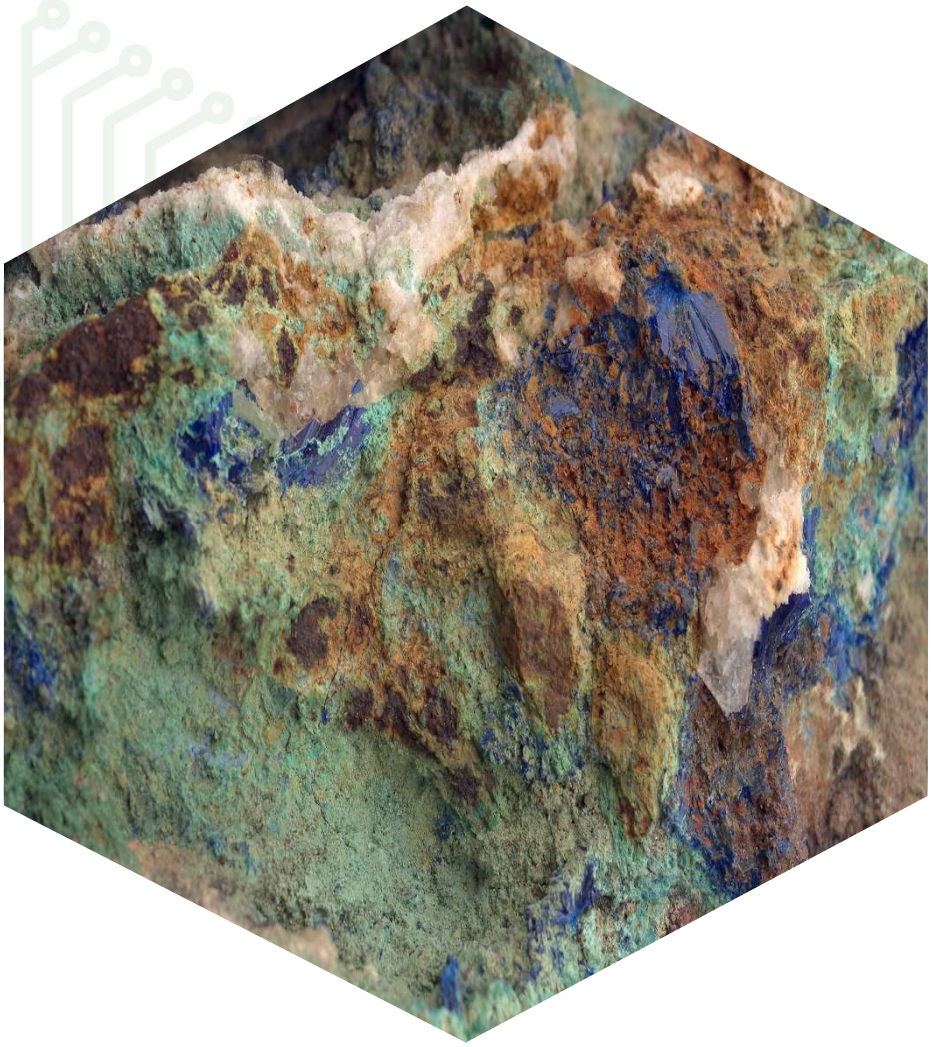
UK Critical Minerals Intelligence Centre

Overview of activities and policy related to critical raw material standards and resource management

Decarbonisation and Resource Management Programme

Commissioned Report CR/21/124



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British Geological Survey

BRITISH GEOLOGICAL SURVEY

DECARBONISATION AND RESOURCE MANAGEMENT PROGRAMME

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Overview of activities and policy related to critical raw material standards and resource management

T Bide, S Horn, A G Gunn

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BRITISH GEOLOGICAL SURVEY

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British Geological Survey offices

Nicker Hill, Keyworth,
Nottingham NG12 5GG

Tel 0115 936 3100

BGS Central Enquiries Desk

Tel 0115 936 3143
email enquiries@bgs.ac.uk

BGS Sales

Tel 0115 936 3241
email sales@bgs.ac.uk

The Lyell Centre, Research Avenue South,
Edinburgh EH14 4AP

Tel 0131 667 1000
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road,
London SW7 5BD

Tel 020 7589 4090
Tel 020 7942 5344/45
email bgslondon@bgs.ac.uk

Cardiff University, Main Building, Park Place,
Cardiff CF10 3AT

Tel 029 2167 4280

Maclean Building, Crowmarsh Gifford,
Wallingford OX10 8BB

Tel 01491 838800

Geological Survey of Northern Ireland, Department of Enterprise, Trade & Investment, Dundonald House, Upper Newtownards Road, Ballymiscaw,
Belfast, BT4 3SB

Tel 01232 666595
www.bgs.ac.uk/gsni/

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU

Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

UK Research and Innovation, Polaris House,
Swindon SN2 1FL

Tel 01793 444000
www.ukri.org

Website www.bgs.ac.uk
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Summary

There is considerable global interest in how sustainable supplies of raw materials can be secured to underpin the attainment of the net zero agenda and the sustainable development goals. Of particular concern are critical raw materials (CRMs), which play an essential role in low carbon technologies and for which demand is rapidly increasing. Many CRMs are extracted as by-products of major industrial metals from a small number of sources worldwide. Supplies are delivered through complex, dynamic international supply chains, which are vulnerable to disruption from diverse economic, environmental, social and political causes.

A wide range of policy related to both critical and non-critical mineral resources has been developed in recent years aiming to:

- improve security of raw material supply;
- reduce carbon emissions associated with the life cycle of raw materials;
- reduce environmental and societal harm related to raw material production and consumption;
- promote the development of a circular economy.

Although these objectives are varied in character they all require a long-term strategy for the sustainable management of mineral resources. Such a strategy is fundamentally dependent on improving our understanding of how raw materials are produced, the impacts of their production and use, and how they flow through society. To fulfil these requirements, we need a broad range of metrics for the complete material life cycle, including data on numerous geological, economic, material processing, social and environmental factors. Current and planned legislation requires this data and understanding and, together with the UK's ambitions for economic growth, gives a new level of urgency to resolving these matters.

The development of a standardised global approach using new frameworks and tools for whole value chain mapping and for the inclusion of ESG (Environmental, Social and Governance) metrics is recommended. Such tools developed by the United Nations Economic Commission for Europe (UNECE) include the UNFC (United Nations Framework Classification) and the UNRMS (United Nations Resource Management System). The UNFC is a standard for the harmonised classification of mineral resources and reserves based on the concept of categorising resources according to their socio-economic viability, technical feasibility and geological knowledge. It is a powerful tool in standardising data, and understanding the development status of a variety of different types of projects, both in terms of resource types and different stages of development. However, it does not cover the data requirements for the entire value chain nor for detailed ESG reporting. Consequently it is not sufficient for the required holistic system for reporting. The UNRMS builds on the concepts of the UNFC with the aim of forming a global standard for sustainable integrated resources management, applicable to all resources focusing on resource efficiency and responsible resource use. The UNRMS is currently at the conceptual stage but could provide the framework (through the incorporation of UNFC) to meet the requirement for an integrated system of mapping stocks and flows and for reporting on a wide range of diverse impacts related to both critical and non-critical raw materials. The aims of the UNRMS are well aligned to current policies and strategies around sustainable sourcing, traceability, circular economy and decarbonisation.

In response to these challenges, international bodies, national governments and Non-Governmental Organisations (NGOs) have produced a wide range of new policy, legislation, standards and tools to facilitate a transition to a sustainable, zero-harm supply chain, meeting the decarbonisation and circular economy agenda. This document summarises recent and ongoing activity that is relevant to the sustainable supply of CRMs. The results of this review will be used to inform recommendations for reporting on, and management of, critical raw materials and identification of best practice in dealing with ESG and circular economy issues. They will also contribute to evaluating the function and scope of a potential UK-based UNECE-backed International Centre of Excellence in resource management.

1 Introduction

The need for improved management of mineral resources brings with it a requirement for better data, tools and frameworks to ensure that mineral supplies are delivered in a secure and sustainable manner. Recent events, such as the UK hosted, G7 summit held in June 2021 and UN Climate Change Conference COP-26 held in October 2021, have highlighted concerns about maintaining an adequate and reliable supply of materials critical for the transition to a low carbon economy as well as the need for improving the governance of raw material extraction. These forums also highlighted the lack of common standards for a wide range of metrics from environmental standards to economic indicators as a barrier to achieving these goals. The United Nations Economic Commission for Europe (UNECE) has developed two tools that are aimed at lowering these barriers: the UNFC (United Nations Framework Classification), which provides a system for the consistent definition of different types of natural resources and their status; and the UNRMS (United Nations Resource Management System), which provides a conceptual framework for a holistic approach of all aspects of managing the entire value chain for raw materials.

Whilst the security of raw material supply has long been a focus of resource strategies in many countries, in recent years the emphasis has broadened to include improving the understanding of all aspects of mineral supply chains, from extraction and processing through to manufacturing, use, recycling and disposal. The main drivers of this change are:

- mitigation of the harmful effects of climate change and the subsequent need to decarbonise, via the use of technologies such as renewables and batteries, and the industrial transition associated with this.
- reduction of the negative environmental effects of resource extraction and consumption and of harm to local communities affected by these activities.
- transition towards a circular economy (CE) in which materials and products are kept in use for as long as possible and waste is minimised.

To understand these numerous and diverse aspects of resource use, a large amount of data and associated data standards are required to ensure resources are managed efficiently and sustainably (Figure 1). In order to ensure sustainable sourcing of raw materials it is necessary to consider in detail all parts of the value chain in terms of the underlying ‘principles’ (as defined by UNRMS, Figure 2) and thus to define the data that is needed at each stage. In a perfect world this data needs to be collected across the board in a standardised way to ensure its reliability and usefulness. The UNRMS is intended to deliver this kind of holistic resource management system.

Understanding and mapping how raw materials flow through society is a fundamental part of any resource management system. In this way supply chain risks can be pinpointed and opportunities for intervention and mitigation identified. This process is complex and involves mapping the value chains in detail and then ascribing quantitative information with regards to stocks and flows. This may then be subsequently augmented by data on environmental impacts, emissions etc. However, this approach is dependent on the availability of interoperable data to ensure valid comparison between different geographic areas and products.

The UK is highly dependent on mineral raw materials, which are essential for industries, jobs and growth. Part of the strategy to ensure security of supply of mineral raw materials is to improve the quality and harmonisation (and subsequent understanding) of statistical data. This is essential not just for investigating supply vulnerability, but also for facilitating information sharing at different levels both nationally and internationally. A key requirement is to understand the resource potential of different geographic regions, by evaluating known ‘geological stocks’ of mineral raw materials using statistics for resources and reserves. The lack of

interoperable data for mineral resources is a fundamental barrier to understanding the physical availability of raw materials. This can only be solved by the application of a standardised system for reporting mineral resources and reserves, such as the UNFC. Without some level of data interoperability it is difficult to compare the quantity and quality of the mineral resources present and the associated environmental, social and economic impacts of their extraction in different locations. The development of a coherent industrial strategy that relies largely on imported mineral supplies, remains problematic without suitable comparable standards in place. For example, sustainable sourcing cannot be achieved unless environmental data from all supplier countries are comparable.

The need for harmonised classification of mineral resources and for effective and sustainable resource management are now widely recognised as key elements of strategies for the sourcing and use of raw materials. As a result, there is now considerable global interest in the use of UNFC and development of the UNRMS. This document aims to review the scope and policy landscape around the UNECE resource management tools by summarising relevant projects, key stakeholders and their linkages. We have focussed on critical raw materials (CRMs) because of the growing concerns about secure and stable supplies of these minerals and metals that are required for decarbonisation.

1.1 NEW DATA REQUIREMENTS

Most minerals and metals are sourced through complex global supply chains involving various activities from mining and beneficiation to refining, manufacture, use, recycling and disposal. These activities typically involve numerous stakeholders at many different locations. Large amounts of data are required in order to determine the benefits, risks and impacts of mineral resource extraction, processing and use throughout the supply chain.

Figure 1 shows the key supply chain stages and the related data requirements which arise from the need to consider numerous underlying factors (identified as ‘Principles’ in the UNRMS guidance document[1], Figure 2).

While this systemic approach is valid for all minerals and metals, for many CRMs the knowledge base is limited compared with major industrial metals such as copper, aluminium and iron. For example, at the extraction stage, data is required on the location, quantity and physical and chemical properties of the CRMs in ores in order to determine the feasibility of a project. However, for many CRMs such data are often of poor quality or lacking altogether because they have not previously been considered for extraction (being primarily used in new technologies). Following mining, data is also required on how the CRMs are separated from the ores and subsequently refined and processed for use in manufacturing. At each stage data is required on the associated environmental and social impacts. These Environmental, Social and Governance (ESG) metrics have become increasingly important to the modern global extractive industry and its upstream users. When dealing with raw materials needed for low-carbon technologies, including many CRMs, it is especially important to make sure that their production is achieved in a responsible and sustainable way[2]. This, in turn, facilitates:

- improved understanding of the environmental footprint of CRM use and identification of mitigation to ensure our resource consumption aligns with the Sustainable Development Goals (SDGs)
- comparison of the use of primary and secondary resources in terms of benefits and impacts
- secure and sustainable access to the minerals and metals needed for the transition to a low carbon and circular economy.

Tools like Material Flow Analysis (MFA) can be used to map material stocks and mass flows along the value chain of an individual raw material. However, this approach requires large amounts of quantitative data for each stage in the raw materials life cycle in order to provide an overall global assessment. Furthermore MFA presents only part of the overall picture as it does not include all relevant ESG data and seldom considers resources. Figure 3 shows an example of MFA for lithium used in two types of battery. This illustrates how complex these

can be when considering multiple end-uses. This kind of analysis, complex as it may be, only forms a small part of the data requirements as shown in Figure 1.

The UNRMS, and use of UNFC within it, provides a conceptual model for use of CRMs that is focussed on ESG aspects, balancing the use of primary and secondary raw materials whilst, at the same time, also yielding economic benefits.

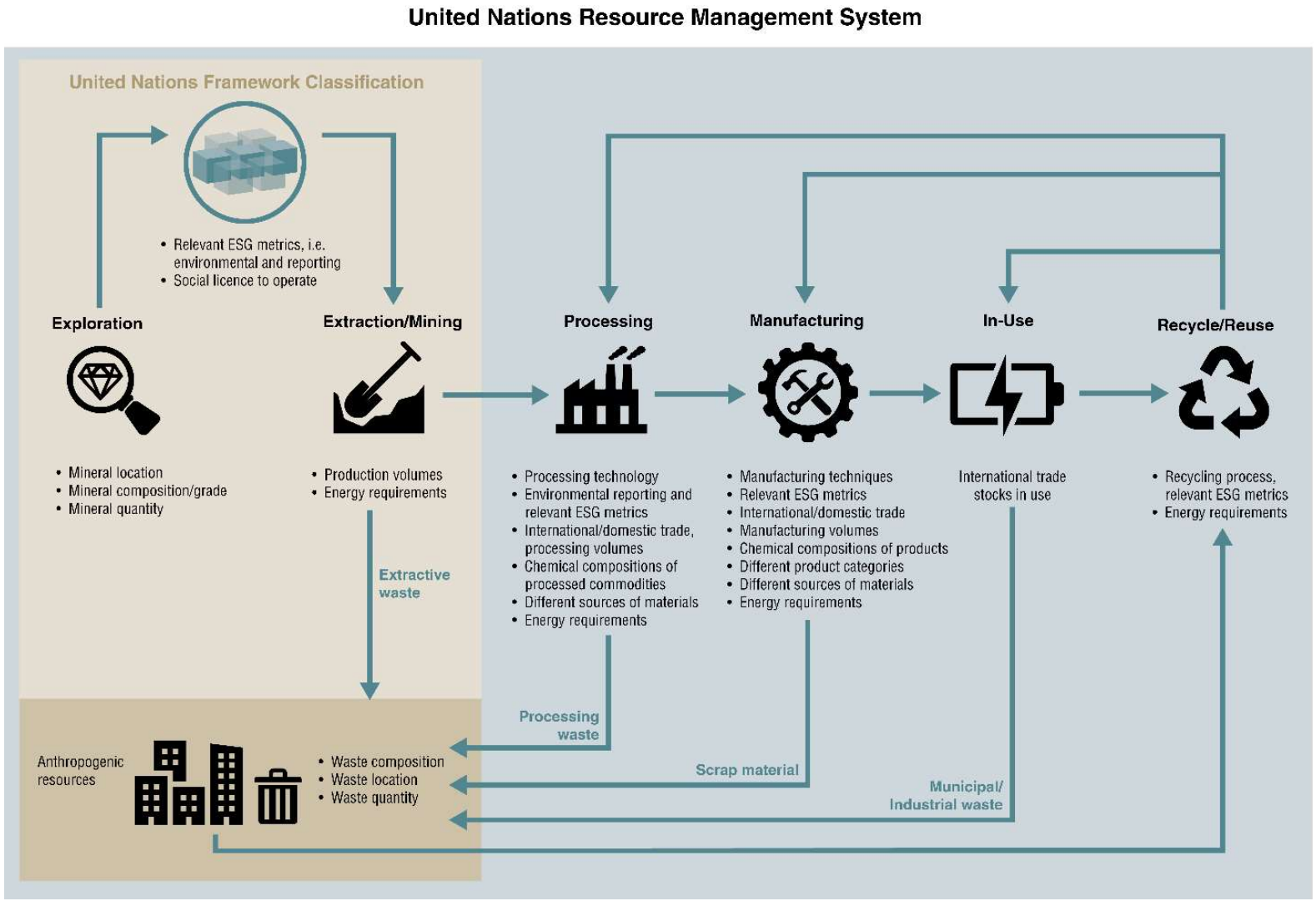

Figure 1. Schematic representation of the value chain and data requirements at each stage to meet new policy requirements and the linkages to UNFC and UNRMS. While UNFC assesses data in the exploration and extraction phases of raw materials, the UNRMS is based on twelve principles, which require data for the whole value chain (see Figure 2).

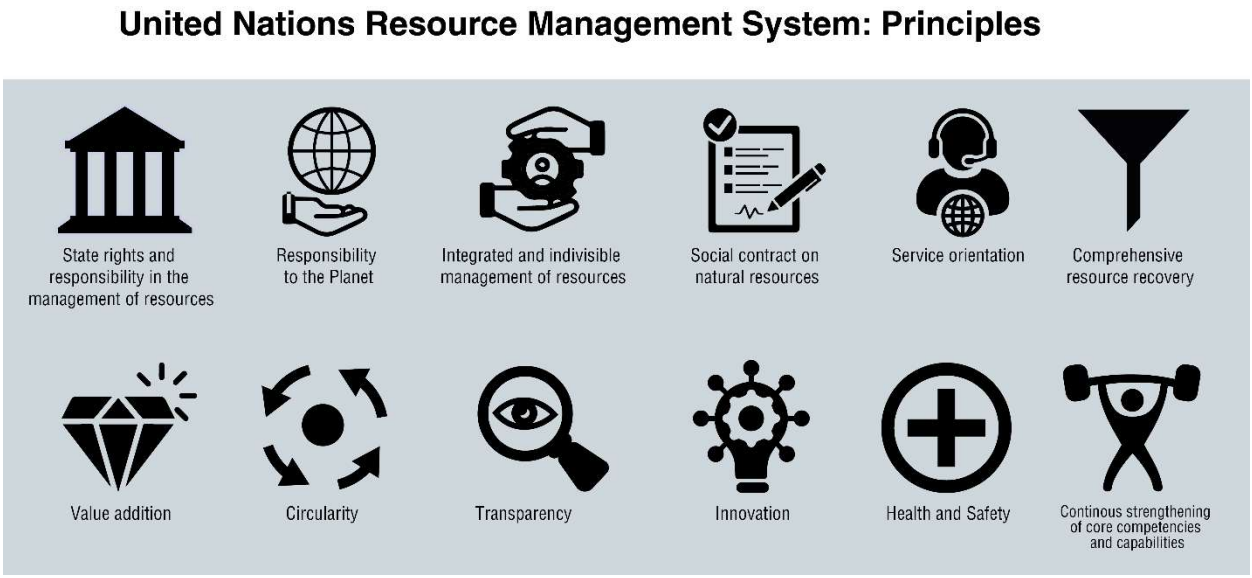

Figure 2. The twelve principles of the UNRMS, which apply to all stages of the value chain.

