



Deliverable D 6.1

Review of protocols for permitting and ESIA to be applied at the three demonstration sites

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Title of the project: New Exploration Tools for European Pegmatite Green-Tech Resources' — 'GREENPEG'

Grant Agreement number: 869274

Funding Scheme: HORIZON 2020 IA

Work Package: WP6

Lead Editor: UNEXE

Start date: 01.05.2020

Delivery Due Date: October 2020

Date of Delivery: 30th October 2020 (updated 28th January 2022)

Contact Duration: 56 months

Version: Draft v2 / Final

Project Website: www.GREENPEG.eu

Deliverable type and dissemination level	
Report	PU Public

Executive Summary

Many of the raw materials for green energy production, such as high purity quartz, silicon metal, lithium, rare earth elements, beryllium, tantalum, ceramic feldspar and caesium, can be sourced from a rock type known as pegmatite. The varieties of these which are most sought after are lithium-caesium-tantalum (LCT) and niobium-yttrium-fluorine (NYF) pegmatites, which are relatively common in Europe.

The GREENPEG project will develop and test a set of high-level exploration technologies and algorithms to be integrated and up-scaled into flexible, ready-to-use toolsets for the identification of buried pegmatite ores. Validation of the new approach will be carried out in industry-led trials at demonstration sites in Norway (Tysfjord), Ireland (Leinster) and Austria (Wolfsberg) and application studies will also be done in Portugal and Spain. As well as the technical development and assessment of these technologies and algorithms, a key goal of GREENPEG is to minimise the environmental, social and safety impact of these developments.

This report has been prepared to share information amongst the consortium so that project members are aware of the context of each demonstration site, reflecting knowledge within GREENPEG at the time of writing (October 2020, with updates in January 2022, prior to external review, mainly to reflect the changes to the organisation of governmental geoscience offices in Ireland in January 2021). It provides a review of protocols for permitting and environmental and social impact assessments at each of the three GREENPEG demonstration sites, an overview of international voluntary good practice and information on complementary EU projects. It also introduces the life cycle assessment (LCA) approach that will be used to compare and assess the exploration methods and consider how best to predict and mitigate the mining impacts during the exploration and development phase. The aim is to help consortium members share internal best practice and to highlight to the consortium external schemes and recent relevant research project results.

The extractive industries sector is fundamental to the global economy. Humans rely on minerals to sustain their existence. Responsible exploration and mining is about how to deal best with environmental impacts, local communities with interests in the project area and broad social and public interests, technological innovation and resource governance. Geoethical aspects include transparency in communication and social responsibility to protect the interests of all: stakeholders, citizens, human health and the environment.

Most exploration projects and mines are required to produce an environmental and social impact assessment (ESIA) or screening before exploration or mine development goes ahead. This is usually stipulated by the country's legislation and can be subject to even more requirements and obligations to fulfil during the permitting process at regional level. Safety is also governed by legislation. In addition to any social impact assessment required by regulation, understanding the social context is an important part of work to gain the informal 'social licence to operate' (SLO). This 'social licence' is the informal, and often intangible and impermanent community approval or acceptance for an exploration or mining project, such that local and wider communities perceive the company, project, and industry as a whole, as trustworthy and legitimate.

The three main GREENPEG demonstration sites each have different histories and environmental and social conditions. Two, in Norway and Austria, have current or previously worked mines whereas the project in Ireland is exploring a new 'greenfield' site. In Norway, mining and processing has been established in the area for 100 years and is an important employer for the local Sámi and Norwegian communities. In Austria and Ireland, GREENPEG project partners already have active exploration

projects. In all three areas, community acceptance is highlighted by the partners as particularly important. Informal and formal communication methods, design of exploration activities guided by community feedback, and likewise future mine plans where applicable, as well as activities such as staff volunteering in the community are being used to build and strengthen company-community relationships. Environmental concerns include water quality management, preservation of forest, noise and traffic, and disturbance to livestock. Amongst the three main demonstration sites, in Austria and Ireland there is some anti-mining sentiment, at least in part related to either historical local poor mining environmental performance or to a wider more general European anti-mining view.

Legislation in Ireland, Austria and Spain is linked to EU regulations, and likewise Norway, whilst not formally a member of the EU is also closely aligned to the EU regulatory environment. The main points the legislation in these countries have in common are the need for environmental impact assessments and landowner permissions at certain stages in the permitting process. The main differences are that systems for administering permitting and the opportunities for community consultation and public involvement in the permitting process varies between countries. Norway notably has legislation particularly addressing consultation with the Sámi indigenous community.

Beyond the national and international legislation that companies must adhere to, there are multiple voluntary schemes, led mainly by industry, the World Bank and the United Nations, to support environmental, social and safety best practice. These overlap with corporate social responsibility schemes (CSR) and the driver may come from investors, or be linked to 'social licence to operate', although adherence to such schemes is increasingly becoming the industry norm. The standards in these schemes, especially for public consultation and community interaction, are higher than the legislative requirements in Europe.

The GREENPEG partners take part in various voluntary initiatives, including industry associations such as the European Industrial Minerals Association (IMA-Europe) that facilitate sharing of best practice, the UN Commission initiative to legislate Product Environmental Footprint (PEF) and Organisation Environmental Footprint (OEF), the Mining Association of Canada 'Towards Sustainable Mining' guidelines, PDAC e3Plus, JORC and NI 43-101 reporting codes, GRI, IFC, and IRMA. All partners agree about the importance of good community engagement, discussing and working with local stakeholders. Establishment of long-term goals for positive community benefits during the exploration stage of projects can also be important in helping to ensure the mining company (who may well be different from the exploration company) will follow through with such commitments later, should a project advance to extraction.

Of these schemes, e3 Plus, the exploration stage guidance from the Prospectors and Developers Association of Canada is the one scheme particularly aimed at the exploration industry rather than the mining industry. Several strands of the guidance focus on social factors, as well as environmental issues: wellbeing and community engagement. Two GREENPEG partners already use this scheme and it is regarded as practical and straightforward to implement. It highlights the need for baseline data and monitoring, transparency, communication and consultation.

We have identified some 30 recent and current European-funded projects that relate to mining and its environmental and social impacts and/or to low environmental and social impact exploration methods. Social sustainability and SLO feature in many of these projects; the social aspects seem to have been a focus of far more European activity than the environmental impacts recently. We conclude that this is because the environmental impacts are better established and already incorporated into legislation, guidelines and reporting frameworks. Many of the outcomes of European projects do, however, echo the guidance of industry schemes such as e3 Plus and IRMA, and they add to the evidence base by showcasing best practice.

Few of these schemes use a life cycle assessment (LCA) approach that is now becoming the technique of choice to assess environmental impacts throughout manufacturing and product life cycles. In GREENPEG, LCA will be developed as the main method to compare and quantify the environmental impacts of the exploration techniques and to predict the likely environmental impacts of potential future mining and processing. LCA has been applied in the raw materials sector by various industry associations who have carried out LCA to produce average impacts for their commodities, including cobalt, copper and nickel. There has however been limited research and development for LCA approaches in the exploration phase of raw material projects and exploration is commonly considered to be outside the system boundary of mining or mineral LCAs. Exceptions include the LCA studies of exploration in aggregate mining in Vietnam and the development phase of rare earth projects, for which guideline documents have been developed by the Rare Earth Industry Association (REIA). Although LCA has most commonly been employed to quantify environmental impacts, the approach can be used to encompass all three pillars of sustainability: environmental, economic, and social. When these approaches are brought together in a single study this is referred to as a Life Cycle Sustainability Assessment.

Abbreviations

BLI: Blackstairs Lithium Ltd.

ECM: European Lithium / ECM Lithium AT GMBH

GKZ: Geokompetenzzentrum Freiberg EV

NGU: Norges Geologiske Undersokelse

TERRA: terratec Geophysical Services GMBH & CO KG

UCD: University College Dublin

UNEXE: University of Exeter

UPORTO: Universidad do Porto

UPV: Universidad del Pais Vasco / Euskal Herriko Unibertsitatea

Contents

1. Introduction	7
2. Key concepts	8
2.1 Broad context	8
2.2 Environmental and social impact assessment	8
2.3 Social licence to operate and corporate social responsibility	8
2.4 Safety	9
3. Overview of mining-related legislation and ESIA requirements in the EU	10
4. GREENPEG	12
4.1 Project overview	12
4.2 Life Cycle Assessment	14
5. Demonstration sites (first phase of field sites)	15
5.1 Ireland	15
5.1.1 Permitting in Ireland	15
5.1.2 GREENPEG demonstration field site in Leinster, Ireland	18
5.2 Austria	20
5.2.1 Permitting in Austria	20
5.2.2 GREENPEG demonstration field site in Wolfsberg, Austria	21
5.3 Norway	21
5.3.1 Permitting in Norway	22
5.3.2 GREENPEG demonstration field site in Tysfjord, Norway	24
6. Application sites (second phase of field sites)	26
6.1 Portugal	26
6.1.1 Permitting in Portugal	26
6.1.2 GREENPEG application sites in Portugal	26
6.2 Spain	28
6.2.1 Permitting in Spain	28
6.2.2 GREENPEG application sites in Spain	28
7. Safety and GREENPEG	29
8. Overview of international best practice guidance	30
8.1 Financial sector-led guidance: The World Bank and the Equator Principles	33
8.2 Industry-led management and reporting: International Council on Mining and Metals and the Global Reporting Initiative	34
8.3 Industry-led guidance	34
8.3.1 e3 Plus: A framework for responsible exploration	34
8.3.2 Initiative for Responsible Mining Assurance (IRMA)	36
8.4 GREENPEG partner protocols and best practice experience	37
9. Key points of environmental, social and safety best practice from other EU projects	38
9.1 Social Licence to Operate	38
9.2 Communication, community engagement and collaboration	41
9.3 Non-invasive exploration	42
10. Summary and conclusion	44
11. References	45
12. Acknowledgments	48
Appendix 1: Data collection methodology	49
Appendix 2: Table of EU legislation	49
Appendix 3: Table of guidelines, standards, management and reporting schemes	51
Appendix 4: Table of EU projects	53
Appendix 5: Life cycle assessment	57

1. Introduction

This report is intended to help share best practice within the consortium and to familiarise project partners with the context of GREENPEG field localities early in the project. Changing and growing knowledge about field sites will be communicated within the GREENPEG consortium throughout the duration of the project, and will be reflected in deliverable D6.4 which addresses environmental and social impacts of mineral exploration. This report also provides an overview of international and EU best practice, and a review of protocols for permitting and environmental and social impact assessments to be applied at each of the three GREENPEG demonstration sites. Although the main body of the report was written and submitted in October 2020 the sections on permitting processes in Ireland, Austria and Norway were updated in January 2022 to reflect changes to government departments in Ireland and laws in Austria and Norway since the initial report submission.

The GREENPEG project will develop and test a set of high-level exploration technologies and algorithms to be integrated and up-scaled into flexible, ready-to-use toolsets for the identification of buried pegmatite ores. Validation of the new approach will be carried out in industry-led trials at locations in Austria, Ireland and Norway, while application studies will also be done in Portugal and Spain. As well as the technical development and assessment of these technologies and algorithms, a key goal of GREENPEG is to minimise the environmental, social and safety impact of these developments across their life cycle.



Figure 1: Scope of D6.1 report

2. Key concepts

2.1 Broad context

The extractive industries sector is fundamental to the global economy, and as a contributor to a circular economy. Humans rely on minerals to sustain their existence, not only to maintain living standards but also to foster social wealth and wellbeing, for example, by facilitating new and advanced technologies in life sciences, machinery and digitisation. However, mining has had, and still has, impacts upon the environment and society. As such it is imperative to foster, but also to regulate, the exploration for and mining of raw materials. Nevertheless, only in recent years has a discourse about global resource policy been developed. Responsible exploration and mining concerns the principles and ethics of sustainable development applied to exploration for, and exploitation and use of economic mineral resources (Ali et al. 2017, Arvanitidis et al. 2017, Goodland 2012, Hund et al. 2020, IIED and WBCSD 2002) and concerns over responsible mining may be a key risk for future minerals and metal availability for industry (Jowitt et al. 2020).

Responsible exploration and mining is about environment impacts, local communities with interests in the mine area and broad social and public interests, technological innovation and resource governance. Geoethical aspects include transparency in communication and social responsibility to protect the interests of all: stakeholders, citizens, human health and the environment.

There is no unified international law governing exploration and mining projects, they are subject to national and regional level legislation. However, there are multiple voluntary international codes and standards developed within the industry or imposed by investors and thus self-regulated (Siegel, 2013). Due to the multiplicity of these schemes, holistic approaches to governance and guidance are required to avoid misaligned strategies having negative unintended consequences (Bilham, in prep).

2.2 Environmental and Social Impact Assessment

An Environmental and Social Impact Assessment (ESIA) is “the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of proposed development proposals prior to major decisions being taken and commitments made” according to the International Association for Impact Assessment (2009). Ultimately an ESIA aims to protect the environmental and social aspects of an area and to ensure that a proposed exploration and mining project avoids, reduces, or mitigates adverse impacts and maximises benefits. ESIA developed from expansion of the concept of Environmental Impact Assessments (EIA). While assessment of environmental impact is well established across many spheres, social impact assessments are a newer concept and procedures for this are at an earlier stage of development and application (Tiess et al 2019).

2.3 Social licence to operate and corporate social responsibility

Social sustainability is important for exploration and mining companies and has become increasingly recognised as such over the last 15 years. Included within social sustainability are all aspects of a project that involve respectful and ethical treatment of people either working for the company, in the local community or wider afield, such as well-being, equity, fairness and trustworthiness, as well as minimising negative impacts on people and maximising positive impacts. Both social licence to operate (SLO) and corporate social responsibility (CSR) fall under the banner of social sustainability (Tuulentie et al. 2019) and describe measures that often go beyond the legal requirements for exploration and extraction permitting, and later mine operation and rehabilitation.

SLO is used to describe the informal, and often intangible and impermanent community approval or acceptance for an exploration or mining project, such that local and wider communities perceive the company, project, and industry as a whole, as trustworthy and legitimate (Parsons and Moffat, 2014). There are no standard methods to achieve SLO, and although some lessons can be carried between projects in many cases SLO is very much a project-specific issue. To some extent, SLO is beyond the control of companies and operators, with policy and governance also playing important roles. SLO largely evolved from broader concepts of corporate social responsibility and social acceptability. Within the policy and governance spheres of several EU member states and mining regions the term SLO is not well known or used and there the process, apart from the permitting, is more commonly known as 'social acceptance'. In contrast, SLO is a term well known in the exploration and mining industry. Surveys of the mining industry in the last year have highlighted social licence to operate as a top business risk (Ernst & Young, 2019, KPMG, 2020).

2.4 Safety

Safety in the context of exploration and mining covers health and safety at work practices, public health issues and safe transport of raw materials and processing chemicals. These latter two aspects overlap with environmental and social impact assessments. The numbers of worker accidents at mine sites has significantly improved in recent decades in many countries, with yearly fatality rates falling internationally (Elgstrand et al, 2017), associated with technological developments, organisational solutions and behaviour changes (Löow and Nygren, 2019). However, risks and health hazards remain a high priority for the mining and exploration industries.

3. Overview of mining-related legislation and ESIA requirements in the EU

Most exploration projects and mines around the world are required to produce an environmental impact assessment (EIA), and some an environmental and social impact assessment (ESIA), before exploration or mine development goes ahead. This is usually stipulated by the country's legislation.

Disclosure of environmental studies, permitting and social or community impact is required by the international reserves and resources reporting codes, representing risks to a project and thus one of the modifying factors that affects project value. The Committee for Mineral Reserves International Reporting Standards (CRIRSCO) oversees these reporting codes and the Canadian NI 43-101 and Australian JORC (Australasian Joint Ore Reserves Committee) disclosure schemes are perhaps the best known. Although these schemes are neither guidelines nor legal requirements and their focus is generally on minimum standards for technical reporting, best practice guidance does feed into their design. The form for the technical report required for NI 43-101, for example, is informed by the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) definition standards for mineral resources and mineral reserves and the Canadian Securities Administrators have a companion policy (43-101CP) which is likewise informed by CIM best practice guidance (Waldie et al. 2018). The qualified person completing the technical reporting form, though not required to follow CIM guidelines, would be expected to use their experience and respect industry best practice as a 'professional' in their choice of methods, assumptions, verification and interpretation of data included in their report (Waldie et al. 2018).

Companies seeking loans are likely to also come under the Equator Principles and International Finance Corporation (IFC) code (see section 8.1), sets of guidelines driven by financial institutions.

In all countries where GREENPEG will be working there are formal requirements for environmental protection relevant to exploration and mining projects, although these vary between different legislatures. The relevant requirements are outlined in the following sections.

Social acceptance is less consistently defined at the national level. Tiess et al (2019), in a review of permitting requirements across the EU found that the social acceptance of a company and project is considered within the regional mining policy framework through public consultation in Portugal and Spain, and in Ireland the local planning process takes into account social acceptance of companies and projects through community participation and an appeals process. In Austria the mining strategy considers social acceptance but there are no formal requirements or guidelines for companies to follow.

