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

Grant Agreement 101057789

Deliverable 5.2

Mapping and assessment of key occupations

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Deliverable 5.2	
Due date of Deliverable	30.06.2025
Start - End Date of Project	01.07.2022 – 31.12.2025
Duration	3.5 years
Deliverable Lead Partner	GIG-PIB
Dissemination level	Public
Work Package	WP 5
Digital File Name	D5.2 Mapping and assessment of key occupations
Keywords	Key occupation, value chain, coal mine, renewable energy sources

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Table of contents

List of Figures

List of Tables

Executive Summary

As Europe accelerates its transition towards a low-carbon future, regions historically reliant on coal mining face the dual challenge of economic restructuring and workforce reintegration. This report, developed as part of the GreenJOBS initiative, explores the re-skilling potential of workers in coal-dependent regions by mapping occupations, identifying transferable competencies, and designing targeted training interventions aligned with the renewable energy sector (RES).

Drawing on comprehensive field data from GreenJOBS project partner, the study presents a methodology rooted in ESCO-based occupational mapping and value chain analysis. Key occupations were assessed for their adaptability to RES sectors such as photovoltaics, wind energy, geothermal, green hydrogen, and energy storage. Findings highlight significant opportunities for reskilling, particularly for medium-skilled technical workers whose existing competencies - such as equipment maintenance, electrical systems, and safety compliance - are readily transferable to RES roles.

The report also analyses the competency gaps that must be bridged to ensure a successful transition. While many workers demonstrate high adaptability and openness to technological change, gaps in digital literacy, interdisciplinary collaboration, and sustainability-oriented thinking remain. Tailored, modular training programmes, will be essential to meet these needs.

A particular focus is given to the development of flexible, site-specific education models that recognise prior learning, accommodate diverse skill levels, and address demographic trends such as ageing workforces. In parallel, the study calls for strong policy support and strategic investment in human capital to ensure a Just Transition that is both socially inclusive and economically sustainable.

This document is intended as a practical reference for policy-makers, industry stakeholders, training providers, and regional planners involved in the energy transition. By identifying actionable pathways for workforce reskilling, it offers a framework for aligning local labour profiles with the evolving needs of the green economy - turning structural challenges into long-term development opportunities.

1. Introduction

As Europe advances toward its climate neutrality goals, the energy transition from fossil fuels to renewable sources is reshaping industrial structures, labour markets, and skill requirements. Coal mining regions, long reliant on extractive industries, now face the dual challenge of economic restructuring and social inclusion. While the phase-out of coal addresses environmental imperatives, it simultaneously threatens employment, regional stability, and community identity. This transformation, however, also opens a window of opportunity: the development of green jobs in sectors such as solar, wind, geothermal, and energy storage offers an alternative path forward - provided that affected workers can successfully transition to these emerging domains. The concept of a "just transition" has gained prominence in European policy discourse, aiming to ensure that no one is left behind as economies decarbonise. In this context, reskilling and upskilling become critical mechanisms for enabling workers from carbon-intensive sectors to re-engage with the labour market in new, sustainable roles. Traditional industries like coal mining - although declining - hold latent potential due to the transferable competencies embedded within their workforce. These include technical expertise, operational resilience, and familiarity with high-risk, regulated environments. The challenge lies in identifying those transferable skills, addressing the gaps, and developing targeted training programmes that align with the requirements of the green economy.

This report, grounded in research conducted at Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. - Bobrek Mine (Poland), offers an in-depth analysis of the re-skilling potential within the coal sector. It maps out occupational overlaps between mining and renewable energy sectors using ESCO-based classification and evaluates worker perceptions, attitudes, and readiness for change. Moreover, the report examines systemic barriers such as age, health, educational mismatch, and local labour market constraints that may hinder smooth transitions. Through a combination of quantitative data, competency profiling, and stakeholder insight, the study provides actionable recommendations for policymakers, training institutions, and industry leaders. It highlights the critical importance of accessible, modular training programmes, tailored to regional contexts, and integrated with support mechanisms such as mentoring, job placement services, and employer incentives. By leveraging the existing strengths of the coal workforce while addressing identified gaps, this transition can be both equitable and economically viable.

In doing so, the report contributes to the broader European debate on managing industrial transformation in a socially responsible manner. It reinforces the notion that environmental and employment goals can-and must-be pursued in tandem. The coal workforce is not obsolete; with the right interventions, it can become a vital asset in building a sustainable and inclusive energy future.

2. Methodology

The GreenJOBS project developed a dedicated methodological framework to evaluate the re-skilling potential of workers in coal-intensive regions, with particular focus on their transition readiness for employment in the renewable energy sector. The methodology, while tailored to the mining context, has broader applicability for carbon-intensive sectors undergoing structural transformation. It combines occupational mapping, competency audits, and worker-centred analysis embedded within the concept of a just transition. The approach draws on international best practices and labour market classification tools, and integrates quantitative and qualitative insights to inform practical training and policy recommendations.

2.1. Occupational Mapping and Skills Transferability

At the core of the GreenJOBS methodology lies a structured occupational mapping exercise based on the European Skills, Competences, Qualifications and Occupations (ESCO) framework. This allowed the research team to systematically match existing occupations in the coal mining sector with emerging roles in renewable energy technologies such as photovoltaic systems, wind power, green hydrogen, geothermal energy, and energy storage. Particular attention was paid to overlapping Essential Knowledge, such as mechanical engineering, electricity, geology, and Essential Skills, such as troubleshooting, equipment operation, and workplace safety.

This approach is aligned with the broader theoretical argument that labour market transitions are more feasible when task-based similarities exist between occupations (Gathmann & Schönberg, 2010). It is also supported by policy frameworks on green transitions that promote identification of transferable competences to mitigate risks of job displacement (ILO, 2023; Vona et al., 2018). The mapping results served as the foundation for targeted skills audits and training needs analysis.

2.2. Competency Audit and Gap Identification

Building on the mapping exercise, the research introduced a structured skills audit, comparing current mining competences with those required in the green economy. The ESCO framework again played a central role in identifying missing technical, digital, and interdisciplinary skills, which are essential in new sectors but often underdeveloped in traditional mining roles.

The gap analysis revealed significant deficiencies in technology-specific knowledge, including operation of renewable energy systems (e.g., solar inverters, wind turbine diagnostics), digital literacy (CAD software, data interpretation), and sustainability-related competences (such as environmental awareness, life-cycle thinking, or public communication). These findings align with recent studies on green skills shortages and the complexity of sustainability transitions (Cook & Elliott, 2025; Fleming et al., 2024). The skill gap matrix helped define priority areas for reskilling and guided the design of modular training pathways. It also reinforced the need to incorporate soft skills and interdisciplinary competencies into vocational education programmes (CEDEFOP, 2012; Winberg & Hollis-Turner, 2023).

2.3. Worker Survey and Learning Capacity Assessment

A key strength of the GreenJOBS methodology is its integration of worker perspectives, collected via standardised surveys. These surveys provided insights into perceived skill utility, openness to learning, preferred forms of support, and subjective barriers to occupational change. The survey population included workers with diverse profiles in terms of age, education level, and employment contracts.

The data revealed strong learning adaptability (over 60% of respondents in both countries reported ease in acquiring new knowledge) and high levels of multitasking and task flexibility (>48% in both countries). However, the surveys also identified significant psychological and systemic barriers, including concerns over age, lack of certificates, job insecurity, or low confidence in non-mining sectors (Sitek & Chmielewska, 2022; Beckfield & Evrard, 2023). Incorporating these insights enabled the development of responsive training strategies grounded in realistic assessments of learner readiness, while also identifying areas requiring confidence-building, mentoring, or personalised guidance.

2.4. Just Transition Orientation and Context Sensitivity

A distinguishing feature of the methodology is its alignment with the Just Transition framework, ensuring that socio-economic and institutional conditions of the mining workforce were factored into the analysis. Rather than assuming homogenous conditions across regions or countries, the methodology accounted for local labour markets, institutional support systems, and community expectations. Data collection and interpretation were therefore guided not only by labour market logic but also by the goal of equity and fairness, recognising the historical contribution of coal regions and their need for sustainable reintegration into the green economy (ILO, 2023; Chen et al., 2020).

3. Mapping of Key Occupations

In the case of energy transition, especially in coal-dependent regions, there is a methodological imperative to shift from job title-based comparisons toward competence-based analyses, which allow for greater insight into functional overlaps, skill mismatches, and retraining pathways. As highlighted in literature (McGuinness, S., Pouliakas, K., & Redmond, P., 2018; Awasthi, S. & Kumar, S., 2016), competence frameworks are more effective in capturing the complexity of workplace performance than occupation-only approaches. Moreover, institutions such as CEDEFOP and ILO have emphasized the importance of skills anticipation, competence mapping, and data-driven policy tools in enabling a fair and inclusive transition (CEDEFOP, 2012; ILO, 2015).

This analysis builds upon such methodologies to explore skill and knowledge gaps using ESCO-coded data. It applies both occupational mapping and skill-level alignment techniques to identify priority areas for upskilling. These approaches are essential to ensuring that the energy transition is not only technologically feasible but also socially just, economically inclusive, and empirically grounded (OECD, 2021; UNESCO-UNEVOC, 2019).

As a continuation of the preliminary work identifying key occupations across the coal and renewable energy sectors, this deliverable focuses on standardizing occupational profiles in the coal mining industry using the European Skills, Competences, Qualifications and Occupations (ESCO) classification[1]. The goal is to ensure consistency in terminology and qualification descriptors when mapping skill transferability to the renewable energy value chains.

In the previous phase (Deliverable 5.1), occupational identification was performed through a combination of expert interviews and a comprehensive literature review. This approach allowed for the extraction of sector-specific roles that are integral to each phase of the value chain — from resource extraction, through processing, logistics, and maintenance, to management and post-operational services.

In the current phase, the occupations are generalised and structured within the mining and RES sector value chains, enabling a better understanding of their functional relevance and potential reapplication and transfer. Each occupation has been annotated with its associated Essential Skills and Competences and Essential Knowledge, as defined by ESCO.

[1] The publication uses the European Commission's ESCO classification

3.1. Key Occupations in the Coal Mining Sector

The systematic mapping of occupations within the coal mining value chain has been conducted using the ESCO classification as a foundational reference framework. This approach ensures terminological and conceptual consistency when comparing job profiles across sectors, particularly in the context of a just transition toward renewable energy systems.

Each occupation identified in the coal mining sector was analyzed not only in terms of its functional relevance within specific segments of the mining value chain — such as extraction, maintenance, logistics, safety, or management — but also through the lens of Essential Skills and Competences and Essential Knowledge, as formally defined in the ESCO taxonomy.

The Essential Skills and Competences refer to the core abilities and know-how required to perform occupational tasks effectively, such as operating specialized equipment, interpreting geotechnical data, or implementing health and safety protocols. The Essential Knowledge component encompasses the theoretical and contextual understanding necessary to underpin professional practice, including geology, mining technologies, environmental regulations, and risk mitigation strategies.

By grounding occupational profiles in these two ESCO dimensions, this mapping facilitates:

1. a deeper understanding of the capabilities embedded within each role,
2. the identification of overlapping skill sets with emerging sectors (notably renewables),
3. evidence-based workforce transition planning in coal-dependent regions.

Furthermore, each occupation is positioned within a specific phase of the mining value chain, highlighting its contribution to value creation — from the initial phases of coal extraction to downstream logistics, equipment maintenance, health and environmental safety, and management (which is related to report - Deliverable 5.1. Identification and categorization of key occupations).

This ESCO-aligned mapping serves as the analytical groundwork for cross-sectoral transferability assessments, which will be elaborated in subsequent sections of the report. It also offers a transparent and standardized reference point for stakeholders engaged in policy development, workforce reskilling, and regional transformation planning across Europe's coal regions in transition. The results are shown in the table below.

Table 3-1. Description of key occupations in the mining sector

Occupation	Primary Value Chain Segment	Essential Skills and Competences	Essential Knowledge
1. Dewatering Technician (8111.1)	Maintenance	4. collect samples 5. maintain records of mining operations 6. manage storage tanks 7. manage sumps 8. treat contaminated water 9. troubleshoot 10. work ergonomically	11. chemistry
2. Driller (8111.2)	Coal Extraction	12. check borehole depth 13. coordinate drilling 14. inspect drilling equipment 15. maintain drilling equipment 16. operate drilling equipment 17. position drills 18. record drilling 19. set up drilling rigs 20. transport drilling rigs 21. troubleshoot	22. N/A
3. Environmental Mining Engineer (2143.1.1)	Safety / Administrative	23. address problems 24. critically adjust engineering designs 25. approve engineering design 26. assess environmental impact 27. communicate on minerals issues 28. communicate on the environmental impact of mining 29. develop environmental policy 30. ensure compliance with environmental legislation 31. ensure compliance with safety legislation 32. maintain records of mining operations 33. manage environmental impact 34. perform scientific research 35. maintain records of mining operations	42. chemistry 43. civil engineering 44. engineering principles 45. engineering processes 46. mining, construction and civil engineering machinery products 47. technical drawings

Occupation	Primary Value Chain Segment	Essential Skills and Competences	Essential Knowledge
		36. manage environmental impact 37. perform scientific research 38. prepare scientific reports 39. supervise staff 40. troubleshoot 41. use technical drawing software	
4. Import- export manager in mining, construction and civil engineering machinery (1324.3.2.24)	Logistics	48. abide by business ethical code of conducts 49. apply conflict management 50. build rapport with people from different cultural backgrounds 51. comprehend financial business terminology 52. conduct performance measurement 53. control trade commercial documentation 54. create solutions to problems 55. direct distribution operations 56. ensure customs compliance 57. have computer literacy 58. maintain financial records 59. manage processes managing a business with great care 60. meet deadlines 61. monitor international market performance 62. perform financial risk management in international trade 63. produce sales reports 64. set import export strategies 65. speak different languages	66. embargo regulations 67. export control principles 68. export regulations of dual-use goods 69. international commercial transactions rules 70. international import export regulations 71. mining, construction and civil engineering machinery products
5. Mine Geologist (2114.1.6)	Coal Extraction / Safety	72. address problems critically 73. advise on geology for mineral extraction 74. advise on mining environmental issues 75. communicate on minerals issues 76. communicate on the environmental impact of mining 77. deal with pressure from unexpected circumstances	84. Chemistry 85. geology

Occupation	Primary Value Chain Segment	Essential Skills and Competences	Essential Knowledge
		78. determine characteristics of mineral deposits 79. plan mine operations 80. prepare scientific reports 81. provide information on geological characteristics 82. supervise staff 83. use mine planning software	
6. Mine Health and Safety Engineer (2146.7)	Safety	86. address problems 87. critically develop health and safety strategies in mining 88. ensure compliance with safety legislation 89. investigate mine accidents 90. maintain records of mining operations 91. manage emergency procedures 92. prepare scientific reports 93. prevent health and safety problems 94. supervise staff 95. train employees in mine safety	96. electricity 97. geology 98. mine safety legislation 99. safety engineering
7. Mine Manager (1322.1)	Management	100.address problems critically 101.assess operating cost 102.communicate on minerals issues 103.communicate on the environmental impact of mining 104.communicate with customers 105.deal with pressure from unexpected circumstances 106.develop health and safety strategies in mining 107.ensure compliance with safety legislation 108.ensure mining records are maintained 109.evaluate mine development projects 110.forecast organisational risks 111.identify process improvements 112.interface with anti-mining lobbyists 113.manage commercial risks 114.manage emergency procedures 115.manage mining plant equipment	123.electricity 124.impact of geological factors on mining operations 125.mine safety legislation 126.mining engineering

Occupation	Primary Value Chain Segment	Essential Skills and Competences	Essential Knowledge
		116.manage staff 117.monitor mine production 118.optimise financial performance 119.oversee mine planning activities 120.present reports 121.supervise staff 122.think proactively	
8. Mining Electrician (7412.9)	Maintenance	127.communicate mine equipment information 128.conduct inter-shift communication 129.install electrical mining machinery 130.maintain electrical mine machinery 131.maintain records of mining operations 132.report mine machinery 133.repairs test mine equipment 134.train operators in using mine machinery 135.troubleshoot	136.electrical mine machinery manuals 137.electricity 138.electronics
9. Mining Equipment Mechanic (7233.11)	Maintenance	139.communicate mine equipment information 140.conduct inter-shift communication 141.install mining machinery 142.interpret mechanical mine machinery manuals 143.maintain mine machinery 144.maintain records of mining operations 145.report mine machinery repairs 146.test mine equipment 147.train operators in using mine machinery 148.troubleshoot	149.mechanics
10. Mining Geotechnical Engineer (2142.1.6)	Safety / Coal Extraction	150.address problems 151.critically advise on construction materials 152.advise on geology for mineral extraction 153.design infrastructure for surface mines 154.manage geotechnical staff 155.plan geotechnical investigations in the field	159.impact of geological factors on mining operations 160.geology

Occupation	Primary Value Chain Segment	Essential Skills and Competences	Essential Knowledge
		156.prepare scientific reports 157.supervise staff 158.use mine planning software	
11. Quarry Manager (1322.2)	Management / Administrative	161.communicate on minerals issues 162.communicate on the environmental impact of mining 163.develop health and safety strategies in mining 164.ensure compliance with safety legislation 165.ensure mining records are maintained 166.evaluate mine development projects 167.identify process improvements 168.inspect mine safety conditions 169.maintain plans of a mining site 170.manage commercial risks 171.manage emergency procedures 172.manage mining plant equipment 173.monitor mine costs 174.monitor mine production 175.optimise financial performance 176.oversee mine planning activities 177.supervise staff	178.
12. Shotfirer (Blaster) (7542.1)	Coal Extraction	179.check borehole depth 180.connect blasting circuit 181.examine area after blast 182.examine prospective blast area 183.follow health and safety procedures in construction 184.handle explosives 185.insert charges into drill holes 186.make independent operating decisions 187.report misfires 188.safely detonate explosives 189.signal for explosion 190.troubleshoot	192.electricity 193.explosives 194.marksmanship

Occupation	Primary Value Chain Segment	Essential Skills and Competences	Essential Knowledge
		191.work ergonomically	
13. Surface Mine Plant Operator (8342.10)	Coal Extraction / Logistics	195.address problems critically troubleshoot 196.communicate mine equipment information 197.conduct inter-shift communication 198.deal with pressure from unexpected circumstances 199.inspect heavy surface mining equipment 200.make independent operating decisions 201.operate mining tools 202.perform minor repairs to equipment 203.react to events in time-critical environments	204.excavation techniques 205.impact of geological factors on mining operations 206.mechanics
14. Underground Heavy Equipment Operator (8111.4)	Coal Extraction / Maintenance	207.address problems critically 208.troubleshoot 209.communicate mine equipment information 210.conduct inter-shift communication 211.deal with pressure from unexpected circumstances 212.inspect heavy underground mining equipment 213.operate mining tools 214.perform minor repairs to equipment 215.react to events in time-critical environments 216.make independent operating decisions	217.mechanics 218.impact of geological factors on mining operations 219.electricity 220.health and safety hazards underground
15. Underground Miner (8111.5)	Coal Extraction	221.address problems critically 222.operate a range of underground mining equipment 223.operate hydraulic pumps 224.operate mining tools 225.perform minor repairs to equipment 226.troubleshoot 227.work ergonomically 228.address problems critically 229.troubleshoot 230.communicate mine equipment information 231.conduct inter-shift communication 232.deal with pressure from unexpected circumstances	238.health and safety hazards underground 239.impact of geological factors on mining operations

Occupation	Primary Value Chain Segment	Essential Skills and Competences	Essential Knowledge
		233.inspect heavy surface mining equipment 234.make independent operating decisions 235.operate mining tools 236.perform minor repairs to equipment 237.react to events in time-critical environments	

3.2. Key Occupations in Renewable Energy Sectors

As a continuation of the structured analysis conducted for the coal mining sector, this section identifies and classifies the key occupations within the Renewable Energy Sector (RES) using the European Skills, Competences, Qualifications and Occupations (ESCO) framework.