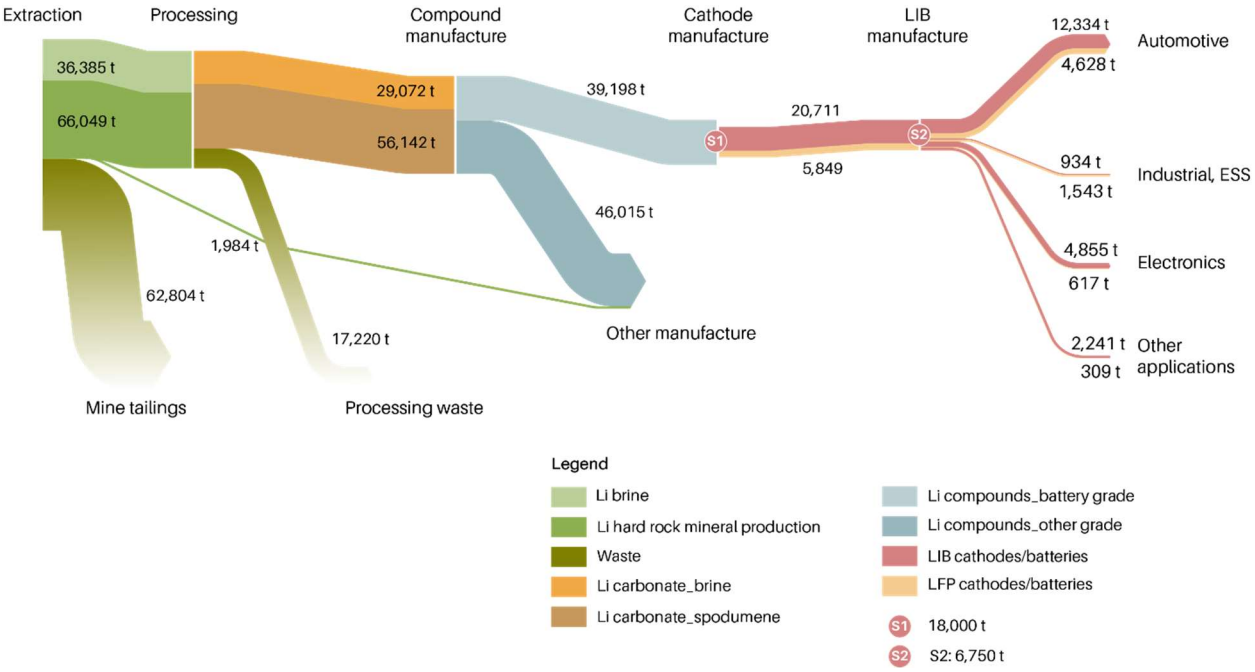

Figure 3. Material Flow Analysis (MFA) for the global supply of lithium used in lithium ion (LIB) and lithium iron phosphate batteries (LFP). The stages in the value chain from extraction to use are shown together with the waste generated at the extraction and processing stages. From Petavratzi and Josso (2021)[3].

1.2 WHAT ARE CRITICAL RAW MATERIALS?

Global concerns are growing over the long-term availability of secure and adequate supplies of the minerals and metals needed by society. Of particular concern are so-called 'critical raw materials', which are of increasing economic importance but have a relatively high risk of supply disruption. The escalating demand for CRMs is being driven by the rapid uptake of novel technologies (e.g. digital systems and devices; renewable energy and energy storage; electric mobility; autonomous vehicles) that are being deployed on an unprecedented scale, most notably to decarbonise the global economy.

These technologies utilise a wide range of minerals and metals, which are sourced through complex and dynamic global supply chains. Consequently resource-consuming economies, which are highly reliant on imports of these materials, are potentially vulnerable to supply disruption. Such supply restriction is seldom due to limited geological availability, instead it most commonly arises from other causes of a geopolitical, economic, environmental or social nature. It is, therefore, important to assess what materials are at risk of supply restriction and the severity of consequent impacts that may result. This, in turn, assists in the development of appropriate mitigation strategies.

It is, however, important to stress that there is no single, fixed or correct list of CRMs because the content of such a list will depend on who is asking the question, for what purpose and over what timescale. Consequently criticality assessment has been undertaken in many different ways since publication of the first systematic studies by the US and the EU in 2008 and 2010, respectively[4,5]. The UK has recently published a national assessment of technology-critical minerals and metals[6]. The USA and EU undertake periodic revisions of their assessments at intervals not exceeding 3 years[7,8]. Other recent notable assessments have been carried out by the governments of Australia, Canada and Japan [9-11].

In general assessment is undertaken by evaluating two key dimensions of criticality:

- the likelihood of supply disruption, commonly referred to as supply risk; and
- the impact of, or vulnerability to, supply disruption. This is generally estimated by measuring the economic importance of the industrial sectors that depend on supply.

In the past decade numerous criticality assessments have been published by governments, NGOs, academics and commercial companies (see review by Schrijvers et al., 2020[12]). These have varied considerably in scope, with some assessing large numbers of materials and others restricted to those used in a particular industry sector or technology. They have also differed in geographical focus with some being global, while others are concerned with individual countries or regions. All assessments rely on the availability of data to allow quantification of the two key dimensions of criticality (supply risk and economic vulnerability). Where data are lacking or unreliable, expert judgement is often used for estimation of the metrics utilised. This inevitably diminishes the objectivity and robustness of the derived results. The report by Schrijvers [12] gives a thorough review of the methods and data used in criticality assessments. It provides discussion on the nature of the risk being evaluated, the materials assessed, the indicators used to estimate criticality and the interpretation and presentation of the derived results.

Another serious limitation of all criticality assessments results from the use of available data, past and present, to attempt to identify problems in the future. Forecasts and scenarios of future demand are now being increasingly utilised to address this shortcoming and anticipate possible challenges. Nevertheless criticality assessment has an important role to play in decision-making by governments and industry. They are widely used in the development of policy and research aimed at underpinning security of supply, encompassing entire mineral supply chains from deposit formation to exploration, mining, processing, manufacturing and recycling. They also elucidate other possible supply barriers such as trade restrictions, social licence to operate and environmental constraints related to land, water and energy use. They highlight those materials where further in-depth analysis is required, where data availability and quality are inadequate and insight into future supply and demand scenarios is lacking.

Most major industrial metals, such as aluminium, copper and iron, have a long history of industrial use and are supplied through long-established and relatively stable, diversified supply chains. Their production is commonly measured in millions, or tens of millions, of tonnes per year. In general, because they have been used by industry for many decades, we have relatively good knowledge of how and where to find new resources and how to mine and process their

ores in an efficient and sustainable manner. We also know how they can be safely used in manufacturing and recycled or disposed of at the end of life. In contrast, the knowledge base for many CRMs is seriously deficient because their applications are novel and highly specialised. They are typically produced in small amounts, hundreds or thousands of tonnes per year, from a few sources worldwide. Many lack their own production infrastructure and are recovered only as by-products of the extraction of another, parent metal. For example, almost all cobalt is a by-product of the mining of copper or nickel, while most rhenium, tellurium and selenium are recovered only as by-products of copper extraction[13,14]. Another serious issue, especially when considering the development of sustainable resource management strategies, is that national and global reserve and resource data for many CRMs are poorly known or entirely lacking. This deficiency is most pronounced for minor technology metals that are produced as by-products.

On account of the concentration of production and processing capacity in a small number of countries, together with their small and relatively opaque markets, many CRMs are characterised by high levels of price volatility. This is a significant barrier to investment in new projects and also a serious concern to consuming industries that require secure and stable supplies of these materials.

Many CRMs are essential to the performance and function of particular products and devices and consequently they cannot be readily substituted by alternative materials in many applications[15]. With few exceptions end-of-life recycling rates of CRMs are very low because they are typically used in small amounts in consumer products which are not collected at the end of their useful life. Furthermore, the technology to recover CRMs from many products is highly complex and is currently available for only a few waste streams at a small number of locations worldwide[16].

1.3 INTRODUCTION TO RESOURCE CLASSIFICATION AND MANAGEMENT

Mineral resources and reserves are of fundamental importance to the global mining industry because they identify deposits that are currently economically and legally extractable (reserves) and those where economic and legal extraction of a commodity is potentially feasible (resources). It is important to differentiate between the fundamental concepts of mineral 'reserves' and 'resources' which are used to distinguish material that is *currently* economic to extract from that which is *potentially* economic.

The following definitions are accepted industry standards published by CRIRSCO (Committee for Mineral Reserves International Reporting Standards[17]), more details can be found at http://crirsco.com/national.asp:

- A ‘mineral resource’ is a concentration or occurrence of material of economic interest in or on the Earth’s crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, continuity and other geological characteristics of a mineral resource are known, estimated or interpreted from specific geological evidence and knowledge. Mineral resources are subdivided, in order of increasing geological confidence, into inferred, indicated and measured categories.
- A ‘mineral reserve’ is the economically mineable part of a measured and/ or indicated mineral resource. It includes diluting materials and allowances for losses that may occur when the material is mined. Appropriate assessments to quantify the 'modifying factors' which may include feasibility studies, have been carried out and include consideration of and modification by realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governance factors. These assessments demonstrate that, at the time of reporting, extraction could reasonably be justified. Mineral reserves are subdivided in order of increasing confidence into probable mineral reserves and proved mineral reserves.

Reserves can be regarded as working inventories at a particular point in time, determined by numerous variables including discovery and extraction rates, technologies for extraction, processing and use, and various political, legal, economic and social factors that influence their accessibility. As a result of their dynamic nature and the inherent uncertainties in global and national totals, published reserve estimates should not be regarded as reliable indicators of the future availability of mineral commodities[18].

The size of mineral resources and reserves are critically dependent on the commodity price prevailing at a particular time. If the commodity price rises, then a greater proportion of the deposits containing that mineral will become economically profitable to extract and these could be added to the figures for reserves (providing there are no other factors to prevent this). Conversely, if the commodity price falls, then some deposits previously considered as reserves may become uneconomic and these would no longer be classified as reserves (but may be considered as resources).

Different jurisdictions have different ways of measuring and reporting mineral resources and reserves. These variations must be clearly identified and taken into account in any attempt to harmonise resource data from different sources. The template developed by CRIRSCO is a widely recognised industry standard. CRIRSCO includes representatives of organisations that are responsible for developing mineral reporting codes and guidelines chiefly for the provision of market-related reporting and financial investment data to stock exchanges.

The various reporting systems derived from CRIRSCO set out minimum standards, recommendations and guidelines for the public reporting of exploration results, mineral resources and ore reserves. For example, in Australia companies listed on the Australian Securities Exchange are required to use the Joint Ore Reserves Committee (JORC) code. Companies that report their results on stock exchanges in Canada are required to follow the rules and guidelines of National Instrument (NI) 43-101. Other reporting codes based on CRIRSCO are used in South Africa, USA, Chile and Europe. Many countries also have developed their own national resource code, in eastern Europe and central Asia many of these are based on the code developed by the former Soviet Union.

The UNFC scheme is a fundamentally different approach to classifying mineral resources developed by the UN. This scheme aims to provide national-scale resource assessments for the purpose of resource management, policy development, industrial planning and capital allocation. The UNFC has been designed to be applicable to many different commodities such as petroleum, minerals, renewable energy, nuclear fuel and anthropogenic resources, allowing comparisons to be made between them.

1.3.1 United Nations Framework Classification (UNFC)

The UNFC[19] is a global classification system developed under a mandate from the UN Economic and Social Council and serviced by the Expert Group on Resource Classification (EGRC) of the UNECE. The UNFC is a flexible classification system that is capable of meeting the requirements for application at national, industrial and institutional level. It can also be used for international communication and trans-national assessments. It should be emphasised that UNFC is a classification and not a full reporting standard. It provides no guidance on data quality or validation, or on methods and formats of reporting.

In the UNFC system, quantities are classified using a numerical coding scheme for three fundamental criteria: economic and social viability (E); field project status and feasibility (F); and uncertainty, mostly related to geological knowledge (G). Combinations of these criteria can be displayed and visualised in three dimensions (Figure 4) or reduced to two dimensional presentations (Table 1).

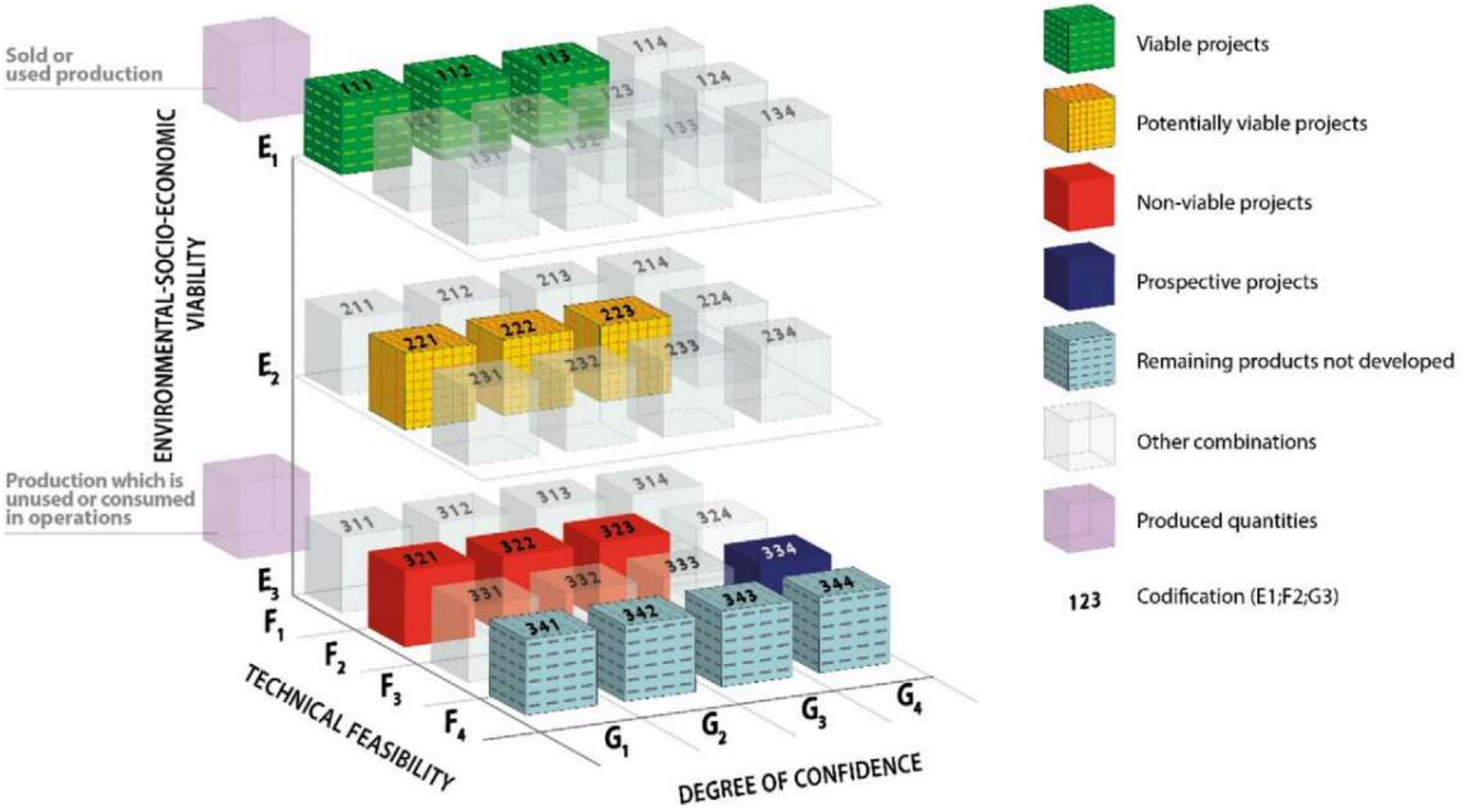

Figure 4. The UNFC classification system, From United Nations Framework Classification for Resources Updated 2019, UNECE, © (2022) United Nations. Reprinted with the permission of the United Nations [19].

Table 1. Abbreviated version of UNFC-2019, showing the primary classes. From United Nations Framework Classification for Resources Updated 2019, UNECE, © (2022) United Nations. Reprinted with the permission of the United Nations [19].

		Class	Categories		
			E	F	G
Total products	Produced		Sold or used Production		
			Production which is unused or consumed in operations		
	The project's environmental-socio-economic viability and technical feasibility has been confirmed	Viable Projects	1	1	1, 2, 3
	The project's environmental-socio-economic viability and/ or technical feasibility has yet to be confirmed	Potentially viable Projects	2	2	1, 2, 3
		Non-viable Projects	3	2	1, 2, 3
	Remaining products not developed from identified projects		3	4	1, 2, 3
	There is insufficient information on the source to assess the project's environmental-socio-economic viability and technical feasibility	Prospective Projects	3	3	4
	Remaining products not developed from prospective projects		3	4	4

The UNFC system has been designed to create mineral inventories in a harmonised way that can be easily combined across regions and national borders for the purpose of developing mineral policies and planning. Unlike the CRIRISCO template, the UNFC can accommodate resources that are not economic to extract under current market conditions. The UNFC system does not use the term 'reserves', rather all categories are considered 'resources'. Unlike investor-focussed industry standards, UNFC can accommodate 'uneconomic' and 'undiscovered' resources, including early stage exploration, giving a full picture of mineral stocks. It has been designed for national- or continent-scale reporting and has the flexibility to accommodate a wide range of different types of information.

1.3.2 Resource management and The United Nations Resource Management System (UNRMS)

Resource management has long been a key tool of the extractives sector to monitor stocks, qualities and production quantities to ensure supply is matched to demand, the appropriate quality of product is maintained and profitability is ensured. To date some of the most advanced resource management systems have been developed by the petroleum industry, as this is managed on a national level in many countries. The best developed system is the Petroleum Resources Management system (PRMS)[20,21]. Many of the tools developed under PRMS have been incorporated into the UNFC. Traditionally resource management systems

have focussed on managing the production of the mined/ extracted products and on achieving maximum profitability. While this does not preclude good stewardship of natural resources and consideration of ESG aspects (it would be likely that neglect of these factors would adversely affect project development) they are not the main focus. In addition, only the extraction stage is considered and no consideration is given to the other parts of the life cycle, namely processing, manufacturing, use, recycling and disposal.

The UNRMS recognises that future resource management should integrate all aspects of the value chain and should incorporate ESG factors at its core. The UNRMS is developed around twelve fundamental principles to ensure a sustainable resource management (Figure 2). Furthermore, the UNRMS considers resources not as isolated and independent, but will examine resources from all sectors (e.g. mineral resources and groundwater resources) in one holistic system[1]. Such a system has much greater complexity than existing resource management practices. The UNRMS is currently in the early stages of development, outlining the main concepts required for the establishment of such a system and how it may be achieved by integration of existing standards. Such standards include the UNFC for resources and environmental standards such as the UN System of National Accounts (SNA) and its System of Environmental-Economic Accounting (SEEA)[1]. Such a system also requires the ability to attribute all this information to individual elements, compounds, components and products as they change chemical and physical form moving through the value chain.

Several pilot studies are currently in early stage development by UNECE to demonstrate how the UNRMS may work in practice. These cover a diverse range of topics from resources as a service to the use of neural networks and the use of parts of the UNFC metrics to make robust comparisons between projects. UNRMS will likely be further developed by building on individual case studies, rather than the top-down approach as used by the prescriptive and rule-based UNFC. In certain respects at this early stage in development, UNRMS is a conceptual model for a holistic management system of the entire value chain, linking techniques such as MFA with resources classification and appropriate ESG metrics. Many policies for sourcing, use and recycling of CRMs will likely require such management systems, although how this may be achieved in practice is still unclear. These policies are already driving development of systems to capture some of the data required for resource management, including supply chain traceability and product 'passports'.

