



JRC TECHNICAL REPORT

Towards more sustainable management of material resources in Europe

Review of available data and knowledge for the Raw Materials Information System (RMIS)

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Abstract

Raw materials are essential for modern economies and the transition to a climate-neutral and sustainable Europe as laid out in the European Green Deal (EGD). However, obtaining raw materials can also be associated with adverse environmental and social impacts along the supply chain. Europe is dependent on raw material imports, e.g., for metal and metalloids required for low-carbon technologies or modern information and communication systems. Achieving the ambitious goals of the EGD, therefore, requires robust knowledge and data on primary and secondary material flows and stocks to better manage these and strengthen the competitiveness of European industry.

Against this background, the European Commission's (EC) Raw Materials Information System (RMIS) aims at providing a structured knowledge base related to non-fuel, non-agricultural raw materials from primary to secondary sources. Among the RMIS' overarching goals are to facilitate: (1) the availability, coherence, and quality of knowledge required by EU raw materials policies and EC services, and (2) access to key raw materials information from knowledge bases within and beyond Europe.

This report summarizes results of an ongoing cooperation between the European Environment Agency (EEA) and the EC Joint Research Centre (JRC) on compiling knowledge around the security and sustainability of raw materials. For this, relevant EEA projects and additional data sources are summarized both at EU-level and in a pilot investigation for four EIONET countries (i.e., Germany, Spain, Ireland, and Portugal), and ideas for monitoring the performance of the EU raw materials situation are presented. Using a country-questionnaire, data and knowledge available at the national level are highlighted and data needs from the perspective of the countries summarized.

Results from this study highlight that a wide range of high-quality data and information are already available to monitor the raw materials situation of individual EU countries. EIONET-countries hold detailed information with regard to: (1) mining, supply, and trade, (2) investments and the regulatory (mining) framework, (3) indicators and data about environmental, social and governance, and circular economy/resource efficiency aspects, and (4) pilot studies on emerging topics (e.g., environmental criticality or material stocks). Such information could be taken up by the RMIS in specific sections of the country profiles or dedicated tiles such as on "Member state legislation" or the "RMIS knowledge gateway". However, some of the data and information on mining can be outside the scope of EIONET (with a focus on Europe's environment) and future data collection efforts might involve other relevant institutions such as national geological surveys.

Some of the quantitative data needs of the EIONET-countries such as on materials stocks, footprint indicators, spending on repair, or the production of CRMs could be taken up when developing an RMIS indicators dashboard. The dashboard highlights aspects at EU member state level for the thematic areas of security of supply, material & resource efficiency, priority value chains, environmental sustainability, and social sustainability (responsible sourcing) across the EU-27 countries. Future research is required to account for additional data needs by EIONET such as on circular economy skills profiles or the residence time of materials in the economy. It is hoped that the indicator dashboard provides solid background information to complement RMIS country profiles and the EEA knowledgebase on raw materials, and to kick-off a continued exchange within EIONET on specific data/knowledge availabilities and needs.

Foreword

This report is the final outcome of the collaboration that took place in 2021 and 2022 between the Joint Research Centre (JRC), the European Environment Agency (EEA) and its European Topic Centre (ETC) on Circular Economy (CE). This collaboration entails the area of efficient and circular management of material resources and, in particular, of raw materials. Ultimately, this report and underlying data/knowledge findings are meant to support the further development of the EC's Raw Materials Information System (RMIS). This report is included in both EEA's and JRC's 2021-2022 work programmes. Fundings are linked to the "RMIS project" (Institutional budget) and through EEA/ETC task 4.3.1.1

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1 Introduction

1.1 Background

The contribution of (raw) materials such as, e.g., metals and metalloids, non-metallic minerals, or wood to achieve a prosperous, modern, competitive, circular, and climate-neutral economy is widely acknowledged (EC, 2018a). They are essential for maintaining and improving the quality of life, and are recognized as contributing, directly or indirectly, to practically all sustainable development goals (SDGs) (Mancini et al., 2019). Raw materials – and in particular critical raw materials (CRMs) (EC, 2022a) – form the physical basis for Europe's economy. Their secure and sustainable supply is important to the competitiveness and jobs growth of the Single Market⁽¹⁾. Raw materials are essential in the "strong, open, and fair-trade agenda"⁽²⁾, in the "comprehensive strategy on Africa"⁽³⁾, as well as to European strategic autonomy and security.

