SkiComCu-Lifelong Learning Course for skills &competences in the copper sector

Project number:	23043
Project short title:	SkiComCu-LL
Project starting date:	01.09.2023
Project ending date:	31.08.2026
Project duration:	36 months

Report on the assessment & validation of needs for Cu-oriented education chain selected groups

Internal Identifier:	D.2.1
Description:	This is a report presenting the results and key conclusions with regards to the skills gaps observed in the Cu-sector of RIS territories. Skills gaps are presented in the form of sets of skills and social competences necessary for the Cu-sector. This deliverable highlights those that are necessary to raise the innovativeness of the sector in RIS territories and integrate the requirements of industries 4.0 & 5.0 as well as green transition and circular economy to the RIS territories' Cu-sector. The structure of the report corresponds to the successive stages of the research work. Each section ends with a brief summary. The research results are complemented by examples of good practices from outside the RIS countries.
Included in BP year:	2024
Date:	30/06/2024
Version No.:	v.1

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Executive Summary

The raw material mining and processing sectors (including copper) have been for many years struggling with facing a number of challenges, including the need to improve efficiency, reduce costs, decrease its impact on the natural environment, insufficiently qualified personnel and the lack of public acceptance. This report aims to assess the training needs of selected groups of employees in the Cu sector to ensure its competitiveness and to enable the sector to cope with these challenges.

A comprehensive approach was applied to both: 1) the copper sector (understood as three complementary areas of activity: exploration; extraction and processing; manufacturing and recycling) and 2) its human resources (categorising employees according to their roles and levels of responsibility: (senior) managers, engineers/ professionals (middle management) and operational staff/workers).

The methodological approach included a triangulation of the research methods used: 1) desk research of relevant documents (incl. internal documents and information provided by the industrial partners of SkiComCu project), 2) on-line survey (for key competence profiles selected by project partnership as strategic for the future of the sector) and 3) interviews with representatives of different groups of copper sector employees (FGI).

Observed changes in the competence requirements for workers in the copper industry are not only the result of the megatrends affecting the European labour market as a whole (technological progress, sustainable development, green and digital transition, demographic changes, globalization), but also a specific social perception of the copper sector as a 'dirty industry' responsible for significant environmental pollution – especially unattractive for young people. Extensive international studies have shown, that global trends, which are most likely to transform the mining and metals industry include broader application of Environmental, Social and Governance (ESG) standards, and investments that facilitate the green as well digital transition of businesses. The vision of the "mine of the future" is based among others on such assumptions like: remote control of mining activities; reducing the risk associated with the human-machine interface by implementing modern robotics and autonomous device solutions; virtual and augmented reality (VR, AR) applications. These IT solutions require new competences from employees. In terms of the expected professional (technical) skills, proper management of the production process and maintenance of equipment remain very important. These are to ensure work safety and production efficiency. Similar results were obtained during SkiComCu's online survey. On the other hand, both - the available publications and statements by stakeholders representing different groups of copper sector employees - pointed to the importance and growing role of soft (social) skills, like teamwork, interpersonal communication, people management as well as cognitive skills e.g. solving problems, creativity, critical thinking, flexibility, adaptability. Additionally, participants of the FGIs emphasized the need to build a common awareness of the copper life cycle (from its mining to manufacturing and recycling) and about the importance of the process in which they participate. Employees should have a global perspective of the structure of the copper supply chain.

Finally, the good practices section, which includes ideas on how to deal with the challenges faced by the copper sector (examples from non-RIS territories) adds practical insights to the report.

1. Objectives, and EIT Impact Framework and KIC Impact

Objectives

Objective	Description	Status
Objective of this deliverable is to present the key conclusions with regard to the skills gaps observed in the Cu-sector of RIS territories	The report presents the results of a study of skills gaps among employees in the copper sector. Three methods were used: desk research, online survey and focus group interviews. Skills gaps are presented in the form of sets of professional skills and social competences necessary for the Cu-sector. This deliverable highlights those that are necessary to raise the innovativeness of the sector in RIS territories and integrate the requirements of industries 4.0 & 5.0 as well as green transition and circular economy to the RIS territories' Cu-sector.	Achieved

In case of not achieved objectives, explain the reason.

EIT Impact Framework and KIC Impact

To address the shortages of human resources in Cu sector in EU, SkiComCu, in light of the EIT RM 2021-2027 programme, aims to develop a lifelong learning course for current and future professionals in the EIT RIS countries. The competency gaps for workers in the copper sector presented in this report, constitute the basis and starting point for mentioned learning course. The key aspect is to provide the necessary skills related to industry 4.0 & 5.0, green transition and circular economy that a) boost the responsible sourcing of critical and strategic raw materials in Europe thereby securing their supply (Lighthouse Responsible Sourcing) and b) advance innovation and education related to circular economy and closing materials' loops for the Cu-sector in the EU (Lighthouse Circular Societies), in parallel with facing technological, structural and human changes management.

Impact on EIT RM strategic objectives

1. The provision of upskilled and reskilled personnel through the training curriculum will allow for achieving greater efficiency in the functioning of the Cu-industry, thereby leading to higher production levels and less EU dependency on imported raw and advanced materials, thereby contributing to EIT SO1 – securing raw materials supply.
2. The provision of skills about state of the art technologies, industry 4.0 & 5.0, green transition & circular economy as well as the reorientation of training methodologies to satisfy the needs of and attract young people (with a special focus on encouraging the incorporation of women and vulnerable social groups) in the sector is expected to indirectly increase the social acceptance of the raw and advanced materials extraction and production, thereby contributing to EIT SO1 – securing raw materials supply and SO3 – closing materials loops.
3. The emphasis of the programme to the whole life cycle of the Copper production, from mining to manufacturing and recycling, as well as the continuous updates in the training programme to be achieved by WP2 will assist the EU Cu-sector to maintain the mining of copper and the design & production of advanced materials, components and products that enable the transition to a carbon neutral Europe, thereby contributing to EIT SO 2 - designing materials solutions.

Impact on EIT RIS KPIs:

The diagnosis of competence gaps presented in this report will indirectly (by ensuring an appropriate selection of training content and innovative educational tools that are in real demand among Cu sector employees) influence the achievement of core EIT RIS KPIs:

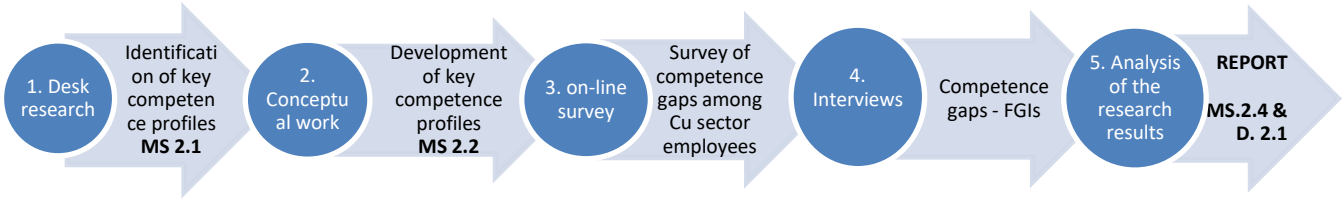
- EITHE2.4 by launching the innovative SkiComCu course.
- EITHE8.1 by providing the lifelong learning programme to the industrial partners' staff.

During the project, the consortium plans to receive EIT label and hence, EITH8.1 will be turned into EITHE07.1: "sum of graduates from EIT labelled master's, PhD programmes and other education activities awarded the EIT Label".

2. Introduction

This report is the result of work carried out as part of the SkiComCu project, Task 2.1, which aimed to assess the training needs of selected groups of employees in the Cu sector, in the context of building the potential of this sector, in particular in the countries covered by the RIS scheme, to ensure its competitiveness by, among others, integrating the requirements of industry 4.0 and 5.0, the requirements of green transformation and the circular economy.

The research work was divided into several phases, which are illustrated in the diagram below:



Research methods used:

- desk research,
- on-line survey,
- participatory assessment (focus group interviews).

Partners involved:

Industry partners	Academic and research partners
• KGHM Polska Miedź	• Łukasiewicz Research Network-Institute for Sustainable Technologies (Leader)
• Elval Halcor	• KGHM Cuprum
• Aurubis	• National Technical University of Athens
	• La Palma Research Centre

The following part of this report presents the results of the research works.

3. Skills gaps in the copper sector according to the desk research

3.1. Methodology

Objective: to identify occupations/skills/competences currently operating in the Cu sector and key competences for the future and competitiveness of this sector

Key areas of investigation

Competence requirements for current and future employees of the Cu sector, including:

- In which professions/profiles are employees employed in Cu companies (broadly defined groups of operational staff, technicians/engineers, designers, managers)?
- What positions they are employed in with descriptions of these positions (in terms of competence requirements, possibly required authorisations)?
- What competences should/must be demonstrated by Cu sector employees (in terms of learning outcomes: knowledge, skills, social competences/attitudes)?
- Education/training offer (formal and non-formal) currently dedicated to current and future Cu sector employees?
- Trends and directions of changes in the competence requirements for Cu sector employees, with particular reference to the requirements of Industry 4.0 and 5.0, Green Transformation, circular economy?
- Directions of investments in the development of competencies of Cu sector employees (i.e. what are the deficiencies in the competencies of the staff, which employees are the most difficult to acquire/retain in a Cu sector company)?
- Which competences of Cu sector employees are considered key/crucial for its future and competitiveness in the reality of the global economy?

Sources of investigation

Desk research covered an extensive literature review (scientific publications, industry reports) but also relevant institutional documents related to HR systems, provided by the industrial partners of SkiComCu project, including:

- (Internal) documents of Cu companies concerning the strategy of managing the competence profile of their employees, in particular job descriptions, competence requirements for specific groups of employees/positions, career paths, employee training programs (including learning outcomes) etc.;
- Reports, studies, industry, national and EU analyses on the current state and future of the sector (developed/published by enterprises, NGOs, industry associations, R&D sector, EU industry centres/observatories);
- Scientific publications on the above-mentioned topics;
- Sectoral Qualifications Frameworks for the raw materials sector (if any) or for related sectors;
- Others.

3.2. Findings

Present situation

Securing reliable and unhindered access to raw materials is important for the European Union, where there are at least 30 million jobs depending on their availability[1]. The copper sector, to which the SkiComCu project is dedicated, is an important subsector of the raw materials industry. Given the types of processes, it is most often understood comprehensively as a sector encompassing the following areas of activity (this is also the approach taken by the project SkiComCu):

- Copper exploration, including: collection, analysis, and integration of various thematic geoscience data obtained by surface and subsurface exploration methods and techniques; Geological modelling, target generation, and estimation of resources;
- Mineral extraction and processing, including: exploitation of copper deposits using mining techniques; Mineral processing, including comminution, concentration and methods of separating commercially valuable minerals from their ores;
- Materials engineering and waste recycling, including: methods and processes of copper extraction from mineral concentrates and solutions, mechanical and chemical recycling processes to recover copper and minerals from waste (see Fig. 1).

Figure 1. Raw Materials Value Chain
Source: EIT Raw Materials Strategic Agenda 2021-2027

[1] European Commission. Policy and strategy for raw materials: https://single-market-economy.ec.europa.eu/sectors/raw-materials/policy-and-strategy-raw-materials_en

The above-listed three areas of activity can be further divided into subareas and processes relating to the extraction and processing of raw materials, including copper:

Table 1. Raw materials extraction and processing - subareas and processes

Areas	Copper exploration	Copper extraction and processing	Materials engineering and recycling of waste containing copper
Subareas and processes	• Exploration logistics and planning • Surveying and mapping • Legal and regulatory requirements • Acquisition, processing, and analysis of digital terrain data in geological applications • Drilling and sampling techniques • Distribution of elements in rocks, soils, sediments, and other natural media in relation to mineralization • Geophysical methods applied to minerals' exploration • Resource and opportunity evaluation • Community relations	• Permits • Mine design and planning • Procurement • Mine development (including infrastructure and facilities) • Ore extraction and ore processing • Environmental assessment and management • Waste disposal and site restoration • Cost monitoring • HR management • Corporate social responsibility • Data management / digital technologies • Geotechnics • Mining technologies • Community relations	• Materials science (including ores and composite materials) • Metallography and crystallography • Extractive metallurgy • Metalworking • Collection, crushing, and shredding • Separation, melting, and purification • Cost monitoring • HR management • Corporate social responsibility

Source: Correia V. et al., 2019

Despite this distinction, these areas of activity are intertwined and have several common operations and procedures, which means that each of them employs specialists with similar expertise and skills.

Table 2. Examples of jobs in the Cu sector

Copper exploration	Copper extraction and processing	Materials engineering and recycling of waste containing copper
• driller • assistant driller • exploration coordinator • foreman/team leader	• driller • assistant driller/assistant land surveyor • labourer	• waste sorting plant worker • machine/equipment operator • steel mill operator

• laboratory technician • land surveyor • geophysicist • geologist • geotechnics engineer • geo-spatial analyst • mine engineer • operations planner • permit specialist/investment planning specialist • geological mapping and mineral deposit identification manager • project manager	• drill and hoist operator • blaster • assay lab technician • laboratory technician • foreman • welder • mechanic • miner (builder) • electrician • process operator • land surveyor • geologist • mine engineer • geotechnics engineer • metallurgy engineer • operations planner • health and safety manager • environmental coordinator • mine manager	• baler operator • loader operator • assistant machine operator • operations assistant • foreman • welder • mechanic • electrician • laboratory technician • metallurgy engineer • materials engineer • steelworks inspector • operations planner • environmental coordinator • health and safety manager • recycling centre manager

Source: Correia V. et al., 2019

Study conducted by Ernst and Young (2023) shows that HR specialists in the copper sector underline the importance of changing staff recruitment and retention strategies and focusing on upskilling and retraining of existing employees. This is supported also by forecasts by the World Economic Forum (WEF, 2023), indicating higher investment in developing professional competencies of existing employees and in retaining employees with special skills and qualifications, as talent availability when hiring will be much lower.

Different training and education requirements hinder sometimes the free flow of workers from one region or industry to another. This is driving countries to develop National Qualification Frameworks (NQFs) and attempt to relate them to international system – European Qualification Framework (EQF).

A qualifications framework is a formalized structure into which accredited qualifications are placed, allowing learners, training providers and employers to gain information about the broad equivalence of qualifications (UNESCO, 1984). Transparency and homogeneity about what people have learnt in order to obtain a qualification are crucial to ensuring that learners, training providers and employers give the appropriate economic, social and academic value to qualifications. Qualifications frameworks use learning outcomes, compared to learning level descriptors and qualifications. Learning level descriptors are statements that provide a broad indication of learning appropriate to attainment at a particular level, describing the characteristics and context of learning expected at that level (Vlasceanu at al. 2007).

There are different types of qualifications frameworks. The scope of frameworks may be comprehensive of all learning achievement and pathways or may be confined to a particular subsector of the education and training system – for example, initial education, adult education and training or an occupational area (European Training Foundation, 2011). Keevy et al. (2010) classify qualification frameworks accordingly to their scope and geographical coverage. In this approach, there are three main types of qualification frameworks:

- Sectoral qualifications frameworks, that are developed with a specific sectoral focus and that have a national focus (e.g. the Polish Sectoral Qualifications Framework for Mining Sector[2]) or international focus (International qualification framework for the raw materials sector SQF-RM [3]);
- National frameworks: those that have a national focus (e.g. 8 levels' NQF in Bulgaria, Poland, Greece, Portugal and Spain);
- Transnational frameworks: developed across a range of countries (e.g. the European Qualifications Framework).

The qualifications frameworks establish a basis for improving the quality, accessibility, linkages and employers' recognition of qualifications within a country and internationally. Work in this area is still ongoing. They require a compromise consisting in achieving an appropriate level of universality and durability (resilience) of the defined learning outcomes, and their usefulness e.g. in training design processes.

The above-mentioned examples of frameworks for sectors related to the copper sector will be taken into account in the further work of the SkiComCu Partnership, in particular during the development of competence framework for Responsible Sourcing, Sustainable Material and Circular Societies (Deliverable 2.2).

FROM THE EXPERIENCE OF INDUSTRY PARTNERS OF THE PROJECT

The SkiComCu project partnership comprises companies that are key to the European copper sector: ELVAL HALCOR (EL), Aurubis (BY) and KGHM Polska Miedź S.A (PL). They are leaders in copper ore mining, processing and recycling. Their copper divisions operate not only in Europe but all over the world.

Their HRD policies/ strategies, defined in internal documents, have several objectives, including: ensuring the safety of the workforce, increasing the efficiency of production processes, caring for the environment. The solutions implemented in companies (e.g. competence models, job descriptions, etc.) as well as their expectations from the SkiComCu project are briefly characterised below.

KGHM Polska Miedź S.A. is a key player in the copper ore mining and processing market, not only in Poland but also in Europe (headcount: 18,000 in KGHM Polaska Miedź and 34,000 in the entire KGHM Group). Training topics for KGHM employees are determined in a responsible manner, through the prism of the company's current and future business objectives. Trainings provided in the company are aimed at:

- Ensuring work safety and compliance with applicable regulations (e.g. occupational health and safety, or training and examinations giving entitlements to take up specific positions requiring specialist skills);
- Developing employees' competences necessary to perform their tasks (e.g. improving language, managerial or interpersonal competences);
- Building competences necessary for the development of career paths, e.g. influencing the structure of employees' education (co-financing of higher education and postgraduate studies).

[2] Sectoral Qualifications Framework for the Mining Sector (SQFM); https://kwalifikacje.edu.pl/sectoral-qualifications-framework-for-the-mining-sector-sqfm/?lang=en [accessed 16.05.2024]
[3] International Network of Raw Materials Training Centres (INTRMIN); Horizon 2020 research and innovation programme under grant agreement No 689527: https://interminproject.org/ [accessed 15.01.2024]

The topics of training provided to KGHM employees over the past three years included, but were not limited to, the following:

- First aid and mine rescue;
- OHS and fire safety;
- Use of hazardous materials and substances;
- Professional issues, such as cranes, F-gases;
- Construction-related issues;
- Exercise of supervision;
- Electrical energy;
- Copper extraction and processing
- Pedagogical credentials;
- Radiology;
- Welding;
- Belt and horizontal transport.

Competency model being developed, may be in the future one of the main HR policy tools used for selection and recruitment, periodic assessment of competences and development planning, talent management and career path planning. Its concept was based on the company's values and strategic goals. It is a reflection of the general requirements for employees and job candidates. It distinguishes two groups of skills:

1. General skills (concerning managers, blue- and white-collar workers):
   - Result/goal orientation (effective implementation of goals and objectives with optimal use of available resources, regardless of the difficulties encountered).
   - Relationship building and cooperation (maintaining good relationships, effective cooperation; knowledge and experience sharing).
   - Reliability and occupational health and safety (diligent, safe, and responsible performance of tasks assigned).
   - Engagement and initiative (commitment to tasks, recommending and effecting improvements in own area of operation; openness to changes).
   - Communication (ensuring undisturbed flow of information; clear presentation of own opinions; active listening and giving feedback).
2. Managerial skills (concerning managers only)
   - Leadership (being a leader, also in difficult situations; setting goals/courses of action and enforcing them; encouraging commitment and influencing).
   - Operational Management/Direction (ensuring the effective work of the team by planning, organising, delegating, as well as monitoring and accounting for the tasks performed; solving problems).
   - Decision making (making analysis-based and informed decisions; courage to make decisions and assume responsibility).
   - Team building (building an effective and committed team).