2 Current policy related to CRMs, UNFC and UNRMS

There is a growing body of international, European and UK policy which relates to CRMs, albeit commonly in a non-specific, indirect manner. However, wherever the need for sustainable supply, circular economy, supply diversification and other resource management issues are mentioned in policy there are significant implications for raw material management and associated requirements for new data and greater understanding of raw material supply chains. The policy drivers are characteristically economic (e.g. security of supply) or environmental (e.g. the need to decarbonise and transition to a circular economy). The implications for the data requirements needed to implement these policy decisions are commonly similar. A few documents with a specific focus may mention UNFC or UNRMS, but most identify a more general need for greater understanding or more data. UNFC seems the best suited international standard of use by governments and national institutions for resource classification and accounting. UNRMS is intended to be appropriate for more general resource management applications, incorporating all parts of the value chain and associated ESG metrics. Relevant ESG metrics are a significant issue due to the lack of accepted industry-wide standards. For example, a recent report into the harmful effects of mining reviewed numerous reported incidents and found companies use a wide array of different metrics for workforce injuries and environmental incidents[22]. The applicability and value of UNRMS are likely to become clearer as it is increasingly transformed into a workable system, but it is clear that UNRMS and many of the policies relating to resource management have similar objectives.

2.1 INTERNATIONAL POLICY

One of the most important policy drivers in this area is the Paris Agreement[23], which set out a legally-binding international treaty to reduce the effects of climate change by seeking to limit global temperature increases this century to less than 1.5° Celsius. This has had a considerable effect, both in terms of greatly increasing the demand for the materials used in technologies for decarbonisation and also in raising awareness of the need to reduce raw material consumption and emissions related to production and use. In addition, the implementation of the UN Sustainable Development Goals and the 2030 Agenda[24] (i.e. the need to reduce harm whilst promoting prosperity and growth) have also led to the adoption of new policy in many countries.

These themes are prominent in the UNECE policy brief 'Transforming extractive industries for sustainable development'[25]. This document outlines how good resource governance can contribute to sustainable development and includes a call for action around financing, governance, a just transition for sustainable systems and the role new technology and innovation may play within this. The implementation of a shared, principle-based, integrated, sustainable resource management framework, using UNFC and UNRMS, is included within this brief.

The G7 Panel on Economic Resilience[26], established in 2021, published policy recommendations on ensuring resilient supply chains due to threats to economic development of concentrated supply constricting trade flows. The Panel's policy recommendations include the establishment of a ‘Critical Supply Forum’, of which one component would be consideration of critical minerals, and the creation of an information-sharing platform, ‘Critical Minerals and Metals Information System (CriMMIS)’. The policy recommendations make no mention of specific standards, classifications or frameworks required to do this, although the need to link with the International Organisation for Standards (ISO) to promote market circularity is highlighted (the work of ISO is detailed in section 4.1.1).

2.2 EU POLICY

The EU has developed a broad range of policy related to many aspects of raw material

value chains (from primary resources through to products). Particular emphasis has been placed on CRMs with the aim of securing sustainable supplies from domestic and overseas sources to meet the needs of EU industry.

EU policy related to CRMs is particularly important given the rapidly growing demand for CRMs used in batteries for transport and energy storage and EU plans to scale up battery production. The 2009 Ecodesign Directive[27] set a framework for improving energy efficiency and reducing pollution. It requires that the manufacturers of all products, such as batteries, would be required to provide data on the environmental impact over the entire life cycle of a product. Although the Directive focuses on energy consumption during the in-use phase, it also applies to mineral extraction, processing and manufacturing. Specific metrics that may be required include: recycled material content; generation of waste material; emissions to water, air and soil; and potential of product/ material recycling. This also implies that valuable materials such as CRMs should be readily accessible for recycling. Such metrics require a robust system for monitoring and management of individual raw materials and components used. There is also a requirement for comparison between different environmental aspects of the product and clear standards of reporting on environmental impacts of raw materials used.

The 2020 update to the Batteries Directive[28] built on the requirements for batteries set out in the Ecodesign Directive. This update, yet to be formally enacted, defined more detailed and explicit requirements for various data types that would be required to be included with the production and trade of batteries. The Directive explicitly states that information on recycled content will be required by 2027 and, from 2030 onwards, there will be a requirement for a minimum content of recycled metals contained within the battery. Such requirements indicate the need for clear standards and systems for raw material sourcing/ tracing through the complex processing and manufacturing cycle of batteries. The Directive also states that batteries will be required to be capable of being removed and replaced by end users and third parties. This means that reporting systems will have to be accessible to a wide range of end users and not limited to individual producing and manufacturing industries. There are also requirements to disclose the country of origin of the raw materials used in batteries.

The EU Circular Economy Action Plan[29], which is part of the EU Green Deal[30], provides more guidance on what will be required for the use of raw materials in various industrial sectors and products. Guidance and regulations related to batteries are most relevant to CRMs, aiming to provide the necessary regulatory framework to ensure the efficient recovery of battery raw materials while improving sustainability and transparency along the battery supply chain. This includes reducing the carbon footprint of battery manufacturing, ensuring ethical sourcing and security of supply of raw materials, and facilitating reuse, repurposing and recycling.

None of these documents describes how such reporting is to be achieved. However, it is clear that a resource management system will be required that incorporates some form of traceability, or 'passport', which will need a large amount of data regarding the sourcing of individual metals used in batteries.

EU ‘conflict minerals’ legislation, enacted in 2017 and implemented in 2021[31], defined supply chain due diligence obligations for EU importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas. The legislation requires supply chains of these conflict minerals to carry out due diligence and promote responsible sourcing so that funding of armed conflict is prevented and forced labour is not employed in their extraction. This requires the provision of data on source, composition and other supply factors. that are attached to any imported goods. This regulation follows similar international and national policies, i.e. the 2016 Organisation for Economic Co-operation and Development (OECD) Due Diligence Guidance for Responsible Mineral Supply Chains of Minerals from Conflict-Affected and High-Risk Areas[32] and the US-specific Dodd-Frank Wall Street Reform and Consumer Protection Act (2002)[33].

More recently the European Commission has published “Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability” (2020)[34]. This looks at the current and future challenges for CRM supply and proposes actions to reduce Europe's dependency on third countries, diversifying supply from both primary and secondary sources and improving resource efficiency and circularity while promoting responsible sourcing worldwide. The Action Plan does not specifically mention UNFC or UNRMS, but it does recommend cooperation with the UN regarding resource management and mineral governance. The Action Plan builds on a growing body of research into both domestic sources of CRMs and harmonised standards. This aims to allow the comparison of different projects (i.e. primary and secondary) to assess how the most sustainable outcomes can be delivered (see also section 6.1). It should be noted that UNFC has become the de-facto classification scheme for resources used by the EC and by a growing number of EU member states. It is also a major component of some projects, and EU-funded groups, such as the Geological Service for Europe (section 6.1.2), and the European Raw Materials Alliance (section 6.1.6). The UNFC is, therefore, likely to become further integrated into EU legislation in the future.

2.3 UK POLICY

UK policy and legislation has followed a broadly similar trajectory to that of Europe, focusing on the need to understand society's use of minerals and metals and to develop UK manufacturing especially in clean energy technologies. Promotion of the transition to a circular economy and ensuring raw materials are sourced in a sustainable manner are also high priorities for UK policy.

Although now several years old, and superseded by the Net Zero Strategy[35] and 10-point plan for the green industrial revolution[36], the industrial strategy (2017)[37] gives context to current policy and legislation framework relevant to CRMs in the UK. There is a focus on clean growth, resource efficiency and the need to create new industries around low carbon technologies, which will require large amounts of CRMs. The need for a transition towards a circular economy is also highlighted, which will require improved resource management and the collection of a wide range of underpinning data. The industrial strategy is being further developed with a series of policy documents related to specific challenges. The most relevant is clean growth[38] by development of low-carbon technologies with lower costs than carbon alternatives. This has significant implications for CRM consumption, and for emissions reporting related to consumption. The Mineral Products Association mirrors many of these points in its 2018 UK mineral strategy[39]. This document calls for recognition of the importance of industrial and metalliferous minerals to the UK economy and trade, highlighting concerns over import reliance.

Other high-level policy documents, include the UK 10-point plan for the green industrial revolution[36] and the Department for Business, Energy and Industrial Strategy (BEIS) Net Zero Strategy[35].The 10-point plan does not mention CRMs specifically, but highlights the need for increased supply of minerals and metals and the requirement for this supply to be sustainable for more integrated resource management. The Net Zero Strategy makes particular reference to CRMs, it reiterates the need for sustainable supply through ESG standards, developing alongside the British Standards Institute (BSI), and notes the establishment of an expert committee on critical minerals in late 2021 and plans to publish a critical minerals strategy in 2022.

These issues are further explored in the recently published report “The Integrated Review of Security, Defence, Development and Foreign Policy”[40]. This presents a high-level vision for many aspects for the UK economy. Unlike many previous policy documents, there is specific reference to mineral resources, critical mineral resources and their management. It is recognised that supply issues and increased competition for CRMs exist and are likely to increase. It is essential that mineral resource supply is managed in an effective way, so that national ambitions regarding developing the industrial sectors that rely on these as feedstocks can be realised. The need to diversify the supply of CRMs is highlighted, as is the need for better resource management and to progress a circular economy. There is no mention of resource standards or data but these aspects

may be included in the UK critical minerals strategy planned for 2022.

The recently published Environment Act[41] includes specific environmental requirements for the sourcing of CRMs in that they must not be linked to deforestation (Schedule 17). This is in addition to requirements for responsible sourcing such as those required by the EU conflict minerals legislation. It has broadly similar requirements for products as those specified in the EU ecodesign regulation. Schedule 6 of the Act, Resource Efficiency Information, specifies the requirement to provide information on products regarding various metrics, such as the materials and resources used in a product's manufacture and the associated pollutants released. Similarly, Schedule 4, regarding producer responsibility obligations, requires the prevention of a product or material becoming waste, or reducing the amount of a product or material that becomes waste, as well as promoting the re-use, redistribution, recovery or recycling of products or materials. With regard to CRMs (or any mineral raw materials) both these schedules require the attribution of large volumes of information identifying the composition and sourcing of materials within products. The Environment Act also contains requirements for the tracking of waste, and waste compositions, overlapping with the requirements for tracking the composition (and recycled content) of materials in batteries in the EU Batteries Directive.

Various UK-based organisations are beginning to incorporate some of these policies into their own working practices. For example, the London Metal Exchange (LME) now has a requirement for responsible sourcing for commodities traded on the exchange[42]. The LME implemented this by following the OECD framework for risk-based due diligence in mineral supply chains[32]. The LME states the need for ISO 14001 and Occupational Health and Safety Assessment Series (OHSAS) 18001 / ISO 45001, or equivalent, standards to be applied to mineral production and processing facilities.

The growing requirement for material supply chain transparency and traceability, and the associated data needs, highlight the importance of developing resource management systems. This is exemplified by 'battery passports', which are a requirement of the EU Battery Directive, and will likely become more widely used in the future. A battery passport is designed to be a digital representation (or 'digital twin') that conveys all applicable information regarding the ESG and lifecycle requirements of a battery. This information can be traced through the entire lifecycle of the battery and battery components. Such passports are likely to be particularly challenging to develop and implement as they will need to link data on responsible sourcing (e.g. ESG metrics related to extraction), and energy and emissions throughout the entire value chain of the battery and involving multiple changes in custody of both raw materials and products. This will require the collection of data using established standards and metrics and the use of innovative technologies, such as blockchain, to ensure data is securely transferred across the whole value chain. The relevance of the EU's conflict minerals legalisation to the UK has been complicated by Brexit, as the legislation was passed in 2017 but not implemented until 2021, thus spanning Brexit and not fully integrated into UK law.

3 UNFC & UNRMS

3.1 STRUCTURE OF UNECE AND EXPERT GROUP ON RESOURCE MANAGEMENT (EGRM)

The EGRM is the UNECE body that is responsible for the development and promotion of the UNFC classification, while also developing the UNRMS[1]. The EGRM is managed by the Bureau, which comprises several representatives of the expert group[43]. The UK has been represented by the Director of the British Geological Survey, Dr Karen Hanghøj, since 2021. Below this overarching administrative body are several Working Groups, who are developing and maintaining guidelines and best-practice documents and advising on the application of UNFC by, for example, working with stakeholders on case studies[44]. Seven of these Working Groups are looking into the benefits and challenges that might arise with the use of UNFC in specific sectors (Figure 5). Cross-sector Working Groups on commercial applications, sustainable development goals' delivery and communications are devoted to developing guidelines on specific topics. There are also UNFC taskforces dedicated to specific aspects of the application and revision of the UNFC[44].

The Working Groups and task forces are monitored by the Technical Advisory Group (TAG), which is responsible for reviewing documents produced by the Working Groups and for keeping the Bureau informed on current work[45].

3.1.1 Minerals Working Group

The Minerals Working Group is responsible for developing guidelines for the use of UNFC and UNRMS. It also conducts case studies on mineral resources to identify specific challenges in this sector, including resources containing CRMs. The most important work of the group is the development of bridging documents that allow a simple conversion of global reporting standards to the UNFC classification. Bridging documents between the UNFC and the CRIRSCO reporting template, as well as the Chinese National

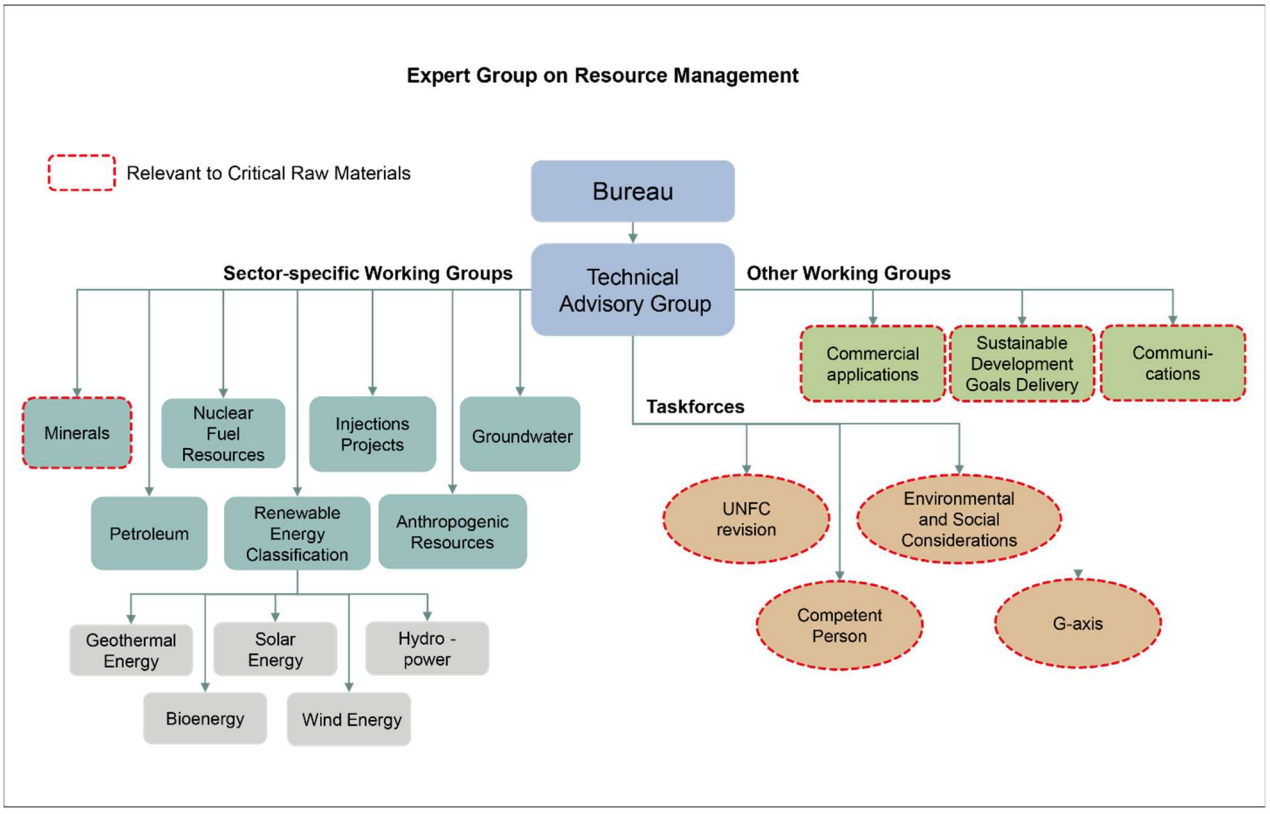

Figure 5. Structure of the UNECE Expert Group on Resource Management (EGRM).

Standard on mineral resource reporting, have been published[46,47]. CRIRSCO-compliant reporting codes are the most widely used by exploration and mining companies globally. Their main purpose is to provide consistent mineral resource standards for public reports aimed at investors[17] (section 1.3). The CRIRSCO template is not intended for compiling national inventories for the development of mineral planning policy. On the other hand, the Chinese national standard (GB/T 17766-1999) is not only used for classifying mineral resources, but also for mineral resource planning and policy making on a national scale[47]. The Working Group has published several case studies (Table 2) including national assessments of the mineral resources of Finland, Sweden and Norway using UNFC[48]. There are two published case studies on resources of CRMs, rare earth elements in Argentina and phosphate rock in Egypt[49].

3.1.2 Working Group on Anthropogenic Resources

The Working Group on Anthropogenic Resources is considering how to classify man-made resources, which are usually designated as waste material. These secondary materials are potentially important resources of raw materials, which should be assessed if the goals of a circular economy and a zero-waste society are to be achieved. The Working Group was established in 2016 following recommendations by the EGRM and the EU-funded Pan-European network 'Mining the European Anthroposphere (MINEA)'[50]. These experts identified the need to develop a unified methodology to assess, classify and report material resources in the anthroposphere. Three classes of anthropogenic materials are the focus of this work:

1) construction and demolition waste;

2) materials from landfills and mining residues; and

3) solid residues from waste incineration.

Several case studies from the Working Group have been published in peer-reviewed journals. They vary considerably in scope, including the recovery of materials from landfills and electronic waste, magnets from wind turbines and residues from waste incineration. They concern numerous different materials from metals and waste rocks to paper and plastics[51-55]. As many CRMs are widely used in new and green technologies, anthropogenic resources of CRMs will become increasingly important in the future as CRM-containing devices reach their end-of-life. Reprocessing of wastes from the mining and processing of metal ores is another potential source of CRMs. In the past the market for various CRMs was small and it was not economic to recover them as by-products of the ores of the main economic commodity[56]. For example, there is today considerable interest in the recovery of cobalt from tailings and slags from past copper mining activity in the Central African Copperbelt in the DRC and Zambia[57].

3.1.3 Other Working Groups of the EGRM

The Working Group on the Delivery of the Sustainable Development Goals is being set up by the EGRM[44]. It is clear that effective management of mineral resources across the world will help to support the fulfilment of these goals, whether by supporting responsible consumption and production of goods (SDG 12) or by helping to reduce inequalities by reviewing the socio-economic effects on local communities around production sites (SDG 10). CRMs are irreplaceable in technologies to enable sustainable industrial processes (SDG 9), for affordable and clean energy (SDG 7), for sustainable cities and communities (SDG 11) and for climate action (SDG 13). They will also contribute to attaining the goal of Zero Hunger (SDG 2) through effective management of phosphate resources needed for food production.

Table 2. UNFC mineral case studies conducted in collaboration with the Minerals Working Group. CRMs are noted in bold.

Region/Country	Commodity (CRMs in bold)	Collaborators	Year	Reference
Finland /Estland, Sweden, Norway	Limestone, Sand & Gravel	NGU, SGU, Nordkalk, Forsans Sandkompani, Petronavit A.S	2020	https://unece.org/DAM/energy/se/pdfs/egrm/egrm11_apr2020/ECE_ENERGY_GE.3_2020_10_UNFC_Nordic_Case_Studies.pdf[48]
China	Gold, Iron Ore, Coal	Mineral Resources and Reserves Evaluation Center of the Ministry of Natural Resources of China	2020	https://unece.org/DAM/energy/se/pdfs/egrm/egrm11_apr2020/ECE_ENERGY_GE.3_2020_9E.pdf[58]
Argentina	**Rare Earth Elements**, Thorium	National Atomic Energy Commission of Argentina, United States Geological Survey, UNECE	2019	https://unece.org/DAM/energy/images/UNFC_Reserv/publications/1919051_E_ECE_ENERGY_109_WEB.pdf[49]
El Sebaeya Project, Egypt	**Phosphate Rock**, Uranium	Nuclear Materials Authority of Egypt, UNECE		
Venezuela	Uranium, Thorium, Niobium	John Manrique, Universidad Particular de Loja, Ecuador		
“Rio Tinto” in Australia*	Coal	Stephen Henley, representative of CRIRSCO & PERC	2014	https://unece.org/DAM/energy/se/pdfs/egrm/egrc5_apr2014/ECE.ENERGY.GE.3.2014.4_e.pdf[59]
“Rio Tinto” in USA, Indonesia & Mongolia*	Gold			
"Newcrest Resources” in Australia*	Gold, Copper			
“Imerys Resources” in Asia/Pacific, Europe, Africa, North America*	Ball Clays, Carbonates, Clays			

* the study is based on UNFC classification on a company basis, but were not conducted by these companies and only by a study commissioned by UNECE.