EU legislation is similar to, and compares well with, mining-relevant legislation in Australia and US, both of which have long histories of mining (Keith-Roach et al., 2016). EU legislation particularly covers environment and safety (Figure 2, Appendix 2).

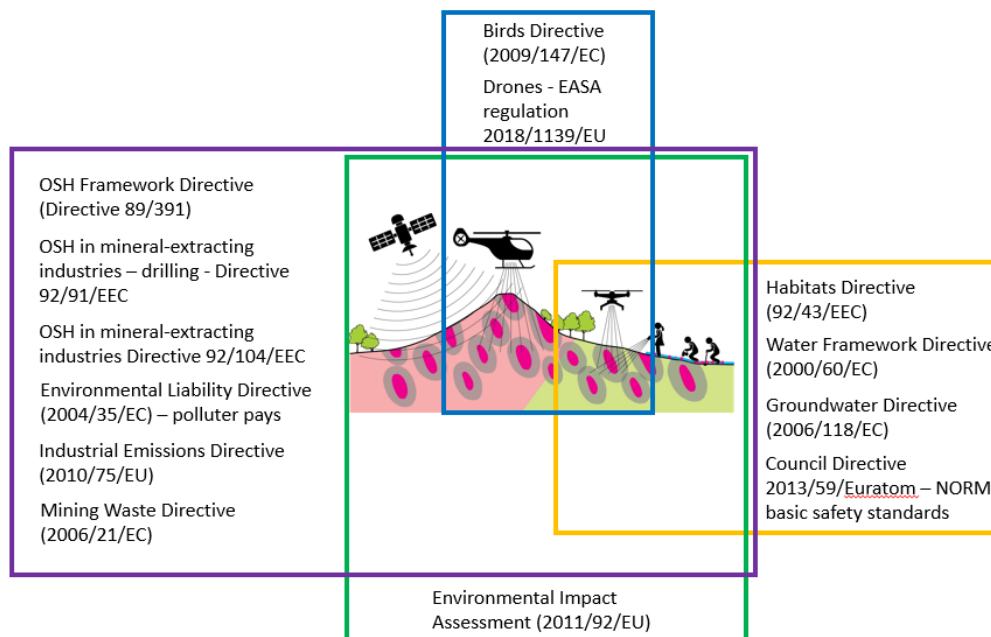


Figure 2: EU legislation applicable to GREENPEG exploration technique fieldwork and data collection activities. Adapted from Keith-Roach et al. (2016), from the EURARE project <http://eurare.org/regulation.html>

Each of the EU member states (in GREENPEG these are Ireland, Austria, Portugal and Spain) follows the European legislation, as well as national regulations applicable in their own jurisdiction, and regionally or provincial level requirements also apply in some states. Although Norway is not a member of the EU it is a member of the European Free Trade Association (EFTA) and the European Economic Area (EEA), and environmental legislation is significantly influenced by the EU (Hojem, 2015). These regulations apply to the different GREENPEG field sites outlined in section 5.

4. GREENPEG

4.1 Project overview

The GREENPEG project will use ‘demonstration field sites’ in Norway (Tysfjord), Ireland (Leinster) and Austria (Wolfsberg) to develop and test exploration tools for pegmatites (Figure 3).

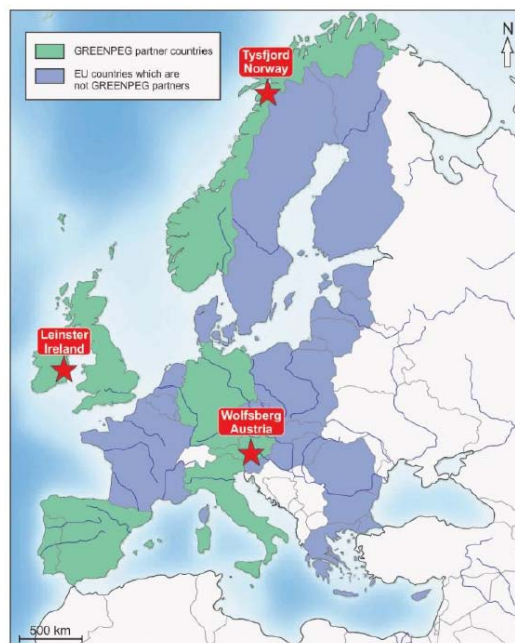


Figure 3: Location of GREENPEG demonstration sites and partner countries (from GREENPEG deliverable D1.1)

Once exploration tools have been developed, they will then be applied to ‘application sites’ in Portugal and Spain. Actions related to field activities at the demonstration and application sites are found in work packages focussing on methodology testing, as well as WP5 that involves final testing and validation. In addition, field visits are planned for the whole consortium to each of the demonstration sites. The following field activities are planned (Figure 4):

WP2 Province scale (<10,000 km²) methodology testing:

- field spectroradiometric campaigns across the demonstration sites using a hand spectroradiometer to complement remote sensing data

WP3 District scale (<500 km²) methodology testing

- airborne ultra-high-resolution gamma ray radiometry, magnetometry, electromagnetics and spectrometry with flight-line distance of 30 to 50 m, adapted to the small size of pegmatite in the three demonstration sites. A nose stinger for the magnetometer will be developed, certificated and applied instead of a bird system.
- Development of low-cost, practicable exploration toolsets applying and combining the most successful remote sensing (WP2 and 3) and ground based (WP4) geophysical methods for the exploration of pegmatite ores.

WP4 Prospect scale (<25 km²) methodology testing

- drone-borne and ground-based geophysics (ground-based HR radiometry, magnetometry, resistivity/IP, low frequency GPR, piezoelectric spectrometry, and gravimetry)

- Utilization of existing exploration drill locations at the 3 demonstration sites for geophysical borehole logging. Logging methods include optical and acoustic scanning and spectral radiometric measurements.
- geological field mapping and lab analyses to understand prospect scale geochemical and mineralogical relationships in ore bodies, stream sediments and soil horizons (sampling in Norway, Austria, Ireland, Portugal and Spain).

WP5 Integration, final testing and validation of exploration methodologies

- Development and testing of a piezoelectric seismometer demo
- Final testing of best exploration method combinations in the three demonstrations sites.

In addition, the following work packages will involve field visits for the purposes of communication with stakeholders and observation and analysis of the exploration techniques:

WP6 Assessment and best practice in environment, social and safety aspects for GREENPEG inventions

- Assessment and best practice in environmental, social and safety impacts to predict and mitigate the environmental impacts of the delivered exploration toolsets and the mining stage that would follow.

WP7 Upscaling and business plan

- Assessment of the industrial feasibility to determine the attractiveness of GREENPEG inventions and guarantee the upscaling based on modular analysis of the pilots.

WP8 Communication/dissemination, clustering and exploitation

- Communication and dissemination of the GREENPEG results.
- Clustering with complementary projects
- Exploitation of the GREENPEG project results

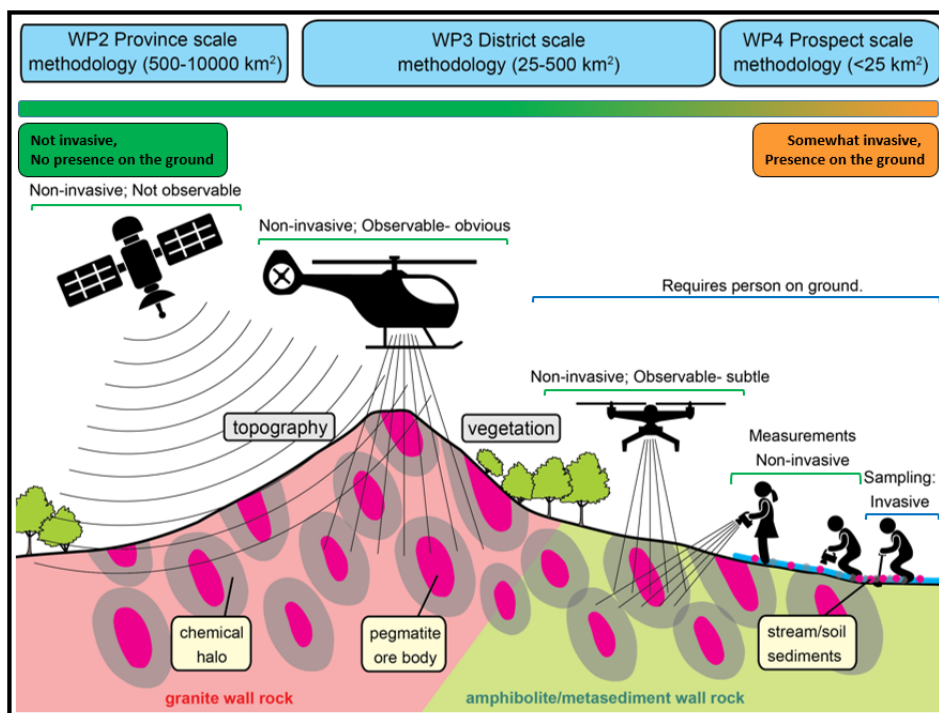


Figure 4: Exploration techniques in GREENPEG, adapted from an original diagram by Axel Muller

Detailed sampling protocols are outlined in GREENPEG deliverable D1.1.

4.2 Life Cycle Assessment

Within WP6 of the GREENPEG project, life cycle assessment (LCA) will be used by UNEXE as a method to compare and quantify the environmental impacts of these exploration techniques. The LCA approach is a holistic, systematic and rigorous approach which has been standardised under ISO 14040 and ISO 14044. It can be used to help identify opportunities to improve the environmental performance of a product or process at various points of its life cycle and to aid industry decision-makers in strategic planning, priority setting, product or process design (ISO, 2006).

The LCA approach is well developed to address the environmental impacts, including use of resources and environmental consequences of releases throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (ISO, 2006).

LCA has been applied in the raw materials sector with industry associations carrying out LCA to produce average impacts for the commodities which they represent (Cobalt Institute, 2016, European Copper Institute, 2018, Nickel Institute, 2018). There has been limited research and development for LCA approaches in the exploration phase of raw material projects, with notable exceptions a study exploring aggregate mining in Vietnam which included the exploration phase as part of the study (Schneider, 2018) and another focussing on applying LCA to rare earth projects in development (Pell, 2019). Exploration is commonly considered to be outside the system boundary of mining or mineral LCAs. However, guideline documents have been developed by the Rare Earth Industry Association (REIA) in collaboration with Minviro Ltd. to provide clear and consistent information on how to carry out an LCA for rare earth projects in the various stages of the project life cycle. These guidelines provide information on which aspects of a project can be included.

Although LCA has been most commonly employed to quantify environmental impacts life cycle approaches, with similar methodologies and aims, can encompass all three pillars of sustainability: environmental, economic, and social. When these approaches are brought together in a single study this is referred to as a Life Cycle Sustainability Assessment (Ekener et al, 2018). As well as quantifying environmental impacts GREENPEG's WP6 will assess the social and safety impacts of the exploration techniques, using life cycle assessment where appropriate.

More information about life cycle assessment approaches is provided in Appendix 5.

5. Demonstration sites (first phase of field sites)

This section outlines the legislation applicable to permitting in each of the GREENPEG ‘demonstration sites’ and summarises some of the environmental and social characteristics of each location (Table 1). Tiess et al (2019) from the MIREU project also provides a good overview of permitting processes across Europe.

Table 1: Summary of some key characteristics of each demonstration site

Pegmatite field demonstration site	Partner in charge	Size of field	Mining history	Climate	Vegetation	Topography	Main concern
South Leinster Ireland	BLI (site explorer)	60 km ²	Exploration greenfield	Temperate	Grassland, fields and forest	Hilly	Water
Wolfsberg Austria	ECM (site owner)	25 km ²	Exploration brownfield: test mining for Li in 2018	Alpine temperate	Forest	Mountainous	Groundwater / water supply concerns
Tysfjord Norway	NGU (site explorer)	20 km ²	Exploration brownfield: HPS: from 1996; Fs: 1906 - 1970	Arctic	Open forest and fields	Mountainous	None known

5.1 Ireland

5.1.1 Permitting in Ireland

The EU-funded MIN-GUIDE project identified the Irish exploration licensing system as a good practice example, because administrative procedures are organised as a one-stop shop and exploration- data are made publicly available, both of which enhance transparency of information and process.

At the start of 2021 governmental geoscience services and functions within the Irish Department of the Environment, Climate and Communications (DECC) were reconfigured, and the Exploration and Mining Division that was previously responsible for both policy and regulation was reorganised into the Geoscience Regulation Office and the Geoscience Policy Division.

The Geoscience Regulation Office (GSRO) is now responsible for overseeing regulation, licensing, compliance and enforcement for exploration, production and decommissioning in the petroleum, mineral and mining sectors, which therefore includes mineral prospecting licences. More information is available about mineral exploration in Ireland is available here:

- <https://www.gov.ie/en/publication/d16da-guidelines-for-mineral-exploration/>
- <https://www.gov.ie/en/publication/b45fe-prospecting-licences-common-questions-and-concerns/>

The Geoscience Policy Division (GSPD)’s focus is on geoscience policies and regulatory frameworks for the minerals, petroleum and geothermal sectors. Also under the umbrella of the Department of Environment, Climate and Communications is Geological Survey Ireland, who also have useful resources on mineral exploration in Ireland on their website:

- <https://www.gsi.ie/en-ie/programmes-and-projects/minerals/activities/mineral-exploration/Pages/FAQs.aspx>

- <https://www.gsi.ie/en-ie/programmes-and-projects/minerals/activities/mineral-exploration/Pages/default.aspx>

The primary pieces of legislation governing mineral extraction in Ireland are the Mineral Development Acts (1940 to 2006). Statutory Instrument 384 of 2018 implements specifics of the Minerals Development Act (1940) as regulations. The GSRO has detailed online guidance for exploration and mining permitting and reporting. Guidelines for exploration are found here:

<https://www.gov.ie/en/publication/d16da-guidelines-for-mineral-exploration>

These practical guidelines refer to commencement and supervision of work, drilling, excavations, water services, pumping and other groundwater tests and airborne geophysical surveys. Many of the points raised relate to environmental, social and safety best practice for working in agricultural areas and for remediation of any impacts following vehicle and drill rig impacts. For safe excavation best practice, companies are directed to the Irish Health and Safety Authority.

Although a full ESIA is not required in Ireland for early stage exploration, an Environmental Screening is done for drilling (but not for mapping, soils or stream sediments) and this determines if an ESIA is required at that stage. This screening includes checks such as distance from wells. If the bar for ESIA requirement is not met then the screening is all that is required. The outcomes of Environmental Screening determinations and decisions are posted online here:

<https://www.gov.ie/en/publication/7d726-environmental-screening-determinations-and-decisions/>

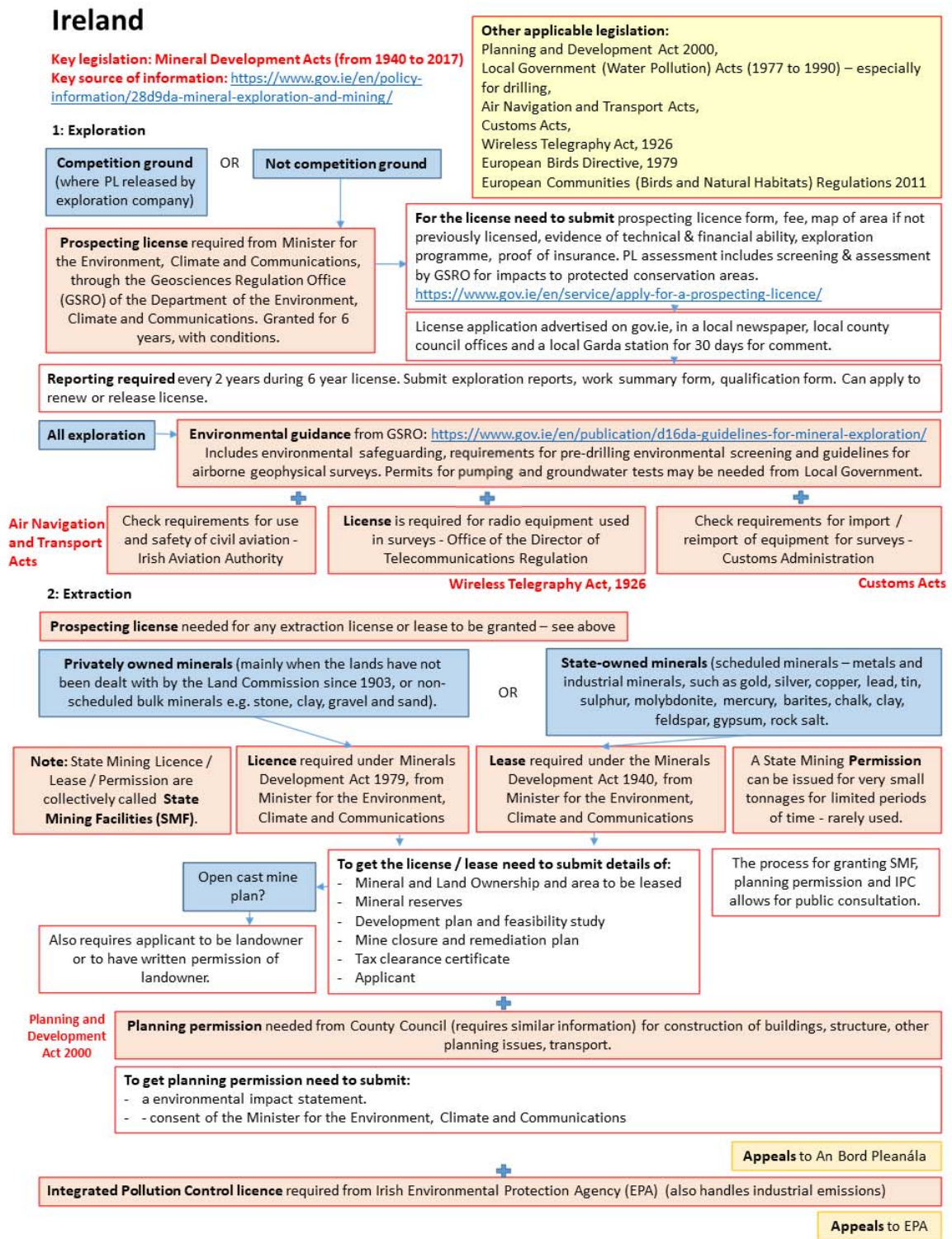


Figure 5: Overview of the permitting process for exploration and mining in Ireland.