Given the technological diversity and varying maturity levels across renewable energy domains — including (A) geothermal energy, (B) photovoltaic (PV) / solar energy, C) wind power (onshore and offshore), (D) unconventional pumped hydro, (E) battery systems, and (F) green hydrogen — the occupational landscape of RES is inherently multidimensional. To maintain analytical coherence and enable cross-technology comparability, the mapping was not conducted separately for each RES subsector. Instead, a unified RES value chain model was adopted, grouping occupations according to functional stages of value creation rather than sector silos.

This cross-cutting value chain approach supports:

- Identification of horizontally applicable occupations (e.g., safety, maintenance, engineering),
- Assessment of modular and hybrid technologies that operate across domains (e.g., hydrogen + solar, batteries + wind),
- Enhanced transferability mapping from the mining sector through shared functional logic.

Each occupation was annotated with corresponding Essential Skills and Competences and Essential Knowledge, as defined in ESCO, ensuring consistency with the methodology applied to the coal sector.

The RES value chain used for this classification comprises six integrated functional stages:

- Project Development & Design (including environmental assessment, site selection, system architecture)
- Manufacturing & Assembly (components, modules, systems)
- Installation & Commissioning (on-site integration, system activation)
- Operations & Maintenance (O&M) (routine servicing, fault diagnostics, performance optimization)
- Safety & Environmental Management (safety & environmental protocols, risk mitigation, sustainability compliance)
- System Management & Grid Integration (load balancing, storage, remote monitoring, smart systems)

Occupational mapping across RES value chain is shown in the table. A detailed description of the occupations with assigned skills and knowledge is included in Appendix 1.

Table 3-2. Occupational Mapping Across RES Value Chain

Occupation	Primary Value Chain Segment	Primary RES sector
1. Geothermal Power Plant Operator (3131.3.4)	Operations & Maintenance	A
2. Geothermal Engineer (2149.9.3)	Project Development & Design	A
3. Geothermal Technician (7412.4)	Installation & Commissioning	A
4. Geologist (2114.1)	Project Development & Design	A
5. Geophysicist (2114.2)	Project Development & Design	A
6. Renewable Energy Engineer (2149.9.7)	Project Development & Design / Operations & Maintenance	ALL (A-F)
7. Renewable Energy Consultant (2433.3)	Project Development & Design	ALL (A-F)
8. Solar Energy Technician (7411.1.4)	Installation & Commissioning	B
9. Solar Energy Engineer (2149.9.8)	Project Development & Design	B
10. Solar Power Plant Operator (3131.3.8)	Operations & Maintenance	B
11. Solar Energy Sales Consultant (2433.5)	System Management / Market Interface	B
12. Onshore Wind Energy Engineer (2149.9.6)	Project Development & Design	C
13. Offshore Renewable Energy Plant Operator (3131.1)	Operations & Maintenance	C
14. Offshore Renewable Energy Technician (3119.11)	Installation & Commissioning / Operations & Maintenance	C
15. Onshore Wind Farm Technician (3131.2)	Installation & Commissioning	C
16. Hydroelectric Plant Operator (3131.3.5)	Operations & Maintenance	D
17. Hydropower Technician (3113.2)	Installation & Commissioning	D
18. Health, Safety and Environmental Manager (1213.7)	Safety & Environmental Management	ALL (A-F)
19. Hydropower Engineer (2142.1.5)	Project Development & Design	D
20. Maintenance and Repair Engineer (2141.8)	Operations & Maintenance	ALL (A-F)
21. Hydrologist (2114.1.5)	Project Development & Design	D
22. Battery System Engineer (2151.4)	Project Development & Design / Grid Integration	E
23. Battery Assembler (8212.3.1)	Manufacturing & Assembly	E

24. Battery Manufacturing Technician (3113.4)	Manufacturing & Assembly	E
25. Alternative Fuels Engineer (2149.9.1)	Project Development & Design / Grid Integration	F

Source: own elaboration

*(A) geothermal energy, (B) photovoltaic energy, (C) wind power, (D) unconventional pumped hydro, (E) batteries, (F) green hydrogen

3.3. Similarities and Gaps Across Value Chains

As part of the occupational transition mapping from the coal mining sector to renewable energy value chains, this section presents a systematic analysis of common skill sets identified across both domains - Essential Skills and Competences and Essential Knowledge. The objective is to uncover shared functional capabilities that can serve as a foundation for reskilling and upskilling programs, workforce redeployment, and transition planning in coal-dependent regions.

The analysis builds on previous mapping exercises by comparing the Essential Skills and Competences and Essential Knowledge attached to each mining occupation with those of renewable energy roles, using the ESCO framework as the reference taxonomy.

As part of the broader effort to assess occupational transferability from the coal mining sector to RES sectors, this section presents a structured analysis of shared skill sets and knowledge domains, based on a comparative review of ESCO-classified occupational data. The objective is to identify functional and knowledge commonalities that can serve as a foundation for targeted reskilling, upskilling, and workforce transition strategies in coal-dependent regions.

The analysis is grounded in a one-to-many mapping methodology, in which each coal-related occupation is systematically compared against occupations in various RES sub-sectors - including geothermal, photovoltaic, wind, hydropower, battery systems, and green hydrogen. Rather than assessing job titles alone, the analysis focuses on two key ESCO dimensions (mentioned before):

- Essential Skills and Competences: Core capabilities required to perform occupational functions (e.g., troubleshooting, operating equipment, using technical drawings).
- Essential Knowledge: Foundational domain knowledge that supports professional practice (e.g., geology, electricity, environmental legislation).

The comparative review presented in the annexed document illustrates the degree of alignment between occupations in both sectors, highlighting areas of high compatibility (e.g., electrical engineering, maintenance, health and safety compliance) as well as more specialized knowledge areas (e.g., subsurface geology, environmental monitoring). By examining these overlaps, the analysis contributes to the systematic base for designing training programs, qualification pathways, and just transition policies aligned with real-world labor market data. The identification of horizontal and sector-specific skills is particularly relevant for regional transition frameworks aiming to leverage existing workforce assets in the move toward a decarbonized energy system.

The table synthesizes the key findings of this comparison, clustering skills and knowledge areas that are recurrent across both mining and RES occupations.

Table 3-3. The combination of skills and knowledge between the mining and RES sector professions

Occupation in mining sector	Essential Skills and Competences (Number of matches) – RES sector occupations	Essential Knowledge (Number of matches) – RES sector occupations
1. Dewatering technician (8111.1)	Troubleshoot (7) - Battery manufacturing technician; Battery system engineer; Geothermal power plant operator; Geothermal technician; Hydropower engineer; Hydropower technician; Maintenance and repair engineer	N/A
	Work ergonomically (1) - Solar energy technician	
	Operate drilling equipment (1) - Geothermal technician	
2. Driller (8111.2)	Troubleshoot (7) - Battery manufacturing technician; Battery system engineer; Geothermal power plant operator; Geothermal technician; Hydropower engineer; Hydropower technician; Maintenance and repair engineer	N/A
3. Environmental mining engineer (2143.1.1)	Approve engineering design (6) - Alternative fuels engineer; Geothermal engineer; Hydropower engineer; Onshore wind energy engineer; Renewable energy engineer; Solar energy engineer	Civil engineering (2) - Onshore wind energy engineer; Renewable energy engineer
	Assess environmental impact (1) - Geothermal engineer	Engineering principles (9) - Alternative fuels engineer; Battery system engineer; Hydropower engineer; Hydropower technician; Maintenance and repair engineer; Onshore wind energy engineer; Onshore wind energy engineer; Renewable energy engineer; Solar energy engineer;
	Develop environmental policy (1) - Hydrologist	Mining, construction and civil engineering machinery products (2) - Onshore wind energy engineer; Renewable energy engineer

Occupation in mining sector	Essential Skills and Competences (Number of matches) – RES sector occupations	Essential Knowledge (Number of matches) – RES sector occupations
	Ensure compliance with environmental legislation (4) - Alternative fuels engineer; Geothermal engineer; Hydrologist; Onshore wind energy engineer	technical drawings (7) - Alternative fuels engineer; Geothermal engineer; Hydropower engineer; Hydropower technician; Onshore wind energy engineer; Renewable energy engineer; Solar energy engineer
	Ensure compliance with safety legislation (3) - Alternative fuels engineer; Onshore wind energy engineer; Renewable energy engineer	
	Manage environmental impact (1) - Health, safety and environmental manager	
	Perform scientific research (7) - Alternative fuels engineer; Geologist; Hydrologist; Hydropower engineer; Onshore wind energy engineer; Renewable energy engineer; Solar energy engineer	
	Prepare scientific reports (1) - Geophysicist	
	Troubleshoot (7) - Battery manufacturing technician; Battery system engineer; Geothermal power plant operator; Geothermal technician; Hydropower engineer; Hydropower technician; Maintenance and repair engineer	
	Use technical drawing software (5) - Alternative fuels engineer; Hydropower engineer; Onshore wind energy engineer; Renewable energy engineer; Solar energy engineer	
4. Import export manager in mining, construction and civil engineering machinery (1324.3.2.24)	Abide by the business ethical code of conducts (1) - Health, safety and environmental manager	Mining, construction and civil engineering machinery products (2) - Onshore wind energy engineer; Renewable energy engineer
	Create solutions to problems (1) - Maintenance and repair engineer	
	Have computer literacy (1) - Battery manufacturing technician	
	Meet deadlines (1) - Battery assembler	

Occupation in mining sector	Essential Skills and Competences (Number of matches) – RES sector occupations	Essential Knowledge (Number of matches) – RES sector occupations
	Speak different languages (2) - Geologist; Hydrologist	
5. Mine geologist (2114.1.6)	Address problems critically (1) - Offshore renewable energy plant operator	Geology (3) – Geologist; Geophysicist; Geothermal engineer
	Prepare scientific reports (1) - Geophysicist	
6. Mine health and safety engineer (2146.7)	Address problems critically (1) - Offshore renewable energy plant operator	Electricity (12) - Battery assembler; Geothermal engineer; Geothermal power plant operator; Geothermal technician; Hydroelectric plant operator; Hydropower engineer; Hydropower technician; Offshore renewable energy plant operator; Offshore renewable energy technician; Onshore wind farm technician; Solar energy technician; Solar power plant operator
	Ensure compliance with safety legislation (3) - Alternative fuels engineer; Onshore wind energy engineer; Renewable energy engineer	Geology (3) - Geologist; Geophysicist; Geothermal engineer
	Manage emergency procedures (2) - Offshore renewable energy technician; Onshore wind farm technician	Safety engineering (2) - Battery manufacturing technician; Battery system engineer
	Prepare scientific reports (1) - Geophysicist	
7. Mine manager (1322.1)	Address problems critically (1) - Offshore renewable energy plant operator	Electricity (12) - Battery assembler; Geothermal engineer; Geothermal power plant operator; Geothermal technician; Hydroelectric plant operator; Hydropower engineer; Hydropower technician; Offshore renewable energy plant operator; Offshore renewable energy technician; Onshore wind farm technician; Solar energy technician; Solar power plant operator
	Ensure compliance with safety legislation (3) - Alternative fuels engineer; Onshore wind energy engineer; Renewable energy engineer	
	Identify process improvements (2) - Battery manufacturing technician; Battery system engineer	
	Manage emergency procedures (2) - Offshore renewable energy technician; Onshore wind farm technician	

Occupation in mining sector	Essential Skills and Competences (Number of matches) – RES sector occupations	Essential Knowledge (Number of matches) – RES sector occupations
8. Mining electrician (7412.9)	Troubleshoot (7) - Battery manufacturing technician; Battery system engineer; Geothermal power plant operator; Geothermal technician; Hydropower engineer; Hydropower technician; Maintenance and repair engineer	Electricity (12) - Battery assembler; Geothermal engineer; Geothermal power plant operator; Geothermal technician; Hydroelectric plant operator; Hydropower engineer; Hydropower technician; Offshore renewable energy plant operator; Offshore renewable energy technician; Onshore wind farm technician; Solar energy technician; Solar power plant operator
		Electronics (4) - Alternative fuels engineer; Offshore renewable energy plant operator; Offshore renewable energy technician; Onshore wind farm technician
9. Mining equipment mechanic (7233.11)	Troubleshoot (7) - Battery manufacturing technician; Battery system engineer; Geothermal power plant operator; Geothermal technician; Hydropower engineer; Hydropower technician; Maintenance and repair engineer	Mechanics (6) - Alternative fuels engineer; Maintenance and repair engineer; Offshore renewable energy plant operator; Offshore renewable energy technician; Onshore wind farm technician; Solar energy technician
10. Mining geotechnical engineer (2142.1.6)	Address problems critically (1) - Offshore renewable energy plant operator	Geology (3) - Geologist; Geophysicist; Geothermal engineer
	Prepare scientific reports (1) - Geophysicist	
11. Quarry manager (1322.2)	Ensure compliance with safety legislation (3) - Alternative fuels engineer; Onshore wind energy engineer; Renewable energy engineer	N/a
	Identify process improvements (2) - Battery manufacturing technician; Battery system engineer	
	Manage emergency procedures (2) - Offshore renewable energy technician; Onshore wind farm technician	

Occupation in mining sector	Essential Skills and Competences (Number of matches) – RES sector occupations	Essential Knowledge (Number of matches) – RES sector occupations
12. Shotfirer (blaster) (7542.1)	Follow health and safety procedures in construction (1) - Solar energy technician Troubleshoot (7) - Battery manufacturing technician; Battery system engineer; Geothermal power plant operator; Geothermal technician; Hydropower engineer; Hydropower technician; Maintenance and repair engineer Work ergonomically (1) - Solar energy technician	Electricity (12) - Battery assembler; Geothermal engineer; Geothermal power plant operator; Geothermal technician; Hydroelectric plant operator; Hydropower engineer; Hydropower technician; Offshore renewable energy plant operator; Offshore renewable energy technician; Onshore wind farm technician; Solar energy technician; Solar power plant operator
13. Surface mine plant operator (8342.10)	Address problems critically (1) - Offshore renewable energy plant operator Troubleshoot (7) - Battery manufacturing technician; Battery system engineer; Geothermal power plant operator; Geothermal technician; Hydropower engineer; Hydropower technician; Maintenance and repair engineer	Mechanics (6) - Alternative fuels engineer; Maintenance and repair engineer; Offshore renewable energy plant operator; Offshore renewable energy technician; Onshore wind farm technician; Solar energy technician
14. Underground heavy equipment operator (8111.4)	Address problems critically (1) - Offshore renewable energy plant operator	Electricity (12) - Battery assembler; Geothermal engineer; Geothermal power plant operator; Geothermal technician; Hydroelectric plant operator; Hydropower engineer; Hydropower technician; Offshore renewable energy plant operator; Offshore renewable energy technician; Onshore wind farm technician; Solar energy technician; Solar power plant operator

Occupation in mining sector	Essential Skills and Competences (Number of matches) – RES sector occupations	Essential Knowledge (Number of matches) – RES sector occupations
	Troubleshoot (7) - Battery manufacturing technician; Battery system engineer; Geothermal power plant operator; Geothermal technician; Hydropower engineer; Hydropower technician; Maintenance and repair engineer	Mechanics (6) - Alternative fuels engineer; Maintenance and repair engineer; Offshore renewable energy plant operator; Offshore renewable energy technician; Onshore wind farm technician; Solar energy technician
15. Underground miner (8111.5)	Address problems critically (1) - Offshore renewable energy plant operator	N/a
	Troubleshoot (7) - Battery manufacturing technician; Battery system engineer; Geothermal power plant operator; Geothermal technician; Hydropower engineer; Hydropower technician; Maintenance and repair engineer	

The tabular analysis presented above additionally makes it possible to indicate for each occupation from the mining sector a visual presentation of the data - taking into account the split by skills and knowledge. Below is an example of a graphical presentation of comparative data for an environmental mining engineer.

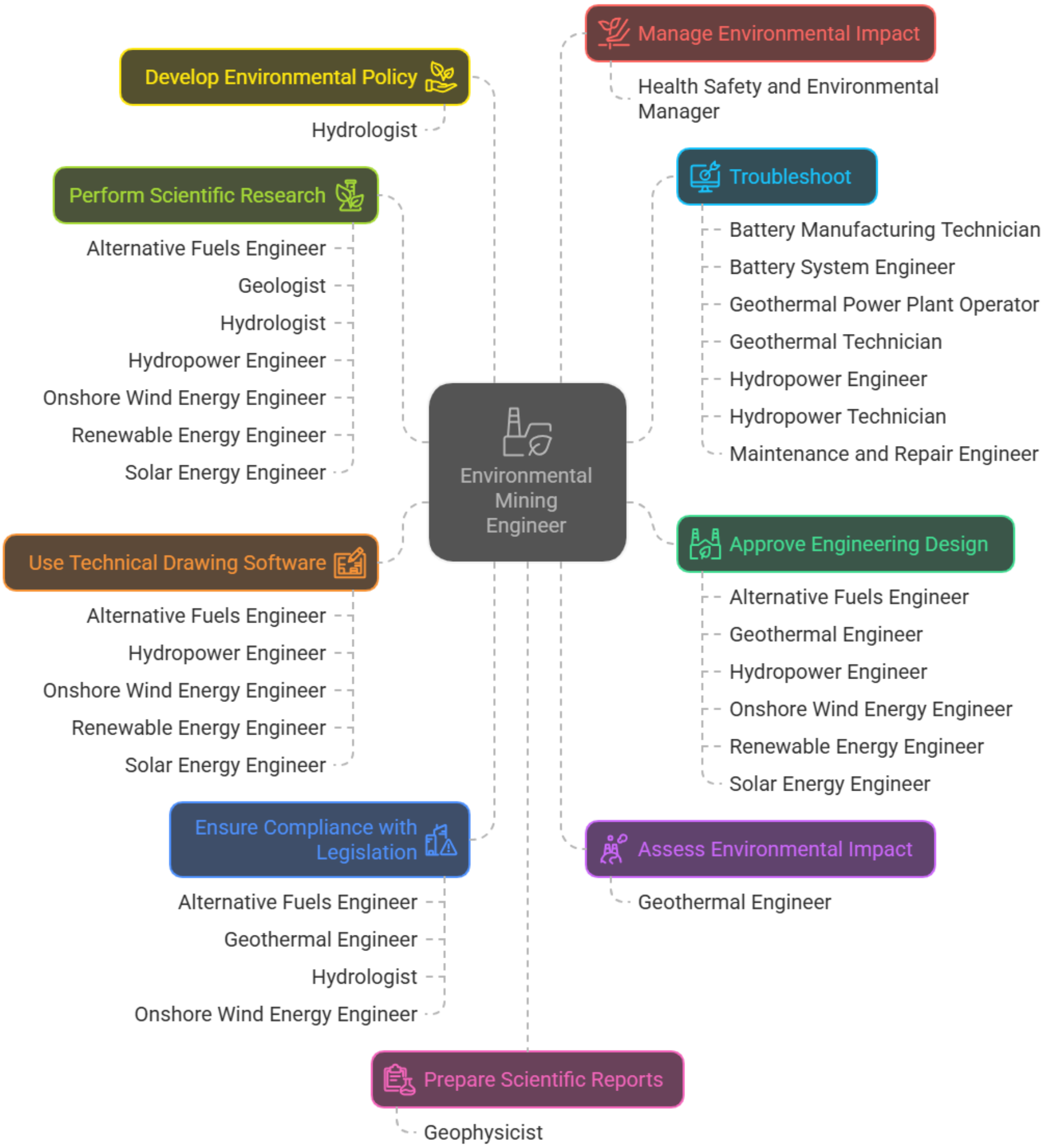

Figure 3-1 Retraining directions by skills and competencies - an example for an environmental mining engineer

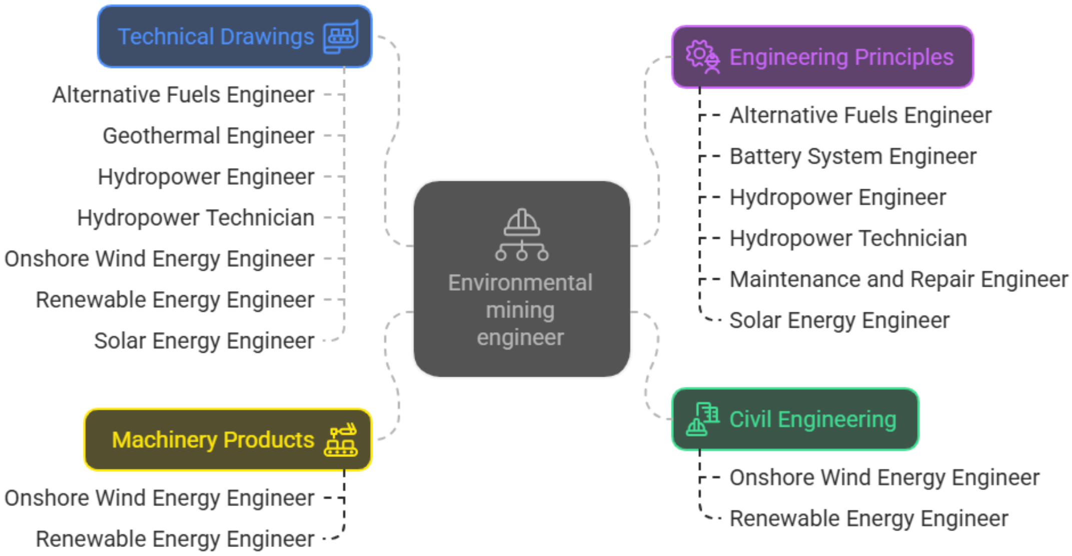

Figure 3-2 Retraining directions by knowledge - an example for an environmental mining engineer

The analysis conducted across two critical ESCO dimensions — Essential Skills and Competences and Essential Knowledge — offers a granular perspective on the readiness of coal mining professionals to transition into renewable energy occupations. Although mining sector roles demonstrate solid technical grounding in areas such as troubleshooting, electrical equipment handling, and mechanical operations, the data reveal a marked asymmetry in newer, domain-specific skills that are central to the functioning of renewable energy value chains (Appendix 2).