The SDG Working Group is planning to produce documents based on the use of UNFC and UNRMS in supporting the attainment of the SDGs.

The Commercial Applications Working Group is investigating factors that can affect the feasibility of a project and how that affects the UNFC classification itself. It gives recommendations on the commercial assessment of projects and considers project valuation. Consideration is given not only to the value and quantity of saleable products and resources, but also to related costs, emissions, labour and material needs for the extraction and processing of these products through the life of the project[60].

The Communications Working Group deals with the promotion, communication and outreach for UNFC and sustainable resource management, operating in collaboration with all the other Working Groups. This group is responsible for the formulation of mission and vision statements, as well as for the development of news stories and promotional material such as brochures and leaflets[61].

The Taskforce on Environmental and Social Considerations was previously a sub-group on the E-axis of the UNFC classification, but is now also working on ESG issues related to the UNRMS along the whole supply chain. The Taskforce has developed recommendations on social and environmental factors, such as including the environmental viability in the definition of the E-axis[62]. The work of this Taskforce has shown that environmental and social effects of a minerals project are now more important than ever for ensuring sustainable production.

The Competent Person Taskforce aims at developing guidelines for UNFC and UNRMS Competent Person requirements for resource reporting[63]. Competent or qualified persons are appointed to conduct or audit resource estimates based on the relevant resource reporting code and are well established within the minerals sector for quality assurance of exploration results and resource estimates[17]. Guidance documents for governments and other entities who want to implement the UNFC as a resource classification system are, therefore, of particular interest to the mining and minerals sector.

The role of the G-axis Taskforce is to review and update specifications for the degree of confidence (geological uncertainty) within the UNFC classification.

The function of the UNFC Revision Taskforce is to continually review the classification framework, adapting it where appropriate, to include new classes of resource as well as accommodating feedback from ongoing application of UNFC.

4 Standards and their relation to UNFC and UNRMS

The UNFC classification brings together various standards of resource reporting and classification and, by expanding it to include the UNRMS, it is envisaged that this system should become a voluntary global standard for sustainable resource management. The UNRMS includes many different fields of resource management along the whole supply chain of raw materials. Therefore, a wider review of current standards and definitions in these various fields is required. This includes technical standards for raw materials and commodities, ESG standards, circularity, traceability and transparency standards for raw materials and many more. This is especially important for CRMs as the current increase in trading volumes of these materials require standardisation and harmonisation of their handling along the supply chain to ensure sustainable production, use and end-of-life treatment. The relevant standards for the resource aspects have been introduced in section 1.3.

4.1 TECHNICAL STANDARDS

4.1.1 International Organization for Standardization (ISO)

The ISO is a non-governmental organisation that connects a network of national standard bodies and experts in the field of standardisation, including the BSI. There are a number of technical committees within ISO that develop standards, including the ISO sector '73 Mining and Minerals'. These include material specifications, tolerance levels and methods of production and testing. While there are many technical committees and standards for base metals such as iron, copper and zinc, there are fewer Working Groups looking at CRM standardisation. The technical committee on Rare Earth Elements (REE) (ISO/TC 298 Rare Earths) is formulating standards in the mining and extraction and the sustainable handling of REEs and has so far published seven standards[64]. There is also the technical committee on lithium (ISO/TC 333 Lithium), which is developing terminology, technical conditions of delivery, unified testing and quality improvement for lithium products. This committee was formed in 2020 but to date it has not published any standards[65]. BSI is a participating member of both technical committees which also includes members from the British Geological Survey. The ISO has also established the Strategic Advisory Group on Critical Minerals to review the current landscape of standards in the field of CRMs, to identify gaps and to make recommendations on future work for ISO[66].

In addition to these committees on individual CRMs, many other relevant standards have been published, or are in development, by ISO that are aimed at effective and sustainable management of critical minerals, including standards on block chain technology for traceability of goods, on circularity and on second use of materials.

4.1.2 International Electrotechnical Commission (IEC)

The International Electrotechnical Commission (IEC) is a standards organisation for electrical and electronic goods that works closely with ISO. While the IEC has no specific standards for mining or CRMs, it has developed many standards that support efficient use of raw materials needed for modern technologies, including end-of-life management and efficient manufacturing techniques to reduce electronic waste[67].

4.1.3 Current development and collaborations

There is currently increased interest in setting standards for CRMs among European countries in order to influence the way these materials are managed. The reason for this is the dominant control of many critical raw material supply chains by China and its influence on setting standards[68].

The UNECE maintains close contact with both ISO and IEC, but no cooperative projects are currently underway.

4.2 INSPIRE

The INSPIRE Directive of 2007[69] lays down a general framework for a Spatial Data Infrastructure (SDI) for the purposes of European Community environmental policies and other activities which may have an

impact on the environment. INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications, including Mineral Resources and Geology. For definitions and standards to be included in European environmental data they need to be covered by the INSPIRE Directive. To ensure that the spatial data infrastructures of the Member States are compatible and usable in a community and transboundary context, the INSPIRE Directive requires that additional legislation or common Implementing Rules (IR) are adopted for a number of specific areas (metadata, interoperability of spatial data sets and services, network services, data and service sharing, and monitoring and reporting). These are published either as Commission Regulations or as Decisions[69].

4.2.1 INSPIRE mineral resources data model

The European Union has approved data models (a framework for organising data and standards and their relationships, generally consisting of standardised code lists and databases) for mineral resources, including primary and secondary resources, i.e. mining wastes. The specific data models which allow interoperability with relation to minerals are known as Earth Resource ML (ERML) for minerals and Geoscience Markup Language (GeoSciML) for geological data. It is now recognised that the UNFC is becoming widely used in many parts of Europe and is, therefore, being incorporated into the mineral resources model (undertaken by the Optimising quality of information in raw materials data collection across Europe (ORAMA)[70] and Mineral Intelligence for Europe (Mintell4EU)[71] projects).

4.3 ESG AND SUSTAINABILITY STANDARDS AND GUIDELINES

Responsible management of ESG and sustainability issues is of critical importance for the modern extractive industry. The UNFC-2019 has been updated and adapted to include social and environmental considerations for the classification on a project basis via the E-axis.

In order to establish the UNRMS for sustainable resource management, the management of the overall social and environmental impacts created by production and use of resources will be considered in the system[1]. There are several voluntary standards, guidelines and frameworks that have been implemented, some to be used by the industry and some by governments and are described in the following sections. These should be considered when developing a strategy for the standardisation of ESG metrics in the UNRMS. However, given the wide variety of approaches, development of a standardised and integrated reporting system remains a long-term goal.

4.3.1 OECD Due Diligence Guidance

The OECD has developed Due Diligence Guidance for responsible supply chains of minerals from conflict-affected and high-risk areas[32]. They include detailed recommendations for companies concerning how they should operate and manage their resource-related activities to respect human rights and avoid contributing to conflicts in high-risk areas[32]. The guidance was specifically developed for the responsible management of mineral resources and it has since been used as a template for many subsequent regulations and frameworks, including the new EU Regulation 2017/821 on conflict minerals (section 2.2).

4.3.2 International Finance Corporation

The financial sector has a strong interest in the effective handling of ESG factors as they impact on new mining and processing projects. The International Finance Corporation (IFC), which is part of the World Bank Group, is a financial institution that provides investment and encourages private-sector development in developing countries. It has established various environmental and performance standards dealing with risk management, labour, resource efficiency, community, land resettlement, biodiversity, indigenous people and cultural heritage. Clients of the IFC are required to fulfil these standards, so that they can perform risk mitigation and management of environmental and social factors[72]. These standards can be

applied to projects in different industries, including mining. The IFC performance standards are internationally recognised in the finance sector and have been used as a template for another scheme called the Equator Principles. The Equator Principles have been adopted by 127 institutions in 38 countries and are a financial benchmark for determining, assessing and managing environmental and social risks[73].

4.3.3 Global Reporting Initiative

The Global Reporting Initiative (GRI) was established in 1997 by the US non-profit organizations Coalition for Environmentally Responsible Economies (CERES), the Tellus Institute with support from the United Nations Environment Programme. The purpose was to develop an accountability mechanism to ensure companies adhere to ESG principles following the Exxon Valdez oil spill and related environmental damage. A series of sustainability standards has been published for use by companies, government bodies, NGOs and other organisations to understand and measure the sustainability impacts of various businesses. Standards are organised into three inter-related series:

1) Universal standards
2) Sector standards
3) Topic standards.

There are three universal standards that apply to all organisations. These set the foundation of how organisations identify and assess their impacts and what information should be disclosed. Sector-specific standards identify the topics relevant to each sector, ensuring that organisations report comprehensively on all potential impacts. Each of these topics has its own standard which defines how organisations have to report and what they need to disclose (e.g. GRI 206 Anti-corruption or GRI 304 Biodiversity)[74]. At present only one sector standard has been released, that being for the Oil and Gas sector. The GRI is currently developing standards for 40 different sectors including mining, with a planned release in 2023. This standard will cover organisations involved in exploration through to primary processing of minerals[75].

4.3.4 Initiative for Responsible Mining Assurance

The Initiative for Responsible Mining Assurance (IRMA) has developed a standard for mining companies and projects[76]. This allows companies to become certified and provides independent and credible information on the companies' responsible sourcing practices to their purchasers. It also helps to create transparency within the mining sector so that companies further along the supply chain can assure sustainable material sourcing to their customers. The IRMA standard is based on four overarching principles: 1) business integrity; 2) planning and managing for positive legacies; 3) social responsibility; and 4) environmental responsibility[76]. Stakeholders from mining companies, purchasers, NGOs and other organisations can become members of IRMA and help to develop and review the standard. A mining company only becomes a member when it commences a third-party audit based on these principles. This audit can then determine the level of certification that is achieved depending how many requirements of the IRMA standard are met. Purchasing companies can become members to encourage their mineral suppliers to engage with IRMA, while NGOs and similar organisations can promote the use of the IRMA standard to improve environmental and social best practices. Currently three mining companies are members of IRMA, while 14 mining and exploration companies are pending members. Eleven purchasing companies are members including the BMW group and Microsoft corporation. The majority of the 32 members are NGOs, labour unions, community representatives and other organisations[77].

4.3.5 Towards Sustainable Mining initiative by the Mining Association of Canada

The initiative Towards Sustainable Mining (TSM) is a voluntary scheme to evaluate and manage environmental and social responsibilities of mining companies and metallurgical facilities and aims to improve the industry's ESG performance[78]. Members

of the Mining Association of Canada (MAC) are mandated to participate in the TSM initiative for their Canadian operations. However, the initiative is not only used in Canada but has also been adopted by mining associations elsewhere, including Australia, Brazil, Finland, Spain and Norway. Mining facilities are assessed on the basis of three pillars: communities and people; environmental stewardship; and energy efficiency. Each company has to self-assess and publish its performance annually. The assessment is externally verified every three years[78].

4.3.6 International Council on Mining and Metals

The International Council on Mining and Metals (ICMM) is an organisation that was formed to tackle environmental and social challenges that arise from mining. Members of ICMM have to follow ten principles and eight position statements that address specific challenges to the mining industry[79]. In addition, company members have to publish their sustainability performance in accordance with the GRI reporting standard. A third-party undertakes an annual assessment of each member to ensure compliance with these conditions[80]. The organisation currently has 35 mining and metals company members and over 35 national, regional and commodity association members.

4.3.7 Other voluntary schemes on ESG standards

The initiatives and schemes mentioned above cover all mineral resource commodities, but are mainly focussed on the first stages of the mineral supply chain (exploration, mining and on-site processing). There are a number of other schemes which are aimed at specific commodities or groups of commodities (gold, tin, tantalum, tungsten, cobalt, diamonds, aluminium, natural stone, coal and others) and, in some cases, are concerned with additional parts of the supply chain. For example, the so-called ‘conflict minerals’, the 3TG group includes tin and gold, as well as the critical metals tantalum and tungsten. There are several schemes relating to this group of minerals, many of which are produced in high-risk countries and are associated with human rights abuses. These schemes include, for example, the Regional Certification Mechanism by the Regional Initiative against illegal exploitation of Natural Resources (RINR)[81] and the Responsible Minerals Assurance Process (RMAP) established by the Raw Materials Initiative (RMI)[82]. There are also several initiatives for responsible sourcing of cobalt, where the dominant production comes from the Democratic Republic of Congo and part of its production is associated with child labour and other human right abuses[57]. Initiatives include the Responsible Cobalt Initiative (RCI)[83] developed by the Chinese Chamber of Commerce for Metals, Minerals & Chemicals (CCCMC) and the OECD. There is also the Cobalt Industry Responsible Assessment Framework (CIRAF) established by the Cobalt Institute[84].

The German Geological Survey (BGR) published an in-depth report on the status of voluntary ESG and sustainability standards in 2017, comparing nineteen different schemes on mineral resources[85]. The report highlights the variety of approaches towards assurance, capacity building and impact reporting. It concludes that a harmonised scheme with consistent transparency and assurance mechanisms, while also being adaptable to different commodities and conditions, would benefit the common goal of sustainable mining and resource management. This would simplify the current landscape of sustainability standards and help stakeholders to report their actions consistently, while gaining credibility and understanding. There is potential for the Expert Group on Resources Management to use the newly conceptualised UNRMS to build this harmonised scheme along the whole supply chain. The UNRMS principles align closely with the goals of the ESG and sustainability schemes and such a resource management system should include an overall standard for the reporting and assessment under these guidelines. This can be widely promoted in the large network of UNECE member countries and collaborators to ensure a global application of a unified system.

4.4 GOVERNANCE STANDARDS

4.4.1 The Extractive Industries Transparency Initiative

The Extractive Industries Transparency Initiative (EITI), formed in 2003 as a non-profit association, aims to improve governance and transparency on natural resource management for oil, gas and mineral resources on a country level. There are currently 56 country members of the initiative. Each country must follow the EITI Standard[86], requiring them to disclose information about contracts and licences, production, revenue collection and allocation and social and economic spending[87]. Each country has a national multi-stakeholder group, consisting of government, company and civil society representatives, which is responsible for how the EITI is applied in their country. Key information on the country's governance is reported annually, allowing public debate and recommendations to improve governance and benefits to the public from the extractive industry. The international board of the EITI is responsible for monitoring and assessing the alignment with the EITI standard in a validation process. In comparison to the aforementioned ESG and sustainability standards, which are applied by the industry, the EITI standard is a voluntary commitment aimed at government bodies to be open about financial flows between the industry and government.

The UK became an EITI candidate country in 2014 and published its first EITI report in 2016[88]. Publications and reports from the UK can be found at: https://www.ukeiti.org/publications-reports.

5 National and regional work towards development of UNFC and UNRMS from UNEC

While the EGRM and its Working Groups are chiefly responsible for developing the core structure and concept of the UNFC and the UNRMS, their application and promotion need to be delivered at regional and national scales. Several projects and initiatives have been set up worldwide for this purpose, where the UNECE is collaborating with local partners.

5.1 CENTRES OF EXCELLENCE ON SUSTAINABLE RESOURCE MANAGEMENT

The UNECE has begun to establish several International Centres of Excellence on Sustainable Resource Management (ICE-SRM) aimed at promoting the use of UNFC and UNRMS for attainment of the 2030 agenda for sustainable development. ICE-SRM's are essentially a collaborative network of the resource development community and a resource management hub. They are responsible for supporting research, testing, consultation, education, advocacy within their activity footprint and, where appropriate, certification of e.g. competent persons to apply UNFC and UNRMS[89] (Figure 7). The ICE-SRM's must have a physical infrastructure and regional, national and local political support. They should also have a strong relationship with the resource development community in the area. There are currently five ICE-SRM's at the planning stage: Russia, China, Mexico, Europe and the CCOP (see section 5.3). In Russia, the ICE-SRM will be based in Moscow and is the most advanced of these centres regarding its planning and implementation. The centre was initiated in collaboration with the Russian Ministry of Natural Resources (GKZ), Moscow State University (MSU) and the Eurasian Union of Experts in Subsoil in Subsurface Management (EUES). It is supported by industry (Gazprom, Rosneft) and financial institutions in Russia and the BRICS bank[90]. The centre will aim to work on the harmonisation of the Russian classification by developing bridging documents to UNFC and on the application of UNFC and UNRMS in the Commonwealth of Independent States (CIS)[91].

In China, it is planned to open an ICE-SRM to follow on from the recent publication of the bridging documents between the Chinese national standards on mineral resources and petroleum. The ICE-SRM will be formed to support the global application of UNFC and UNRMS and to facilitate sustainable resource management in China.

In Mexico a recent pilot study on the application of UNFC and UNRMS in the petroleum sector emphasised the importance of assessing social and environmental risks in resource management and project planning[92]. In addition, the study showed how UNRMS and UNFC can be tailored to the Mexican and Latin American markets and their legislative systems. Another pilot study in the minerals sector is planned to add to these insights.

In Europe the future project on the Geological Service for Europe (section 6.1.2) plans to involve the development of an ICE-SRM at the Slovenian Geological Survey to promote the use of UNFC and UNRMS in Europe[93]. The development of the ICE-SRM at the centre of this newly formed Geological Service for Europe will enable the direct implementation of the UNFC and UNRMS as a unified system for sustainable resource management in Europe. The project will have a focus on critical raw materials and will include the assessment of both primary and secondary resources. The European Commission is generally supportive of the application of UNFC and UNRMS in the European Union and of the establishment of an ICE-SRM in Slovenia.

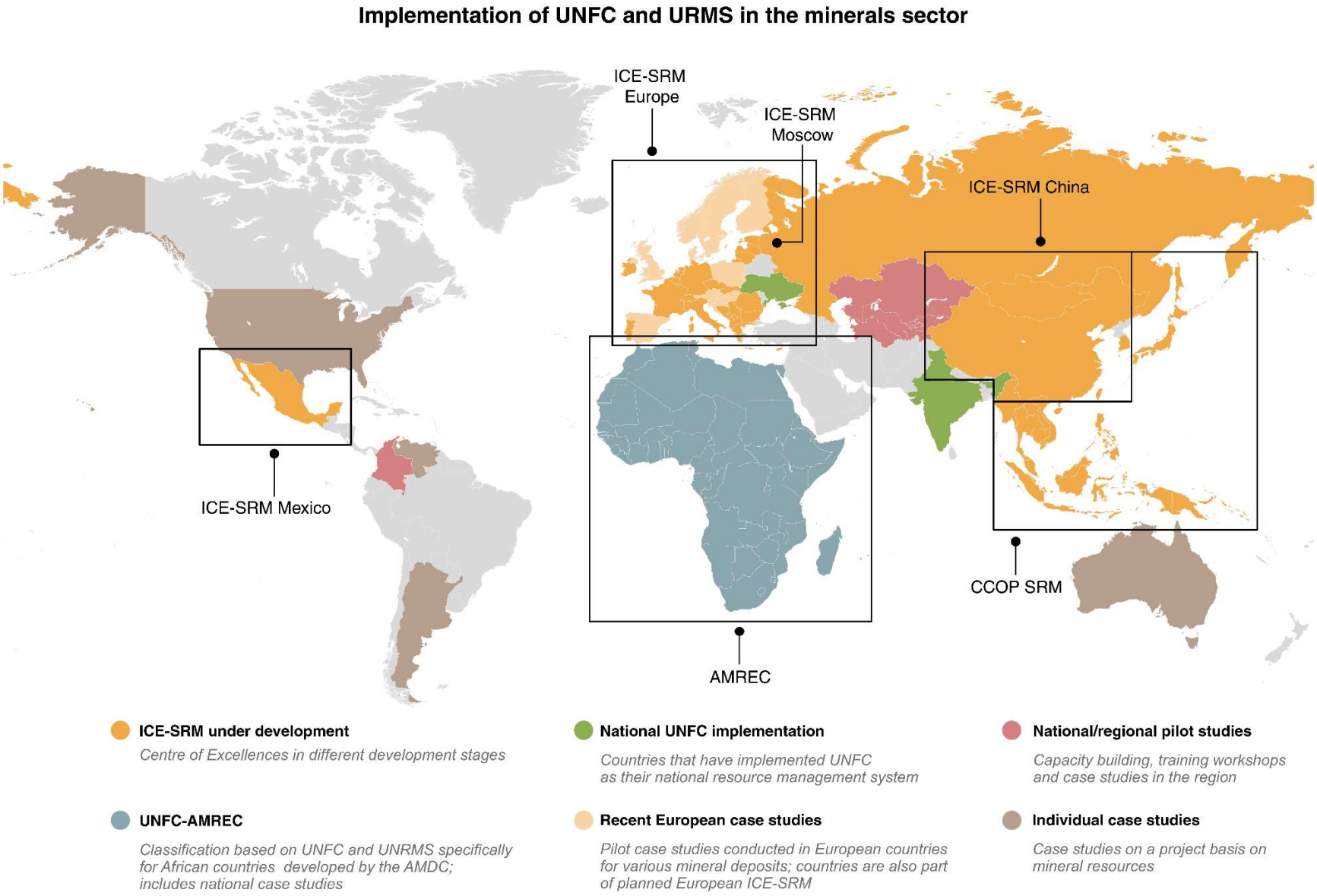

Figure 6. Distribution of various projects and initiatives for the implementation of UNFC and UNRMS in the minerals sector.