Raw materials are also key for Europe to deliver on the ambitions of the European Green Deal (EGD) (i.e., to achieve climate-neutrality by 2050, decouple economic growth from natural resource use, and leave no person and no place behind) as well as to become a "world leader in circular economy and clean technologies" (EC, 2019). As such, primary and secondary raw materials are expected to provide an important part of the future materials demand for low-carbon technologies (e.g., renewable energy, electric mobility, information and communication, energy-efficient housing, etc.). At the same time, a reduction in overall materials input to the European Union (EU) economy and associated losses to the environment (e.g., through materials- and energy-efficiency gains, better reuse and recycling, and consumer behavioural changes) are crucial to achieve the ambitious goals of the EGD (EC, 2019). This requires sound monitoring of the raw material flows and stocks across their full life-cycle in order to enable better raw materials management and benchmark performance against the goals of EU policies, as well as a more circular use of (raw) materials that allows to reduce extraction of primary resources

Responding to a specific action in the 2015 Circular Economy Action Plan (CEAP) (COM(2015) 614) (EC, 2015), the **Raw Materials Information System (RMIS)** hosted at the European Commission (EC) **Joint Research Centre (JRC)** acts as the EC's reference knowledge platform on non-energy and non-food raw materials from primary to secondary sources, along the entire raw materials value chains. The RMIS provides the core basis for raw materials knowledge and analysis required to support EU policy, such as, e.g., the European Green Deal COM(2019) 640) (EC, 2019), the 2020 Circular Economy Action Plan (CEAP) (COM(2020) 98) (EC, 2020a), and the 'Industrial Strategy for Europe' (COM(2020) 102) (EC, 2020b). The RMIS supports EC policy needs through data management and a web interface, in particular addressing knowledge needs identified by the EC related to the secure and sustainable raw materials systems and value chains.

Resource efficiency (RE) and circular economy (CE) are also key topics in the 2021–2030 strategy of the **European Environment Agency (EEA)** and the European Environment Information and Observation Network (EIONET) (EEA, 2021a). Specifically, the EEA aims at monitoring progress of Europe's transition to a circular economy including the environmental and climate benefits and trade-offs related to this. This includes assessing Europe's efforts of reducing impacts caused by the consumption and production of raw materials, products, services, and waste (secondary) materials. For this, EEA aims to provide evidence-based monitoring, targeted inputs to inform policy makers and the public, and will support the building stronger networks and partnerships.

This **report** highlights results of an ongoing cooperation between the JRC and the EEA which aims to compile knowledge around the security and sustainability of raw materials, with a focus on specific priority raw material value chains and for selected EU countries. It aims to support governments and experts at European and national levels in taking more informed decisions in the areas of secure, sustainable, and responsible resource management.

1.2 Policy context and need

Metals and minerals are fundamental to almost every aspect of our modern society and are essential prerequisites for the development of strategic sectors (e.g., for use in various low-carbon technologies). However, the EU industry is largely dependent on imports for many primary and secondary materials. Furthermore, the extraction and processing of raw materials also requires energy and the use of auxiliary materials. The International Resource Panel (UNEP IRP) estimates that the extraction and processing of raw materials (i.e., fossil energy carriers, non-metallic minerals, metal ores, and biomass) is responsible for around 50% of global greenhouse gas (GHG) emissions and more than 90% of global water stress and land-use related biodiversity loss (International Resource Panel, 2019). At the same time, social impacts of mining, such as e.g. adverse human

⁽¹⁾ https://ec.europa.eu/growth/single-market_en

⁽²⁾ https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_645

⁽³⁾ https://ec.europa.eu/international-partnerships/africa-eu-partnership_en

rights issues or unequal distribution of resources, but also benefits from income and employment in the sourcing countries, are frequently reported (Mancini and Sala, 2018). Therefore, responsible sourcing of materials both with regards to environmental and social aspects is essential for transitioning to a low-carbon Europe and achieving the ambitious goals of the EGD (Mancini and Nuss, 2020).

Against this background, the 2008 EU Raw Materials Initiative (RMI) aims at ensuring: (i) a fair and sustainable supply of raw materials from global markets, (ii) sustainable supply of raw materials within the EU, and (iii) resource efficiency and supply of 'secondary raw materials' through recycling (EC, 2008). The RMI recognizes the importance of raw materials for the functioning of EU industries and their competitiveness, and emphasizes the need for 'sustainable' production and a circular economy to achieve supply security.

In 2010, the "Europe 2020 strategy" and related flagship initiatives outlined the vision of fostering a resource-efficient and GHG-neutral EU economy (EC, 2010). The CE strategy from 2015 (including a CE action plan, monitoring framework, and plastics strategy) builds the basis for more sustainable materials management in the EU (COM(2015) 614) (EC, 2015). The CE action plan explicitly mentions the RMIS as a critical platform to "improve the availability of data on secondary raw materials" and "support EU-wide research on raw materials flows". The RMIS also aims to support the European Union Raw Materials Knowledge Base (EURMKB) (EC, 2022b). The need for the EURMKB is emphasized in action area No II.8 of the 2013 Strategic Implementation Plan (SIP) of the European Innovation Partnership (EIP) on raw materials (EIP-SIP) (EC, 2013).