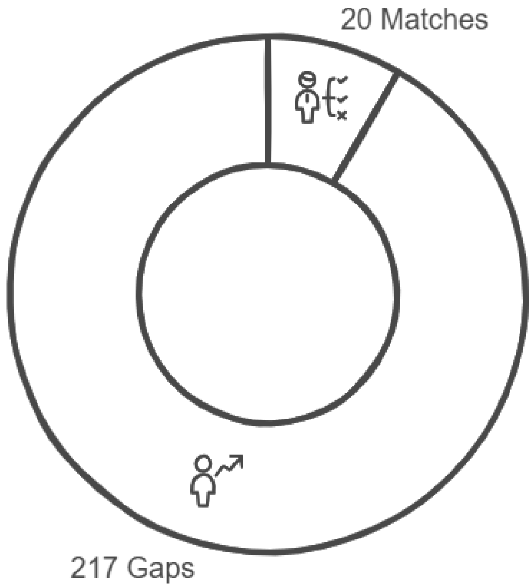

Figure 3-3 Essential Skills and Competences perspective – share of gaps and matches

From the Essential Skills and Competences perspective, only a handful of capabilities show strong continuity between coal and RES sectors. Notably, skills such as troubleshooting, scientific research, safety compliance, and project design approval exhibit a degree of overlap, implying a subset of mining professionals could directly transition with minimal retraining. For example, the ability to "approve engineering designs" or "ensure compliance with environmental legislation" is present in both sectors, suggesting that engineers in mining can align with RES standards relatively quickly.

However, the dominant pattern in the data is one of unidirectional gaps — RES sector occupations require a broader and more specialized range of technical, digital, and sustainability-related skills than those typically held by mining professionals. Among the most striking skill deficiencies are:

240. Electrical and renewable energy system operations: Skills such as "monitor electric generators", "install electrical equipment", and "adjust voltage" are scarcely represented in the mining sector despite being widespread in RES roles.
241. Digital and data-oriented competences: Skills like "use technical drawing software", "analyse test data", or "apply statistical techniques" are underrepresented among miners, highlighting the need for upskilling in data literacy and engineering software.
242. Sustainability and interdisciplinary integration: Mining professionals largely lack skills like "promote sustainable energy", "integrate gender dimension in

research", and "communicate with non-scientific audiences", which are increasingly embedded in RES occupational profiles.

The same asymmetry applies to risk management, preventive maintenance, and smart infrastructure operation, which are central to maintaining the integrity and resilience of modern energy systems but underdeveloped in the mining context.

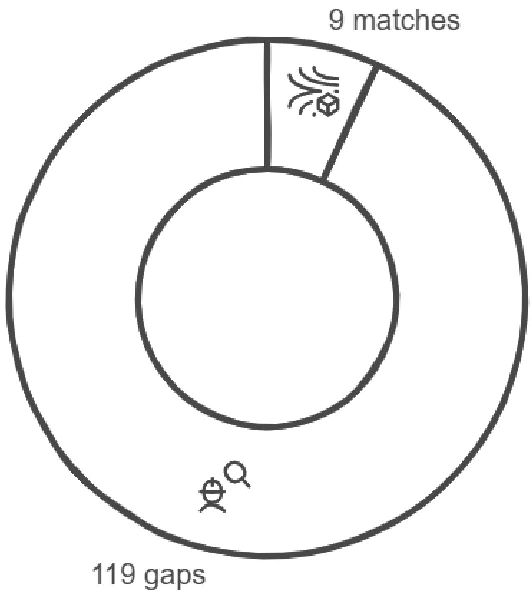

Figure 3-4 Essential Knowledge perspective – share of gaps and matches

The Essential Knowledge gap analysis further confirms that while basic engineering knowledge — such as electricity, mechanics, and technical drawings — is partially transferable, the conceptual ecosystem of RES occupations is considerably broader and more technologically diverse (Appendix 3).

Only a few knowledge domains are shared:

- "Electricity" appears across 5 mining roles and 12 RES roles.
- "Mechanics", "engineering principles", and "geology" show medium levels of overlap.

However, the overwhelming majority of critical knowledge areas for RES are absent from mining occupations. These include:

- technology-specific domains such as "photovoltaic systems", "geothermal energy systems", "wind energy", and "battery chemistry".
- Cross-sectoral competencies such as "environmental legislation", "energy efficiency", "project management", and "resource-efficient technologies".

- Digital knowledge areas like “CAD software”, “data storage”, “smart grid systems”, and “embedded systems”.

These gaps underscore the specialization gap between legacy fossil-based infrastructures and the technologically integrated environments of RES projects. While mining workers may hold deep operational knowledge of extractive processes and site-based logistics, they often lack exposure to systems thinking, interdisciplinary planning, and modern engineering principles necessary for deploying decentralized, renewable technologies.

The evidence presented in both dimensions point to a two-tiered upskilling implications:

1. Foundational reorientation: there is a pressing need to introduce miners to the principles and operational logics of renewable energy systems — including thermodynamics, solar and wind technologies, storage integration, and environmental governance frameworks.
2. Specialized technical and digital training: RES jobs increasingly demand cross-disciplinary fluency, blending mechanical-electrical knowledge with software literacy and sustainability orientation. Training programs must incorporate: (a) retraining in electrical and sensor systems, control platforms, and predictive maintenance; (b) digital toolkits, including CAD/CAM, technical diagnostics, data recording, and energy performance analysis; (c) soft skills related to project management, communication, and professional interaction in multidisciplinary environments.

These insights should inform the development of competency-based training programs aligned with ESCO standards, capable of producing certified RES professionals from mining backgrounds. The modularization of training, combined with prior learning recognition schemes, could further ease this transition, especially for occupations with partial overlaps (e.g., electricians, mechanics, geologists).

Table 3-4. Occupation mapping from mining to RES

Mining Occupation	Closest RES Occupation	RES Sector (s)	Justification (based on ESCO)
Mining electrician	Geothermal technician / Solar technician / Wind farm technician	A, B, C	Overlap in electrical maintenance, safety procedures, troubleshooting
Mine manager	Renewable energy engineer / HSE manager / Plant manager	ALL	Leadership, project management, safety, financial optimization

Quarry manager	Solar/wind/hydro plant operator	B, C, D	Site operations, safety, equipment management, environmental impact
Underground miner	Battery assembler / Solar installer / Hydro technician	B, D, E	Equipment operation, minor repairs, physical endurance
Surface mine plant operator	Wind farm technician / Solar field technician	B, C	Machine operations, inspection, troubleshooting
Heavy equipment operator	Offshore energy technician / Wind technician	C, D	Hydraulic/pump operation, mechanical systems, maintenance
Shotfirer	Hydro plant operator / Battery assembler (safety focus)	D, E	Safety, electrical knowledge, risk mitigation, explosives-related safety skills
Environmental mining engineer	Renewable energy consultant / HSE manager	ALL	Environmental legislation, impact assessment, safety policy
Driller	Geothermal driller / Geothermal technician	A	Operation of drilling equipment, equipment maintenance
Geotechnical engineer	Geothermal engineer / Hydrologist	A, D	Geology, civil engineering, terrain evaluation, CAD tools
Dewatering technician	Hydropower technician / Geothermal technician	A, D	Water management, contamination treatment, pump operation
Mine H&S engineer	HSE manager / Offshore wind safety technician	ALL	Risk analysis, emergency protocols, safety standards
Mining equipment mechanic	Maintenance and repair engineer	ALL	Equipment maintenance, troubleshooting, documentation
Import-export manager	RES supply chain/logistics coordinator	ALL	Export/import law, trade compliance, product-specific knowledge
Mine geologist	Geophysicist / Geologist (RES)	A, D, F	Geological analysis, scientific research, field data gathering

Source: own elaboration

*(A) geothermal energy, (B) photovoltaic energy, (C) wind power, (D) unconventional pumped hydro, (E) batteries, (F) green hydrogen

The occupation mapping from the coal mining sector to renewable energy sectors (geothermal, photovoltaic, wind, unconventional hydro, battery storage, and green hydrogen) demonstrates that many mining-related roles possess a high degree of transferability. By comparing essential skills, competences, and knowledge components there can be identify a clear potential for workers in mining to transition into roles across the RES value chains—often with only moderate upskilling requirements.

By conducting a detailed ESCO-based value chain analysis for both coal and RES sectors, the study identifies critical occupations with transferable skill sets, providing a data-driven foundation for designing reskilling pathways. The findings demonstrate that many mining sector occupations, particularly in technical, operational, and managerial domains, have a high potential for integration into the emerging green economy — provided that targeted upskilling addresses key gaps.

Electrical and technical occupations in mining, such as electricians and equipment mechanics, align closely with technician roles in geothermal, wind, and solar energy. These roles share core competences such as troubleshooting, electrical system maintenance, and adherence to high safety standards. Similarly, operational roles (e.g. underground miners, drillers, surface plant operators) show strong compatibility with field-based RES positions — particularly in geothermal drilling, solar and battery operations, and hydropower — where experience in mechanical maintenance and work in physically demanding environments is highly valued.

Engineering and managerial roles, including mine managers, environmental engineers, and geotechnical specialists, are particularly well-suited for transition into renewable energy project development, safety supervision, and environmental consultancy. These roles require strategic planning, regulatory compliance, and leadership — competences shared across both traditional and renewable energy infrastructures.

In addition, geology-related roles (e.g. mine geologists, geotechnical engineers) exhibit a natural transferability to geothermal and hydrological energy sectors, where subsurface modelling and scientific research play a foundational role. Even logistics- and trade-oriented occupations (such as import/export managers) could pivot into RES supply chain coordination functions, provided they gain additional knowledge in sustainability criteria, circular economy practices, and green product standards.

Despite this potential, the analysis clearly reveals widespread competence and knowledge gaps, especially in areas such as:

- technology-specific systems (e.g. solar PV, wind turbines, hydrogen production),
- digital and remote monitoring tools (e.g. CAD, data logging, control systems),
- environmental policy and compliance frameworks,
- smart grid and integrated energy systems.

Bridging these gaps is not only feasible but also strategically essential to securing a socially inclusive energy transition that leverages existing industrial experience. The ESCO framework proves highly effective in the initial design of competence-based retraining pathways that are both structured and evidence-driven.

However, it is critical to recognize that while general mapping provides valuable guidance, individual cases must be assessed in detail. Mining facilities differ in operational scope, workforce structure, and regional context. Therefore, site-specific mapping of occupational profiles should be conducted for each mining site to reflect local conditions and training needs accurately.

Moreover, the effectiveness of these mappings can be significantly enhanced by integrating survey-based research (Chapter 4), including workforce self-assessments, employer interviews, and flexibility diagnostics. These tools provide essential insight into attitudes toward change, adaptability, and informal skill sets not captured in formal classifications. They also help customize reskilling programs, making them more responsive to actual learning capacity and motivational profiles within the mining workforce.

In conclusion, while ESCO-based occupational mapping forms the backbone of systemic transition planning, its full potential is realized only when complemented by context-sensitive, participatory approaches. This includes combining quantitative mapping with qualitative diagnostics to ensure that training, policy, and workforce transition strategies are truly inclusive, adaptive, and grounded in the realities of each region and enterprise.

4. Survey Results – Occupational Flexibility in the Mining Sector

4.1. Overview of flexibility and conducted survey

As part of the GreenJOBS project, a targeted survey was conducted to evaluate the occupational flexibility and preparedness of coal mining sector employees for transitioning to green and quality jobs. This research, embedded within the "Mapping and Assessment of Key Occupations" work package, seeks to provide a comprehensive understanding of workers' adaptability in regions affected by mine closures, particularly in Poland and Slovenia, where the survey was implemented between December 2024 and March 2025. External constraints, including logistical and administrative challenges, prevented the inclusion of the Spanish partner site, narrowing the study's geographical scope. The survey's primary objective is to generate actionable insights to support reskilling and upskilling initiatives, enabling a just transition toward sustainable employment in green sectors such as renewable energy, environmental restoration, and circular economy initiatives.

The contemporary workforce faces significant challenges driven by rapid technological advancements, digitalization, and the global shift toward sustainability. In carbon-intensive industries like coal mining, the closure of mines due to decarbonization policies necessitates a workforce equipped with new competencies to thrive in emerging green industries. The need for reskilling and upskilling has never been more urgent, as industries transform to align with environmental responsibility while addressing evolving job demands. This survey addresses these challenges by assessing key dimensions of occupational flexibility: learning capacity, adaptability to change, openness to new technologies, and willingness to undertake new responsibilities. These dimensions are critical for preparing workers for roles in sustainable sectors, ensuring both individual employability and regional economic resilience.

The survey was developed and administered by GIG-PIB, with contributions from international partners, including academic institutions and industry stakeholders. It targeted a diverse group of coal mining employees, ranging from underground miners to technical and administrative staff, to capture a broad spectrum of perspectives on occupational flexibility. The questionnaire was structured into four sections to ensure comprehensive and consistent data collection. The first section introduced the study's purpose, emphasizing anonymity and voluntary participation to foster honest responses. The second gathered demographic and professional data, such as gender, age, education level, occupation, and work experience, to contextualize respondents' profiles. The third section, the core of the survey, included 15 detailed questions assessing occupational flexibility, focusing on self-reported learning capacity, adaptability to change, openness to new technologies, and willingness to take on roles outside traditional specializations. The final section explored workers' training needs, motivational factors for career transitions, and attitudes toward employment in green sectors, identifying barriers and enablers for reskilling.

The rationale for this survey is grounded in a robust body of literature highlighting the importance of occupational flexibility in the context of industrial transitions. Learning capacity is a cornerstone of workforce adaptability, particularly in sectors undergoing structural shifts. Prieto-Sandoval et al. (2019) argue that training strategies aligned with sustainability goals, such as on-the-job training and mentoring, create engaging learning environments that facilitate gradual skill acquisition. These approaches are particularly relevant for mining workers transitioning to roles in renewable energy or environmental restoration. Han et al. (2023) further emphasize that green training initiatives enhance workplace satisfaction and retention, invigorating employees' motivation to embrace new responsibilities. For example, training in renewable energy technologies, such as solar panel installation or wind turbine maintenance, can prepare miners for green jobs while fostering a sense of purpose.

Adaptability to change is equally critical in an era marked by disruptions like the COVID-19 pandemic and the global push for decarbonization. Ouanhlee (2024) notes that adaptability enhances workforce resilience, enabling employees to navigate evolving market demands and technological advancements. Albertz and Pilz (2025) highlight the role of vocational education and training (VET) in aligning workers' skills with the requirements of green jobs, such as environmental monitoring or energy-efficient technologies. These programs build confidence in employees' ability to adapt, which, as Bernardes et al. (2019) suggest, correlates with higher job satisfaction and engagement. The survey's focus on adaptability provides insights into how mining workers perceive their ability to embrace change, informing tailored VET interventions.

Openness to new technologies is a defining trait for modern employees, particularly in sectors transitioning to sustainable practices. Shafaei and Nejati (2023) argue that fostering a culture of technological openness is essential for preparing workers for green roles, which often rely on tools like geographic information systems (GIS) or energy management software. Popp et al. (2022) emphasize that green jobs require proficiency in technologies that enhance operational efficiency and reduce environmental impact, such as carbon capture systems or renewable energy infrastructure. Green human resource management (GHRM) practices play a pivotal role in nurturing this openness. Zhang et al. (2019) demonstrate that GHRM initiatives, such as training in eco-friendly technologies, encourage sustainable workplace behaviors, positioning miners for roles in wind or solar energy projects.

Willingness to undertake new responsibilities is closely tied to organizational efforts to provide developmental opportunities. Tashobya et al. (2022) find that organizations investing in employee development foster a culture of growth, enhancing workers' motivation to assume new roles. In the mining sector, where safety and sustainability are paramount, employees equipped with skills in mine reclamation or waste management can contribute to organizational goals while transitioning to green sectors (Anyona, 2023). The survey explores this willingness to identify motivational factors and potential barriers to career transitions.

Figure 4-1 Occupational flexibility as a complex construct

Source: own elaboration

The need for consistent reskilling and upskilling is driven by the rapid evolution of job roles in response to digitalization and the green economy. Li (2021) highlights that digital tools, such as data analytics for environmental monitoring, require workers to acquire new competencies to remain competitive. Prokopenko et al. (2024) emphasize that green jobs demand a blend of technical and soft skills, which comprehensive training programs can address. Institutional support mechanisms, such as educational resources and learning-friendly environments, are critical for preparing workers for green job opportunities. Chen et al. (2020) argue that green training programs provide a framework for developing environmental skills, while Yong et al. (2019) note that integrating sustainability into educational curricula equips workers for a transformed economic landscape.

Recent reports further validate the survey's purpose. The International Labour Organization (ILO, 2023) projects that the transition to a green economy could create millions of jobs globally, but only if workers are equipped with the necessary skills. The European Commission's "Just Transition Mechanism" report (European Commission, 2024) underscores the need for targeted training to support workers in regions affected by mine closures, such as Poland and Slovenia. These reports reinforce the survey's objective of mapping workers' adaptability and training needs to facilitate a just transition.

4.2. Key findings

4.2.1. Statistical description of survey respondents

The results of the study are presented comparatively for two mining companies: Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. – Bobrek Mine (Poland). Although HUNOSA (Spain) was initially expected to contribute survey data, company representatives have informed that, due to ongoing collective bargaining concerning the definition of new post-coal activities following the closure of all mines, the survey was not conducted. This decision was made to avoid creating parallel debates during what they described as a complex and sensitive transformation process, which is closely aligned with the objectives of the GreenJOBS project.

The quantitative and age structure of the respondents from both sites is summarized in the table below.