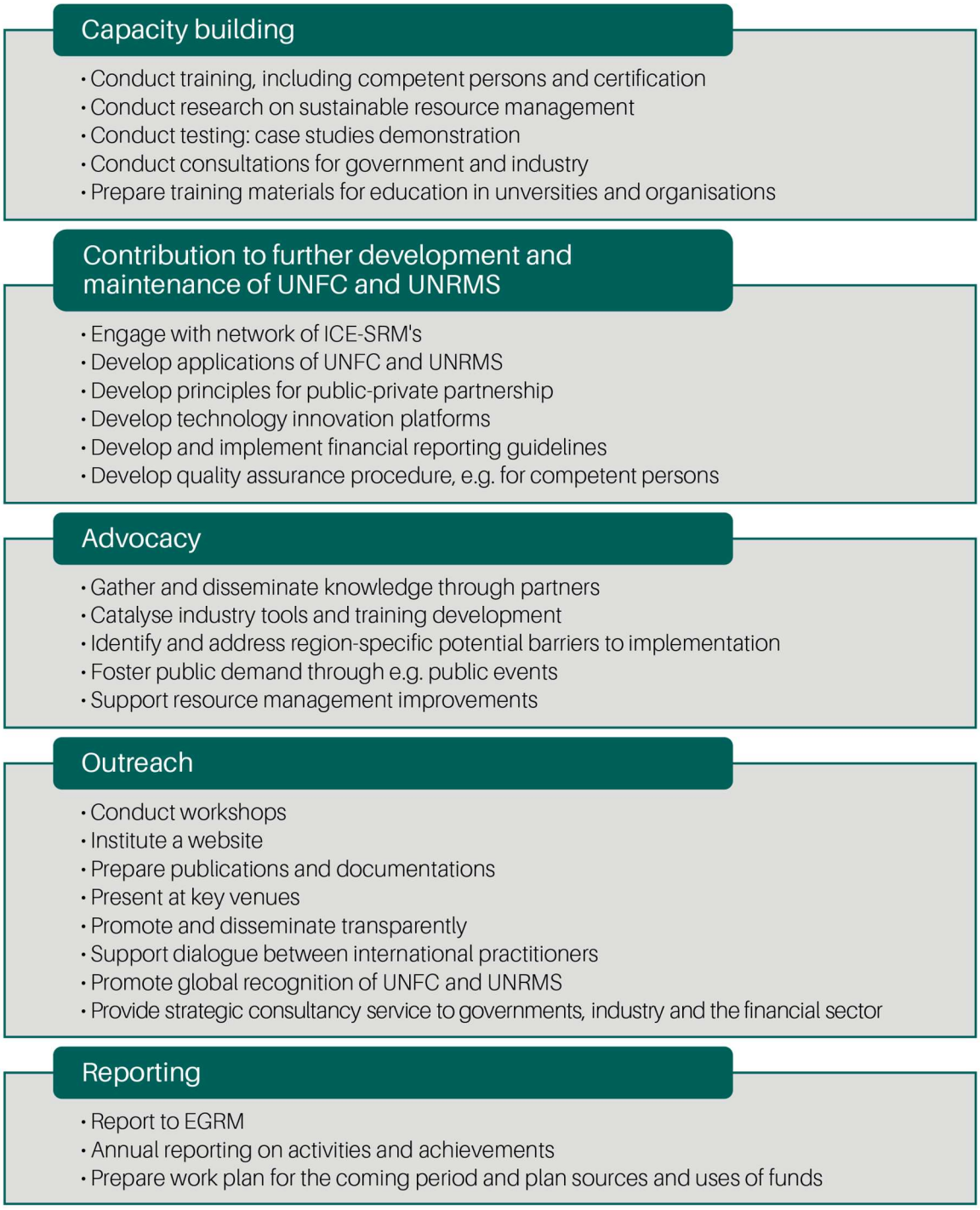

Figure 7. Proposed activities of the UNECE's International Centres of Excellence for Sustainable Resource Management[89].

5.2 UNFC AND UNRMS IN AFRICA

In addition to the ICE-SRM, other centres being developed by partners of the UNECE are aiming to incorporate UNFC and UNRMS into their work. The African Minerals Development Centre (AMDC) was launched in 2013 by the UN Development Programme and is co-sponsored by the Economic Commission for Africa (UNECA), the African Union Commission (AUC) and the African Development Bank (AfDB)[94]. The centre is currently located in Addis Ababa, but there are plans to move it to Guinea. The main goals of the Centre are to implement the Africa Mining Vision in order to take advantage of the mineral endowment of many African countries for the development and growth of their economies. In order to

establish the principles of the Africa Mining Vision[95], the AMDC has developed the African Mineral Resource Classification (AMREC). AMREC is based on the UNFC system, but is designed specifically for application on the African continent. While current work is focussed on specifications and guidelines of the UNFC system, it is also planned to develop a resource management system similar to UNRMS that enables the sustainable management of resources along the whole value chain[96]. As part of AMREC, the Pan-African Resources and Reserves Reporting Code (PARC) has been developed. This serves as a unified public reporting code and standard for African countries, and is needed for financial institutions such as the 25 stock exchanges represented by the African Securities Exchanges Association (ASEA)[97] It is envisaged that PARC will help to promote and secure investment in exploration and mining in Africa and assist investors in making informed decisions[96].

An important aspect of resource management in Africa is the addition of value to mineral production, which is also one of the UNRMS principles (Figure 2). As the majority of raw material production in Africa is exported overseas in the form of ores and concentrates, and is not further processed or refined, the economic benefit accruing to the producing country is low and the benefits to local communities are generally limited. The technical Working Group of AMREC recently completed case studies at four mines in Uganda with resources of gold, tin and salt to evaluate the sustainability of these projects. All four projects scored below expectations in terms of value addition and beneficiation[98].

Although AMREC is intended for use with both minerals and energy resources, the current focus of the centre's work is on mineral resources. The UNECE is supporting the development of AMREC with workshops and courses on the application of UNFC. There is also a need for significant capacity building and training before AMDC develops a greater involvement in the industrial and financial dimensions. The EU-funded Pan-African Support to the EuroGeoSurveys-Organisation of African Geological Surveys (PanAfGeo) capacity-building project99 helps European geological surveys to share their knowledge with African partners. It has incorporated UNFC into its training programmes in Africa.

5.3 COORDINATING COMMITTEE FOR GEOSCIENCE PROGRAMMES IN EAST AND SOUTHEAST ASIA

The UNECE is working with the Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) on developing an ICE-SRM for Southeast Asia. A workshop convened by both organisations in 2012 highlighted that efficient resource management and assessment over the whole Asia-Pacific region is key for the enhancement of energy security and sustainability in the region[100]. The CCOP has sixteen member states, including China, and its function is to coordinate geoscience programmes on many topics including sustainable resource development. There are also fifteen cooperating countries, which support the CCOP, including the United Kingdom. The current strategic plan of the CCOP includes the goal to develop an ICE-SRM for the standardisation of resource management in the region[101].

5.4 OTHER INTERNATIONAL COOPERATION OF UNECE

There are several other schemes in which the EGRM has collaborated with national ministries, institutions and mining authorities to implement the use of UNFC. In India the UNFC classification system was implemented in 2001 as the national resource classification system for solid fuels and minerals by the Indian Bureau of Mines. It has been updated to UNFC-2009, which is still in use and has not been updated to the current version UNFC-2019. A workshop held in 2013 encouraged stakeholders to actively use the classification system to support sustainable resource management[102].

Ukraine was the first country to mandate the use of UNFC in 1997[103]. In 2018, the national mineral resource classification system was modified and aligned to the UNFC-2009 system.

In central Asia a two-year project funded by the Russian Federation and completed in 2019 aimed at improving national capacities for sustainable management of energy and mineral resources and the application of

UNFC. Case studies and workshops were conducted in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan to improve the knowledge and skills of national stakeholders and to identify best practice for the use of UNFC in the region[104].

In Colombia a pilot project on the use of UNFC in the mineral sector commenced in 2021 in collaboration with the National Mining Agency of Colombia (ANM). Colombia has resources of gold, copper and several other minerals and metals that will be investigated during this project[105].

6 Application of UNFC by organisations not affiliated to the UNEC

The use of UNFC for resource classification has gone from being a relatively niche application to a well-established method over the last 5-10 years. Numerous case studies of individual projects and national exercises in resource classification using UNFC have been carried out in that period. Most have been undertaken by national geological surveys and other national research institutions with responsibility for long-term resource planning. There has been much less adoption by industry, who are generally required to use CRIRSCO template reporting standards for investor reporting.

There are few examples of the application of UNFC specifically to CRMs, with most studies having a more general scope. It is important to note that those issues concerning most minerals are also applicable to CRMs. However, the converse is not necessarily true as some issues related to CRMs are not relevant to other mineral commodities. A notable example was published in 2021 by Horn, et al. [106]. This study compared cobalt deposits across Europe using UNFC and showed how it can be used for comparison of a wide range of deposit types at different development stages on a continental scale. There have also been several studies concerned with petroleum resources, but these are beyond the scope of this report.

6.1 EUROPE

Many of the completed case studies are based on European examples. This is because the application of UNFC in Europe is being strongly promoted by the European Commission and by research carried out by the Joint Research Centre (JRC) and under the EU-funded H2020 programme. The use of UNFC is now a specific requirement of many European funding calls regarding raw materials (specifically by the Horizon program[107]). A detailed description of the development of UNFC in Europe can be found in Bide [108]. The most significant recent activities are described below.

6.1.1 Mintell4EU

The Mintell4EU project[71] covered a wide range of themes relating to primary and secondary resources in Europe. The project collected data on mineral resources from about 30 European countries. Although the data were requested to be provided using UNFC only a small amount was reported in this format, with most being in national codes or other industry standards. However, this was still a significant improvement on the previous data collection exercise carried out in 2015 for the Minerals4EU project[109], when almost no data was reported in UNFC. The most useful aspect of the Mintell4EU project for resource management was the compilation of several case studies demonstrating the applicability of UNFC. These dealt with various commodities in several different countries and are useful to assess the current status and key challenges concerning the application of UNFC across Europe. They also provided recommendations for optimizing resource classification and aggregation procedures using UNFC. Nineteen case studies were undertaken, with several related to CRMs (including cobalt, REEs, manganese and graphite). The work highlighted significant data gaps in the reporting of co- and by-product minerals, as well as the lack of reporting for many industrial minerals[110]. The case studies form a body of work that can guide other potential users in the application of UNFC. They also showed clearly how UNFC can be used to develop a national inventory of resources (and barriers to development) alongside data gaps.

6.1.2 Geological Service for Europe

The Geological Service for Europe[111] is a planned programme of work under the Horizon Europe funded Coordination and Support Action (CSA). The Service aims to operate over a range of geoscience themes involving: collection, storing and analysing data; providing advice to government; and creating data products and services aligned to European strategy and policy. One work package is focussed specifically on the

implementation of UNFC/UNRMS in Europe. The main objectives of this are:

- to re-evaluate European resources in primary raw materials, in both onshore and offshore domains, and in mining wastes, with a focus on critical raw materials, filling existing gaps in harmonised data and information at the European level;
- to create and develop the EU international Centre of Excellence in Sustainable Resource Management;
- to promote the use of UNFC and UNRMS for mineral resources management in Europe.

This work is the continuation of a series of European-funded projects looking at mineral resource reporting and UNFC in Europe but has a long-term focus in setting up a permanent European ICE-SRM (see section 5.1). This project aims to build capacity related to UNFC/UNRMS and to establish a knowledge centre for promoting the UNFC and supporting the UNRMS.

6.1.3 EuroGeoSurveys (EGS) UNFC practitioner group

This expert group, set up in the second half of 2021 aims to bring together geological surveys in Europe to share experiences of use of UNFC from practical examples of projects undertaken by members, providing good practice on the application of UNFC and feedback of relevant experience to UNECE. The group is not limited to EU member states and has UK representation. It has direct links to UNECE and significant overlaps with the work proposed by the Geological Service for Europe.

6.1.4 Raw Materials Information System (RMIS)

The RMIS is the JRC's web-based repository for information on non-fuel and non-agricultural raw materials to provide and share key raw materials data within and beyond Europe[112]. The platform hosts a wide range of data and publications including commodity and country profiles, trade data, foresight studies and policy and legislation. It is part of the EU Raw Materials Knowledge Base (EURMKB), a collaboration between JRC and Eurostat (the European Commission Directorate-General for statistics). The platform hosts the European criticality studies for CRMs and the data behind them. These are in the form of the European list of critical raw materials, a series of detailed factsheets and maps showing major deposits (although not with resource data). Resource data available in UNFC format from the Mintell4EU project is provided in country profiles. Of specific relevance to resource management are efforts by JRC to conduct MFA for a range of materials (including CRMs). The MFA studies use standards for data reporting set out by the EU-funded Minventory study[113]. The MFA approach is essential for anything that requires detailed understanding of the value chain and associated stocks and flows of CRMs, such as detailed commodity or product-based management, as required by policies such as sustainable sourcing or battery passports.

6.1.5 Horizon Europe projects

This recently-closed call for the Horizon Europe programme included specific mention of developing a database with harmonised data on mineral resources and reserves according to UNFC. It also included a call for proposals on the development of an EU International Centre of Excellence on Sustainable Resource Management focused on promoting and building capacity on UNFC for mineral resources (primary and secondary) and supporting the UNRMS in line with the UN 2030 Agenda for Sustainable Development (see section 6.1.2). Most EC-funded research on the application of UNFC and UNRMS in the near future will be funded by this programme.

6.1.6 European Raw Materials Alliance

The European Raw Materials Alliance (ERMA)[114] was initiated in September 2020 as part of the Action Plan on Critical Raw Materials[115]. The Alliance, funded by the EC and industry partners, forms a network of international public and private sector organisations representing the entire raw materials value chain. The priority areas of work are rare earth magnets and motors, batteries and fuel cells, aiming to identify barriers, opportunities and investment cases to build European capacity in CRMs. No results of the Alliance's work have been published, but a workstream in development is a database for all CRM projects in Europe

(from across the value chain). These are required to be reported using the UNFC. This development highlights how industry partners may begin to use the classification system and diversify its use away from mainly national institutions.

6.1.7 National studies

6.1.7.1 Nordic countries

In 2017 the geological surveys of Norway (NGU), Sweden (SGU) and Finland (GTK) published guidance for the application of UNFC for mineral resources[116]. The document aimed to support users in the Nordic countries by clarifying how the UNFC can be used to facilitate policy and strategy formulation, for government resource management, for industry business processes and for project capital allocation. The document promotes the use of UNFC in the target countries giving additional guidance through the use of specific examples. The document was published with the aim of stimulating minerals exploration and simplifying licensing procedures by using UNFC to standardise data. It also served to highlight potential barriers to project development as well as allowing government to aggregate resource data on national and regional levels to aid policy development. The project was also concerned with how UNFC can be applied to provide better harmonisation of mineral resource data across projects ranging from poorly-known, reconnaissance stage prospects to well defined resources and reserves.

This document recognises that the industry reporting standards are mostly employed in developing or on-going mining projects and are required only for listed companies. These industry standards are not used, nor intended to be used, comprehensively, and are therefore not suitable tools for comparing and aggregating resource, and potential resource, inventories.

NGU is also currently working to convert the Norwegian resource inventory and historic data to UNFC. NGU has also conducted individual case studies for specific commodities, although none on CRMs (section 3.1.1). The use of UNFC and other standards (specifically INSPIRE nomenclature) has allowed NGU to categorise its mineral database according to national importance.

Finland began using UNFC for its resource inventory in 2014 and case studies[48,110,116] have been undertaken on a variety of commodities since. In these studies deposits have been classified according to the UNFC for demonstration purposes and a formal reporting exercise to classify according to UNFC is ongoing. Through the Mintell4EU project GTK is planning to make a UNFC report for one of these case studies. GTK is also currently undertaking UNFC classification of all mineral resources and reserves. This is a complex task, with GTK having identified many non-compliant resource estimates and data gaps (especially with regard to by- and co-product CRMs) as significant issues.

6.1.7.2 Polish Minerals Yearbook

The Polish Geological Institute (PGI)[117] has compiled a detailed case study converting the Polish classification system to the UNFC in its publication ‘The Mineral Resources of Poland’. This outlines in detail how the Polish classification system can be bridged across to the UNFC and explores some of the issues such as the lack of a definition for ‘reserves’ in the Polish system.

This case study shows the difficulty in converting data between two systems that, although they share many basic principles, have many substantial differences. For example, the Polish system is hierarchical and higher-level categories include figures from lower level ones, as opposed to UNFC in which no category is included within another. Despite such barriers, a robust system for bridging between the two classifications systems has been developed, and the PGI is able to publish an inventory of its national mineral resources using UNFC[118].

6.1.7.3 UK case study

As part of the ORAMA project, BGS attempted to create an inventory of national resources for the UK using the UNFC. The UK has no centralised system of data collection for mineral resources, although data are collected for some aggregate minerals[108]. As a result, for most commodities BGS had to compile resource figures from a range of disparate sources such as company

reports, historical estimates, regional assessments and data inferred from geological mapping.

This work attempted to create a resource inventory using the full range of categories available in the UNFC. Consequently, efforts were made to collect both published industry data and data for the uneconomic parts of individual deposits where geological and economic confidence was low. In some cases, figures were calculated using spatial analysis to estimate the quantities of resources for certain minerals (mainly for aggregate and industrial minerals where deposit level data is lacking). There are considerable inherent uncertainties associated with such calculations. This was done by applying assumptions, such as thickness of deposit, mineral to waste ratios and mineral quality, to surface mapping of mineral resources, which had been conducted previously by BGS. This method of spatial analysis using geological information is the only way to estimate inferred resource quantities for many minerals in the UK due to a lack of any data.

Other studies in the UK are currently being carried out by the Circular Economy Centre of Technology Metals (Met4Tech[119]), which is developing a comprehensive circular economy geomodel on mineral resources in southwest England. The region has a long mining history and there are several exploration companies currently exploring for copper, tin, tungsten, zinc and lithium. The Met4Tech Working Group at the Camborne School of Mines is collaborating with some of these companies to build an inventory of mineral resources for the area using the UNFC system. The focus lies on the technology metals lithium, tin and tungsten. The case study also aims to develop an integrated resources management system including not only primary resources, but also secondary, anthropogenic and energy resources in their model. It will also consider the environmental, social and economic implications of the technology metals industry in the region[119]. It is therefore considering the use of the UNRMS to incorporate all these factors into a regional resource management system. This includes potential application of the concept and UNRMS principle 'Resource as a Service'. The idea behind 'Resource as a Service' is that materials do not change ownership through their life cycle, but are seen as a service to a subscriber at the centre of the business model. The concept aims to improve traceability of materials and to retain the highest value in a circular economy[120].

6.1.7.4 HUNGARIAN CASE STUDY

The Hungarian Geological Survey (MBFSZ) has conducted several case studies[108,110], converting their mineral resource inventory to UNFC. Most of these are concerned with construction minerals. Hungary has a national resource code[121] based on the Russian system, which is fundamentally different to that of some industry standards (e.g. the Pan European Reserves and Resources Reporting Committee (PERC) etc.), although both are actually CRIRSCO-compliant. MBFSZ is also an active member of the UNECE expert group for resources.

