Green JOBS
RFCS RESEARCH PROJECT

Leveraging the competitive advantages of end-of-life underground coal mines to maximise the creation of green and quality jobs

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Deliverable 5.1

Identification and categorisation of key occupations

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Authors

Mariusz Kruczek, Karolina Jąderko - Skubis, Alicja Krzemień

CENTRAL MINING INSTITUTE – NATIONAL RESEARCH INSTITUTE

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Executive Summary

This deliverable identifies and categorizes key occupations in coal mining and renewable energy sectors, aligning with the project's objectives.

The focus is on a detailed analysis of the transition from traditional coal mining to renewable energy industries, with particular emphasis on the value chains of geothermal, photovoltaic, wind power, unconventional pumped hydro, batteries, and green hydrogen.

A comprehensive value chain analysis was conducted for both coal mining and renewable energy sectors. This allowed for the identification of critical roles that can be transitioned from coal mining to renewable energy industries, highlighting the potential for workforce reskilling and adaptability.

By analyzing current employment structures in coal mining, the report provides insights into roles that are well-positioned to support the growth of renewable energy projects. The findings serve as a foundation for policymakers, educational institutions, and energy companies to develop targeted reskilling programs. These programs will ensure that coal sector workers can successfully transition into green jobs, supporting the broader goal of a just transition. This effort also promotes social inclusion and workforce sustainability, contributing to global climate change mitigation objectives.

1 Introduction

As the transition process towards a greener economy advances, many industries, including traditional ones like mining, are re-evaluating their practices to align with environmental sustainability. Coal mining, which, despite reaching the end of its economic life, offers an opportunity to repurpose its infrastructure for renewable energy projects. This transformation requires new competencies and the development of "green jobs." These new roles are focused on emerging sectors such as renewable energy, including wind, solar, and geothermal power. The creation of these green jobs highlights the need for reskilling workers from traditional industries like coal mining, offering them a pathway to participate in the evolving energy landscape.

Key occupations in renewable energy sectors require a diverse set of skills, ranging from technical expertise in engineering and project management to new qualifications in sustainability and environmental sciences. Workers transitioning from coal mining may leverage their existing skills in areas such as logistics, heavy machinery operation, and technical maintenance, while also acquiring new competencies essential for renewable energy systems and technologies. This shift toward sustainable energy systems is a vital component of achieving global climate goals and requires a well-trained workforce capable of navigating the challenges and opportunities that come with this transformation.

The aim of this report is to identify and categorize the key occupations necessary for transitioning from traditional coal mining to renewable energy sectors. The focus is on leveraging the existing infrastructure of underground coal mines nearing the end of their economic life to support green job creation. The main sections of the report include a value chain analysis of both coal mining and renewable energy sectors. The report highlights the potential for repurposing mining jobs through reskilling, ensuring workforce adaptability in the evolving energy landscape.

2 Methodology

The methodology for this research focuses on identifying and categorizing key occupations within the coal mining and renewable energy sectors using a value chain approach. This task involved direct collaboration with mining companies, which provided valuable data about their employment structure, specific job roles, and the current workforce situation. The identification of occupations relied heavily on input from mining companies, specifically job descriptions from the coal mining sector, as well as their operational needs and future transitions to renewable energy.

The conceptual approach to renewable energy occupations was developed through extensive expert knowledge and experience. This method combined qualitative insights from industry professionals, gathered through interviews and collaborative discussions, with a broad literature review. The literature review offered a comprehensive understanding of roles required in renewable energy, such as those in geothermal energy, photovoltaics, wind power, and green hydrogen. It also facilitated a comparison of these roles with traditional coal mining jobs, aiming to explore potential overlaps and transitions for workers moving from mining to renewable energy sectors. Additionally, the research employed a thorough review of existing models in both coal mining and renewable energy.

The structured analysis of value chains was critical for understanding the key roles that contribute to the successful operation of both sectors. This process involved mapping each stage of production, from equipment manufacturing to installation and maintenance, and identifying the occupations required at each stage. The integration of knowledge from both sectors, supported by the value chain methodology, ensured that the categorization was comprehensive and aligned with current industry needs.

Expert input played a crucial role in clarifying the competencies and qualifications required for key occupations in both sectors. Furthermore, the literature review, which included both industry reports and academic studies, ensured that the research reflected the latest developments in energy transformation and that the categorization was up to date. Several detailed tasks were carried out to ensure a comprehensive understanding of key occupations in both industries:

- **Identification of key occupations**. Based on data from mining companies, detailing current employment structures and job roles. Expert knowledge and industry reports ensured that the most critical roles were identified.
- **Development of a comprehensive value chain template**. This outlined various stages of both coal mining and renewable energy operations, from project development to installation, operation, and maintenance. The template helped align mining roles with those in renewable energy sectors.

- **Analysis of value chains**. The specific value chains of mining companies in countries like Poland, Slovenia, and Spain were analyzed to identify existing roles and compare them to those in renewable energy technologies. Roles were categorized systematically based on their significance in the production process.
- **Survey assumptions for occupational flexibility**. This aimed to understand if mining employees could transition into renewable energy roles. The survey gathered insights into the adaptability of the mining workforce, focusing on the skill sets needed for new green jobs.

This methodology did not focus on competency gap analysis but rather on the identification and classification of roles crucial to both sectors. Competency gap analysis will be addressed in deliverable 5.2, following competence mapping in the mining and renewable energy sectors. The importance of expert knowledge and direct input from mining companies in creating a precise map of essential occupations for the energy transition is emphasized. This foundational work will guide future studies, particularly in the areas of reskilling and workforce development, as the renewable energy sector continues to grow.

3 Value Chain Analysis

Value chain analysis in the context of the energy transition is becoming a key issue in view of global efforts to achieve a low-carbon economy. As energy systems transform from the fossil fuel dominance to renewable energy sources, existing value chains must be transformed and new ones must be created, with different challenges and opportunities.

One of the main challenges of the energy transition, is the need to integrate different stakeholders in order to develop new sustainable business models. Integration of different stakeholders along the value chain may become essential in the area of innovative and disruptive technologies (such as hydrogen), where close collaboration between producers, distributors and consumers is crucial for successful market introduction (De Blasio & Zheng, 2022; Riva Sanseverino & Luu, 2022).

However, it should be noted that the segmentation and separation of value chains allows for service and product differentiation, which can increase competitiveness in areas where companies can offer unique solutions. In the context of renewable energy development, segmentation can lead to the creation of market niches where specific technologies gain an advantage through unique value (Peng et al., 2024).

Energy transformation depends significantly on technological innovations that affect the efficiency of production processes and supply chain management. Companies need to analyze their value chains to identify areas for optimization and minimize environmental impact. Research shows that effective supply chain management can lead to increased competitiveness in the renewable energy market, which is particularly important in the context of global efforts to reduce CO2 emissions (Zheng et al., 2022).

The value chain analysis was carried out for each of the conventional and RES sectors. However, it should be noted that for the coal-mining sector, this analysis was carried out taking into account the specifics of the project partners, who supported this analysis process by providing the developed value chains specific to their company.

In the case of RES, an attempt was made to conceptualize the value chains with a sectoral instead of individual approach as a goal. This is to ensure the development is an universal approach.

The correlation between value chains and occupations is direct and strong. It refers especially to the way in which different professions contribute to the creation of value in the highlighted processes - the production of goods or the provision of services. The role of the occupations and the quality of the execution of their work, whether directly involved in the creation process or as a supporting element - contributes to the success of the entire value chain.

Value chain analysis is the first step in identifying occupations, because it defines key processes and also indicates which activities and roles in the organization / sector / industry have the greatest impact on the final value of the product or service provided. Based on this analysis, it is possible to identify those occupations that are most important for achieving value and consequently - competitive advantage.

Accordingly, research was carried out that included:

- understanding and identifying operations and activities carried out in the organization / sector / industry (as applicable) performed to produce a product / deliver a service;
- identifying primary and supporting processes, according to M. Porter's approach;
- identification of value flows, highlighting specific processes for a given example;
- value chain mapping.

As a result, value chains for mine sector in Slovenia, Spain and Poland were prepared and also conceptual value chains for RES

3.1 Mine sector value chains

Over the decades, the mining sector has played a key role in the economic development of many countries and regions, providing the raw materials necessary for heavy industry, energy and infrastructure. Over these years of operation, mining value chains have been well developed and optimized, enabling the efficient and effective exploitation of raw materials. Compared to other sectors, such as RES, the mining sector is characterized by better stability and resilience, both in terms of supply chain organization and access to skilled labor and technology. Developed structures and specialized professional roles, both directly related to mining and in indirect areas, provide the mining sector with a solid operational foundation. Nevertheless, the dynamic changes in the international economy - particularly in the context of the energy transition - are forcing the mining sector to change and adapt both in terms of its operations and the structure of its value chains themselves.

This subsection presents the value chain structures developed for the following listed mining companies included in the project:

1. Premogovnik Velenje (Velenje Coal Mine), an associated company of Holding Slovenske Elektrarne, is still an important and indispensable pillar of the Slovene energy industry. Together with Termoelektrarna Šoštanj (Šoštanj Thermal Power Plant), it has been striving for decades to ensure undisturbed and reliable power supply for one third of Slovenia (Figure 1).

2. The Węglokoks Kraj S.A. belongs to the Węglokoks Capital Group, which was established in 1951. Mining is carried out at Bobrek mine, which is owned by the company and employs approximately 2,500 people (Figure 2).
3. Hulleras del Norte, S.A. (HUNOSA) is a state-owned coal mining company based in Asturias, in the north of Spain. It currently owns one underground coal mine, one washery and a power plant equipped with a capture CO_2 facility. HUNOSA is nowadays involved in a process of transition from a company based on coal extraction and fossil fuel energy production to a company focused on renewable energies (Figure 3).

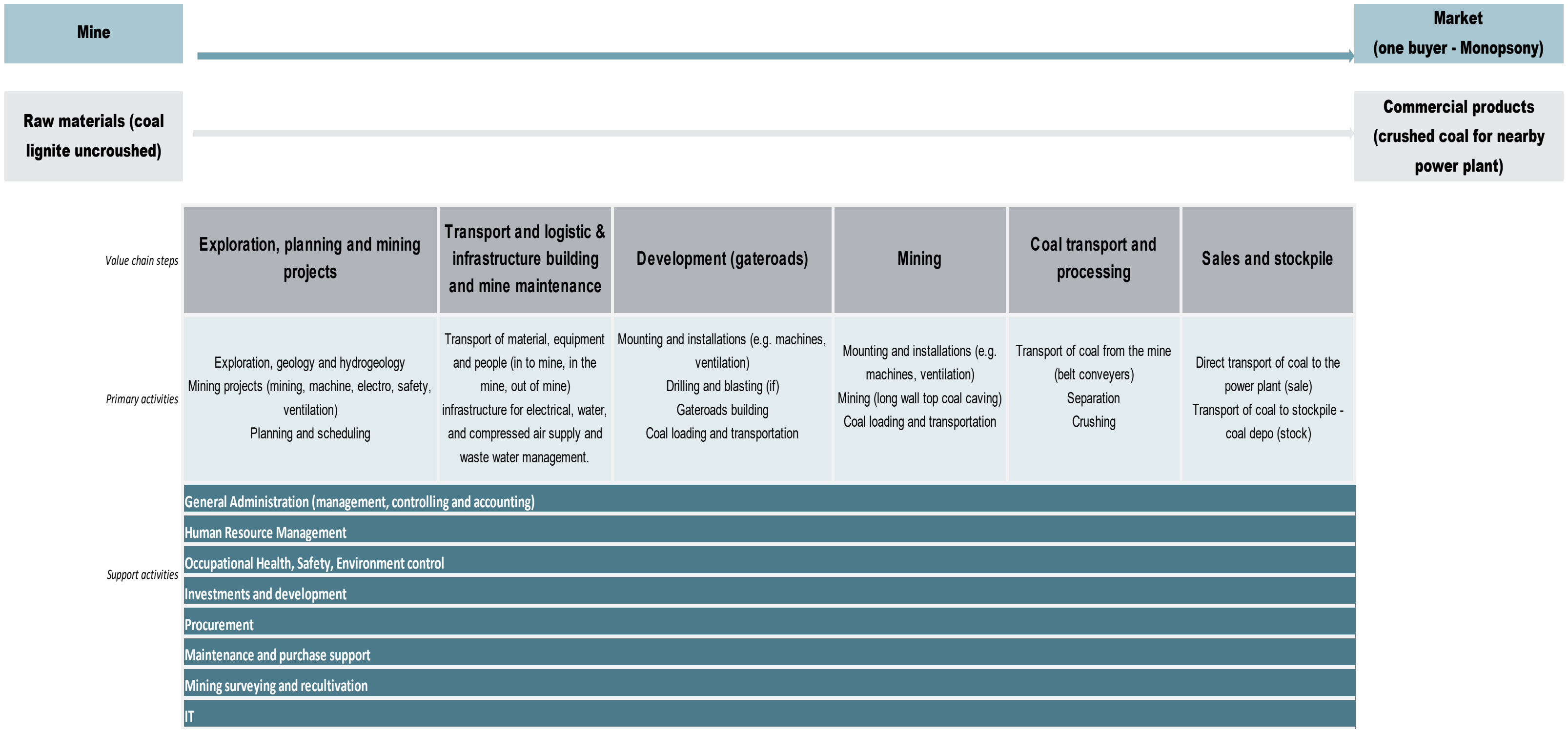

Figure 1 Value chain for Velenje Coal Mine

Source: elaborated by Premogovnik Velenje, d. o. o.