The long-term vision for a climate-neutral Europe stresses the continued role of primary raw materials for climate action in the short- to medium-term, while RE and CE are expected to foster competitiveness and jobs as well as reduce energy requirements and decrease pollution and GHG emissions (EC, 2018a). With the EGD (COM(2019) 640), Europe has embarked on a transition towards a climate-neutral, resource-efficient, circular, competitive, and just and inclusive economy (EC, 2019). The EGD emphasizes a number of concrete actions, among them, e.g., a new CE action plan (EC, 2020a), a new industrial strategy (EC, 2020b), increased climate target ambition until 2030 (COM(2020) 562) (EC, 2020e), a renovation wave (COM(2020) 662) (EC, 2020c), and zero pollution strategy (COM(2021) 400) (EC, 2021c). All of these are relevant also from the perspective of the RMIS as a secure and sustainable materials basis and subsequent monitoring are required to ensure sound raw materials management and achieve related policy goals.

Related to this, the action plan on CRMs emphasizes the need for a diversified and sustainable supply of CRMs and promotes more responsible mining practices (EC, 2020d). The issue of responsible sourcing is specifically addressed in the Conflict Minerals Regulation (EU 2017/821) (tackling 3TGs (Tungsten, Tantalum, Tin and Gold) (EC, 2017), the Strategic Battery Action Plan (COM(2018) 293 final, Annex 2) (fostering more ethical raw materials sourcing for batteries and the EU Battery Alliance (EBA) to develop competitive battery manufacturing value chains in the EU) (EC, 2018c), or the RE-SOURCING project (Global Stakeholder Platform for Responsible Sourcing) (Horizon 2020 funding). Furthermore, the EC launched in 2019 the online portal "Due Diligence Ready!"⁽⁴⁾, which provides guidance to businesses regarding the metals and minerals entering their supply chains.

Against the background of the above EU policy landscape, the RMIS aims at providing a structured knowledge base related to non-fuel, non-agricultural raw materials from primary to secondary sources. Among the RMIS' overarching goals are to facilitate: (1) the availability, coherence, and quality of knowledge required by EU raw materials policies and EC services, and (2) access to key raw materials information from knowledge bases within and beyond Europe⁽⁵⁾.

1.3 Goal and scope

This report deals with **non-energy and non-food (raw) materials**, with special focus on CRMs (i.e., those materials with a high supply risk and economic importance) and priority value/supply chains identified by the EC (e.g., batteries). In particular, its scope includes aspects related to **(1) the secure (i.e., "supply risks"), (2) sustainable (i.e., environmental consequences), and (3) responsible (i.e., social aspects) sourcing and management of materials (both from primary and secondary sources)**.

Specific objectives of the report include:

- Highlight selected EU- and country-level knowledge and data within the scope of RMIS and with a focus on the JRC and EEA knowledgebase (reports, data sets, etc.) (*review of existing data (chapter 2)*).
- Increase the visibility and accessibility of such knowledge and data, highlight data gaps, and develop a streamlined analytical tool (*i.e., an indicator dashboard in (chapter 3)*) to compare the knowledge.

⁽⁴⁾ https://ec.europa.eu/growth/sectors/raw-materials/due-diligence-ready_en

⁽⁵⁾ <https://rmis.jrc.ec.europa.eu/?page=goal-and-scope-00f939>

- Provide an overview of country data deemed important by selected EU member states and account for this in the indicators dashboard (*incl. results from a country questionnaire sent to four individual countries (chapter 4)*).
- Make suggestions on where to locate this in the RMIS and outline future steps.

For this, the report builds upon (1) available knowledge (i.e., data, indicators, analysis, and any other type of knowledge output) available, e.g., in the RMIS and from EEA sources (e.g., reports) both at EU- (*chapter 2*) and national-level (*chapter 3*), as well as (2) newly collected data and information obtained through an EEA-JRC-questionnaire sent to selected countries within the EIONET (*chapter 4*).

The overarching goal is to provide EU and national governments and experts with relevant knowledge and tools to strengthen resource-governance and help to facilitate more informed decisions in the areas of secure, sustainable, and responsible resource management.

2 Mapping of available knowledge at EU

This chapter briefly presents selected EU-level knowledge within the scope of RMIS, with a **special focus on recent JRC and EEA products**. It covers the three areas of: (1) efficient and circular use of raw materials (e.g., use of secondary material sources), (2) sustainable and responsible sourcing of raw material (environmental and social aspects), and (3) CRMs for strategic technologies and sectors. Boxes at the end of each knowledge source indicate (a) where the knowledge might be linked to in RMIS and (b) whether it contains mainly qualitative or quantitative data.

2.1 Towards a more efficient and circular use of material resources

2.1.1 Introduction

The RMIS already includes a range of knowledge and data on circular economy and material flows, secondary raw materials, and waste. For example, the RMIS links directly to the **EC Circular Economy Monitoring Framework**⁽⁶⁾, the **EC Resource Efficiency Scoreboard**⁽⁷⁾, or the **EC resilience dashboard**⁽⁸⁾. The **EU Raw Materials Scoreboard**⁽⁹⁾ with its indicators is integrated into the RMIS. This includes a variety of indicators such as, e.g., on material flows and accumulation from **economy-wide material flow analysis (EW MFA)** (Eurostat, 2018) and the **Eurostat circular economy Sankey diagram**⁽¹⁰⁾. While these data sources will not be highlighted in detail in this chapter, they are partly included in *chapter 2.4* (monitoring EU raw materials use) and in the proposed *indicator dashboard of chapter 3*.