Exploration reporting requirements can be found here:

<https://assets.gov.ie/76644/29940b95-ccaa-42b4-bfc5-5e5be0092c14.pdf>. Details of all exploration techniques, particularly novel ones, must be included in the report:

“A detailed account of each of the techniques used. For standard exploration techniques a brief description of the methodology used is adequate, but where a new technique or a novel approach was used, an explanation of that technique or approach should be included.”

There is no requirement mentioned for environmental, social or safety guidelines or impact assessments at the prospecting licence application, early exploration or exploration reporting stages. However, the GSRO is the Competent Authority to screen for and assess impact to conservation areas in line with the European Habitats and Birds Directives (reflected in Irish Law as The European Communities (Birds and Natural Habitats) Regulations 2011 (as amended)), and this is required to be carried out during the prospecting licence application process. An Environmental Screening is required for drilling (but not for mapping, or study of soils or stream sediments) and this determines if an ESIA is required. If the bar for ESIA requirement is not met then the screening is all that is required. The outcomes of Environmental Screening determinations and decisions are posted online here: <https://www.gov.ie/en/publication/7d726-environmental-screening-determinations-and-decisions/>

Exploration geophysics requirements are given particular mention in the requirements for reporting. For ground geophysical surveys:

“Cables must not be left unattended in areas where livestock are present. If necessary, arrangements should be made with the landowner to remove livestock at a mutually convenient time for the duration of the work.”

For airborne geophysics surveys see:

<https://assets.gov.ie/76749/a8bbf495-4fb1-4acb-887c-092c24841855.pdf> for detailed guidelines about requirements from GSRO, and also how to find details about the Air Navigation and Transport Acts, other civil aviation safety legislation and about obtaining a licence under the Wireless Telegraphy Act, 1926, as amended, for radio systems for use in such surveys, and importation or re-importation of radio systems and survey equipment in compliance with the Customs Acts.

In 2017 the Department of Communications, Climate Action and Environment (now called the Department of the Environment, Climate and Communications) commissioned environmental consultants to produce expert guidance on environmental best practice for exploration methodologies and mining in Ireland, particularly in relation to Annex I habitats and Annex II species listed in the EU Birds and Habitats Directives (<https://www.gov.ie/en/publication/6e80f-environmental-effects-of-certain-exploration-methodologies/>). These guidance documents are available online and particular advice is provided for:

- mapping and prospecting (Lewis et al. 2017)
- geochemical surveying (Gordon et al. 2017a)
- geophysics (Gordon et al. 2017b)
- drilling (Gordon et al. 2017c)
- trenching (Gordon et al. 2017d)

5.1.2 GREENPEG demonstration field site in Leinster, Ireland

The Leinster LCT Pegmatite Belt is located in the counties of Carlow and Wicklow, orientated NNE-SSW along a c. 60 km transect through rural farmland. The GREENPEG prospect-scale demonstration area consists of a ~4.5 km² section, about 4.5 km long and just over 1 km wide, centred on Moylisha Hill.

Exploration licences are held by Blackstairs Lithium Ltd. Eight exploration licences were originally granted to TNR Gold Corp in August 2009 for the Leinster Pegmatite Belt, covering 292 km². Initially the project was called Blackstairs and then it was renamed Avalonia. Preliminary exploration was carried out at many of the 19 lithium pegmatite occurrences in the 1970s by Irish Base Metals.

The region is characterised by lowlands and gentle hills, dominated by agriculture and forestry. Commercial forestry is run by the Irish national forestry company, Coillte. Pegmatites are unexposed, being known only from boulder accumulations, which drilling has proved to be very close to bedrock. Both soils and streams are available for sampling.

In County Carlow groundwater is an important water source – 12.7% of the population source their water from private groundwater wells, 11.6% of publicly supplied groundwater also comes from groundwater and 75.7% of publicly supplied drinking water comes from surface water (Kavanagh et al. 2017). In some rural areas most properties will rely on private wells for their water supply. There is no requirement to monitor lithium in drinking water in Ireland, and thus there is no expected safety standard. Despite this, Kavanagh et al (2017) carried out water quality analyses in County Carlow to act as a baseline study prior to extraction of waters, exploration and mining. These analyses were carried out at the same lab that is used by the local community for well water testing, well beyond any legislative requirements for water quality monitoring.

Some concerns have been raised among local communities about potential future mining in this area (Newstalk, 2016). In part, this reflects poor mining practices in the past in the region. The Blackstairs Lithium project is operating within sight of properties and close to farms.

Interviews in summer 2020 about community relationships across the whole of the Blackstairs Lithium prospecting licence areas in Ireland highlighted how community engagement is important for the exploration project, and a local geologist employed by Blackstairs Lithium helps with this, but communication can be challenging due to multiple separate communities along the 50 km long exploration project belt, and negative information from some campaign groups. Personal discussions with households in the local communities, landowners and residents near to drill sites, especially in areas the company will be working in for a while, are important and allow concerns to be heard by the company and suitable compromises discussed. For example, concerns about potential impacts to horses were eased by agreeing to conduct soil sampling and mapping two fields away rather than immediately adjacent to the horses.

Since these interviews further concerns have been raised in local communities around Moylisha Hill where Blackstairs Lithium carried out drilling in 2013, 2018 and 2021 and where GREENPEG has begun testing exploration techniques. An application to renew the prospecting licences has increased community interest, and most of the concerns raised are focussed on worries about impacts to environment and health should there be a mine in the area in the future, rather than about the impacts of exploration. This most recent situation will be discussed in D6.4, covering the social impacts of mineral exploration, along with lessons from fieldwork in Ireland and the other demonstration field sites carried out from summer 2021 onwards. The GREENPEG consortium will be kept up-to date about the community context as required throughout the project to support project partners' fieldwork preparations and GREENPEG community relations.

5.2 Austria

5.2.1 Permitting in Austria

The Austrian Mineral Law is based on the Mineral Raw Materials Act (MinroG) from 1999, with an amendment in 2016. The law includes exploration and extraction of minerals free for mining, state-owned minerals and landowner's minerals. The responsible authority is Montanbehörde (Mining Authority) and the responsible ministry is Bundesministerium für Landwirtschaft, Regionen und Tourismus (Federal Ministry for Agriculture, Regions and Tourism, <https://www.bmlrt.gv.at/english/>). The same ministry is also responsible for forestry and water usage permissions. Environmental protection is covered by another authority: Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology, <https://www.bmk.gv.at/en.html>).

Figure 6 has a summary of permitting requirements.

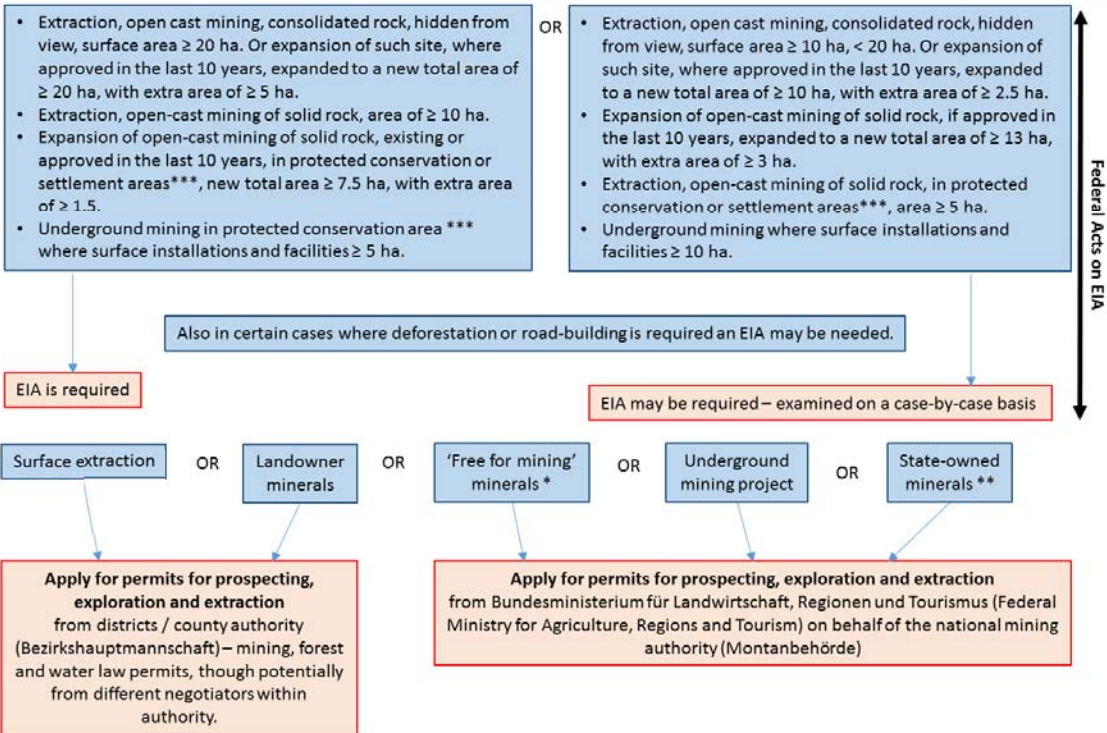
Austria

Key legislation:

Mining Law (MinroG Act No. 38/1999, as last amended by BGBl I 95/2016)
Mineral Raw Materials Act (BGBl. I Nr. 80/2015)

- Other applicable legislation:**
- Commercial Code 1994 (BGBl. Nr. 194),
 - Federal Acts on Environmental Impact Assessment (UVP-G 2000) - Federal Law Gazette No. 697/1993, Federal Law Gazette I No. 77/2012
 - Water Management (215/1959)
 - Construction Coordination (BauKG 37/20099),
 - Acts on Nature Protection and Acts on Land Use Planning (each Federal State has its own)
 - Work Inspection Act 1993 (ArbIG),
 - Forest Law (Forstgesetz 1975)

Prospecting, exploration and extraction



- Extraction agreement needed with landowner: a land transfer declaration or lease agreement is required.**
- For extraction: provincial authority consulted: land use planning, protection of nature/environment, tourism, other aspects. May also consult transport, environment, water and other authorities.**
- Extraction licence required. Conditions likely to be set to ensure protection of property, neighbours, safety, environment.**

* Includes all minerals from which iron, manganese, chromium, molybdenum, tungsten, vanadium, titanium, zirconium, cobalt, nickel, copper, silver, gold, platinum and the platinum group metals, zinc, mercury, lead, bismuth, antimony, arsenic, sulfur, aluminum, beryllium, lithium, rare earth minerals or compounds of these elements can be extracted, as far not listed as federal or landowner’s minerals. Also gypsum, anhydrite, barite, fluorspar, graphite, talc, kaolin, and leukophyllite, all kinds of coal and oil shales, magnesite, limestone (with a CaCO₃ content of at least 95%), and diabase (basaltic rock), as long as they are solid rock, as well as quartz sands (with an SiO₂ content of at least 80%) and clays in unconsolidated form.

** Halite and other coexisting salts, hydrocarbons and minerals containing uranium and thorium.

*** Protected Area Categories A and E:

- A: conservation areas, areas protected by the birds or habitat directives, national parks, areas of community importance, forest reservations, UNESCO world heritage sites.
- E: settlement areas, including land for residential construction and for construction of areas for community facilities.

Figure 6: Overview of the permitting process for exploration and mining in Austria.

5.2.2 GREENPEG demonstration field site in Wolfsberg, Austria.

The Wolfsberg Project is located in Carinthia in Austria. It is an underground mine in development since 2019, located in an alpine area with commercial forestry, within the biggest occurrence of Li-

pegmatites in the Eastern Alps. As of 2019 European Lithium holds exploration permits from the Mining Authority in Leoben (the Austrian mining authority has regional sections - Montanbehörde Süd) for 54 exploration fields, mining permits for 11 mining fields, as well as from 2016 -2020 for several underground and surface exploration and drilling programs. Applications will be made to the Mining Authority in Leoben for final mining extractive work and any further exploration work.

Baseline environmental monitoring has been carried out at the site. To minimise environmental impact during the drilling campaigns angled drillholes were used and some planned drillholes were skipped, reducing the need to cut down trees or build new roads. To avoid any pollution equipment was placed upon sheeting to ensure that if any hydrocarbon leaks occurred, they could be contained. A groundwater monitoring programme assesses the water levels and water quality in drillholes.

An environmental and social impact assessment will be carried out for the State of Carinthia. Legal guidance prior to the 2018 pre-feasibility study indicated that no EIA is required for the Wolfsberg mine, but formal screening will be carried out to confirm this and the mine operating plan, to be submitted to the Mining Authority, will cover environmental issues as well as production information, mining techniques and safety. An EIA will be required for licencing and development of the hydrometallurgical plant (presently farmland), to be presented to the regional environmental authority of Carinthia. It is planned that mining and processing waste will be used as a fill in the mine and in construction, so no permanent tailings dam will be required, although a temporary waste stockpile will be required.

The local mayor and Carinthian government have been introduced to the Wolfsberg project and were supportive (European Lithium, 2018). Local stakeholders include farmers and rangers. Older generations are also supportive due to historical coal mining in the area. However, mining has a poor image across Europe, and this also influences perception of mining in Austria.

Prior to the release of the pre-feasibility study in 2018 a conflicts assessment was carried out (European Lithium, 2018). This identified community concern over increased road traffic through Frantschach St Gertraud. To mitigate this only the spodumene concentrate en route to the hydrometallurgical plant in Wolfsberg will travel through the town, all other products will be transported in another direction.

All workplace and safety regulations under the Austrian Mining and Industrial Standards are and must be strictly followed at the Wolfsberg demonstration site. European Lithium have zero harm, zero lost time incidents and zero medical treatment incidents to date.

GREENPEG work at the Wolfsberg site will involve prospect-scale exploration technique development covering a 12.4 km² area of actual exploration works near Weinebene, as well as district scale (362km²) and province scale (3530km²) research. The areas cover most of the tectonic unit (Koralpe-Wölz nappe system) in which the majority of the Austrian pegmatites are located. Pegmatites are exposed in outcrop and exposures in mining operations and there are soils and stream sediments available for sampling.

5.3 Norway

5.3.1 Permitting in Norway

Figure 7 outlines the relevant legislation, permits and permissions required for exploration and mining in Norway.