   For each skill, behavioural indicators, i.e. criteria for verifying possession of a given skill, were defined along with the desired degree of fulfilment of each criterion for different groups of employees. Six groups of employees were distinguished:
   - Top management (including chief executives of Divisions and at the Head Office, heads of departments, some chief engineers);
   - Senior management (including chief engineers, department heads, division heads, central project managers);

- Middle management (branch foremen, local project managers);
- Team managers (shift foremen, masters, senior masters);
- Experts;
- Blue- and white-collar workers.

The degree of criterion fulfilment is determined based on the developed five-point descriptive scale. The model supplements job descriptions, which present detailed qualification requirements for individual positions. KGHM has about 750 different jobs in the above-mentioned groups.

ELVAL HALCOR is a Greek entity affiliating leading metalworking companies throughout Europe. It is a leading global producer of copper tubes and aluminium rolled products. It employs approx. 2,500 people in the following main job groups:

- Department Directors / Managers;
- Production Managers (incl. Maintenance Managers);
- Industrial engineers;
- Foremen;
- Machine operators and technical workers.

These jobs are described according to a standardised structure (Tab.3).

Table 3. Structure of the job descriptions in Elval Halcor company

1 JOB DESCRIPTION	2 REQUIREMENTS, including:	3 SOFT SKILLS
• Who do they report to? • Who reports to them? • Accountability and responsibility • What the properly done job consists of (what does success look like?) • What are the objectives of their work?	• qualifications (certificates) • technical and special skills/expertise/experience • relations and contacts • professional development	• Are they needed? (yes/no) • If yes, what are they? • How important are they?

Table 4. Skills indicated by Elval Halcor as needed in the Cu sector

Soft Skills:
• Effective Communication (communicating clearly with all job level employees, avoiding misunderstandings and develop a suitable corporate profile); • Time Flexibility (the key here is to gain the right approach in order to prioritize tasks better in times of pressure so as to remain productive); • Managing Teams & Individuals (how to give feedback – positive or negative – in order to develop others, make a proper delegations, giving directions in a right way, how to inspire your team etc.); • Coaching (working with tools – questions, attitudes, changes- in order to demonstrate the attitudes of a proper manager); • Change & Adaptability (the cultivation of the appropriate methods so that the mandatory changes can pass in the groups without resistance);

• Negotiation Skills (negotiating tools in order to gain the daily negotiation task, not only with clients but with internal and external stakeholders).
Hard skills:
Casting
• Basic principles of physical metallurgy; • Metallurgy of non-ferrous metals (copper and copper alloys) + phase transformations; • Solidification process (casting); • Furnace technology (melting, casting, preheating, annealing etc.); • Casting and microstructure defects; • Effect of impurities on semi-finished (cast) and final products; • Mining and processing of copper ores; • Scrap management; • Recycling of copper (i.e. pyrometallurgical refining, melt treatment, thermomechanical processes); • Principles of production management.
Extrusion
• Extrusion of copper and copper alloys and technology in general; • Influence of Extrusion process parameters on microstructure and mechanical properties. Focus on copper mother tube seamless direct extrusion; • Mechanisms of oxides creation during Extrusion process. Copper extrusion common defects and factors affecting them; • Critical Copper Billet characteristics affecting extrusion; • Quenching effect on tube microstructure and material properties; • Extrusion tooling design and optimization. Tool materials for copper tube extrusion. Advancements in material selection, coatings and heat treatments; • Technology advancements and best practices on extrusion tool preheating/ cleaning/ lubricating/ handling; • Technology advancements and best practices on copper billet preheating/cleaning/descaling; • Monitoring of Extrusion Presses.
Pilgering
• Pilger technology and materials
Drawing
• Boundary conditions of drawing process (initial, fundamental conditions); • Design of dies and floating plugs (geometry and materials selection); • Lubrication/Lubricant properties. Effect of lubrication on the interface of copper tube/dies-floating plugs. Quantity, frequency of outer lubrication, timing, temperature of lubrication. Frictional properties. How to choose the lubricant, optimal life-time of lubricant; • Spinner Blocks: process specifics (drum coiling, eccentricity control); • Spinner Blocks: sequential reduction using two sets of dies and plugs; • Drawing/Pulling force calculation methods. Best approach for real life applications;

• Resistance to deformation of copper. Calculation methods and tools, dependencies; • Chattering effect of drawing (plug) tools. Factors and control / prevention mechanisms; • Drawing ratio and the effect on mechanical properties of copper (work hardening); • Optimal and economical design of drawing passes. Calculation models (in reference to drawing ratio and work hardening); • Effects of drawing velocity in general; • Development on cutting technologies (mitigation of process scrap and chip creation, deburring); • Advancements on eccentricity measurement systems. Best practices (in line – while working); • End of tube lip creation mitigation/control; • Optimum Sequence design of final customer tube (Cost&Quality); • Tube Straightening Process and Principles; • Eddy Current and Other NDT for Copper Tubes Production.
IGT Specific
• Design and selection of inner grooving tools; • Collaboration of mandrel, balls, ring and tube.
Annealing
• Effect of Annealing parameters on copper tube microstructure and material properties; • Sticking effect on copper products on annealing furnaces.
Metallurgy
• Metallurgy of non-ferrous metals (copper and copper alloys) + phase transformations; • Copper oxidation mechanisms.
Insulated Copper Tubes
• Thermoplastic materials handling; • Thermoplastic materials degradation mechanisms; • Thermoplastics extrusion mechanism, process, and principles; • Optimization methodology for thermoplastics extrusion with single screw extruder; • Quality management in thermoplastics extrusion; • Chemical foaming mechanism for thermoplastic extruded foams; • Physical foaming mechanism for thermoplastic extruded foams.

In the last 3 years, it was particularly difficult for the company to find candidates for the jobs of Electrical Engineers, Operators, and Technicians. Additionally, for Elval Halcor priority training topics are:

- Health and safety;
- Environment;
- Soft skills(particularly in more advanced jobs -managers, leaders);
- Issues concerning Industry 4.0 and Industry 5.0, green transformation and circular economy (they are new, not identified as the company's training needs so far).

GENERAL TRENDS OF CHANGE IN THE WORLD

According to the forecasts by the International Copper Association (ICA), copper is one of the raw materials for which demand continues to grow, also because of its application in energy generation, efficient buildings, and electrified transportation. Its physical and chemical properties make it a key material for many technologies enabling the transition to a climate-neutral economy: renewable energy generation, energy storage and efficient energy transfer, as well as electric cars or heat pumps. As an essential raw material for electronics, copper plays an important role in digital transformation.

Available reports, academic, industry studies indicate that the European labor market, including the mining and processing sector, is shaped by the interaction of four megatrends: technological progress, sustainable development, demographic change, globalization. But the more deep and specific studies run by experts of World Economic Forum have shown that **global trends** that are most likely to transform the mining and metals industry include (Fig. 2):

- broader application of Environmental, Social and Governance (ESG) standards;
- greater localization of supply chains (process of sourcing materials, components, and services from local suppliers to meet the needs of a company);
- climate-change induced investments into adapting operations;
- investments that facilitate the green transition of businesses.

As result, **technologies that will affect job creation** and displacement will be adopted. They are:

- climate-change mitigation technologies (Alternative Energy, Greenhouse gases);
- environmental management technologies (e.g. pollution abatement, recycling);
- big-data analytics (AI);
- power storage and generation;
- encryption and cybersecurity.

Figure 2. Trend outlook for mining and metals
Source: WEF, 2023, p. 221

What is important, however, is the purpose behind these changes. The most important changes in mining are improved safety, increased productivity, care for the environment and more efficient use of resources (Beloglazov, Petrov, & Bazhin, 2020). This is the aim of transformation 4.0. It is based on the consolidation of systems and the integration of people with digitally controlled machines that make extensive use of the wireless network, information and communication technologies. It means integrating devices with the virtual world. This gives full control over the production process to enterprises that use Industry 4.0 solutions (Dardzinska & Zdrodowska, 2020).

The most important technologies of the transformation process are automation and robotics, artificial intelligence, the internet of things, drones, digital twins, virtual reality and the use of excavations for energy storage (Wachnik, 2022; Pałaka et al., 2020). This is reflected also in the vision for the "mine of the future" based on the following assumptions (Weber-Youngman, 2017):

- Remote control of most mining activities;
- Reducing the risk associated with the human-machine interface by implementing modern robotics and autonomous device solutions;
- Virtual and augmented reality (VR, AR) applications;
- Real-time monitoring and analysis of mine production through scanning, monitoring, and real-time decision-making based on incoming data.
- Planning and optimization of the mine project in real-time (digital twin concept).
- The holography of the mine design.

The presented above "picture" are based on IT solutions, which are changing the demand for new miners' competencies. A miner of the future working in mine 4.0 have to have different competencies and skills compared to the current competencies of a miner. The competencies of the new Miner-Operator 4.0 will be directly related to automatization, digitization and interoperability (Lööw et al., 2019; Mackenzie, 2020; Ulewicz, 2022).

However, the raw material mining and processing sectors (including copper) in many countries have for many years been struggling with a problem of insufficiently qualified personnel (Ernst & Young, 2023). In an increasingly competitive labour market, the sector's poor brand, ('dirty industry' responsible for significant environmental pollution), discourages workers, especially younger ones, who are far more attracted to energy transition-related undertakings. This results in serious demographic challenges for the sector.

Changing skills landscape

Global digitalisation and robotisation processes and their impact on competence requirements in the raw materials sector have been analysed for the Australian Minerals Council (EY, 2019). According to the published report, these studies have shown among others, that robotics and automation through drones, autonomous vehicles and remote-controlled operational systems will be rolled out more widely to enhance exploration efforts and mining operations. These innovations are predicted to redesign traditional occupations such as drill operators, surveyors and field geologists, and increase demand for remote vehicle operators and geologists, to name a few, with greater skills in contemporary data and digital technologies. There will be increasing demand for Data and Digital literacy skills across all phases of the mining value chain that will redesign most occupations as the human-to-machine interface evolves and becomes more prevalent. These

skills can be expected to increase in demand into the future and play an important role in enhancing decision-making and work optimisation processes.

Cloud computing, information sharing and big data continue to change the nature of work and enable integrated operating centres so more work can be performed remotely and more flexibly. This trend will accelerate within the sector and increasingly take employees away from hazardous on-site events to an improved work health and safety rating and enhanced workplace conditions.

All industry skill types are observed as increasing in demand, with some skills in the technical skill type category representing decreasing/slow growth in demand.

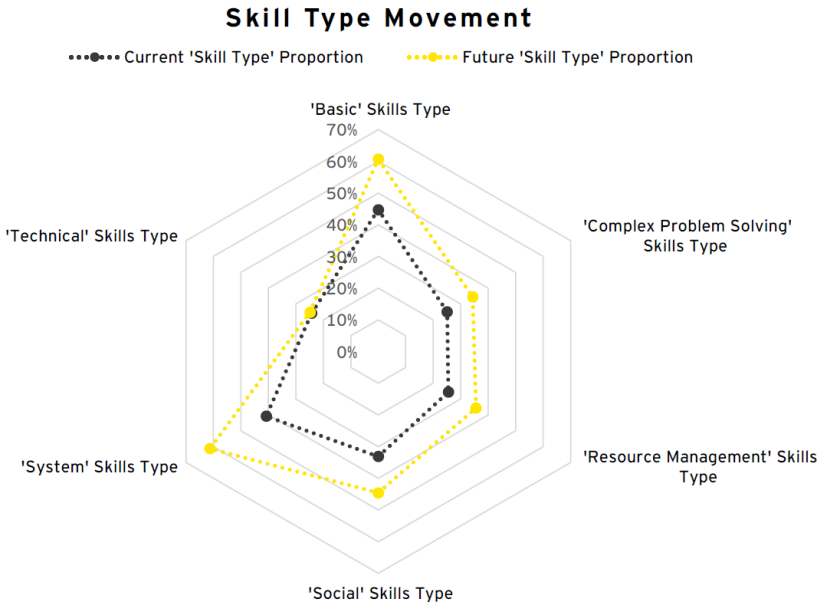


Figure 3. Skill type movement in the sector
Source: EY, 2019. p.14

The analysis identified the following future skills as increasingly important for occupations in the sector, and also most resistant to the impact of technology:

A) Future focused skills:	B) Industry focused skills:
• Change Management • Collaboration • Complex Stakeholder Engagement • Creativity • Data Analysis • Data and Digital Literacy • Design Thinking • Stakeholder Analysis • Strategic Planning	• Blast hole drilling • Configuration and maintenance • Geospatial analytics • Governance and risk management • Load Handling • Materials extraction • Vehicle operations • Work Health and Safety

In the context of constant change, it is important that organisations in the sector look at workforces as an asset to grow, rather than a fluctuating resource, expendable in response to volatile changes in external environments. Focus and consideration of an organisation's people operating model across the following five domains will better position firms to take advantage of the benefits technology offers, and strategically respond to the future of work:

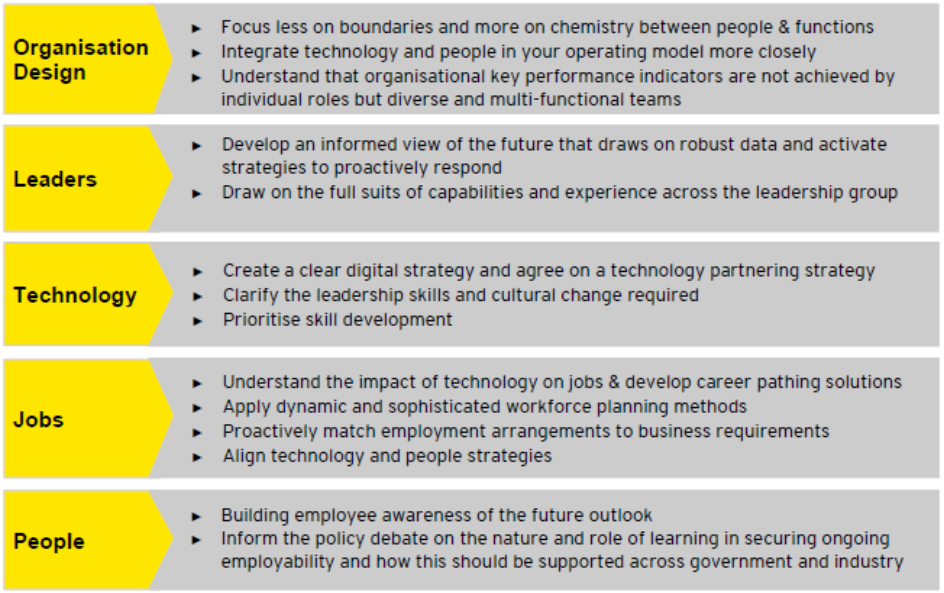


Figure 4. People operating model.
Source: EY, 2019, p.20

Competencies of the future - key skills (different approaches)

A study commissioned by the Polish Development Fund and Google (Włoch, Śledziewska, 2020) shows that in the era of digitization and automation, competencies that differentiate work done by humans from that carried out with the use of or by information systems, robots or artificial intelligence are becoming crucial, because in these areas, humans will still be difficult to replace. These competencies are considered competencies of the future. They are specific skills necessary to perform tasks in a work environment that is fundamentally flexible, geographically dispersed, prone to frequent and rapid change, assumes the need to use digital technologies and cooperate with automated systems and machines using artificial intelligence. They include cognitive, social, digital, and technical skills (Fig.5).

Figure 5. Competencies of the future broken down into three skill groups
Source: Włoch R., Śledziewska K.,2020, p.11

McKinsey Global Institute (MGI) analysts assigned skills that are increasingly important in the labour market to the similar three groups:

1) Technological and digital skills:
- advanced (understanding of advanced technologies and ability to innovate, develop, and adapt them) – through 2030, time spent using advanced technological skills will increase by over 40% in Europe. People with these skills will inevitably be a minority and demand for advanced IT and programming skills will grow as much as 90%;
- basic (ability to use digital technologies in everyday work, particularly in decision-making and information processing) – by 2030, demand for these skills will increase by 65%.

2) Social skills: demand for social and emotional skills will grow across all industries by 22% in Europe. The rise in demand for entrepreneurship and initiative taking will be the fastest growing in this category, with a 32% rise in Europe.

3) Higher cognitive skills: demand for higher cognitive skills, such as creativity, critical thinking, decision making, and complex information processing, will grow through 2030, by 14% in Europe. At the same time, basic data-input and -processing skills will be particularly affected by automation, falling by 23% in Europe.

Additionally, they also point out that in the era of rapid economic transformation (automation, digitization), it is worth associating competencies with the development of certain attitudes, ways of thinking, learning and acting, rather than with specific learned skills only, which in the face of the aforementioned changes will be constantly changing (MGI, 2018). According to the WEF report (2023), analytical thinking and creative thinking remain the most important skills for workers (generally) (Fig.6).

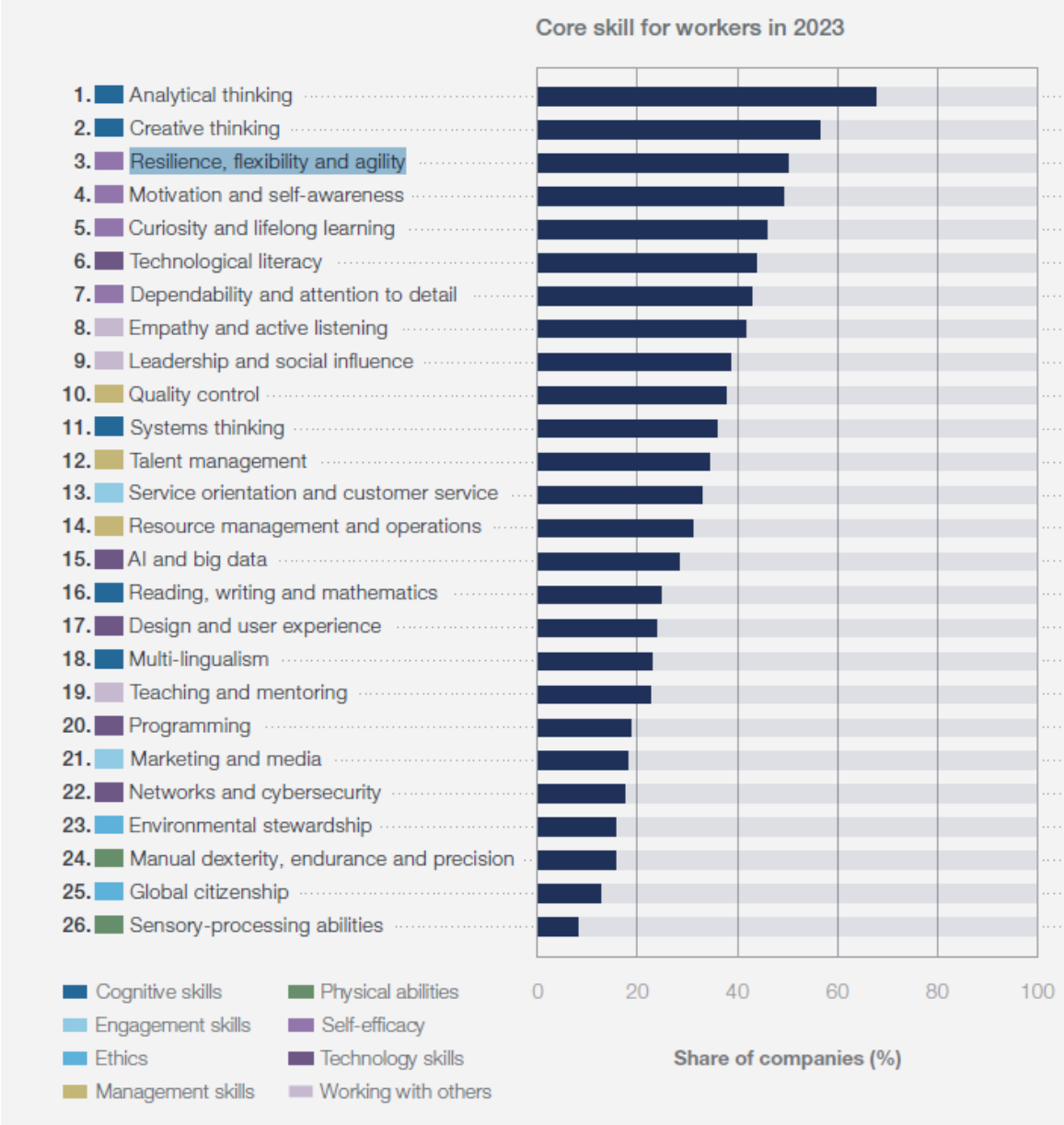


Figure 6. Core skills for workers in 2023
Source: WEF,2023, p. 38

They are also among skills most prioritized for reskilling and upskilling in the next five years for mining and metals sector (Tab.5).