Furthermore, the RMIS covers secondary raw materials generation, use, applications, trade, end-of-life, and any related aspects along the value chain and highlights priority value chains⁽¹¹⁾ (e.g., CRMs, C&D waste, plastics, food waste, bio-based products) and related data sources⁽¹²⁾ (e.g., from Eurostat and H2020 projects). Material flow indicators such as domestic material consumption are included in country profiles.

The following sections highlight additional relevant knowledge and data sources on primary and secondary raw materials that could be further integrated into the RMIS.

2.1.2 Reducing resource losses from EU waste management

Efficient use of secondary raw materials and improved recycling are essential in ensuring a supply of (critical) raw materials for Europe and in reducing environmental and human health impacts. An **EEA and ETC/WMGE (European Topic Centre on Waste and Materials in a Green Economy) report** analysed batteries, WEEE, textiles, plastics, and rubber waste streams and related material losses, and concluded that large fractions of valuable resources are currently lost during waste management (EEA, 2019). The resource losses are, however, highly dependent on the waste stream, e.g., in case of batteries nearly all lead acid batteries are collected and recycled, whereas for other battery types the collection rates are much lower. Reasons behind resource losses are numerous and cross-linked, including inefficient waste collection, consumer behaviour and a lack of awareness, market-related aspects, technological barriers, design complexities, and the hazardous nature of embedded materials.

RMIS tile(s): 'Circular economy, secondary raw materials & waste' 'Foresight, strategic value chains & material flows' (for batteries)	Data type and geographical focus: WEEE, textiles, plastics, rubber waste streams in the EU
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Taking Waste Electrical and Electronic Equipment (WEEE) as an example, a recent **report by Baldé et al on WEEE collection rates in Europe** shows that the collection rate is affected by a combination of interlinked factors, grouped into three main groups: 1) WEEE flows outside of the formal WEEE system, 2) How the WEEE legislation has been implemented at the national level, 3) Behavioural and economic factors (Baldé et al., 2020). Related to these specific waste streams and with the aim to improve the recovery of CRMs, the EU funded project

⁽⁶⁾ <https://rmis.jrc.ec.europa.eu/?page=circular-economy-monitoring>

⁽⁷⁾ <https://rmis.jrc.ec.europa.eu/?page=resource-efficiency-scoreboard-8a9baf>

⁽⁸⁾ <https://rmis.jrc.ec.europa.eu/?page=the-ec-resilience-dashboards-c24e1b>

⁽⁹⁾ <https://rmis.jrc.ec.europa.eu/?page=scoreboard2021#/>

⁽¹⁰⁾ <https://ec.europa.eu/eurostat/web/circular-economy/material-flow-diagram>

⁽¹¹⁾ <https://rmis.jrc.ec.europa.eu/?page=introduction-ce8f3f>

⁽¹²⁾ <https://rmis.jrc.ec.europa.eu/?page=sources-of-data-563388>

CEWASTE⁽¹³⁾, developed and tested a standard and the related certification scheme for the collection, transport and treatment facilities of WEEE and waste batteries. Results of the piloting process revealed that tackling the resource losses requires efforts in multiple domains. On the economic side, huge capital costs needed for setting up the recycling process, low and volatile prices of CRMs and financial challenges to achieve high quality secondary materials were highlighted. On the legal side, it was stressed that there is a need for specific mandatory requirements focusing on recovery of these materials. On the technological and social side, key aspects such as improvements in the collection infrastructure, increased consumer awareness and design of products for reuse or recycling, as well as in communication among stakeholders in the value chain were highlighted.

RMIS tile(s): 'Circular economy, secondary raw materials & waste'	Data type and geographical focus: WEEE collection rates and targets in the EU-28, Norway, Switzerland, and Iceland
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The **COLLECTORS**⁽¹⁴⁾ **project** developed a web platform focused on the collection of three waste streams namely plastic packaging, WEEE and Construction and Demolition waste (CDW). The online database documents the organization and performances of 242 European waste collection systems.

RMIS tile(s): 'Circular economy, secondary raw materials & waste'	Data type and geographical focus: Database of waste collection systems in selected EU cities and regions
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The **ProSUM project and Urban Mine Platform**⁽¹⁵⁾ provide data on waste flows and material compositions for electrical and electronic equipment (EEE), vehicles and batteries for the EU-28 + Switzerland and Norway. See also chapters 2.2.5 and 2.3.