Velenje Coal Mine has developed the following value chain steps: exploration, planning and mining projects, transport and logistic & infrastructure building and mine maintenance, development (gateroads), mining, coal transport and processing, sales and stockpile where:

1. Exploration, planning and mining projects means: (1) exploration, geology and geomechanic, hydrogeology studies and elaborates, (2) mining projects - includes chapters for mining, machine, electro, safety, ventilation, and (3) planning and scheduling - plan of production which includes gateroads (stabile, mine panell, access), mine faces, gateroads liquidation, other objects (e.g. shafts, ventilation connections).
2. Transport and logistic & infrastructure building and mine maintenance mean: (1) transport of material, equipment and people (in to mine, in the mine, out of mine); (2) Ways of transport for material and equipment: outside rail, shaft & hoisting machine, ground rail accumulator locomotive U/G, monorail roof diesel locomotive U/G, on working site monorail manipulators (diesel, hydraulic, pneumatic)); (3) different transport units are used regarding transport material; (4) for people transport: haft & hoisting machine, ground rail accumulator locomotive U/G, monorail roof diesel locomotive U/G, chair lift; (5) all affiliated infrastructure (which is not under gateroads and mining) for sufficient electrical, water, and compressed air supply for all activities including suitable water management arrangements (dewatering of waste water).
3. Developments mean: gateroads building which include several phases where main ones are: mine surveying, drilling (if), machines and drivage installation, installation of steel arch support, gateroad closing and isolation, installation of gateroad infrastructure (monorails, gas sensors).
4. Mining means: (1) mining is done by Velenje mining method ("longwall top coal caving") where before mining activities are needed: installation of equipment (hydraulic roof support, chain conveyers with crushers, shearer and mine face infrastructure). Minig basically considers phases of cutting, sub-level caving, advancing; (2) coal transport from mine face is done in parallel with production.
5. Coal transport and processing mean: (1) transport of coal in the mine and from the mine is done by versus belt conveyers of different dimensions and capacity. Basically, is separation of mine faces and gateroads conveyers and main conveyers (transport via dip); (2) surface coal transport via belt conveyers, phase of separation (removal of wood, steel parts) and crushing; (3) coal transport to the power plant or to the coal depo.
6. Sales and stockpile mean: (1) after separation and crushing coal is primary directly transport to the power plant (sale), secondly it is stockpile at coal depo (stock); (2) by need coal is transported from coal depo to the power plant

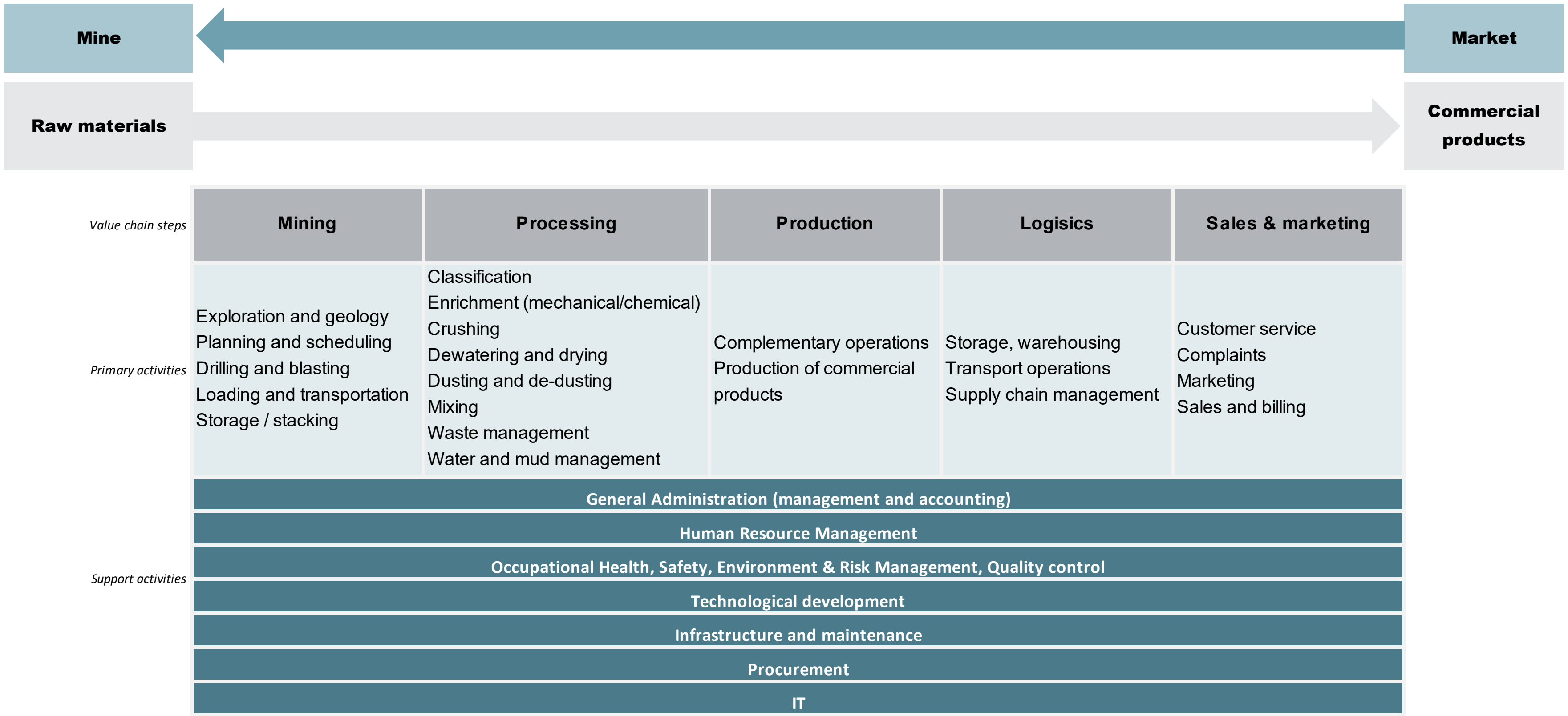

Figure 2 Value chain for Bobrek coal mine

Source: own elaboration based on Węglokoks Kraj S.A.

The value chain for this Bobrek Mine is representative for mature and well-established coal mines, which is characterized by operational stability and strong horizontal and vertical integration.

Suppliers of mine consumables and services are both local and international companies that provide the necessary technical equipment, tools and engineering support for the day-to-day operation of the mine. The final product is processed and classified into various fractions, including thermal and fuel coal, allowing the offer to be tailored to the needs of different customer segments.

The Bobrek coal mine, as a mine with a long tradition, stable production and an extended logistics structure, plays a key role in the local value chain, while adapting to the dynamic changes in the energy sector and the growing demands of the energy and ecological transition.

In the Bobrekmine value chain, the key stages are:

1. Exploration and mining: the mine's annual production reaches up to 2.6 million tons of coal.
2. Processing and distribution: The mined raw material goes through a process of enrichment and processing, which allows the product to be adjusted to the requirements of the energy market. The mine also offers products dedicated to retail customers, such as “Skarbek” eco-pea.
3. Distribution and sales: Sales are made both nationally and internationally, covering the residential and industrial customer segments. Coal goes to both the power and heating industries, as well as the municipal and utility markets.

In addition, the value chain is supported by highly integrated management structures and supplier relationships, enabling it to operate effectively in changing market conditions.

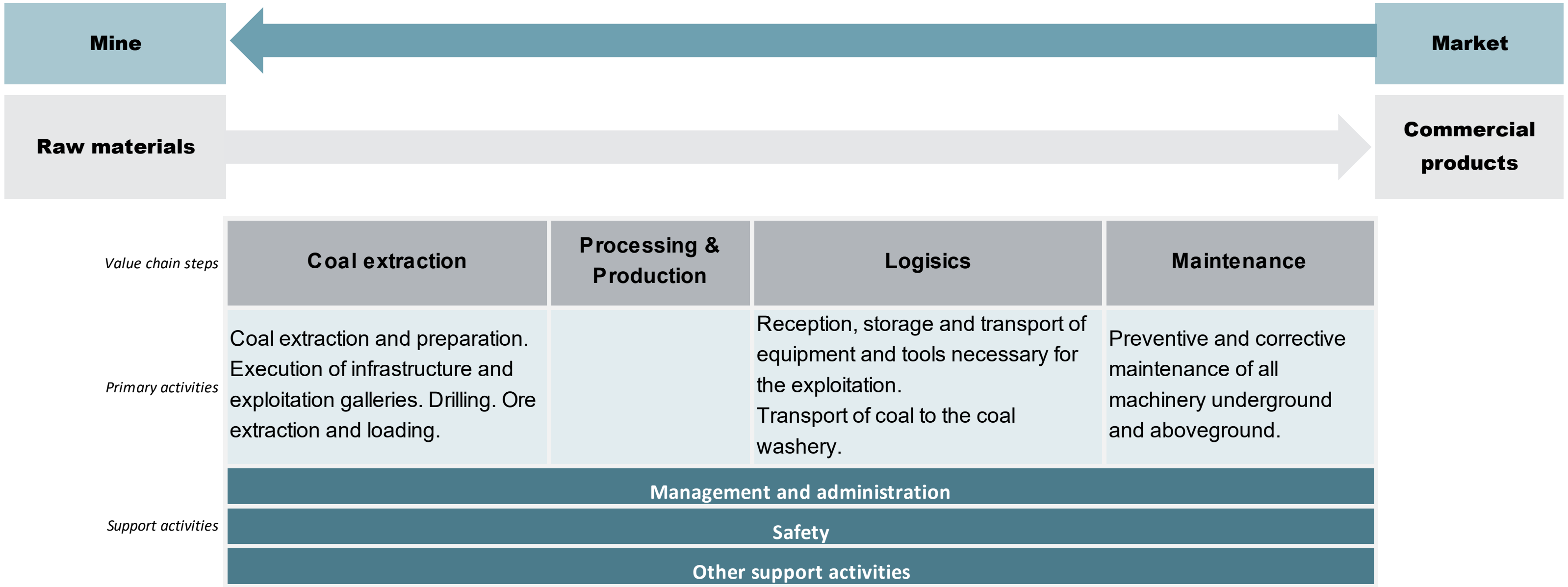

Figure 3 Value chain for HUNOSA

Source: own elaboration based on HUNOSA

In view of the fact that El Pozo Sotón is a coal mine that operated from 1922 to 2014, and belonging to the HUNOSA Group (public company dedicated to mining in the central area of the Principality of Asturias) a model example of mine operation was analysed as part of the representation of the value chain. In this connection, we highlight:

1. Logistics - (1) reception, storage and transport of equipment and tools necessary for the exploitation; (2) transport of coal to the coal washery.
2. Coal extraction- (1) coal extraction and preparation; (2) execution of infrastructure and exploitation galleries; (3) drilling; (4) ore extraction and loading.
3. Maintenance - preventive and corrective maintenance of all machinery underground and aboveground.
4. Safety - control of ventilation gauging, gas measurement, safety inspections, workers training, etc.
5. Administrative work - receive, order and store all relevant daily form documentation.
6. Management - supervision, planning, financial management, personnel management, direct communication with support activities.

During HUNOSA's current transformation, one of the key activities is to manage relationships with existing suppliers and industrial customers, while seeking new markets for renewable energy products which consequently means creating a new value chain.

3.2 Renewable Energies Sector

The dynamic development of RES technologies, such as wind, solar, geothermal and energy storage technologies, is creating both opportunities and challenges for organizing and optimizing value chains in this sector. Renewable energy value chains include the full life cycle of a technology, from research and development, production and installation, to operation, servicing and disposal or recycling of used components. However, due to the young age of the sector and rapidly changing market, regulatory and technological conditions, these chains and the business models of companies operating in the sector are not yet fully developed.

One of the fundamental challenges facing the RES sector is the need to build stable and sustainable value chains that will support both further development of the technology and adaptation processes in the global economy. In contrast to mature sectors such as mining or traditional energy, RES does not yet have fully structured and effective business models. There is also a lack of process standardization in many areas, such as recycling of components. As a result, the RES sector needs to go through a phase of intense adaptation to create integrated supply and value chains that can meet the demands of the energy transition.

In view of these challenges, an attempt was made to create conceptual models of value chains for the technologies included in the project's analyses

The value chain of geothermal technologies (Figure 4) is complex and includes both the design (with R&D) and operational phases, with critical importance for international component manufacturing processes, including key ones such as turbine manufacturing. In this regard, it should be noted that the development of this type of technology often requires international cooperation.

The figure above shows the key stages of the value chain for geothermal technologies - indicating a model/conceptual approach to the issue. In the context of value creation for geothermal technologies, the activities described below deserve special attention:

- Design activities, as well as R&D - including both geological research, identification of geothermal resources and modelling of geothermal systems, taking into account all the necessary technological and logistical assumptions, as well as other multidimensional aspects of the analysis conducted.
- Operational activities, carrying out the necessary trials and tests in areas potentially suitable for investment - their proper conduct results in a decision to start or stop work.
- Geothermal power plant design activities - which require specialized knowledge, selection of key energy conversion components, selection of infrastructure. Ultimately, this will affect the efficiency of geothermal technology operation.

- Manufacturing processes of turbines and other components - which require advanced engineering processes.
- Logistics and transportation - the size of the individual power plant components and infrastructure requires specialized logistics and large-scale transportation.
- Construction and installation of power plants, including integration of all components as well as systems and automation. One of the more complex activities in the entire value chain, which requires specialized knowledge in various fields.
- Validation and implementation as well as all related operational and maintenance activities, requiring monitoring of system performance and functioning infrastructure.