Table 4-1. Age of the responders

	Premogovnik Velenje (SLO)	Węglokoks Kraj S.A. (Bobrek Mine) (PL)
Women	14	49
Men	108	99
Total	122	148

The age distribution of the survey participants from both Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. – Bobrek Mine (Poland) reveals some notable differences between the two workforces. In both countries, the youngest age group (under 25 years) is marginally represented, with only 1.6% of respondents in Slovenia and 1.4% in Poland. This indicates that very few young workers are currently employed in the mining sector at these sites. The 26–35 age group accounts for 18.0% of respondents in Slovenia and 14.2% in Poland, showing a moderate presence of early-career workers. The largest age group in both countries is 36–45 years, but with a marked difference: this group comprises 51.4% of respondents in Poland, compared to 34.4% in Slovenia. This suggests that the Polish site has a more concentrated middle-aged workforce. Conversely, the 46–55 age group is more prominent in Slovenia (35.2%)

than in Poland (20.3%), indicating an older workforce profile at Premogovnik Velenje in this segment. Lastly, the 55 and over group represents 10.7% of Slovenian respondents and 12.8% of Polish respondents, reflecting a slightly higher share of older workers at the Polish site.

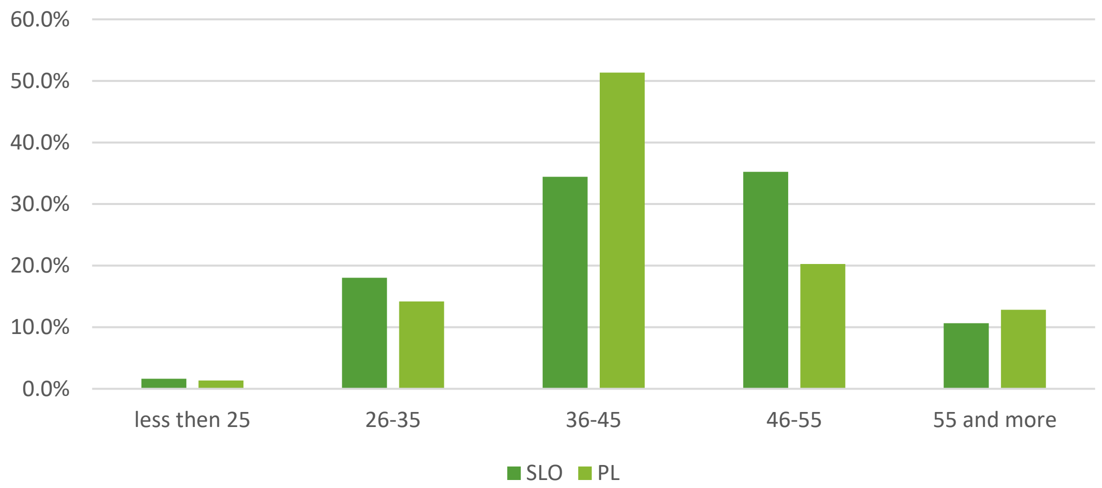

Figure 4-2 Age structure of respondents

The educational background of respondents from Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. – Bobrek Mine (Poland) varied across several levels. In Slovenia, 2.4% of participants reported completing only elementary or primary school, compared to 0.7% in Poland. Lower middle school education was indicated by 16.3% of Slovenian respondents, while this level was not represented in the Polish group. Vocational education was completed by 23.6% of respondents in Slovenia and 7.4% in Poland. The highest proportion of participants in both countries had completed high school or its equivalent—32.5% in Slovenia and 47.3% in Poland. A bachelor's or engineer's degree was held by 19.5% of Slovenian respondents and 12.2% of Polish respondents. At the Master’s degree level, there was a significant difference, with 3.3% in Slovenia and 32.4% in Poland. Lastly, a doctoral degree or higher was reported by 2.4% of Slovenian participants, while none of the Polish respondents indicated this level of education.

The occupational structure of respondents from Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. – Bobrek Mine (Poland) shows a distribution across various job categories. Workers, including both underground and surface operators, made up 33.3% of respondents in Slovenia and 37.4% in Poland. Employees involved in maintenance, service, and repairs constituted a similar proportion in both countries—6.7% in Slovenia and 6.1% in Poland. Engineering and technical personnel, including supervisory roles, represented the largest group in Slovenia at 37.5%, while in Poland this group accounted for 25.9%. Management staff made up 9.2% of Slovenian respondents and 6.1% of Polish respondents. Meanwhile, administrative and economic staff represented 13.3% of the Slovenian sample and 24.5% of the Polish one.

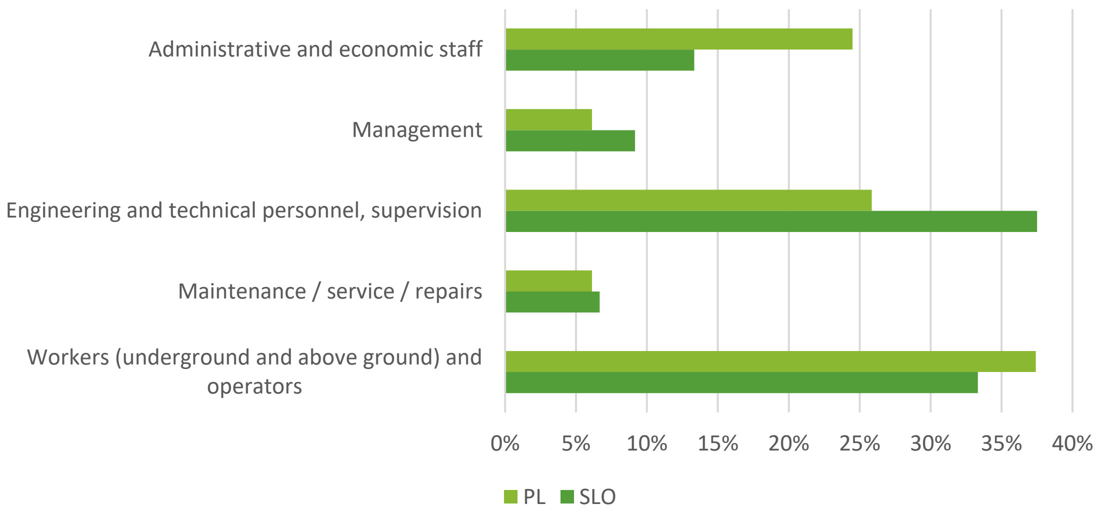

Figure 4-3 Occupational structure of respondents

The survey gathered information on both the total work experience and the number of years remaining until retirement among the group of respondents from Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. – Bobrek Mine (Poland). Although the results do not represent the entire workforce, they provide useful insights into the composition of the participating employees.

Regarding total work experience, Slovenian respondents were relatively evenly distributed across the experience spectrum, with 15.6% having the least experience and 27.9% falling into the most experienced group. In the Polish sample, there was a more concentrated presence in the mid-range categories: 28.4% reported substantial experience, while only 7.4% fell into the least experienced group. This may suggest that, among the surveyed individuals, Polish respondents tended to have longer tenure in the mining sector.

When considering years remaining until retirement, the Slovenian group again showed a more balanced distribution, with approximately one-third of respondents expecting mid to long-term career continuity. In Poland, however, there was greater variation. While a significant share (34.3% and 38.5%) of respondents had many years left until retirement, 14.7% were nearing the end of their professional careers.

Although these results are based on a limited group of employees, they indicate that the Slovenian sample reflects a more evenly spread professional trajectory, whereas the Polish group suggests a dual trend — both a younger group with a long career ahead and a noticeable portion of employees approaching retirement. This diversity may be important when designing targeted strategies for workforce transition in the context of the shift toward green jobs.

The final element used to characterize the surveyed group concerned their field of education in relation to their current job. It is important to note that nearly all respondents were employed under standard employment contracts, which may limit their flexibility in taking up alternative forms of work — an important consideration in the context of labour market transformation and the shift toward green jobs.

In terms of educational background, 38.2% of respondents in Slovenia and 26.4% in Poland reported having studied mining, indicating that a significant share of the surveyed workforce has education directly tied to an industry undergoing substantial structural change. Additionally, 35.8% of Slovenian and 37.2% of Polish respondents had completed specialized studies (e.g., technical, economic, scientific, or humanities) that are directly related to the work they currently perform. This alignment may facilitate internal mobility or targeted requalification within evolving industrial sectors.

In contrast, 12.2% of respondents in Slovenia and 24.3% in Poland reported having qualifications in fields not directly related to their current roles. This may reflect past transitions or employment mismatches, but it also highlights a degree of adaptability within the group — an important factor when designing support mechanisms for occupational transitions. A smaller proportion of respondents — 9.8% in Slovenia and 9.5% in Poland — reported having received non-profiled or general education, and a very limited group (4.1% and 2.7%, respectively) could not determine whether their education was connected to their present job.

Taken together, these results suggest a varied educational foundation among the surveyed workers. While many have training closely tied to their current work, others may already possess or require the flexibility to shift toward new professional areas. However, the widespread presence of traditional employment contracts among respondents could pose an institutional barrier to more flexible or hybrid employment pathways during the green transition.

4.2.2. Analysis and evaluation of occupational flexibility in the mining sector

Based on a review of the relevant literature, four key dimensions of occupational flexibility were identified as crucial for understanding how employees cope with change, especially in sectors undergoing structural transformation such as the mining industry. These dimensions (1) Learning Capacity, (2) Adaptability to Change, (3) Openness to New Technologies, and (4) Willingness to Undertake New Responsibilities - reflect core competencies necessary for managing transitions, adopting innovations, and maintaining employability in evolving labour markets. In order to explore these aspects in practice, a set of diagnostic survey questions was developed and grouped according to the identified dimensions. This structuring enabled a comprehensive assessment of the readiness and flexibility of workers in the context of organizational, technological, and sectoral change. The questions addressed subjective perceptions of competence, motivation, and the ability to adapt, providing insights into both individual and systemic capacity for transformation.

The first dimension, **Learning Capacity**, refers to an individual's ability to acquire new knowledge and skills efficiently and apply them effectively in their work. In this area, questions examined how respondents assess their ability to absorb new information, keep up with developments in their industry, and learn independently - including from sources outside their current professional domain. This dimension is essential in contexts where roles evolve rapidly and reskilling is a key component of adaptation strategies.

The second dimension, **Adaptability to Change**, captures how employees manage transitions in the work environment — whether related to changing schedules, reassigned tasks, multitasking, or broader organizational restructuring. It reflects psychological resilience, problem-solving in uncertain conditions, and the ability to maintain performance levels amid disruption. Measuring this capacity provides insight into how effectively individuals can function in dynamic or unstable contexts, which is especially relevant during large-scale economic or technological transitions.

The third dimension, **Openness to New Technologies**, focuses on the readiness and competence to adopt digital tools, modern systems, and innovative procedures. It includes the ability to work with new software, integrate changes into daily routines, and positively evaluate proposed improvements. As digitalization accelerates across industries, this dimension is a direct indicator of how smoothly individuals can transition into technology-enhanced roles or workflows.

Finally, the fourth dimension, **Willingness to Undertake New Responsibilities**, encompasses motivation, initiative, and role flexibility. It concerns the extent to which employees are open to tasks outside their formal job description, as well as their readiness to lead or engage with new solutions. This element is particularly important when jobs are being redefined or restructured, and workers are expected to assume broader or more cross-functional roles.

Together, these four dimensions form a multidimensional framework for analyzing occupational flexibility. They not only reflect individual capacities but also signal areas where targeted support, training, or structural adjustments may be required to facilitate a just and effective transition — especially in sectors like mining, where the green transformation brings significant changes to employment patterns and job content.

4.2.2.1. Learning Capacity

The ability to absorb new information quickly was assessed with a question that revealed high self-assessed competence among both Slovenian and Polish respondents. Over half of Slovenian participants (51.6%) and nearly half of Polish respondents (48.3%) declared that they are good at absorbing new information quickly and usually do so efficiently. An additional 11.5% (SLO) and 14.3% (PL) reported performing very well in this area. Only a small proportion in both groups admitted significant difficulties, confirming that information absorption is generally seen as a strength among the surveyed mining employees. Responses to the question on the timeliness of knowledge about changes in the industry were slightly more varied. While nearly half of Slovenian respondents (49.2%) stated they are good at staying up to date with sectoral changes, Polish responses were more distributed: 39.5% felt they were up to date, but 35.4% admitted they needed more time to assimilate changes. Interestingly, a comparable percentage in both groups (~11.5%) stated they regularly update their knowledge, indicating a core group with strong engagement in continuous learning.

In terms of readiness to absorb knowledge from outside the industry, Slovenian respondents most frequently (50.8%) claimed they are generally good and do so willingly, while Polish respondents were slightly more reserved - only 39.2% selected this response. However, a larger share of Polish workers (10.8%) claimed to be very good and proactive in seeking such knowledge compared to only 3.3% in Slovenia. Notably, about 28-29% in both groups expressed concern that acquiring external knowledge would be too time-consuming, showing a potential barrier to broadening knowledge beyond their current sector. When asked about learning new technologies independently, both groups showed relatively high levels of confidence. In Slovenia, 45.1% reported being good at this task and 9% stated they use the knowledge effectively. In Poland, 39.9% and 11.5% respectively claimed the same. Only a small minority in both countries reported difficulty or a need for support, with Polish respondents showing slightly more uncertainty.

The collected responses indicate that the surveyed employees in both Slovenia and Poland generally assess themselves positively in terms of their learning capacity. In all four evaluated areas — absorbing new information, staying current with industry developments, gaining knowledge from outside the sector, and learning about technologies independently - the largest groups in both countries consistently selected the second-highest self-assessment category, such as "I am good at...". This suggests a broad base of workers who are confident in their ability to learn and adapt, even if not all see themselves as highly advanced or proactive learners. The ability to absorb new information quickly, in particular, stands out as a key strength. Over 60% of respondents in each country rated themselves as either "good" or "very good" in this respect. This capacity is essential in any workplace transformation process, where individuals are required to rapidly understand new systems, technologies, or workflows. The fact that very few respondents reported feeling overwhelmed or completely lost in this area indicates that the majority of the workforce is not only willing but also cognitively prepared for change.

When it comes to keeping up with changes within their industry, results were slightly more differentiated. While many respondents (especially in Slovenia) claimed they are regularly up to date, a noticeable proportion - especially in Poland - acknowledged that they require additional time to assimilate new information. This may point to structural or cultural differences in information flow, training access, or exposure to innovation. Nonetheless, the intent and habit of updating knowledge appear well established in both countries. A more nuanced picture emerges in the area of absorbing knowledge from outside one's current sector. While many Slovenian and Polish respondents expressed interest and general openness, concerns about the time and effort required were frequently noted. Roughly one-third in both countries indicated that gaining such knowledge could be burdensome. At the same time, it is encouraging that only a small minority rejected the need for external knowledge entirely. Importantly, Polish respondents were more likely than their Slovenian peers to describe themselves as actively and confidently seeking out knowledge beyond their sector, suggesting a potential advantage in cross-sectoral adaptability.

Finally, responses regarding independent learning about new technologies reinforce the image of a workforce that is capable and increasingly self-directed. Over 50% in both countries stated they learn technologies on their own effectively. This capacity is critical in modern labour markets, where digital transformation often outpaces formal training systems and requires workers to take initiative in staying current.

The high level of self-assessed learning capacity among respondents provides a solid foundation for successful occupational transition, especially in regions and sectors affected by the green transformation. As the mining industry restructures and gradually phases out carbon-intensive operations, employees will be required to engage in reskilling, upskilling, and, in some cases, complete career reorientation. A workforce that already demonstrates confidence in learning and knowledge acquisition is more likely to adapt proactively to these new demands.

Particularly valuable is the finding that most workers not only learn effectively but are also open to acquiring knowledge from outside their traditional domain. This cross-sectoral readiness is critical, as many green jobs require interdisciplinary competence (e.g., combining technical skills with environmental awareness or digital literacy). Workers who are already accustomed to learning autonomously and staying informed may be more receptive to training programs, credentialing initiatives, or lateral mobility into growing sectors such as renewable energy, circular economy, or environmental monitoring. However, the expressed concern about the time and effort required to learn - especially in unfamiliar areas - should not be overlooked. This signals a need for well-structured, accessible, and time-efficient training formats that align with workers' cognitive preferences and life circumstances. Tailored learning paths, blended learning models, and employer-supported learning time could all contribute to easing this transition. In conclusion, the high learning potential demonstrated by respondents represents a major asset for just transition planning. Leveraging this strength through targeted learning strategies and removing practical barriers could significantly enhance the capacity of mining workers to reorient their careers - and to do so with confidence and competence.

4.2.2.2. Adaptability to Change

The ability to function in a changing work environment, such as when work structure, location, or organization shifts, received predominantly positive assessments. In both countries, the majority of respondents rated themselves as handling such situations well or very well. In Slovenia, 43.0% reported adapting quickly, and another 13.2% declared being fully ready for any change. Poland showed a similar overall tendency, although the proportion of those reporting difficulty (8.8%) or resistance to change was noticeably higher than in Slovenia (2.5%). This may suggest that while Polish respondents are generally adaptable, there is a slightly more diverse range of attitudes toward structural change.

Regarding sudden changes in work schedules, a substantial share of employees in both countries reported coping effectively. Over 44% of Polish and 45% of Slovenian respondents said they adapt quickly or deal very effectively with such disruptions. A smaller group in both countries - around 13–20% - indicated that such changes require more effort or time to handle, but only a small minority reported experiencing strong difficulty or resistance. These results suggest that schedule-related flexibility is broadly developed, although not uniformly effortless. Responses to sudden changes in assigned tasks reflected a similar pattern. More than 40% of respondents in each country stated that they adapt well or very well to unexpected task reassignments. Interestingly, the proportion of Slovenian respondents indicating that such changes require extra time or effort (41.5%) was slightly higher than in Poland (32.2%), perhaps suggesting greater sensitivity to task redefinition. On the other hand, Polish respondents more frequently reported high levels of efficiency and confidence in completing newly assigned tasks (13.7% vs. 8.9%).

As for multitasking, both groups demonstrated high levels of comfort. Close to half of all respondents in both Slovenia (48.4%) and Poland (48.3%) stated they were usually good at multitasking, with an additional 10% in each country claiming to be "very good" or highly efficient at it. These results indicate that the majority of workers are accustomed to managing multiple demands simultaneously, which is often a necessity in changing or restructured job environments.

Finally, in relation to handling diverse tasks not necessarily within one's core responsibilities, most respondents reported strong competence. In Slovenia, 60.3% said they usually manage such variety effectively, and another 11.6% rated themselves as highly efficient in doing so. In Poland, responses were slightly more varied—while over half of the participants (52.4%) expressed confidence, nearly one-third acknowledged needing more effort (28.6%) or support (3.4%). This suggests that Polish workers may experience a slightly steeper learning curve when it comes to handling task variety beyond their typical scope. The data across all five indicators show a generally high level of adaptability among mining sector employees, with most respondents in both Slovenia and Poland reporting an ability to respond effectively to a range of work-related changes. These include flexibility in adjusting to schedule disruptions, redefined tasks, changing environments, and an increased variety of assignments. Rather than extremes, most self-assessments clustered around mid-to-high adaptability levels, particularly the responses that acknowledge competence while also recognizing the effort required to remain effective in dynamic conditions. This realism strengthens the credibility of the responses, suggesting that employees are aware of the demands posed by change and generally capable of meeting them, even if not without challenges.

From the perspective of occupational transition - especially in the context of green transformation and labour reskilling - these findings are encouraging. Employees who can handle ambiguity, adapt workflows, and juggle multiple responsibilities are typically better positioned to transition into newly emerging or redefined roles. However, the presence of respondents - particularly in Poland - who reported resistance or difficulty, even if in a minority, highlights the importance of individualized support measures, such as mentoring, coaching, or phased role adjustments during transition periods. Moreover, the results imply that future transition strategies should not only focus on technical reskilling but also account for task fluidity and cross-functional flexibility. Since adaptability involves both behavioural and emotional components, interventions that combine practical training with change-readiness support (e.g., workshops on task management, dealing with uncertainty) may be particularly effective in mining communities undergoing systemic shifts.