RMIS tile(s): 'Circular economy, secondary raw materials & waste' 'Foresight, strategic value chains & material flows' (for batteries)	Data type and geographical focus: Waste flows and compositions for batteries, WEEE, end of life vehicles in the EU28+2
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2.1.3 Limits of recycling

In 2020, Europe's circular material use rate (CMUR)⁽¹⁶⁾ was around 12.8%⁽¹⁷⁾ and the EC aims at doubling this rate in the next 10 years (EC, 2020a). The question of how much recycling potentials could increase for selected waste streams in the EU has been assessed in a number of publications. An **EEA report** examined recycling potentials for municipal solid waste (MSW), construction and demolition (C&D), and electronic waste (WEEE) in Europe (EEA, 2020d; Trinomics, 2020). The study finds that MSW and WEEE waste recycling could be doubled (from 43% and 31% to around 80% and 75%, respectively) if separate collection is increased. For C&D waste, recycling potentials could theoretically increase from 74% to 96%. However, current barriers to recycling include the low market prices of virgin materials and commingled waste streams (i.e., with a complex composition). Especially WEEE contains precious metallic resources including CRMs. Note also that for MSW untapped potentials are mainly related to food, garden waste, plastics, and textiles with the former two waste categories being outside the scope of RMIS.

RMIS tile(s): 'Circular economy, secondary raw materials & waste'	Data type and geographical focus: Recycling potentials (WEEE, C&D,
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⁽¹³⁾ <https://cewaste.eu/>

⁽¹⁴⁾ <https://www.collectors2020.eu/>

⁽¹⁵⁾ <http://www.urbanmineplatform.eu/homepage>

⁽¹⁶⁾ This indicator measures the contribution of recycled materials towards the overall use of materials (https://ec.europa.eu/eurostat/web/products-datasets/-/cej_srm030).

⁽¹⁷⁾ https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Circular_economy_-_material_flows

	MSW) in EEA countries
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The **JRC** has published a possible approach for estimating the maximum potential contribution of recycling to the total material input for materials covered in the EU Raw Material System Analysis (MSA) studies, and applied this to tungsten and indium in case studies (Talens Peirò et al., 2018). This builds on the existing 'end-of-life recycling input rate (EOL-RIR)'⁽¹⁸⁾ as an indicator of the EU CE monitoring framework. The EOL-RIR measures for individual raw materials how much of its input into the EU economy stems from the recycling of "old scrap" (i.e. scrap and waste derived from the treatment of products at their end-of-life (EOL))⁽¹⁹⁾. To our knowledge, the approach described in (Talens Peirò et al., 2018) on maximum recycling potentials has not been further developed or applied to other raw materials, but might be an interesting approach to build on in the future for individual raw materials.

RMIS tile(s): 'Circular economy, secondary raw materials & waste'	Data type and geographical focus: Recycling potentials for individual raw materials in the EU-28
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Furthermore, the **ETC CE**⁽²⁰⁾ is carrying out an analysis in 2022 to estimate potentials for future increases in the circular material use rate (CMUR), which is a central indicator in EC CE monitoring (ETC task 4.1.1.6). Results from this exercise could subsequently be fed into RMIS (ETC report forthcoming).

2.1.4 Boosting secondary raw materials (SRMs) markets

Improving secondary raw materials (SRM) markets is an important component of the EU Circular Economy (CE) strategy. While SRM markets already exist for many waste materials (metals, paper, wood, plastics, construction & demolition (C&D) materials, biomaterials, etc.), there are major differences in terms of their operational characteristics, historical and current developments, degree of closure of their material cycle, business and economic importance.

Secondary raw material markets have been analyzed by the **EEA** for the following materials: aluminium, paper and cardboard, wood, glass, plastics, textiles, C&D aggregate waste, and biowaste in the forthcoming EEA report (EEA, forthcoming), including evaluation of the maturity of the SRM market using criteria-based taxonomy for 'well working' SRM markets. Market size and material quality (from the industrial-use point of view) were found to be the factors that dominate the emergence of a well-working 'mature' secondary material market; thus promotion of the quality of SRMs and increasing the demand for these materials are considered essential in boosting SRM markets.

RMIS tile(s): 'Circular economy, secondary raw materials & waste'	Data type and geographical focus: Market analysis for the EU
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The **RMIS** already has a dedicated section for 'Circular economy, secondary raw materials & waste' with specific subsections for CRMs, electric and electronic equipment, mobility, and mining waste and landfills. These include for example data on reuse, recycle and recovery of materials in specific industry sectors (such as WEEE, ELVs).

2.1.5 Towards more circular management of construction and demolition waste (CDW)

Construction and demolition waste (CDW) is the largest waste stream in the EU in terms of mass (35.9 % of total waste, 2018)⁽²¹⁾. While the recovery rates of CDW are generally high (EU27 average 88 %, 2018)⁽²²⁾, the recovery is largely based on backfilling operations and low-grade recovery, such as using recycled aggregates in road sub-bases⁽²³⁾. There is thus potential for more circular management of CDW. For example, Material Economics estimates that circular use of building materials could cut the CO₂-emissions by over 50% (with measures such as cement recycling, waste reduction, reuse of components, material efficiency, sharing and prolonged lifetime) (Material Economics, 2018). An **EEA briefing** suggests a number of actions improving circularity of CWD

⁽¹⁸⁾ https://ec.europa.eu/eurostat/cache/metadata/en/cei_srm010_esmsip2.htm

⁽¹⁹⁾ Note that while the EOL-RIR focuses on individual raw materials (e.g., iron or cobalt) the CMUR looks at aggregate material flows (i.e., metal ores, fossil energy carriers, non-metallic minerals, and biomass).