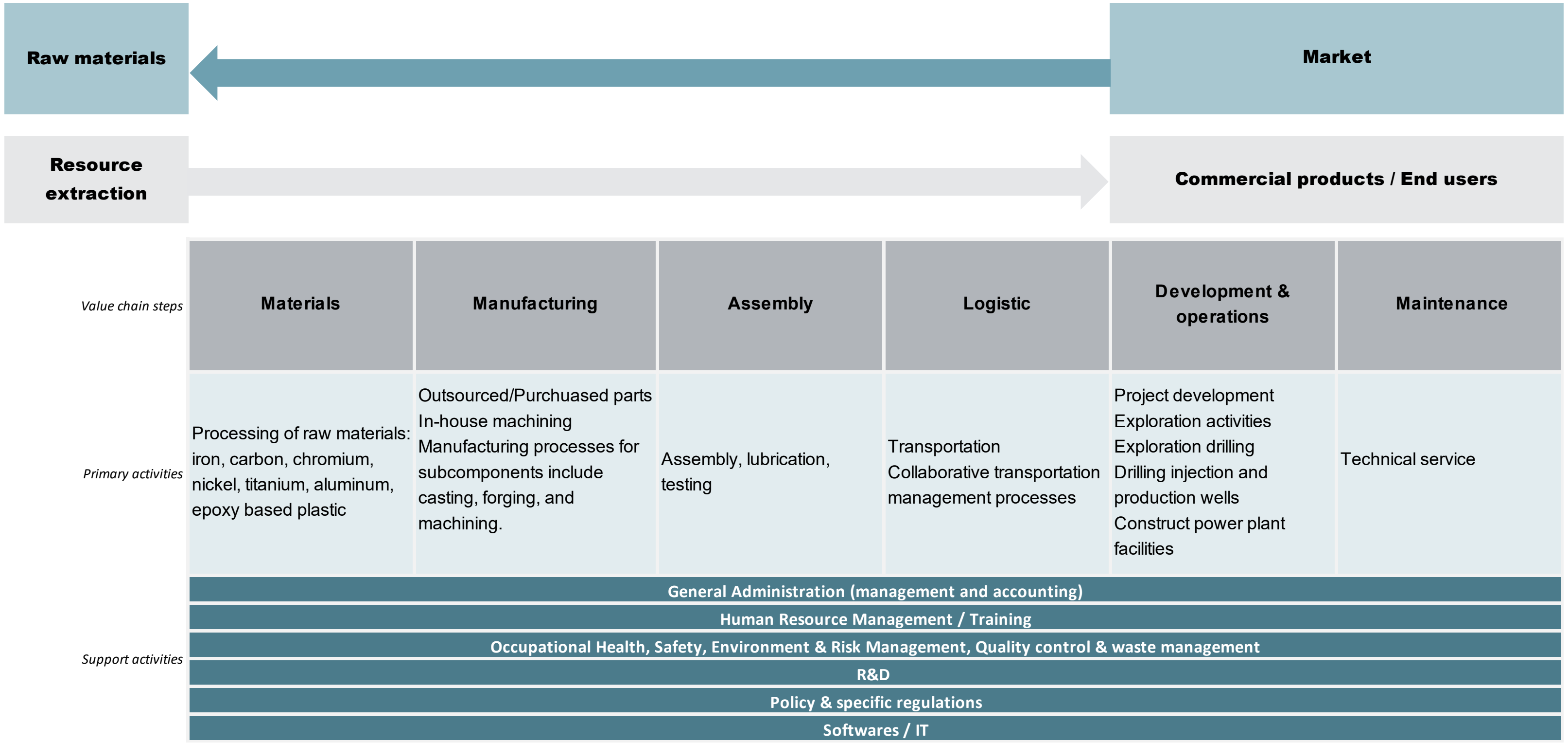

Figure 4 Value chain for geothermal energy - conceptual model

Source: own elaboration based on (Akar et al., 2021; Jelti et al., 2021; Vonsée et al., 2019)

The value chain for the photovoltaic (PV) industry (Figure 5) is global and complex, involving both intensive research / technological development, complex manufacturing and distribution processes. The key elements of the value chain are:

- Research and development, with a particular focus on technological innovation and new materials, which are key to the efficiency of PV cells.
- Production of advanced materials, photovoltaic cells made of silicon and then - photovoltaic modules. At this stage, it is crucial to optimize production processes to reduce costs and increase the quality of materials, which directly affects the efficiency of PV panels. Module production requires high precision and advanced technology to ensure durability and efficiency. Automation of production processes and optimization of materials play an important role here.
- Transportation, logistics and distribution - delicate photovoltaic panels require appropriate packaging and means of transportation to minimize the risk of damage. This is particularly important because transportation often takes place in international markets.
- Installation and system integration - a technically demanding, specialized stage, involves the design and installation of PV systems on buildings or on the ground. This requires trained technicians and engineers, as well as integration with local power grids.
- Operations and maintenance - long-term maintenance to ensure maximum efficiency requires regular monitoring of systems, cleaning of panels, and repair or replacement of components in case of failure. High-quality service is key to ensuring the longevity of the installation.
- Recycling and disposal - increasing attention is being paid to the final stage of the life cycle of PV panels. The growing number of PV installations is creating the need to develop recycling technologies to reduce environmental impact and to recover valuable raw materials - such as silicon and metals (e.g., silver and copper).

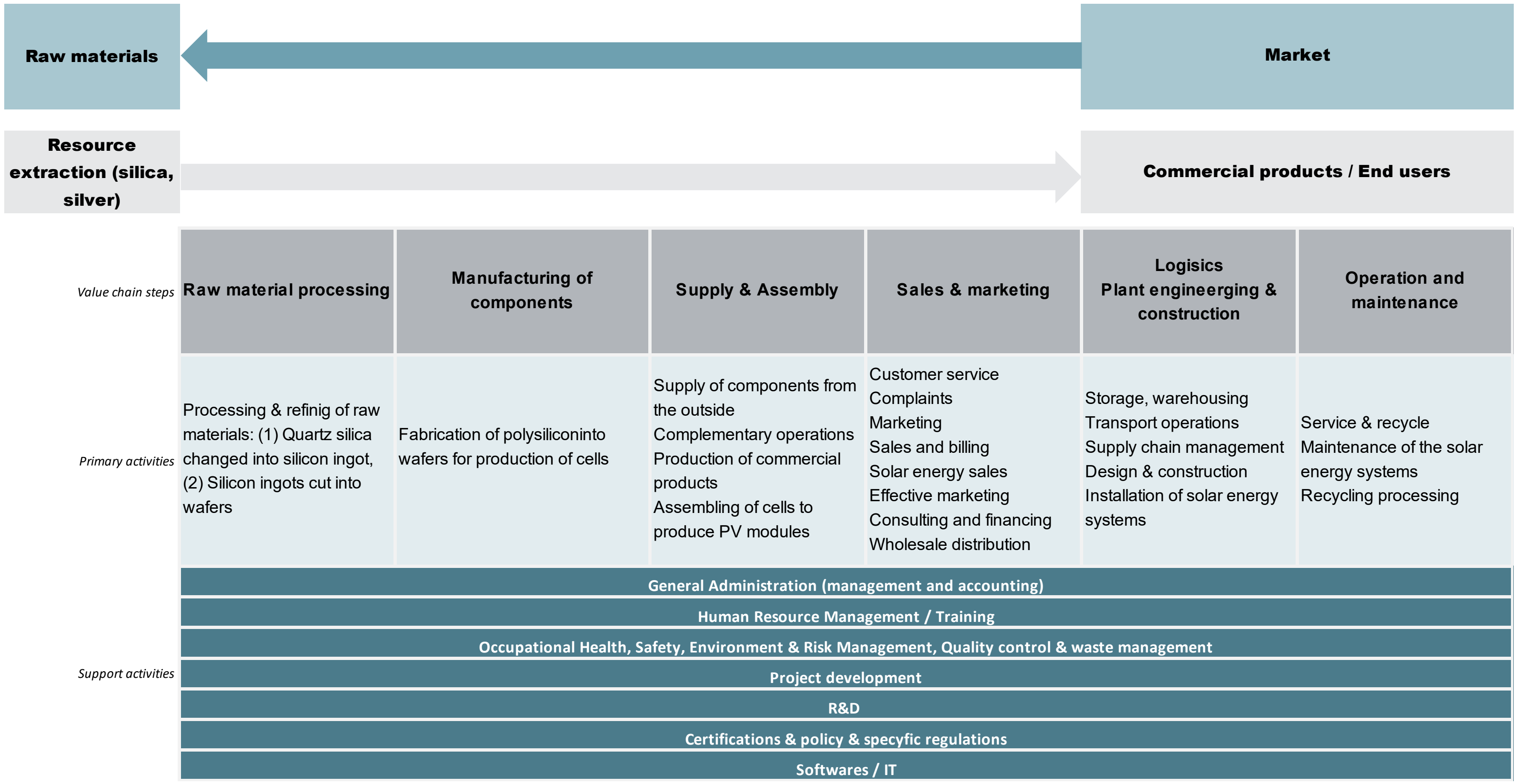

Figure 5 Value chain for photovoltaic energy - conceptual model

Source: own elaboration based on (Haley & Schuler, 2011)

The wind power value chain (Figure 6) issue involves a complex set of activities, from the early stages of research and development to long-term operations and maintenance. As an important part of the global energy transition, the industry is characterized by dynamic technological development and complex relations among the various participants in this ecosystem. The following key stages in this chain and potential challenges and opportunities in its structure are highlighted.

- Research and development (R&D) and turbine design - which includes the design of wind turbines and the development of technologies to improve turbine efficiency and durability. Innovations in aerodynamics, structural mechanics, materials science and energy efficiency of the systems are crucial at this stage.
- Component manufacturing - a highly capital-intensive stage that involves the production and assembly of major components, which requires specialized engineering expertise. Component manufacturing is done in different parts of the world.
- Transportation and logistics - transport of wind turbine components, poses significant logistical challenges due to their size and weight. This requires specialized transportation solutions, both by road and at sea, in the case of offshore installations.
- Installation and assembly - The installation stage requires specialized equipment and skilled labor. Onshore installation is relatively simpler than offshore turbines, which require complex installation platforms, specialized vessels and geotechnical analysis of the seabed. Costs are higher for offshore installations, and the availability of technical infrastructure, such as turbine installation vessels, is becoming a critical success factor. Digital technology and automation are also growing in importance to better manage assembly processes and minimize errors.
- Deployment, operations and maintenance - once a system is implemented, a key aspect becomes their long-term operations and maintenance. Real-time monitoring systems that allow for rapid fault detection and efficiency optimization become an essential part of this stage. For offshore turbines, maintenance is particularly challenging due to more difficult access and harsh environmental conditions. The rise of predictive technologies and advanced operation management systems (e.g., artificial intelligence) are making it possible to predict failures and optimize maintenance.
- End-of-life management (recycling). Recycling of wind turbines, especially composite blades, is a growing challenge in terms of ecology and sustainability. Components such as steel, copper and aluminium can be recycled, but composite blade materials require advanced processing technologies. As the industry grows and plants aging, the need to develop efficient recycling processes becomes more necessary.

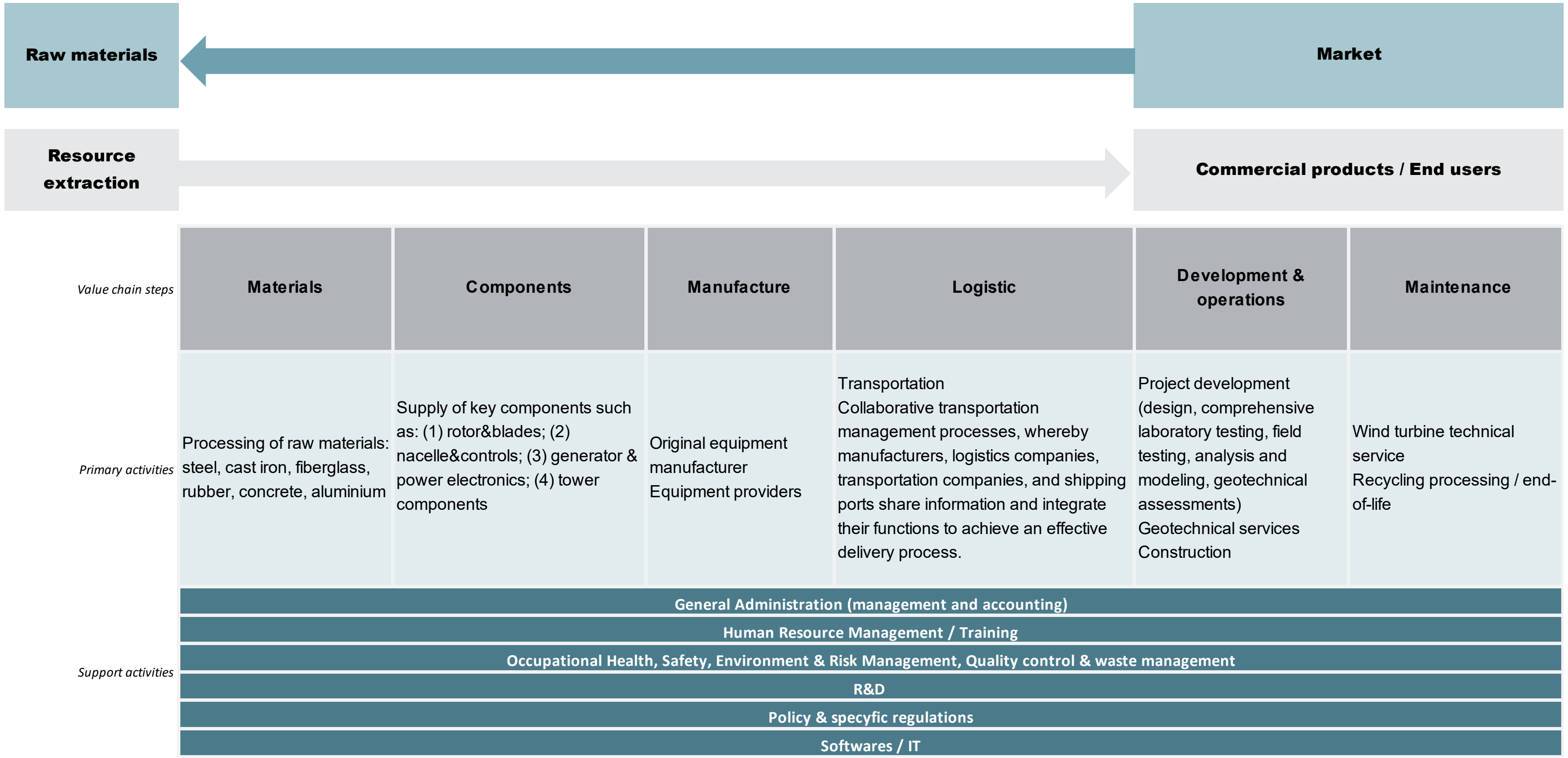

Figure 6 Value chain for wind power - conceptual model

Source: own elaboration based on (Kandrot et al., 2020; Liu et al., 2018; Morris et al., 2022)

The conceptual model of the value chain for unconventional pumped storage power plants is based on the following value-creating components, i.e. materials, large volume smelting and converting, component manufacture & assembly, plant engineering & project development, installation and construction, maintenance.

Unconventional pumped hydro storage systems (UPH), represent a promising energy storage technology, especially in the context of sustainable energy transition. The analysis of the value chain of this technology, as well as the challenges and opportunities for its development are important issues in the context of its implementation. In the context of this research and based on the value chain conceptual model presented above, the following processes deserve special attention:

Project development - Research and Development (R&D) - in the context of this technology, innovations in hydropower system design, optimization of efficiency, and minimization of environmental impact are crucial. Research areas include i.a.: designing from UPH systems, developing underground technologies that enable the construction of UPH systems in mines or other facilities with significant differences in elevation, Innovations in pump and turbine materials and technologies that can optimize the efficiency and life of systems, as well as minimize their costs.