4.2.2.3. Openness to New Technologies

Most respondents in both countries reported a positive attitude and self-assessed competence in working with new technologies. In Slovenia, nearly 46% of participants described themselves as usually good at incorporating new technologies into their work, with an additional 23% claiming they are very good and adopt them quickly. The Polish group showed a very similar pattern: 48.6% and 21.6%, respectively. Only a small minority expressed difficulties - 5.8% in Slovenia and 8.1% in Poland reported lacking confidence or needing support. These results suggest that the vast majority of respondents feel at ease when it comes to technological change in their job environment.

When it comes to introducing new procedures, the picture remains positive. Over half of respondents in both countries - 57.4% in Slovenia and 56.1% in Poland - said they adapt quickly and usually manage to implement new procedures without major issues. A smaller, though meaningful, group in each country (23.0% in Slovenia and 18.2% in Poland) admitted that while they can introduce changes, it sometimes takes them longer. Very few respondents indicated feeling lost or needing frequent assistance, which suggests a relatively independent and capable workforce in terms of procedural adaptation. Mastering new tools and software produced a comparable pattern. The most common response in both groups was that they handle new tools relatively quickly (40.5% in Slovenia, 39.5% in Poland), followed by those who said they learn very quickly and effectively (19.8% and 21.8%, respectively). Around one-third in each group admitted that they can learn but may need more time. Only a small portion - less than 10% in both cases - reported substantial difficulties. These proportions indicate that digital literacy and technical learning are generally manageable for most workers in the mining sector.

In terms of evaluating new solutions or ideas, the majority again expressed openness and engagement. In Slovenia, 47.1% said they are usually good at evaluating new ideas and are happy to accept them, while 10.7% described themselves as active supporters of innovation. Poland showed similar tendencies (42.2% and 7.5%, respectively), although slightly more respondents (12%) expressed either scepticism or low acceptance of new ideas. Still, the dominant trend is one of openness rather than resistance.

The data show that most employees are comfortable with new technologies, processes, and tools, and that they tend to evaluate change and innovation with a reasonably open mind. What's notable is the consistency across all four questions in this dimension - there is no major drop-off between technological usage, procedural adaptation, or innovation assessment. This suggests a coherent and functional approach to change at the individual level. What also stands out is that the most common response category in all items was the second-highest positive rating - that is, employees consider themselves competent and open, but not necessarily highly advanced or fast adopters. This is a realistic and encouraging sign, that indicates a high level of baseline technological and procedural readiness, without suggesting overconfidence. It also shows that the workforce is not "lagging" but may benefit from targeted support to move from "capable" to "proactive" in handling innovation.

Importantly, resistance to change or technology was rare. While some respondents expressed doubts or required more time, only a very small percentage reported consistent difficulty or reluctance. This finding is particularly valuable in the context of digital transformation or green innovation, where technological adoption is often a central part of occupational change. In practical terms, this means that if technological or procedural shifts are introduced with reasonable pacing, clear communication, and user-friendly tools, the majority of this workforce is likely to keep pace with transformation. Moreover, because a notable proportion of employees already see themselves as quick adopters, they could act as internal change agents or peer mentors in the process of rolling out new systems or workflows.

4.2.2.4. Willingness to Undertake New Responsibilities

When asked about their ability to lead the introduction of new solutions, the majority of respondents in both countries placed themselves in the mid to high competence range. In Slovenia, 45.5% stated they are generally good at leading such initiatives and often take them on. In Poland, the proportion was slightly lower at 37.4%. An additional 32.2% (SLO) and 35.4% (PL) noted they are capable of taking the lead but may require additional time or support. These responses suggest that a substantial portion of the workforce is not only open to innovation but willing to engage proactively in implementing it. At the same time, differences emerged in the percentage of those who do not see themselves in leadership roles: only 0.8% of Slovenian respondents declared that they lack leadership character and avoid initiating new solutions, compared to a significantly higher 8.2% in Poland. This could reflect differences in organizational culture or role expectations, possibly indicating more conservative perceptions of leadership among the Polish group. Still, both countries show similar proportions (~9%) of respondents who feel insecure or struggle with this responsibility.

In terms of taking on new responsibilities outside one's core role, responses were largely positive in both countries. About half of the respondents in both Slovenia (48.4%) and Poland (49.0%) reported that they are usually good at taking on new responsibilities and completing them effectively. A further 18.0% of Slovenian and 10.2% of Polish respondents rated themselves as "very good" in this area, showing a higher self-reported adaptability at the upper end among the Slovenian group. Interestingly, a slightly higher share of Polish respondents (33.3%) stated that while they can take on new responsibilities, it takes them more time and effort - compared to 26.2% in Slovenia. This indicates that while the willingness exists, task expansion might feel more burdensome to a significant portion of the Polish sample. Still, only small minorities in either group - 7.3% (SLO) and 7.4% (PL) - expressed a clear sense of difficulty or discomfort with this aspect of their work.

This dimension reveals that a large proportion of employees across both countries are open to broader roles and the challenges that come with them. Whether it involves leading the introduction of new ideas or accepting responsibilities beyond one's primary position, most respondents placed themselves in a position of capability, with a notable number showing strong initiative. Two related but distinct trends can be observed:

- Slovenian respondents appear slightly more confident in initiating and leading new solutions and in taking on expanded responsibilities quickly.

- Polish respondents, while still showing strong readiness, included a slightly larger share of individuals who require more time, support, or experience a higher cognitive load when assuming additional duties.

What stands out is the relatively low rate of resistance or avoidance of new responsibilities across both groups. This suggests that structural transition processes - such as job redefinition, role hybridization, or task redistribution - are likely to be accepted by most employees, provided they receive the right degree of guidance and time for adaptation.

The findings offer a promising perspective in the context of green transition and workforce reorganization. The combination of initiative, adaptability, and low resistance to change provides a strong base for implementing re-skilling programs, job redesign, or participatory innovation models (e.g., involving workers in shaping new procedures or tools). However, to ensure effective and inclusive transformation, support measures should acknowledge the presence of a non-negligible group who require more time or assistance. These individuals are not necessarily unwilling but may need clearer expectations, mentorship, or structured onboarding into new tasks. Overall, this dimension suggests that the mining workforce is not only able to respond to change but is also willing to help shape it - a key asset in any successful, sustainable transition strategy.

4.2.3. Ways to increase flexibility and main barriers

Following the analysis of the four key dimensions of occupational flexibility, it is important to consider what forms of support employees perceive as most helpful in increasing their ability to transition to new jobs. Understanding these preferences provides insight not only into perceived deficits or challenges, but also into the types of interventions that may facilitate more effective and inclusive transformation processes. When asked what kind of support would be most beneficial in the context of job change, respondents from Slovenia and Poland indicated differing priorities, though both groups clearly recognized the importance of employer or institutional involvement.

The most frequently selected form of support was training and courses, identified by 65.5% of Polish respondents and 38.8% of Slovenian respondents. This finding is consistent with earlier observations: while a significant portion of respondents from both countries rate their learning abilities positively, many still acknowledge that structured and formal educational opportunities remain a crucial enabler in the face of professional reorientation. These preferences gain further relevance when contrasted with actual participation in training. In both groups, the majority attend trainings frequently or very frequently (SLO: 61.5%, PL: 56.7%), indicating that engagement in learning is already part of many workers' routines. However, Polish respondents more often reported attending training only occasionally (37.8%), compared to 23% in Slovenia, which may explain their stronger emphasis on training as a desired form of support. This could reflect gaps in training relevance, targeting, or accessibility in Poland, especially if existing opportunities do not align well with perceived future needs.

Interestingly, Slovenian respondents demonstrated greater interest in mentoring and counselling (27.3%) compared to their Polish counterparts (15.2%). This may reflect a preference for more personalized, relationship-based forms of support, which could be especially relevant in contexts where emotional readiness and self-confidence play a role in the ability to embrace change. It also aligns with previous findings that Slovenian workers more often expressed openness to absorbing knowledge from outside their industry, an area that may require interpretive support or guidance in translating insights across sectors.

Another point of divergence lies in the perceived need for access to new technologies, which was emphasized by 24.0% of Slovenian workers and only 9.7% of Polish respondents. This may suggest that Slovenian respondents place greater value on the practical, hands-on aspects of workplace modernization – or alternatively, that they experience greater limitations in access to such tools. Either way, this underlines the importance of infrastructural readiness as a precondition for real flexibility, particularly in environments undergoing technological change.

In both countries, relatively few respondents pointed to "additional days off to look for another job" as a key support factor – 9.1% in Slovenia and 4.8% in Poland – indicating that time availability may not be the primary obstacle to career transition. Rather, the data suggest that access to resources, relevant knowledge, and confidence are more pressing barriers, reinforcing the idea that effective support should focus on capability-building and reducing perceived risks.

Lastly, a small but noteworthy group selected the "Other" category – 0.8% in Slovenia and 4.8% in Poland. While these responses were not specified, they may reflect demand for more tailored or systemic forms of support, such as:

- Financial support or security mechanisms during transition;
- Independent career counselling or labor market navigation assistance;
- Recognition of skills and qualifications across industries;
- Peer exchange networks or opportunities for experiential learning;
- Transparent communication about company-level restructuring plans and reskilling pathways.

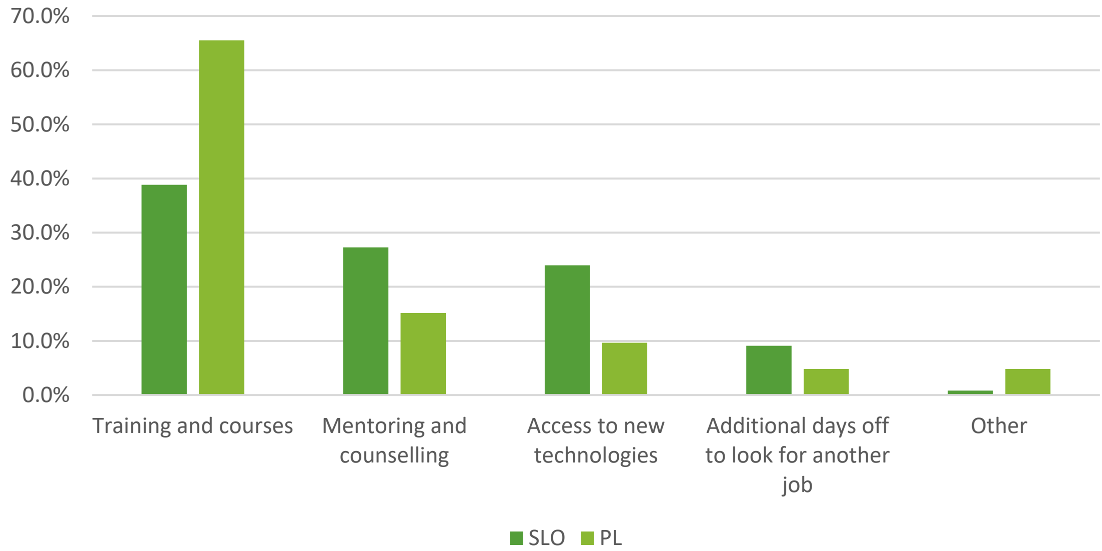

Figure 4-4 Expected forms of support to increase flexibility for mine workers

Therefore, **effective workforce transformation strategies** - especially in sectors like mining - must go beyond merely identifying transferable skills. They **should proactively address workers' confidence, remove structural barriers to participation in training, and ensure that workers can see clear, realistic pathways into the green economy**. Without this comprehensive approach, skill mismatches may persist not due to a lack of competencies, but due to a lack of conviction, visibility, or systemic support.

While many respondents acknowledge that parts of their existing skillsets could transfer into green economy roles, their readiness to act on these opportunities may be limited by non-skills-related barriers. Based on the listed factors, we can identify several clusters of potential obstacles (figure bellow)

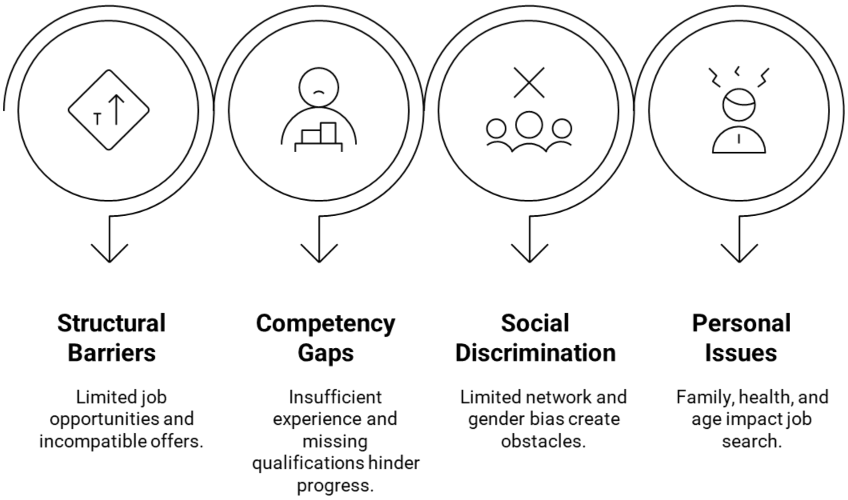

Figure 4-5 Individual and structural factors on workers' decision to change jobs

The table below presents a summary of respondents' evaluations regarding the potential impact of various personal and structural factors on their decision to change jobs. The listed items include a wide range of barriers — such as family obligations, health issues, limited job availability, lack of qualifications or experience, and perceived discrimination — that may constrain individuals' occupational mobility. This overview helps contextualize broader patterns of flexibility, highlighting the complexity of factors that influence workers' readiness or reluctance to pursue new employment opportunities, particularly in the context of sectoral transformation and labour market transition.

Table 4-2. Evaluation of factors influencing the decision to change jobs [%]

Factor	Very low impact		Low impact		Negligible, moderate impact		High impact		Very high/key impact		No opinion	
	SLO	PL	SLO	PL	SLO	PL	SLO	PL	SLO	PL	SLO	PL
Family situation / family care	1,7	8,9	9,9	8,2	11,6	12,3	23,1	30,8	52,9	27,4	0,8	12,3
Health status	5,7	11,6	12,3	15,8	19,7	15,8	24,6	31,5	34,4	15,8	3,3	9,6
Lack of job opportunities in the local labor market	4,1	4,1	8,2	8,3	27,9	15,9	28,7	33,8	27,9	21,4	3,3	16,6
Lack of offers compatible with my education	5,7	6,9	18,9	14,6	24,6	16	24,6	22,2	22,1	22,9	4,1	17,4
Lack of experience / insufficient experience	5,7	11,2	26,2	18,2	32,8	21	22,1	23,8	9,8	11,9	3,3	14
Lack of contacts and connections	6,7	9	15,8	15,9	38,3	17,2	23,3	22,8	12,5	20,7	3,3	14,5
Gender discrimination	43,4	46,9	27	13,1	13,1	9	4,1	4,8	4,1	3,4	8,2	22,8
Poor professional background	16,5	18,6	21,5	20,7	36,4	20,7	11,6	18,6	8,3	4,1	5,8	17,2
Low salary offered	0,8	0	6,7	2,1	18,3	4,1	25,8	43,4	42,5	42,1	5,8	8,3
Lack of relevant certificates and authorisations	7,5	5,6	18,3	11,8	44,2	25	11,7	24,3	11,7	18,1	6,7	15,3
Age	9,9	7,5	13,2	10,3	33,9	23,3	15,7	28,8	22,3	16,4	5	13,7
Lack of experience in the recruitment process (lack of skills in preparing CVs, conducting interviews)	14,9	24,1	20,7	22,1	36,4	20,7	10,7	14,5	12,4	3,4	5	15,2

The study exploring why workers in the mining sector in Slovenia and Poland consider changing jobs reveals how personal circumstances, job market conditions, and systemic barriers shape their decisions. While workers in both countries face similar challenges, they differ in how much weight they give to these obstacles. One of the biggest differences is around family responsibilities. In Slovenia, over half of the respondents (52.9%) say that family situation or caregiving duties have a massive impact on their job choices, compared to just 27.4% in Poland. Interestingly, 8.9% of Polish workers feel family has very little influence on their decisions, while only 1.7% of Slovenians agree. This suggests that family obligations are seen as a major hurdle in Slovenia, whereas opinions in Poland are more divided.

Health is another key factor, especially for Slovenians. A significant 34.4% of them rate their health as having a very high impact on job decisions, with another 24.6% calling it a major issue. In Poland, only 15.8% see health as a critical factor, though 31.5% still consider it important. This difference might stem from variations in healthcare access, rehabilitation support, or overall living conditions between the two countries. Similarly, the local job market poses challenges: 27.9% of Slovenians and 21.4% of Poles cite a lack of job opportunities as a major barrier, but even more (33.8% in Poland and 28.7% in Slovenia) rate it as a significant issue. This highlights how much regional economic conditions influence career choices.

When it comes to qualifications and job readiness, the lack of relevant certificates or authorisations is a concern for over 23% of workers in both countries, though Slovenians are more likely to see this as a moderate issue (44.2%) rather than a dealbreaker. Polish workers, meanwhile, are more likely to say they're unsure (15.3%), which might reflect uncertainty about what qualifications are needed. Gaps in experience, whether it's not enough work experience or unfamiliarity with recruitment processes, seem to hit harder in Poland. For instance, 24.1% of Polish workers say a lack of recruitment skills has very little impact, compared to 14.9% in Slovenia, but only 3.4% of Poles see it as a major issue compared to 12.4% of Slovenians. This could reflect different job market experiences: Slovenians may have more exposure to career transitions or support programmes, while some Polish workers might be navigating the open job market for the first time in years.

Finally, pay is a much bigger driver in Poland than in Slovenia. A striking 42.1% of Polish workers say low salaries are a critical factor in wanting to change jobs, closely echoed by 42.5% of Slovenians. However, Poles (43.4%) are more likely to stress its importance compared to Slovenians (25.8%), who see it as significant but less decisive. Other factors like age, gender discrimination, or weak professional backgrounds get mixed responses, with none standing out as dominant. For example, only 4.1% of Slovenians and 3.4% of Poles view gender discrimination as a major issue. Overall, the data show that while some challenges like low pay and job availability affect workers in both countries similarly, personal factors like family care, age, or recruitment know-how reveal bigger differences. This suggests that supporting workers through job transitions will need tailored approaches, considering both the systems in place and the real-life experiences of individuals.

When looking at whether these workers would accept a lower salary to switch sectors, it's clear that financial security is a top priority. In both Slovenia and Poland, most workers are reluctant to take a pay cut, with 47.1% of Slovenians and 44.6% of Poles saying they wouldn't accept any reduction at all. What's more, many even hope for a pay rise in a new role—33.1% in Slovenia and 26.4% in Poland expect to earn more. Only a small fraction, around 5% in each country, would consider a modest cut of up to 5%, and even fewer would accept larger reductions. This shows that for workers in a sector like mining, where pay is relatively stable, taking a step back financially isn't an appealing option, even if other job aspects might be tempting. These findings underline that any strategy to support workers moving to new sectors must prioritise maintaining or improving wage levels to meet their expectations and ensure financial stability drives their motivation.

The factors that could influence the acceptance of lower wages among mining sector employee reveals that financial compromises are generally only considered when accompanied by substantial non-financial benefits (see figure below).