⁽²⁰⁾ <https://www.eionet.europa.eu/etcs/etc-ce>

⁽²¹⁾ https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics

⁽²²⁾ Eurostat (**ENV_WASTRI**) https://ec.europa.eu/eurostat/databrowser/view/cei_wm040/default/table?lang=en

⁽²³⁾ https://www.eea.europa.eu/data-and-maps/daviz/mineral-waste-from-construction-and#tab-googlechartid_chart_13

management, such as designing buildings for easy disassembly, material passports, selective demolition and use of high grade materials with high-recycled content (EEA, 2020a, 2020b). Barriers for implementing these actions include uncompetitive pricing, lack of trust in the quality of secondary materials, lack of information on the composition of materials used in existing buildings and the long delay between implementing actions on new buildings and their effect on waste management several decades later.

<p>RMIS tile(s):</p> <p>‘Circular economy, secondary raw materials & waste’</p>	<p>Data type and geographical focus:</p> <p>Identification of CE strategies in the EU-27</p>
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The EU renovation wave strategy aims to boost renovation and improve the energy efficiency of EU building stocks (EC, 2020c). Although the focus is on measures improving energy efficiency, the strategy also highlights that renovation activities need to respect and be in line with the CE principles. Synergies between the energy-focused renovation wave and the promotion of circularity in the residential and commercial/public buildings sector have been identified in an unpublished **ETC report** (ETC/WMGE, 2021). Highest circularity potential in renovation actions relate to the choice and use of insulation materials and the reusability and recyclability of window frame and glasses.

The **RMIS** contains a section under secondary raw materials (SRMs) in priority areas of the Circular Economy Action Plan (CEAP) section entitled “construction & demolition”, but it is so far empty.

2.2 Sustainable and responsible sourcing of raw materials

2.2.1 Overview

Knowledge and data with regard to environmental and social aspects of (raw) materials sourcing, processing, use, and end-of-life management are located in the tile “environmental & social sustainability” of the RMIS⁽²⁴⁾. On the environmental side, this includes, e.g., information on the life-cycle impacts of raw materials throughout their full life-cycle, industrial emissions, air pollution, water use, and land-use/soils. The RMIS also links to the European Platform on Life-Cycle Assessment (EPLCA)⁽²⁵⁾ for life-cycle inventory data on raw materials and secondary materials, and related products. For the social dimension, aspects such as artisanal and small-scale mining, employment, the social license to operate, occupational safety and health, good governance, and international initiatives are presented. Further aspects relate to the UN Sustainable Development Goals (SDGs) and responsible sourcing (e.g., conflict diamonds and conflict minerals). The sections below discuss additional potential knowledge sources identified during the literature search.

2.2.2 Sustainable sourcing of raw materials to mitigate climate change and other environmental implications

Supply-side emissions savings:

According to the UNEP IRP, the extraction and processing of non-food and non-energy raw materials⁽²⁶⁾ is globally responsible for almost a quarter of all GHG emissions (IRP, 2020). Therefore, implementing more climate friendly sourcing practices can be an important leverage point for GHG-emissions-reductions.

The **EEA** estimates that the GHG-emissions associated with the extraction and processing of selected non-energy, non-agricultural raw materials (i.e., copper, iron, gold, limestone and gypsum, bauxite and aluminium, timber, chemical and fertilizer minerals, and salt) used in the EU-27 account for 18% of all GHG-emissions associated with EU consumption (EEA, 2021b). A range of climate-friendly sourcing practices were identified including standards and certification, commitments to voluntary roadmaps, sectoral performance benchmarking, technology innovations, economic instruments, and awareness raising. The raw materials processing stage was identified as being responsible for a larger share of GHG emissions than extraction and trade.

<p>RMIS tile(s):</p> <p>‘Environmental & social sustainability’, ‘Environmental dimension’, ‘Climate change and decarbonization’</p>	<p>Data type and geographical focus:</p> <p>Raw materials volumes for EU-27 demand and GHG emission factors for</p>
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⁽²⁴⁾ <https://rmis.jrc.ec.europa.eu/?page=environmental-intro-e924a3>

⁽²⁵⁾ <https://rmis.jrc.ec.europa.eu/?page=el pca-b9f212>

⁽²⁶⁾ The study examines: iron and steel; aluminium; copper; precious metals; lead, zinc and tin; other non-ferrous metals; cement, lime and plaster; stone; sand and clay; other non-metallic minerals; glass; wood; pulp; paper; rubber and plastic; and basic plastics.

	individual raw materials (cradle-to-gate)
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The UNEP IRP has published country factsheets⁽²⁷⁾ in which the GHG emissions, particulate matter (PM) health impacts, water stress, and land-use related biodiversity losses due to raw materials extraction and processing were quantified for the G20 countries including the EU-27 as well as the EU member states France, Germany, Italy, and in addition also Poland.