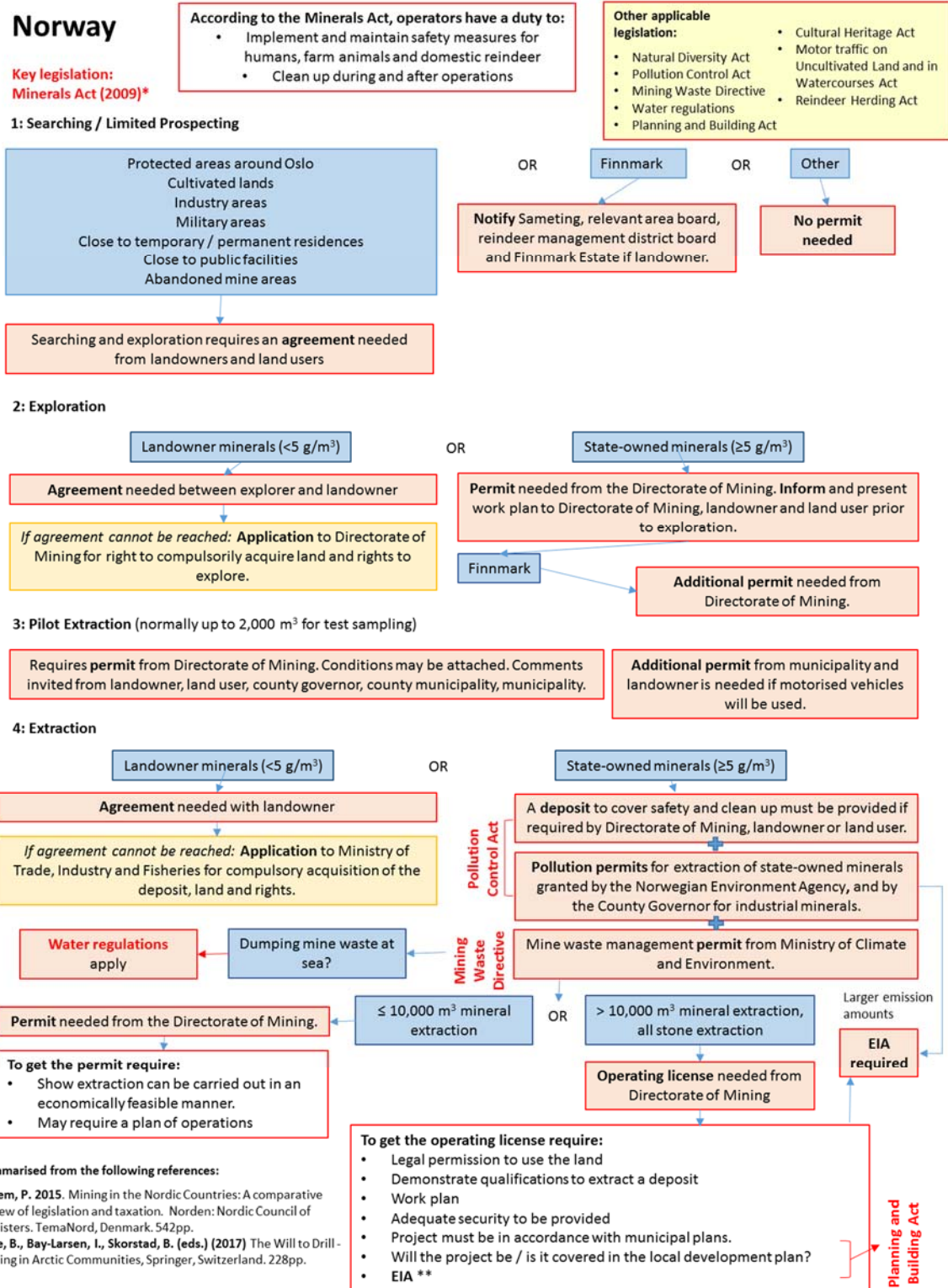


Figure 7: Overview of the permitting process for exploration and mining in Norway.

The Minerals Act (2009) is designed to “promote and ensure socially responsible administration and use of mineral resources in accordance with the principle of sustainable development’. It applies to

exploration and exploitation of landowner- and state- owned minerals but does not include Svalbard or Finnmark.

“[w]ithin the framework of section 1, the administration and use of mineral resources pursuant to this Act shall ensure that the following interests are safeguarded: a) value creation and industrial and commercial development; b) the foundation of Sami culture, commercial activity and social life; c) the surroundings and nearby areas while operations are being carried out; d) the environmental consequences of extraction; and e) long-term planning relating to subsequent use or reclamation of the area.”

Norway was the first country to ratify ILO Convention number 169 (Indigenous and Tribal Peoples Convention, 1989) and the Norwegian authorities are obliged to support the rights of the Sámi peoples through this convention. The Sámi Act (1987) is intended to enable the Sámi people in Norway to safeguard and develop their language, culture and way of life. Consultation agreements exist between the Sámi Parliament and the Norwegian government (2005) and the Norwegian Water Resources and Energy Directorate (2009), and procedural requirements about consultation and right to object to plans impacting upon Sámi culture and commercial interests are written into the Public Administration Act (1970), Energy Act (1990), Planning and Building Act (2008) and the Reindeer Husbandry Act (2007). In June 2021 the Norwegian government adopted a bill on changes to the Sámi Act making the obligations and rights of consultation statutory (Tennberg et al. 2021).

5.3.2 GREENPEG demonstration field site in Tysfjord, Norway

The Tysfjord/Divtasvuodna field area is in Hamarøy in the north of the county of Nordland in Norway.

The Tysfjord-Hamarøy pegmatite field includes about 25 major NYT pegmatite bodies, hosted by the Tysfjord granite (Husdal et al. 2017, GREENPEG deliverable D1.1). Most of the pegmatite bodies are located around the village of Drag where the district-scale (25 x 22 km) and prospect-scale (4 x 2 km) demonstration sites for GREENPEG are located. Pegmatites in this area were first mined in 1906 in the Hundholmen pegmatite and in Drag in 1907, continuing in Tysfjord and Hamarøy until 1970. Porcelain-grade K-feldspar, quartz and fluorite were the main minerals of interest. Mining resumed for high-purity quartz in 1996 at Nedre Øyvollen and at Jennyhaugen for gravel production in 2006 (Husdal et al. 2017). More information about the pegmatites is available in Müller et al. (2017).

Mineral and mining rights for the Tysfjord site are owned by The Quartz Corporation. The Quartz Corporation specialises in high purity quartz mining and processing, with most mining activity taking place in the USA. They also hold mining permits for some mines in northern Norway, but mining is very limited in this area; the most recent blasting there took place two years ago and the low utilisation of the deposit makes it under materiality levels in many respects. Mining is carried out underground so has additional associated safety requirements. The Quartz Corporation uses outside advisors for all technical mining aspects of the business (geological models, mine planning and mining). The majority of the activity of The Quartz Corporation in Norway happens at their processing plant for high purity quartz located in Drag.

The Hamarøy area, north of the Arctic Circle, is dominated by steep mountains and the GREENPEG site is alongside the deep fjord of Tysfjorden / Divtasvuodna. Bare rock with little till cover is found on higher slopes of the area, whereas the lower valley slopes have thick till cover and woodlands of pine, birch and aspen. There are several nature reserves in the region, mainly protected coastal woodland ecosystems. Although there is soil cover on the demonstration sites, the pegmatites are well exposed. No streams are present for sampling.

There are two main towns in the area where the extractive industries are particularly important; Drag / Ájluokta, where The Quartz Corporation run a pure quartz processing plant, is on the western shore of Tysfjord and Kjøpsvik/ Gásluokta, where Norcem run a cement factory using local limestone, is on the eastern shore. The local population is multi-cultural, Sámi and Norwegian, and is officially bilingual. Many people in the community consider the extractive industries to have been important to the local economy and heritage for the last 100 years and mining has been key to livelihoods for many families, including the Sámi population (Murguia et al, 2018). This is particularly the case for the cement factory. There has been no need for the extractive industries to claim land from residents in recent decades, and this helps with community satisfaction. Murguia et al (2018) reported that there was no expectation among the Sámi community for companies to provide additional funding to support livelihoods, culture or business.

The state and state regulations for best practice in mining and the extractive industry are well respected in Norwegian society, since state guidelines are generally considered to be to a higher standard than international ones (Murguia et al., 2018).

The Quartz Cooperation aims to be exemplary in responsibly mining. Over the last 1.5 years, in the USA, The Quartz Cooperation has increased investment in rehabilitation at mine sites and also focussed on community relationships and innovate approaches to community relations and social programmes. Every year all employees are given a day to carry out voluntary work in the community, such as building gardens in retirement homes or developing playgrounds in schools.

NGU (Norges Geologiske Undersøkelse) will be the GREENPEG partner carrying out the main exploration activities in Tysfjord. NGU will carry out airborne and ground based geophysical measurements at the Tysford test site, at prospect scale, as well as airborne measurements at district scale. For the airborne survey no special permits are required since there are no protected areas such as national parks and flying at low altitude is permitted. However, NGU will inform the local authorities in advance by email and also send a press release to local newspapers, the radio and TV. Ground-based geophysics measurements will be carried out in close cooperation with The Quartz Corporation.

The routine NGU follows for fieldwork is developed and adjusted to the varying conditions; flexibility and a willingness to compromise are necessary and mostly works well. Fieldwork both on the ground and in the air relies on a close and good dialogue with the local community, with the authorities but especially with the local people.

NGU reported no undue concerns for environmental, social or safety issues in relation to fieldwork at the Tysfjord site. There are good relationships with the local community and they will be working at mine sites. Although explosives will be used for the piezo-electric instrument that will be developed by NGU they have very strict safety routines and the environmental impact will be minimal since the amount of explosives per charge will be small and explosives will not be detonated in hard rock.

6. Application sites (second phase of field sites)

This section outlines the national legislation applicable to permitting in each of GREENPEG ‘application sites’, where the new exploration method will be developed and tested, and summarises some of the environmental and social characteristics of each location.

6.1 Portugal

6.1.1 Permitting in Portugal

The EU-funded MIN-GUIDE project identified the Portuguese regulations as a good example of integrating policy on land use planning and mining, allowing the use of different natural resources (minerals, forestry, agriculture etc) to be balanced in the official planning.

The General Legal Framework for the Discovery and Use of Geological Resources (Law No 54/2015) covers exploration and exploitation of mineral resources in Portugal. In addition, the mineral deposits regulation (Minerals Law: Decree Law No 88/90) also applies. Regulations on the environment, public procurement, health and safety, labour, tax, planning and expropriation of lands also apply to mining. The Direção-Geral de Energia e Geologia (DGEG - Directorate General for Energy and Geology) within the Ministry of Environment and Energy Transition is the main relevant authority, designing, promoting and evaluating policies related to geological resources, in relation to sustainable development and security of supply.

All mineral deposits and occurrences are owned by the Portuguese state. The land in villages in Portugal is often governed by the community, in a form of hybrid public-private ownership. Local owners can vote on decisions about what happens to the land. Where ownership is entirely private the owner owns the surface and the state owns the subsoil beneath 30 cm.

Licences or concession contracts with the state are required for preliminary evaluation, exploration, experimental exploitation and exploitation rights. As part of this permitting process regional and national bodies, such as municipalities, local planning bodies, and authorities responsible for environmental protection, culture, agriculture and regional development are consulted.

An amendment to the Law No 54/2015 (Law No 10/2022) mentions that in all cases of attribution of exploration rights and of mining concessions, the applicant needs to promote, in each municipality and parish covered, at least one public clarification session, directed essentially to the population of the territories covered by the claim. This public clarification session must be announced at least 20 days in advance in two newspapers, one with national circulation and the other with regional circulation, and on websites of the municipality and DGEG. Although this amendment to the law is not intended to apply to research projects, GREENPEG researchers in Portugal have considered the guidance on timeframes for communication and will now contact communities earlier than before about intended fieldwork, at least a fortnight prior to the arrival of researchers in the field.

6.1.2 GREENPEG application sites in Portugal

Application sites in Portugal that are planned to be used to validate GREENPEG exploration techniques are owned by Felmica. Felmica hold 26 licences for pegmatite mines in the north, centre, and interior of Portugal.

Important environmental priorities for Felmica include the control and monitoring of dust, environmental noise and water resources, on the surface and underground. Land use pressures in

areas of tourism, particularly where there are golf courses or housing, has increased community concern about lorry traffic noise and dust, and Felmica addresses this with regular, frequent meetings with the residents' association, spraying roads to control dust and changing lorry routes. Dust is further controlled by water irrigation systems in the summer. To avoid contamination of ground water the company ensures that the base of operational extraction does not reach the water table. Felmica implements environmental restoration plans for all operations sites.

To further best environmental practice Felmica has developed an environmental policy that is related to the development of a sustainable mining charter aligned with the UN Sustainable Development Goals. Waste from customers is used in products; although more expensive for the company this is an environmentally sustainable action. The company aims to reduce energy use and transition to renewable energy sources. Felmica plans to employ a member of staff to particularly address environmental issues. As a commitment to green mining Felmica plans to use land owned by the company for community projects.

As elsewhere in Europe, public perception of mining in Portugal is negatively impacted by historical poor mining practices by other companies, and modern mining practices are not well known, nor are the links between minerals and modern quality of life or the differences between exploration and exploitation (for example, see Balch, 2019). Limited community engagement by other companies has also negatively impacted public perception for the industry as a whole in Portugal as well as for research projects, particularly related to lithium. Environmental pressure groups have used extensive media campaigns to reach wide community audiences in Portugal, often making use of international examples of pollution and large-scale mining. Some communities are not open to discussion about exploration, and access to privately owned land for research or exploration purposes can be difficult or impossible.

Safety concerns and practices at Felmica sites include providing PPE for all on site, accident monitoring, training, separation of moving plant and equipment from people, automatic stop systems on moving parts, use of video cameras, lights and alarms in factories, safety fencing and signage for public awareness and training for staff. Awareness training includes an annual 'Safety Week' involving employees in activities and games.

UPORTO and UPV will be carrying out fieldwork at sites run by Felmica in north Portugal as part of the GREENPEG project.

The field research teams are taking a proactive approach to community engagement in areas where lithium exploration could be interesting, and where communities are receptive to discussion and to the possibility of lithium exploration. Early, transparent dialogue is very important. Communities in this area have populations of 3000 – 5000. Initial contact is with municipality mayors and those who own or manage communal land. In 2020 these meetings had already begun in preparation for fieldwork 1 to 2 years into the future. Meetings cover the background and expertise of the research team, the planned work and that eventually both open pit or underground mines could be possible, and then discussions of the pros and cons of both scenarios. Lots of opportunities are provided for discussion and questions. It is also important that the research teams explain that pegmatite exploration and lithium mines do not result in acid mine drainage (because there are no sulphides) because some campaigners have inferred that this is a major risk for lithium extraction.

The UPORTO team aims to have exploration as non-intrusive as possible before the drilling stage of any project. Non-intervention exploration includes the application of remote sensing via satellites or drones but avoiding using planes and helicopters due to potential community concerns.

Measurements of some soil characteristics can also be done in the field using portable instruments (portable XRF and portable LIBS can be trained on stored samples at the Geological Survey of Portugal prior to measuring parameters in the field).

UPV will carry out some soil and stream sampling in the field, alongside the work of UPORTO at open mine sites.

6.2 Spain

6.2.1 Permitting in Spain

The Spanish Mining Law 22/1973 covers different types of resources and the authorisations and permits required for mining in Spain. In addition, Royal Decree 975/2009 covers the management of extractive industries waste and the protection and rehabilitation of the sites affected by mining activities and Law 21/2013 focusses on environmental assessment. The main national authority is the Ministry of Energy, Tourism and Digital Agenda, led by the Directorate General on Energy Policy and Mines. In addition to these national-scale regulations regions can develop more local requirements for management of environmental protection, the promotion of regional economic development and more local mining development. Health and safety regulations directly related to mining are covered by Royal Decree 863/1985 on the General Regulation on Basic Rules of Mining Safety.

Mineral resources belong to the State. Exploration and exploitation permits are required, and requirements vary depending on the nature of the resource of interest, the person applying and the characteristics of the site. In some cases, for example where the proposed extraction area will be over 25 ha or extend below the water table, an environmental impact assessment will be required, similar to other EU states.

6.2.2 GREENPEG application field sites in Spain

UPV will work in the following areas in Spain during the GREENPEG project to carry out fieldwork and validate exploration techniques:

- Galicia Region (mainly in the Pontevedra province),
- Castilla and León Region (Salamanca and Zamora provinces).
- Extremadura Region (Cáceres and Badajoz provinces).

UPV will write to landowners to ask for permission to carry out fieldwork and to sample soils and stream sediments. Most of the sites are in old, closed open-pit mines, rather than on privately owned land, and the fieldwork is discrete with very limited environmental impact. Where sites are located in national parks, then permission needs to be sought from the local government. In such communications it is important to emphasize the purpose of the work and that all impact will be kept to a minimum. Permission to use drones for surveying can be difficult to obtain in Spain and is required if drones will be used.

In recent years objections have been raised by local communities in Spain and local and international interest groups about Infinity Lithium's plans to develop a lithium mine at the San José-Valdeflórez project in Extremadura around 3 km from the centre of the town of Cáceres in Spain. Concerns focus on impacts to the environment, water and tourist industry (Macintosh, 2018; Rhoades, 2020). GREENPEG project work, which is focussed on validation of exploration tools, is unrelated to the development of the San José-Valdeflórez project.

7 Safety and GREENPEG

Safety procedures and practices are governed by well-established legislation in all the GREENPEG study areas. For GREENPEG the following safety considerations are most relevant:

- Environmental and weather conditions
- Working at closed or operational mine sites
- Remote operations
- Trips, slips and falls
- Manual handling
- Safe equipment use
- Effective communications and safety check-ins for research teams
- Drill site safety
- Radiation safety
- Helicopter safety
- COVID-19

Risk assessments will be carried out prior to all field activities.

8 Overview of international best practice guidelines

Beyond the national and international legislation that companies must adhere to, there are multiple schemes, led mainly by industry, the World Bank and the United Nations, to support environmental, social and safety best practice (Figure 8, Appendix 3). These overlap with corporate social responsibility schemes (CSR) and the driver may come from investors, or be linked to social licence to operate, although adherence to such schemes is increasingly becoming the industry norm.