Table 5. Skills crucial for business transformation in the mining and metals sector

Core skills needed to perform well in key, stable roles (%)	Skills most prioritized for reskilling and upskilling in the next five years (%)

• Cognitive skills (22%) • Engagement skills (6%) • Management skills (17%) • Physical abilities (4%) • Technology skills (12%) • Ethics (3%) • Self-efficacy (22%) • Working with others (15%)	• Analytical thinking (54%) • Leadership and social influence (46%) • AI and big data (31%) Creative thinking (31%) • Environmental stewardship (31%) • Motivation and self-awareness (31%) • Resilience, flexibility and agility understood as the power of moving quickly and easily (31%) • Resource management and operations (31%) • Talent management (31%) • Technological literacy (31%)

Source: based on WEF,2023

3.3. Conclusions

Analysing the collected source materials and the selected data quoted above, it is possible to indicate some of the most important observations and conclusions:

1. Megatrends shaping labour market (incl. Cu sector) are: technological progress, sustainable development, demographic change.
2. Global trends that are most likely to transform the mining and metal industry are following:
   - broader application of Environmental, Social and Governance (ESG) standards;
   - greater localization of supply chains;
   - climate-change induced investments into adapting operations;
   - investments that facilitate the green transition of businesses.
3. In terms of technological changes that affect the competence requirements of current and future employees in the copper sector, these will be related to automation and digitalisation processes, including:
   - Remote control of most activities;
   - Reducing the risk associated with the human-machine interface by implementing modern robotics and autonomous device solutions;
   - Virtual and augmented reality (VR, AR) applications;
   - Real-time monitoring and analysis of production through scanning, monitoring, and real-time decision-making based on incoming data.
4. Skills that are increasingly important for the future of employees, who have to adapt to the changing situation in companies undergoing dynamic processes of transformation can be grouped into the following three categories:
   - Technological and digital skills (understanding of advanced technologies and ability to innovate, develop, and adapt them);
   - Social skills (e.g. entrepreneurship, initiative taking, cooperation with others);

- Higher cognitive skills (e.g. creativity, critical thinking, decision making, complex information processing, solving complex problems).

5. Core competences for the copper sector (connecting skills specific for the raw materials sector with professional and personal skills) should include:
   - The ability to communicate clearly verbally and in writing;
   - Mathematical, scientific, and technological skills;
   - General understanding of sustainability as well as energy and materials efficiency;
   - General understanding of the raw materials (copper) value chain;
   - Knowledge and understanding of geological processes;
   - Digital skills;
   - Knowledge of and commitment to safe working practices.

6. Among the skills crucial for business transformation in the mining and metals sector, following are indicated as needed for reskilling and upskilling in the next five years:
   - Analytical thinking
   - Leadership and social influence
   - Creative thinking
   - AI and big data
   - Environmental stewardship
   - Motivation and self-awareness
   - Resilience, flexibility and agility understood as the power of moving quickly and easily
   - Resource management and operations
   - Talent management
   - Technological literacy.

3.4. Knowledge & Skills catalogue

Taking into account all the data and information obtained through desk research, as well as its own experience, the Project Partnership proposes a catalogue of skills which are currently needed by employees in the copper sector in various job positions. They allow employees to carry out their professional tasks efficiently and to ensure adaptation in the conditions of digital and environmental transformation.

Table 6. Knowledge & Skills catalogue (Milestone 2.1)

Core business area I: *Mineral (copper) exploration*	
GENERAL	OCCUPATIONAL
Knowledge (knows and understands): 1. The structure and principles of operation of raw materials extraction and processing companies and the interdependencies of tasks carried out at their different business units; 2. The principles of corporate social responsibility and code of conduct; 3. What Industry 4.0 is and is familiar with the general assumptions, opportunities, and threats of digital transformation; 4. What Industry 5.0 (i.e. sustainable industry) and circular economy are; 5. Basic occupational health and fire safety regulations in place and in use at mineral extraction and processing companies; 6. The principles of teamwork; 7. The principles of effective communication; 8. The principles of negotiation;	**Knowledge (knows and understands):** 1. Elementary geometry, algebra, and trigonometry; 2. The principles of mapping and navigation as well as the principles of use of global positioning systems and equipment; 3. Geology and the principles and requirements of and guidelines for geological work – including geological processes, mechanisms, cross sections, and maps as well as mineral (particularly copper) exploration methods and factors affecting the effectiveness of mineral exploration programmes; 4. The applicable regulations and standards concerning mineral (particularly copper ore) exploration; 5. The opportunities offered or threats posed by the use of smart technologies in mineral (including copper) exploration, e.g. AI, integration of machines and production processes using digital technologies (Internet of Things), clouds and real-time analytics big data analysis; 6. The opportunities offered or threats posed by the application of the principles of Industry 5.0 (i.e. sustainable, environmentally friendly, human-centric, and crisis-resistant industry) in mineral (including copper) exploration; 7. Good environmental and social practices concerning mineral exploration activities; 8. The interdependencies of value chains based on mineral raw materials, including copper as well as the basics of sustainable development and circular economy;

	9. The principles of investment projects concerning copper ore exploration; 10. The principles of site and property management, and the corresponding environmental and social obligations; 11. The occupational health and fire safety regulations in place and in use at mineral (including copper) exploration companies;
Skills (is able to): 1. Build relationships and work in a team; 2. Communicate clearly and successfully with different target (end user) groups and provide them with feedback; 3. Work under pressure; 4. Manage own work and the work of teams, which includes planning and delegating tasks and enforcing their proper and timely completion; 5. Conduct negotiations (with internal and external stakeholders); 6. Solve problems affecting the scope, quality or timeliness of mineral exploration activities, using the achievements of digital transformation, i.e. smart technologies; 7. Use technical documentation (incl. digital); 8. Use IT equipment and software to organise and report activities in a safe manner (including cybersecurity); 9. Improve his/her/their work performance by analysing errors and irregularities (ability to plan and optimize work);	Skills (is able to): 1. Use geoscience information to generate predictive models; 2. Perform tasks following the standard procedures of mineral (including copper) exploration methods and using smart technologies, e.g. AI, integration of machines and production processes using digital technologies (Internet of Things), clouds, and real-time analytics; 3. Design mineral (including copper) exploration programmes, using different methods and technologies, sticking to the budget, keeping in mind client's goals and requirements, and complying with good practices, standards, and legal requirements; 4. Develop and update technical and financial plans of mineral (particularly copper) exploration activities, using IT equipment and software in a safe manner (including cybersecurity); 5. Prepare reports on mineral (including copper) exploration programmes in a manner consistent with applicable reporting regulations and standards; 6. Cooperate with subcontractors, coordinate, monitor, and validate their work and, where necessary, identify and choose new subcontractors; 7. Implement and develop initiatives to save energy and water, curb emissions of greenhouse gases, and manage waste in accordance with good practices and principles of circular economy applicable to mineral (copper) exploration;

10. Apply the principles of corporate social responsibility and business code, including the principles of sustainable industry and circular economy; 11. Speak English.	8. Implement and develop solutions intended to minimise businesses' negative environmental impact by counteracting the depletion and degradation of natural resources; 9. Win and manage orders; 10. Manage, control, and assesses mineral (including copper) exploration activities; 11. Properly assess opportunities and counteract threats in the implementation of mineral (particularly copper) exploration programmes; 12. Follow the occupational health and fire safety regulations in place and in use at mineral (including copper) exploration companies; 13. Use business English.

Social competence (is ready to):

- Make decisions relating to the tasks assigned;
- Assume responsibility for the tasks assigned and the decisions made;
- Motivate co-workers and subordinates, including to effectively achieve goals, to comply with regulations, best practices, and codes of conduct;
- Establish and maintain good interpersonal relations with different stakeholders (local communities, direct reports, customers, and subcontractors) by building trust, showing respect, and improving communication;
- Perform tasks in a responsive, accurate, and timely manner;
- Undertake initiatives to improve and increase the effectiveness of the tasks carried out;
- Change and adapt to new conditions;
- Share his/her/their expertise with colleagues, direct reports, and subcontractors;
- Improve his/her/their professional qualifications by participating in different forms of formal and informal education and training.

Core business area II: *Mining and processing*	
GENERAL	OCCUPATIONAL
Knowledge (knows and understands): 1. The structure and principles of operation of raw materials extraction and processing companies and the interdependencies of tasks carried out at their different business units; 2. The principles of corporate social responsibility and code of conduct; 3. What Industry 4.0 is and is familiar with the general assumptions, opportunities, and threats of digital transformation; 4. What Industry 5.0 (i.e. sustainable industry) and circular economy are; 5. Basic occupational health and fire safety regulations in place and in use at mineral extraction and processing companies; 6. The principles of teamwork; 7. The principles of effective communication; 8. The principles of negotiation;	Knowledge (knows and understands): 1. Elementary geometry, algebra, and trigonometry; 2. Elementary physics and chemistry; 3. Elementary geology, including geological processes and mechanisms involved; 4. Material properties (materials science including endurance, mechanical properties, thermal properties, physical properties and characteristics, crystalline structure, metallurgy , metallography); 5. Industrial manufacturing processes and material processing methods/techniques (alloy production, shaping, heat treatment, and surface treatment); 6. The copper ore extraction cycle, the methods and techniques used in mineral extraction and/or processing, and the factors affecting the effectiveness of these processes; 7. The applicable regulations, standards, and requirements concerning mineral (particularly copper) extraction and processing and the methods and technologies used; 8. The opportunities offered or threats posed by the use of smart technologies in mineral (including copper) extraction and processing, e.g. AI, integration of machines and production processes using digital technologies (Internet of Things), clouds, and real-time analytics; 9. The opportunities offered or threats posed by the application of the principles of Industry 5.0 (i.e. sustainable, environmentally friendly, human-centric, and crisis-resistant industry) in mineral (including copper) extraction and processing; 10. The interdependencies of value chains based on mineral raw materials, including copper; 11. The raw materials value chain and the core principles of sustainability and circular economy;

	12. Good environmental and social practices concerning mineral (including copper) extraction and/or processing activities; 13. The principles of site and property management applicable to mineral extraction contracts (including corresponding environmental and social obligations); 14. The occupational health and fire safety regulations in place and in use at mineral (including copper) extraction and/or companies, including mine/plant rescue operations.
Skills (is able to): 1. Build relationships and work in a team; 2. Communicate clearly and successfully with different target (end user) groups and provide them with feedback; 3. Work under pressure; 4. Manage own work and the work of teams, which includes planning and delegating tasks and enforcing their proper and timely completion; 5. Conduct negotiations (with internal and external stakeholders); 6. Solve problems affecting the scope, quality or timeliness of mineral extraction and/or processing tasks, using the achievements of digital transformation, i.e. smart technologies; 7. Use technical documentation (including digital); 8. Use IT equipment and software to organise and report activities in a safe manner (including cybersecurity); 9. Improve his/her/their work performance by analysing errors and irregularities (ability to plan and optimize work);	Skills (is able to): 1. Use geoscience information to generate predictive models; 2. Perform tasks following the standard procedures of mineral (including copper) extraction and processing methods and using smart technologies, e.g. AI, integration of machines and production processes using digital technologies (Internet of Things), clouds, and real-time analytics; 3. Design mineral (including copper) extraction and/or processing programmes, sticking to the budget, keeping in mind client's goals and requirements, and complying with good practices, standards, and legal requirements; 4. Develop proper materials and tools and use them in mineral (including copper) extraction and processing; 5. Use IT equipment and mineral extraction and/or processing documentation software as well as innovative solutions (clouds, real-time analytics, etc.); 6. Develop and update technical and financial plans of mineral (particularly copper) extraction and processing activities, using IT equipment and software in a safe manner (including cybersecurity); 7. Implement and develop initiatives to save energy and water, curb emissions of greenhouse gases, and manage waste in accordance with good practices and principles of circular economy applicable to copper ore extraction and processing;

10. Apply the principles of corporate social responsibility and business code, including the principles of sustainable industry and circular economy; 11. Speak English.	8. Implement and develop solutions intended to minimise businesses' negative environmental impact by counteracting the depletion and degradation of natural resources; 9. Cooperate with subcontractors, coordinate, monitor, and validate their work and, where necessary, identify and choose new subcontractors; 10. Win and manage orders; 11. Manage, control, and assesses mineral (including copper) extraction and/or processing activities; 12. Properly assess opportunities and counteract threats in the implementation of mineral (particularly copper) extraction and/or processing programmes; 13. Follow the occupational health and fire safety regulations in place and in use at mineral (including copper) extraction and processing companies; 14. Use business English.

Social competence (is ready to):

- Make decisions relating to the tasks assigned;
- Assume responsibility for the tasks assigned and the decisions made;
- Motivate co-workers and subordinates, including to effectively achieve goals, to comply with regulations, best practices, and codes of conduct;
- Establish and maintain good interpersonal relations with different stakeholders (local communities, direct reports, customers, and subcontractors) by building trust, showing respect, and improving communication;
- Perform tasks in a responsive, accurate, and timely manner;
- Undertake initiatives to improve and increase the effectiveness of the tasks carried out;
- Change and adapt to new conditions;
- Share his/her/their expertise with colleagues, direct reports, and subcontractors;
- Improve his/her/their professional qualifications by participating in different forms of formal and informal education and training.

Core business area III: *Cu materials engineering and recycling*	
GENERAL	OCCUPATIONAL
Knowledge (knows and understands): 1. The structure and principles of operation of raw materials extraction and processing companies and the interdependencies of tasks carried out at their different business units; 2. The principles of corporate social responsibility and code of conduct; 3. What Industry 4.0 is and is familiar with the general assumptions, opportunities, and threats of digital transformation; 4. What Industry 5.0 (i.e. sustainable industry) and circular economy are; 5. Basic occupational health and fire safety regulation in place and in use at mineral extraction and processing companies; 6. The principles of teamwork; 7. The principles of effective communication; 8. The principles of negotiation;	**Knowledge (knows and understands):** 1. Elementary arithmetic, geometry, algebra, and trigonometry;. 2. Elementary physics and chemistry; 3. Material properties (materials science including endurance, mechanical properties, thermal properties, physical properties and characteristics, crystalline structure, metallurgy , metallography); 4. Industrial manufacturing processes and material processing methods/techniques (alloy production, shaping, heat treatment, and surface treatment); 5. The physical and chemical processes and mechanisms involved in copper production and/or recycling; 6. The methods and techniques used in metal (including copper) production and recycling as well as the factors affecting the effectiveness of these processes; 7. The applicable regulations and standards concerning the methods and techniques of metal (including copper) production and recycling; 8. The opportunities offered or threats posed by the use of smart technologies in materials engineering and metal (including copper) recycling processes, e.g. AI, integration of machines and production processes using digital technologies (Internet of Things), clouds, and real-time analytics; 9. The opportunities offered or threats posed by the application of the principles of Industry 5.0 (i.e. sustainable, environmentally friendly, human-centric, and crisis-resistant industry) in metal (including copper) production and recycling; 10. The interdependencies of value chains based on mineral raw materials, including copper;

	11. The raw materials value chain and the core principles of sustainability and circular economy; 12. Good environmental and social practices concerning metal (particularly copper) production and/or recycling activities; 13. The regulations applicable to metal (particularly copper) production and/or recycling activities; 14. The principles of site and property management applicable to metal production and/or recycling, and the corresponding environmental and social obligations; 15. The occupational health and fire safety regulations in place and in use at metal (including copper) production and recycling companies.
Skills (is able to): 1. Build relationships and work in a team; 2. Communicate clearly and successfully with different target (end user) groups and provide them with feedback; 3. Work under pressure; 4. Manage own work and the work of teams, which includes planning and delegating tasks and enforcing their proper and timely completion; 5. Conduct negotiations (with internal and external stakeholders); 6. Solve problems affecting the scope, quality or timeliness of tasks concerning materials engineering and recycling of waste containing copper, using the achievements of digital transformation, i.e. smart technologies; 7. Use technical documentation (including digital);	Skills (is able to): 1. Plan and conduct metal production and/or recycling operations in accordance with good practices, standards, and legal requirements and using smart technologies, e.g. AI, integration of machines and production processes using digital technologies (Internet of Things), clouds and real-time analytics, Big Data analysis; 2. Combine different metal (including copper) production and/or recycling methods and techniques, sticking to the budget and keeping in mind client's goals and requirements; 3. Perform the metal (including copper) production and recycling tasks effectively, promptly, and in compliance with applicable regulations; 4. Develop proper materials and tools and use them in metal (including copper) production and/or recycling; 5. Develop and update technical and financial plans of metal production and/or recycling activities in accordance with applicable regulations and using IT equipment and documentation software in a safe manner (including cybersecurity); 6. Prepare reports on mineral (including copper) exploration programmes in a manner consistent with applicable reporting regulations and standards;

8. Use IT equipment and software to organise and report activities in a safe manner (including cybersecurity); 9. Improve his/her/their work performance by analysing errors and irregularities (ability to plan and optimize work); 10. Apply the principles of corporate social responsibility and business code, including the principles of sustainable industry and circular economy; 11. Speak English.	7. Implement and develop initiatives to save energy and water, curb emissions of greenhouse gases, and manage waste in accordance with good practices and principles of circular economy applicable to metal (including copper) production and/or recycling; 8. Implement and develop solutions intended to minimise businesses' negative environmental impact by counteracting the depletion and degradation of natural resources; 9. Cooperate with subcontractors, coordinate, monitor, and validate their work and, where necessary, identify and choose new subcontractors; 10. Win and manage orders; 11. Manage, control, and assesses metal (including copper) production and/or recycling activities; 12. Properly assess opportunities and counteract threats in the implementation of metal (particularly copper) production and/or recycling programmes; 13. Follow the occupational health and fire safety regulations in place and in use at metal (including copper) production and recycling companies; 14. Use business English.

Social competence (is ready to):

- Make decisions relating to the tasks assigned;
- Assume responsibility for the tasks assigned and the decisions made;
- Motivate co-workers and subordinates, including to effectively achieve goals, to comply with regulations, best practices, and codes of conduct;
- Establish and maintain good interpersonal relations with different stakeholders (local communities, direct reports, customers, and subcontractors) by building trust, showing respect, and improving communication;
- Perform tasks in a responsive, accurate, and timely manner;
- Undertake initiatives to improve and increase the effectiveness of the tasks carried out;

- Change and adapt to new conditions;
- Share his/her/their expertise with colleagues, direct reports, and subcontractors;
- Improve his/her/their professional qualifications by participating in different forms of formal and informal education and training.