RMIS tile(s): 'Environmental & social sustainability', 'Environmental dimension', 'Life-cycle impacts'	Data type and geographical focus: Exiobase with satellite accounts for the G20 + Poland.
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The EU FINEPRINT project⁽²⁸⁾ provides an interface to visualize global, geospatial data, such as land areas from surface mining and deforestation. It can be used to assess the implication of land use on ecosystems associated with mining in the EU and globally.

RMIS tile(s): 'Environmental & social sustainability', 'Environmental dimension'	Data type and geographical focus: Geospatial data on mine sites. Global
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The World Bank Climate Smart Mining Initiative aims at supporting resource-rich countries of the Global South to ensure that the mining sector is managed with environmentally-friendly sourcing practices in mind (World Bank, 2019).

RMIS tile(s): 'Environmental & social sustainability', 'Environmental dimension', 'Climate change and decarbonization'	Data type and geographical focus: Qualitative (e.g., link to activities)
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Demand-side emissions savings:

Traditionally, GHG-emissions savings have focused on the supply side as discussed above. However, many of the resource efficiency (RE) and circular economy (CE) related actions and policy measures such as more intensive materials use of existing products, material substitution, better stock management, and reuse and recycling of materials already present in the economy focus on the demand side instead. Related studies highlight the emission reduction potentials associated with moving toward a more circular economy.

For example, Material Economics estimates that demand-side actions could decrease EU industrial emissions by about 56% in 2050 (~300 Mt per year) through a combination of materials recirculation, product materials efficiency, and new circular business models (e.g., sharing) (Material Economics, 2018).

RMIS tile(s): 'Environmental & social sustainability', 'Environmental dimension', 'Climate change and decarbonization'	Data type and geographical focus: Raw materials volumes for EU-27 demand and GHG emission factors (cradle-to-gate)
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The ongoing EU project "Study on the Contribution of the Circular Economy (CE) to EU Climate Policies"⁽²⁹⁾ aims at developing a methodology to quantify CE contributions to addressing climate change. This study focuses exclusively on future GHG emissions. Results have not yet been published.

Other recently funded EU-projects planning to look at demand side changes within the realm of resource efficiency and circular economy including the climate benefits include "Circular Economy Modelling for Climate Change Mitigation (CircoMod)"⁽³⁰⁾ and "Developing circular pathways for a EU low-carbon transition (CircEular)"⁽³¹⁾.

Other:

⁽²⁷⁾ <https://www.resourcepanel.org/reports/natural-resource-use-group-20>

⁽²⁸⁾ <https://www.fineprint.global/visualisations/>

⁽²⁹⁾ <https://etendering.ted.europa.eu/cft/cft-display.html?cftId=5501>

⁽³⁰⁾ <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/org-details/999999999/project/101056868/program/43108390/details>

⁽³¹⁾ <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/org-details/999999999/project/101056810/program/43108390/details>

The UNEP-SETAC Life-Cycle Initiative recently published the updated Sustainable Production and Consumption Hotspot Analysis Tool (SCP-HAT) 2.0⁽³²⁾ which includes three modules to provide key information regarding a country's environmental performance (i.e., material use, GHG-emissions, air pollution, land use, energy use, water use, and water pollution) (Piñero et al., 2021). The tool reports on both domestic and footprint-based environmental impacts in the time period 1990-2018 and allows for a detailed breakdown by sector (including those sectors of immediate relevance to RMIS such as ore mining, construction material quarrying, wood and paper, basic metals, and fabricated metals).

RMIS tile(s): 'Environmental & social sustainability', 'Environmental dimension', 'Life-cycle impacts'	Data type and geographical focus: For most world countries incl. EU-27 member states
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The EU Consumption Footprint allows the analysis of environmental impacts in five different product baskets (i.e., housing, mobility, food, household goods, and household appliances) (Sala et al., 2019). While the indicator focuses on the overall consumption-related environmental impacts of the EU-27, the underlying data have a high granularity (around 165 products, consumption statistics for 2010-2018, and 16 midpoint impacts using the ILCD method) and could therefore be of relevance also to highlight resource-related impacts (e.g., resource use, mineral and metals) and consumption patterns of relevance to RMIS (e.g., electronic goods, buildings, etc.).

RMIS tile(s): 'Environmental & social sustainability', 'Environmental dimension', 'Life-cycle impacts'	Data type and geographical focus: 5 product baskets, 165 products, EU-27 and individual member states
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2.2.3 Environmental impact of CRMs in strategic sectors

CRMs are used in numerous applications related to renewable energy and e-mobility (for example, REEs used in magnets for e-motors, cobalt, lithium and natural graphite used in batteries, to mention a few) (Bobba et al., 2020; EC, 2022a), and are thus considered essential in decarbonization of the society and in meeting Europe's environmental goals. At the same time, the lifecycle of CRMs is associated with significant environmental impacts globally and locally. An **EEA study** looked at the environmental impacts of CRMs (and their substitution solutions) used in magnets, batteries, alloys, mineral fertilizers and printed circuit boards, with a focus on impacts from raw material extraction and processing (EEA, 2020c). Particularly high global environmental impacts can be observed for CRMs used in producing functional metal alloys and in agricultural fertilizer production, due to the high production volumes of these applications.