- Sourcing and manufacturing of components - the production of components for UPH systems requires advanced technologies, especially for pumps, turbines, pipelines and control systems. The production of these components requires specialized knowledge as well as industrial infrastructure.
- UPH plant design and construction - the process of designing and building UPH systems is extremely complex, especially in the context of non-standard locations such as mines, valleys, or other non-standard geological formations. It requires specialized engineering expertise in hydrology and geotechnical engineering.
- Logistics and transportation - the transportation of large components, such as turbines and pipelines, is one of the logistical challenges. As with conventional hydropower plants, this often requires specialized transportation solutions.
- Operations and maintenance - these are key steps in the life cycle of UPH systems. They include real-time monitoring of system performance, ensuring efficient operation of turbines and pumps, and regular maintenance to avoid breakdowns. UPH systems, unlike some other energy storage technologies, have a long operating lifetime, but require ongoing maintenance, especially in the area of mechanical/engineering/energy systems management. High-tech digital technologies, such as AI-based monitoring systems and the Internet of Things (IoT), allow for more precise and efficient maintenance management. Predictive maintenance technologies make it possible to detect problems at an early stage, reducing the risk of failure and extending system life.

- Recycling and end-of-life management - while UPH systems have a long operating lifetime, a key challenge is end-of-life management, including disassembly and recycling of components. While materials such as steel, concrete and piping can be recycled, UPH technologies, especially in underground locations, can create additional challenges for disassembly and safe disposal.

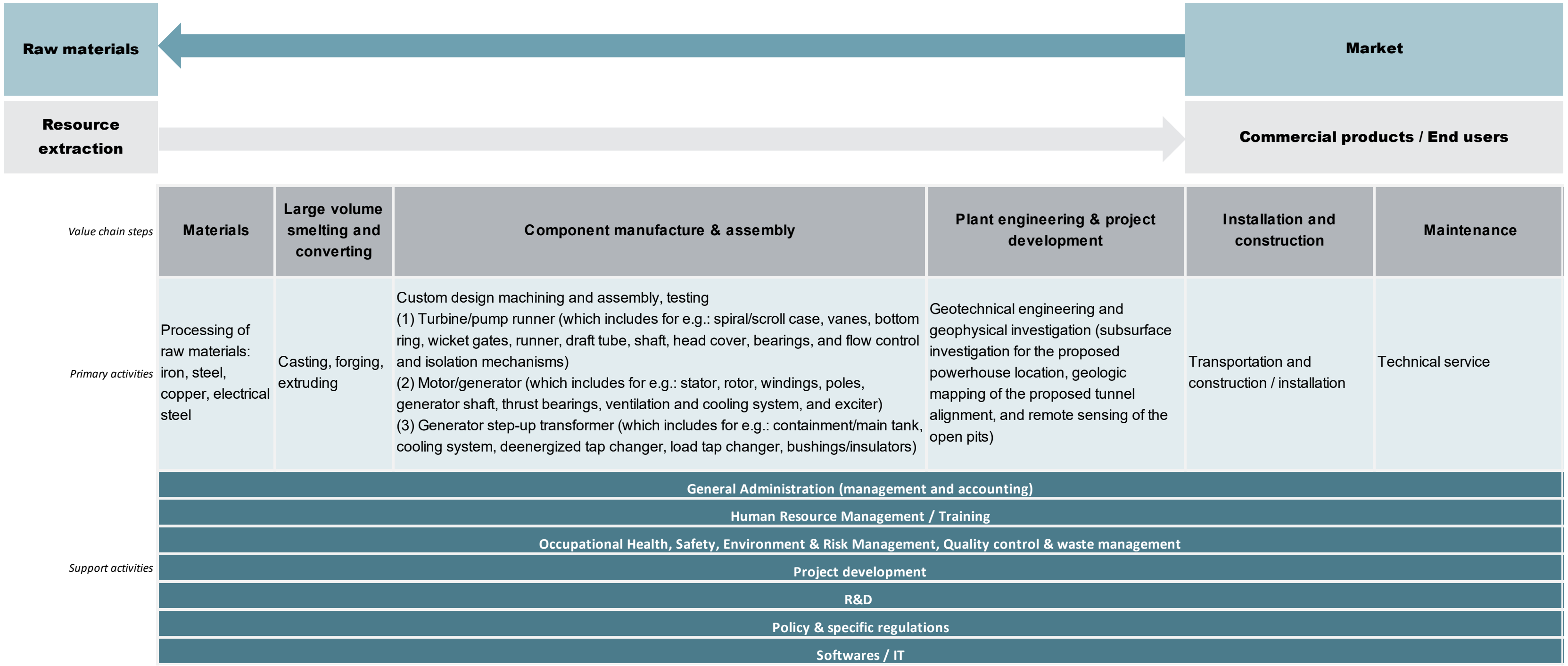

Figure 7 Value chain for unconventional pumped hydro - conceptual model

Source: own elaboration based on: (Putsche et al., 2024)

The value chain issues for battery-based energy storage (Figure 8) encompasses a number of stages, from raw material extraction, cell manufacturing to grid integration and life cycle management of these technologies.

- Raw material extraction and processing. At the core of the battery value chain are raw materials such as lithium, cobalt, nickel, manganese and graphite, which are essential for the production of modern lithium-ion cells. Battery production, especially lithium-ion, is heavily dependent on global raw material supply chains.
- The production of battery cells and modules is a technologically advanced, high-value-added process. This segment of the value chain is characterized by high geographic concentration. The production of lithium-ion batteries requires advanced technologies and expertise to achieve high energy density, long operating lifetimes and optimal performance.
- Integration of energy storage systems. Integrating energy storage requires advanced energy management systems (EMS - Energy Management Systems) that can optimize energy use and manage energy flow on the grid. In addition, energy storage must be flexible and scalable to integrate with both small prosumer systems (e.g., home solar PV) and large power grids.
- Maintenance. These systems, while relatively reliable, require regular monitoring and maintenance to ensure their effective operation over their lifetime. For battery energy storage systems, thermal failures and fires are a key risk, especially in large industrial installations. It is necessary to develop advanced safety systems that minimize the risk of failure.
- Recycling and end-of-life management. Battery recycling is a growing challenge that will be critical in the coming decades as large numbers of batteries reach the end of life. Recycling processes must be optimized in terms of both cost and recovery efficiency.

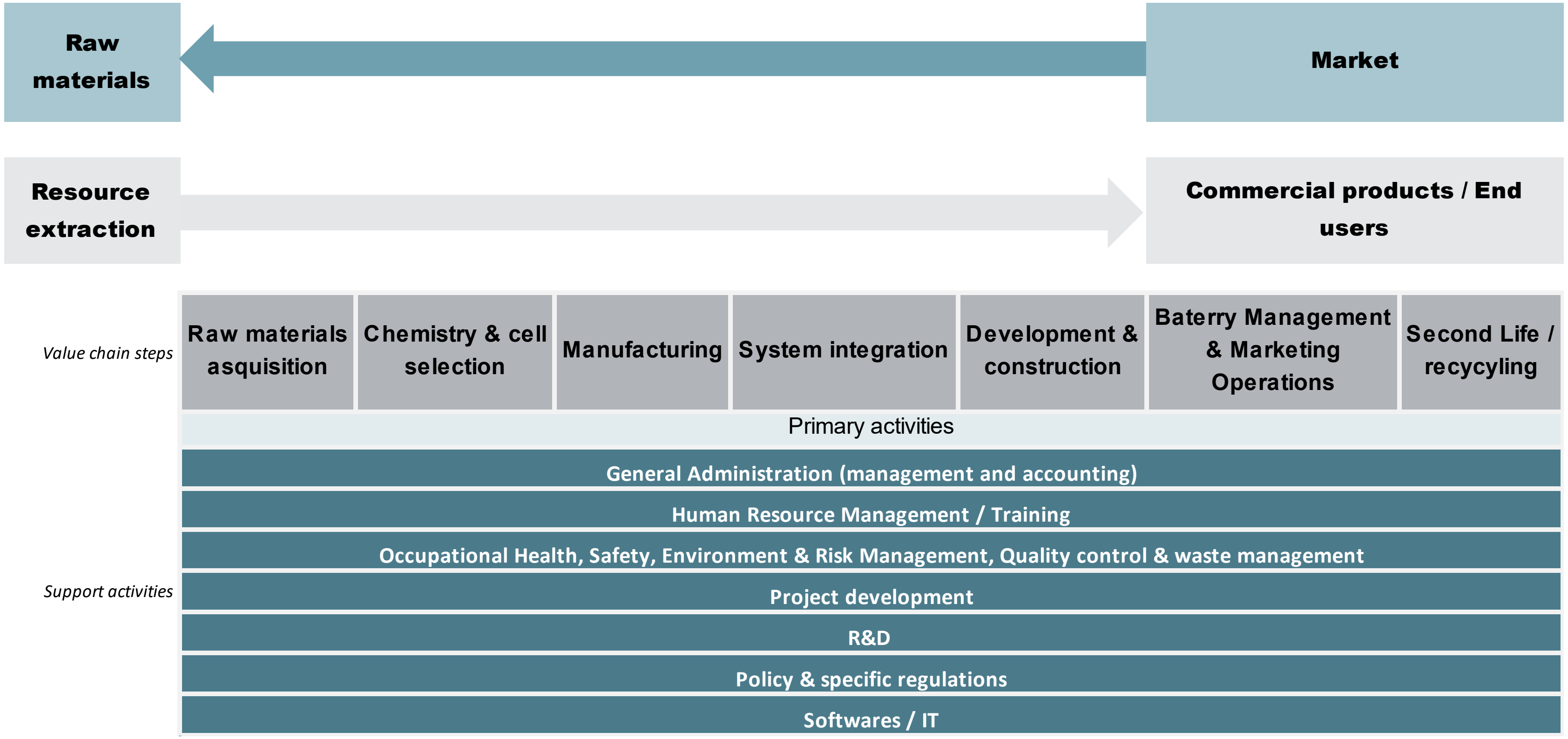

Figure 8 Value chain for batteries - conceptual model

Source: own elaboration based on (Vonsée et al., 2019; Zheng et al., 2022)

Green hydrogen (Figure 9), extracted by electrolysis using renewable energy sources, plays a key role in decarbonizing sectors such as heavy industry, transportation and power generation. Hydrogen is considered the energy carrier of the future, capable of stabilizing systems based on variable renewable energy sources such as wind and solar, as well as storing excess energy. However, the development of green hydrogen poses challenges along the entire value chain, from energy production to storage and transportation infrastructure to final use.

- The first step in the green hydrogen value chain is to obtain electricity from renewable sources, such as wind, solar and hydroelectric power. The key challenge at this stage is to ensure a stable supply of renewable electricity so that the electrolysis process, which requires a significant amount of energy, can be carried out continuously and cost-effectively.
- Electrolysis and green hydrogen production. This process is a key step in the value chain that requires a high capital investment and advanced technology to increase efficiency and reduce costs.
- Hydrogen storage and transportation. Once produced, green hydrogen must be stored and transported to where it will be consumed. In this aspect, there are technical and logistical challenges related to hydrogen's properties, making its storage and transportation more difficult and expensive compared to traditional fuels.

Green hydrogen has a wide range of applications that include industry, energy and transportation. Hydrogen can be used as a fuel in fuel cells, as a feedstock in industrial processes (e.g., in steel or chemical production), and as an energy carrier for storing surplus energy from RES. There are a number of challenges along the green hydrogen value chain that require further innovation and policy support.

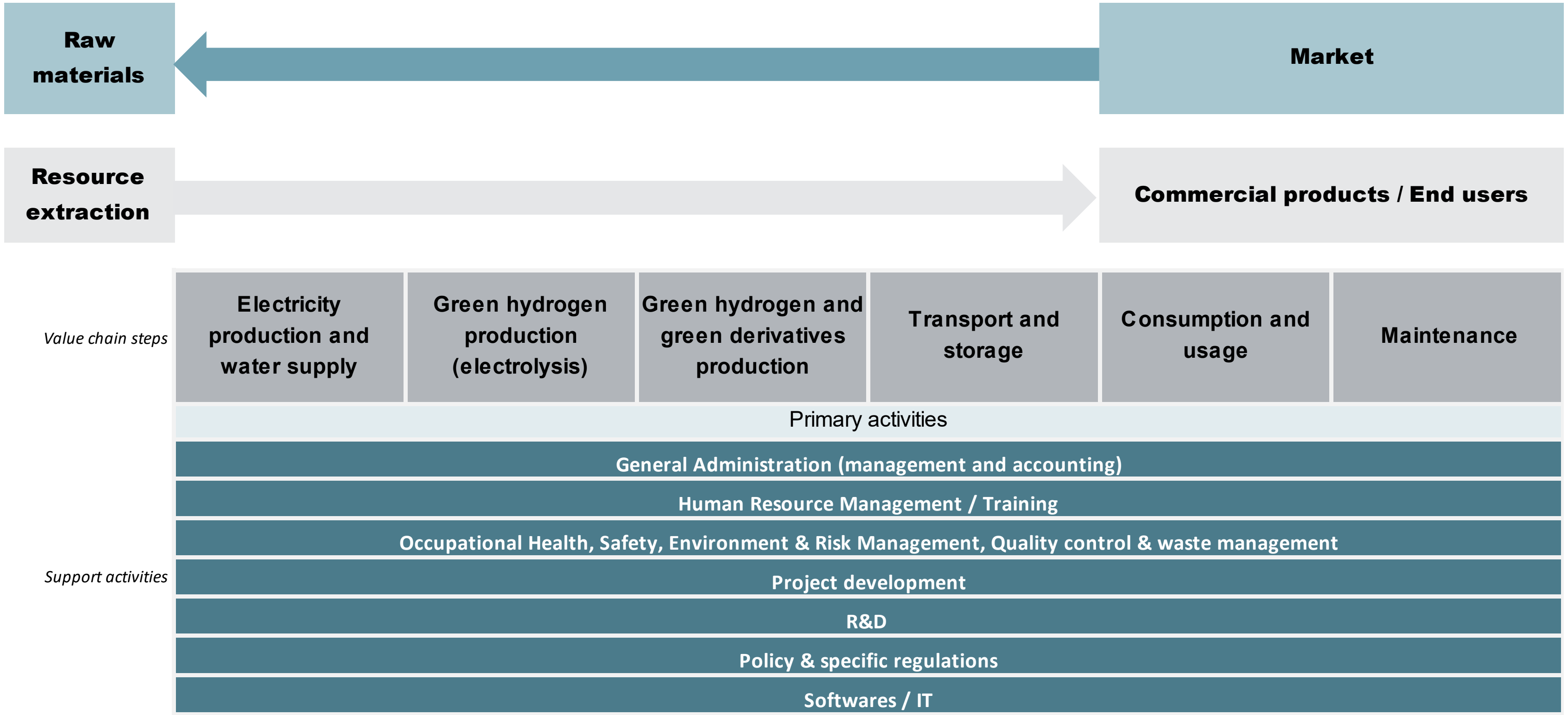

Figure 9 Value chain for green hydrogen - conceptual model

Source: own elaboration based on (Carmona et al., 2024; Chen et al., 2019; Coleman et al., 2020; Eicke & De Blasio, 2022)

3.3 Indirect Job Roles

The energy sector, including renewable energy sources, creates numerous jobs both direct, related to the production/manufacturing and installation of technology, and indirect (known as Indirect Job Roles). In the context of RES, indirect jobs refer to positions that support the development, maintenance, operations and management of the entire energy ecosystem, not always directly related to energy production itself. Indirect jobs cover a wide range of occupations, from material suppliers to financial, educational and regulatory services to research and development (R&D) (Figure 10).