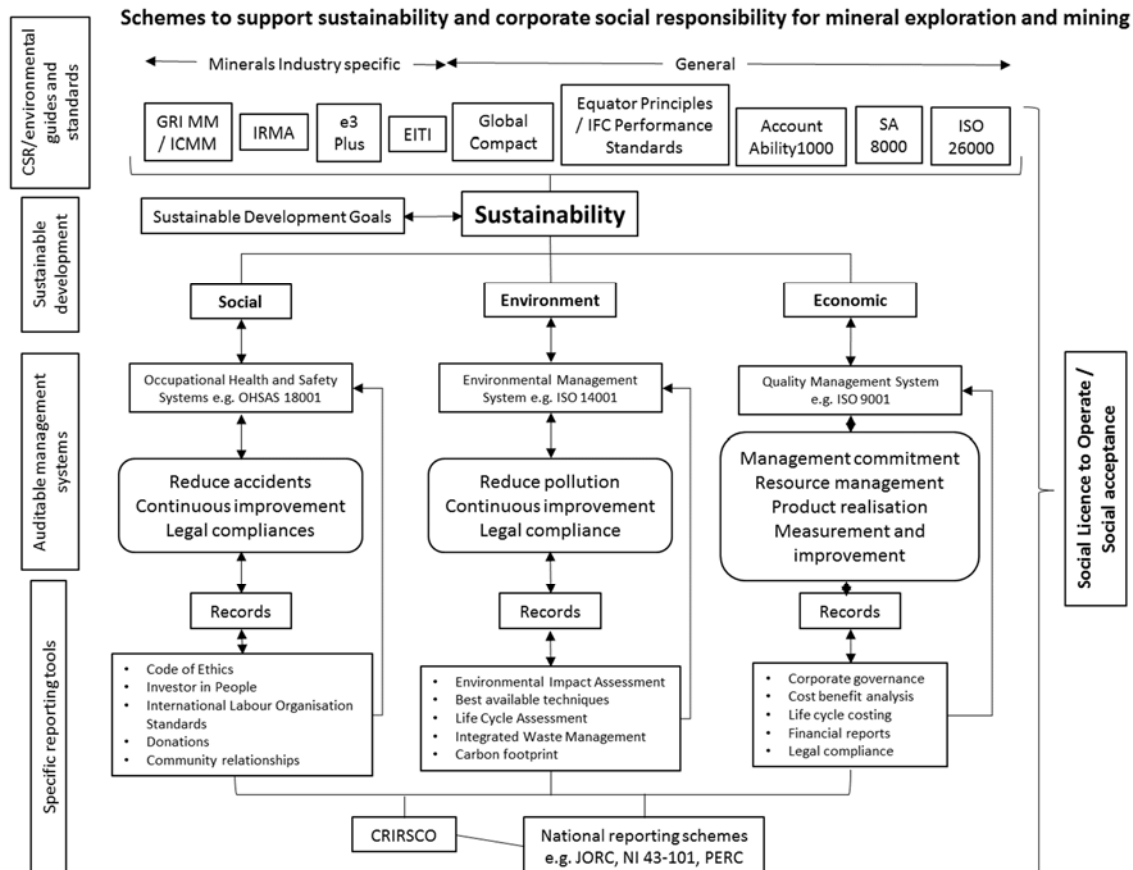


Figure 8: Schemes to support sustainability and corporate social responsibility in mineral exploration and mining. Adapted from Oliver Heidrich (pers. Comm.).

Here we describe the most relevant schemes for exploration activities within the GREENPEG project (Table 2). For a thorough review of exploration and mining related legislation and guidance see McNamara (2009).

Table 2: Comparison of most relevant guidance frameworks and schemes for GREENPEG

		e3 Plus (2014)	Equator Principles (2020)	IFC Performance Standards (2012)	IRMA (2019)
Business integrity	Governance	1. Adopt responsible governance and management.	7. Independent Review 9. Covenants		
	Legal compliance	7. Protect the Environment: - Planning Needs	3. Applicable Environmental and Social Standards		1.1. Legal Compliance
	Ethics	2. Apply ethical business practices	6. Grievance mechanism		1.4. Complaints and Grievance Mechanism and Access to Remedy
	Finance	4. Commit to project due diligence and risk assessment	1. Review and categorization		1.5. Revenue and Payments Transparency
	Independent assessment		7. Independent Review 9. Independent monitoring and reporting		Self-assessment is encouraged as a first step and IRMA auditors can verify.
	Information accessibility		10. Reporting and transparency		
Social	Social impact assessment and management		2. Environmental and Social Assessment 3. Applicable Environmental and Social Standards 4. Environmental and Social Management System and Equator Principles Action Plan	1: Assessment and Management of Environmental and Social Risks and Impacts 5: Land Acquisition and Involuntary Resettlement	2.1. Environmental and Social Impact Assessment and Management 2.4. Resettlement
	Community engagement	5. Engage host communities and other affected and interested parties	5. Stakeholder Engagement	5: Land Acquisition and Involuntary Resettlement 7: Indigenous Peoples	1.2. Community and Stakeholder Engagement 2.2. Free, Prior and Informed Consent (FPIC) – indigenous peoples 2.4. Resettlement
	Development	6. Contribute to community development and social wellbeing			2.3. Obtaining Community Support and Delivering Benefits 3.6. Artisanal and Small-Scale Mining
	Human Rights	3. Respect human rights	2. Environmental and Social Assessment (inc. climate change impact and human rights impact)	2: Labor and Working Conditions	1.3. Human Rights Due Diligence 3.1. Fair Labor and Terms of Work 3.4. Mining and Conflict-Affected or High-Risk Areas 3.5. Security Arrangements
	Health and Safety	8. Safeguarding the health and safety of workers and the local population - General Safety Principles - Emergency Response - Personal Safety - Field Equipment Safety - Safe Traversing Practices - Knowing Your Location - Survival - Weather and Environmental Risks	3. Applicable Environmental and Social Standards	4: Community Health, Safety, and Security	2.5. Emergency Preparedness and Response 3.2. Occupational Health and Safety 3.3. Community Health and Safety



		<ul style="list-style-type: none"> - Wildlife - Surveying - Travel Safety and Security - Vehicles - All-Terrain Vehicles - Snowmobiles - Aircraft - Boats, Canoes and Inflatables - Field Project and Camp Set-up - Project/Camp Communications - Drilling Sites - Advanced Exploration and Road Building - Abandoned Surface 			
	Heritage			8: Cultural Heritage	3.7. Cultural Heritage
Environment	Environmental impact assessment, management and protection	7. Protect the environment: <ul style="list-style-type: none"> - Good Practice Guidelines - Archaeological and Cultural Sites - Land Disturbance - Site Management - Air Management - Fish and Wildlife Management - Water Use and Conservation - Waste Management - Guidelines for Uranium Exploration 	2. Environmental and Social Assessment (inc. climate change impact and human rights impact) 3. Applicable Environmental and Social Standards 4. Environmental and Social Management System and Equator Principles Action Plan	1: Assessment and Management of Environmental and Social Risks and Impacts 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	2.1. Environmental and Social Impact Assessment and Management 4.1. Waste and Materials Management 4.2. Water Management 4.3. Air Quality 4.4. Noise and Vibration 4.5. Greenhouse Gas Emissions 4.6. Biodiversity, Ecosystem Services and Protected Areas
	Pollution	7. Protect the environment: Hazardous Material Spill Management		3: Resource Efficiency and Pollution Prevention	4.7. Cyanide 4.8. Mercury Management
Legacy	Mine closure	7. Protect the environment: Reclamation and Closure		2.6 Planning and Financing Reclamation and Closure	

8.1 Financial sector led guidance: The World Bank and the Equator Principles

The ‘World Bank’ is a combination of the International Bank for Reconstruction and Development, and the International Development Association. The ‘World Bank Group’ also includes the International Finance Corporation (IFC) and the Multilateral Investment Guarantee Agency. In 2003 the International Finance Association released guidelines called the Equator Principles, for use in the financial services industry, based on environmental and social screening using the IFC’s earlier (1998) globally recognised performance standards, for project financial advice or project finance, where project capital costs are 10 million USD or more, or for loans with a capital cost of 50 million USD or more. Participating financial institutions agree not to lend money to projects unless a category A and B projects (Table 3) have carried out detailed environmental assessment has been carried out by the borrower, minimum standards of due diligence followed and a plan laid out for how the project will meet sustainable development criteria and social goals. The minimum loan size means that the Equator Principles only apply to larger projects. However, since banks will require a company to have met these standards through the life of a project, smaller projects are wise to aim to meet these same goals.

Table 3: Equator Principles project categorisation and requirements for environmental impact assessments.

Category	Description	Requirements
A	Project is likely to have significance adverse environmental impacts that are sensitive, diverse or unprecedented. A sensitive impact is irreversible or affects vulnerable groups or ethnic minorities, involve involuntary displacement or resettlement, or affect significant cultural heritage sites.	An environmental assessment is required, issues to be addressed are specified. An environmental management plan is required covering mitigation, action plans, monitoring and management of risks. May also include a decommissioning plan and independent environmental expert verification.
B	Potential adverse environmental impacts on human populations or environmentally important areas (e.g. wetlands, forests, grasslands and other natural habitats) are less adverse than those of Category A projects. Impacts are site-specific, mostly are reversible and most often mitigation can be designed more easily than for Category A projects.	An environmental assessment is required, issues to be addressed are specified. Where appropriate, an environmental management plan is required covering mitigation, action plans, monitoring and management of risks. May also include a decommissioning plan and independent environmental expert verification.
C	Projects likely have no or very limited environmental impacts.	Screening only is required.

In addition to these guidelines, there are several national schemes of reporting to inform investors about exploration and mining projects and to ensure companies meet set standards (Table 4).

Table 4: National/European reporting schemes most relevant to GREENPEG

Abbreviation	Scheme	Publisher/Organisation	Applicable country	Year	Comments	Available reports
JORC	Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves	Joint Ore Reserves Committee of the Australasian Institute of Mining & Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia	Australasia	2012	The latest edition (JORC, 2012) and came into full effect in December 2013. Compliance is required for companies listing on the Australian and New Zealand stock exchanges.	
CIM (NI 43-101)	Canadian Institute of Mining Metallurgy and Petroleum (CIM) Definition Standards for Mineral Resources and	Canadian Institute of Mining Metallurgy and Petroleum (CIM)	Canada	2014	The Mineral Resource, Mineral Reserve, and Mining Study definitions are incorporated into NI 43-101 (National instrument for the Standards of Disclosure for Mineral Projects) Applies to companies that own or explore mineral properties	See System for Electronic Document Analysis and Retrieval (SEDAR).

	Mineral Reserves				in Canada, and companies trading on stock exchanges overseen by the Canadian Securities Administrators (e.g. Toronto Stock Exchange and TSX Venture Exchange).	
PERC	Pan-European Reserves and Resources Reporting Committee	The Pan-European Reserves and Resources Reporting Committee	Europe and UK	2008		
SME	Guide for Reporting Exploration Results, Mineral Resources, and Mineral Reserves	The Resources and Reserves Committee of the Society for Mining, Metallurgy, and Exploration, Inc (SME)	USA	2014		

These national-level reporting schemes are standardised by The Committee for Mineral Reserves International Reporting Standards (CRIRSCO) that consists of representatives from each of the national schemes. CRIRSCO has produced standard definitions and incorporated these into an International Reporting Template (most recently in 2013), and these are then reflected in the national reporting schemes. Each of the schemes is therefore relatively similar in terms of content and requirements, while also taking into account national level legislation.

8.2 Industry-led management and reporting: International Council on Mining and Metals and the Global Reporting Initiative

The International Council on Mining and Metals (ICMM) is an industry group representing (at the time of writing, 2020) 27 mining and metals companies and 38 regional and commodity associations. It was formed in 2001 out of the Mining, Minerals and Sustainable Development project in response to criticism of the mining industry from NGOs and the public in the 1990s. The ICMM member companies self-regulate safety practices, environmental and social best practice and sustainable development performance using the Global Reporting Initiative guidelines. Independent, external assurance for this reporting is available.

The Global Reporting Initiative (GRI) is a recognised mechanism by which companies can produce sustainability reports, covering environmental, social and economic performance. It is organised by the Coalition for Environmentally Responsible Economics (CERES) which is an organisation of investors and other interest groups. The GRI framework allows voluntary, generally accepted, reporting from many different sectors around the world, including mining.

8.3 Industry-led guidance

8.3.1 e3 Plus: A Framework for Responsible Exploration

e3 Plus is a package of guidance on social, environmental, and health and safety performance for exploration companies, with a range of information accessible online. It was launched as a flagship CSR scheme in 2009 by the Prospectors and Developers Association of Canada (PDAC) and grew out of the earlier e3 environmental excellence guidance produced in 2003. “e3” refers to three excellence strategies: environmental stewardship, social responsibility and health and safety. e3 Plus consists of several components. Each component has clear, online materials and many have downloadable

booklets or documents, and is regularly edited and expanded to stay up to date. PDAC is reviewing the possibility of developing a reporting and certification system based on this guidance.

Principles and Guidance Notes highlight important priorities for the exploration industry (<https://www.pdac.ca/priorities/responsible-exploration/e3-plus/principles>):

1. Adopt responsible governance and management.
2. Apply ethical business practices
3. Respect human rights
4. Commit to project due diligence and risk assessment
5. Engage host communities and other affected and interested parties
6. Contribute to community development and social wellbeing
7. Protect the environment
8. Safeguarding the health and safety of workers and the local population

Responsible Exploration Toolkits (<https://www.pdac.ca/priorities/responsible-exploration/e3-plus/toolkits>) give practical advice:

- Environmental Stewardship) <https://www.pdac.ca/priorities/responsible-exploration/e3-plus/toolkits/environmental-stewardship/e-toolkit-good-practice-guidelines>)
- Health and Safety (<https://www.pdac.ca/priorities/responsible-exploration/e3-plus/toolkits/health-and-safety>)
- Social Responsibility (<https://www.pdac.ca/priorities/responsible-exploration/e3-plus/toolkits/social-responsibility>)

Community Engagement Guide (<https://www.pdac.ca/priorities/responsible-exploration/e3-plus/community-engagement-guide/introduction>):

- Lots of advice on how to approach community engagement at all stages of projects
- Includes best practice guidance:
 - o Say what you do and do what you say.
 - o Listen
 - o Show that you have listened
 - o Engagement must be ongoing
 - o Manage expectations about involvement
 - o You can also influence the quality of company-community relationships in three more ways:
 - Take, and be seen to take, responsibility for project impacts, be they environmental, social, health-related, and so on.
 - Distribute benefits (jobs, contracts, community projects) transparently so your efforts are perceived as fair.
 - Demonstrate respect for local stakeholders and their concerns.

Unlike other guidance and standards, e3 Plus is particularly aimed at the exploration industry rather than the mining industry, potentially making it more applicable to the GREENPEG project. In addition, several strands of the guidance focus on social factors, as well as environmental issues: wellbeing and community engagement.

8.3.2 Initiative for Responsible Mining Assurance (IRMA)

IRMA, unlike e3 Plus, has been designed for operating mines, but has many mentions of exploration. However, during the exploration phase of projects it is worth operating to these same standards, so that projects are set up well to be following a best practice path. The main standard says:

“At present, assessment of compliance is expected to occur after a mine becomes operational. While the current Standard focuses on certifying operating mines it is possible that future versions will include additional nodes applying to specific phases (e.g., exploration, construction) so that companies might be assessed during these early stages and be certified as a prospective “IRMA Ready” mine project (having met requirements related to social engagement and environmental protection for those particular stages of development).”

As well as offering a set of responsible mining standards IRMA, third party audits of individual mine sites can be carried out leading to different levels of certification which encourages companies to work towards increasingly levels of responsible mining practices (the IRMA 50, IRMA 75 and IRMA 100 Certified levels for further improved performance).

8.4 GREENPEG partner protocols and best practice experiences

Felmica is a member of the European Industrial Minerals Association (IMA-Europe) which allows it to share best practice with other companies in a non-competitive environment, as well as on the boards of the European Association of Feldspar Producers (EUROFEL) and the European Kaolin and Plastic Clays Association (KPC). As part of these roles Felmica is involved with the UN Commission initiative to legislate Product Environmental Footprint (PEF) and Organisation Environmental Footprint (OEF), required because at present there is no common international framework for tracking environmental footprint. Guidelines from The Mining Association of Canada 'Towards Sustainable Mining' and JORC are followed by Felmica. European Lithium also follows guidelines from the GRI, IFC, IRMA and JORC. Blackstairs Lithium did not identify any particular scheme that they follow for guidance, but they aim to follow the most stringent guidelines from all countries that they work in, rather than aiming just to meet the legal requirements in a particular project country. They note that the environmental regulations in Canada are well defined and exacting. Blackstairs Lithium's parent company, International Lithium Corp, reports using the NI 43-101 code.