Source: own elaboration

4. Skills gaps in the copper sector according to on-line survey

4.1. Methodology

Assumption: due to the complexity of the copper sector (diversity of areas of activity and thus the wide range of competencies needed by employees to properly perform their professional tasks and to ensure development and competitiveness), it was assumed that research and development work will cover chosen professions and competencies operating in the copper ore mining and processing sector.

Objective: to identify competence gaps among employees in the Cu sector in relation to the key competence profiles, which have been recognized in the SkiComCu partnership as strategic/key for the development of the Cu sector.

Workflow

STEP 1 – Development of descriptions of key competence profiles for the sector

On the basis of the results of the desk research study, the analysis of the collected source materials, and methodological experience of the project team, six competence profiles were chosen as the strategic/key for the development of the sector:

1. Miner Self-propelled Mining Machine Operator (EQF level 3);
2. Solid Mineral (copper ore) Processing Technician (EQF level 4 & 5);
3. Mining Engineer Supervisor / Chief foreman (EQF level 6 & 7);
4. Mining Geologist (EQF level 6 & 7);
5. Metallurgical Engineer – Non-Ferrous Metallurgy (EQF level 6 & 7);
6. Copper Recycling Process Engineer (EQF level 6 & 7).

The selection of profiles is guided by specific criteria, allowing us to seamlessly align with both the requisites outlined in the application form and the expectations set forth by the SkiComCu partnership, serving as a representative perspective of the copper sector.

The reasoning behind opting for these particular professions (areas of competence) is underpinned by several compelling arguments:

1. European Qualifications Framework baseline:

Our selection is attuned to the diverse levels (3-7) within the European Qualifications Framework, ensuring a diverse approach that accommodates varied skill sets.

2. Alignment with employee groups:

Taking into account the categorization of groups of employees in the copper sector, it includes 3 groups of employees (also articulated in the application form): a) Foremen & Operational Staff, b) Professionals and c) Managers and Senior Professionals, matching our choices to their unique needs.

3. Holistic approach to the copper sector:

The chosen professions are informed by a comprehensive understanding of the copper sector, as envisioned in the SkiComCu project concept. This understanding is structured around the three pivotal areas of activity in the sector: Mineral Exploration; Mining and Processing; Materials Engineering and Recycling.

4. Adaptation to SkiComCu Industrial Partners:

Our selection takes into consideration the diverse business profiles of SkiComCu industrial partners, ensuring that the chosen professions are well-aligned with the specific needs and expertise of our collaborative partners.

5. Leveraging experience:

Our rationale is based on a strategic, comprehensive and forward-looking approach, meticulously designed to meet the multi-faceted demands of the SkiComCu partnership and the dynamic landscape of the copper sector. The selection is influenced by our experiences and positive outcomes from previously carried out projects focused on the raw materials sector. Furthermore, lessons learned from initiatives aimed at developing human resources for the current needs of the economy enhance the strength of our chosen professions.

The descriptions of chosen profiles have been developed according to an agreed structure. Learning outcomes have been arranged in the configuration: skills and social competence.

Descriptions of competence profiles can be found in Annex No 1.

STEP 2 – Identification of competence gaps (ON LINE SURVEY)

Method: Survey using the on-line questionnaire

Tools: On-line survey questionnaires

For each of the six above-mentioned key professions for the copper industry, a questionnaire has been developed available online at the link or using a QR code :

Miner Self-Propelled Mining Machine Operator
Link to survey in English:
https://forms.office.com/e/1FF8chyYB0

Solid Mineral Processing Technician
Link to survey in English:
https://forms.office.com/e/W7q7UgMRM8

Mining Engineer Supervisor/Chief foreman
Link to survey in English:
https://forms.office.com/e/40fzsYWcdG

Mining Geologist
Link to survey in English:
https://forms.office.com/e/NCxDTgK2Fm

Metallurgical Engineer - Non-Ferrous Metals Metallurgy
Link to survey in English:
https://forms.office.com/e/Cpaz4bT9A3

Copper Recycling Process Engineer
Link to survey in English:
https://forms.office.com/e/xBqymw90p8

Survey area: Copper ore mining and processing companies operating in the RIS countries.

Target group: employees of the copper sector (at various levels), performing the above-mentioned professions or their superiors. All together 250 respondents took part in online survey.

4.2. Findings

The respondent, who is an employee of the surveyed profession, was asked to assign the level of individual professional and social skills characterizing this profession, observed in the respondent's opinion in himself and in his co-workers.

The respondent, who is the supervisor of employees performing the surveyed profession, was asked to express a similar opinion in relation to the employees he manages.

In the survey, respondents rated individual skills on a 5-point Likert scale, with weights assigned accordingly:

- Very low (weight = 1)
- Low (weight = 2)
- Satisfactory (weight = 3)
- High (weight = 4)
- Very high(weight = 5)
- Not applicable (weight = 0)

If the respondent could not take a position on a given issue, it was possible to select the "Not applicable" option. The "N/A" option has a weight of "0" and was not counted towards the average of the results.

The results expressed as the average grade for each profile are ranked below in ascending order.
(Detailed results for each profile see in Annex 2).

Assessment of professional skills and social competence for Miner Self-Propelled Mining Machine Operator

Table 7. Miner Self-Propelled Mining Machine Operator – results of the competency gap survey in the area of social skills and competences (n=50).

ASSESSMENT OF PROFESSIONAL SKILLS	Average score (n=50)
Maintains the operating book of the self-propelled mining machine on an ongoing basis	3,9
Applies the environmental regulations and rules applicable to operators of a self-propelled mining machinery	4,0
Reports self-propelled mining machinery for inspection and maintenance work	4,0
Checks the correct operation of the electrical system of a self-propelled mining machine	4,0
Checks the correct operation of all electrically powered equipment on a self-propelled mining machine	4,0
Performs the commissioning of a self-propelled mining machine including checking the correct operation of the starter	4,0

Applies health, safety and fire regulations and rules applicable to operators of a self-propelled mining machinery	4,1
Distinguishes between natural and technological hazards in the position of a a self-propelled mining machine operator	4,2
Checks the correct operation of the hydraulic system of a self-propelled mining machine.	4,2
Checks and interprets the indicators on the dashboard and pressure gauges in the operator's cab	4,2
Checks and operates the fire extinguishing system of a self-propelled mining machine	4,2
Performs minor repairs to self-propelled mining machinery	4,3
Performs shift and periodic maintenance on self-propelled mining machines	4,4
Communicates the machine malfunction to his supervisor (foreman)	4,4
Steers and controls self-propelled mining machinery	4,5
Tests the operability of a self-propelled mining machine’s lighting intended to illuminate the path of travel and the working area of the machine	4,5
Tests the operability of a self-propelled mining machine's audible signal used when navigating intersections in underground mines	4,5
Secures the damaged machine and informs the supervisor (foreman) if the machine needs to be repaired in the repair chamber or if the factory service needs to be called	4,5
ASSESSMENT OF SOCIAL COMPETENCE	
Applies stress management techniques	3,9
Applies problem-solving methods and techniques	3,9
Modifies behaviour taking into account other team members	3,9
Expresses emotions, feelings and views in accordance with generally accepted norms and rules of social intercourse	4,0
Applies the principles of interpersonal communication	4,0
Carries out a self-assessment of the quality of the work produced	4,1
Suggests ways to solve problems related to the performance of professional tasks under unpredictable conditions	4,1
Engages in the implementation of joint team activities	4,1
Is willing to share knowledge	4,1
Accepts responsibility for professional information entrusted	4,2
Respects confidentiality rules associated with the profession and the workplace	4,2
Plans the task responsibly	4,3
Anticipates the consequences of improper work activities at the workplace, including the handling of hazardous substances, and the improper operation of machinery and equipment at the workplace	4,3
Takes responsibility for actions taken	4,4

Findings

Based on the results of the competence gap survey among selected groups of employees in the copper sector (competency profile: Miner Self-Propelled Mining Machine Operator), the following are the professional skills and social competence whose level in the opinion of the respondents is currently the lowest (a unified threshold of the average value of the assessment of 4.0 was adopted).

It is justified to include employees in targeted educational activities developing the following skills:

PROFESSIONAL SKILLS

- Maintains the operating book of the self-propelled mining machine on an ongoing basis.

SOCIAL COMPETENCE

- Applies stress management techniques.
- Applies problem-solving methods and techniques.
- Modifies behaviour taking into account other team members.

Assessment of professional skills and social competence for Solid Mineral Processing Technician

Table 8. Solid Mineral Processing Technician – results of the competency gap survey (n=82).

ASSESSMENT OF PROFESSIONAL SKILLS	Average score (n=82)
Operates a storage and loading process for solid copper mineral processing products	3,4
Operates a storage process for feedstock	3,7
Defines the rules for the use of machinery and equipment for grinding copper solid minerals	3,9
Carries out the pretreatment and dosing of copper feedstock for the main processes of solid mineral processing	3,9
Performs minor repairs to machinery and equipment	4,0
Conducts the grinding of solid copper minerals	4,1
Operates machinery and equipment used in the process of classifying and crushing copper solid minerals	4,1
Operates machinery and equipment for drying	4,2
Leads the copper solid mineral classification process	4,2
Organises the workplace in accordance with ergonomic requirements	4,2
Performs ongoing maintenance and inspection of machinery and equipment	4,4
Assesses the quality of the copper solid mineral enrichment process	4,4
Performs adjustments to the operation of machinery and equipment	4,5
Applies the environmental regulations and rules applicable to the processing of solid minerals	4,5
Operates machinery and equipment used in the enrichment of copper solid minerals	4,5
Operates a copper solid mineral enrichment process	4,5
Carries out dewatering processes, treatment of circulating water, thickening and drying of solid copper mineral processing products	4,5
Applies health, safety and fire regulations and rules applicable to the processing of solid minerals	4,6
Determines the working conditions and organisation of work ensuring the required level of protection of health and life against the hazards present in the working environment	4,6
Reads from measuring instruments the operating parameters of machinery and equipment	4,6

Monitors and controls the technical and technological parameters of the processing of solid copper minerals	4,6
Applies personal and collective protective equipment in the processing of solid copper minerals	4,7
ASSESSMENT OF SOCIAL SKILLS	
Suggests ways to solve problems related to the performance of professional tasks under unpredictable conditions	3,7
Modifies behaviour taking into account other team members	3,7
Carries out a self-assessment of the quality of the work produced	3,8
Engages in the implementation of joint team activities	3,8
Applies the principles of interpersonal communication	3,9
Applies problem-solving methods and techniques	3,9
Applies stress management techniques	4,0
Expresses emotions, feelings and opinions in accordance with generally accepted norms and rules of social coexistence	4,0
Takes responsibility for actions taken	4,1
Accepts responsibility for professional information entrusted	4,2
Anticipates the consequences of improper work activities at the workplace, including the handling of hazardous substances, and the improper operation of machinery and equipment at the workplace	4,2
Is willing to share knowledge	4,4
Plans the task responsibly	4,5
Respects the rules regarding the observance of professional and workplace confidentiality	4,6

Findings

Based on the results of the competence gap survey among selected groups of employees in the copper sector (competence profile: Solid Mineral Processing Technician), the following are the professional skills and social competence whose level in the opinion of the respondents is currently the lowest (a unified threshold of the average value of the assessment of 4.0 was adopted).
It is justified to include employees in targeted educational activities developing the following skills:

PROFESSIONAL SKILLS

- Operates a storage and loading process for solid copper mineral processing products.
- Operates a storage process for feedstock.
- Defines the rules for the use of machinery and equipment for grinding solid minerals.
- Carries out the pretreatment and dosing of feedstock for the main processes of solid mineral processing.

SOCIAL COMPETENCE

- Suggests ways to solve problems related to the performance of professional tasks under unpredictable conditions.
- Modifies behaviour taking into account other team members.

- Carries out a self-assessment of the quality of the work produced.
- Engages in the implementation of joint team activities.
- Applies the principles of interpersonal communication.
- Applies problem-solving methods and techniques.

Assessment of professional skills and social competence for Mining Engineer Supervisor

Table 9. Mining Engineer Supervisor – results of the competency gap survey in the area of social skills and competences (n=28).

ASSESSMENT OF PROFESSIONAL SKILLS	Average score (n=28)
Supervises the transport of ore by conveyor belt to the enrichment plants	2,6
Supervises the hauling of ore to the surface with skip equipment in the mining shafts	2,9
Prepares graphical studies and presentations using selected computer programmes, including those supporting the planning, implementation and evaluation of the effects of sourcing activities	3,2
Plans mining works using appropriate computer software	3,5
Supervises the crushing of large lumps of rock (oversize) on the branch dump crag	3,6
Supervises the transport of ore by belt conveyors (or rail transport) to the crusher chambers at the shaft retention tanks	3,6
Counteracts water hazards (manifested particularly during shaft sinking)	3,6
Prepares (independently or as part of a team) basic technical documentation related to the extraction of raw materials, including: deposit exploitation design, deposit development concept, work schedule, simplified economic analysis, etc.	3,7
Applies the principles of mining company economic	3,8
Counteracts thermal hazards by using technical solutions to ensure an appropriate microclimate	3,9
Applies the environmental regulations and rules applicable to laboratory and production work	4,0
Applies the intellectual property protection laws of mining companies	4,0
Applies the principles of mining company logistic	4,0
Supervises and controls the quality of blast hole drilling and arming the holes with explosive charges	4,0
Counteracts the dangers of drowning during the mining process, the technical protection of the mine as well as the organisation of the work	4,0
Applies the principles of mining enterprises	4,2
Reads surveying, geological, drilling and geophysical documentation	4,2
Oversees and controls the quality of the stripping in the faces and pits	4,2
Applies health, safety and fire regulations and rules applicable to laboratory and production work	4,3

Selects the appropriate machinery and equipment for the workplace depending on the dimensions and mining regulations	4,3
Supervises and controls the quality of the execution of the anchor shoring	4,3
Supervises the haulage of excavated material to branch dumps on conveyor belts	4,3
ASSESSMENT OF SOCIAL COMPETENCE	
Demonstrates social and entrepreneurial activity in the workplace	3,3
Is ready to initiate actions for sustainable development	3,7
Adheres to the principles of professional ethics	3,9
Builds and maintains good relationships with different stakeholder groups (local communities, subordinates, customers and subcontractors) by strengthening mutual trust, respect and improving communication	3,9
Is ready to assess the risks and consequences of undertaking mining activities	3,9
Is flexible and willing to solve problems in the workplace	4,0
Is willing to take responsibility for the tasks assigned and decisions made	4,0
Motivates colleagues and subordinates to effectively achieve objectives, comply with regulations, implement good practices and professional ethics	4,0
Is willing to share knowledge	4,0
Is aware of the importance of the extractive industry for socio-economic development	4,0
Is ready to make decisions within the scope of the tasks assigned	4,1

Findings

Based on the results of the competence gap survey among selected groups of employees in the copper sector (competence profile: Mining Engineer Supervisor), the following are the professional skills and social competence and whose level in the opinion of the respondents is currently the lowest (a unified threshold of the average value of the assessment of 4.0 was adopted).
It is recommended to include employees in targeted educational activities developing the following skills:

PROFESSIONAL SKILLS

- Supervises the transport of ore by conveyor belt to the enrichment plants.
- Supervises the hauling of ore to the surface with skip equipment in the mining shafts.
- Prepares graphical studies and presentations using selected computer programmes, including those supporting the planning, implementation and evaluation of the effects of sourcing activities.
- Plans mining works using appropriate computer software.
- Supervises the crushing of large lumps of rock (oversize) on the branch dump crag
- Supervises the transport of ore by belt conveyors (or rail transport) to the crusher chambers at the shaft retention tanks.
- Counteracts water hazards (manifested particularly during shaft sinking).
- Prepares (independently or as part of a team) basic technical documentation related to the extraction of raw materials, including: deposit exploitation design, deposit development concept, work schedule, simplified economic analysis, etc.
- Applies the principles of mining company economics.
- Counteracts thermal hazards by using technical solutions to ensure an appropriate microclimate.

SOCIAL COMPETENCE

- Demonstrates social and entrepreneurial activity in the workplace.
- Is ready to initiate actions for sustainable development.
- Adheres to the principles of professional ethics.
- Builds and maintains good relationships with different stakeholder groups (local communities, subordinates, customers and subcontractors) by strengthening mutual trust, respect and improving communication.
- Is ready to assess the risks and consequences of undertaking mining activities.

Assessment of professional skills and social competence for Mining Geologist

Table 10. Mining Geologist – results of the competency gap survey in the area of social skills and competences (n=15).

ASSESMENT OF PROFESSIONAL SKILLS	Average score (n=15)
Draws up applications for the establishment of a mining area and site or its liquidation, and develops projects for the reclamation of areas after mine liquidation	2,7
Applies modern statistical and geostatistical methods to the assessment of deposits and uses modern computer software in documentation work	3,2
Prepares and communicates warnings to public authorities of dangerous phenomena occurring in groundwater recharge and abstraction zones	3,5
Conducts structural, mineralogical and petrographic studies to determine geological phenomena and anticipatory and reconnaissance studies	3,6
Applies the principles of economics of mining enterprises	3,7
Applies the principles of mining company logistics	3,7
Develops projects for the dewatering of mineral deposits and the injection of water into rock masses	3,7
Develops hydrogeological maps of groundwater resources	3,7
Assesses the environmental impact of planned copper ore mining	3,7
Organises and co-ordinates all issues related to the geological and hydrogeological service of the mining site	3,9
Identifies geometrical, hydrogeological, geological-engineering, gas and temperature conditions for copper ore mining	3,9
Analyses, uses and updates the content of geological maps and photogrammetric materials to synthesise geological findings	3,9
Conducts periodic analyses of ore management and documents the causes of losses in copper ore reserves	3,9
Carries out hydrogeological measurements, observations and tests to determine infiltration, porosity, water absorption and water permeability of rocks	4,0
It conducts exploration and appraisal of copper ores and estimates their size and reserves.	4,0

Applies health, safety and fire regulations and rules applicable to hydrological and exploration geological work	4,1
Performs ongoing analysis and assessment of the hydrogeological situation at mining operations	4,1
Supervises mining and drilling works, taking into account the rational use of minerals, the compliance of works with the concession and the deposit development project, the mining plant operation plan, the selective exploitation and the heaping of multi-commodity deposits	4,1
Prepares documentation of geological and mining work and a record of changes in copper ore reserves	4,1
Applies environmental regulations and rules applicable to hydrological and exploration geological work	4,2
Applies the principles of mining enterprises	4,2
Develops the design of mapping, profiling and testing of mining and drilling operations	4,2
Conducts the study and quality control of the ore body and investigates the variability of quality parameters in the copper ore mining process	4,2
Applies the intellectual property protection laws of mining companies	4,3
Plans the work at the mining site in accordance with the provisions of the Geological and Mining Law	4,3
Inspects and supervises the operating documents with regard to their compliance with geological and mining legislation	4,3
Performs survey work in determining the presence and extent of underground water resources in areas affected by mining activities	4,3
Samples deposits in mine workings for chemical, mineral-petrographic, technological, stratigraphic, etc. studies	4,3
Controls the implementation of the mining works geologically with the applicable Mining Plan	4,4
It controls the quality and variability of water quality parameters in the copper ore mining process	4,4
Resolves groundwater inflow problems in mining operations	4,5
Conducts periodic and planned inspections of underground works at the mine site	4,6
Informs the Mine Site Manager of any discrepancies found during the execution of mining works	4,6
ASSESSMENT OF SOCIAL COMPETENCE	
Demonstrates social and entrepreneurial activity in the workplace	3,4
Is ready to assess the risks and consequences of undertaking mining activities	3,4
Motivates colleagues and subordinates to effectively achieve objectives, comply with regulations, implement good practices and professional ethics	3,5
Builds and maintains good relationships with different stakeholder groups (local communities, subordinates, customers and subcontractors) by strengthening mutual trust, respect and improving communication	3,5
Is ready to initiate actions for sustainable development	3,6
Demonstrates a willingness to solve problems in the workplace in a flexible manner	3,7

Is willing to take responsibility for the tasks assigned and decisions made	3,8
Adheres to the principles of professional ethics	3,9
Is ready to make decisions within the scope of the tasks assigned	3,9
Is willing to share knowledge	4,1
Is aware of the importance of the extractive industry for socio-economic development	4,1

Findings

Based on the results of the competence gap survey among selected groups of employees in the copper sector (competence profile: Mining Geologist), the following are the professional skills and social competence whose level in the opinion of the respondents is currently the lowest (a unified threshold of the average value of the assessment of 4.0 was adopted).
It is justified to include employees in targeted educational activities developing the following skills:

PROFESSIONAL SKILLS

- Draws up applications for the establishment of a mining area and site or its liquidation, and develops projects for the reclamation of areas after mine liquidation.
- Applies modern statistical and geostatistical methods to the assessment of deposits and uses modern computer software in documentation work.
- Prepares and communicates warnings to public authorities of dangerous phenomena occurring in groundwater recharge and abstraction zones.
- Conducts structural, mineralogical and petrographic studies to determine geological phenomena and anticipatory and reconnaissance studies.
- Applies the principles of economics of mining enterprises.
- Applies the principles of mining company logistics.
- Develops projects for the dewatering of mineral deposits and the injection of water into rock masses.
- Develops hydrogeological maps of groundwater resources.
- Assesses the environmental impact of planned copper ore mining.
- Organises and co-ordinates all issues related to the geological and hydrogeological service of the mining site.
- Identifies geometrical, hydrogeological, geological-engineering, gas and temperature conditions for copper ore mining
- Analyses, uses and updates the content of geological maps and photogrammetric materials to synthesise geological findings.
- Conducts periodic analyses of ore management and documents the causes of losses in copper ore reserves.