The growth of the RES sector requires the coordinated input of many industries and professionals outside of traditional manufacturing jobs. Publications and industry reports highlight the key role of these indirect jobs in supporting the energy transition. The issue of indirect jobs in the energy sector includes issues related to value creation, skills development, supportive policies, and sustainability challenges.

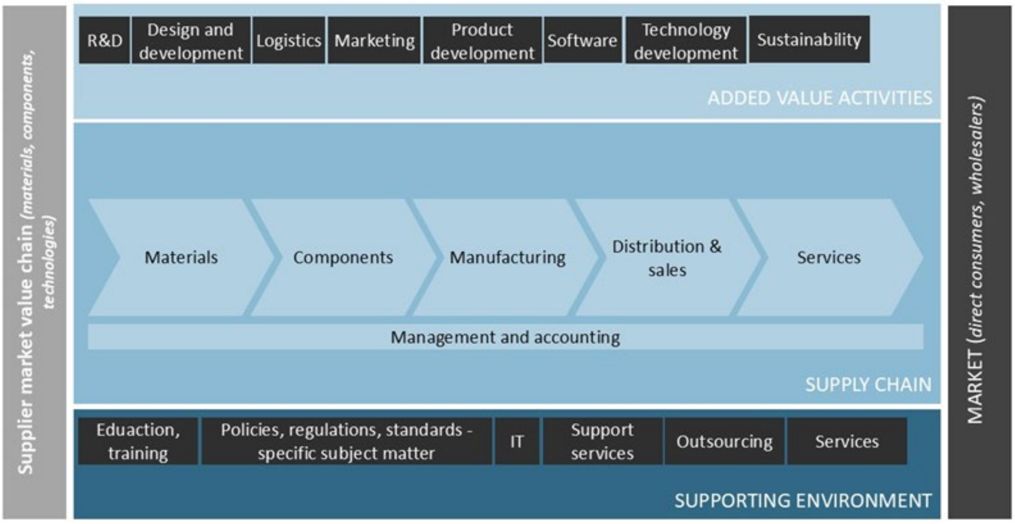

Figure 10 Map of processes and flows

The energy sector, including renewable energy sources, creates numerous jobs both direct, related to the production/manufacturing and installation of technology, and indirect (known as Indirect Job Roles). In the context of RES, indirect jobs refer to positions that support the development, maintenance, operations and management of the entire energy ecosystem, not always directly related to energy production itself. Indirect jobs cover a wide range of occupations, from material suppliers to financial, educational and regulatory services to research and development (R&D).

In this case, the issue of indirect job roles in the context of the mining sector is particularly important. The mining-related sector, which includes businesses and economic activities directly or indirectly related to the mining industry, plays a key role in the economy of many regions with a traditionally strong mining industry presence. Its importance is particularly evident in terms of employment, as it provides jobs both directly in the mines and indirectly in companies that provide maintenance, logistics or technology services to the mining industry (e.g., engineers, technical specialists, service and logistics workers, environmental and remediation specialists). In view of the energy transition, this sector as well as related indirect job roles are sensitive to change and require adaptation measures. In the context of the energy transition, the mining-related sector can play a key role in the development of new industries, such as renewable energy.

The growth of the RES sector requires the coordinated input of many industries and professionals outside of traditional manufacturing jobs. Publications and industry reports highlight the key role of these indirect jobs in supporting the energy transition. The issue of indirect jobs in the energy sector includes issues related to value creation, skills development, supportive policies, and sustainability challenges.

Indirect job roles in the energy sector are positions related to indirect services or production that support the main activities of the sector but are not directly related to the physical production of energy. In renewables, these include a number of sectors i.e.: supply chain, Logistics, accounting / finance, R&D, training and education: Training of specialists in new technologies, energy policies and infrastructure management.

The transformation of the mining sector and therefore the development of the RES sector is generating wide demand for indirect jobs, which affects economic growth and employment, especially in the context of local communities.

4 Identification and Categorization of Key Occupations

4.1 Identification of the key occupations - initial systematization

In the context of the GreenJOBS project, the term "key occupations" refers to specific roles essential for industries transitioning from traditional coal mining to sustainable, green economies. These occupations drive technological innovation, environmental sustainability, and regional economic development. Key occupations are those that hold a significant influence on how an industry can adapt and grow in response to evolving economic and environmental demands. According to the International Labour Organization (Mahmud & Strietska-Ilina, 2019), the shift towards a green economy necessitates the creation of new skills and redefined roles, such as renewable energy engineers, environmental scientists, and sustainability managers. These roles are pivotal in promoting green technologies and sustainable practices. The importance of key occupations is highlighted in economic transformation and workforce development literature. M. E. Porter (1990) emphasizes that the skills and capabilities of the workforce are key to driving innovation and maintaining global competitiveness. Investment in these roles is critical for industries undergoing significant changes. The European Commission's "Just Transition Mechanism" (European Commission, 2020) emphasizes the need to support workers and communities impacted by the coal sector's decline.

Identifying key occupations helps foster a just transition by promoting economic diversification and social inclusion, aligning with the United Nations' Sustainable Development Goals, particularly Goal 8, which advocates for decent work and economic growth. From a regional perspective, key occupations mitigate the negative socioeconomic effects of coal mine closures. The World Bank (Stanley et al., 2018) stresses that proactive strategies like workforce retraining and new industry promotion are vital for managing coal mine shutdowns. By focusing on these occupations, the project aims to create quality jobs that support the long-term resilience and prosperity of affected communities.

Key occupations within GreenJOBS project's framework are defined as roles vital to the current operation and future transformation of industries towards sustainability. These roles drive innovation, enable change, and provide the specialized skills necessary for sectors to thrive in the green economy. Recognizing and investing in these key occupations is crucial for maximizing the creation of green and quality jobs and ensuring the benefits of economic transformation are widely and sustainably shared. In the context of the project scope, the identification of key occupations is a crucial step in ensuring a smooth transition for both the workforce and the industry. This process is methodologically grounded in a combination of qualitative and quantitative analyses, specifically focusing on the evolving needs of the labour market and emerging technologies in the post-mining era.

For the purposes of the GreenJOBS project, key occupations are defined as critical roles within an industry that are essential for its operational success and future growth, especially during periods of transformation or restructuring. These occupations typically encompass jobs that significantly impact productivity, innovation, and the overall transition process of a sector. In the context of industries like mining, where environmental and technological shifts are driving change, key occupations include not only traditional roles such as miners and engineers but also emerging positions related to renewable energy, environmental sustainability, and digital technologies. Identifying these roles is vital to ensure the workforce is prepared for upcoming challenges and opportunities, and to maintain the continuity of operations during transformation. Literature (Switasarra & Astanti, 2021; Wu & Lin, 1999) suggests that key occupations are identified based on their centrality to both the current functioning and the future needs of the industry. For example, in the mining sector, these roles might evolve as the industry transitions towards greener practices. A meta-analysis of job descriptions emphasizes that understanding the evolving nature of key occupations is critical for aligning workforce training and educational programs with future labour market demands.

For the GreenJOBS project, the identification of key occupations was carried out through expert interviews and a literature review focused on both the mining sector and the Renewable Energy Sector (RES). This process emphasized roles critical to the current functioning of these sectors, as well as those poised to support the necessary transition toward sustainable energy sources. Key occupations were identified based on their impact on operational efficiency, innovation, and the adaptation to green technologies. The occupations were categorized separately for mining (Table 1) and RES (Table 2-Table 7) to reflect their distinct contributions to the energy transition.

Table 1 Key occupations for mining sector

Key Occupation	Description	Justification
Underground Miner	Extracts coal from underground deposits using various methods (e.g., longwall mining, room and pillar mining). (**T**)	This role is central to mine productivity as miners directly engage in the extraction process, managing the use of machinery and tools to ensure a steady output
	Technical training, physical fitness. (**Q**)	
	Safe and efficient extraction of coal. (**R**)	

Open-Pit Miner (Brown Coal)	Operates large open-pit equipment (excavators, bulldozers) to extract brown coal from surface mines. (**T**)	This role is crucial in brown coal mining due to the specific requirements of surface mining, which demands different machinery and environmental awareness
	Heavy equipment training, safety certifications. (**Q**)	
	Managing equipment and ensuring optimal extraction of lignite. (**R**)	
Blaster	Uses explosives to fracture and break apart rock or coal seams for extraction. (**T**)	Blasting is key to efficient extraction in both types of coal mining, where controlled explosions enable access to deeper or more compact deposits
	Explosive handling certification, knowledge of geology. (**Q**)	
	Ensuring precise blasting to minimize waste and environmental impact. (**R**)	
Heavy Machinery Operator	Operates vehicles like trucks, draglines, and loaders for moving coal and overburden. (**T**)	This role is essential for both open-pit and underground mining operations, as it ensures that materials are moved efficiently to maintain production
	Equipment operator license, basic mechanical skills. (**Q**)	
	Maintaining production flow and safety. (**R**)	
Geotechnical Engineer	Monitors ground conditions to ensure safety in mining operations. (**T**)	This role is critical in both underground and open-pit operations, particularly in ensuring the structural integrity of mine workings and the safety of workers
	Engineering degree in geology or geotechnics. (**Q**)	
	Assessing risks of land subsidence and ground stability. (**R**)	
Environmental Restoration Specialist (Brown Coal)	Oversees land rehabilitation post-mining, restoring ecosystems. (**T**)	This occupation is crucial in brown coal mining due to the large-scale environmental impact of open-pit operations, requiring focused efforts to restore ecosystems
	Environmental science degree, experience in land restoration. (**Q**)	
	Ensuring compliance with environmental regulations	

	and effective site restoration. (**R**)	
Electrician	Maintains and repairs electrical systems used in mining machinery and infrastructure. (**T**)	This occupation ensures operational continuity and safety, as electricity is essential for most mining equipment
	Electrical certification, experience with industrial equipment. (**Q**)	
	Ensuring uninterrupted power supply to mining operations. (**R**)	
Safety Officer	Monitors workplace safety protocols, inspects equipment, and ensures compliance with safety regulations. (**T**)	Ensuring worker safety is paramount in both types of mining, and this role is responsible for enforcing safety protocols to prevent accidents
	Certification in occupational safety, knowledge of mining regulations. (**Q**)	
	Minimizing risks of accidents and ensuring worker safety. (**R**)	
Geologist	Studies rock formations and coal deposits to guide extraction. (**T**)	Geologists are key to the planning process, ensuring that extraction is targeted efficiently to maximize coal yield while minimizing unnecessary disruption to the environment
	Degree in geology, knowledge of resource evaluation. (**Q**)	
	Identifying resource-rich areas and advising on efficient extraction methods. (**R**)	
Maintenance Engineer	Responsible for the upkeep and repair of all mining equipment, including conveyors, trucks, and machinery essential for extraction and transport. (**T**)	The efficiency of mining operations relies on the continuous functioning of equipment. Breakdowns can halt production and lead to costly repairs. Expert recommendations emphasize the need for skilled maintenance
	Engineering degree in mechanical or electrical fields, specialized training in heavy industrial equipment. (**Q**)	

	Performs regular inspections, preventive maintenance, and emergency repairs to minimize downtime and ensure the smooth operation of mining equipment. (**R**)	engineers to ensure high operational efficient
Transport Manager	Coordinates all logistics and transportation activities within the mining operation. This includes organizing the movement of coal, machinery, and personnel across the mine. (**T**) Requires a degree in logistics, industrial management, or equivalent. (**Q**) Ensures smooth and safe transport of materials, coordinates with heavy machinery operators, and minimizes delays in material delivery to processing areas or external facilities. (**R**)	This role is crucial in maintaining the mine's production schedule. Inefficient or unsafe transportation can cause costly delays and accidents, affecting productivity. Expert input shows that transport issues are a common bottleneck in mining operations

Legend: T – tasks; Q – qualification, R - responsibilities

Source: expert's opinion and literature review i.a. (Coogan & Hundal, 2022; Johansson et al., 2010; Pešout et al., 2022; Rahimi, 2024; reddirst Personel Group, 2023; Zell-Baran et al., 2023; Zhang et al., 2024)

A similar preliminary analysis of key professions has been conducted for the RES sectors addressed in the project. In this case, the analysis primarily drew on information from previous reports and a review of the literature, identifying the most critical occupations, some of which are common across all RES sectors. The description of the required competencies has also been presented in a simplified manner, as it will be further developed during the mapping phase and the creation of reskilling programs. The results are shown in the tables below.

Table 2 Key occupations for geothermal energy

Key Occupation	Description	Justification
Geothermal Engineer	Design geothermal systems, monitor performance. (**T**)	Key in system design and ensuring efficient

	Mechanical/Electrical Engineering degree. (**Q**) Ensure optimal energy extraction and system reliability. (**R**)	geothermal energy generation.
Drilling Technician	Operate drilling machinery. (**T**) Certification in drilling operations. (**Q**) Execute precise drilling to access geothermal reservoirs. (**R**)	Essential for resource access and minimizing environmental impact.
Environmental Scientist	Assess environmental impacts. (**T**) Degree in environmental science. (**Q**) Ensure compliance with environmental regulations. (**R**)	Crucial for maintaining ecosystem balance and regulatory approval.
Geophysicist	Analyze subsurface structures. (**T**) Geophysics degree. (**Q**) Identify geothermal resource locations. (**R**)	Determines optimal drilling sites, maximizing resource recovery.
Maintenance Technician	Maintain geothermal equipment. (**T**) Technical training in machinery maintenance. (**Q**) Ensure the operational efficiency of plants. (**R**)	Ensures continuous, reliable operation of geothermal facilities.
Energy Economist	Evaluate the economic viability of geothermal projects. (**T**) Degree in economics or energy markets. (**Q**) Analyze costs and returns of geothermal ventures. (**R**)	Supports investment decisions and long-term project sustainability.
Health and Safety Officer	Enforce safety protocols on-site. (**T**) Safety training and certification. (**Q**) Ensure worker and environmental safety during drilling and operation. (**R**)	Ensures safe and compliant operations, preventing accidents and legal issues.