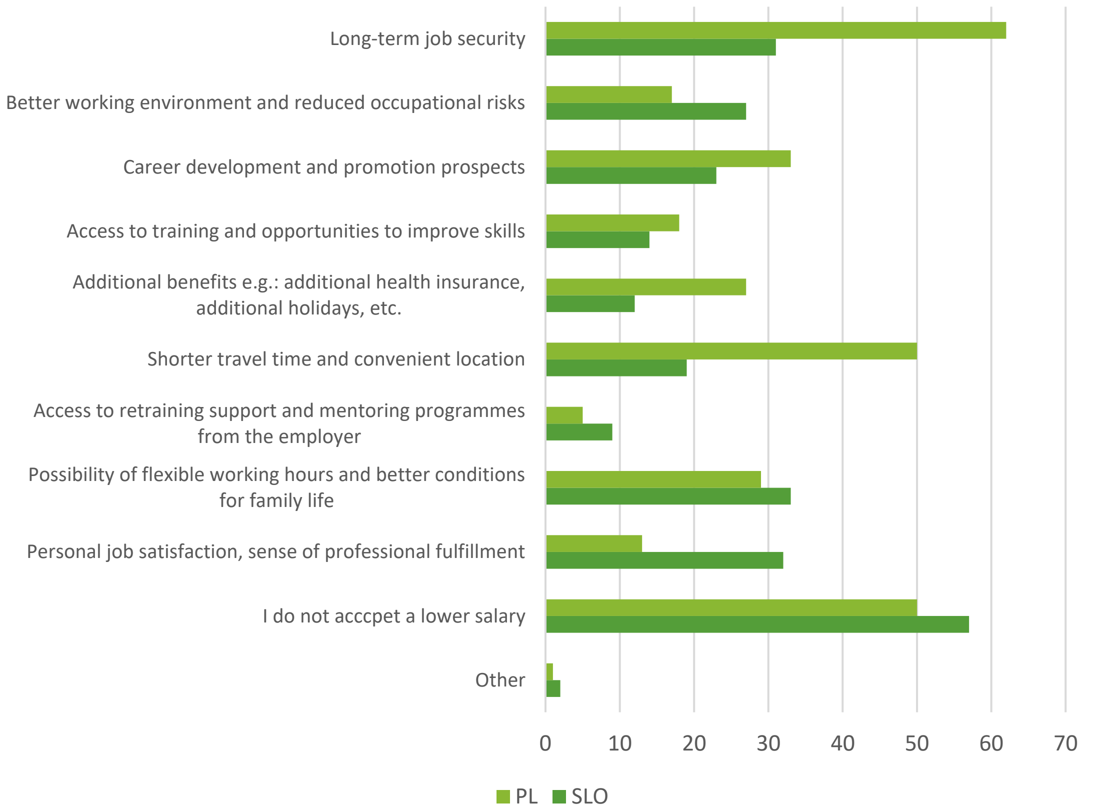

Figure 4-6 Factors influencing acceptance of lower wage

Across both Slovenia and Poland, respondents pointed most frequently to elements that support personal well-being and long-term satisfaction - such as a sense of professional fulfillment, improved working conditions, and long-term job security. This suggests that workers are willing to re-evaluate salary expectations if the broader employment context offers stability, reduced physical strain, or alignment with personal values and goals.

There are also visible indications that reskilling and development opportunities—whether through training access or employer-supported mentoring - are meaningful motivators in the context of wage flexibility. While monetary compensation remains a core concern, many participants appear to recognize the trade-off value of improved future prospects and personal growth. Moreover, additional benefits such as extended health coverage or paid leave were seen as important, particularly in the Polish group, which may reflect higher expectations toward social safety nets during employment transitions.

Interestingly, flexible working conditions - like remote work or family-compatible schedules - also emerged as persuasive factors for some, although with differing importance between countries. Taken together, these results underline that lower pay may be accepted, but only in exchange for a more supportive, meaningful, and secure work environment - underscoring the need for holistic job quality improvements in transition policies.

4.3. Observations and summary

The workforce profiles of Premogovnik Velenje in Slovenia and Węglokoks Kraj S.A. – Bobrek Mine in Poland reveal distinct demographic and professional characteristics critical for competency mapping during the mining sector's green transition. Slovenia's workforce shows a balanced age and experience distribution, with a notable share of older workers (46–55 years, 35.2%) and minimal representation of those under 25 (1.6%). Poland, conversely, has a concentrated middle-aged group (36–45 years, 51.4%) and a dual trend of younger workers with long careers ahead and those nearing retirement (14.7%). Educationally, high school qualifications dominate (32.5% SLO, 47.3% PL), but Poland has more Master's degree holders (32.4% vs. 3.3% SLO), while Slovenia has higher vocational training (23.6% vs. 7.4% PL). A significant portion of workers have mining-specific education (38.2% SLO, 26.4% PL), though some possess unrelated qualifications (12.2% SLO, 24.3% PL), indicating adaptability. Occupationally, Slovenia has more technical roles (37.5%), while Poland has a higher share of administrative staff (24.5%), with workers comprising about one-third of respondents in both.

The occupational flexibility of these workers, assessed across learning capacity, adaptability to change, openness to new technologies, and willingness to undertake new responsibilities, forms a strong foundation for transition. Over 60% of respondents in both countries excel at absorbing new information, with 45.1% (SLO) and 39.9% (PL) confident in learning technologies independently, though 28–29% note time constraints as a barrier to external knowledge acquisition. Adaptability is robust, with over 40% handling schedule and task changes effectively and nearly half demonstrating strong multitasking skills. Resistance to change is low, though slightly higher in Poland (8.8% vs. 2.5% SLO). Openness to new technologies is widespread, with 46% (SLO) and 48.6% (PL) comfortable integrating tools and over 50% adapting quickly to new procedures. Most workers are also willing to take on new responsibilities, with 45.5% (SLO) and 37.4% (PL) confident in leading initiatives, though Polish workers report needing more time or support (33.3% vs. 26.2% SLO).

Support preferences and barriers highlight tailored needs for effective transformation. Training is the top priority, especially in Poland (65.5% vs. 38.8% SLO), reflecting occasional training participation (37.8% PL vs. 23% SLO). Slovenian workers value mentoring (27.3%) and technology access (24.0%) more than their Polish counterparts (15.2% and 9.7%, respectively). Family responsibilities (52.9% SLO, 27.4% PL) and health issues (34.4% SLO, 15.8% PL) are significant barriers, particularly in Slovenia, while low salaries (42.5% SLO, 42.1% PL) and limited local job opportunities (27.9% SLO, 21.4% PL) affect both. Polish workers show more uncertainty about required qualifications (15.3%). Financial security is critical, with 47.1% (SLO) and 44.6% (PL) unwilling to accept pay cuts, though non-financial benefits like job security or better conditions could encourage flexibility.

These findings emphasize the **need for comprehensive transition strategies**. The workforce’s strong learning capacity, adaptability, and technological openness provide a solid base for reskilling into green jobs, but time-efficient training and clear career pathways are essential to address time constraints and qualification uncertainties. Slovenia’s balanced workforce suggests broad adaptability, yet personal barriers like family and health require targeted support. Poland’s dual demographic necessitates flexible strategies for both younger and retiring workers. Maintaining or improving wage levels is crucial, as is addressing structural barriers like traditional contracts and limited job markets through skill recognition and recruitment support. By leveraging these strengths and addressing specific needs, transition strategies can enhance occupational mobility and ensure a just transformation for mining workers.

5. Assessment of Re-skilling Potential

5.1. Transferability of Mining Skills to RES Sectors

The transition from coal mining to renewable energy sectors (RES) is a critical component of the global energy transition, driven by the need to phase out fossil fuels and embrace sustainable energy systems. The ESCO-based occupational mapping conducted in this study identifies several coal mining roles with significant potential for redeployment into RES, including geothermal, photovoltaic, wind, unconventional hydro, battery storage, and green hydrogen sectors. These occupations demonstrate high transferability due to shared Essential Skills and Competences (e.g., troubleshooting, safety compliance, equipment operation) and Essential Knowledge (e.g., electricity, mechanics, geology), aligning with the findings of Gathmann and Schönberg (2010), who highlight that labour market skills are portable when task requirements overlap across industries. Key occupations with high transition potential include:

- **Electrical and Technical Roles**: Electricians and equipment mechanics in coal mining possess skills directly applicable to technician roles in RES, particularly in geothermal, wind, and solar energy. Their expertise in troubleshooting, electrical system maintenance, and adherence to stringent safety standards aligns closely with tasks such as installing and maintaining solar panels or wind turbines. The International Labour Organization (ILO) emphasizes that such technical skills are critical for green jobs, underscoring the need for targeted reskilling to bridge minor gaps in technology-specific competencies (MEMİŞ & Sapancalı, 2024).

- **Operational Roles**: Underground miners, drillers, and surface plant operators are well-positioned for field-based RES positions, such as geothermal drilling, solar panel operations, and hydropower maintenance. Their experience in mechanical maintenance and physically demanding environments is highly valued in these roles, which require similar operational resilience and technical know-how. Ram et al. (2020) note that renewable energy sectors generate significantly more jobs per megawatt than fossil fuel industries (1.7 to 14.7 times more), highlighting the potential for these workers to transition into high-demand operational roles with moderate upskilling.

- **Engineering and Managerial Roles**: Mine managers, environmental engineers, and geotechnical specialists are ideally suited for RES project development, safety supervision, and environmental consultancy. Their competencies in strategic planning, regulatory compliance, and leadership are directly transferable to roles overseeing renewable energy projects or ensuring environmental standards. Vona et al. (2018) suggest that these roles, while requiring some adaptation to RES-specific contexts, benefit from the portability of managerial and technical skills, facilitating smoother transitions.

- **Geology-Related Roles**: Mine geologists and geotechnical engineers exhibit strong transferability to geothermal and hydrological energy sectors, where subsurface modelling and scientific research are foundational. Their deep understanding of geological processes aligns with the needs of geothermal energy exploration and unconventional hydro projects. This transferability is critical, as Elliott et al. (2021) indicate that renewable energy roles often demand specialized knowledge, necessitating tailored training to fully leverage existing expertise.

- **Logistics and Trade Roles**: Import/export managers in mining can pivot to RES supply chain coordination, provided they acquire knowledge in sustainability criteria and circular economy practices. These roles involve managing complex logistics and trade networks, skills that are increasingly relevant in the green economy. Faia et al. (2021) emphasize the importance of structured policies to support such transitions, ensuring workers can adapt to new supply chain dynamics in RES.

The survey results from Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. – Bobrek Mine (Poland) reinforce this potential, with 38.2% (SLO) and 26.4% (PL) of respondents holding mining-specific education, and 12.2% (SLO) and 24.3% (PL) possessing qualifications in unrelated fields, indicating inherent adaptability. The concept of a "Just Transition" (MEMİŞ & Sapancalı, 2024) underscores the need for equitable support to ensure these workers can capitalize on their transferable skills. The high job creation potential in RES, as highlighted by Ram et al. (2020), combined with the portability of skills identified by Gathmann and Schönberg (2010), positions these occupations as viable pathways for coal workers facing displacement due to mine closures. However, as Elliott et al. (2021) note, the higher educational and specialized skill requirements in RES necessitate targeted interventions to bridge gaps and enhance employability, ensuring a socially inclusive and economically viable transition.

5.2. Competency Gaps and Upskilling Needs

The transition from coal mining to renewable energy sectors (RES) demands significant reskilling to address the distinct competency gaps between traditional extractive roles and the diverse skill sets required in green job opportunities. The ESCO-based analysis identifies critical areas where mining workers must develop new competencies to align with the demands of geothermal, photovoltaic, wind, unconventional hydro, battery storage, and green hydrogen sectors. These gaps, coupled with the evolving needs of the green economy, necessitate a blend of technical, digital, and soft skills to ensure a resilient and adaptable workforce capable of thriving in the energy transition (Fleming et al., 2024).

- **Technology-Specific Skills**: Proficiency in operating and maintaining RES technologies is paramount, as these skills are often underrepresented among coal workers. For instance, competencies such as “monitor electric generators,” “install electrical equipment,” and “adjust voltage” are critical for roles in photovoltaic systems, wind turbines, and green hydrogen production but are not typically part of mining skill sets (Cook & Elliott, 2025). Cheluszka (2016) emphasizes the need for reskilling in high-tech solutions, such as computer-aided design (CAD), to support the shift from traditional mining to sustainable energy technologies. These skills are essential for integrating renewable sources into modern energy infrastructures, ensuring operational efficiency and system reliability.

- **Digital and Data-Oriented Competencies**: The adoption of advanced technologies like smart grids and automated system monitoring in RES requires familiarity with digital tools and data-driven diagnostics. Skills such as using technical drawing software (e.g., CAD), statistical analysis, and data logging are increasingly vital but often lacking among mining workers (Cook & Elliott, 2025). Li and Liu (2017) highlight that digital competencies are crucial for navigating the technological complexities of the green economy, enabling workers to perform tasks like energy performance analysis and control system operations. Addressing these gaps through targeted training is essential to prepare miners for data-intensive RES roles.

- **Sustainability and Interdisciplinary Skills**: RES roles demand competencies in promoting sustainable energy, integrating environmental considerations, and communicating effectively with non-scientific audiences, which are underdeveloped in mining contexts. These interdisciplinary skills are critical for aligning with the broader goals of the energy transition, such as environmental governance and stakeholder engagement (Fleming et al., 2024). Cook and Elliott (2025) note that fostering these skills enhances workers’ ability to contribute to sustainability-driven projects, such as renewable energy policy compliance and community outreach, which are integral to modern RES value chains.

- **Risk Management and Smart Infrastructure**: Skills in preventive maintenance, risk mitigation, and smart grid operations are central to ensuring the resilience and efficiency of renewable energy systems but are less prevalent among mining professionals. Loorbach and Rotmans (2010) underscore the importance of these competencies in maintaining operational integrity in decentralized energy systems. For example, understanding smart grid operations is vital for efficient power distribution, a key component of RES integration (Cook & Elliott, 2025).

Training in these areas will enable miners to transition into roles that prioritize system reliability and safety in dynamic energy environments.

- **Soft Skills**: Project management, interdisciplinary collaboration, and adaptability to dynamic work environments are critical for success in RES roles, requiring miners to enhance their flexibility and communication abilities. Cook and Elliott (2025) emphasize that soft skills, such as effective communication and teamwork, are essential for managing complex renewable energy projects that involve diverse stakeholders. The survey results from Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. – Bobrek Mine (Poland) indicate strong adaptability (over 40% handle task changes effectively) and multitasking capabilities (48.4% SLO, 48.3% PL), providing a foundation for developing these skills further. However, targeted training is needed to bridge gaps in interdisciplinary collaboration and project management to meet RES demands.

This comprehensive set of competencies aligns with the findings of Gathmann and Schönberg (2010), who highlight the portability of skills across industries when task requirements overlap, as seen in roles like electricians and geologists transitioning to RES. However, as Elliott et al. (2021) note, the higher educational and specialized skill requirements in RES necessitate tailored programs to bridge these gaps. The survey's evidence of strong learning capacity (over 60% of respondents excel at absorbing new information) and openness to new technologies (46% SLO, 48.6% PL) suggests that miners are well-positioned to acquire these competencies with appropriate training. By addressing these skill gaps, reskilling initiatives can facilitate a just transition, leveraging the workforce's existing technical strengths while preparing them for the technological and interdisciplinary demands of the green economy (MEMİŞ & Sapancalı, 2024).

5.3. Training Strategies for a Just Transition

The analysis underscores a pressing need for structured, competency-based training programmes to address identified skill and knowledge gaps:

- **Foundational Reorientation**: Training must introduce miners to RES principles, including thermodynamics, renewable energy technologies, storage integration, and environmental governance, to build a foundational understanding of the sector.

- **Specialised Technical and Digital Training**: Programmes should focus on electrical and sensor systems, control platforms, predictive maintenance, and digital tools like CAD/CAM, alongside energy performance analysis and data recording.

- **Modular and Flexible Learning**: Training should be modular, allowing workers to build on existing skills while accommodating diverse learning paces. Prior learning recognition schemes can accelerate transitions for roles with partial overlaps (e.g., electricians, geologists).

- **Soft Skills Development**: Programmes must incorporate project management, teamwork, and communication training to prepare workers for interdisciplinary RES environments.

- **Site-Specific Tailoring**: Given variations in mining facilities and regional contexts, training should be customised to reflect local workforce profiles, operational scopes, and job market needs.

Survey results indicate strong learning capacity (over 60% of respondents excel at absorbing new information) and openness to new technologies (46% SLO, 48.6% PL), providing a solid foundation for effective training. However, time constraints (28–29% cite external knowledge acquisition as time-consuming) and traditional employment contracts highlight the need for accessible, time-efficient, and employer-supported programmes.

The transition from coal mining to renewable energy sectors (RES) necessitates a comprehensive, competency-based approach to training and reskilling to bridge identified skill and knowledge gaps, ensuring workers can adapt to the diverse demands of geothermal, photovoltaic, wind, unconventional hydro, battery storage, and green hydrogen sectors. The ESCO-based analysis underscores the urgency of structured programmes that not only address technical deficiencies but also foster adaptability and interdisciplinary skills, aligning with the broader goal of a just and sustainable energy transition (Fleming et al., 2024). The survey results from Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. – Bobrek Mine (Poland) indicate strong learning capacity (over 60% of respondents excel at absorbing new information) and openness to new technologies (46% SLO, 48.6% PL), providing a robust foundation for effective training. However, challenges such as time constraints (28–29% cite external knowledge acquisition as time-consuming) and traditional employment contracts highlight the need for accessible, time-efficient, and employer-supported programmes (Dunphy et al., 2023).

- **Foundational Reorientation**: Training must equip miners with a foundational understanding of RES principles, including thermodynamics, renewable energy technologies, storage integration, and environmental governance. Winberg and Hollis-Turner (2023) emphasize that core subjects like energy performance analysis are pivotal for building technical proficiency in RES. These programmes should introduce workers to the operational logics of renewable systems, enabling them to navigate the conceptual shift from fossil fuel-based to sustainable energy infrastructures (MEMİŞ & Sapancalı, 2024). This reorientation is critical for workers transitioning from roles like underground miners to field-based RES positions, ensuring they grasp the technological and environmental frameworks of the green economy.

- **Specialised Technical and Digital Training**: Programmes must prioritize skills in electrical and sensor systems, control platforms, predictive maintenance, and digital tools like CAD/CAM, which are essential for RES but underrepresented in mining roles. Parker (2016) highlights that training in specialized areas such as storage integration and predictive maintenance enhances workers' ability to manage evolving RES technologies. Additionally, Panda (2021) underscores the growing reliance on data-driven technologies, such as smart grid operations, necessitating proficiency in digital diagnostics and technical drawing software. These competencies support operational efficiency and risk mitigation, aligning with industry needs and improving employability in roles like wind turbine technicians or solar system operators (Cook & Elliott, 2025).

- **Modular and Flexible Learning**: To accommodate diverse learning paces and leverage existing skills, training should adopt modular formats and incorporate prior learning recognition schemes. Nguyen et al. (2015) advocate for flexible learning pathways that personalize training, enabling workers like electricians and geologists to build on their technical expertise while acquiring RES-specific skills. Cioccolanti et al. (2024) emphasize that recognizing prior learning accelerates transitions by reducing training duration for roles with partial overlaps, such as maintenance technicians. The survey's indication of strong learning capacity supports the feasibility of modular approaches, though time constraints necessitate employer-supported, accessible formats to ensure uptake.

- **Soft Skills Development**: Effective collaboration in interdisciplinary RES environments requires robust soft skills, including project management, teamwork, and communication. Nguyen et al. (2015) and Dunphy et al. (2023) note that these skills are critical for managing complex renewable energy projects involving diverse stakeholders. The survey results show high adaptability (over 40% handle task changes effectively) and multitasking capabilities (48.4% SLO, 48.3% PL), providing a foundation for further developing these competencies. Training programmes must integrate these skills to prepare workers for roles like project development coordinators, where stakeholder engagement and interdisciplinary collaboration are paramount (Cook & Elliott, 2025).

- **Site-Specific Tailoring**: Given variations in mining facilities and regional contexts, training must be customized to reflect local workforce profiles, operational scopes, and job market needs. Araújo (2018) highlights that region-specific training enhances relevance by addressing unique energy needs and technology adoption rates. For instance, Slovenia's balanced workforce and Poland's dual demographic (younger and retiring workers) require tailored interventions, with Slovenia prioritizing mentoring (27.3%) and Poland emphasizing training (65.5%) (Ратнер, 2020). Local governance and energy policy frameworks should be integrated into training to ensure workers understand regional RES priorities, enhancing their effectiveness in roles like environmental consultants or grid integration specialists.