SOCIAL COMPETENCE

- Demonstrates social and entrepreneurial activity in the workplace.
- Is ready to assess the risks and consequences of undertaking mining activities.
- Motivates colleagues and subordinates to effectively achieve objectives, comply with regulations, implement good practices and professional ethics.

- Builds and maintains good relationships with different stakeholder groups (local communities, subordinates, customers and subcontractors) by strengthening mutual trust, respect and improving communication.
- Is ready to initiate actions for sustainable development.
- Demonstrates a willingness to solve problems in the workplace in a flexible manner.
- Is willing to take responsibility for the tasks assigned and decisions made.
- Adheres to the principles of professional ethics.
- Is ready to make decisions within the scope of the tasks assigned.

Assessment of professional skills and social competence for Metallurgical Engineer

Table 11.1. Metallurgical Engineer – Non-ferrous Metals – results of the competency gap survey in the area of social skills and competences (n=75).

ASSESSMENT OF PROFESSIONAL SKILLS	Average score (n=75)
Plans and organises individual and team work in solving material problems in the metallurgical and copper industry, also of an interdisciplinary nature	2,9
Prepares, makes presentations and participates in discussions and seminars in the areas of non-ferrous metal engineering, fundamentals of economics, patent and copyright law	3,4
Designs technologies for the production of modern materials specific to the copper and other non-ferrous metal industries	3,4
Applies the principles of metallurgical company logistics.	3,5
Designs and improves material processing processes in the non-ferrous metals industry, particularly in the areas of traditional and modern metallurgical process engineering, copper processing and materials engineering.	3,5
Applies basic IT techniques to develop measurement results from the field of materials engineering	3,5
Directs the manufacturing processes of semi-finished copper and copper-based products and non-ferrous metal-based multi-material composites, using various synthesis techniques	3,6
Uses advanced information and communication techniques to solve material problems in the metallurgical and copper industries	3,6
Liaises with specialists and expert groups on difficult technical and organisational problems in the workplace	3,6
Applies knowledge of mathematics, physics and chemistry to the design of processes specific to materials and metallurgical engineering, in particular metallurgy and recycling and the processing and metallurgy of copper and other non-ferrous metals, taking into account process automation	3,7
Applies the fundamentals of physics, mathematics and statistics necessary to interpret and process measurement data	3,7
Analyses properties and selects non-ferrous metals for technical applications	3,7
Applies the basic techniques used in materials and process research related to the processing of copper and other non-ferrous metals	3,8

Applies the principles of metallurgical company economics.	3,8
Assesses the suitability of specific test methods for determining the structure and properties of copper and other non-ferrous metals	3,8
Applies the principles of metallurgical enterprises.	3,9
Applies knowledge from the field of materials engineering to shape the properties and structure of materials from copper and other non-ferrous metals	4,0
Operates simple measuring and testing apparatus during laboratory testing of copper and other non-ferrous metals	4,0
Applies the intellectual property protection laws of metallurgical companies.	4,1
Applies health, safety and fire regulations and rules applicable to laboratory and production work.	4,3
Applies the environmental regulations and rules applicable to laboratory and production work.	4,3

Notice:
Due to the specificity of the area of activity of the company in Greece, the survey was expanded in this country to include four additional questions on professional skills. The results of the assessment of the level of mastery of these skills by employees representing a given competence profile are presented below (in contrast to the other average indicators, these four refer only to data from Greece; Table 11.2):

Table 11.2. Metallurgical Engineer – Non-ferrous Metals – results of the competency gap survey in the area of social skills and competences (continuation, n=51).

ASSESSMENT OF ADDITIONAL PROFESSIONAL SKILLS (only in Greece)	Average score (n=51)
Applies specialized knowledge in tooling design and optimization across various manufacturing processes within the copper tubes plant.	3,5
Displays expertise in the selection of appropriate tooling for different stages of the manufacturing process.	3,5
Understands phase transformations and their implications in shaping the microstructure and properties of copper, copper alloys and other non-ferrous metals in the manufacturing process	3,6
Utilizes knowledge of common defects in metal processing processes, along with preventative measures, to enhance product quality and process efficiency.	3,6

Table 11.3. Metallurgical Engineer – Non-ferrous Metals – results of the competency gap survey in the area of social skills and competences (continuation, n=75).

ASSESSMENT OF SOCIAL COMPETENCE	Average score (n=75)
Is ready to make decisions within the scope of the tasks assigned.	3,5
Is ready to assess the risks and consequences of undertaking mining activities.	3,5
Is aware of the importance of the extractive industry for socio-economic development.	3,5
Motivates colleagues and subordinates to effectively achieve objectives, comply with regulations, implement good practices and professional ethics.	3,7

Builds and maintains good relationships with different stakeholder groups (local communities, subordinates, customers and subcontractors) by strengthening mutual trust, respect and improving communication.	3,7
Demonstrates social and entrepreneurial activity in the workplace.	3,8
Is willing to take responsibility for the tasks assigned and decisions made.	3,8
Is willing to share knowledge	3,8
Is ready to initiate actions for sustainable development.	3,8
Is flexible and willing to solve problems in the workplace.	4,0
Adheres to the principles of professional ethics.	4,1

Findings

Based on the results of the competence gap survey among selected groups of employees in the copper sector (competence profile: Metallurgical Engineer – Non ferrous Metals), the following are the professional skills and social competence whose level in the opinion of the respondents is currently the lowest (a unified threshold of the average value of the assessment of 4.0 was adopted).
It is recommended to include employees in targeted educational activities developing the following skills:

PROFESSIONAL SKILLS

- Plans and organises individual and team work in solving material problems in the metallurgical and copper industry, also of an interdisciplinary nature.
- Prepares, makes presentations and participates in discussions and seminars in the areas of non-ferrous metal engineering, fundamentals of economics, patent and copyright law.
- Designs technologies for the production of modern materials specific to the copper and other non-ferrous metal industries.
- Applies the principles of metallurgical company logistics.
- Designs and improves material processing processes in the non-ferrous metals industry, particularly in the areas of traditional and modern metallurgical process engineering, copper processing and materials engineering.
- Applies basic IT techniques to develop measurement results from the field of materials engineering.
- Directs the manufacturing processes of semi-finished copper and copper-based products and non-ferrous metal-based multi-material composites, using various synthesis techniques.
- Uses advanced information and communication techniques to solve material problems in the metallurgical and copper industries.
- Liaises with specialists and expert groups on difficult technical and organisational problems in the workplace.
- Applies knowledge of mathematics, physics and chemistry to the design of processes specific to materials and metallurgical engineering, in particular metallurgy and recycling and the processing and metallurgy of copper and other non-ferrous metals, taking into account process automation.
- Applies the fundamentals of physics, mathematics and statistics necessary to interpret and process measurement data.
- Analyses properties and selects non-ferrous metals for technical applications

- Applies the basic techniques used in materials and process research related to the processing of copper and other non-ferrous metals.
- Applies the principles of metallurgical company economics.
- Assesses the suitability of specific test methods for determining the structure and properties of copper and other non-ferrous metals.
- Applies the principles of metallurgical enterprises.
- Applies specialized knowledge in tooling design and optimization across various manufacturing processes within the copper tubes plant.
- Displays expertise in the selection of appropriate tooling for different stages of the manufacturing process.
- Understands phase transformations and their implications in shaping the microstructure and properties of copper, copper alloys and other non-ferrous metals in the manufacturing process.
- Utilizes knowledge of common defects in metal processing processes, along with preventative measures, to enhance product quality and process efficiency.

SOCIAL COMPETENCE

- Is ready to make decisions within the scope of the tasks assigned.
- Is ready to assess the risks and consequences of undertaking mining activities.
- Is aware of the importance of the extractive industry for socio-economic development.
- Motivates colleagues and subordinates to effectively achieve objectives, comply with regulations, implement good practices and professional ethics.
- Builds and maintains good relationships with different stakeholder groups (local communities, subordinates, customers and subcontractors) by strengthening mutual trust, respect and improving communication.
- Demonstrates social and entrepreneurial activity in the workplace.
- Is willing to take responsibility for the tasks assigned and decisions made.
- Is willing to share knowledge.
- Is ready to initiate actions for sustainable development.

4.3. Conclusions

1. Research has shown that in the copper ore mining and processing sector (industrial partners of the SkiComCu project), the area of competence related to the recycling of copper-containing materials is not distinguished as a separate profession. Professional tasks related to this important area of operation of copper industry enterprises are partly performed by representatives of other professions (e.g. metallurgical engineers). The increasing importance of recycling processes in the overall management of copper resources, justifies the assumption that this will probably prove to be insufficient in the near future. Engineers specialising in the recovery of copper from production waste are likely to be needed.
2. Online survey identified competency gaps among selected groups of employees in the copper sector. The survey covered 5 competency profiles that the project partnership identified as key for the future of the sector (excluding Copper Recycling Process Engineer for reasons explained above). Gaps were examined in two categories: professional skills and social competencies.
3. The survey confirmed the (originally identified in the desk research) generic diversity of skills that are important for current and future Cu sector employees and that respondents believe need to be developed in training. These included (examples are given below):

Technological and digital skills (examples):	Social skills (examples):	Higher cognitive skills (examples):
– Carries out the pretreatment and dosing of feedstock for the main processes of solid mineral processing; – Applies modern statistical and geostatistical methods to the assessment of deposits and uses modern computer software in documentation work; – Supervises the transport of ore by belt conveyors (or rail transport) to the crusher chambers at the shaft retention tanks; – Designs and improves processes in the non-ferrous metals industry, particularly in the areas of traditional and modern metallurgical process engineering, copper processing and materials engineering	– Engages in the implementation of joint team activities; – Modifies behaviour taking into account other team members; – Builds and maintains good relationships with different stakeholder groups; – Assesses the environmental impact of planned copper ore mining; – Initiates actions for sustainable development; – Demonstrates social and entrepreneurial activity in the workplace;	– Applies problem-solving methods and techniques; – Applies the principles of interpersonal communication; – Makes decisions; – Takes responsibility for the tasks assigned; – Motivates colleagues and subordinates to effectively achieve objectives, comply with regulations, implement good practices and professional ethics;

4. The professional skills gaps, are different for each of the profiles studied. They are presented above in detail for each profile separately.

5. Among the social competences (common sets for EQF levels 3 and 4 and for EQF levels 5 and 7), in the opinion of the respondents, the following competences in particular require development:

a)for competences of EQF levels 3 and 4

- Applies problem-solving methods and techniques
- Modifies behaviour taking into account other team members

b)for competences of EQF levels 6 and 7

- Demonstrates social and entrepreneurial activity in the workplace
- Initiate actions for sustainable development
- Builds and maintains good relationships with different stakeholder groups
- Assess the risks and consequences of undertaking mining activities.

6. The survey consisted to a considerable extent of self-assessment (more than 80% of respondents were employees in the surveyed profession). It is noticeable that the results are in line with the general correlation that, as the educational level of the respondents increases, their level of awareness and critical view of their own competences and need for development increases. In the SkiComCu study, the least deficiencies in the skills possessed were indicated by respondents commenting on the competences of a mining machinery operator (EQF 3). Almost all the required professional skills and social competences received a very high rating for their level of mastery by employees.

7. In the free comments and remarks, respondents further highlighted the following issues relevant to the potential thematic areas of the proposed training courses:

7.1 Social competence:

- readiness to share knowledge / building interpersonal relationships: *"**Sharing knowledge** with colleagues is very important, from the quality of work, the way of working or stressful situations. I believe that talking to other employees will help to eliminate unnecessary stressful situations during work and be clearer, safer which will translate into completing the tasks assigned";*
- *"……, increased **communication** is needed for **problem-solving**";*
- *"The knowledge and expertise is not available throughout the company in a standardized way. Synergies towards better **collaboration** between departments in needed".*

7.2 Professional skills:

- *"ability to identify and quantify the **process-microstructure-properties-performance linkages** that exist within the process that she/he oversees" (metallurgical engineer);*
- *"a fundamental/ deep **understanding of physical metallurgy principles** that influence metal processing for engineers, while a basic understanding of metallurgy for production personnel. This knowledge can aid in areas such as Life Cycle Assessment (LCA) analysis, the integration of production KPIs with financial KPIs, and Quality Assurance (QA) KPIs";*
- *"… specific knowledge in the area **of applications and performance of metallic components under service and operating conditions**";*
- *Skills related to **quality management** and defect reduction, e.g. Six Sigma methodology.*

8. Relating the results of the online survey to the results of desk research, the following common elements (skills gaps) can be seen:

Professional skills:	Soft skills (social & cognitive):
• Scientific and technological skills (e.g. understanding of metallurgy principles and processes; storage, loading and transport processes for solid copper mineral processing products). • Safe working practices. • Use of dedicated computer programmes (AI, big data, other digital skills). • Preparing technical documentation and reporting. • Information processing and sharing.	• Problem solving. • Adaptability and flexibility. • Risk assessment and decision-making. • Accountability (taking responsibility for actions taken). • Relationship building – interpersonal communication. • Teamwork. • Social and entrepreneurial activity in the workplace. • Motivating and self-awareness (e.g. motivating others and stress management).

9. Identified gaps in professional skills and social competence provide recommendations for the subject matter of the training modules being developed as part of the SkiComCu project (WP3), dedicated to chosen groups of copper sector employees.

5. Skills gaps in the copper sector according to the opinions of the FGIs' participants

5.1. Methodology

Objective: to identify competence gaps for current and future employees of Cu sector (obtaining additional data to supplement the on-line surveys results).

Method: focus group interview (FGI) - research technique used to collect data through group interaction.

FGI - General approach:

- Defined research scope;
- Small groups of selected participants (5-12 people), who discuss a given topic answering questions;
- Questions (a few): open-ended and flexible, impossible to answer „yes/no", neutral, unambiguous (getting straight to the point), including:
  - Engagement questions (making your participants feel comfortable and at ease)
  - Exploration questions (drilling down to the focus of your analysis)
  - Exit questions (picking up on anything you may have previously missed in your discussion)
- Discussion run by moderator/ facilitator (as an active participant), according to the scenario;
- Duration: about 90 min.

Tool: Interview scenario with guidelines (see **Annex 3**).

Target groups (participants of SkiComCu FGIs): representatives of different groups of Cu sector's employees (about 8 people) including:

- Mid-managers and office personnel (suggestion for participation of 3 representatives),
- Technical and labour-position personnel (suggestion for participation of 3 representatives),
- Senior managers (suggestion for participation of 1 representative),
- Personnel of HR department (suggestion for participation of 1 representative).

The interviews were organised and conducted with the key involvement of the industrial partners of the SkiComCu project (supported by other partners), with the participation of employees of copper companies representing the 3 RIS countries: Poland, Greece and Bulgaria.

5.2. FGIs' organising and findings

FOCUS GROUP INTERVIEW IN GREECE

- Date: May 2024
- Duration: about 90 minutes
- Format: f2f meeting
- Participants - Employees of HALCOR company representing (as specified in methodology) different groups of copper sector workers:
  - Senior managers (6 persons)
  - Mid-management personnel (4 persons)
  - Technical staff and labor position personnel (3 representatives)
  - HR Department (1 representative)

Additionally, team of HALCOR was supported by team of National Technical University of Athens – four experienced researchers of theoretical and practical issues related to the mining and processing of copper ores, active didacticians preparing technical staff for work in mines and copper ore processing plants.

Course of the interview

Question 1:

You are all employees of the copper sector. What are your views on the challenges facing the sector?

Plant Manager

- Attraction and retention of technical staff and skills at all levels. Currently, the industry is not as attractive as other sectors of employment that are associated with services (e.g., due to the nature of the work, compensation, challenges, etc.).
- Difficulty of replacing the skills of experienced existing staff with skills available in the labor market.

Production Senior Manager

- Technological challenges - Industry 4.0, Energy and Green Transition, reduction of Carbon Footprint.
- The industry in Greece is characterized by low levels of automation.
- Lack of specialization and innovation also in external partners.
- The regulatory framework in Asia for the copper sector is much more flexible than the European one.
- The culture of the new generation of workers supports changing jobs every 3-4 years → superficial knowledge of the subject (lack of specialization). The metal industry requires deep knowledge of the technical subject.

- The need for the industry to provide opportunities for professional development.
- Limited innovation and production of new ideas due to the frequent movement of personnel.

Strategic Planning & Sustainability Senior Manager

- Adaptation to external factors and new trends (applications of augmented reality in education, etc.).
- Net-zero carbon footprint by 2050: European legislation for achieving zero carbon emissions.
- Strong competition from the Asian market.
- Need for adapting corporate culture to changes through strategic infrastructure. Matching technical skill requirements and quality of human resources.
- Employee principles – about the ethics/culture.

Production-Process Managers/ Engineers

- The copper industry is a very specialized sector and it is difficult to find technical personnel in the market that are oriented towards the needs of copper processing.
- Necessary parallel transition in human resources through the framework of Change Management in conjunction with the entire copper supply chain.
- Intense competition in the copper sector between Europe and Asia. European legislation is comparatively much more restrictive, leading to defensive solutions such as forced cost reduction.

Technical personnel - Foremen

- Need for adaptation to the transition of technological developments considering the company's history.
- Challenge in finding machine operators because the workforce in the geographical area is more oriented towards agricultural services.
- Need to cultivate the culture of the "industrial worker" and better familiarize them with the factory environment.
- Knowledge retention: need to provide an effective and friendly training framework for newcomers to the sector that enhances their retention in the copper industry. The training framework needs to be realistic both in terms of the industry's requirements and the workload of the trainer and trainee.
- Organization of the educational process to enhance the assimilation of knowledge.