Legend: T – tasks; Q – qualification, R - responsibilities

Source: expert's opinion and literature review i.a. (Arcelay et al., 2021; Czako, 2020; European Commision, 2024; ILO, 2011; Indeed Editorial Team, 2024; Kayahan Karakul, 2016; Lehr et al., 2008; Malamatenios, 2016 ; Sooriyaarachchi et al., 2015; WorldSkills, 2024)

Table 3 Key occupations for photovoltaic energy

Key Occupation	**Description**	**Justification**

Solar PV Engineer	Design, install, and optimize solar systems. (**T**) Electrical Engineering degree or qualifications. (**Q**) Maximize energy output and ensure safety compliance. (**R**)	Vital for expanding and optimizing solar energy infrastructure.
Solar Panel Installer	Install solar panels. (**T**) Certification in solar PV installation. (**Q**) Ensure efficient and safe panel installation. (**R**)	Key in deploying solar capacity on residential and commercial properties.
Solar Project Manager	Oversee large solar projects. (**T**) Project management experience. (**Q**) Coordinate between engineers, clients, and contractors. (**R**)	Ensures that solar projects are delivered on time, within budget, and to specifications.
Electrical Technician	Connect solar panels to electrical grids. (**T**) Electrical certification. (**Q**) Ensure safe and compliant electrical connections. (**R**)	Connects the solar system to power grids, ensuring reliable energy distribution.
Energy Storage Specialist	Integrate batteries with solar systems. (**T**) Electrical engineering, energy storage expertise. (**Q**) Develop energy storage solutions for uninterrupted solar energy supply. (**R**)	Crucial for ensuring solar energy availability when sunlight is not present.
Solar Designer	Create layouts for solar panel installations. (**T**) Architectural or engineering background. (**Q**) Design aesthetically pleasing and efficient solar panel arrays. (**R**)	Key in optimizing space utilization for maximum energy output.

Legend: T – tasks; Q – qualification, R - responsibilities

Source: expert's opinion and literature review i.a. (Arcelay et al., 2021; Czako, 2020; European Commision, 2024; ILO, 2011; Indeed Editorial Team, 2024; Kayahan Karakul, 2016; Lehr et al., 2008; Malamatenios, 2016; Sooriyaarachchi et al., 2015; WorldSkills, 2024)

Table 4 Key occupations for wind power

Key Occupation	Description	Justification
	Design wind turbines. (**T**)	

Wind Turbine Engineer	Mechanical Engineering degree. (**Q**) Ensure efficient turbine operation. (**R**)	Fundamental to increasing energy production through improved turbine designs.
Wind Farm Technician	Repair and maintain wind turbines. (**T**) Technical certification in wind technology. (**Q**) Ensure turbines run smoothly and efficiently. (**R**)	Essential for maintaining continuous energy generation from wind farms.
Wind Resource Analyst	Analyze wind patterns for site selection. (**T**) Degree in meteorology or renewable energy. (**Q**) Identify the best locations for wind farms. (**R**)	Crucial for maximizing the energy yield from each wind farm.
Wind Farm Project Manager	Manage wind farm construction projects. (**T**) Project management certification. (**Q**) Oversee construction, budgeting, and timelines. (**R**)	Ensures projects are completed on time, within budget, and to high standards.
Electrical Grid Engineer	Integrate wind farms into the electrical grid. (**T**) Degree in electrical engineering. (**Q**) Ensure efficient and safe energy transmission. (**R**)	Manages the flow of electricity from wind farms to consumers, critical for energy stability.
Blade Repair Technician	Repair and maintain wind turbine blades. (**T**) Certification in blade repair. (**Q**) Ensure blades are aerodynamic and damage-free. (**R**)	Essential for maintaining the performance and longevity of wind turbines.
Safety Officer	Enforce safety measures at wind farms. (**T**) Health and safety certification. (**Q**) Prevent workplace accidents and ensure regulatory compliance. (**R**)	Ensures safe working conditions and reduces risks in wind farm operations.

Legend: T – tasks; Q – qualification, R - responsibilities

Source: expert's opinion and literature review i.a. (Arcelay et al., 2021; Czako, 2020; European Commision, 2024; ILO, 2011; Indeed Editorial Team, 2024; Kayahan Karakul, 2016; Lehr et al., 2008; Malamatenios, 2016; Sooriyaarachchi et al., 2015; WorldSkills, 2024)

Table 5 Key occupations for unconventional pumped hydro

Key Occupation	Description	Justification
Hydropower Engineer	Design and maintain hydro storage systems. (**T**)	Key in developing efficient energy storage systems for renewable energy.
	Mechanical or civil engineering degree. (**Q**)	
	Ensure water flow efficiency and power generation. (**R**)	
Civil Engineer	Design and build infrastructure. (**T**)	Ensures robust and safe infrastructure for energy storage projects.
	Civil Engineering degree. (**Q**)	
	Oversee dam, tunnel, and reservoir construction. (**R**)	
Environmental Scientist	Evaluate environmental impact. (**T**)	Balances energy generation with environmental preservation.
	Environmental science degree. (**Q**)	
	Ensure projects are environmentally sustainable. (**R**)	
Water Resource Manager	Manage water resources for storage. (**T**)	Ensures efficient water management, critical for hydro storage operations.
	Degree in water resource management. (**Q**)	
	Optimize water usage and storage capacity. (**R**)	
Maintenance Technician	Maintain hydro storage infrastructure. (**T**)	Keeps the system running efficiently, reducing downtime and increasing reliability.
	Technical certification in hydropower maintenance. (**Q**)	
	Ensure that equipment operates smoothly. (**R**)	
Structural Engineer	Assess structural integrity. (**T**)	Prevents structural failures that could lead to costly downtime or disasters.
	Degree in structural engineering. (**Q**)	
	Ensure safety and durability of hydro structures. (**R**)	
Hydrologist	Study water flow and distribution. (**T**)	Ensures efficient energy generation by understanding water flow patterns.
	Degree in hydrology. (**Q**)	
	Provide data to optimize water use for energy storage. (**R**)	

Legend: T – tasks; Q – qualification, R - responsibilities

Source: expert's opinion and literature review i.a. (Arcelay et al., 2021; Czako, 2020; European Commision, 2024; ILO, 2011; Indeed Editorial Team, 2024; Kayahan Karakul, 2016; Lehr et al., 2008; Malamatenios, 2016; Sooriyaarachchi et al., 2015; WorldSkills, 2024)

Table 6 Key occupations for batteries

Key Occupation	Description	Justification
Battery Engineer	Design and optimize battery systems. (**T**) Materials Science or Electrical Engineering degree. (**Q**) Improve energy storage and efficiency. (**R**)	Crucial for developing reliable storage solutions for renewable energy.
Electrochemist	Develop and test battery materials. (**T**) Degree in chemistry or materials science. (**Q**) Innovate new battery chemistries for higher efficiency. (**R**)	Drives the advancement of battery technology, increasing storage capacity and lifespan.
Energy Systems Analyst	Model energy storage solutions. (**T**) Degree in energy systems. (**Q**) Evaluate battery and hydrogen usage in energy grids. (**R**)	Ensures optimal integration of storage technologies into the energy system.
Battery Technician	Maintain battery systems. (**T**) Technical certification in battery maintenance. (**Q**) Ensure batteries function properly in storage systems. (**R**)	Essential for reliable energy storage in renewable energy systems.

Legend: T – tasks; Q – qualification, R - responsibilities

Source: expert's opinion and literature review i.a. (Arcelay et al., 2021; Czako, 2020; European Commision, 2024; ILO, 2011; Indeed Editorial Team, 2024; Kayahan Karakul, 2016; Lehr et al., 2008; Malamatenios, 2016; Sooriyaarachchi et al., 2015; WorldSkills, 2024)

Table 7 Key occupations for green hydrogen

Key Occupation	Description	Justification
Green Hydrogen Engineer	Design and optimize hydrogen production systems. (**T**) Degree in Chemical Engineering or Physics with experience in electrolysis. (**Q**) Ensure compliance with environmental regulations. (**R**)	Essential for the advancement of green hydrogen technology.

Renewable Energy Technician	Install and maintain renewable energy systems. (**T**)	Critical for integrating hydrogen production with renewable sources.
	Technical certifications, vocational training in renewable energy technology. (**Q**)	
	Ensure system efficiency. (**R**)	
Hydrogen Storage Specialist	Develop and manage hydrogen storage solutions. (**T**)	Important for safe and effective hydrogen management.
	Background in materials science or mechanical engineering. (**Q**)	
	Ensure safety and efficiency in storage systems. (**R**)	
Fuel Cell Engineer	Research and develop fuel cell technologies. (**T**)	Key to enabling hydrogen as a clean energy carrier.
	Engineering degree in Electrical Engineering or a related field with fuel cell experience. (**Q**)	
	Improve fuel cell performance for various applications. (**R**)	
Research Scientist in Hydrogen	Conduct research on hydrogen technologies. (**T**)	Critical for advancing knowledge and technology in the sector.
	PhD in Chemistry, Chemical Engineering, or a related discipline. (**Q**)	
	Innovate solutions to enhance hydrogen applications. (**R**)	
Project Manager for Hydrogen	Oversee hydrogen-related projects from inception to completion. (**T**)	Essential for the successful execution of hydrogen projects.
	Experience in project management. (**Q**)	
	Coordinate teams and resources effectively. (**R**)	

Legend: T – tasks; Q – qualification, R - responsibilities

Source: expert's opinion and literature review i.a. (Arcelay et al., 2021; Czako, 2020; European Commision, 2024; ILO, 2011; Indeed Editorial Team, 2024; Kayahan Karakul, 2016; Lehr et al., 2008; Malamatenios, 2016; Sooriyaarachchi et al., 2015; WorldSkills, 2024)

The information compiled in this section offers a generalized classification of occupations that experts consider crucial for operations in both the mining industry and the Renewable Energy Sector. By aligning with international standards, we acknowledge that specific requirements may vary across countries. In particular, some nations may have more detailed regulations, specifying particular certifications or authorizations that employees must possess and additional sector-specific professions. These roles may require specific physical and psychological aptitudes, highlighting the necessity for tailored workforce development strategies. It is important to emphasize that legal regulations within each EU member state prohibit discrimination in access to specific professions, thereby promoting equal opportunities in the labor market. Our analysis intentionally excludes occupations related to auxiliary and managerial processes common to all enterprises. From the perspective of this study, such roles are likely to exhibit greater intersectoral flexibility, enabling employees to transition between enterprises while performing similar tasks. Focusing on core technical occupations allows for a more precise assessment of sector-specific labor needs and potential skill gaps.

4.2 Categorise key occupations across coal mining and renewable energy sectors value chains

Identifying key occupations within an already defined value chain involves mapping out the critical roles contributing to each step in the value creation process. The value chain represents all the activities required to transform inputs into a final product or service. By analyzing this chain, coal sector as well as RES sector can pinpoint the essential occupations at each stage, from procurement and production to marketing and after-sales services. The process started with breaking down the value chain into its core activities, such as inbound logistics, operations, outbound logistics, marketing, sales, and service (see previous chapter). Each of these activities relies on specific occupations vital for adding value to the product or service. Therefore, for the three industrial partners participating in the project whose activities are based on mining, a review of the occupations that occur at each value chain stage was carried out. Gained information are summarized in the tables below for each mining company HUNOSA Spain (Table 8), Węglokoks Kraj S.A. Poland (Table 9), Premogovnik Velenje, d. o. o. Slovenia (Table 10).

Table 8 Key occupations in HUNOSA (Spain)

Element of value chain	Occupation (group of employees)	Synthetic description of the occupation, occupation-specific positions and job tasks	Descriptions of professional qualifications, competencies needed to perform professional tasks
Logistics	Warehouse	Receiving and delivering materials. Inventory management	Office skills
	Transport	Transport of the materials from receipt to the point of work	Job-specific knowledge
	Artilleryman	Transportation of explosives. Explosives loading and detonation	Knowledge of explosives safety and management. Gunner licence
Coal extraction	Specialized miner	Coal extraction or advance of galleries	Job-specific knowledge
	Assistant	Coal extraction or advance of galleries	Job-specific knowledge
Maintenance	Electrical	New equipment installations and maintenance	Knowledge of electrical maintenance. Mining electrician license
	Mechanical	New equipment installations and maintenance	Knowledge of mechanical maintenance.
Safety	Safety operator	Control of ventilation gauging, gas measurement, safety inspections, workers training, etc.	Job-specific knowledge
Administrative work	Administrative	Information of each work relay. Daily production information. Access controls.	Office skills
Management	Mining Engineer	Management of one or more mine departments	Degree in Mining Engineering
	Master in Mining Engineer	General mine management	Master in Mining Engineering

Table 9 Key occupations in Węglokoks Kraj S.A. (Poland)

Element of value chain	Occupation (group of employees)	Synthetic description of the occupation, occupation-specific positions and job tasks	Descriptions of professional qualifications, competencies needed to perform professional tasks
Mining	Miner	Performs underground work, operates mining machinery, and extracts minerals.	Vocational education or training in mining, knowledge of mining processes, and safety protocols.
	Underground Supervisor	Oversees operations in the underground part of the mine, ensuring safety and productivity.	Must have several years of mining experience and certification in underground mining management.
	Surface Supervisor	Manages activities on the mine's surface, coordinating with the underground operations.	Experience in mining management, leadership skills, and relevant safety qualifications.
	Mine Foreman (Nadsztygar)	Supervises and coordinates all mining activities, ensures compliance with safety and production standards.	Formal mining qualification and leadership experience, safety certificates.
	Geophysicist	Conducts geological surveys and assesses the earth's structure to guide mining operations.	Degree in geophysics or geology and experience with geological surveying.
	Shot-Firing Instructor	Responsible for instructing and supervising blasting operations in the mine.	Certification in explosives handling and safety protocols, extensive experience.
Processing	Senior Electrician	Installs and maintains electrical systems in the mine, including high-voltage equipment.	Electrician's certification, knowledge of electrical systems used in mining.
	Electrician	Conducts routine maintenance and repairs on electrical systems and machinery.	Electrical vocational qualification and on-site experience.
	Conveyor Operator	Operates conveyors used to transport mined materials to processing areas.	Mechanical knowledge and experience operating mining machinery.
	Machine Operator	Operates various heavy machinery used in the processing of mined materials.	Certification in heavy machinery operation and safety training.