All partners agree about the importance of good community engagement, discussing and working with local stakeholders, in addition to meeting legislative requirements for official permits and licences. Both TERRA and UPORTO follow guidance provided in the e3plus Framework for responsible exploration and advice provided at PDAC meetings. TERRA, UPORTO and Felmica all arrange meetings with local community leaders and community groups as part of community engagement and to listen to and discuss community concerns. NGU have informal, open discussions with local landowners and interested parties, and Blackstairs Lithium also make particular efforts to engage personally with local farmers and landowners directly affected by exploration activities and to listen to concerns to allow compromise solutions to be found that suit all parties as well as possible. TERRA note that when working at mine or exploration sites run by other companies, they learn from the local company about which stakeholders to engage with initially.

As well as developing good community relations, Blackstairs Lithium considers it important to establish long-term goals for positive community benefits during the exploration stage of projects because this helps to ensure mining companies will follow through with such commitments later on, even if the company carrying out mining is different from the one carrying out exploration work.

9 Key points of environmental, social and safety best practice from other EU projects

Many EU projects relate to exploration and mining; see Appendix 4 for a list of relevant projects and deliverable reports associated with environmental, social and safety best practice in exploration.

While environmental impact assessment practices are well established and have been widely incorporated into international guidance, reporting frameworks and legislation, social impact assessment is less so. The focus therefore of many recent EU projects has been social sustainability and SLO. In addition, several projects have been developing non-intrusive exploration techniques which can reduce both environmental and social impacts.

Many of these projects echo the guidance of industry schemes such as e3 Plus and IRMA, highlighting the need for baseline data and monitoring, transparency, communication and consultation. The research projects add to the guidance documents by showcasing best practice examples and by developing and analysing an evidence base from multiple projects and communities across Europe.

9.1 Social Licence to Operate

The Horizons 2020 coordinating and support action project, Mining and Metallurgy Regions of Europe 'MIREU' project has produced guidelines for European SLO (D4.3, Tost et al, 2020; Lesser et al, 2020), based upon international guidelines and investigation of case studies of what does and does not work for social license to operate with local communities and broader acceptance of mining. NGOs and citizen movements were invited to review and contribute to these SLO guidelines. These guidelines highlight that building trust and relationships with stakeholders is important for achieving and maintaining SLO (Figure 9).

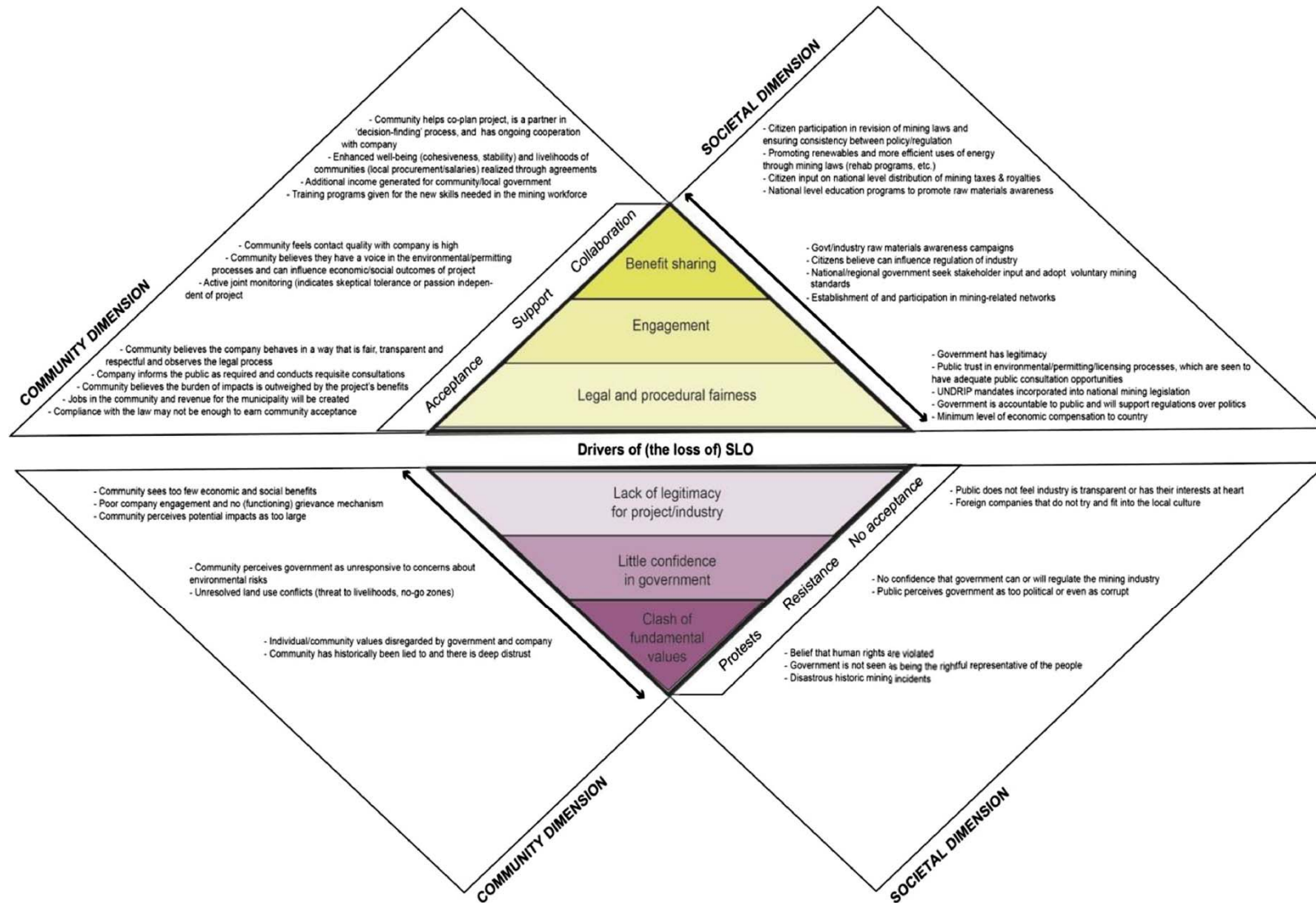


Figure 9: Social Licence to operate in Europe (Lesser et al. 2020)

MIREU also carried out a perception of mining survey. The most relevant findings of this survey for GREENPEG are:

- In Europe the public trusts legislation and governance more than industry-led voluntary schemes for good practice.
- It is important that companies become much more transparent and improve significantly when it comes to engagement and collaboration with communities.
- The outcomes of the SLO process and mining must guarantee security, fairness, justness, and a social purpose, values identified by MIREU as important to most Europeans.
- Community expectations must be clearly and transparently addressed.
- The resolution of problems with stakeholders must occur in a collaborative way

Some of these points are addressed in Figure 10, which highlights that SLO can be local or associated with a wider community. Critically, issues of importance locally may be different from those of value at a societal or wider level (Lesser et al. 2020).



Figure 10: Drivers of trust and acceptance (Lesser et al. 2020)

Although seeking to find Europe-wide commonalities in SLO, the MIREU project also identified regional differences in issues that concerned communities (Figure 11).

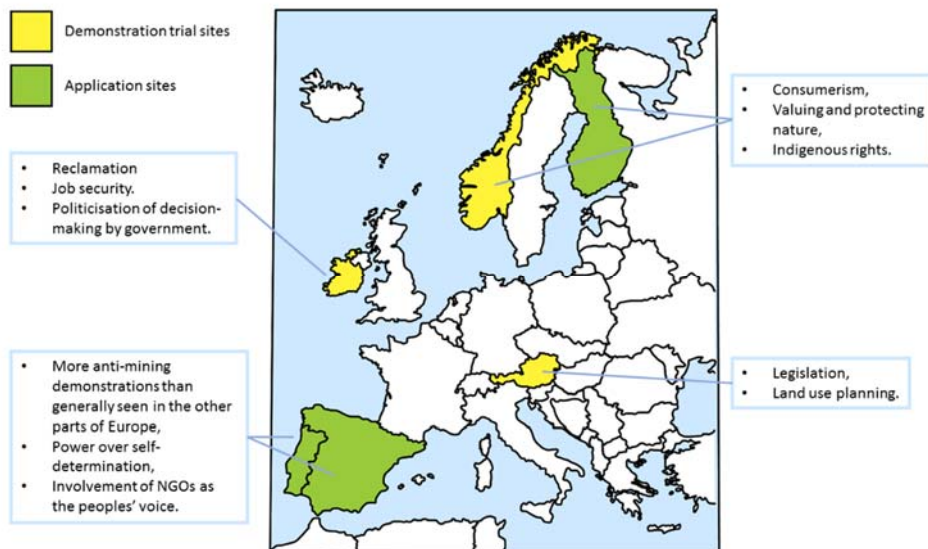


Figure 11: Key SLO debates in different areas of Europe, as identified by the MIREU project. The map highlights the GREENPEG demonstration and application sites.

This is also reflected in the experiences of different GREENPEG partners working in different counties across Europe, and it is important for project partners to be aware of issues of importance in each demonstration area.

9.2 Communication, community engagement and collaboration

The quality, quantity and approach to communications with communities are all important and multiple recent research projects have focused on communication strategies. Here we highlight the work of three projects that have tackled these topics; information about other projects is included in Appendix 4.

Table 5: Three example projects tackling communication, community engagement and collaboration

Project	Funding	Website	Environmental and Social
MINEFACTS	EIT RawMaterials	https://www.minefacts.eu/	Best practice example of public communication. See for example sections relevant to this report - permitting: https://www.minefacts.eu/the-permitting-process - benefitting from mining: https://www.minefacts.eu/who-benefits-from-the-mine - life of the mine and environment: https://www.minefacts.eu/life-of-mine-and-the-environment
SOCRATES	H2020	https://etn-socrates.eu/	WP6 – dissemination and exploitation. Deliverable on SLO: http://kuleuven.sim2.be/wp-content/uploads/2018/03/SOCRATES_METGROW_PolicyBrief_SLO_MARCH2018.pdf
SLIM	H2020	https://www.slim-project.eu/	WP3: Environmental impact and safety WP7: Economic and environmental assessment WP10: Public awareness, acceptance, trust and communication

‘MINEFACTS: Building the social license to operate by offering facts on exploration and mining’ is a project from EIT RawMaterials, the main output of which was a website, <https://www.minefacts.eu/> featuring very clear information about how exploration and mining related activities work, particularly using Sweden as a case study. These explanations include topics that are often covered in limited detail on company websites such as how permitting works, and the potential environmental and health impacts of mines. This clear communication aids transparency about exploration and mining.

The 'SOCRATES' project has developed what they call 'lessons', points that are not well generally understood that are useful when is conversations about raw materials with communities and stakeholders. These 'lessons largely address the need for mining in Europe and could be useful reference for GREENPEG project partners to refer to in dissemination and communication activities (SOCRATES, 2018).

Many of these are also reflected in the learning outcomes of the HiTech AlkCarb project FutureLearn Technology Metals for a Green Future course (<https://www.futurelearn.com/courses/technology-metals-for-a-green-future>) which was developed as an outreach tool for a project on carbonatites and alkaline rocks (HiTech AlkCarb) but has a broader remit of educating about the mining value chain and responsible mining.

The SLIM project has produced social communication recommendations (Berraondo et al. 2018a and 2018b):

- Identify and map the stakeholders of the company
- Define a communication strategy, with appropriated channels and periodical plans
- Work on communication messages
- Use new technologies and social media
- Integrate communications to enhance sustainability efforts at internal and external level
- Stakeholder engagement
- Respond to stakeholders demands and meet their expectations
- Invest in social actions
- Seek shared value via partnerships
- Support local employment and local procurement
- Connect the company to the local communities
- Integrate the UN Guiding Principles on Business and Human Rights
- Report on CSR/sustainability issues
- Materiality analysis
- Measure the impact of the strategies implemented

A key aspect of several of these projects, along with more recent industry guidelines, is the need to engage with and work with communities, and not just inform them of project goals and intentions. Few regulations require this engagement, although some do allow for community consultation in permitting processes.

9.3 Non-invasive exploration

Considering potential environmental impacts and public concern at exploration projects there are clearly advantages to exploration techniques which can provide valuable data on the geology and characteristics of field sites while also reducing impact through being non-invasive. The projects identified in Table 6 are developing such techniques, and where possible GREENPEG will also be considering this aspect of exploration technique development.

Table 6: Projects developing non-invasive or less invasive exploration techniques.

Project	Funding	Website	Technical	Environmental and Social
IMPACTMIN	FP7	https://impactmin.geonardo.com/	UAV use: https://impactmin.geonardo.com/research_and_innovation.php	https://impactmin.geonardo.com/results_and_downloads.php
EO-MINERS	FP7	https://cordis.europa.eu/project/id/244242/reporting	Focus on earth observation	Assessed policy requirements at the macro (public) and micro (mining companies) levels. Defined environmental, socio-economic, societal and sustainable development criteria and indicators using earth observation.
LIGHTS	H2020 ERAMIN-2 network	http://lights.univ-lorraine.fr/	Detecting Lithium (Li) Mineralizations from Space: Current Research and Future Perspectives: https://www.researchgate.net/publication/339756580_Detecting_Lithium_Li_Mineralizations_from_Space_Current_Research_and_Future_Perspectives Constraints and potentials of remote sensing data/techniques applied to lithium (Li)-pegmatites: https://pubs.geoscienceworld.org/canmin/article-abstract/57/5/723/573882/Constraints-and-potentials-of-remote-sensing-data?redirectedFrom=fulltext	
PACIFIC	H2020	https://www.pacific-h2020.eu/	WP1-WP4: technical work packages on passive seismic surveys. See more here https://www.pacific-h2020.eu/about/objectivesandresults/	WP5: Environmental and safety risk assessment WP6: Social acceptance and perception of risk for mining activities.
NEXT	H2020	http://www.new-exploration.tech/	http://www.new-exploration.tech/docs/Press/NEXT_WP7_PR_20180704_DMT.pdf	http://www.new-exploration.tech/sustainability.html WP5

10. Summary and conclusion

Investigation of permitting requirements at the different GREENPEG field locations and consultation with consortium partners has demonstrated that the environmental and social issues of concern at each site vary based on local conditions and circumstances. This is to be expected, and reflects the findings of other recent studies, particularly those considering social licence to operate. In some cases, there is overlap between important issues at sites, such as water quality priorities at Leinster and Wolfsberg.

Following review of national and EU legislation in Europe, as this applies to GREENPEG, and international best practice guidelines, we conclude that especially for public consultation and community interaction, voluntary industry guidelines have higher standards than legislation.

Environmental best practice is well integrated into both legislation and best practice guidelines, following decades of research and industry experience. Recent research has therefore focussed on social impacts and acceptance more than environmental assessment. Of course, responsible environmental practices are integral to social best practice and ethical working. European funded projects with results particularly relevant to GREENPEG include MIREU, and projects focussed on non-invasive exploration techniques, such as IMPACTMIN and LIGHTS. In addition, new advances in using life cycle assessment at exploration stage to quantify environmental impacts, and even potentially social impacts, are gaining interest and will be developed further in GREENPEG to compare exploration techniques.

To ensure that the GREENPEG consortium is best prepared to ensure environmental, social and safety concerns we recommend awareness about relevant legislation, consulting with local project partners when working at field sites and communicating well in advance to stakeholders about the GREENPEG project and field work plans. We highlight a range of resources and guidelines that can be referred to for practical advice and note the approaches already being carried out at project sites and by project teams, so that consortium members can effectively share information.

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12 Acknowledgements

Thanks to the following organisations for contributions of information for this report and for feedback on earlier drafts: Blackstairs Lithium, European Lithium, Felmica, Geo Unterweissacher, GKZ Freiberg eV, Natural History Museum (University of Oslo), Norges Geologiske Undersøkelse, terratec Geophysical Services, University College Dublin, University of Exeter, University of Porto, University of the Basque Country.

Appendix 1: Data collection methodology

Data was collected from project partners and demonstration site owners through semi-structured interviews and the completion of short proforma documents requesting information on planned activities within GREENPEG, permitting, environmental and social issues and best practice experiences. Further information was obtained for this report from literature review.