6.2 CURRENT UK RESEARCH INTO CRM'S AND RESOURCE MANAGEMENT

The following provides an overview of the major initiatives in the UK that have an interest in data standards or resource management for CRMs. There are many initiatives currently looking at data collection, standards, and supply issues around CRMs. The Critical Elements and Materials (CrEAM) network was set up in 2017 in response to potential supply shortages faced by industry. The network has produced a policy document[16] containing detailed background on many aspects of the critical metals value chain. Within the policy document there is specific mention of the UNRMS but only with regard to resource governance tools for the ESG aspects of sourcing. The policy document additionally highlights a lack of data for technology critical metals, both primary and secondary, specifically with regard to the material flows. Data for cobalt and nickel are highlighted as being insufficient to allow traceability across the UK supply chain. The lack of data on the location of components such as batteries and magnets in waste supply streams is also highlighted.

The policy document supports resolution of these data issues through the establishment of a National Materials Datahub (NMDH)[122].

The development of this is currently being explored by BEIS, ONS and via the UKRI Circular Economy programme through the Met4Tech project. This collaboration would bring together data of sufficient granularity on sources, stocks, flows and destinations of primary and secondary materials. It would provide a macro-level view of bottlenecks, scarcities and opportunities for sourcing and producing recycled material of specified grades and enable scenario modelling. The NMDH was suggested after an initial scoping phase in 2018 identified significant data gaps in tracing materials across UK value chains and that available data was not sufficiently granular (with regard to a breakdown of products and commodities as well as timescales). The discovery phase focussed on plastic bottles. It is likely that CRMs would be considerably more difficult to unravel due to the complexity of their value chains compared to plastic bottles. The NMDH will also investigate innovative technologies, such as the use of blockchain and the creation and use of synthetic datasets. However, there are still significant feasibility questions regarding competition concerns from the collection of industry data. It is recognised that there needs to be a cultural change over the collection of such data. The NMDH is focused on transparency and traceability of supply, potentially significantly overlapping with other UK work on battery passports and also the objectives of UNRMS. It is also looking at common product classifications, similar to the work of the REE and Lithium ISO technical committees (see section 4.1.1).

Closely related to this is the Critical Minerals Intelligence Centre (CMIC), which is mentioned in the October 2021 Net Zero strategy[35] by BEIS and currently in a proposal stage. It will focus on mapping of critical mineral stocks, flows and associated risks. Similarly, the Met4Tech project will be producing MFA analyses of a variety of technology metals (as well as conducting a UNRMS pilot study, see section 6.1.7.3). This work is currently feeding into the development of the NMDH.

The ONS Integrated Data Service (IDS), which started in in March 2021, is planned to be developed over a four-year period. The IDS is building a central data service enabling access across government. It is potentially scalable to wider public services and beyond.

Part of this work involves a new UK-based criticality assessment undertaken by BGS[6] to generate a critical raw materials list for the UK. This work, funded by BEIS, was carried out to inform the UK critical mineral strategy due to be published in 2022. This is being guided by an expert group of industry and academic experts, the Critical Minerals Expert Committee (CMEC). The UK's CRM industry has formed the Critical Mineral Association[123] (CMA) as a trade body. It was founded by companies with interests in mineral development in south-west England as well as mineral processors and others with interests in various stages of the CRM value chain. The CMA has provided resources for the formation of an All-Party Parliamentary Group on critical minerals[123].

There also several work programmes looking specifically at the need for traceability in CRM supply chains. The UKRI-funded Faraday Battery Challenge, although focused on battery technology, includes work to reduce the harmful impacts of manufacture and technologies to improve recycling. UK research (through the National Physics Laboratory, NPL) is represented through the Global Battery Alliance who are in the early stages of developing passports, as outlined in their Vision for a Sustainable Battery Value Chain in 2030[124]. The minerals industry is beginning to adapt to these new requirements and there are UK-based consultancy services using innovative techniques and technologies to provide traceability and value chain mapping. Such examples may provide insight as to how sector-wide or national implementation of these polices may be achieved.

Other UK-focussed projects related to CRMs include:

- The Global Supply Chains Intelligence project, run by the Department of International Trade, funded by HM Treasury. This two-year project plans to build prototype datasets as a proof-of-concept pilot exercise designed to improve understanding of global supply chains. This project is pan-governmental in scope and has also begun to engage with industry, including a central platform for Bill of Lading (Detailed list of a ship's cargo) data.

- In 2019 DEFRA funded an initiative to establish an electronic waste tracking system[125]. This system allows real-time tracing of waste flows and will contain information regarding the quantities and composition of waste as well as the source and destination. It is designed to help track prohibited waste being shipped overseas and illegal waste activity in the UK. It aims to replace the existing paper-based system and aligns with the requirements of the Environment Bill in terms waste tracking.
- The Cabinet Office has initiated a programme of work to develop a Single Trade Window (STW) for UK trade[126]. This will enable traders to submit their supply chain data through a single trusted system with the data being available to all relevant border authorities and agencies. This will allow better risk assessment and traceability of goods and is currently being tested on commodities including REEs. This aligns with the 2025 Border Strategy policy document[127].

Many of these initiatives contain provision for the development of MFAs for CRMs or mapping of supply chains for sustainable sourcing, aspects which are all well aligned with UNRMS principles and provide opportunities for future collaboration.

7 Current landscape overview and conclusion

Driven by the goals set by the Paris Agreement and the 2030 Agenda, there are two major challenges facing the security of future supply of CRMs:

- the need to rapidly increase supply of metals that were previously used in small amounts, but which are now required in much larger quantities for low carbon technologies such as batteries and clean energy generation.
- the need to ensure supply is low-carbon, causes minimal environmental harm and provides long-term social and economic benefits to affected communities.

It should be noted that the second of these challenges is equally applicable to minerals and metals that are not currently classified as critical.

The longstanding need to maintain positive trading links with international partners is also increasingly important as the UK is heavily reliant on imported supplies of minerals and metals. CRMs enter the UK economy from numerous overseas sources in a multitude of forms including ores and concentrates, refined metals, intermediate materials and incorporated in products.

In response to these challenges, international organisations, national governments and NGOs have produced a wide range of new policy, legislation, standards and tools to enable a transition to a sustainable, zero-harm supply chain, meeting the decarbonisation and circular economy agenda. The UNFC and UNRMS are important examples of these tools.

The UNFC has rapidly transitioned from a new and niche toolkit for the classification and management of resources to a widely accepted means for the classification and comparison of resources on a variety of scales. The use and international acceptance of UNFC seems set to increase in response to diverse drivers and demonstrated applications:

- mandatory use in Horizon Europe funding calls
- mandatory inclusion in the new European Raw Materials Alliance
- integration within the planned Geological Service for Europe
- the development of UNECE Centres of Excellence for Sustainable Resource Management
- the development of AMREC and PARC in Africa
- the adoption of UNFC for use in national reporting (e.g. Ukraine)
- the creation of national case studies using UNFC for resource inventories
- the development of UK national case studies by BGS and the regional application in south-west England by the Met4Tech project.

The success of UNFC is derived from its ability to facilitate rapid comparison across multiple commodities and resource types. The integration of an ESG component also adds considerably to its value.

UNFC has become a widely adopted tool for resource reporting due the ease with which a wide range of datasets can be included. It is not limited to the ‘currently economic’ subset as many industrial standards are. It can also simply show the barriers to project development through the use of a three axis classification. This permits better understanding of the policy interventions that may be required to develop projects and how resource management is best undertaken with respect to the criteria set out in the three axes. For example, the use of UNFC in AMREC allows direct comparison of projects, notably in terms of their ESG performance. This helps to determine which projects should be developed.

UNFC is not, however, widely used by the extractive industry, where industry standards are well suited to their business models. This is a significant issue as industry stakeholders are the ultimate creators and reporters of data. This may change in the future as a result of the work of the UNECE International Centres of Excellence. These centres should stimulate increased uptake, and promote the use of, UNFC in national standards and in policy which may introduce a requirement for the use of UNFC in resource reporting.

Whilst UNFC is a useful tool it does not cover all the data requirements for the entire value chain. It does not give a framework for detailed ESG reporting, although it does have a clear ESG focus on the 'E' Axis. Furthermore, it does not map stocks and flows and does not include data for 'emissions'. It can be used for some aspects of resource management but is far from a holistic system for understanding, reporting on, and management of the entire value chain. A detailed understanding of all these aspects, together with associated data for their measurement, are becoming increasingly important for many new policies, including those related to:

- Material traceability and product passports, as required by Ecodesign regulations, conflict mineral regulation and the Batteries Directive, which require integration of a wide range of metrics, from ESG through to manufacturing and recycling.
- Decarbonisation as identified in the Environment Act[41], EU Green Deal[30], UK Industrial Strategy[37], the Integrated Review[40] and the UK Net Zero strategy[35].
- Transition to circular economy, as stated in the Environment Act, EU Circular Economy Action Plan[29], the EU Green Deal, UK Industrial Strategy, Integrated Review of Security, Defence, Development and Foreign Policy[40] and Net Zero Strategy require the generation of detailed stocks and flows data to fully understand value chains and to implement concepts such as 'Resource as a Service'.
- Security of material supply, as required by the G7 Economic Resilience Panel policy recommendations[26], the Integrated Review of Security, Defence, Development and Foreign Policy and the UK Net Zero Strategy. This requires detailed understanding of the location and attributes of mineral resources, both domestically and internationally, as well as knowledge of processing technology and capacity, supply bottlenecks and trade flows.

The quantity, quality and variety of data required to achieve these aims are complex and their integration into the entire supply chain is not possible using current tools such as MFA, Life Cycle Assessment (LCA), and UNFC for CRMs. In this respect UNRMS could play an important complementary role alongside the existing tools. UNRMS has many similarities with these tools and has the added benefit of being able to link points in the value chain to ESG and other data as well as stocks and flows.

The UNRMS is currently at the conceptual stage but could provide the framework (via the incorporation of UNFC) to meet these policy objectives. How exactly the various existing systems could be harmonised and how new data can be incorporated into UNRMS are yet to be decided, but there are clearly significant synergies and scope for collaboration with UNECE.

One significant issue is the lack of data on ESG metrics for stocks and flows data. The absence of this data will continue to be a major obstacle to the development of a holistic and broadly applicable resource management system. While some data may be available, its quality and granularity may not be fit for purpose. In other cases data may exist but insufficient metadata granularity reduces its usefulness. In addition, industry will need clear guidance on the information they need to report and the required data format.

There is clearly a high level of interest in these issues with many, diverse initiatives and projects underway or in the planning stages in the UK that deal with some aspects of an integrated resource classification and management systems. A unified approach to the standardisation of frameworks, classifications and tools, as potentially available from the UNRMS, would, therefore, be mutually beneficial to all stakeholders, as would opportunities for shared learning with current and planned programmes of the UNECE.

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Appendix 1 Acronyms used

RESOURCE CODES, CLASSIFICATIONS AND STANDARDS

AMREC	The African Mineral Resource Classification is an Africa-specific resource classification based on UNFC.
CBBR	Guide for Reporting Exploration Results, Mineral Resources, and Mineral Reserves in Brazil.
CCRR	Comisión Colombiana de Recursos y Reservas Mineras, the Columbian mineral resource standard.
Certification Code for Exploration Prospects, Mineral Resources and Ore Reserves (Chile)	The code required for resource reporting in Chile.
CFCP	Conflict-Free Smelter Programme by the Conflict-Free Sourcing Initiative.
CIM	Canadian Institute of Mining Metallurgy and Petroleum, which develops the NI 43-101 reporting code.
CIRAF	The Cobalt Industry Responsible Assessment Framework, by the Cobalt Institute. The Cobalt Institute is a trade association composed of producers, users, recyclers and traders of cobalt.
CRIRSCO	Committee for Mineral Reserves International Reporting Standards. Body responsible for publishing and maintaining the CRIRSCO International Reporting Template ('CRIRSCO Template'). Member organisations of CRIRSCO are known as National Reporting Organisations (NROs) from 7 countries and regions (including Europe). Each is responsible for developing and maintaining a code or standard incorporating CRIRSCO definitions and principles alongside national or regional regulatory requirements.
ESG	Environmental, Social and Governance; this represents a set of standards and metrics to ensure development takes place with a social licence to operate, minimising environmental harm and benefiting local communities. It can relate to specific projects or companies and often used by investors/ financiers to assess risk.
INSPIRE	Infrastructure for Spatial Information in the European Community. The INSPIRE Directive in Europe establishes an infrastructure for spatial information to support community environmental policies and policies or activities that may impact on the environment. The purpose of the INSPIRE Directive is to ensure that the spatial data infrastructures of the Member States are compatible and usable in a community and trans-boundary context.
JORC	Joint Ore Reserves Committee. A body managing the JORC Code which is the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves. JORC is a

	member of CRIRSCO, being the National Reporting Organisation for Australasia. Reports prepared in accordance with the JORC Code and issued with a certificate of consent from the Competent Persons who prepared them are accepted by all major international stock exchanges including those regulated by the European Securities and Market Authority (ESMA) in Europe.
KAZRC	The Code of the Republic Kazakhstan subsoil and subsoil use (including minerals).
KCMI Code	Indonesian Committee for Mineral Reserves.
MRC Code	Mongolian Resource Committee Code
NAEN	Russian Code for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves. Published by The Society of Russian Experts on Subsoil Use (OERN). Reports prepared in accordance with the NAEN Code and issued with a certificate of consent from the Competent Persons who prepared them are accepted by stock exchanges including those regulated by ESMA in Europe.
NI 43-101	National Instrument for Standards of Disclosure for Mineral Projects within Canada. The reporting code is developed by the Canadian Institute of Mining Metallurgy and Petroleum (CIM). The code is used by companies listed on the Toronto Stock Exchange.
PARC	The Pan African Resource/Reserve Estimation Code is a planned code for the public reporting of minerals for stock exchanges and legal purposes in Africa.
PERC	Pan-European Reserves and Resources Reporting Committee. A not-for-profit organisation responsible for the PERC Reporting Standard, which incorporates all definitions and principles set out in the CRIRSCO International Reporting Template. PERC is a member of CRIRSCO being the National Reporting Organisation for Europe. Reports prepared in accordance with the PERC Standard and issued with a certificate of consent from the Competent Persons who prepared them are accepted by all major international stock exchanges including those regulated by ESMA in Europe.
PRMS	Petroleum Resources Management System. A petroleum resources classifications framework sponsored by a range of industry bodies and published by the Society of Petroleum Engineers (SPE).
RCI	Responsible Cobalt Initiative, by the Chinese Chamber of Commerce for Metals, Minerals & Chemicals (CCCMC) and the OECD.
RMAP	Responsible Minerals Assurance Process. An assessment utilising independent third-party of smelter/refiner management systems to

	ensure a company-level management processes for responsible mineral procurement.
SAMREC	South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves. A Working Group under the joint auspices of the Southern African Institute of Mining and Metallurgy and the Geological Society of South Africa. Responsible for the South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves ('SAMREC Code'). SAMREC is a member of CRIRSCO being the National Reporting Organisation for South Africa. Reports prepared in accordance with the SAMREC Code and issued with a certificate of consent from the Competent Persons who prepared them are accepted by all major international stock exchanges including those regulated by ESMA in Europe.
SDG	Sustainable Development Goals. These are 17 integrated goals, developed by the UN, and set out in the 2030 Agenda, and are designed as a call to action to end poverty, protect the planet and ensure that by 2030 all people enjoy peace and prosperity.
SEEA	System of Environmental-Economic Accounting. This is a framework that integrates economic and environmental data to provide a comprehensive view of the inter-relationships between the economy and the environment and the stocks and changes in stocks of environmental assets they bring.
SNA	System of National Accounts is the internationally agreed set of recommendations on how to compile measures of economic activity.
SPE-PRMS	Society of Petroleum Engineers - Petroleum Resource Management System.
TSM	Towards Sustainable Mining Initiative by the Mining Association of Canada.
UMREK Code	National Resources and Reserves Reporting Committee for Turkey.
UNFC	United Nations Framework Classification for Resources.
UNRMS	United Nations Resource Management System (incorporates the UNFC).

ORGANISATIONS AND GROUPS

AMDC	African Minerals Development Centre
ANM	National Mining Agency of Colombia
AUC	African Union Commission
AfDB	African Development Bank
BEIS	Department for Business, Energy & Industrial Strategy of the United Kingdom

BGR	Geological Survey of Germany
BGS	British Geological Survey
BRIC	Group acronym for Brazil, Russia, India and China
BSI	British Standards Institute
CCCMC	Chinese Chamber of Commerce for Metals, Minerals & Chemicals
CCOP	Coordinating Committee for Geoscience Programmes in East and Southeast Asia
CIS	Commonwealth of Independent States in Eastern Europe and Asia
CMA	Critical Metals Alliance
CMIC	Critical Minerals Intelligence Centre
CMEC	Critical Metals Expert Committee
DEFRA	The Department for Environment, Food and Rural Affairs of the United Kingdom
DG Grow	The European Commission's Directorate-General for internal market, industry enterprise and SMEs
EGS	EuroGeoSurveys. The Geological Surveys of Europe, a not-for-profit organisation representing 33 national geological surveys and some regional geological surveys in Europe.
EITI	The Extractive Industries Transparency Initiative
ERMA	European Raw Material's Alliance
ESMA	European Securities and Market Authority
EUES	Eurasian Union of Experts in Subsoil in Subsurface Management
GeoZS	Geological Survey of Slovenia
GKZ	Russian Ministry of Natural Resources
GTK	Geological Survey of Finland
GRI	Global Reporting Initiative
MBFSZ	Hungarian Geological Survey
ICMM	International Council on Mining and Metals
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IRMA	Initiative for Responsible Mining Assurance
ISO	International Standards Organisation
JRC	Joint Research Centre, the EC's science and knowledge service
LME	London Metal Exchange
MAC	Mining Association of Canada
MBFSZ	Mining and Geological Survey of Hungary
MINEA	Mining the European Anthroposphere
MREG	Mineral Resources Expert Group (one of several EuroGeoSurveys' expert groups)

MSU	Moscow State University
NGU	Geological Survey of Norway
NPL	National Physical Laboratory
OECD	Organisation for Economic Co-operation and Development
OERN	Society of Russian Experts on Subsoil Use.
ONS	Office for National Statistics of the United Kingdom
PanAfGeo	Pan-African support to the EuroGeoSurveys' Organisations of African Geological Surveys. An EU-led capacity building programme in Africa.
RMI	Responsible Minerals Initiative
RINR	Regional Initiative against Illegal Exploitation of Natural Resources
SGU	Geological Survey of Sweden
STW	Single Trade Window by the UK Cabinet Office
UKRI	United Kingdom Research and Innovation
UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UNECE EGRM	United Nations Economic Commission for Europe - Expert Group on Resource Management, formerly the Expert Group on Resource Classification (EGRC).
USGS	United States Geological Survey

OTHERS

3T or 3TG	Acronym for the minerals tin, tantalum and tungsten (including gold for 3TG).
CRM	Critical Raw Material. These are raw materials that are deemed to be economically and strategically important but have a high risk associated with their supply.
EURMKB	European Union Raw Materials Knowledge Base
ICE-SRM	International Centre of Excellence on Sustainable Resource Management
IDS	Integrated Data Service, developed by the Office of National Statistics
LCA	Life Cycle Analysis. This is a method used to evaluate the environmental impact of a product through its life cycle.
NGO	Non-Governmental Organisation
MFA	Material Flow Analysis. This is an analytical method to quantify flows and stocks of materials or substances.
NMDH	National Materials Datahub. This is a planned collaboration between several government bodies to gather and manage sufficient data on raw materials to allow better understanding of UK supply chains and future scenario modelling.
REE	Rare Earth Element. This is a group of 17 chemically-similar metals that are essential to many applications in new and green technology.
RMIS	Raw Materials Information System (administered and managed by JRC)
SDG	Sustainable Development Goals

Appendix 2 Glossary

Anthropogenic Resources

See ‘Secondary raw materials’

By-product

By-products are materials that are produced incidentally to the main economic product(s) of a mining operation. They are typically present at very low levels in the ores of the main or parent product. They generally lack their own production infrastructure and make no, or only a minor, contribution to the economic viability of a project. Extraction and processing technologies aim to maximise recovery for the main commodity, so, if recovery of by-products is undertaken, it is commonly inefficient and large amounts may go into waste streams. In addition, data on production and resources of by-products are not always reported so that resource management of these materials is difficult.