	Maintenance Technician	Conducts regular maintenance on processing machinery to ensure optimal operation.	Mechanical engineering background and certification in equipment maintenance.
Production	Senior Mechanic	Oversees the mechanical maintenance of mining equipment, supervises junior mechanics.	Extensive mechanical experience, technical certification in machinery.
	Welder	Performs welding tasks, repairing and maintaining equipment used in production.	Vocational training in welding and certification in industrial equipment repair.
	Miner's Assistant (Younger Mechanic)	Assists more experienced mechanics or welders in performing maintenance tasks.	Vocational training in mechanics and practical experience in a mine.
Logistics	Dispatcher (Mining Traffic)	Coordinates and controls the movement of materials and people within the mining site.	Logistical experience and knowledge of mine layout and transportation systems.
	Machine Dispatcher	Coordinates machine usage and scheduling for efficient logistics in mining.	Training in logistics and machinery management, strong organizational skills.
	Locomotive Operator	Operates locomotives transporting materials and personnel within the mining complex.	Certification for operating industrial locomotives and safety protocols.
	Hoist Operator	Manages the hoisting systems that transport materials and workers between levels.	Training in hoist operation and extensive safety qualifications.
Sale & Marketing	Marketing Specialist	Develops strategies to sell mined products, analyzes market demand, and works with clients.	Knowledge of mining products and markets.
	Sales Manager	Oversees the sales team, establishes client relationships, and sets sales targets.	Strong sales background, experience in the mining industry, and management skills.

Table 10 Key occupations in Premogovnik Velenje, d. o. o. (Slovenia)

Element of value chain	**Occupation (group of employees)**	**Synthetic description of the occupation, occupation-specific positions and job tasks**	**Descriptions of professional qualifications, competencies needed to perform professional tasks**
Exploration, planning and mining projects	Project designer	• Collaboration in the preparation of projects, changes, amendments, or deviations from projects and other technical documentation	• Technical Competence: Technical skills and knowledge required to effectively perform job. • Accuracy

		• Preparation of individual parts of projects or attachments to projects • Participation in project teams • Participation in technical and periodic inspections	• Ability to analyze information, problem-solve, and make informed decisions. • Ability to anticipation • Adaptability, Flexibility and resourcefulness: Ability to adapt to changing circumstances, learn new skills, and adjust to new environments or challenges, problem-solving abilities to handle unexpected situations. • Creativity and Innovation: Ability to generate new ideas, approaches, or solutions to problems. • Openness to changes and new things • Team work Competence: Skills in building relationships, teamwork, and collaborating effectively with others.
Transport and logistic & infrastructure building and mine maintenance	Mix of below table	• Mix	• Mix
Development (gateroads)	Miner	• Execution of all mining works, including construction, maintenance, excavation, and decommissioning of mine structures • Preparation of materials and equipment, transport tasks, assistance with the installation and dismantling of electro-mechanical equipment • Operation of haulage and other machinery, operational control	• Ability to work in a hazardous environment – appropriate awareness and training • Technical Competence: Technical mining skills and knowledge required to effectively perform job. • Physical fitness & health • Ability to anticipation

		• Operation of auxiliary equipment and devices for performing tasks • Cleaning and maintenance of mine structures	• Adaptability, Flexibility and resourcefulness: Ability to adapt to changing circumstances, and adjust to new environments or challenges, problem-solving abilities to handle unexpected situations. • Communication skills: adherence to hierarchy. • Team work Competence- work in smaller teams on work sites.
Mining	Miner	• Same as Development	• Same as Development
Coal transport and processing	Belt conveyer server	• Management and operational control of haulage machinery (conveyors, hoisting machines, etc.) • Dust and material removal in underground structures • Arrangement and construction of walkways, bases, dumps, minor maintenance of underground structures • Cleaning of underground structures and equipment • Removal of unsuitable material from haulage and spills	• Ability to work in a hazardous environment – appropriate awareness and training • Communication skills: adherence to hierarchy.
Sales and stockpile	N/A	N/A	N/A
Transport and logistic	Transport machines operator, locomotive driver	• Operation of machinery and equipment for transporting materials and people • Preparation and execution of the transportation of materials and people • Performing assembly, disassembly, and maintenance work on transport equipment	• Ability to work in a hazardous environment – appropriate awareness and training • Technical Competence: machines operation and knowledge of maintenance.

		• Inspection and testing of transport equipment and devices • Operation of auxiliary equipment and devices for performing tasks • Assisting in the execution of simple mining tasks during maintenance interventions • Recording the execution of tasks	• Physical fitness & health • Adaptability, Flexibility and resourcefulness: Ability to adapt to changing circumstances, and adjust to new environments or challenges, problem-solving abilities to handle unexpected situations. • Communication skills: adherence to hierarchy.
Electro machine department	Maintainer & mounting	• Performing assembly, disassembly, and maintenance work on machinery and installations • Inspection and testing of machinery including electrical and other measurements, Handling of high-voltage and low-voltage switchgear equipment, • Recording the execution of tasks • Preparation of materials and equipment, minor transport tasks • Operation of auxiliary equipment and devices for performing tasks • Operation of haulage and other machinery • Assisting in the execution of simple mining tasks during maintenance interventions	• Ability to work in a hazardous environment – appropriate awareness and training • Technical Competence: specific machines operation and knowledge of maintenance. • Knowledge of additional safety protocols • Physical fitness & health • Adaptability, Flexibility and resourcefulness: Ability to adapt to changing circumstances, and adjust to new environments or challenges, problem-solving abilities to handle unexpected situations. • Team work Competence: Skills in building relationships, teamwork, and collaborating effectively with others. • Communication skills: adherence to hierarchy.

Ventilation and mine objects	Maintainer & builder	• Implementation of work in the construction, maintenance, assembly, and dismantling of ventilation structures, devices, and facilities; • Execution of mining activities in excavation, construction, maintenance, and decommissioning of underground structures; • Preparation of materials and equipment, transport tasks, assistance in the installation and dismantling of electro-mechanical equipment; • Mine drilling, • Operation of haulage and other machinery, operational control; • Operation of auxiliary equipment and devices for performing tasks; • Cleaning and maintenance of underground structures;	• Ability to work in a hazardous environment – appropriate awareness and training • Technical Competence: Technical mining skills and knowledge required to effectively perform job. • Physical fitness & health • Ability to anticipation • Adaptability, Flexibility and resourcefulness: Ability to adapt to changing circumstances, and adjust to new environments or challenges, problem-solving abilities to handle unexpected situations. • Communication skills: adherence to hierarchy. • Team work Competence- work in smaller teams on work sites. • Specific knowledge of mine ventilation • Specific knowledge of mine drilling
Logistic and dispatching surface	Warehouse staff, Dispatching staff	• Work in the preparation of mortar and emulsions, in accordance with restrictions. • Work in the inspection and completion of steel arch support. • Work in the loading and unloading of equipment and materials, in accordance with restrictions. • Work in the washing of equipment, in accordance with restrictions. • Inspection and cleaning of transport routes.	• Technical Competence: Technical skills and knowledge required to effectively perform job. • Accuracy • Ability to analyze information, problem-solve, and make informed decisions. • Ability to anticipation • Team work Competence: Skills in building relationships, teamwork, and collaborating effectively with others.

		• Work in the inspection, sorting, classification, and stacking of waste materials. • Receipt, issuance, and quantity control of goods. • Delivery of goods. • Participation in handling complaints. • Participation in inventories. • Ensuring order and cleanliness of the work environment.	• Communication skills: adherence to hierarchy, knowledge of verbal and non verbal, presentations, negotiations etc.)

Based on the provided data concerning occupations within the mining supply chains of three countries - Poland, Slovenia, and Spain as well as information gathered during panel discussions with entrepreneurs, the following conclusions on these nations' mining industries can be formulated:

- the mining industries in analysed countries present a consistent value chain structure. This structure encompasses several key elements: exploration and planning, mining operations, maintenance, logistics, safety, and administration. In the exploration phase, project designers and geophysicists prepare documentation and conduct geological studies. Core mining operations are managed by miners and specialized workers responsible for underground extraction and mine development. Maintenance technicians, both electrical and mechanical, ensure operational efficiency by maintaining equipment. Logistics workers handle the transport of materials and personnel, while safety officers manage ventilation, gas measurement, and explosives control. Administrative staff, including mining engineers and supervisors, oversee the smooth flow of information and departmental management. This unified value chain structure facilitates efficient mining operations across these countries and highlights shared practices in safety, logistics, and technical management, contributing to the overall effectiveness of the sector.
- despite regional differences, the mining industries in the three countries exhibit significant similarities in key occupational roles and responsibilities. Miners are responsible for performing underground work, operating machinery, and extracting minerals. Maintenance technicians handle the installation and upkeep of both electrical and mechanical equipment, ensuring smooth operations. Logistics operators coordinate the transport of materials and personnel, managing conveyors and locomotives. Safety personnel play a critical role by ensuring compliance with safety protocols, conducting inspections, and providing necessary training. Lastly, management roles are focused on overseeing operations, maintaining productivity, and ensuring safety standards are met across the workforce.
- the professional qualifications and competencies required across the mining industries are largely unified and consistent. Workers must possess technical expertise, often obtained through vocational education or specialized training in fields such as mining, electrical, or mechanical systems. Safety awareness is also critical, including knowledge of safety protocols and training for hazardous environments, as well as certifications such as mining electrician licenses or qualifications in explosives handling.
- physical agility is essential, as many tasks are physically demanding and occur in challenging conditions. Additionally, strong teamwork and communication skills are needed to collaborate effectively and follow hierarchical communication structures. Workers must also demonstrate adaptability and problem-solving

abilities to handle unexpected situations, respond to changes, and devise innovative solutions. Lastly, a solid understanding of regulatory compliance, including adherence to national and international mining standards, is mandatory to ensure safe and lawful operations.

- safety is a critical focus in the mining industries of all three countries, with strict safety protocols in place. Standardized measures, including regular inspections and mandatory safety training, are essential to ensure workplace safety. Workers are required to obtain specific certifications to handle explosives, operate machinery, and perform underground tasks. Furthermore, dedicated personnel are responsible for overseeing and enforcing these safety measures to maintain compliance with regulations.
- vocational and technical education also plays a vital role in mining. Educational pathways prioritize vocational training, technical expertise, and ongoing professional development. Skill development is centered on both theoretical knowledge and hands-on practical experience, often gained through apprenticeships and on-the-job training, ensuring that workers are equipped to handle the demands of the industry.

The analysis of key occupations in legacy supply chains also covered important structural aspects - gender, employee size and age, precisely length of service to retirement. The table (Table 11) presents the total number of employees in each company and the structure by gender (Figure 11).

Table 11 Sex and employment in mining companies

Company	Female	Male	Total employment
Hulleras del Norte, S.A. (HUNOSA)	5	134	139
Węglokoks Kraj S.A.	211	1 630	1841
Premogovnik Velenje, d. o. o.	75	1 861	1936

Source: mining companies

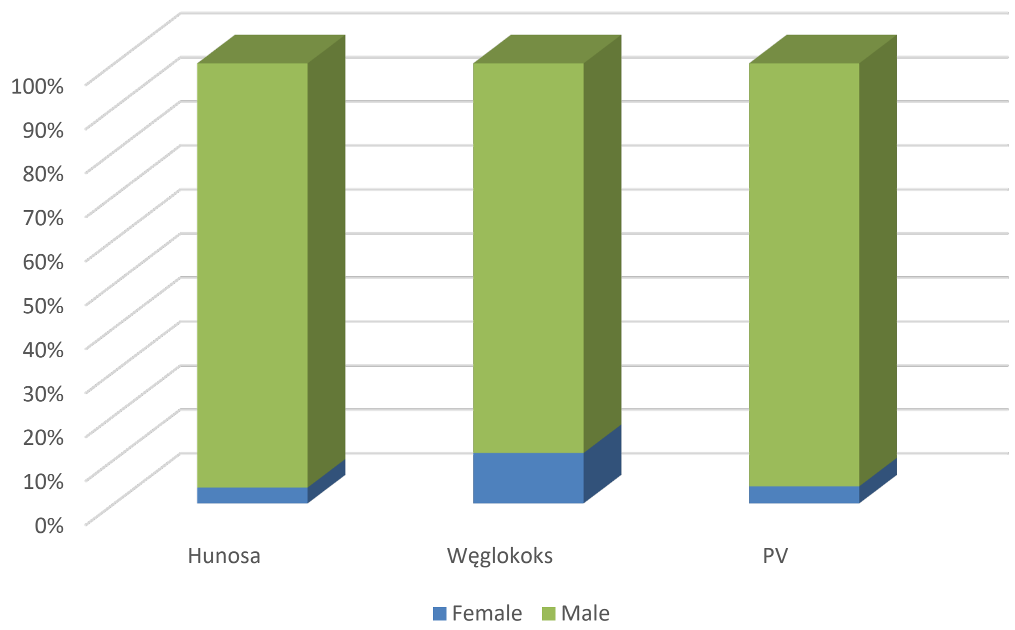

Figure 11 Structure of employment in mining companies by gender

The employment statistics for the three mining companies reveal a significant gender disparity. Hulleras del Norte, S.A. (HUNOSA) employs only 5 women out of 139 total employees, reflecting an extremely low female representation of about 3.6%. Węglokoks Kraj S.A. shows a slightly better scenario with 211 women out of 1,841 employees, accounting for approximately 11.5%. In contrast, Premogovnik Velenje has 75 women among 1,936 employees, resulting in about 3.9%. This data can be used to highlight the gender imbalance in mining employment across all companies. Access for women in the mining sector remains severely limited, with only about 15% of the workforce comprising female employees (Perks & Ford, 2024). This disparity highlights systemic barriers, including cultural biases and inadequate workplace policies, which restrict women's employment opportunities in this male-dominated field (ILO, 2021). Moreover, the challenges faced by women in mining extend beyond access. They often contend with hostile working conditions, including safety issues and inadequate support systems. Despite these obstacles, many women demonstrate resilience and adaptability, leveraging their skills to navigate these challenges effectively, though support from management and better workplace practices is crucial for sustained progress. (Eiter et al., 2023; Mahlasela et al., 2023)

From the perspective of an energy transition, some workers will undergo the re-skilling process, but some will acquire pension privileges. Therefore, carrying out an analysis that takes into account the number of employees who will become eligible for retirement is essential in the planning process for mine closures. Quantitative information on the years until retirement of the employees of the analysed mines is presented below, and in the graph, also the structure of these groups in total employment is given.