Appendix 2: Table of EU legislation

(adapted from euRare 2014 internal guidance report
<http://eurare.org/docs/internalGuidanceReport.pdf>)

Legislation	Description	Relevance to GREENPEG
Directive 2000/60/EC (Water Framework Directive)	Establishing a framework for Community action in the field of water policy	Taking care to protect groundwater, water courses and water bodies from pollution.
Directive 2006/118/EC (Groundwater Directive)	On the protection of groundwater against pollution and deterioration	Important for any aqueous emissions and tailings management
Directive 92/43/EEC on (Habitats Directive)	On the Conservation of Natural Habitats and of Wild Fauna and Flora	Taking care to assess potential impact to flora and fauna at demonstration sites and ensure this is minimal. Taking care to avoid breeding seasons of animals. Protect vegetation from potential impacts.
Directive 2009/147/EC (Birds Directive)	On the Conservation of Wild Birds that codifies Directive 79/409/EEC.	For helicopters and drones: to assess and be aware of protection bird species in the surrounding area. Also important the ground-based fieldwork does not impact nesting birds.
Council Directive 2013/59/Euratom (BSS)	Basic Safety Standards (2013) – NORM - Basic Safety Standards (2013). Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom. Official Journal of the European Union vol 57, L13.	Handling and transport of radioactive samples.
Industrial Emissions Directive (2010/75/EU)	Industrial emissions directive (2010). Integrated pollution prevention and control. Official Journal of the European Union L 334/18. - regulates the integrated prevention and reduction of environmental pollution as a result of industrial activities. It also provides for rules to prevent and, if this is not possible, to reduce emissions to air, water and soil and to avoid waste in order to achieve a high level of protection for the environment Best available technique reference documents (BREFs) are used in the EU to promote good environmental practice, defined in the Industrial Emissions Directive (2010/75/EU): <ul style="list-style-type: none"> • Tailings and waste rock management • Non-ferrous metals industries 	Applies to any emissions from exploration activities or at active mine sites.
EC directive 2012/18/EU (Seveso III)	On the control of major-accident hazards involving dangerous substances (Seveso).	Applicable to fieldwork at active and disused mine sites. <i>“disused mines.... as</i>

	Amending and repealing Council Directive 96/82/EC	<i>well as operational tailings disposal facilities, including tailing ponds or dams, containing dangerous substances shall be included within the scope of this Directive”</i>
EC Directive 2006/21/EC of the European Parliament and Council (Mining Waste Directive)	On the management of waste from extractive industries. Amending Directive 2004/35/EC (Environmental Liability Directive)	Applies to waste resulting from the prospecting, extraction, treatment and storage of mineral resources and the working of quarries.
Directive 2011/92/EU (Environmental Impact Assessment Directive)	On the assessment of the effects of certain public and private projects on the environment	Applies to demonstration site owners and managers more than other partners “-pit mines and quarries with a surface area exceeding 25 hectares”
Directive of the European Parliament and of the Council 2004/35/EC (Environmental Liability Directive)	On environmental liability with regard to the prevention and remedying of environmental damage	Polluter pays principle, prevention and remediation of environmental damage
Council Directive 98/83/EC (Quality of Drinking Water Directive)	On the quality of water intended for human consumption	Indicator parameters are listed for selected substances
Council Directive 89/391/EEC (Health and Safety at Work Directive) and later amendments	On the introduction of measures to encourage improvements in the safety and health of workers at work	Applies to all workers in the project
Council directive 92/104/EEC	On the minimum requirements for improving the safety and health protection of workers in surface and underground mineral extracting industries	Focussed on mining
Council Directive 92/91/EEC	Concerning the minimum requirements for improving the safety and health protection of workers in the mineral- extracting industries through drilling	Applicable to any exploration and mining projects where drilling is used.
Directive 2002/49/EC (Environmental Noise Directive)	Relating to the assessment and management of environmental noise	Applicable to GREENPEG sites and exploration techniques where machinery is used.
Directive 2006/42/EC (Machinery Directive)	On machinery	Application at exploration and mine sites. Unlikely to be applicable to exploration techniques being developed.

Appendix 3: Table of guidelines, standards, management and reporting schemes

Name	Description and further information
CSR and environmental guides and standards	
Global reporting Initiative (mining and metals)	<p>Voluntary reporting standards, covering environmental, social and economic performance (positive and negative impacts). See 300 series of GRI reporting standards: https://www.globalreporting.org/standards/gri-standards-download-center/</p> <p>The GRI Sector Program is developing sector-specific guidance. While these are being developed the previous G4 Sector Disclosures can be used for guidance, including those for the Mining and Metals sector: https://www.globalreporting.org/Documents/ResourceArchives/GRI-G4-Mining-and-Metals-Sector-Disclosures.pdf</p> <p>Section 3.2: Category: Environmental: Includes environmental management, effluents and waste, emissions. Category: Social: occupational health and safety.</p> <p>Refers to International Finance Corporation (IFC) Environmental, Health and Safety Guidelines, April 2007. Section 1.1 relates to air emissions and ambient air quality.</p>
Initiative for Responsible Mining Assurance	<p>https://responsiblemining.net</p> <p>Certification and third-party verification. Multi-stakeholder advisory group.</p> <p>Chapter 4.1 Waste and materials management, Chapter 3.2 Occupational Health and Safety</p>
OECD Due Diligence Guidance for Meaningful Stakeholder Engagement in the Extractive Sector	<p>Guidelines for extractive industry (mining, oil, gas) practitioners, based on OECD Guidelines for Multinational Enterprises. Focus on stakeholder engagement, includes assessment framework and guidance specifically for aboriginal people and women. Multi-stakeholder advisory group and online public consultation.</p> <p>http://mneguidelines.oecd.org/stakeholder-engagement-extractive-industries.htm https://www.oecd.org/publications/oecd-due-diligence-guidance-for-meaningful-stakeholder-engagement-in-the-extractive-sector-9789264252462-en.htm</p> <p>Main recommendations</p> <ul style="list-style-type: none"> • Integrating stakeholder engagement into project planning and regular business operations through sharing of decision-making power with interested and affected parties; • Practising stakeholder engagement that is driven by stakeholders through ongoing consultation and follow-through; • Developing a stakeholder engagement strategy which prioritises engagement with most severely affected rather than most influential stakeholders.
Towards Sustainable Mining (TSM), The Mining Association of Canada	<p>https://mining.ca/towards-sustainable-mining/</p> <p>Mining Association of Canada's (MAC) responsible mining initiative. Members of MAC must participate in TSM, a scheme including environmental, community and safety guidelines. Assessments are carried out at facility level, with annual publicly accessible reporting and third-party validation.</p>
Responsible Mining Index Framework	<p>RMI Framework matches reporting criteria against various international schemes (GRI, IFC).</p> <p>https://www.responsibleminingfoundation.org/media/responsible-mining-index-framework-2020-published/</p>
The Extractive Industries Transparency Initiative (EITI)	<p>https://eiti.org/</p> <p>For open and accountable management of resources (oil, gas and mineral resources). Requires disclosure of information along the extractive industry value chain from the point of extraction, to how revenues make their way through the government, and how they benefit the public.</p>
UN Global Compact	<p>https://www.unglobalcompact.org/</p> <p>A voluntary initiative based on CEO commitment to implement sustainability goals, with principles covering human rights, labour, environment and anti-corruption.</p> <p>Applies to all industry sectors.</p>
Equator Principles	<p>The Equator Principles (EPs) is a risk management framework, adopted by financial institutions, for determining, assessing and managing environmental and social risk in projects and is primarily intended to provide a minimum standard for due diligence and monitoring to support responsible risk decision-making. Applies to all industry sectors.</p> <p>https://equator-principles.com/wp-content/uploads/2020/05/The-Equator-Principles-July-2020-v2.pdf</p>
IFC's Performance Standards on Environmental and Social Sustainability	<p>https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_handbook_pps</p> <p>IFC requires investment clients to have a sustainability policy as part of clients' overall environmental and social management system. This allows businesses to anticipate environmental and social risks posed by their</p>

	activities and avoid, minimize, and compensate for such impacts as necessary. Recommends consultation with stakeholders and a means for complaints from workers and local communities to be addressed.
e³plus Framework for responsible exploration.	Prospectors and Developers Association of Canada (PDAC) - https://www.pdac.ca/priorities/responsible-exploration/e3-plus
Rare Earth Industry Association (REIA)	Life cycle assessment based approach under consideration https://global-reia.org/sustainability/
International Standards	
ISO 14000 family, ISO14001 (2015) environmental management	The ISO 14000 family sets out framework for an environmental management system: 'guidance on the establishment, implementation, maintenance and improvement of an environmental management system and its coordination with other management systems.' https://www.iso.org/iso-14001-environmental-management.html ISO 14001 (2015) requires: <ul style="list-style-type: none"> - Environmental management to be more prominent within the organization's strategic direction • A greater commitment from leadership - The implementation of proactive initiatives to protect the environment from harm and degradation, such as sustainable resource use and climate change mitigation - A focus on life-cycle thinking to ensure consideration of environmental aspects from development to end-of-life - The addition of a stakeholder-focused communication strategy
ISO 14040 (2006) Life Cycle Assessment principles and framework	ISO 14040 (2006) describes the principles and framework for life cycle assessment (LCA) including: definition of the goal and scope of the LCA, the life cycle inventory analysis phase, the life cycle impact assessment phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements. https://www.iso.org/standard/37456.html
ISO 14044 (2006) Life Cycle Assessment requirements and guidelines	ISO 14044 (2006) specifies requirements and provides guidelines for life cycle assessment (LCA). https://www.iso.org/standard/38498.html
ISO 45001 (2018) International Standard for Occupational Health and Safety Management Systems	Occupational Health and Safety https://www.iso.org/iso-45001-occupational-health-and-safety.html ISO 45001 builds on earlier international standards such as OHSAS 18001, the International Labour Organization's ILO-OSH Guidelines, various national standards and the ILO's international labour standards and conventions.

Appendix 4: Table of EU projects

Project (alphabetical order)	Scope and link to GREENPEG	WP6-relevant results & recommendations for ESIA / SLO / safety, if any	Project website / Reference
Ongoing projects at time of writing - 2020			
AlSiCaI (2019 - 2023)	Towards sustainable mineral and metal industry: ZERO Bauxite Residue and ZERO CO ₂ from co-production of aluminium, silica and precipitated calcium carbonate by the Aranda-Mastin technology. Includes environment and society and uses LCA approaches.	Outcomes pending.	https://www.alsical.eu/
CrEAM (2018-2021)	New strategies to safeguard end users against shortage for Critical Raw Materials		https://gtr.ukri.org/projects?ref=EP%2FR020140%2F1
CROCODILE (2018-2022)	The Crocodile project aims to drastically reduce the supply risk of cobalt for the European industries by increasing the efficiency of recovery processes for cobalt (and other relevant materials).	Includes a bottom-up and top-down civil-society-engagement strategy. D8.2 – Civil society engagement & Social License to Operate (due 31 January 2022).	https://h2020-crocodile.eu/
INFACI (2017 – 2021)	Designs innovative, non-invasive and socially acceptable mineral exploration technologies to help unlock unrealised potential in new and established sites. Focus on Finland, Germany, Spain.	<p>- D2.3: Slightly positive acceptance of mining in Europe, higher in traditional mining regions. Key factors are trust in public governance over mining companies, potential negative environmental impacts and fairness of wealth distribution within local communities.</p> <p>- D2.4 (public opinion): Positive attitude towards economic importance of mining, employment, security of supply, infrastructure and facilities. Environment impact is very important. No concern about non-invasive methods, e.g. helicopters and drones, though perhaps noise and invasion of privacy might be a concern. 10 to 15% of participants have a very negative attitude towards mining and exploration.</p> <p>- Overview paper: https://www.earthdoc.org/content/papers/10.3997/2214-4609.201901668</p>	https://www.infactproject.eu/
INTERMIN (2018-2021)	Focus on international training centres and opportunities for the raw materials sector.	Possible that GREENPEG expertise, results and dissemination can be used to strengthen and support training associated with INTERMIN.	https://interminproject.org/
LIGHTS (2018 – 2021)	Lightweight Integrated Ground and Airborne Hyperspectral Topological Solution. Integration of the newest developments of drone-borne systems for LCT pegmatite exploration	Lessons for GREENPEG on lithium pegmatite exploration, including deployment of UAVs. Publications can be found here: http://lights.univ-lorraine.fr/new-publications/	http://lights.univ-lorraine.fr/
MIREU (2017 – 2020)	Strategies for the improvement of conditions for SME and LE to stimulate mining in Europe	Deliverables: https://mireu.eu/publications?page=2 – particularly note deliverables on policy and SLO	https://cordis.europa.eu/project/id/776811
NEMO (2018 – 2022)	Near-zero-waste recycling of low-grade sulphidic mining waste for critical-metal, mineral and construction raw-material production in a circular economy.	D6.1: Environmental assessment report of NEMO processes (Oct 2021). D7.3: Report on the organization and outcome of workshops on Sustainability Assessment and Social License to	https://h2020-nemo.eu/

		Operate with “H2020 SC5 projects” (Oct 2022).	
NEXT (2018 – 2021)	New strategies for the reduction of exploration costs and public awareness building for exploration activities	http://www.new-exploration.tech/docs/Press/NEXT_WP7_PR_20180704_DMT.pdf http://www.new-exploration.tech/sustainability.html WP5	http://www.new-exploration.tech/
PACIFIC (2018 – 2021)	Passive seismic surveying	WP5: Environmental and safety risk assessment WP6: Social acceptance and perception of risk for mining activities Especially note D6.2: Report identifying psychological mechanisms that contribute to comprehension and (mis)conceptions. Available, along with other deliverables, here: https://cordis.europa.eu/project/id/776622/results	https://www.pacific-h2020.eu/
rECOMine	Networking expertise across industries for sustainable remediation and extraction of raw materials.		https://www.recomine.net/en/startpage.html
REMIX (2017 – 2021)	Smart and Green Mining Regions of EU, an Intereg project, encouraged environmentally and socially acceptable production of raw materials, including critical raw materials, developed best practices and aimed to influence policy. New strategies for efficient and environmentally and socially acceptable production of raw materials in Europe.	Good practice examples can be searched on the REMIX database: https://www.interregeurope.eu/policylearning/good-practices/ https://www.interregeurope.eu/remix/library/#folder=1015 – common scenarios related to mining in Europe	https://www.interregeurope.eu/remix/
SCALE (2016 – 2020)	Production of Scandium compounds and Scandium Aluminium alloys from European metallurgical by- products.	Deliverable D5.1: Environmental, health and safety controls that should be taken into account in SCALE technology development. https://cordis.europa.eu/project/id/730105/results	http://scale-project.eu/
SLIM (2016 – 2020)	Sustainable Low Impact Mining solution for exploitation of small mineral deposits based on advanced rock blasting and environmental technologies	WP3: Environmental Impact and Safety. WP7: Economic and environmental assessment. Includes life cycle analysis (D7.1) WP10: Public awareness, acceptance, trust and communication D10.1: Best practices on social awareness communication – Berraondo et al. (2018a) – includes case studies of best practice. D10.2: Social awareness guidelines for local communities – Berraondo et al (2018b)	https://www.slim-project.eu/wp-content/uploads/2020/05/D10.1-BEST-PRACTICES-ON-SOCIAL-AWARENESS-COMMUNICATION_Final.pdf https://www.slim-project.eu/wp-content/uploads/2020/05/D10.2-SOCIAL-AWARENESS-GUIDELINES-FOR-LOCAL-COMMUNITIES_Final.pdf
Smart Exploration (2017 – 2020)	Develops cost-effective and environmentally friendly solutions for deep mineral exploration in brownfield (abandoned industrial property) and greenfield (area of land that has never been developed or built up) areas.	No environmental or social work package but there may be useful lessons for exploration and geophysics techniques.	https://smartexploration.eu/
TARANTULA (2019 – 2023)	Recovering refractory metals from waste streams.	WP6: The main goal of the WP6 is to assure that technical, environmental, economic and societal issues are addressed in the upscaling of	https://h2020-tarantula.eu/