Question 2: *What are the most urgent competency gaps in the sector?*

Plant Manager

- Leadership style within the company at all levels.

Production Senior Manager

- Experimental engineering – interpretation of results and integration with processes, lack of knowledge of basic Cu properties/characteristics (necessary in positions such as foreman or even at lower levels).

Strategic Planning & Sustainability Senior Manager

- Effective collaboration between departments (medium/senior management).
- Gap analysis

Production-Process Managers/ Engineers

- Multitasking skills – flexibility.
- Micromanagement management.
- Management of automation systems in the factory.
- Knowledge of MS Excel.
- Knowledge of digitalization/digital transition issues.

Technical personnel - Foremen

- Lack of personnel in foreman positions.
- Lack of "industrial worker" profile - most incoming operators are foreigners and come from a different field than copper metallurgy (metal industry) – more training and familiarization time is required for them to integrate into the industry.
- Difficulty matching digital knowledge with manual work at the operator level.

HR department

- Soft skills at all hierarchical levels – communication, collaboration.

Question 3: *What training (subject matter) would you sign up for today, but have not found the right offer on the market? What form of this training would suit you best (f2f/online/ blended learning)?*

Chief Technical manager

- Accelerate average training time - Reduction of average training time
- Ease the training process by incorporating simulation tools, making training more interactive, user-friendly, and accessible.
- Improve training procedures to address more complex or unusual issues that occur less frequently during production (in these cases, the development of training tools with simulation tools helps).

Production-Process Managers/ Engineers

- Familiarity with fundamental concepts in the subject – necessary for the industry (e.g., chemical elements, melting temperature of Cu), basic knowledge of physical metallurgy, metalworking, and mechanical engineering (foremen/production engineers) – f2f/classroom learning (contributes to direct interaction with the industrial environment).

Technical personnel - Foremen

- How to attract technical personnel for operator/foreman positions. The contribution of the local community is significant.
- Simulation tools using Augmented Reality technology are useful in the educational process.

Conclusions

Training tools prioritized by HALCOR executives to be developed within the SkiComCu project framework include:

1. Presentation of the entire life cycle of Cu from mining to recycling to educate all employees on the importance of the production process in which they participate.
2. Training on the basic concepts of the production process of HALCOR's industrial unit (e.g., chemical elements, melting temperature of Cu), basic knowledge of physical metallurgy, metalworking, and mechanical engineering (foremen/production engineers). The stages of the process where more emphasis will be given should be selected by industrial partners.
3. Basic training on the economic and environmental framework governing the production, demand, and supply of Cu in Greece, Europe, and internationally.

FOCUS GROUP IN BULGARIA

- Date: June 2024
- Duration: about 90 minutes
- Participants
  Employees of AURUBIS company representing (as specified in methodology) different groups of copper sector workers:
  - 1 Senior manager
  - 3 representatives of mid-management personnel
  - 4 representatives of technical and labor position personnel
  - 1 representative of HR Department
- Format: hybrid (2 participants on line)

Course of the interview

Question 1: *You are all employees of the copper sector. What are your views on the challenges facing the*

sector?

The participants in the focus group outline as a main challenge in front of the cooper sector the ability of the industry to take advantage of the technology development. The development of the artificial intelligence has been indicated as one of the major topics that is needed to be considered in the upcoming years in the light of the future development of the employees in the sector. For example, the new technologies are more and more developed and used in the work of Commercial and Procurement Departments which requires higher skills from the employees to respond to the technology development. The base technology education is indicated as a must for the future employees.

In addition, it was indicated that the green transition and the development of the companies in direction of the ESG transition is also a major driven topic which should be taken in consideration. Here the new regulation in the sector requires a better understanding by the responsible employees of the structure of the business and the development of each of its segments.

As a conclusion it could be outlined that the two main challenges indicated during the discussion are: 1) the development of the technologies and their implementation in the everyday work of the companies in the sector as well as 2) the green transition and its reflection over the business of the companies in the sector in the light of regulation on one side and understanding of the business on the other side.

Question 2: *What are the most urgent competency gaps in the sector?*

As a main competency gap in the sector which need immediate actions was indicated the lack of overall view of the business by the employees. It was outlined that most of the employees in the sector are not familiar with the method of working of the business as well as of key sectors in connection with its operation (e.g., the financial operations, the logistic operations). The importance of the green transition and ESG reporting was also indicated as a major topic which needs attention in the process of professional development of the employees of the sector. This is a new topic and the lack of official professional educational framework in the country requires the companies to undertake special actions in this direction.

As a conclusion it could be outlined that it is needed to develop a global view over the business in the employees. In addition, it is recommendable also to be developed a view of the structure of the supply chain of the business (e.g. one step before – the work of the mining companies and one step after – the operations of the companies which produce products from cathodes). This requirement was outlined valid for the new employees as well as for the current employees of the company. For the new employees this includes a well-developed and structured onboarding plan which stress over the understanding of the parts of the production cycle that are important for each function and that could be indicated in the competence matrix and schedule for the development of this function. For the current employees it is also recommendable to be developed a plan which includes familiarization with these parts of the production cycle which are directly connected with the working functions of each specific group of employees. Beside this it is recommendable to be developed a list with the minimal requirements for the employees on the ground of which to be indicated the practical trainings which are of importance for the specific function.

Question 3: *How to attract new employees to the Cu sector?*

As a major challenge and factor for the attraction of employees in the sector the level of salary was indicated. It is of a great importance the sector to be competitive in the light of payment to the other sectors in the country and especially in the area. In the area there are also other companies in the sector which lead to a very competitive environment for attraction of new employees and preservation of the current employees.

Also, other important factor is the image of the sector in comparison with other "cleaner" and "greener" sectors. It was indicated that the efforts should be stressed on the branding and marketing of the company and its image on the market of employees to attract young specialists.

Finally, it is very important for the company to provide an opportunity for career development for the employees to make sure that they will have a solid career path in the process of development in the company. This could be approached by development of a vision in the company for the profile of the people that are needed and development of their profile.

Conclusions

It was indicated that at the current moment the interest is toward trainings directly related with the implementation and role of the artificial intelligence as a general working tool as well as its implementation in the specific functions of the employees in the sector.

In addition, the feedback is that it is preferable the educations courses to be held in a f2f format.

FOCUS GROUP IN POLAND

- Date: June 2024
- Duration: about 120 minutes
- Format: f2f meeting
- Participants – employers of KGHM Polska Miedź - different groups of workers:
  - Senior managers (2 persons)
  - Mid-management personnel (2 persons)
  - Technical staff and labour position personnel (2 representatives)
  - HR Department (2 representative)

Course of the interview

Question 1: *You are all employees of the copper sector. What are your views on the challenges facing the sector?*

According to the interviewees, the biggest challenge facing the industry is to adapt the functioning of the company to technological changes, changing social culture, organizational culture and generational differences, including the way of communication, the way of performing tasks at the workplace, and the

implementation of new technologies. On the other hand, the copper sector, like the economy as a whole, faces the challenge of an ever-increasing pressure to increase productivity and process speed.
Technological challenges in the copper industry are primarily related to process **automation and remote control of machines**. On the other hand, social challenges are primarily **demographic changes** – an aging society and the need to implement solutions that ensure the replacement of generations. FGI participants forecast the need for technological changes in workplaces to adapt them to the capabilities of the aging workforce. The lack of basic technical skills among younger workers was considered a major challenge – changes in the education system are needed in this area.

Question 2: *What are the most urgent competency gaps in the sector?*
The interviewees pointed out the competence gaps of employees in the copper ore mining and processing sector. The competencies were divided into four categories: 1) technical, 2) digital, 3) soft, 4) management.

1) Technical competence gaps: basic technical skills (technical culture, basic craft competences);
2) Digital competence gaps: Many people with potential are reluctant to learn new technologies, they do not want to get new knowledge or learn new skills.
3) Soft skills gaps:

- Communication, especially intergenerational communication;
- Listening;
- Involvement;
- Motivation for change;
- Trust and knowledge sharing;
- Perseverance in achieving success (expecting results here and now);
- Resistance to stress;
- Dealing with criticism.

4) Gaps in management competences:

- Transmission of instructions/ orders/ commands;
- Knowledge management and sharing;
- Perseverance in achieving success;
- Organizational memory (things that have already been implemented are implemented as new by subsequent managers);
- Searching for "talents" and recruiting them within the organization;
- Building clear pathways to promotion;

- Building competency-based teams.

Among those mentioned above, the most urgent competence gaps were considered:

- Gaps in technical skills,
- Communication deficiencies (lack of open communication, intergenerational communication),
- Lack of commitment and identification with the company,
- Lack of continuity of management (this is due to the conditions of companies with a large state shareholding).

Question 3: *How to attract new employees to the Cu sector?*

What discourages potential new employees is: difficult working conditions and the resulting risks, lack of information flow about new hires within the company (as an encouragement).

The participants of the interview indicated the following ways to make the job prospects in the copper sector more attractive: increasing salaries; informing candidates and new recruits about benefits for employees (e.g. PPE Employee Pension Program); building a system of profits that will be visible and felt by employees in a shorter time perspective (faster); implementing creative ideas from employees so that they have a sense of influence on shaping the organization and identify more with it.

Question 4: *Is the training offer for developing the competences of current workers of the copper sector (reskilling, upskilling) accessible, satisfactory, based on the latest technical developments? How should it be improved?*

The training offer satisfies procedural aspects, i.e. it includes those trainings that must be carried out in accordance with legal provisions. Most of the training is determined top-down, which the employees themselves have no influence on. Due to the reduction of costs, training dedicated to a given plant is not taken into account, and most often offers from the market are selected, the scope of which is very general, in order to fit the needs of people from various professions or positions. The trainers usually have no knowledge about a given company (company), and the training itself is boring and theoretical.

In addition, the industry places too little emphasis on the organization of targeted soft training, and individual thematic areas in this area of competence are carried out separately, without mutual relations, which makes it impossible for employees to use them effectively at work. The need for connection and mutual relationship of individual training blocks was emphasized – training should be mutually interconnected, create a coherent program taking into account the procedures and provisions of normative acts prevailing in the company.

The participants of the interview unanimously have a very negative opinion about online training and definitely prefer training taking place in a stationary form (F2F). As attractive forms of training, they indicate formulas using new technologies (e.g. using VR) and multimedia (films) and activating participants - in an interactive form (practical tasks, case studies, etc.)

What can be improved in the area of training:

- Provide more soft training, primarily in the field of communication and diversity management;

- Training should be tailored to the needs of different groups of employees, i.e. a different curriculum path for blue-collar positions and a different curriculum path for managerial staff);
- Organize discussion meetings, exchange of views (profiled conversation, led by a moderator);
- Develop a dedicated training package for given positions, adequately to the competences, qualifications and skills required for this position;
- Introduce training in new technologies for employees;
- Use only training conducted by competent trainers who know the specifics of the industry and a given company;
- Implement practical on-the-job training – from the acquisition of knowledge, through the performance of activities (application and practical improvement of the acquired knowledge), to the verification of learning outcomes.
- Trainings should be conducted in a stationary form (F2F), in an interesting, engaging and interactive way using diversified methods, new technologies and VR or AR.

Remark: after reviewing the results of the online survey, the FGI participants indicated that in order to be able to make unambiguous conclusions about the competence gaps for the individual competence profiles, a detailed verification of the individual survey records and their interpretation by the interviewees is necessary.

5.3. SUMMARY (all FGIs)

In the general opinion of interview participants, the ethos of the "industrial worker" as a co-creator of wealth should be (re)built, and the workers themselves should be made aware of their role/importance in the entire production process.

Participants of focus group interviews confirmed that there is a serious problem of replacing experienced workers in copper industry companies, which are not attractive to young people in terms of working conditions (including payments). The work culture of the younger generation is not conducive to employment stability (changing jobs every 3-4 years on average), which would allow them to explore technical issues and gain the necessary competence and experience in the sector. Therefore, it is important to point young people to opportunities for professional development and to chart paths for advancement.

It was stressed that copper processing is a highly specialized field, requiring, on the one hand, basic technical knowledge of, for example, the physical and chemical properties of copper, or metallurgical processes, and, on the other hand, facing the challenges of advanced green and digital transformation. In other words, it needs to compose basic (but not easy) knowledge and skills in physics, chemistry, mechanics with modern automation and digitalization, including virtual and augmented reality (VR, AR) applications or implementation of artificial intelligence in the specific functions of the employees in the sector.

It was also pointed out that training needs in soft skills, are equally important and urgent. Interview participants indicated skills such as: communication, collaboration & teamwork, leadership, analytical thinking (data interpretation), flexibility.

FGI's participants stressed the need to increase the effectiveness and attractiveness of training processes through interactive simulation/ augmented reality tools. At the same time, the value of face-to-face classes enabling interaction, direct exchange of opinions, experiences etc. was emphasised.

6. Good practices for the copper sector from non-RIS International territories

Meeting the growing demand for copper is not a simple task. It requires a range of talents and expertise to get to the copper without harming the environment more than the copper ultimately helps it, as a material utilized in renewable energy sources. Resources are significantly more difficult to find and extract, and successful companies are increasingly those that transform practices and invest in technology—all while being swift about it. But while these forms of innovation build business resilience and overall organizational capacity for adapting to rapid change, a key gap in the mining sector remains the impact of these changes on talent attraction, development and retention.

Below we present some examples of good practices in this area.

6.1. Talent acquisition and retention– NORCAT approach (Canada)

NORCAT was founded by a team of business and academic visionaries who recognized the need for an organization to promote, educate, and support local entrepreneurs, tech innovators, and skilled labour workers to enable long-term and sustainable economic and social prosperity for Northern Ontario[4]. Together with Deloitte Canada have analysed key trends in the mining industry, where the focus shifts to the people equation. They examined where investments in innovation and technology are having an impact on the work, workers and the mining workplace, for both front-line employees and management. More importantly, they provided an approach to talent acquisition and retention that organizations can use right away to identify and address these impacts.

In the mining industry factors contributing to the shift in the mining work, workforce and workplace can be summarized across three drivers:

[4] NORCAT - a not for profit technology and innovation centre headquartered in Greater Sudbury, Ontario, Canada. It provides health and safety training for the mining industry, occupational health and safety services, and product development assistance to small, medium and large industrial enterprises. NORCAT provides access to one of the few training mines in North America; https://www.norcat.org/ [accessed 18.06.2024]

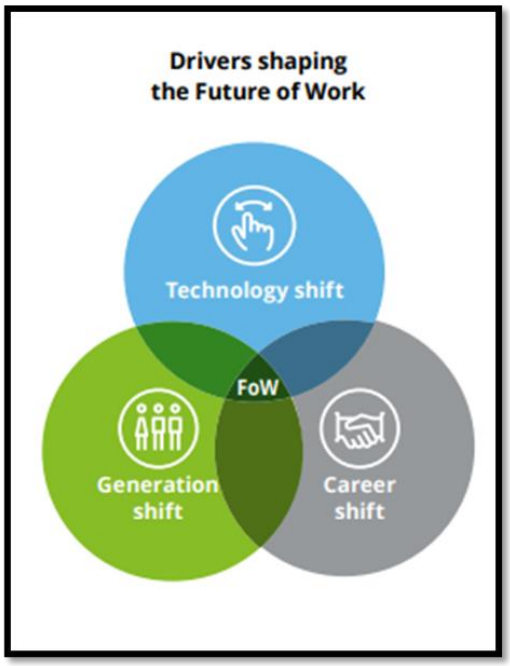


Figure 7. Diversity shaping the future of work
Source: Deloitte, 2022, p. 2

Technology shift

Technology has never been so extensive, interconnected and inexpensive, helping to lower operating costs and making some work less dangerous — in the use of remotely operated equipment in underground blasting, for example, or in just decreasing overall equipment downtime since workers can continue to operate machines remotely and from a safe distance. At the same time, however, investment in technology is not simply about acquiring the latest apps and/or recruiting more people from the gaming or "joystick" generation — technology shift is ultimately about making digital tools core to an operation's mindset and integrating them in the overall flow of the work and workplace.

Furthermore, generic training and development programs that provide fundamental knowledge of how this technology works, the skills to operate equipment, trouble-shoot technology and install equipment in an underground mining environment simply don't exist. To make incremental real-time decisions in their roles, a new generation of workers will need to be trained.

Generation shift

For an industry that has historically been perceived as very traditional and structured, mining companies now must also appeal to a dynamic generation. In Canada, the mining industry is on the verge of undergoing a human capital transformation unlike at any time in the industry's history. At the same time, an ageing workforce, pending labour shortages, continued development in rural/vulnerable communities, as well as significant investments in emerging and innovative technologies, are driving the need for new and innovative training and development programs to educate miners on the "new world of work." Here, the industry will need to continue building new kinds of partnerships, including with educational institutions and other

stakeholders such as NORCAT to ensure new and existing workers are up to speed on the efficient, productive, and safe use of new technologies.

Career shift

The very nature of careers is changing, with job and career-hopping the new normal, and the half-life of skills pegged at roughly 5 years. This will continue to have an impact on lower skilled workers who need upskilling. It will also complicate the recruiting of "gig economy" workers who arrive with virtual reality and AI-related skills and who perceive company "loyalty" as measured in months, not years. For the mining industry, a key challenge will be helping frontline employees become "protean" workers—where they too shift to self-directed careers and embrace upskilling, and where companies will be challenged to find a balance between managing their resources internally as well as closing the skills shortages through outsourcing.

Research suggests that upwards of half of all current jobs for frontline workers will be lost to automation and other forms of technological advance, putting even more pressure on organizations to ensure they remain competitive. In many ways, however, the concern is not so much about frontline workers being able to adapt and keep pace with disruption and changes to work, but around the organization's ability to adapt along with them.

Talent approach methodology

Framing one's thinking around an overall talent strategy is a critical factor in determining an organization's success. The approach proposed below is designed to help leaders as they conceptualize the work, engage their frontline workers and think through the overall workplace experience.

The process is broken down into a set of five questions to be answered in each of the contexts of the work, worker and workplace (Fig.8).

	What are our goals and aspirations?	Where will we focus?	How will we succeed?	What capabilities must be in place for us to succeed?	How do we measure ongoing success?
	Key questions that should be considered are...				
Work	· What are the business goals and aspirations, and what role should talent strategy play to deliver on them?	· Which employee stakeholder groups are needed to achieve this vision and how will they be engaged?	· What is our value proposition for each employee stakeholder group? What is our key point of differentiation? · What does the business strategy require of our people that is different? · How should we prioritize our talent strategy initiatives?	· Which talent and organizational capabilities are required to enable our culture and the future direction of the business?	· How do we govern and manage as the organization's skills requirement changes? · What are the critical success factors and KPIs we will measure against?
Worker	· What does the future employee experience look like? · How ambitious do we want our employee experience to be?	· How are employee needs changing? What are the unmet needs?	· How will we attract and retain top talent? · What is the role of innovation in achieving the future employee experience?	· What partnerships and ecosystems will be required? Who will manage and lead them?	· How do we engage and communicate with an increasingly diverse group of employees during this change?
Workplace	· How will employees interact with each other and conduct their work?	· What is the level of technology needed by our employees to achieve the organization's strategy?	· How can digital technologies be leveraged to improve business outcomes and connectivity?	· How do we prioritize and sequence the implementation of initiatives into the workplace?	· How do we iterate our approach to easily adopt new technology and scale initiatives?