Table 12 Period to obtain pension privileges in mining companies

Company	Years till retirement		
	0-5	5-10	more than 10
Hulleras del Norte, S.A. (HUNOSA)			139
Węglokoks Kraj S.A.	335	663	843
Premogovnik Velenje, d. o. o.	366	219	1351

Source: mining companies

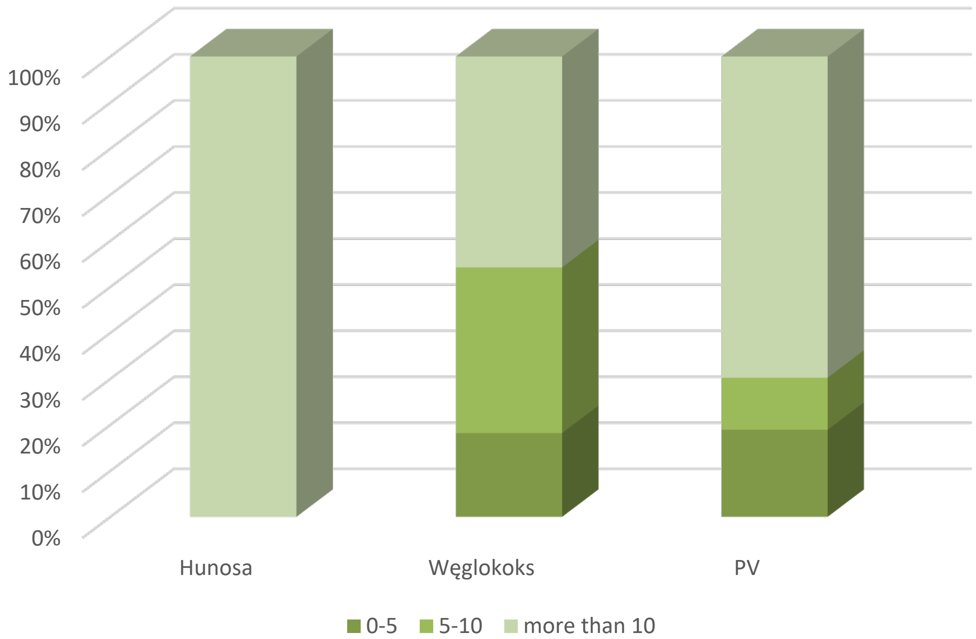

Figure 12 Structure of employment in mining companies including employee years until retirement

The retirement data reveals varying timelines across different mining companies. At Hulleras del Norte, S.A. (HUNOSA), 100% of employees are set to retire in more than 10 years. Węglokoks Kraj S.A. shows a distribution of 27% retiring in 0-5 years, 54% in 5-10 years, and 19% in more than 10 years. Meanwhile, Premogovnik Velenje, d. o. o. has 27% of its workforce nearing retirement within 0-5 years, 15% in 5-10 years, and a significant 58% in more than 10 years. This landscape shows the urgent need for transformative strategies and re-skilling initiatives to adapt to the shifting workforce dynamics and ensure sustainable operations in the mining sector.

Slightly more complicated is the identification of the key occupations in the supply chains for renewables. However, some of them are characterised by a market maturity that makes it possible to identify the main links in the value chain and assign specific professions to them (e.g. photovoltaics, wind energy), in some cases this is rather difficult. One has to rely on the few existing models and concepts that will evolve significantly with the development of these forms (this applies, e.g., unconventional pumped hydro, green hydrogen or batteries). Not all occupations are described by national or international standards of competence. Therefore, the analysis was carried out only to list typical occupations found in the value chains of the RES analysed. Appropriate occupations were assigned for the value chain patterns developed earlier (Table 13). The following are worth noting:

- in the analysis of value chains in the renewable energy sector (RES) reveals a wide variety of professions needed at every stage of production and operations. The most sought-after roles include engineers, technicians, and specialists in logistics and management. In each RES value chain, professions related to materials and mechanical engineering are essential, indicating the need for education in these fields. Materials engineers, electricians, and chemists are present in almost every area—from green hydrogen production to energy storage technologies.
- logistics managers and project development engineers play a key role in the logistical and operational phases. This shows that education in operational management, supply chain management, and logistics is as crucial as technical education. The RES sector also shows a growing demand for environmental protection and sustainability specialists, suggesting the need to develop educational programs in these areas.
- the increasing importance of jobs related to servicing and maintaining energy infrastructure, such as service technicians and reliability engineers, highlights the need for practical training in the operational maintenance of RES technologies. These roles are crucial not only for the operation of systems but also for extending their lifecycle. Overall, the analysis indicates that education must cover a broad spectrum, from technical engineering skills to project management and environmental protection, to meet the demands of the diverse and dynamically growing RES sector.
- despite not being explicitly listed, IT professionals such as software engineers, data analysts, and cybersecurity specialists will be indispensable. As renewable energy systems become more advanced and integrate complex control systems, automation, and smart grid technologies, the role of IT will be essential for ensuring efficient operations. This is particularly true for the control and monitoring of these intricate systems, as well as for maintaining their security.
- connecting renewable energy installations to national grids and balancing the energy supply and demand will require advanced grid management solutions.

This further highlights the importance of digital and IT skills in renewable energy, especially in grid integration and energy balance maintenance.

Table 13 Occupations for analysed RES value chains

Geothermal energy	Phases in thevalue chain	Materials	Manufacturing	Assembly	Logistic	Development & operations	Maintenance
	Key occupations	Materials Engineer, Procurement Specialist, Metallurgist	Mechanical Engineer, Electrical Engineer, CNC Machinist, Quality Control Inspector, Production Manager	Field Technician, Assembler	Logistics Coordinator, Supply Chain Manager, Transport Planner, Warehouse Manager	Geothermal Engineer, Geologist, Project Manager, Environmental Scientist, Operations Manager, Drilling Supervisor	Maintenance Technician
Photovoltaic energy	Phases in the value chain	Raw material processing	Manufacturing of components	Supply & Assembly	Sales & marketing	Logisics Plant engineerging & construction	Operation and maintenance
	Key occupations	Mining engineers, Metallurgists, Chemical engineers, Process technicians	Mechanical engineers, Electrical engineers, Production managers, Quality control specialists, Manufacturing technicians	Installation technicians, Field engineers	Sales representatives, Marketing managers, Customer service agents	Logistics managers, Transportation coordinators, Fleet managers, Warehouse operators, Inventory specialists, Civil engineers, Structural engineers, Construction managers, Project managers, Site supervisors, Safety inspectors, Cost estimators	Maintenance technicians
Wind power	Phases in the value chain	Materials	Components	Manufacture	Logistic	Development & operations	Maintenance
	Key occupations	Procurement Manager, Materials Scientist, Metallurgist	Electrical Engineer, Mechanical Engineer	Production Manager, CNC Operator, Quality Control Specialist, Welder	Supply Chain Manager, Transport Coordinator	Project Manager, Wind Energy Analyst, Environmental Specialist	Wind Turbine Technician, Maintenance Engineer
Unconventional pumped hydro	Phases in the value chain	Materials	Large volume smelting and converting	Component manufacture & assembly	Plant engineering & project development	Installation and construction	Maintenance
	Key occupations	Materials Engineer, Procurement Manager	Metallurgist, Smelting Technician, Process Engineer	Assembly Technician, Mechanical Engineer, Quality Control Specialist	Project Manager, Civil Engineer, Environmental Engineer, Electrical Engineer	Construction Manager, Site Supervisor, Electrician	Maintenance Technician, Reliability Engineer

Batteries	Phases in the value chain	Raw materials asquisition	Chemistry & cell selection	Manufacturing	System integration	Development & construction	Barttery Management & Marketing Operations	Second Life / recycyling
	Key occupations	Mining Engineer, Geologist, Procurement Specialist	Electrochemist, Materials Scientist	Process Engineer, Quality Control Inspector, Production Operator	Electrical Engineer, Software Engineer	Project Manager, Civil Engineer, Construction Supervisor	Operations Manager, Marketing Specialist, Data Analyst	Recycling Engineer, Environmental Specialist

Green hydrogen	Phases in the value chain	Electricity production and water supply	Green hydrogen production (electrolysis)	Green hydrogen and green derivatives production	Transport and storage	Consumption and usage	Maintenance
	Key occupations	Electrical Engineer, Hydrologist, Power Plant Operator	Electrochemical Engineer, Process Engineer	Chemical Engineer, Industrial Chemist, Plant Operator	Logistics Manager, Supply Chain Analyst, Hydrogen Storage Specialist	Energy Consultant, Hydrogen Systems Engineer	Maintenance Technician, Reliability Engineer

5 Assumptions for survey of occupational flexibility in the mining sector

In order to carry out the next phase of work in WP5 I to develop final dedicated re-skilling programs, a survey was prepared: *Employee readiness for green job transition*[1]. The survey aims to investigate the impact of various factors affecting provide an understanding of the occupational readiness and adaptability of employees facing changes in the labour market related to the transition process and the emergence of new occupations. The research approach for analyzing the flexibility of employees in the mining sector and their readiness to transition to other industries involves a comprehensive overview of key areas of adaptability and learning. Based on expert opinion, the key topics to be addressed in the questionnaire were selected (Figure 13).

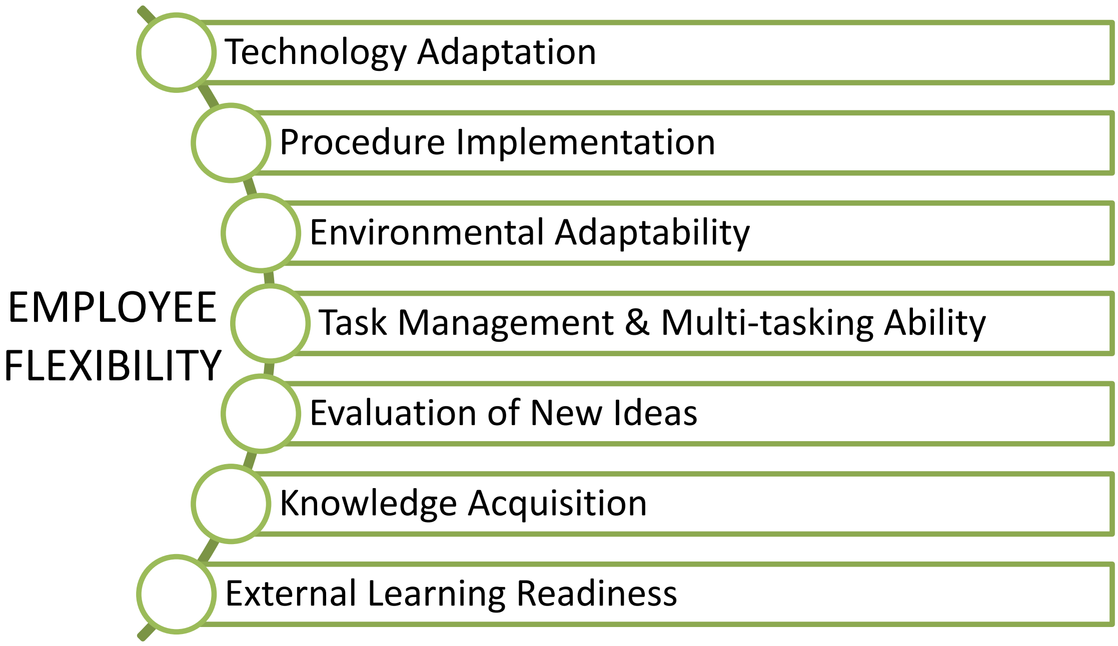

Figure 13 Dimensions of employee flexibility analysis in mines

This structured approach will provide valuable insights into the workforce's flexibility and adaptability, essential for future transitions within or beyond the mining sector.

The second part of the survey focuses on assessing employees' flexibility and the factors influencing their readiness to transition to new roles, particularly in relation to reskilling for green jobs. It begins by exploring how often individuals engage in training or courses to improve their skills, followed by identifying the type of support they need from their

[1]https://forms.office.com/Pages/ResponsePage.aspx?id=TT4ZUe_HQ06kJ31-DzUDltSZL2nNqUlPpAl8cX__JwJUODhFWDk2RTJVNk42MlFNWUpFWEdHRDFQSi4u

employers, such as access to training, mentoring, or new technologies. The survey then asks respondents to evaluate how personal factors like family situation, health, job market conditions, and discrimination impact their decision to change jobs. It also examines how transferable their current skills would be in the green economy, considering industries like renewable energy and waste recycling. Additionally, the questionnaire explores their willingness to accept lower wages for transitioning to a new sector and which factors, such as job security or career development, might make them more likely to accept a reduced salary. This comprehensive inquiry aims to understand the barriers and motivations employees face when considering a transition into emerging green industries, as well as the support needed to facilitate this process.

6 Lessons learnt

The lessons relevant to the Project from this deliverable can be summarised as follows:

1. The transition from coal mining to renewable energy presents significant opportunities to repurpose existing skills and infrastructures. Workers from the mining sector can be reskilled to occupy roles in green technologies, such as geothermal energy and wind power, ensuring a smoother transition for affected regions.

2. A thorough value chain analysis reveals that the mining and renewable energy sectors share many structural similarities. These insights can be leveraged to align job roles across both sectors, enabling a clear roadmap for the transfer of skills between industries.

3. The need for reskilling programs is critical, particularly for coal miners who possess technical knowledge applicable to renewable energy industries. Investment in tailored training initiatives can support the workforce in adapting to new technologies and fulfilling roles in the growing renewable energy sector.

4. Gender disparities within the mining industry remain a challenge, with very low female participation. Addressing this issue through inclusive policies could ensure a more diverse workforce in both traditional and emerging green sectors.

5. The energy transition will require not only a shift in technical skills but also an emphasis on education in project management, environmental protection, and sustainability practices. These competencies are key for the successful deployment of renewable energy projects.

6. Many workers in the coal mining sector are nearing retirement age, highlighting the urgency for workforce planning strategies. The development of reskilling programs should be aligned with demographic trends to ensure a continuous and sustainable workforce.

7. The growing renewable energy market demands roles in both technical and non-technical fields. Beyond engineering, there is a need for expertise in supply chain management, environmental sustainability, and project execution, underscoring the importance of multidisciplinary education and training.

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