The multifaceted approach to training outlined above aligns with the need for a resilient green economy workforce capable of adapting to ongoing changes in the energy landscape (Fleming et al., 2024). By integrating foundational education, specialized technical and digital skills, modular learning, soft skills development, and regional customization, these programmes can leverage the workforce's existing strengths while addressing barriers like time constraints and traditional contracts. The high job creation potential in RES, as noted by Ram et al. (2020), underscores the urgency of these initiatives to ensure a socially inclusive transition, equipping coal workers with the competencies needed to thrive in the evolving energy sector (MEMİŞ & Sapancalı, 2024).

5.4. Summary and Strategic Implications

The findings of this study highlight both the urgency and feasibility of re-skilling coal workers for a future in renewable energy sectors. Many mining-related occupations demonstrate strong transition potential, particularly in technical, operational, and managerial domains, where existing competencies partially overlap with those required in green jobs. However, realising this potential will require coordinated efforts across education, policy, and industry. Survey evidence from Slovenia and Poland confirms a high degree of adaptability among workers and a solid foundation for upskilling, with a large share showing openness to new technologies and strong learning capacity. Nonetheless, persistent barriers - such as skill gaps in digital diagnostics, sustainability knowledge, and interdisciplinary communication - must be systematically addressed. This underscores the need for competency-based, modular training tailored to regional contexts and aligned with labour market demand.

To ensure a just and inclusive transition, reskilling programmes must be supported by employers, responsive to time constraints, and attentive to the evolving needs of the RES sector. Vocational education and training institutions, in close partnership with employers and local authorities, have a critical role in enabling this workforce transformation. The coal-to-green transition is not only technologically necessary but also socially achievable - provided the right skills strategies and structural support are implemented.

Conclusions

The transition from coal-based industries to renewable energy sectors (RES) involves significant changes in workforce structures, skill requirements, and institutional arrangements. Findings from the GreenJOBS project confirm that many roles within the coal mining sector include competences and knowledge areas relevant to RES. This is particularly evident in technical and operational occupations.

Using the ESCO framework, several job profiles were identified with potential for transition to RES roles, including electricians, equipment mechanics, drill operators, underground miners, geologists, environmental engineers, and logistics specialists. These occupations commonly involve competences in equipment maintenance, electrical system operation, safety procedures, and technical problem-solving – all applicable in RES environments. However, despite this potential, direct transfer is limited by clear skill gaps. These are most apparent in areas such as digital tools, technology-specific knowledge (e.g. photovoltaic systems, wind turbines), sustainability principles, and interdisciplinary coordination. Addressing these gaps requires focused training programmes rather than general educational measures.

Survey data from Premogovnik Velenje (Slovenia) and Węglokoks Kraj S.A. - Bobrek Mine (Poland) support these conclusions. Workers demonstrated strong learning capacity, openness to new technologies, and flexibility in handling varied tasks. These indicators suggest readiness to participate in reskilling programmes, provided such programmes are accessible, job-relevant, and aligned with current work schedules. Nonetheless, several structural barriers limit participation in training. These include traditional employment contracts, lack of allocated time for learning, and limited exposure to environments beyond the mining industry. Additional challenges include health conditions, lower levels of formal education, and concerns related to age, particularly among older workers. The Spanish partner HUNOSA did not carry out the workforce survey due to an ongoing collective bargaining process. According to company representatives, conducting the survey during internal negotiations might have introduced unnecessary tension. This decision highlights the complexity of coordinating training and planning during times of organisational transformation.

Based on the above, the following conclusions can be drawn:

- Many occupations in the mining sector exhibit competences and knowledge areas that are transferable to RES, but reskilling remains essential due to clear gaps in digital, sustainability-related, and technology-specific skills.
- Surveyed workers demonstrated willingness and ability to learn, particularly in areas related to task flexibility, adaptation to new technologies, and independent knowledge acquisition.

- Effective training approaches should be modular, recognise prior learning, and reflect local labour market characteristics and workforce demographics.
- Soft skills and interdisciplinary awareness, although often overlooked, are increasingly necessary for long-term integration into RES workplaces and should be embedded into training design.

The differences between coal mining and renewable energy jobs go beyond technical tasks. RES roles are typically embedded in more dynamic environments that require autonomous work, digital reporting, interdisciplinary collaboration, and greater responsiveness to environmental standards. This represents a structural shift from the more hierarchical and functionally siloed models found in the coal industry. Digital competencies are a core component of this shift. Skills such as operating sensor-based systems, using technical software, and interpreting performance data are increasingly in demand across RES sectors. These are not typically part of mining roles and require targeted upskilling. In addition, RES roles often involve cooperation with professionals from other fields, such as environmental sciences, policy, or engineering. Workers are expected to engage with sustainability principles, regulatory frameworks, and project coordination - areas that are rarely covered in traditional mining education.

Survey findings indicate that many mining workers already operate in multitasking contexts and adapt well to changing roles. However, their exposure to interdisciplinary knowledge remains limited, and targeted support is needed to develop competence in sustainability and cross-sector collaboration.

To respond to these challenges, training should be:

- Content-focused, with modules covering energy system monitoring, digital diagnostics, environmental compliance, and project-based workflows.
- Practical and task-oriented, emphasising applied skills over theoretical instruction.
- Flexible, allowing learning to take place without interrupting employment.
- Inclusive of soft skills, including communication, teamwork, and basic project management.

Despite worker interest and learning potential, several barriers still restrict training participation. These include limited time availability, insufficient employer support, and a lack of training formats tailored to adult learners or mid-career professionals. In some cases, existing qualifications do not align with formal recognition systems, creating additional obstacles to upskilling or certification. Regional context also plays a role. In Slovenia, mentoring and intergenerational knowledge transfer appear to be valuable strategies, while in Poland, a greater need for formal training programmes was observed, particularly among mid- and late-career workers. These differences underscore the importance of regionally adapted interventions, designed in collaboration with local stakeholders.

To support an inclusive and effective transition, several overarching recommendations are proposed:

- Reskilling efforts should be rooted in occupational realities, prioritising roles where partial skill overlap exists.
- Training should be modular, short, and tailored, enabling incremental learning without disrupting ongoing employment.
- Recognition of prior informal experience should be formalised, to shorten training pathways and increase accessibility.
- Digital and sustainability-related skills must be embedded in all technical training programmes.
- Soft skills should be treated as essential, particularly for interdisciplinary and externally facing roles.
- Training design should be region-specific, accounting for demographic, institutional, and economic characteristics.

The shift from coal to renewable energy will continue to shape labour markets in regions with strong industrial legacies. While transition speeds may vary, the analysis confirms that coal workers can participate meaningfully in the green economy - provided that the right support systems are in place. Success depends not only on worker willingness, but on coordinated, inclusive, and context-aware strategies that translate potential into concrete employment outcomes.

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 is a realistic and achievable pathway for maintaining regional employment, particularly in coal-dependent areas. The analysis shows that existing skillsets in the mining sector can be effectively reoriented toward renewable energy applications, especially in wind, photovoltaic, geothermal, and energy storage technologies.
2. Occupational mapping using the ESCO framework confirms significant overlaps between technical mining roles and positions in the renewable energy value chain. Occupations such as electricians, mechanics, and equipment operators display high transition potential due to their familiarity with safety protocols, technical diagnostics, and equipment handling.
3. There is a pronounced need to bridge skill gaps in digital systems, sustainability principles, and interdisciplinary collaboration. Competencies in digital tools, data interpretation, and environmental governance were identified as underdeveloped yet increasingly critical in renewable energy roles. These findings highlight the importance of updating training curricula with both technical and transversal content.
4. The surveyed workforce demonstrates readiness for transformation, with strong indicators of adaptability and motivation to learn. High levels of self-reported learning capacity and willingness to embrace new technologies create a solid foundation for successful re-skilling interventions, particularly when training is modular, contextualised, and employer-supported.
5. Workforce development strategies must be tailored to demographic trends. With a considerable proportion of miners approaching retirement, training initiatives should be aligned with life-cycle employment strategies—targeting younger workers for long-term capacity building while also enabling experienced staff to contribute through mentoring, coaching, or advisory roles.
6. Company- and region-specific differences must be acknowledged in designing training solutions. The study found variation in preferred learning methods: for example, Slovenian respondents valued peer learning and on-the-job mentoring, while Polish workers expressed a preference for formal, instructor-led training. Flexibility and contextual adaptation are therefore key.
7. Efforts to future - proof the workforce should include strategies to broaden participation and access. While the mining sector has historically lacked workforce diversity, the emergence of renewable energy industries presents an

opportunity to encourage broader inclusion - not only by gender, but also in terms of age, educational background, and occupational pathways. Training offers should therefore be inclusive, accessible, and sensitive to differing learner profiles.

8. Non-technical competencies are emerging as equally critical to energy transition success. Skills in project planning, stakeholder communication, environmental compliance, and risk management are increasingly valued alongside technical expertise. Interdisciplinary training is essential to prepare workers for the complex, integrated nature of renewable energy operations.
9. The integrated methodology piloted in this task combining, ESCO-based mapping, survey research, and workforce profiling, has proven effective. It enabled precise identification of transferable skills, training gaps, and re-skilling potential, forming a practical basis for future curriculum development and labour policy planning.
10. Ultimately, the reskilling of coal workers is not only possible, it is essential. The findings affirm that with the right tools, partnerships, and pedagogical approaches, displaced workers can be empowered to actively participate in the green transition, supporting social cohesion and economic resilience in structurally affected regions.

Glossary

BESS - Battery Energy Storage Systems

CO_2 - Carbon Dioxide

ESCO – European Skills, Competences, Qualifications and Occupations

FAEN – Fundación Asturiana de la Energía

GIG-PIB – Główny Instytut Górnictwa – Państwowy Instytut Badawczy

HUNOSA – Hulleras del Norte, S.A.

ILO – International Labour Organization

KWK – Kopalnia Węgla Kamiennego (Hard Coal Mine)

O&M – Operation and Maintenance

PL – Poland

PV – Photovoltaics

R&D – Research and Development

REA – Research Executive Agency

RES – Renewable Energy Sources

SLO – Slovenia

UNIOVI – Universidad de Oviedo

WEGLO – Węglokoks S.A.

TVET – Technical and Vocational Education and Training

EU – European Union

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Appendix

Appendix 1.

A detailed description of the occupations with assigned skills and knowledge

Occupation	Primary Value Chain Segment	Essential Skills and Competences	Essential Knowledge
1. Geothermal Power Plant Operator (3131.3.4)	Operations & Maintenance	– apply health and safety standards – control steam flows – maintain electrical equipment – monitor electric generators – monitor valves – operate steam turbine – regulate steam pressure – troubleshoot – wear appropriate protective gear	– electric current – electric generators – electrical power safety regulations – electricity – geothermal energy – geothermal energy systems – geothermal power generation methods – geothermal power plant operations – thermodynamics
2. Geothermal Engineer (2149.9.3)	Project Development & Design	– adjust engineering designs – advise on building matters – apply health and safety standards – apply statistical analysis techniques – approve engineering design – assess environmental impact – design geothermal energy systems – design heat pump installations – design thermal equipment – design thermal requirements	– CAD software – CAM software – electric current – electric generators – electrical power safety regulations – electricity – energy efficiency – energy transformation – environmental legislation – geographic information systems – geology

		– ensure compliance with environmental legislation – operate scientific measuring equipment – perform a feasibility study on heat pumps – perform feasibility study on geothermal energy – perform laboratory tests	– geothermal energy – geothermal energy systems – geothermal power generation methods – geothermal power plant operations – renewable energy – technical drawings – thermodynamics – types of heat pumps
3. Geothermal Technician (7412.4)	Installation & Commissioning	– apply health and safety standards – check compatibility of materials – conduct routine machinery checks – maintain electrical equipment – operate drilling equipment – prevent pipeline deterioration – respond to emergency calls for repairs – test electrical equipment – test pipeline infrastructure operations – test procedures in electricity transmission – troubleshoot	– alternative energy – electric current – electric generators – electrical equipment regulations – electrical power safety regulations – electricity – geothermal energy – geothermal energy systems – geothermal power generation methods – geothermal power plant operations – health and safety in the workplace – switching devices – thermodynamics – types of heat pumps
4. Geologist (2114.1)	Project Development & Design	– apply for research funding	– cartography – geological time scale

		– apply research ethics and scientific integrity principles in research activities – apply safety procedures in laboratory – apply scientific methods – apply statistical analysis techniques – calibrate laboratory equipment – carry out geological explorations – collect geological data – communicate with a non-scientific audience – conduct research across disciplines – conduct soil sample tests – demonstrate disciplinary expertise – develop professional network with researchers and scientists – disseminate results to the scientific community – draft scientific or academic papers and technical documentation – evaluate research activities – execute analytical mathematical calculations – increase the impact of science on policy and society – integrate gender dimension in research – interact professionally in research and professional environments – manage findable accessible interoperable and reusable data	– geology – mathematics – scientific modelling – scientific research methodology – statistics

		– manage intellectual property rights – manage open publications – manage personal professional development – manage research data – mentor individuals – operate open source software – operate scientific measuring equipment – perform laboratory tests – perform project management – perform scientific research – promote open innovation in research – promote the participation of citizens in scientific and research activities – promote the transfer of knowledge – publish academic research – record test data – speak different languages – synthesise information – think abstractly – write scientific publications	
5. Geophysicist (2114.2)	Project Development & Design	– advise on geophysical procedures – conduct field work – document seismic research – engineer seismic equipment – operate seismic equipment – prepare scientific reports	– geology – physics – seismic measurement techniques

		– use measurement instruments	
6. Renewable Energy Engineer (2149.9.7)	Project Development & Design / O&M	– adapt energy distribution schedules – adjust engineering designs – approve engineering design – carry out energy management of facilities – design wind turbines – ensure compliance with safety legislation – inform on government funding – make electrical calculations – manage engineering project – perform project management – perform scientific research – promote sustainable energy – provide information on geothermal heat pumps – provide information on solar panels – provide information on wind turbines – research locations for wind farms – use CAD software – use technical drawing software – use thermal management	– bioeconomy – biogas energy – civil engineering – electrical engineering – energy conservation – energy micro-generation technologies – engineering processes – environmental engineering – fluid mechanics – geothermal energy – green automotive technologies – industrial heating systems – marine energy – mechanical engineering – mining, construction and civil engineering machinery products – photovoltaic systems – power engineering – renewable energy – resource-efficient technologies – solar energy – state estimation – technical drawings – wind energy

7. Renewable Energy Consultant (2433.3)	Project Development & Design	– advise on carbon emissions reduction – advise on heating systems energy efficiency – assess customers – develop professional network – identify energy needs – inform on government funding – instruct on energy saving technologies – perform market research – promote environmental awareness – promote sustainable energy – provide information on geothermal heat pumps – provide information on solar panels – provide information on wind turbines	– alternative energy – characteristics of products – characteristics of services – corporate sustainability – energy conservation – energy efficiency – market analysis – renewable energy – resource-efficient technologies – solar energy – solar products – wind energy
8. Solar Energy Technician (7411.1.4)	Installation & Commissioning	– check compatibility of materials – comply with legal regulations – follow health and safety procedures in construction – follow safety procedures when working at heights – inspect construction supplies – inspect electrical supplies – install circuit breakers – install concentrated solar power systems – install electrical and electronic equipment	– alternative energy – electrical wiring plans – electricity – mechanics – photovoltaic systems – solar energy – solar products

		– install photovoltaic systems – interpret 2D plans – interpret 3D plans – mount photovoltaic panels – operate solar thermal energy systems for hot water and heating – test procedures in electricity transmission – transport construction supplies – use measurement instruments – work ergonomically	
9. Solar Energy Engineer (2149.9.8)	Project Development & Design	– adjust engineering designs – adjust voltage – approve engineering design – conduct engineering site audits – create CAD drawings – design a solar heating system – design solar energy systems – examine engineering principles – maintain concentrated solar power systems – maintain solar energy systems – manage engineering project – operate solar thermal energy systems for hot water and heating – perform feasibility study on solar heating	– alternative energy – electrical engineering – energy – energy market – energy micro-generation technologies – engineering principles – engineering processes – photovoltaic systems – power engineering – solar energy – solar products – sustainable technologies – technical drawings – thermodynamics – types of photovoltaic panels

		– perform scientific research – promote sustainable energy – provide information on solar panels – use technical drawing software – use thermal analysis	
10. Solar Power Plant Operator (3131.3.8)	Operations & Maintenance	– apply health and safety standards – install concentrated solar power systems – install photovoltaic systems – maintain concentrated solar power systems – maintain electrical equipment – maintain photovoltaic systems – maintain records of maintenance interventions – monitor electric generators – respond to electrical power contingencies	– electric current – electric generators – electrical power safety regulations – electricity – photovoltaic systems – solar energy
11. Solar Energy Sales Consultant (2433.5)	System Management / Market Interface	– advise on heating systems energy efficiency – assess customers – develop professional network – identify customer's needs – inform customers on energy consumption fees – inform on government funding – promote environmental awareness	– characteristics of products – characteristics of services – domestic heating systems – electricity market – energy conservation – energy efficiency – industrial heating systems – photovoltaic systems

		– promote sustainable energy – provide information on solar panels	– solar energy – solar products
12. Onshore Wind Energy Engineer (2149.9.6)	Project Development & Design	– adjust engineering designs – adjust voltage – approve engineering design – conduct engineering site audits – design automation components – design wind turbines – develop test procedures – ensure compliance with environmental legislation – ensure compliance with noise standards – ensure compliance with safety legislation – manage engineering project – perform data analysis – perform project management – perform scientific research – promote innovative infrastructure design – provide information on wind turbines – read engineering drawings – record test data – report test findings – research locations for wind farms – test wind turbine blades – use technical drawing software	– aerodynamics – civil engineering – data storage – electric generators – electrical discharge – electrical power safety regulations – energy market – engineering principles – engineering processes – meteorology – mining, construction and civil engineering machinery products – renewable energy – technical drawings – types of wind turbines – wind energy

13. Offshore Renewable Energy Plant Operator (3131.1)	Operations & Maintenance	– address problems critically – apply health and safety standards – arrange equipment repairs – conduct routine machinery checks – ensure compliance with maintenance legislation – ensure equipment maintenance – follow safety procedures when working at heights – gather data – inspect wind turbines – install electrical and electronic equipment – maintain electrical equipment – maintain electronic equipment – maintain hydraulic systems – maintain records of maintenance interventions – maintain sensor equipment – monitor electric generators – prevent marine pollution – respond to electrical power contingencies – survive at sea in the event of ship abandonment – use remote control equipment – work in inclement conditions	– electric generators – electrical discharge – electrical power safety regulations – electricity – electronics – marine energy – marine engineering – marine technology – maritime meteorology – mechanics – offshore constructions and facilities – offshore renewable energy technologies – wind energy

14. Offshore Renewable Energy Technician (3119.11)	Installation & Commissioning / O&M	– analyse test data – apply health and safety standards – arrange equipment repairs – ensure equipment maintenance – follow safety procedures when working at heights – gather data – inspect offshore constructions – inspect tidal stream generators – inspect wave energy converters – inspect wind turbines – install electrical and electronic equipment – install offshore renewable energy systems – maintain electrical equipment – maintain electronic equipment – maintain hydraulic systems – maintain records of maintenance interventions – maintain sensor equipment – maintain wind turbines – manage emergency procedures – monitor electric generators – prevent marine pollution – provide first aid – respond to electrical power contingencies	– electric generators – electrical discharge – electrical power safety regulations – electricity – electronics – marine energy – marine engineering – marine technology – maritime meteorology – mechanics – offshore constructions and facilities – offshore renewable energy technologies – renewable energy – types of wind turbines – wind energy

		– survive at sea in the event of ship abandonment – test sensors – use remote control equipment	
15. Onshore Wind Farm Technician (3131.2)	Installation & Commissioning	– analyse test data – apply health and safety standards – arrange equipment repairs – ensure compliance with noise standards – ensure equipment maintenance – follow safety procedures when working at heights – gather data – inspect wind turbines – install electrical and electronic equipment – install onshore wind energy systems – maintain electrical equipment – maintain electronic equipment – maintain records of maintenance interventions – maintain sensor equipment – maintain wind turbines – manage emergency procedures – monitor electric generators – provide first aid – resolve equipment malfunctions	– electric generators – electrical discharge – electrical power safety regulations – electricity – electronics – mechanics – renewable energy – types of wind turbines – wind energy