Figure 8. Redefining the talent approach
Source: Deloitte, 2022, p. 5

6.2. Skills Map - Methodology of Minerals Council of Australia

To identify the skills required in the future workforce the skills map following methodology was applied. It identified a set of future-focussed skills and added it to the current skills landscape to culminate in a skills map. A 'Technology Impacts Index' was developed from the future of work literature and applied against the occupations to identify how technology and automation would affect the prevalence of occupations in the future, and the subsequent impact on the skills required in the future. Occupations were divided into three comparative 'Occupation Type' categories based on the likely impact of technology and digital, these were: automated, redesigned, and enhanced. This mapping was then used to predict the future composition of the workforce which was then mapped onto the skills map to identify the likely movement or prevalence of each of these skills as a proportion of the future workforce.

This methodology is illustrated in Figure 9.

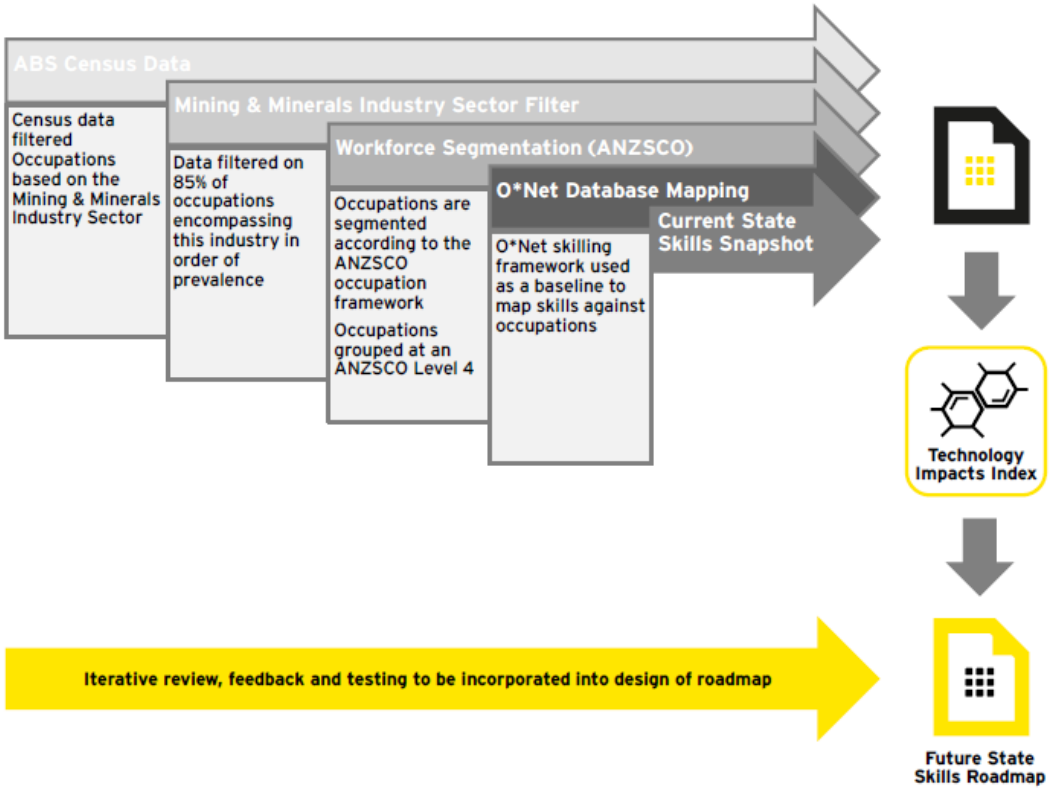


Figure 9. Methodology of Skills Map; Source: EY, 2019.
Where: ANZSCO - Australian and New Zealand Standard Classification of Occupations;
ABS Census Data – data from Australian Bureau of Statistics

From this analysis the most prevalent skills in the industry were identified along with those skills that are likely to both increase and decrease in demand in the future. Throughout this process, there was an iterative feedback and refinement to ensure the Skills Map was both an accurate representation of the data and fit-for-purpose for the minerals industry. It was concluded that all industry *Skill Types* are observed as increasing in demand, with some skills in the Technical skill type category representing decreasing/slow growth in demand. Overall, *System*, *Basic* and *Social Skills* type categories present the greatest demand of skills into the future. This is illustrated in Figure 3 (see section *Skills gaps in copper sector according to desk research* of this report). It also illustrates 'Skills Movement' capturing the prevalence of skill type between current and future workforce proportions, adjusted for the impact of technology. If the skill has a positive growth percentage it is interpreted as having growing future demand, and vice versa if negative.

6.3. Recommendations to address human capital demand and gaps for large scale mining in Chile

According to estimates (The Workforce for 2021-2030 Large-Scale Mining in Chile, 2021), companies in Chile are bound to attract over 25,000 new talents in the next 2021-2030 mobile decade. The study analysed and delved into the Chilean educational offer available for the mining industry as well as into the human capital demand and gaps projected for the next decade. As the trend shows, most human capital demand is seen to occur among mechanical Maintainers, electrical Maintainers, and equipment Operators (mobile and fixed) that, in the aggregate, account for a cumulative demand of over 18000 workers. On the other hand, the three least required profiles continue to be those projected to produce the highest number of graduates from tertiary education (Geologists, Extraction Specialist Engineers, and other Geology-related occupations).

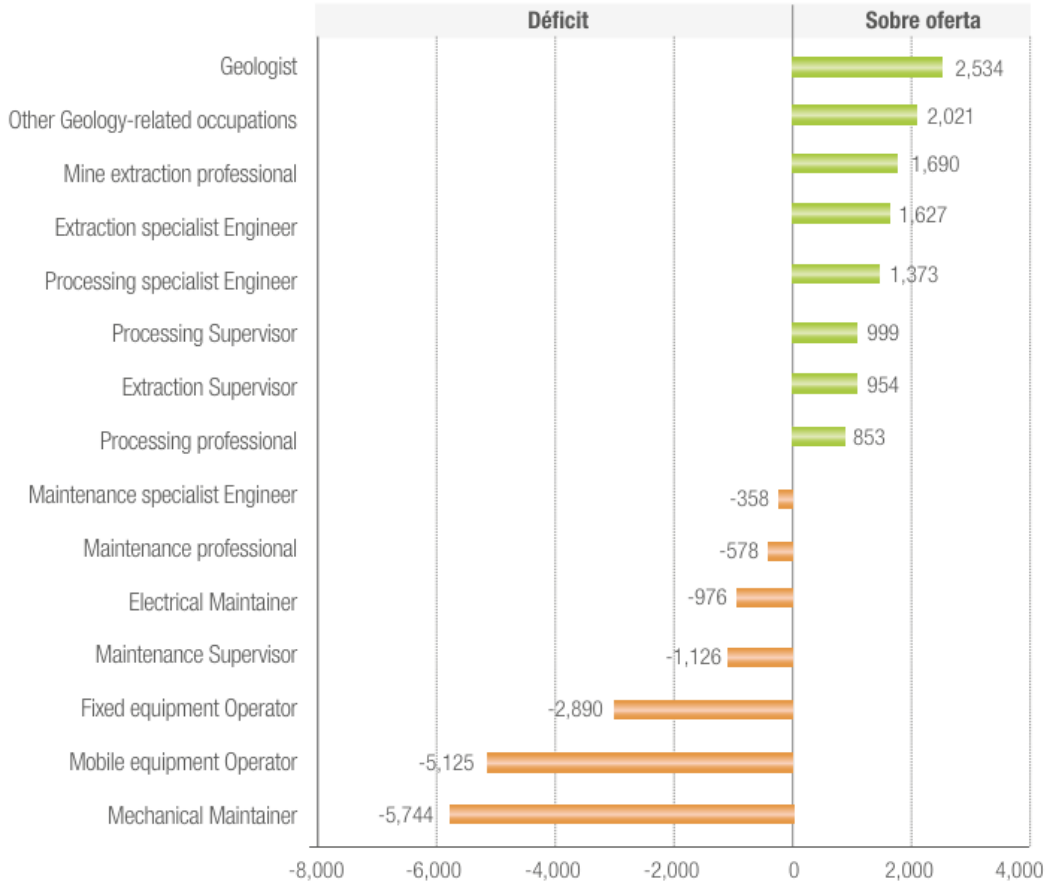


Figure 10. Human Capital Gaps per profile, by 2030
Source: The Workforce for 2021-2030 Large-Scale Mining in Chile, 2021, p. 75

Given the above scenario, reinforcing the sectoral coordination efforts to increase the quality offer of the four profiles that have consistently shown gaps in the last editions of this study -mechanical Maintainers, electrical

Maintainers, mobile equipment Operators, and fixed equipment Operators seems to be the right path to follow.

Experts of Mining Skills Council - authors of the report - suggest the following recommendations to address human capital demand and gaps:

- Draw attention on the positive effects reported by companies that have hired graduates from different MSC Quality Seal-awarded and MQF-aligned institutions and programs. For example, companies might homologate the formation time required to complete MSC Quality Seal-awarded specialties to work experience for enrolment or hiring requirement purposes;
- Reinforce teachers' skills with methodological strategies and assessments applicable to the formation of Maintainers and Operators;
- Increase the number of student trainee vacancies and intensify alternance or dual formation programs by installing in companies the required capacities to accommodate a larger number of students;
- Hands-on training in latest real equipment models (e.g., Caex 794 and 797 CAT for mobile equipment Operators) and not simulators only;
- Put in place dissemination and sensitization strategies among young people on technical formation, mainly for Maintainers and Operators programs[5];
- Increase e-learning opportunities for Operators and Maintainers profiles by applying hybrid models: knowledge theories are conducted through the internet while practical components are provided face-to-face;
- In order to keep training costs low, the election of e-learning and b-learning modes must be encouraged in bidding and hiring processes while training indicators (training hours /total worked hours) should be increased by introducing e-learning training in operations and maintenance, mainly;
- Conduct a survey on the current technological level existing in each mine site and identify their preparedness to move to more advanced automation and optimization processes. This will help individualize the gaps relative to expected potentials which will, in turn, help define the real human capital needs that meet the skills required by the technological absorption process.
- Incorporate non-formal and formal (vocational high schools, VI, VTC, and universities) education players into the joint work, as upgrading the current skills is a required measure to face the new challenges posed by the absorption of new technologies.
- Attract new talents to the industry 4.0 and promote education-work pathways through the homologation of certifications granted for work skills and/or to graduates from MSC Quality Seal-awarded institutions to years of experience.

[5]For example: Mining Skills Organization Pilot (MSOP, Australia): accelerated innovation for mining 4.0 is committed to making vocational formation and training become the education-work pathway of choice for employment in the minerals industry. The project consists of four main hubs: i) apprenticeships; ii) digital transformation; iii) attraction and retention; and iv) qualifications reform trials; https://ausmasa.org.au/mining-organisation-skills-pilot

6.4. Quellaveco in Peru –contribution to society's sustainable development

The International Copper Association (ICA) is the leading advocate for the copper industry. It is a nonprofit organization bringing together the copper industry and its partners to make a positive contribution to society's sustainable development goals and support markets for copper. It is worth noting that 2 industrial partners of SkiComCu (KGHM Polska Miedź and Aurubis) are active participants in these activities, which is shown in the attached infographics (Fig. 10).

The International Copper Association connects the upstream (mining and smelting/refining) and downstream (fabricating) parts of the copper value chain, provide a common platform for the copper industry to advocate for our shared interests with policy makers, regulators and other key stakeholders (e.g., the United Nations, NGOs, etc.). ICA and its Copper Alliance partners are active in more than 60 countries worldwide. One of them is a leading global mining company AngloAmerican which is committed to developing and investing in its regional workforce, protecting not only workplace wellbeing but also jobs through sustainable technological innovation.

AngloAmerican has developed a Quellaveco copper project in Moquegua, Peru, which is the world's second-largest producer of copper. It is committed to working hand-in-hand with community programs in the Moquegua region. Quellaveco is a fully digital mine with a safe and positive working environment. They invest in extensive training programs to prepare local personnel to develop skills and expertise to manage automated technology. Technicians will analyse real-time data and predictive modelling to track and improve operational efficiency and safety, from the removal of the ore to its processing and shipping.

The importance of local involvement for positive societal and economic impact is being highlighted. AngloAmerican is committed to developing and investing in its regional workforce, protecting not only workplace wellbeing but also jobs through sustainable technological innovation.

Conscientious Mining at Quellaveco project: https://www.youtube.com/watch?v=DMc21J1hiFQ

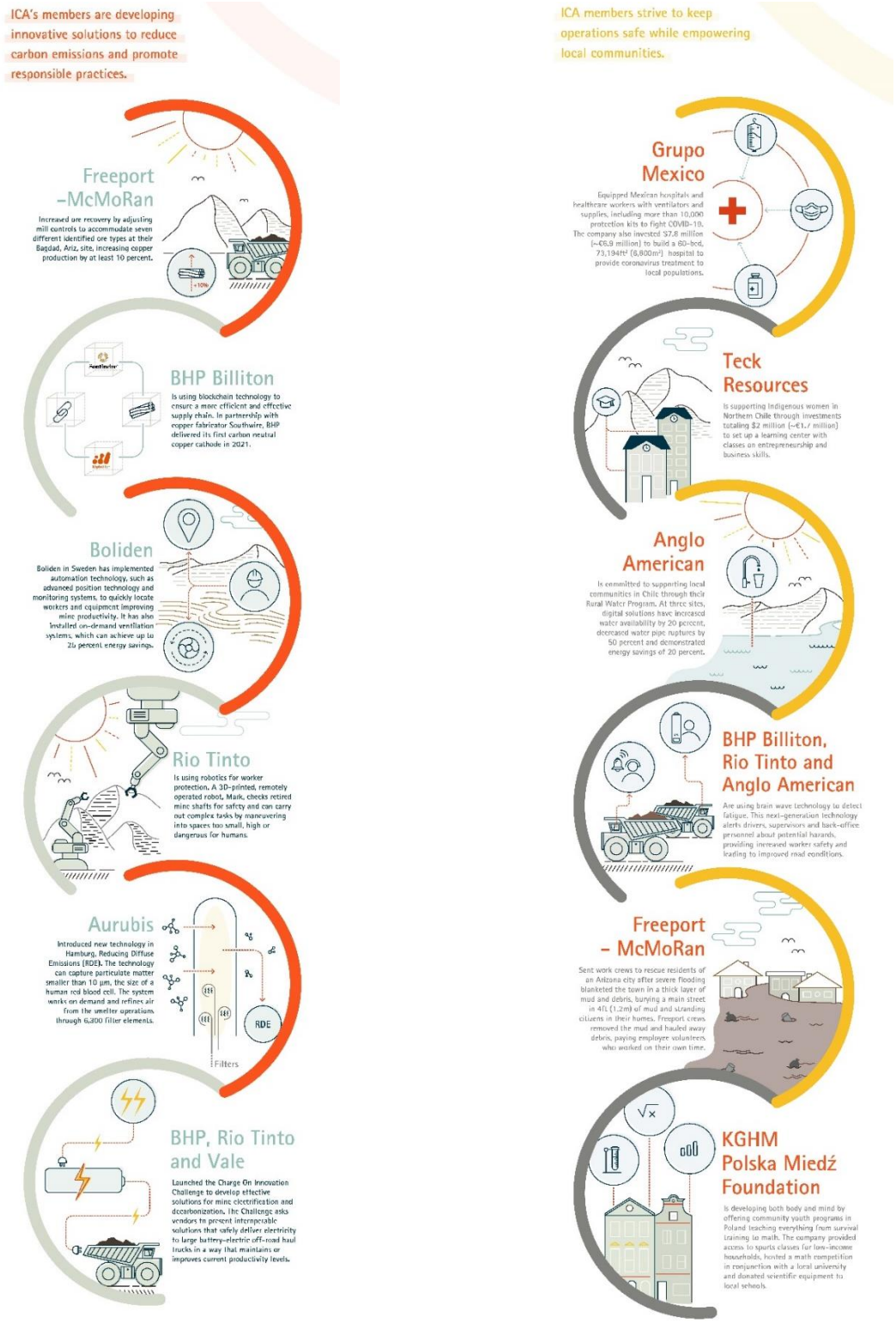


Figure 10. Infographics on activities of ICA's members; Sources: https://internationalcopper.org

6.5. Mining Qualifications Authority in South Africa – skills quality assurance

The Mining Qualifications Authority[6] (MQA) prides itself in ensuring that the Mining and Mineral Sector (MMS) remains at the cutting edge of skills development. The improvement of the skills of South African workforce is imperative for the economic development of the sector, for the improvement of health and safety record and for the growth and wellbeing of all employees.

The MQA is responsible for administering a number of skills development initiatives. Skills programmes and learnerships aim to develop a skilled and educated workforce whose skills are recognised and valued in terms of the National Qualifications Framework (NQF). This is to ensure that the mining and minerals sector has sufficient competent people who will improve health and safety, employment equity and increase productivity. The following six strategic priorities were adopted by the MQA Board to promote skills development in the sector:

- Promote efficient and effective governance and administration;
- Improve skills development planning and decision-making through research;
- Promote work-based skills development to support transformation in the mining and minerals sector;
- Facilitate access to occupationally directed learning programmes for the unemployed;
- Support mine community training initiatives to access economic opportunities;
- Ensure the delivery of quality learning programmes in the mining and minerals sector.

The MQA has a Board structure consisting of the state, employer, labour and community organisations within the sector. The expertise and experience of this partnership with key stakeholders proposes guidance to the MQA's strategic direction. This is underpinned by the Business Plan, the Constitution and Sector Skills Plan (SSP). The SSP determines the skills needs in the sector:

The MQA's activities are funded by the skills levy collected from employers in the mining and minerals sector by the South African Receiver of Revenue (SARS). The MQA disburses the funds back to the industry in the form of grants for providing training and supporting learners in special projects.

What is a Skills Programme?

A skills programme is one of the learning programmes which is recognised as one of the most dynamic and relevant features of the education and training system in South Africa. The role of a skills programme is to up-skill and multi-skill the South African workforce as well as new entrants into the relevant economic sectors. The provision of skills programmes assists workplaces to develop meaningful and relevant career and learning pathways for employees in a highly accessible manner. This in turn leads to the improvement of workplace practices, employability and mobility of the South African working force.

[6] Mining Qualifications Authority: https://mqa.org.za/

The provision of skills programmes assists workplaces to develop meaningful and relevant career and learning pathways for employees in a highly accessible manner. This in turn leads to the improvement of workplace practices, employability and mobility of the South African working force.

The target group for the programme is young unemployed, historically disadvantaged South Africans who have competed degrees/diplomas/ in disciplines as identified in the MQA Sector Skills Plan:

- Metallurgical Engineering
- Jewellery Design Manufacturing and related qualifications
- Geology
- Mining Engineering
- Mechanical Engineering
- Mining Surveying
- Electrical Engineering (Heavy Current)
- Industrial Engineering
- Chemical Engineering (Mineral Processing)
- Environmental Health and Management
- Analytical Chemistry
- Electro Mechanical Engineering/ instrumentation Mechanician
- Occupational Health and Safety
- Occupational Hygiene

6.6. Enhancing awareness about mining careers in Canada

Developed in partnership between the Mining Industry Human Resources Council (MiHR) and the Canadian Institute of Mining, Metallurgy and Petroleum (CIM), the *We Need Mining. Mining Needs You. Career Ambassador Program* raises awareness among diverse youth and key influencers about the career opportunities mining offers and the sector's role in environmental sustainability, social responsibility and technological innovation.

Objectives of the program:

- Enhance awareness among youth of the benefits of careers in mining, including financial rewards, working with cutting edge technology and the ability to make a positive difference to the industry and society.
- Improve youth perceptions of the sector, with a focus on mining's role in environmental sustainability, social responsibility and technological innovation.
- Encourage youth to seek opportunities in the sector and choose mining careers.
- Develop leadership and confidence skills among Career Ambassadors.
- Engage diverse youth and organizations in mining career awareness.