Circular Economy

A circular economy is an economic system of closed loops in which raw materials, components and products lose their value as little as possible, renewable energy sources are used and systems-thinking is at the core. It involves practices such as sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and keeping products in use for as long as possible. The possibility of 'resources as a service' is an example of a circular economy practice.

Co-product

Co-products are materials that occur together in nature and are, therefore, generally mined together. All co-products make an economic contribution to the project from which they are sourced. The platinum-group metals and the rare earth elements are examples of co-product groups that are produced together, sometimes in conjunction with other co-product metals such as nickel or copper.

Flow

In the context of material streams (raw materials, secondary raw materials, wastes etc.) or their components, this is the mass per unit time (i.e. tonnes per year) passing through a defined point or set of points or boundary (e.g. waste collection facilities) in a system (e.g. production, consumption and waste). (Also related to 'Stock' as per entry below.)

Geological stocks

Geological stocks represent the geological endowment of a mineral or commodity, unaffected by economic, technical or environmental considerations, within a particular orebody, deposit or project. It is the maximum amount of commodity that may be extracted from that entity.

Life Cycle Assessment (LCA)

Life Cycle Assessment is the analysis of the environmental impacts associated with all stages of the lifecycle of a specific product. It is an important tool for environmental management. The assessment may include identification of different mass and energy flows, as well as emissions of pollutants and wastes into the environment and their ultimate effects on human health, ecosystem function and the use of non-renewable resources. Typical parameters, which are used to measure these impacts are greenhouse gas emissions (CO_2-equivalent), energy use, water use and SO_x and NO_x emissions. Compared to material flow analysis, an LCA is the analysis of one product containing various materials, while MFA analyses the mass flows of one specific material in various products. (see ‘MFA’).

Material Flow Analysis (MFA)

Material Flow Analysis (MFA) is a tool for investigating material flows and stocks within a system defined in space and time and is based on mass-balance principles. It is used mostly in the management of resources, waste and associated environmental impacts. The detailed analysis of the mass quantities in various products and wastes where a specific material occurs through the supply chain (extraction, processing, manufacturing, recycling, etc.) makes it possible to identify data gaps and material losses. Dynamic material flow analysis can be used to identify future demand and potential supply bottlenecks by using forecasts and scenario analysis. Compared to Life cycle assessment (LCA), MFA focuses on a certain material, occurring in different products, while an LCA analyses the environmental footprint of the

production of a particular product, which can contain various materials. (see ‘LCA’).

Battery/product Passport

This is the digital representation of a battery or product (or 'digital twin') that contains information on a variety of metrics, which may include data on ESG performance related to competent extraction and manufacture, to energy use, composition and recycled content. It is designed to help to improve transparency and traceability of a product through its life cycle.

Raw materials

Raw materials are metalliferous minerals, industrial minerals, and construction minerals that have undergone minimal processing and purification and which are used by industry for the manufacture of products. For the purposes of this study they exclude wood and natural rubber.

Reporting Code

A code of practice that sets the minimum requirements for reporting mineral resources and reserves. Reporting Codes are incorporated in the laws of a particular jurisdiction and, therefore, provide a mandatory system for the reporting of mineral resources and reserves. In many cases reporting codes are used at a national level for public authority reporting (national reporting). However, well-established national reporting codes, such as the JORC code, NI 43-101, SAMREC and NAEN code, aligned to the CRIRSCO reporting template are recognised for use in public reporting of mineral resources and reserves used for financial markets. A reporting code incorporates two parts:

- A classification system, which allows the organisation of different levels of geological data in relation to levels of confidence and different degrees of technical and economic evaluation.
- The reporting rules, which prescribe the underlying principles on the reporting of mineral resources, mineral reserves and exploration results based on the reporting terminology and categorisation set by the reporting code classification system.

Reporting Standard

A code of practice that sets the minimum requirements for reporting mineral resources and reserves. Like a reporting code, a reporting standard is recognised by an official body such as a stock exchange regulator for use by companies or other entities in public reporting of mineral resources and reserves. An example is the CRIRSCO-aligned Pan-European Reserves & Resources Reporting Standard (PERC 2013) which is recognised by ESMA and a number of other stock exchange regulators in Europe and elsewhere. However, a Reporting Standard is not incorporated in the laws of a particular jurisdiction. This is what distinguishes it from a reporting code.

Like a reporting code, a reporting standard incorporates two parts:

- A classification system, which allows the organisation of different levels of geological data in relation to levels of confidence and different degrees of technical and economic evaluation.
- The reporting rules, which prescribe the underlying principles on the reporting of mineral resources, mineral reserves and exploration results based on the reporting terminology and categorisation set by the reporting code classification system.

Reporting template

A template is not itself a standard or a code but is a prototype designed to be used in preparation of new standards or codes. The CRIRSCO template is based upon an agreed set of the common features of standards and codes maintained by the members of CRIRSCO.

Reserve

According to the CRIRSCO definition a ‘mineral reserve’ is the economically mineable part of a measured and/ or indicated mineral resource. It includes diluting materials and allowances for losses that may occur when the material is mined. Appropriate assessments to quantify the 'modifying factors' which may include feasibility studies, have been carried out and include consideration of and modification by realistically assumed mining, metallurgical,

economic, marketing, legal, environmental, social and governance factors. These assessments demonstrate that, at the time of reporting, extraction could reasonably be justified. Mineral reserves are subdivided in order of increasing confidence into probable mineral reserves and proved mineral reserves.

Resource

According to the CRIRSCO definition a 'mineral resource' is a concentration or occurrence of material of economic interest in or on the Earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, continuity and other geological characteristics of a mineral resource are known, estimated or interpreted from specific geological evidence and knowledge. Mineral resources are subdivided, in order of increasing geological confidence, into inferred, indicated and measured categories.

Resource as a service

The concept that materials do not change ownership through their life cycle, but are seen as a service to a subscriber at the centre of this business model. The concept aims to improve traceability of materials and retain the highest value in a circular economy.

Resource management

With regard to minerals, this refers to ensuring the maximum economic benefit is realised and maximum value is added, throughout the life time of a project. Traditionally it refers to mining and processing practices, but is now commonly applied more holistically to include the complete life cycle of a material within a product.

Responsible sourcing

Responsible sourcing refers to the practice of ensuring social and environmental considerations are considered when materials are sourced. This aims to ensure materials are sourced with minimal environmental damage, while maximising benefits for affected communities. It addresses sustainability risks in global supply chains.

Secondary raw materials

Waste materials that have been identified for their potential of recycling or reprocessing to generate raw materials (potentially displacing the use of primary materials). They include: mining wastes, manufacturing and processing waste, including scrap, and the contents of landfill. They are also referred to as anthropogenic resources (i.e. raw material stocks found in the anthroposphere). For the purposes of this study, only the long-lived, accumulated and hence permanently geo-located sources have been considered, namely mining and landfill wastes.

Stock (Inventory)

In the context of materials, this is the quantity (typically mass or volume) held at a given point (e.g. a landfill) or set of points (e.g. all waste facilities) in a system at a given time. (see 'Flow').

Supply chain

The supply chain represents all aspects of a material's lifecycle from extraction (in the case of primary minerals) through to processing, manufacture, use, reuse, recycling and disposal. It is usually represented diagrammatically as an input/ output model of stocks and flows and is conceptualised via MFA. Supply chain mapping allows understanding of how materials flow through society and the economy. The term supply chain is often used interchangeably with 'value chain'.

System of reporting

The term is used in this report to describe a reporting code or standard as they both serve similar purposes (i.e. the reporting of mineral resources and reserves). It is introduced to simplify the use of the terms reporting code and reporting standard where it is impossible to distinguish between the two and, in particular, where the harmonisation of data across Europe is discussed.

Appendix 3 Summary information for projects, programmes and policies discussed in this document

PROJECT/ PROGRAMME

Name of project:	African Minerals Development Centre (AMDC)
Web link	https://archive.uneca.org/amdc
Timescale	Started in 2013
Geographical area	Africa
Organisations involved	UN Development Programme, Economic Commission for Africa (UNCEA), African Union Commission, African Development Bank.
Funding source	African Union
Main themes/topics covered	Establish and implement the Africa Mining Vision. Developing the UNFC-AMREC classification system based on specifications and guidelines by the UNFC and UNRMS.
Summary	Africa is well endowed with mineral resources and has a long history of mining, but has so far not reaped the developmental benefits from these resources. This is largely due to the weak integration of Africa's mining sector into national economic and social activities. The African Union (AU) Heads of State and Government have taken deliberate steps to address this weakness, through the endorsement of the Africa Mining Vision (AMV) and the establishment of the African Minerals Development Centre (AMDC) to provide strategic operational support for the Vision and its Action Plan. One part of the centre's work is the development, promotion and application of the African Mineral Resource Classification (AMREC), which is based on the UNFC and UNRMS systems, but targeted toward use in African states.

Name of project/programme:	The Cobalt Industry Responsible Assessment Framework (CIRAF)
Web link	https://www.cobaltinstitute.org/responsible-sourcing/industry-responsible-assessment-framework-ciraf/
Timescale	2021 onwards
Geographical area	International
Organisations involved	Cobalt Institute, RCS Global
Funding source	Cobalt Institute members
Main themes/topics covered	Risk management and industry good practice to improve responsible sourcing in the cobalt supply chain.
Summary	The Cobalt Institute is a trade association of cobalt-producers, users, recyclers and traders. CIRAF is a management tool intended to enhance risk management for Cobalt Institute members and fill gaps of sustainable and responsible supply management that are not yet covered by due diligence activities by the members. It is, therefore,

	specifically designed to not duplicate existing Due Diligence programmes.

Name of project/programme:	CrEAM Network
Web link	https://www.birmingham.ac.uk/documents/college-eps/energy/policy/policy-comission-securing-technology-critical-metals-for-britain.pdf
Timescale	Established 2017
Geographical area	UK
Organisations involved	University of Birmingham, Exeter University and 9 other organisations from industry and academia
Funding source	UK Research and Innovation - Engineering and Physical Sciences Research Council (EPSRC)
Main themes/topics covered	Primary resources, secondary resources, technology metals, critical metals, security of supply.
Summary	The Critical Elements and Materials (CrEAM) network was established in order to bring together academic and industrial expertise regarding mining, materials processing, manufacturing and recycling of critical metals. The network has produced a policy document (see link above) containing detailed background on many aspects of the critical metals value chain. The network also links in with the current UKRI-funded circular economy centre for metals and technology (Met4Tech). Within the policy document there is specific mention of the UNRMS but only with regard to resource governance tools for the ESG aspects of sourcing. The policy document additionally highlights a lack of data for technology-critical metals, both primary and secondary, specifically with regard to the flows of these materials, which needs to be addressed to guide policy. Data for cobalt and nickel are highlighted as being insufficient to allow traceability across the UK supply chain as well as a lack of data for the location of components such as batteries and magnets in waste supply streams (something being considered by the EU Batteries Directive). The policy document highlights how some of these data issues may be addressed by the establishment of a National Materials Datahub (being explored by ONS and the Met4Tech project).

Name of project/programme:	European Raw Materials Alliance (ERMA)
Web link	www.erma.eu
Timescale	2020 onwards
Geographical area	EU
Organisations involved	Over a hundred organisations including major industry, SMEs and governmental organisations from across the value chain of CRM use
Funding source	EIT Raw Materials, European Union
Main themes/topics covered	Primary resources, secondary resources.

Summary	The European Raw Materials Alliance was announced in September 2020 as part of the European action plan on raw materials. The alliance aims to act as an independent forum for discussion and analysis regarding CRM issues and a mechanism for developing potential projects into activities. It is focused on the identification of barriers, opportunities and investment cases to build capacity at all stages of the raw materials value chain. The activities are centred around specific value chains, e.g. rare earth element magnets and motors. ERMA recognises the need for harmonised formats for the comparison of projects using UNFC, which is discussed in the 2021 action plan for rare earth magnets and motors (https://eitrawmaterials.eu/wp-content/uploads/2021/09/ERMA-Action-Plan-2021-A-European-Call-for-Action.pdf).

Name of project/programme:	G7 Economic Resilience Panel policy recommendations
Web link	https://www.g7uk.org/wp-content/uploads/2021/06/G7-Economic-Resilience-Panel-Key-Policy-Recommendations.pdf
Timescale	2021 onwards
Geographical area	Worldwide
Organisations involved	G7
Funding source	N/A
Main themes/topics covered	Resource management, UNFC, UNRMS.
Summary	A key focus of the G7 Economic Resilience panel is ensuring resilient supply chains; they note that CRM supply chains are constrained and concentrated leading to threats to security of supply. They recommend establishment of a 'Critical Supply Forum' to identify emergent risks, to build common vulnerability indicators, share best practice and provide a forum for policy coordination. This is to be focused on health, critical minerals and semiconductors. As well as facilitating forecasting of supply vulnerabilities, the report recommends the creation of an information-sharing platform, 'Critical Minerals and Metals Information System (CriMMIS)', similar to the established Agricultural Marketing Information system. They also advocate promotion of the development of linkages with standards bodies, such as the ISO, to promote market circularity.

Name of project/programme:	Geological Service for Europe
Web link	https://cordis.europa.eu/project/id/731166
Timescale	2022-2027
Geographical area	Europe
Organisations involved	16 European geological surveys (including BGS), EuroGeoSurveys, UNECE (only with regard to the Centre of Excellence).
Funding source	EC Horizon Europe Coordination and Support Action

Main themes/topics covered	Primary resources, secondary resources, UNFC/UNRMS implementation, European Centre of Excellence in Sustainable Resource Management.
Summary	This project is currently in the proposal stage with one work package focussed specifically on implementation of UNFC/ UNRMS in Europe. The main objectives of this WP are: i) to re-evaluate European resources in primary raw materials, in both onshore and offshore domains, and mining wastes, with a focus on critical raw materials, filling existing gaps in harmonised data and information at the European level; ii) to create and develop the EU International Centre of Excellence in Sustainable Resource Management; and iii) to promote the use of UNFC and UNRMS for mineral resources management in Europe. This work is the continuation of a series of European-funded projects looking at mineral resource reporting and UNFC in Europe (e.g. ORAMA, Mintell4EU, FRAME) but has a long-term focus on setting up a permanent Geological Service for Europe with a European International Centre of Excellence imbedded within it. This project aims to be a capacity building and knowledge centre promoting the UNFC and supporting the UNRMS.

Name of project/programme:	Global Battery Alliance
Web link	www.globalbattery.org
Timescale	2017 onwards
Geographical area	Worldwide
Organisations involved	Over 70 from business, governmental, academia, industry and NGOs
Funding source	Membership
Main themes/topics covered	Battery raw materials, recycling, material passports and traceability, responsible sourcing, circular economy.
Summary	The Alliance works to ensure a steady supply of batteries and battery raw materials and also develops methods to ensure human rights are safeguarded and health and environmental sustainability are incorporated in the battery supply chain. The organisation is a public-private platform to allow collaboration between industry and government stakeholders, established at the 2017 World Economic Forum. It aims to establish the pathway for the achievement of a sustainable, responsible, battery value chain by 2030, and is actively investing in technologies for battery passports. It also has workstreams aimed at improving the substantiality of cobalt supply (especially with regard to child labour and the transition to a circular economy for batteries).

Name of project/programme:	Global Reporting Initiative (GRI)
Web link	https://www.globalreporting.org/
Timescale	Established in 1997 and publication of specific standards ongoing; Mining sector standard to be released in 2023.
Geographical area	Worldwide
Organisations involved	Partnerships with a diverse range governments, foundations and other institutions.
Funding source	Current funders: Department of Foreign Affairs and Trade (DFAT), Australia; State Secretariat for Economic Affairs (SECO), Switzerland; Swedish International Development Cooperation Agency (Sida); UK International Climate Finance - UK PACT Green Recovery Challenge Fund, United Kingdom
Main themes/topics covered	Sustainability standards in various fields for 40 sectors to be used by companies, government bodies, NGOs and other organisations.
Summary	GRI develops standards to measure the sustainability impacts of various businesses and organisations. The standards are organised in three series, which are: universal standards (general rules for all organisations); sector standards (selection of relevant standards for different sectors; and topic standards (specific standards on various topics such as biodiversity or anti-corruption). Few sector standards have been published, but a standard for the mining sector is to be released in 2023.

Name of project/programme:	Horizon Europe Work Programme 2021-2022
Web link	https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl4-2021-resilience-01-06
Timescale	2022-2026
Geographical area	Europe
Organisations involved	EC
Funding source	EC (Horizon Europe)
Main themes/topics covered	Primary raw materials, secondary raw materials, resource management, UNFC.
Summary	This recently-closed call for the Horizon Europe funding programme included the development of a database with harmonised data on mineral resources and reserves according to UNFC. It also referred to the development of an EU International Centre of Excellence on Sustainable Resource Management focussed on promoting and building capacity in UNFC for mineral resources (primary and secondary) and supporting the UNRMS in line with the UN 2030 Agenda for Sustainable Development (see entry for GEOERA and Geological Service for Europe). The projects funded by this call will comprise the bulk of EC-funded research regarding the application of UNFC and UNRMS in the short term.

Name of project/programme:	Initiative for Responsible Mining Assurance (IRMA) standard
Web link	https://responsiblemining.net/what-we-do/standard/
Timescale	Established 2006. Current standard v.1.0 from 2018, next revision in 2021 (v.2.0)
Geographical area	International
Organisations involved	Stakeholders from mining companies, purchasers, NGOs and other organisations
Funding source	Self-funded
Main themes/topics covered	ESG standards for the mining sector based on 4 principles: 1) Business integrity; 2) Planning and Managing for positive legacies; 3) Social responsibility; 4) Environmental responsibility.
Summary	Company members can become certified with the IRMA standard in order to provide independent and credible information on responsible-sourcing practices. Members, who source mined material (Purchaser), agree to encourage their mine suppliers to be certified by the IRMA standard. Third-party auditing is required for a company to become a full member. Further audits may be carried out to achieve certain levels of certification, that describe the performance of the company and how many critical requirements are met.

Name of project/programme:	Integrated Data Service (IDS)
Web link	N/A
Timescale	2021 ongoing
Geographical area	UK
Organisations involved	ONS
Funding source	ONS/BEIS
Main themes/topics covered	Data interoperability.
Summary	The ONS Integrated Data Service (IDS), which started in in March 2021, is a planned four-year programme of work. The IDS is building a central data service enabling access across government. It is potentially scalable to wider public services and beyond. Part of this work involves a new UK-focussed criticality assessment by BGS, funded by BEIS, to generate a critical raw materials list specific to the UK.

Name of project/programme:	International Council on Mining and Metals (ICMM) principles
Web link	https://www.icmm.com/
Timescale	2001 ongoing
Geographical area	International
Organisations involved	Mining and metal companies as members and association members
Funding source	Self-funded
Main themes/topics covered	Sustainability and ESG principles: 1) Ethical Business; 2) Decision Making; 3) Human Rights; 4) Risk Management; 5) Health & Safety; 6) Environmental Performance; 7) Conservation of Biodiversity; 8) Responsible Production; 9) Social Performance; 10) Stakeholder Engagement.
Summary	ICMM is an organisation that aims to tackle environmental and social challenges that arise through mining. Members are based all over the world and have to comply with the above-mentioned principles. In addition, members have to publish their sustainability performance using the GRI reporting standards.

Name of project/programme:	International Finance Corporation's Environmental and Social Performance Standards
Web link	https://www.ifc.org/
Timescale	Latest version from 2012
Geographical area	Worldwide
Organisations involved	IFC is a member of the World Bank Group.
Funding source	IFC, self-funded
Main themes/topics covered	Voluntary ESG standards in risk management, labour, resource efficiency, community, land resettlement, biodiversity, indigenous people and cultural heritage.
Summary	The IFC encourages private-sector development in developing countries. As part of its sustainability framework, the IFC has developed these performance standards to be used by various industries. The standards have also been used as a template in the Equator Principles, which is another financial benchmark for ESG in the finance sector adopted by 127 institutions in 38 countries.

