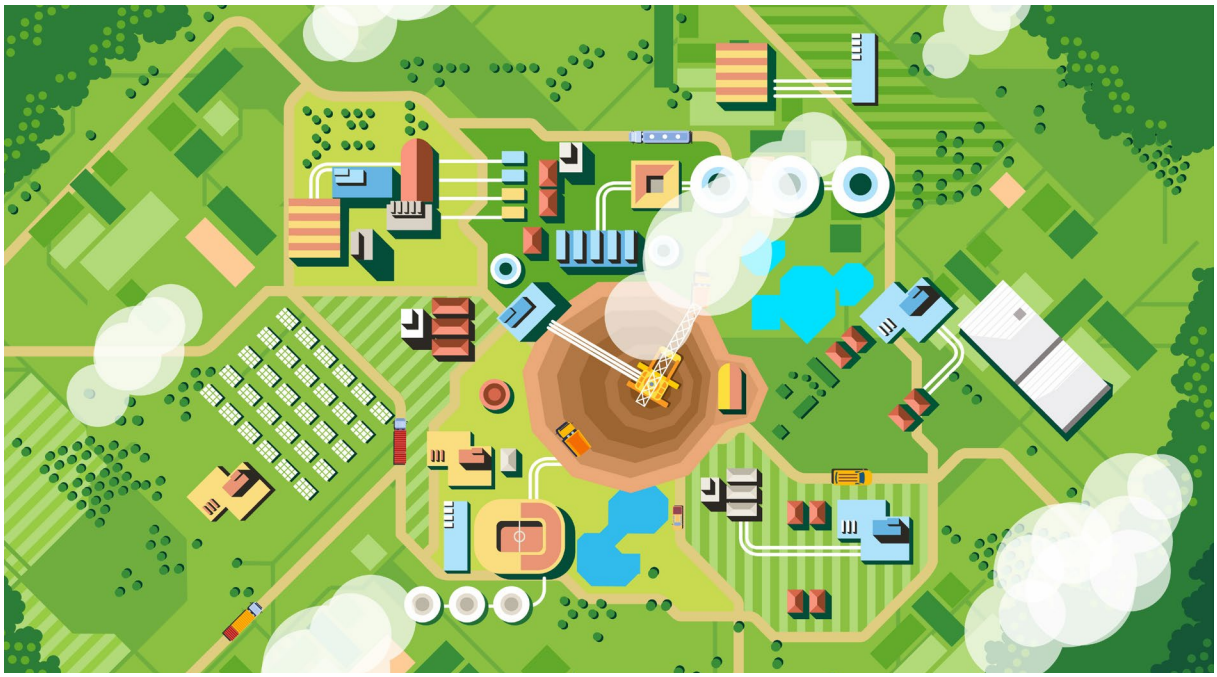
Resources are only helpful if they directly meet the needs of the intended constituencies. SUMEX partnered with industries in Sweden and Spain to incorporate two case studies into the project. The cases focused on two different uses of raw materials - batteries and construction. Feedback from various parties regarding the resources developed by SUMEX have been quite positive.

Rounding out the toolkit with MOOC

Dissemination of information and outreach are critical components of the project. A major goal of SUMEX was for the project to outlive its closing date. One way the project achieved capacity building was by using the sustainability framework and repository to develop a massive open online course MOOC. The second live run of the course occurred in August 2023.

The MOOC was not originally planned but became a viable alternative during the COVID-19 pandemic. According to Tost: "This worked out well for us, because in the first live run in November 2022, we were able to reach far more people, including from outside the European Union, than we had planned for originally."

European sustainability initiatives are ambitious and demanding. Nothing less will help curb climate change.



So that Green Deal initiatives translate into practice, extraction companies, policy makers, permitting authorities and ordinary citizens need access to information that explains what sustainability in mining looks like and how it can be achieved. SUMEX has done much to create and disseminate the necessary resources.

PROJECT
SUMEX - SUstainable Management in EXtractive industries

COORDINATED BY
Montanuniversität Leoben in Austria

FUNDED UNDER
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cordis@publications.europa.eu

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RESULTS PACK ON SUSTAINABLE PROCESSING OF MINERAL RESOURCES

Critical raw materials are of high importance to the EU economy, and there is high risk associated with their supply. This Results Pack showcases EU-funded projects spearheading research that will improve the processing of these raw materials and enhance its sustainability.

Check out the pack here:
cordis.europa.eu/article/id/436347

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