		– respond to electrical power contingencies – test sensors – test wind turbine blades – use remote control equipment	
16. Hydroelectric Plant Operator (3131.3.5)	Operations & Maintenance	– apply health and safety standards – maintain electrical equipment – maintain hydraulic systems – monitor electric generators – operate hydraulic machinery controls – operate hydraulic pumps – wear appropriate protective gear	– electric current – electric generators – electrical power safety regulations – electricity – hydraulics – hydroelectricity
17. Hydropower Technician (3113.2)	Installation & Commissioning	– adjust engineering designs – apply health and safety standards – design electric power systems – maintain electrical equipment – manage engineering project – monitor electric generators – operate scientific measuring equipment – perform risk analysis – promote innovative infrastructure design – troubleshoot	– alternative energy – electric generators – electrical power safety regulations – electricity – energy – energy efficiency – energy micro-generation technologies – energy performance of buildings – energy transformation – engineering processes – environmental engineering – hydroelectricity – marine energy

			– oceanography – renewable energy – technical drawings
18. Health, Safety and Environmental Manager (1213.7)	Safety & Environmental Management	– abide by business ethical code of conducts – advise on government policy compliance – advise on sustainability solutions – communicate health and safety measures – coordinate environmental efforts – develop contingency plans for emergencies – develop training programmes – educate employees on occupational hazards – evaluate company needs – evaluate employees work – implement strategic planning – liaise with government officials – liaise with industry experts – liaise with managers – make health, safety and environment assessments – manage environmental impact of operations – manage health and safety standards – monitor contractor performance	– assessment of risks and threats – audit techniques – business analysis – energy conservation – environmental legislation – framework for a safety management system – health and safety in the workplace – health and safety regulations – health, safety and hygiene legislation – organisational resilience – pollution legislation – pollution prevention – production processes – risk management – strategic planning

		– monitor employee's health – monitor legislation developments – perform risk analysis – plan health and safety procedures – promote health and safety – promote sustainability – shape corporate culture	
19. Hydropower Engineer (2142.1.5)	Project Development & Design	– approve engineering design – design electric power systems – draw blueprints – examine engineering principles – manage engineering project – operate scientific measuring equipment – perform project management – perform risk analysis – perform scientific research – promote innovative infrastructure design – troubleshoot – use CAD software – use CAM software – use technical drawing software	– CAD software – CAM software – electrical power safety regulations – electricity – electronics principles – energy efficiency – energy micro-generation technologies – energy transformation – engineering principles – hydroelectricity – marine energy – project management – renewable energy – resource-efficient technologies – technical drawings
20. Maintenance and Repair Engineer (2141.8)	Operations & Maintenance	– advise on efficiency improvements – conduct quality control analysis – conduct routine machinery checks	– engineering principles – engineering processes – maintenance operations

		– create solutions to problems – inspect industrial equipment – inspect machinery – maintain equipment – maintain machinery – manage budgets – perform machine maintenance – perform test run – resolve equipment malfunctions – troubleshoot – use testing equipment – work safely with machines – write technical reports	– mechanics – quality assurance procedures
21. Hydrologist (2114.1.5)	Project Development & Design	– apply for research funding – apply research ethics and scientific integrity principles in research activities – apply scientific methods – apply statistical analysis techniques – communicate with a non-scientific audience – conduct research across disciplines – demonstrate disciplinary expertise – develop environmental policy – develop professional network with researchers and scientists – develop water purification methods	– environmental policy – geography – hydrology – scientific literature – scientific modelling – scientific research methodology – statistics – water policies – watershed development

		– disseminate results to the scientific community – draft scientific or academic papers and technical documentation – ensure compliance with environmental legislation – evaluate research activities – increase the impact of science on policy and society – integrate gender dimension in research – interact professionally in research and professional environments – manage findable accessible interoperable and reusable data – manage intellectual property rights – manage land resources permits – manage open publications – manage personal professional development – manage research data – mentor individuals – operate open source software – operate scientific measuring equipment – perform project management – perform scientific research – promote open innovation in research – promote the participation of citizens in scientific and research activities – promote the transfer of knowledge	

		– publish academic research – speak different languages – synthesise information – think abstractly – write scientific publications	
22. Battery System Engineer (2151.4)	Project Development & Design / Grid Integration	– analyse test data – conform with production requirements – define integration strategy – develop new products – develop predictive models – identify process improvements – perform product testing – troubleshoot	– battery chemistry – battery design – battery management systems – computer programming – computer science – control systems – electrical engineering – embedded systems – engineering principles – mechanical engineering – project management – project management principles – safety engineering – vehicle electrical systems
23. Battery Assembler (8212.3.1)	Manufacturing & Assembly	– adjust voltage – align components – assemble batteries – attach power cords to electric module – ensure conformity to specifications – ensure public safety and security – fasten components	– battery chemistry – battery components – battery fluids – battery formation – battery management systems – electrical discharge – electricity

		– install low voltage wiring – meet deadlines – monitor machine operations – operate soldering equipment – read assembly drawings – remove defective products – report defective manufacturing materials – wear appropriate protective gear	– quality standards
24. Battery Manufacturing Technician (3113.4)	Manufacturing & Assembly	– analyse test data – assemble batteries – ensure equipment maintenance – have computer literacy – identify process improvements – operate automated process control – perform product testing – remove defective products – troubleshoot	– battery chemistry – battery components – battery formation – battery testers – electrical engineering – materials engineering – production processes – safety engineering
25. Alternative Fuels Engineer (2149.9.1)	Project Development & Design / Grid Integration	– adjust engineering designs – analyse energy consumption – approve engineering design – assess hydrogen production technologies – conduct energy audit – design electric power systems – design electrical systems	– CAD software – alternative fuels – chemical products – circular economy – electrochemistry – electronics – energy efficiency – energy storage systems

		– develop energy saving concepts – dispose of hazardous waste – ensure compliance with environmental legislation – ensure compliance with safety legislation – execute feasibility study on hydrogen – identify energy needs – perform scientific research – plan maintenance activities – promote innovative infrastructure design – promote sustainable energy – provide information on hydrogen – use sustainable materials and components – use technical drawing software – use testing equipment – use thermal management	– engineering principles – environmental legislation – fuel cell types – fuel gas – health, safety and hygiene legislation – market pricing – mechanics – offshore constructions and facilities – offshore renewable energy technologies – power electronics – renewable energy – smart grids systems – statistics – systems development life-cycle – technical drawings – thermodynamics

Appendix 2.

Evaluation of links in occupations (gaps, matches) on the basis of skills and competencies

Essential Skills and Competences	**Number of appearances in mining sector occupations**	**Number of appearances in RES sector occupations**	**Link evaluation**
apply health and safety standards		9	GAP
maintain electrical equipment		8	GAP
monitor electric generators		7	GAP
perform scientific research	1	7	MATCH
troubleshoot	9	7	MATCH
adjust engineering designs		6	GAP
approve engineering design	1	6	MATCH
manage engineering project		5	GAP
operate scientific measuring equipment		5	GAP
perform project management		5	GAP
promote sustainable energy		5	GAP
use technical drawing software	1	5	MATCH
analyse test data		4	GAP
ensure compliance with environmental legislation	1	4	MATCH
ensure equipment maintenance		4	GAP
follow safety procedures when working at heights		4	GAP
install electrical and electronic equipment		4	GAP
maintain records of maintenance interventions		4	GAP
promote innovative infrastructure design		4	GAP
provide information on solar panels		4	GAP
respond to electrical power contingencies		4	GAP
adjust voltage		3	GAP
apply statistical analysis techniques		3	GAP
arrange equipment repairs		3	GAP
conduct routine machinery checks		3	GAP
design electric power systems		3	GAP
ensure compliance with safety legislation	4	3	MATCH
gather data		3	GAP
inform on government funding		3	GAP
inspect wind turbines		3	GAP
maintain electronic equipment		3	GAP
maintain hydraulic systems		3	GAP
maintain sensor equipment		3	GAP

perform risk analysis		3	GAP
provide information on wind turbines		3	GAP
use remote control equipment		3	GAP
wear appropriate protective gear		3	GAP
advise on heating systems energy efficiency		2	GAP
apply for research funding		2	GAP
apply research ethics and scientific integrity principles in research activities		2	GAP
apply scientific methods		2	GAP
assemble batteries		2	GAP
assess customers		2	GAP
check compatibility of materials		2	GAP
communicate with a non-scientific audience		2	GAP
conduct engineering site audits		2	GAP
conduct research across disciplines		2	GAP
demonstrate disciplinary expertise		2	GAP
design wind turbines		2	GAP
develop professional network with researchers and scientists		2	GAP
develop professional network		2	GAP
disseminate results to the scientific community		2	GAP
draft scientific or academic papers and technical documentation		2	GAP
ensure compliance with noise standards		2	GAP
evaluate research activities		2	GAP
examine engineering principles		2	GAP
identify energy needs		2	GAP
identify process improvements	2	2	MATCH
increase the impact of science on policy and society		2	GAP
install concentrated solar power systems		2	GAP
install photovoltaic systems		2	GAP
integrate gender dimension in research		2	GAP
interact professionally in research and professional environments		2	GAP
maintain concentrated solar power systems		2	GAP
maintain wind turbines		2	GAP
manage emergency procedures	3	2	MATCH
manage findable accessible interoperable and reusable data		2	GAP
manage intellectual property rights		2	GAP
manage open publications		2	GAP

manage personal professional development		2	GAP
manage research data		2	GAP
mentor individuals		2	GAP
operate open source software		2	GAP
operate solar thermal energy systems for hot water and heating		2	GAP
perform laboratory tests		2	GAP
perform product testing		2	GAP
prevent marine pollution		2	GAP
promote environmental awareness		2	GAP
promote open innovation in research		2	GAP
promote the participation of citizens in scientific and research activities		2	GAP
promote the transfer of knowledge		2	GAP
provide first aid		2	GAP
provide information on geothermal heat pumps		2	GAP
publish academic research		2	GAP
record test data		2	GAP
remove defective products		2	GAP
research locations for wind farms		2	GAP
resolve equipment malfunctions		2	GAP
speak different languages	1	2	MATCH
survive at sea in the event of ship abandonment		2	GAP
synthesise information		2	GAP
test procedures in electricity transmission		2	GAP
test sensors		2	GAP
test wind turbine blades		2	GAP
think abstractly		2	GAP
use CAD software		2	GAP
use measurement instruments		2	GAP
use testing equipment		2	GAP
use thermal management		2	GAP
write scientific publications		2	GAP
abide by business ethical code of conducts	1	1	MATCH
adapt energy distribution schedules		1	GAP
address problems critically	5	1	MATCH
advise on building matters		1	GAP
advise on carbon emissions reduction		1	GAP
advise on efficiency improvements		1	GAP
advise on geophysical procedures		1	GAP
advise on government policy compliance		1	GAP

advise on sustainability solutions		1	GAP
align components		1	GAP
analyse energy consumption		1	GAP
apply safety procedures in laboratory		1	GAP
assess environmental impact	1	1	MATCH
assess hydrogen production technologies		1	GAP
attach power cords to electric module		1	GAP
calibrate laboratory equipment		1	GAP
carry out energy management of facilities		1	GAP
carry out geological explorations		1	GAP
collect geological data		1	GAP
communicate health and safety measures		1	GAP
comply with legal regulations		1	GAP
conduct energy audit		1	GAP
conduct field work		1	GAP
conduct quality control analysis		1	GAP
conduct soil sample tests		1	GAP
conform with production requirements		1	GAP
control steam flows		1	GAP
coordinate environmental efforts		1	GAP
create CAD drawings		1	GAP
create solutions to problems	1	1	MATCH
define integration strategy		1	GAP
design a solar heating system		1	GAP
design automation components		1	GAP
design electrical systems		1	GAP
design geothermal energy systems		1	GAP
design heat pump installations		1	GAP
design solar energy systems		1	GAP
design thermal equipment		1	GAP
design thermal requirements		1	GAP
develop contingency plans for emergencies		1	GAP
develop energy saving concepts		1	GAP
develop environmental policy	1	1	MATCH
develop new products		1	GAP
develop predictive models		1	GAP
develop test procedures		1	GAP
develop training programmes		1	GAP
develop water purification methods		1	GAP
dispose of hazardous waste		1	GAP

document seismic research		1	GAP
draw blueprints		1	GAP
educate employees on occupational hazards		1	GAP
engineer seismic equipment		1	GAP
ensure compliance with maintenance legislation		1	GAP
ensure conformity to specifications		1	GAP
ensure public safety and security		1	GAP
evaluate company needs		1	GAP
evaluate employees work		1	GAP
execute analytical mathematical calculations		1	GAP
execute feasibility study on hydrogen		1	GAP
fasten components		1	GAP
follow health and safety procedures in construction	1	1	MATCH
have computer literacy		1	GAP
identify customer's needs		1	GAP
implement strategic planning		1	GAP
inform customers on energy consumption fees		1	GAP
inspect construction supplies		1	GAP
inspect electrical supplies		1	GAP
inspect industrial equipment		1	GAP
inspect machinery		1	GAP
inspect offshore constructions		1	GAP
inspect tidal stream generators		1	GAP
inspect wave energy converters		1	GAP
install circuit breakers		1	GAP
install low voltage wiring		1	GAP
install offshore renewable energy systems		1	GAP
install onshore wind energy systems		1	GAP
instruct on energy saving technologies		1	GAP
interpret 2D plans		1	GAP
interpret 3D plans		1	GAP
liaise with government officials		1	GAP
liaise with industry experts		1	GAP
liaise with managers		1	GAP
maintain equipment		1	GAP
maintain machinery		1	GAP
maintain photovoltaic systems		1	GAP
maintain solar energy systems		1	GAP
make electrical calculations		1	GAP

make health, safety and environment assessments		1	GAP
manage budgets		1	GAP
manage environmental impact of operations		1	GAP
manage health and safety standards		1	GAP
manage land resources permits		1	GAP
meet deadlines	1	1	MATCH
monitor contractor performance		1	GAP
monitor employee's health		1	GAP
monitor legislation developments		1	GAP
monitor machine operations		1	GAP
monitor valves		1	GAP
mount photovoltaic panels		1	GAP
operate automated process control		1	GAP
operate drilling equipment	1	1	MATCH
operate hydraulic machinery controls		1	GAP
operate hydraulic pumps	1	1	MATCH
operate seismic equipment		1	GAP
operate soldering equipment		1	GAP
operate steam turbine		1	GAP
perform a feasibility study on heat pumps		1	GAP
perform data analysis		1	GAP
perform feasibility study on geothermal energy		1	GAP
perform feasibility study on solar heating		1	GAP
perform machine maintenance		1	GAP
perform market research		1	GAP
perform test run		1	GAP
plan health and safety procedures		1	GAP
plan maintenance activities		1	GAP
prepare scientific reports	4	1	MATCH
prevent pipeline deterioration		1	GAP
promote health and safety		1	GAP
promote sustainability		1	GAP
provide information on hydrogen		1	GAP
read assembly drawings		1	GAP
read engineering drawings		1	GAP
regulate steam pressure		1	GAP
report defective manufacturing materials		1	GAP
report test findings		1	GAP
respond to emergency calls for repairs		1	GAP

shape corporate culture		1	GAP
test electrical equipment		1	GAP
test pipeline infrastructure operations		1	GAP
transport construction supplies		1	GAP
use CAM software		1	GAP
use sustainable materials and components		1	GAP
use thermal analysis		1	GAP
work ergonomically	3	1	MATCH
work in inclement conditions		1	GAP
work safely with machines		1	GAP
write technical reports		1	GAP

Appendix 3.

Evaluation of links in occupations (gaps, matches) on the basis of knowledge

Essential Knowledge	**Number of appearances in mining sector occupations**	**Number of appearances in RES sector occupations**	**Link evaluation**
electricity	5	12	MATCH
electrical power safety regulations		11	GAP
electric generators		10	GAP
engineering principles	1	9	MATCH
renewable energy		9	GAP
technical drawings	1	7	MATCH
energy efficiency		6	GAP
mechanics	3	6	MATCH
solar energy		6	GAP
thermodynamics		6	GAP
wind energy		6	GAP
alternative energy		5	GAP
electric current		5	GAP
electrical discharge		5	GAP
marine energy		5	GAP
photovoltaic systems		5	GAP
electrical engineering		4	GAP
electronics	1	4	MATCH
energy conservation		4	GAP
energy micro-generation technologies		4	GAP
geothermal energy		4	GAP
solar products		4	GAP
battery chemistry		3	GAP
CAD software		3	GAP
energy transformation		3	GAP
environmental legislation		3	GAP
geology	3	3	MATCH
geothermal energy systems		3	GAP
geothermal power generation methods		3	GAP
geothermal power plant operations		3	GAP
hydroelectricity		3	GAP
offshore constructions and facilities		3	GAP
offshore renewable energy technologies		3	GAP

resource-efficient technologies		3	GAP
statistics		3	GAP
types of wind turbines		3	GAP
battery components		2	GAP
battery formation		2	GAP
battery management systems		2	GAP
CAM software		2	GAP
characteristics of products		2	GAP
characteristics of services		2	GAP
civil engineering	1	2	MATCH
energy market		2	GAP
energy		2	GAP
environmental engineering		2	GAP
health and safety in the workplace		2	GAP
health, safety and hygiene legislation		2	GAP
industrial heating systems		2	GAP
marine engineering		2	GAP
marine technology		2	GAP
maritime meteorology		2	GAP
mechanical engineering		2	GAP
mining, construction and civil engineering machinery products	2	2	MATCH
power engineering		2	GAP
production processes		2	GAP
project management		2	GAP
safety engineering	1	2	MATCH
scientific modelling		2	GAP
scientific research methodology		2	GAP
types of heat pumps		2	GAP
aerodynamics		1	GAP
alternative fuels		1	GAP
assessment of risks and threats		1	GAP
audit techniques		1	GAP
battery design		1	GAP
battery fluids		1	GAP
battery testers		1	GAP
bioeconomy		1	GAP
biogas energy		1	GAP
business analysis		1	GAP
cartography		1	GAP

chemical products		1	GAP
circular economy		1	GAP
computer programming		1	GAP
computer science		1	GAP
control systems		1	GAP
corporate sustainability		1	GAP
data storage		1	GAP
domestic heating systems		1	GAP
electrical equipment regulations		1	GAP
electrical wiring plans		1	GAP
electricity market		1	GAP
electrochemistry		1	GAP
electronics principles		1	GAP
embedded systems		1	GAP
energy performance of buildings		1	GAP
energy storage systems		1	GAP
environmental policy		1	GAP
fluid mechanics		1	GAP
framework for a safety management system		1	GAP
fuel cell types		1	GAP
fuel gas		1	GAP
geographic information systems		1	GAP
geography		1	GAP
geological time scale		1	GAP
green automotive technologies		1	GAP
health and safety regulations		1	GAP
hydraulics		1	GAP
hydrology		1	GAP
maintenance operations		1	GAP
market analysis		1	GAP
market pricing		1	GAP
materials engineering		1	GAP
mathematics		1	GAP
meteorology		1	GAP
oceanography		1	GAP
organisational resilience		1	GAP
physics		1	GAP
pollution legislation		1	GAP
pollution prevention		1	GAP
power electronics		1	GAP

project management principles		1	GAP
quality assurance procedures		1	GAP
quality standards		1	GAP
risk management		1	GAP
scientific literature		1	GAP
seismic measurement techniques		1	GAP
smart grids systems		1	GAP
state estimation		1	GAP
strategic planning		1	GAP
sustainable technologies		1	GAP
switching devices		1	GAP
systems development life-cycle		1	GAP
types of photovoltaic panels		1	GAP
vehicle electrical systems		1	GAP
water policies		1	GAP
watershed development		1	GAP