Name of project/programme:	International Institute for Sustainable Development (IISD) work on sustainable mining
Web link	https://www.iisd.org/topics/mining
Timescale	N/A
Geographical area	Worldwide
Organisations involved	IISD

Funding source	N/A
Main themes/topics covered	Sustainable development, primary raw materials, sustainable sourcing.
Summary	The IISD has a specific topic area on mining and cites the use of UNFC as a tool for transition towards more sustainable extraction. The IISD has conducted several research projects looking at CRMs related to conflict minerals, sustainable sourcing and the location of CRMs in relation to regimes deemed to be unstable or risky jurisdictions to operate in.

Name of project:	Met4Tech Circular Economy Centre – principles for Resource Management and new Geomodels (Theme 2)
weblink	https://met4tech.org/
Timescale	2020-2024
Geographical area	UK
Organisations involved	Uni Exeter (lead on Theme 2), BGS, Uni Leicester, Uni Birmingham, Uni Manchester
Funding source	UK Research and Innovation - Engineering and Physical Sciences Research Council (EPSRC)
Main themes/topics covered	Establish concepts of circular economy in technology metal supply chains.
Summary	Theme 2 of the Met4tech CE centre is about combining geoscience, LCA studies, chemistry, economics, geomicrobiology and primary and secondary raw materials to bring Circular Economy principles to the first stages of the raw material lifecycle. This includes case studies on Cornish exploration projects and their evaluation based on UNFC and UNRMS.

Name of project:	Mining the European Anthroposphere
weblink	http://www.minea-network.eu/
Timescale	2016-2020
Geographical area	Europe
Organisations involved	TU Wien (Grant holder)
Funding source	COST (European cooperation in Science and Technology, funded by Horizon 2020)
Main themes/topics covered	Pan-European Expert network on Anthropogenic resources, Application of UNFC on secondary resources.
Summary	The project has ended. Reporting and availability of secondary materials, focussed on construction and demolition waste, landfills, solid residues from waste incineration. WG 4 worked on the classification and reporting of material resources/ reserves and helped to develop a document on the UNFC application for Anthropogenic Resources in 2018, published by the UNECE Working Group on Anthropogenic Resources.

Name of project/programme:	Mintell4EU
Web link	https://geoera.eu/projects/mintell4eu7/
Timescale	2018-2021
Geographical area	Europe
Organisations involved	25 European Geological Surveys and research institutes, led by GEUS (Geological Survey of Denmark and Greenland)
Funding source	EC, GeoERA programme
Main themes/topics covered	Primary raw materials, raw materials data collection, data standardisation, UNFC.
Summary	The European Union has identified security of supply, improvement in environmental management and resource efficiency as key challenges for the raw materials sector. Data regarding the location and spatial distribution of primary and secondary raw materials, with respect to exploration, exploitation, production and trade activities, underpin decision making in government and industry. The overall aim of this project was to improve the European Knowledge Base on raw materials by updating the electronic Minerals Yearbook produced in the Minerals4EU project and to extend the spatial coverage and quality of data currently in the Minerals Inventory. The project aimed to increase the degree of harmonization, communication and interaction between existing data platforms, with a focus on using UNFC for data harmonisation. The project also included 19 separate case studies using UNFC at the project and national scales.

Name of project/programme:	National materials Datahub (NMDH)
Web link	https://datasciencecampus.github.io/projects/DSC-69-National-Materials-Datahub/
Timescale	2020- ongoing
Geographical area	UK
Organisations involved	ONS
Funding source	ONS, BEIS
Main themes/topics covered	Security of supply, circular economy, material flow analysis.
Summary	The NMD is a project currently in development with ONS with a vision of providing a single source for materials information in the UK. The Datahub plans to cover all aspects of materials information in the UK, mapping stocks and flows within a circular economy context. The outputs are yet to be defined, but data on CRMs and resources are in scope. The Centre will consider tracking materials flow at transnational levels, identifying critical materials, improving data collection methods, modelling policy decisions and identifying

	efficiencies in raw material use, e.g. use of secondary raw materials. The Datahub also has links to the UKRI Circular Economy Hub.
Web link	https://rmis.jrc.ec.europa.eu/
Timescale	2008 onwards
Geographical area	EU
Organisations involved	JRC, EC
Funding source	EC (DG Grow)
Main themes/topics covered	CRMs, primary and secondary resources, circular economy, national minerals data.
Summary	The RMIS is the JRC's platform for sharing minerals information. The platform hosts a wide range of data from commodity and country profiles, trade data and foresight studies to policy and legislation. The platform hosts the European criticality studies for CRMs and the data behind them. Data is made available for country profiles from the data collected by the Mintell4EU project in UNFC only if that was how it was reported by the host country. Of particular relevance to resource management is an effort by JRC to conduct MFA for a range of materials (including CRMs). For the detailed commodity or product-based management required by polices like sustainable sourcing or battery passports MFA systems are essential and need to be linked to other metrics.

Name of project/programme:	Regional Initiative against the Illegal Exploitation of Natural Resources (RINR) – Regional Mineral Certification Mechanism (RCM)
Web link	https://www.icglr.org/index.php/en/rinr
Timescale	2009 onwards
Geographical area	Central Africa
Organisations involved	The International Conference on the Great Lakes Region (ICGLR)
Funding source	N/A
Main themes/topics covered	Sustainability standard for the conflict minerals (tin, tungsten, tantalum and gold, 3TG) in the Great Lakes Region of central Africa.
Summary	The ICGLR developed the RINR and RCM as responses to decades of conflict in the Great Lakes region. RCM requires upstream companies to comply with minimum requirements related to conflict issues and implementation of the OECD Due Diligence Guidance on Responsible Supply Chains of Minerals from Conflict-affected and High-risk Areas. The RCM is implemented at a national and regional level and member states have to facilitate site inspections, chain of custody tracking, mineral export certification and data management. This applies to both large-scale and small-scale mining.

Name of project/programme:	Responsible Minerals Assurance Process (RMAP)
Web link	http://www.responsiblemineralsinitiative.org/responsible-minerals-assurance-process/
Timescale	2017 onwards
Geographical area	International
Organisations involved	Responsible Minerals Initiative (RMI)
Funding source	Self-funded
Main themes/topics covered	Sustainability standard and assessment of smelters and refiners; focussed on tin, tantalum, tungsten and gold (3TG).
Summary	RMAP is the flagship programme of the RMI to help companies make informed choices about responsibly-sourced materials along the supply chain. It focusses on the assessment at smelters and refiners as a 'pinch- point' in the supply chain with relatively few actors so that source tracing is easier to validate. RMAP standards meet requirements for OECD Due Diligence, EU Regulation 2017/821 and the US Dodd-Frank Wall Street Reform and Consumer Protection Act.

Name of project/programme:	Responsible Cobalt Initiative (RCI)
Web link	https://respect.international/responsible-cobalt-initiative-rci/
Timescale	2016 onwards
Geographical area	International
Organisations involved	Chinese Chamber of Commerce for Metals, Minerals & Chemicals (CCCMC) Importers & Exporters and OECD
Funding source	CCCMC and OECD
Main themes/topics covered	Cobalt supply chain due diligence and management.
Summary	RCI aims to have downstream and upstream companies recognise and align their supply chain policies with OECD Due Diligence and Chinese Due Diligence guidelines to increase transparency in the cobalt supply chain. There is also cooperation with the government of Democratic Republic of Congo, as well with civil society and local communities.

Name of project/programme:	Toward Sustainable Mining Initiative (TSM)
Web link	https://mining.ca/towards-sustainable-mining/
Timescale	Established 2004, current standard version from 2013; review started 2020
Geographical area	Originally Canada, but now international

Organisations involved	Mining Association of Canada (MAC)
Funding source	Self-funded
Main themes/topics covered	Mining standard to evaluate and manage environmental and social responsibilities of mining companies and metallurgical facilities; improve the industry's ESG performance.
Summary	TSM is a standard to evaluate the performance of mining companies. Members of the MAC have to take part in respect of their Canadian operations: Companies have to publish a self-assessment of their ESG performance each year, which is externally verified every three years. Assessment is published and rated from Level C to Level AAA.

Name of project/programme:	UKRI National interdisciplinary Circular Economy Research: Circular Economy hubs
Web link	https://ce-hub.org/
Timescale	2020-2024
Geographical area	UK
Organisations involved	A total of 64 universities and 120 industrial partners through 5 thematic centres (lead University of Exeter Business School).
Funding source	UK Research and Innovation National Interdisciplinary Circular Economy Research programme)
Main themes/topics covered	Circular economy, primary raw materials, secondary raw materials, material flow analysis .
Summary	The NICER programme is focused on research allowing the UK to move towards a circular economy. It consists of five National Interdisciplinary Circular Economy Centres of Excellence, each focussed on a speciality material flow, delivering system change to several major resource flows in the UK. These are: Chemicals, Metals, Mineral-based Construction Materials, Technology Metals and Textiles. Each has ambitious proposals to reduce waste, increase circularity and to minimise the environmental impact of their sectors. The centres work with industry to collect, and present new data and identify actionable solutions for circular economy interventions in the UK. The Centre will also host a data hub for raw materials data, aiming to produce a framework and common standards for UK raw materials data for use in material accounting and material flow analysis. This is linked to concurrent work undertaken by ONS in the National Materials Datahub.

Name of project:	UNFC for Central Asia - improving national capacities of central Asian countries to harmonize and implement an internationally applicable system of classification and sustainable management of energy and mineral resources
weblink	https://unece.org/sustainable-energyunfc-and-sustainable-resource-management/unfc-central-asia
Timescale	2017-2019

Geographical area	Central Asia: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan
Organisations involved	UNECE, Russian Federation
Funding source	Russian Federation
Main themes/topics covered	UNFC application and resource harmonisation in central Asia for energy and mineral resources; case studies have been carried out; improve knowledge and skills of national stakeholders to apply UNFC.
Summary	The aim of this project was to improve national capacities of central Asian countries in the application of classification systems such as UNFC. Government policy makers were targeted to improve the management of natural resources. Main results were the production of assessment reports on the current resource classification system, a sub-regional workshop, case studies in energy and mineral resources, as well as a concluding workshop to agree on follow-up actions and recommendations on the application of UNFC.

Name of project/programme:	UNECE Working Group on anthropogenic resources
Web link	https://unece.org/unfc-and-anthropogenic-resources-0
Timescale	2016 onwards
Geographical area	N/A
Organisations involved	UNECE
Funding source	N/A
Main themes/topics covered	Secondary resources, UNFC.
Summary	The anthropogenic Working Group of UNFC has been created to develop draft specifications that would allow application of UNFC to anthropogenic resources. This has been done by the development of case studies, which are expected to be released as a guideline for different commodities/ deposits. Specifications were published in 2018, based on the previous iteration of UNFC. This allows primary and secondary resources to be compared using UNFC, although examples of how this can be achieved in practice are in the early stages of development. Much of the work for the specifications was aided by the EC-funded (COST Action) Mining the European Anthroposphere project.

Name of project/programme:	UNFC practitioners EuroGeoSurveys Working Group
Web link	N/A
Timescale	Ongoing, since 2021
Geographical area	Europe (including non-EC countries)

Organisations involved	Approximately 20 national Geological Surveys, UNECE and EuroGeoSurveys
Funding source	NA
Main themes/topics covered	UNFC, UNRMS.
Summary	This expert group, set up in the latter half of 2021, aims to bring together geological surveys in Europe to share experiences of the use of UNFC from practical examples of projects undertaken by members, to provide good practice on the application of UNFC and to feedback relevant experience to UNECE.

POLICY

Name of policy:	Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability
Web link	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0474&from=EN
Timescale	Published September 2020
Geographical area	EU
Organisations involved	EU
Main themes/topics covered	CRMs, resource management, security of supply.
Summary	This action plan, from the European Union, looks at the current and future challenges for CRM supply and proposes actions to reduce Europe's dependency on third countries, diversifying supply from both primary and secondary sources and improving resource efficiency and circularity, while promoting responsible sourcing worldwide. The Action Plan does not specifically mention UNFC or UNRMS, although it does refer to the need to cooperate with the UN regarding resource management and mineral governance.

Name of policy:	European Commission Batteries Directive 2006 and 2020
Web link	https://eur-lex.europa.eu/resource.html?uri=cellar:4b5d88a6-3ad8-11eb-b27b-01aa75ed71a1.0001.02/DOC_1&format=PDF
Timescale	2005 onwards
Geographical area	Europe
Organisations involved	EC/ UK Government
Main themes/topics covered	Circular economy, product/ material traceability, environmental performance.
Summary	The Directive covers battery sustainability, safety, labelling and information required for reporting on battery production and trade. Targets are set for minimum quantities of recycling of specific raw materials (i.e. CRMs) contained in batteries. How such reporting is

	to be achieved is not specified, but it is clear that some form of traceability, or 'passport' will be required. This will need a large volume of data on the sourcing of individual metals used in production of batteries.

Name of policy:	European Commission Ecodesign Directive 2009
Web link	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02009L0125-20121204
Timescale	2009 onwards
Geographical area	Europe
Organisations involved	EC/ UK Government
Main themes/topics covered	Circular economy, product/material traceability, environmental performance.
Summary	The Directive established a framework for setting 'ecodesign' requirements for energy-related products with the aim of ensuring the free movement of products within the internal market. There is a specific focus on improving energy efficiency and reducing pollution across the product's life cycle. Although the focus of the Directive is on energy consumption, part of it relates to the integration of raw materials in the circular economy and sustainable sources of raw materials. The directive states the requirement for metrics for the environmental aspects of a product as well as the ecological profile of a whole product. Metrics that may be required include, recycled material content, natural capital of materials consumed, generation of waste materials emissions to water air and soil and potential of product/ material recycling including easy access to valuable materials (e.g. CRMs).

Name of policy:	EC Circular Economy Action Plan and Green Deal
Web link	https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN
Timescale	2020 onwards
Geographical area	Europe
Organisations involved	EC
Main themes/topics covered	Circular economy, product/ material traceability, environmental performance.
Summary	The Circular Economy Action plan, part of the European Green Deal, gives guidance on what will be required with regard to the use of raw materials in various industrial sectors and products. Most relevant to CRMs is guidance relating to batteries, which builds on the Batteries Directive, aiming to provide the necessary regulatory framework to ensure the recovery of valuable materials, to improve the sustainability and transparency requirements for batteries taking account of, for instance, the carbon footprint of battery

	manufacturing, ethical sourcing of raw materials and security of supply, and facilitating reuse, repurposing and recycling.

Name of policy:	INSPIRE Directive (Directive 2007/2/EC)
Web link	https://inspire.ec.europa.eu/
Timescale	2007 onwards
Geographical area	Europe
Organisations involved	EU
Main themes/topics covered	Data standards.
Summary	The Inspire Directive aims to ensure that spatial data of European Member states were compatible across national boundaries. It aims to create a European Union spatial data infrastructure for the purposes of EU environmental policies and policies or activities which may have an impact on the environment.

Name of policy:	OECD Due Diligence Guidance for Responsible Mineral Supply Chains of Minerals from Conflict-Affected and High-Risk Areas
Web link	https://www.oecd.org/corporate/mne/mining.htm
Timescale	2016 onwards
Geographical area	worldwide
Organisations involved	OECD (OECD members)
Main themes/topics covered	Conflict minerals, sustainable sourcing and traceability.
Summary	The OECD Due Diligence Guidance provides detailed recommendations to help companies respect human rights and avoid contributing to conflict through their mineral purchasing decisions and practices. This Guidance is for use by any company potentially sourcing minerals or metals from conflict-affected and high-risk areas. The OECD Guidance is global in scope and applies to all mineral supply chains. The latest version clarifies that the Guidance provides a framework for detailed due diligence as a basis for responsible supply chain management of minerals, including tin, tantalum, tungsten and gold, as well as all other mineral resources.

Name of policy:	Regulation 2017/821 of the European Parliament and of the Council of 17 May 2017 laying down supply chain due diligence obligations for European Union importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas
Web link	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32017R0821
Timescale	2017 onwards
Geographical area	EU and UK (to a limited extent, see summary)

Organisations involved	EU
Main themes/topics covered	Conflict minerals, sustainable sourcing and traceability.
Summary	Although not implemented until 2021, thus spanning Brexit and not fully integrated with UK law, this legislation lays down supply chain due diligence obligations for EU importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas. This legislation targets conflict minerals (some of which are CRMs) and requires supply chains to not contribute to the funding of armed conflict and that due diligence is carried out to promote responsible sourcing. This requires that various data on source, composition and other supply factors be attached to any imported goods.

Name of policy:	Regulation (EU) 2017/821 of the European Parliament and of the Council of 17 May 2017 laying down supply chain due diligence obligations for Union importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas
Web link	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R0821
Timescale	2017 onwards
Geographical area	EU (related to global supply chain)
Organisations involved	EU
Main themes/topics covered	Sustainable sourcing, primary resources, traceability.
Summary	The conflict mineral regulation establishes supply chain due diligence obligations for EU importers of ‘conflict minerals’. It sets obligations related to management systems, risk management and independent third-party audits. The regulation applies to importers into the EU for minerals or metals containing or consisting of tin, tantalum, tungsten or gold and requires those importers to perform due diligence in an effort to promote responsible sourcing of those minerals and metals to ensure that their supply chains do not contribute to funding of armed conflict. Covered companies will be required to use the OECD Due Diligence Guidance (2016) as the framework for their supply chain due diligence. The applicability of this regulation to the UK is complex, as although released in 2017, it did not come into full effect until 1/1/21 (post Brexit). As a result the core provisions do not apply regarding the due diligence or reporting in England, Wales and Scotland. They do, however, apply in Northern Ireland.

Name of policy:	Global Britain in a competitive age, The Integrated Review of Security, Defence, Development and Foreign Policy
Web link	https://www.gov.uk/government/publications/global-britain-in-a-competitive-age-the-integrated-review-of-security-defence-development-and-foreign-policy

Timescale	2021 onwards
Geographical area	GB
Organisations involved	HM Government
Main themes/topics covered	Primary raw materials, security of supply, rare earth elements.
Summary	The document presents a high-level vision for many aspects for the UK economy. It includes specific mention of mineral resources, critical mineral resources and management of these resources. It is recognised that supply issues and increased competition for CRMs exist, are likely to become greater and need to be managed. This is imperative to ensure development of industrial sectors which rely on these as feedstocks. The need to diversify the supply of CRMs is specifically mentioned. The need to progress to a circular economy is also highlighted as a driver for better integration of resource data. There is no mention specifically of resource standards or data, but the aspirations regarding CRMs and mineral resources in general clearly require robust frameworks.

Name of policy:	UK Environment Act
Web link	https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted,
Timescale	2021 onwards
Geographical area	UK
Organisations involved	UK Government
Main themes/topics covered	product/ material traceability, environmental performance.
Summary	The Environment Act 2021 gives similar but not identical powers as contained in the Ecodesign legislation for non-energy related products. Much like the Ecodesign legislation, Schedule 6 of the Act, Resource Efficiency Information, gives information on the data requirement of products. Similarly, Schedule 4, regarding producer responsibility obligations, gives a requirement on waste prevention and increased levels of recycling.

Name of policy:	UK Industrial Strategy
Web link	https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future
Timescale	2017 onwards
Geographical area	UK
Organisations involved	HM Government
Main themes/topics covered	Primary raw materials, manufacturing, decarbonisation.
Summary	The UK Industrial Strategy, now four years old, outlined the significant challenges and opportunities for Britain's economy

	alongside key policies. With regard to CRMs there is a focus on clean growth and the need to create new industries around low carbon technologies (which will require large amounts of CRMs) and resource efficiency. There is also mention of the need for a transition towards a circular economy, which will require enhanced resource management. The industrial strategy is being developed with a series policy documents related to specific challenges, of which clean growth is one.

Name of policy:	UK Net Zero Strategy
Web link	https://www.gov.uk/government/publications/net-zero-strategy
Timescale	2021 onwards
Geographical area	UK
Organisations involved	HM Government
Main themes/topics covered	Decarbonisation, circular economy, secondary raw materials, raw material and product standards.
Summary	This policy paper sets out policies and proposals for decarbonising all sectors of the UK economy to meet the UK's net zero target by 2050. In relation to CRMs specifically, the strategy refers to the need for sustainable supply through ESG standards which are to be developed alongside the BSI, the establishment of an expert committee on critical minerals, the foundation of a Critical Minerals Intelligence Centre (CMIC) and publishing a critical minerals strategy in 2022.