		<p>TARANTULA technologies. Includes using LCA approach.</p> <p>WP8: Communication, dissemination, exploitation & clustering.</p> <p>Possible lessons from project work on SLO: Communication, Dissemination and Civil Society Engagement strategies with respect to obtaining and maintaining the “Social License to Operate” for future heavy-duty metallurgical processing.</p>	
Completed projects at time of writing - 2020			
EO-MINERS (2010-2013)	Focus on earth observation	<p>Assessed policy requirements at the macro (public) and micro (mining companies) levels.</p> <p>Defined environmental, socio-economic, societal and sustainable development criteria and indicators using earth observation.</p>	https://cordis.europa.eu/project/id/244242/reporting
EU Rare (2013-2017)	Development of a sustainable exploitation scheme for Europe's Rare Earth ore deposits.	<p>Review of the EU regulations related to environmental and health impacts in the rare earth element industry (see Figure 2 in text).</p> <p>Review of environmental, health and safety impacts on REEs and their mines. Including section on radiation protection recommendations.</p>	<p>http://eurare.org/regulation.html</p> <p>http://eurare.org/docs/internalGuidanceReport.pdf (2014)</p> <p>http://eurare.org/docs/EURegulationsForTheREEIndustry.pdf (2015)</p>
FAME (2015 – 2018)	Development of flexible and mobile processes for the production of critical metals from skarn, pegmatite and greisen deposits in Europe.	D6.1 Report on best practise examples known from mining of skarn, greisen and pegmatitic ores. (resource efficiency and utilisation of processing rejects) – potential use for companies mining pegmatites associated with GREENPEG	<p>https://cordis.europa.eu/project/id/641650</p> <p>https://cordis.europa.eu/project/id/641650/results</p>
HiTech AlkCarb (2016 - 2020)	<p>Improve geological models for the exploration of 'hi-tech' raw materials associated with alkaline rocks and carbonatites.</p> <p>Application of invented geophysical exploration methods for exploration of REE-enriched lithologies.</p>	<p>D6.2: Radiation needs to be monitored and transparently communicated from the start of projects exploring alkaline rocks and carbonatites.</p> <p>D6.3: Past negative experiences in an area can impact SLO for future projects.</p>	www.carbonatites.eu
IMPACT (2016 - 2020)	New strategies for small-scale deposit exploration and mining.	<p>D5.2: Low-impact mining policy brief: https://epublications.uef.fi/pub/urn_nbn:fi:uef-20200587/urn:nbn:fi:uef-20200587.pdf</p> <p>Sairinen et al 2021: research framework for studying social impacts: https://doi.org/10.1016/j.eiar.2020.106490</p>	http://www.impactmine.eu/
IMPACTMIN (2010 – 2012)	Remote sensing strategies for monitoring environmental impact of mining.	UAV use: https://impactmin.geonardo.com/research_and_innovation.php https://impactmin.geonardo.com/results_and_downloads.php	<p>https://cordis.europa.eu/project/id/244166</p> <p>https://impactmin.geonardo.com/</p>
INTRAW (2015-2018)	Development of synergies in research and innovation for best practices in exploration, extraction, processing.	<p>The following deliverable may be a useful resource and offer lessons related to communication about raw materials: D2.4 - Action plan to enhance international education and outreach activities on raw materials.</p>	https://intraw.eu/
METGROW+ (2016 – 2020)	METGROW+ develops an industrially viable, flexible “New Metallurgical Systems” Toolbox, which consists of a broad range of already existing and newly	<p>Policy brief on Social License to Operate for the Mining and Recycling of Critical Metals: http://metgrowplus.eu/wp-content/uploads/2016/04/SOCRATES_M</p>	https://metgrowplus.eu/

	developed “metallurgical unit operations”.	ETGROW PolicyBrief_SLO_MARCH2018.pdf	
MIN_GUIDE (2016-2019)	MIN-GUIDE, a Horizon 2020 project, aimed to support the secure and sustainable supply of minerals in Europe through the development of an online repository outlining guidance and the latest in good practice.	Several deliverables associated with legislation: https://cordis.europa.eu/project/id/689527/results	https://cordis.europa.eu/project/id/689527
MINATURA2020 (2015- 2018)	Developed a concept and methodology for the definition and subsequent protection of “mineral deposits of public importance” in order to ensure their “best use” in the future in order to be included in a harmonised European regulatory/guidance/policy framework.	D3.1: Multi-sectoral analysis of mineral policies and land use policies in EU countries.	https://minatura2020.eu/
MINEFACTS	Building the social license to operate by offering facts on exploration and mining, a product from EIT RawMaterials.	https://www.minefacts.eu/ , features very clear information about how exploration and mining related activities work, particularly using Sweden as a case study. These explanations include topics that may be covered in less detail on company websites such as how permitting works, and the potential environmental and health impacts of mines.	https://www.minefacts.eu/
MINERA (2010–2013)	Improving environmental risk assessments for metal mines	Minera-model consists of both, ecological and health risk assessments that are preceded by an examination of the mining processes, emissions, the transport of contaminants and the resulting concentrations in the surrounding media.	Kaupilla et al. (2013)
SCREEN (2016 – 2018)	Aimed at the definition of a replicable systemic approach towards a transition to Circular Economy in EU regions within the context of the Smart Specialization Strategy, through the identification and implementation of operational synergies between R&I investments from H2020 and the European Structural and Investment Funds.		http://www.screen-lab.eu/
SOCRATES (2016 – 2020)	The European Training Network for the Sustainable, zero-waste valorisation of critical-metal-containing industrial process residues targets ground-breaking metallurgical processes, incl. plasma-, bio-, solvo-, electro- and ionometallurgy, that can be integrated into environmentally friendly, (near-)zero-waste valorisation flow sheets.	SOCRATES Policy Brief 2 (March 2018): The Social License to Operate for mining and recycling of critical metals (March 2018) – 5 lessons learned To obtain and maintain SLO “companies need to engage with all stakeholders in an open, transparent and continuous dialogue”. http://kuleuven.sim2.be/wp-content/uploads/2018/03/SOCRATES_METGROW_PolicyBrief_SLO_MARCH2018.pdf	https://etn-socrates.eu/

Appendix 5: Life Cycle Assessment methodology



GREENPEG

Introduction to life cycle assessment webinar

18th September 2020

Robert Pell PhD, Founder & CEO, Minviro
Postdoctoral Researcher on GREENPEG

robert@minviro.com



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GREENPEG Life Cycle Assessment webinar

- Introduction to life cycle assessment
- Philosophy behind LCA and life cycle thinking
- LCA theory
 - Goal and scope definition
 - Inventory analysis
 - Impact assessment
 - Interpretation
- Case study of LCA for a technology metal project
- How LCA can be used to reduce environmental impacts and enhance project value?
- Discussion on how LCA can be applied within the GREENPEG project

Introduction to life cycle assessment



- Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.
- It is a scientific approach and can be considered an analysis of the 'externalities'
 - Starts with the idea that we value the function that is being provided by the object being measured
 - Aims to map the non-accounted externalities of this function such as air pollution, water pollution etc.
- LCA does not replace risk assessments, safety assessments or environmental impact assessments. It is complimentary

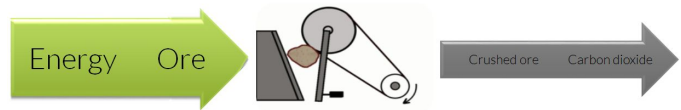
Philosophy behind LCA and LCA thinking

1. What are the impacts through the full life cycle of a product
 - a. Cradle-to-gate
 - b. Gate-to-gate
 - c. Cradle-to-grave
 - d. Cradle-to-cradle
2. We don't want to offset impacts from one category to another
 - a. Does climate change reduction = human health impacts?
 - b. Does reduced impacts in UK = increased impacts globally or elsewhere
3. Integrated with circular economy thinking

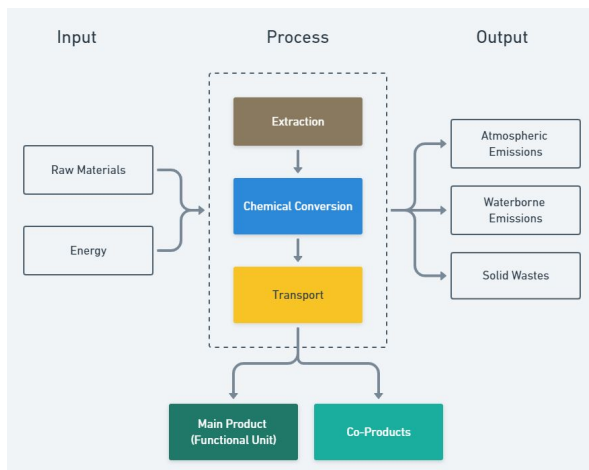
How do we quantify environmental impacts?



“A life cycle assessment allows a quantitative assessment of the environmental performance of a product or process over its entire life cycle”
 (ISO 14044a)



What an LCA contains



Once complete you will have full life cycle inventory (LCI)

Figure 1. Simplified LCA system boundary for technology metal projects (Minviro, 2019)

LCA as a decision making tool in mining project development

When to apply life cycle assessment?

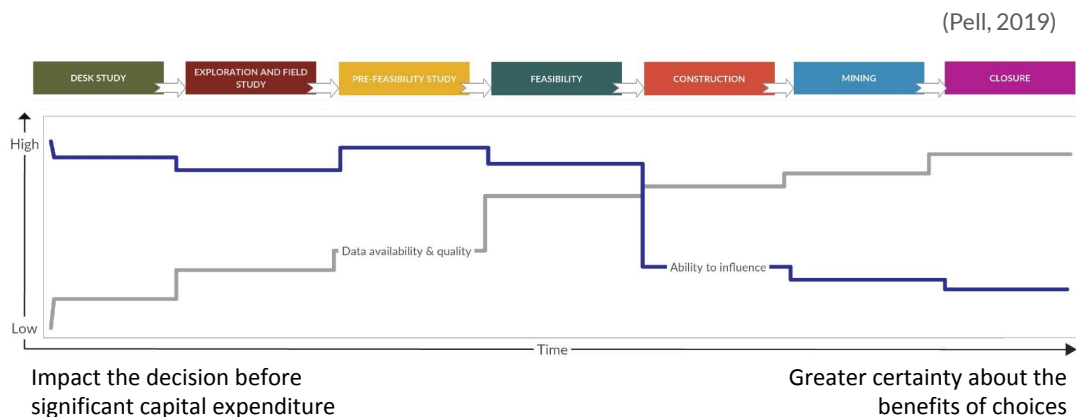


Figure 2. The range of project stages and the ability to influence decisions using LCA (Pell b, 2019)

Assessing a range of project options

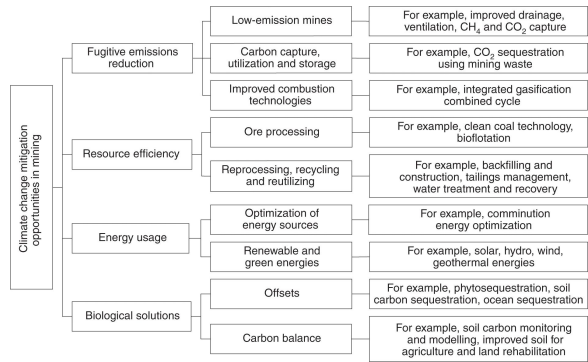
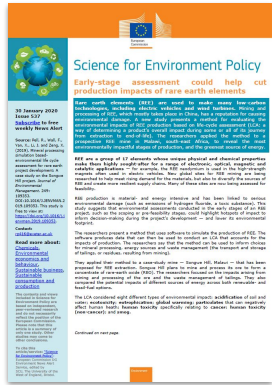


Figure 3. Paper highlighting application of LCA in project development (left) (Pell a, 2019) and options for project impact mitigation (right) (Azadi, 2020)

Impacts are not static

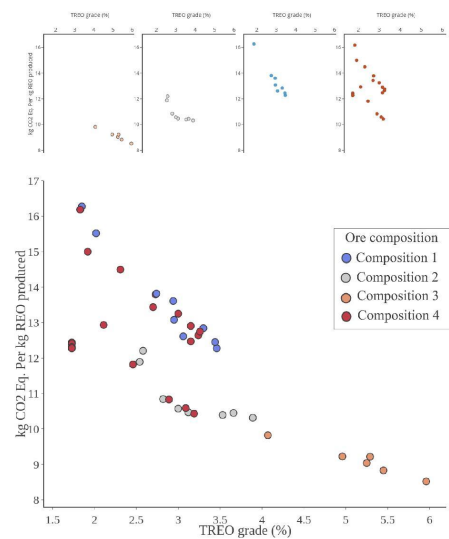
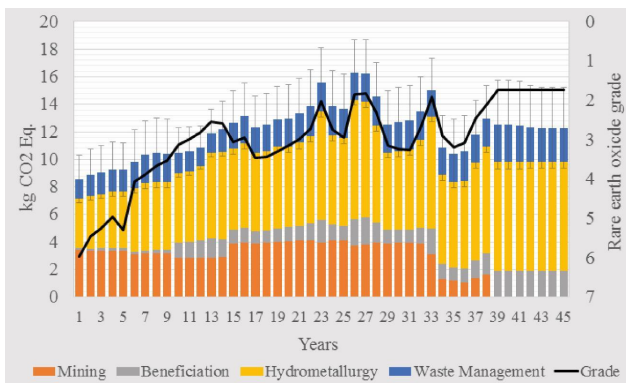


Figure 4. Paper relationship between grade and CO₂ impact over time (left) and relationship between grade, mineralogy and CO₂ impact (right) (Pell et al a, 2019)

Novel applications of LCA

Integrating LCA in mine scheduling

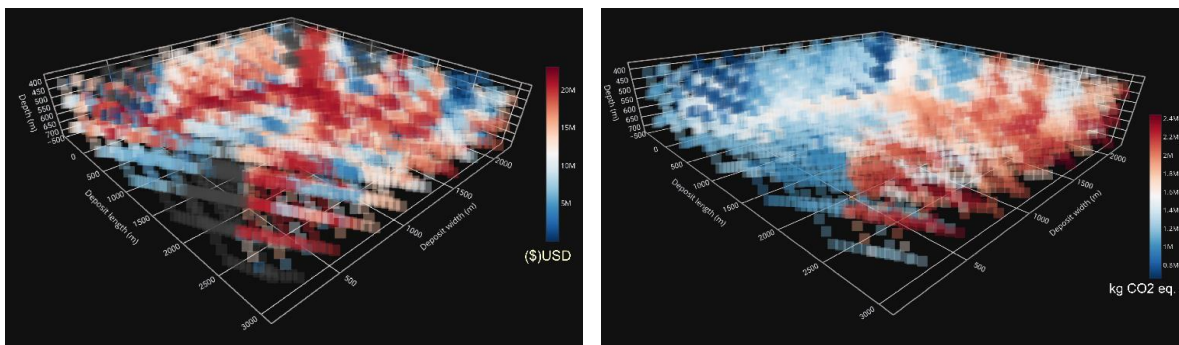


Figure 6. Block models of an iron ore mine (left) environmental block model for the iron ore mine (Pell c, 2018)

Table 1. The range of carbon cost scenarios that were used for optimization scenarios for the iron ore mine (Pell et al C, 2018)

Scenario	Name	Net Present Value	Fe Value (\$/t)	Global Warming (kg CO2 per annum)
1	B	Maximum	Standard -\$108	None
2	Q3	Maximum	Standard -\$108	735 Mt
3	Q2	Maximum	Standard -\$108	629 Mt
4	Q3-1	Maximum	Standard * 1% -\$109	735 Mt
5	Q2-1	Maximum	Standard * 1% -\$109	629 Mt
6	Q3-3	Maximum	Standard * 3% -\$111	735 Mt
7	Q2-3	Maximum	Standard * 3% -\$111	629 Mt
8	Q3-4	Maximum	Standard * 4% -\$112	735 Mt
9	Q2-4	Maximum	Standard * 4% -\$112	629 Mt

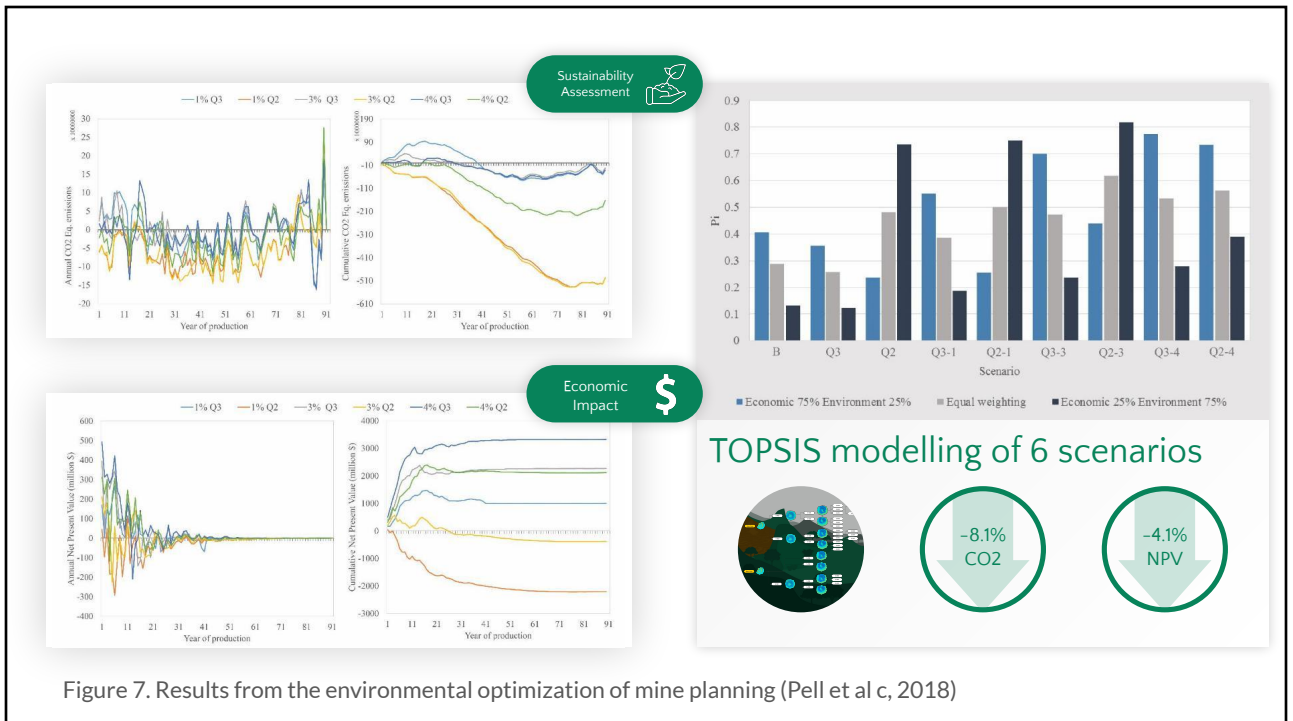


Figure 7. Results from the environmental optimization of mine planning (Pell et al c, 2018)

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