Youth and other jobseekers need to see mining as an innovative, challenging and rewarding career choice – and the mining workforce needs to reflect the diversity of Canada and the communities in which mining companies operate. Knowledgeable and enthusiastic Career Ambassadors deliver speaking engagements to youth in person and virtually to increase awareness, improve perceptions and encourage pursuit of careers in mining.

The most interesting and useful results of the program:

- The interactive world of mining careers: https://www.miningneedsyou.ca/world-of-mining/
- Interactive career quiz https://www.miningneedsyou.ca/interactive-quiz/
- Mining Needs You Career Book https://www.miningneedsyou.ca/wp-content/uploads/2022/08/MiHR-22-CareerProfiles_Aug22.pdf
- Scholarships to support future mining talent https://www.miningneedsyou.ca/scholarships/

It is worth using the Canadian experience when working on solutions aimed at supporting the development of the copper sector staff in RIS countries and building its innovation and competitiveness.

6.7. METS Ignited Australia – example of governmental support to "unlock" the growth opportunities

METS Ignited is an industry-led, government-funded Industry, Growth Centre for the Mining Equipment, Technology and Services (METS) sector. The objectives of the Industry Growth Centre is to accelerate commercialisation of innovation in Australia, enhancing industry skills and capabilities and growing exports in sectors of national competitive advantage.
METS Ignited uses direct funding of collaborative projects, Accelerators, Masterclasses and Cluster Initiatives to invest in the development of multiple innovation hubs, precincts, consortium and support organisations. Some of their initiatives:

- Current and Recent Accelerators: https://metsignited.org/accelerators/
- QuantumTX Australia 2023 Cross-Sector Technology Accelerator is a business incubator for technology centric scale-ups, SMEs or researcher with an innovation sitting at a Technical Readiness Level (TRL) 8 or 9.
- Space and Technology Incubator Program helped start-ups and small-to-medium companies develop technologies and services that support remote operations, including in robotics, artificial intelligence, satellite communications, simulation, digital systems and interoperability.
- The Customer Relationship Management Masterclass explored the benefits of a CRM, how it needs to align with the customer facing processes and the steps businesses can take to make this happen.
- The Export Readiness Masterclass was designed to enhance essential knowledge and preliminary connections to help achieve a meaningful boost to organisations' capability.

A Roadmap for unlocking future growth opportunities for Australia (CSIRO Futures, 2017) explores global mining megatrends and Australia's comparative advantages and identifies opportunities where Australian Mining Equipment, Technology and Services (METS) companies can be internationally competitive. These opportunities are supported by a discussion of the underlying science and technology investments and management skills, culture, processes and business models required to unlock them (Table 12).

Table 12. Summary of changes per growth opportunity

Growth opportunity	Business enablers			Enabling science and technology
	People and skills	Culture and collaboration	Process and standards	
Data driven mining decisions	Foster skills to improve interpretation, modelling and decision making using big and small datasets.	Improve how the business uses and responds to data, moving from reactive to proactive.	Address interoperability and integration issues, working with industry and research to implement appropriate data standards.	• Sensors and the Internet of Things • Analytics and optimisation • Visualisation • Cyber security
Social and environmental sustainability	Establish cross-disciplinary skills – engineering, financial, social, environmental and economic – to better demonstrate the long-term value proposition of triple bottom line solutions.	Connect miner, government, social and environmental groups to support and improve technical and regulatory decision making processes.	Assess operational and regulatory barriers that may limit social and environmental monitoring and reporting, and the associated liabilities.	• Monitoring and sensing • Decision support and stakeholder engagement • Site and equipment design
Exploration under cove	Develop geophysical and geochemical knowledge, data analysis, modelling and geographic information system (GIS) skills.	Increase multidisciplinary collaboration and support activities that improve decision making and resource governance.	Identify and promote best practice in data acquisition, processing, sharing and integration to improve data quality and reduce issues with integrating large exploration datasets.	• Next generation drilling technologies • Expanding exploration knowledge and processes
Advanced extraction	Develop skills in installing, operating and manufacturing advanced extraction technologies as well as advanced drilling, sensing, sorting and processing technologies.	Improve alignment of performance drivers and foster interdisciplinary collaboration across mining, metallurgical and geological personnel.	Support development of regulatory frameworks for advanced extraction technologies, including standards for interoperability of technologies.	• Advanced drilling and cutting technologies • Sensors and ore sorting • Integrated beneficiation technologies
Mining automation and robotics	Foster skills in the operation and maintenance of autonomous and robotic equipment; develop technical expertise in material sciences and nanotechnology.	Challenge the role of automation and robotics in mining, and use change management to address cultural acceptance of technologies.	Support sector wide actions to address interoperability issues, leveraging existing initiatives.	• Machine vision, materials and robotics • Control systems and algorithms • Virtual and augmented reality

Source: CSIRO Futures, 2017, p. 6

As emerging economies continue to develop their mining sectors, support in developing applicable skills, services and technologies will be required for efficient and sustainable exploitation of mineral reserves. In advanced economies, increased adoption of specialised digital technologies are resulting in greater collaboration, new business models and fierce competition for talent.

In order to "unlock" the various **growth opportunities in the area of people and skills**, METS companies should consider the following actions:

- Develop staff to have both domain and data / digital expertise, strengthening their comfort and ability to mathematically and algorithmically interpret, model and make decisions using big (and small) datasets.
- Tap into the skilled ageing workforce to retain globally differentiated mining expertise, particularly given the new players and low barriers to entry with disruptive digital technologies.
- Work with universities to develop 'mining and analytics 101' courses for METS to increase industry maturity, collaboration and knowledge of specialist (but often siloed) functions.
- Develop cross-disciplinary skills by combining technical and engineering knowledge with social, environmental and financial / economic training to better demonstrate the long-term value proposition of environmental and social sustainability challenges.
- Work with universities to develop new training courses that embed total lifecycle assessments into decision making and equipment design.
- Develop system thinking capabilities that account for total lifecycle and circular economy opportunities and risks across the mining value chain.
- Develop geophysical and geochemical knowledge in parallel with data sciences, modelling and geographic information system (GIS) skills. For example develop statistical modelling and interrogation techniques to improve targeting using available data or gaps (uncertainties) within datasets.
- Work with universities to develop graduates that understand established geological fundamentals as well as emerging computational and analytical skills.
- Improve field skills to take advantage of real-time (or near real-time) sensing and targeting data.
- Invest in developing staff with skills in installing, operating, and manufacturing advanced extraction technologies and the necessary underlying drilling, sensing, sorting and processing technologies.
- Develop staff with financial capabilities to demonstrate the long-term value proposition of advanced extraction technologies through assessment of the characteristics and mineralisation of rocks. For example, in ISR, critical parameters include hydrogeological conditions, permeability, leachability, location of mineralisation and chemical composition.
- Draw on non-mining industry innovations and approaches to improve internal technology and engineering approaches towards standardisation, miniaturisation, modularity, repeatability and integration.

- Identify workforce skills gaps in the application, operation and maintenance of autonomous equipment and technologies. This could include: understanding specialist and IT skills required for future site technicians and developing approaches for future remote operators that do not have first-hand experience in a physical mine environment.
- Improve digital literacy skills to help manage and optimise autonomous and robotic fleets and equipment.
- Develop human-machine interface design skills to improve equipment adoption.
- Build on mechanical engineering, electrical engineering and computer science technical expertise to include material sciences and nanotechnology.

6.8. Inclusion & Diversity

The mining industry has traditionally been male-dominated and has not always been welcoming to people from diverse backgrounds. While much progress has been made on gender equity and diversity issues as well as respect for the communities that companies operate in, continuing to focus on diversity and inclusion and positive engagement with communities will help to attract a wider range of talent to the industry. Employing a diverse workforce has never been more important. To remain globally competitive and to attract the best and brightest, the mining industry needs the diversity of thought and experience that comes from employing people from different backgrounds. The mining workforce also needs to reflect the communities in which miners live and work, and that means actively seeking a mix of people across age and gender groups, cultural backgrounds, physical abilities.

According to Minerals Council of Australia, the number of women employed in Australian mining is growing. The goal is to achieve gender balance by 2025. Today women make up the majority of managers on its executive leadership teams. However, the top earners in the UK's mining industry are predominantly male. Women working in mining occupied 11.1% of the top-paying jobs in the industry, with the rest of the top spots (88.9%) occupied by men. On the other end of the pay scale, women occupied 19.6% of the lowest-paid jobs in mining industry. On average, women also received 32.9% less in bonuses compared to their male co-workers according to the UK Government's Gender Pay Gap Service. While much work still needs to be done to encourage women to consider a career in mining, company programs are making an improvement.

7. Conclusions: towards an integrated competence framework

Growing demand in EU and globally for copper is a fact. This metal is crucial for the green transition of EU countries since it is a key material for the development of many sustainability-related applications. It is an essential component of the electrical grid, as well as electric vehicles, wind turbines, and solar panels. In fact, copper is used in most renewable energy technologies, making it a critical resource for the transition to a low-carbon future. The importance of copper for the European economy is evidenced by the fact that this metal is included in the group of critical and strategic raw materials for the future of the EU[7].

At the same time, the EU copper ore mining and processing sector faces a number of challenges such as sustainability, circular economy, industry 4.0 & 5.0, all of which are related to changing competence requirements for employees. The most important technologies of the transformation process in copper sector companies are robotics and automation through drones, autonomous vehicles and remote-controlled operational systems, artificial intelligence, the internet of things, virtual reality.

In addition to the technological challenges, the "image" is equally important since the public perceives the copper sector as dirty, responsible for environmental degradation, and unattractive in terms of work condition (especially to young people). This causes a serious generational problem for the industry - it is difficult to replace experienced but ageing workforce with new generation employees who lack professional skills and are not particularly interested in mining careers.

In the context of constant change, it is important that companies in the sector look at workforce as an asset to grow, rather than a fluctuating resource, expendable in response to volatile changes in external environments. Adequately, the mining labour force needs to be equipped not only with the skills necessary now, but also skills of the future, i.e. future- proof. Mining operations require skilled workers who can incorporate new and more sustainable methods, operate heavy equipment, exhibit IT skills and ensure the safety of workers and the environment. Processing copper ore into usable metal requires ore characterization, chemical, and metallurgical expertise. Finding copper requires geological expertise. Obtaining the necessary environmental and other approvals requires regulatory and technical expertise across a number of disciplines and competencies to achieve and retain social acceptance. Mining companies, especially from RIS EU territories, should continuously invest in training programs to develop the skills and expertise needed to meet the demand for copper. This could include apprenticeships, internships, continuing education programs, or specialized programs to move across sectors.

Therefore, SkiComCu project aims to offer the copper sector innovative lifelong learning courses to help companies from EU RIS territories address challenges mentioned above.

The purpose of this report is to present the results of research work undertaken to identify competence gaps among current and future employees of the copper sector. This will allow the SkiComCu project partnership

[7] Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020 Text with EEA relevance. PE/78/2023/REV/1 OJ L, 2024/1252, 3.5.2024; available at: http://data.europa.eu/eli/reg/2024/1252/oj [19.07.2024]

(at the next stages of the project) to select thematic areas, develop and offer training courses that will meet the real needs of various groups of employees (foremen & operational staff, professionals & office staff, managers & senior professionals and HR personnel), and thus prove attractive and desirable for companies from EIT RIS countries.

The methodological approach included a triangulation of the research methods used: 1) desk research of relevant documents (incl. internal documents and information provided by the industrial partners of project), 2) on-line survey (for key competence profiles selected by project partnership as strategic for the future of the sector) and 3) interviews with representatives of different groups of copper sector employees (FGI). The report presents the results obtained from each of the above-mentioned research methods.

The dynamic transformation processes taking place in companies require employees to be able to adapt continuously to new situations and conditions. These skills will become increasingly important in the future. The analysis of the source materials and data collected during the desk research confirms that those skills can be grouped into the three categories: 1) Technological and digital skills; 2) Social skills and 3) Cognitive skills.

Core competences for the copper sector (connecting skills specific for the raw materials sector with professional and personal skills) include:

- General understanding of sustainability as well as energy and materials efficiency;
- Understanding of the copper value chain;
- Knowledge and understanding of geological processes.

Among the skills crucial for business transformation in the mining and metals sector, the following were indicated for improvement (reskilling and upskilling) in the next five years:

- Analytical thinking;
- Leadership and social influence;
- Creative thinking;
- AI and big data;
- Environmental stewardship;
- Motivation and self-awareness;
- Resilience, flexibility and agility;
- Talent management.

HR specialists in the copper sector underline the importance of changing staff recruitment and retention strategies and focusing on upskilling and retraining of existing employees. A higher investment in developing professional competencies of existing employees (upskilling) and in retaining employees with special skills (reskilling) is observed due to a low availability of new workers. It was also confirmed, that copper ore mining and processing companies, including the SkiComCu project partnership members (which are important stakeholders in the European and international copper market), are actively working on their own human resources management strategies/policies. For example, they build competency models, describe job positions, plan and implement training strategies for their employees. However, these are dispersed activities, tailored to a given company, not subject to any international standards.

Taking into account all the data and information obtained through the desk research, as well as its own experience, the Project Partnership proposes a catalogue of skills which are needed by workers in the copper sector in various job positions. They allow employees to carry out their professional tasks efficiently and to

ensure adaptation in the conditions of digital and environmental transformation (see section DESK RESEARCH for details).

In an online study on competence gaps for selected competence profiles considered as the strategic/key for the sector (Miner Self-propelled Mining Machine Operator; Solid Mineral (copper ore) Processing Technician; Mining Engineer Supervisor / Chief foreman; Mining Geologist; Metallurgical Engineer – Non-Ferrous Metallurgy; Copper Recycling Process Engineer), a diagnosis of both professional skills and social competences was undertaken. As far as professional skills are concerned, the following gaps were identified:

- Scientific and technological skills (e.g. understanding of metallurgy principles and processes; storage, loading and transport processes for solid copper mineral processing products).
- Safe working practices;
- Use of dedicated computer programmes (AI, big data, other digital skills);
- Preparing technical documentation and reporting;
- Information processing and sharing.

With regard to the so-called soft skills, the online research confirmed partly the results obtained at the desk research stage and showed gaps in the following competences:

- Problem solving;
- Adaptability and flexibility;
- Risk assessment and decision-making;
- Accountability (taking responsibility for actions taken);
- Relationship building – interpersonal communication;
- Teamwork;
- Social and entrepreneurial activity in the workplace;
- Motivating and self-awareness (e.g. motivating others and stress management).

The participants of the Focus Group interviews pointed to the necessity of (re)building of the positive image of the "industrial worker" in the public consciousness, with the special attention of local communities. One of the conditions seems to be that the industries provide opportunities and paths for professional development. This will contribute to the attractiveness of the copper sector, especially among young people, and it may bridge the observed generation gap. Educational pathways that enable mobility between the sectors are also necessary.

One of the main challenges for the copper industry is the ability to take advantage of the technological development. On the other hand, copper processing is a highly specialized field that requires basic technical knowledge, e.g.: the physical and chemical properties of copper, or metallurgical processes. On the other hand, in order to make the European sector innovative and attractive, employees and managers have to take into account the realities and requirements of the Industry 4.0, namely, the intelligent technologies, cloud connectivity, real-time data analysis, etc., which are used in remote control of activities, reducing the risk associated with the human-machine interface by implementing modern robotics and autonomous device solutions, virtual and augmented reality (VR, AR) applications, real-time monitoring and analysis of production through scanning, monitoring, and real-time decision-making based on incoming data (digital twin concept) etc.

As mentioned in the report, copper sector companies, alongside unprecedented levels of competition, are facing ever-increasing consumer demand for speed and adaptation. This is supported by the concept of

industry 5.0, which is a flexible industry, resilient to disruptions in supply chains and other crisis situations. It is also human-centric, sustainable industry in which companies strive to reduce their environmental impact by developing circular economy processes, reducing energy consumption, greenhouse gas emissions and waste, as well as avoiding the depletion and degradation of natural resources. This green transition and the development of the companies in the direction of the ESG generates and exposes competence gaps among employees of the copper sector at various levels, both in relation to the new regulations and to understanding of the business.

The examples of good practices from countries outside RIS and EU in general (e.g. Australia, Canada, Chile, South Africa) cited in the final part of the report may provide guidance and inspiration for activities planned at further stages of the SkiComCu project building and developing the potential of human resources in the copper sector companies (development of attractive training materials; development and implementation of innovative educational platform and tools; design and launch of two pilot training centres).

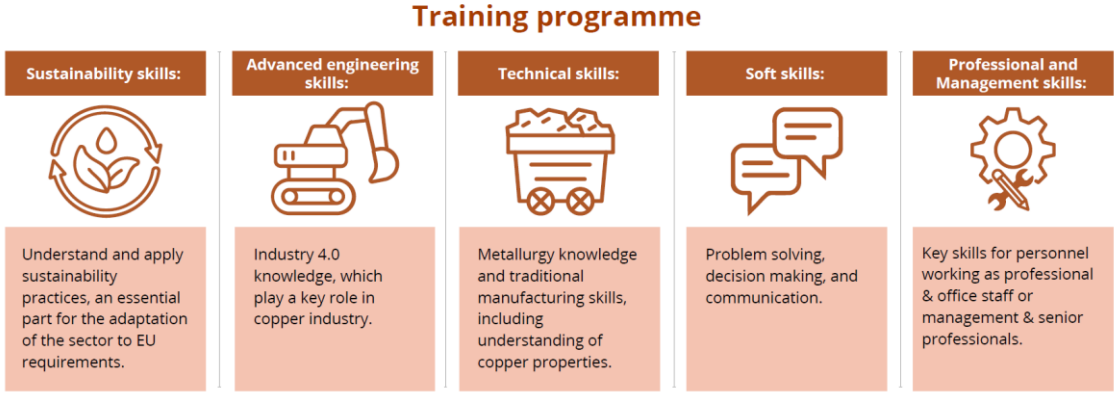
The value of the research results contained in this report results primarily from direct access to professionals – employees of copper ore mining and processing companies, representing different staffing levels of at a company (from operational employees to senior managers). They had the opportunity to express their views on competence gaps both by participating in questionnaire surveys and focus group interviews. Those two methods, based on the direct participation of end users of the SkiComCu results, were complemented by a thorough analysis of available scientific publications, reports and other sources on the training needs of the copper sector's workforce (based on broader research groups). A certain limitation in the research, which the team conducted within only 3 months, was the inability to cover all competence profiles functioning in this very complex sector of the economy. The profiles selected are considered crucial for the future of the industry by the SkiComCu project partnership.

The analysis presented in the report made it possible to diagnose the most urgent training needs of selected groups of employees in the Cu-sector, which was the aim of Deliverable 2.1. The results obtained are the basis for formulating a proposal for training topics and developing training materials corresponding to the real expectations of both current and future employees as well as copper sector companies (WP3). Training material and tools (WP4) will be implemented and tested in two experimental training centres (WP5).

The research tools (survey questionnaires) used in the diagnosis of the training needs and the implemented approach (based on competence profiles) may be used in the future as tools for repeatable (systematic) research. The list and descriptions of key competence profiles should be updated in line with the market developments.

Skills development initiatives need to be balanced across both technical and soft skill competencies. The future demands employees who are collaborative, innovative and system-thinkers, who can manage complexity and see the interconnectedness and the necessity for improvements across the copper value chain. Future employee of the copper sector should to be familiar with and be able to benefit from technological developments and digitalization in the field as well as understand and apply sustainability practices.

Therefore, the thematic scope of the desired training for employees of the copper sector can be schematically presented as follows:



Source: Partnership's elaboration

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