RMIS tile(s): 'Environmental & social sustainability' à 'Environmental dimension' à 'Life-cycle impacts'	Data type and geographical focus: Overview of five environmental impacts for materials in product applications (cradle-to-gate). EU-27.
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Furthermore, extraction and processing of CRMs generates substantial environmental risks in the countries where extraction takes place, often countries with poor environmental legislation. While there are efforts for the substitution of CRMs in strategic applications (Pavel et al., 2016), the development of substitution solutions is driven by performance and functionality, as well as the reduction of costs and supply risks, rather than environmental aspects. In addition, the environmental impacts of the potential substitution solutions are not clear.

The German Environment Agency (UBA) published a study entitled "Environmental Criticality of Raw Materials - An assessment of environmental hazard potentials of raw materials from mining and recommendations for an ecological raw materials policy" which consists of a methodology to assess the environmental criticality of more than 50 mineral raw materials (UBA, 2020). This could complement criticality data in RMIS which solely looks at supply risk and economic importance.

RMIS tile(s): 'Environmental & social sustainability', 'Environmental dimension', 'Life-cycle impacts'	Data type and geographical focus: Environmental criticality scores based on eleven indicators for over 50 raw
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⁽³²⁾ <http://scp-hat.lifecycleinitiative.org/>

The already existing **RMIS raw material profiles**⁽³³⁾ and **critical and non-critical raw material (CRM) factsheets** of the **EU criticality assessment**⁽³⁴⁾ include selected information on environmental aspects for a wide range of non-energy and non-food raw materials. This includes, e.g., information regarding the environmental performance index (EPI) in the sourcing countries (RMIS raw material profiles) or on environmental and health concerns (section on “other considerations” in the CRM factsheets).

2.2.4 Social implications of raw materials sourcing

With a growing global population, increasing urbanization and the expected large-scale deployment of green and digital technologies, the demand for minerals and metals will increase in the coming decades. Considering the current limited supply from secondary resources, a substantial portion of the demand for metals and minerals will be met through extractive activities which are in most cases concentrated in middle to low-income economies. Although these activities can be a potential engine for inclusive and sustainable development, the sourcing of raw materials are often accompanied by a variety of negative social impacts in the sourcing countries and more specifically on communities. An **IRP report by Ayuk and colleagues** has categorized the main social impacts of the extractive sector into social breakdown (e.g. disruption of livelihoods due to displacement, social disharmony due to increased internal economic inequalities, migration), human rights violations, corruption and governance conflicts at local and national level, and occupational safety and health issues (Ayuk et al., 2020). More specifically, the issues associated with **artisanal and small-scale mining (ASM)**, which is estimated to contribute to 15-20% of global minerals production (IGF, 2018), have been the focus of many recent studies.

At international level, guidelines and agreements such as the **UN Guiding Principles on Business and Human Rights** (UN, 2011), the **OECD due diligence for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas** (OECD, 2016), **Kimberly Process**⁽³⁵⁾ and various frameworks by International Labor Organizations are good examples providing detailed recommendations and guideline to help states and companies to respect human rights and prevent, address and remedy human rights abuses committed in business operations. At regional level, the **Africa Mining Vision**⁽³⁶⁾ and the **EU-Latin America Partnership on Raw Materials** and the corresponding networking platform⁽³⁷⁾ can be mentioned as good practices. In 2021, the European Commission announced **EU principles for sustainable raw materials** (EC, 2021d) with a special focus on social aspects.

The **RMIS platform** has a dedicated section on social dimension of raw materials sourcing with relevant data related to ASM, employment, occupational safety and health, social license to operate and good governance and integrity. This includes a comprehensive list of international initiatives that are operating to reduce social and environmental impacts of sourcing and encouraging conflict-free supply chains.

The **Environmental justice Atlas** captures information and data on social conflicts associated with the extractive industry (e.g., mining)⁽³⁸⁾ including a search function to look at individual commodities (e.g., gold, copper, timber, lead, diamonds, etc.)⁽³⁹⁾. It is hosted at the Universitat Autònoma de Barcelona.

<p>RMIS tile(s):</p> <p>‘Environmental & social sustainability’, ‘Social dimension’</p>	<p>Data type and geographical focus:</p> <p>Environmental conflicts by commodity, country, or company. Global.</p>
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2.2.5 Focus on battery raw materials

Considering the key strategic role of the e-mobility sector in achieving the EU policy objectives for a green and just transition, it is crucial to ensure that raw materials used in batteries are sourced in a responsible and

⁽³³⁾ <https://rmis.jrc.ec.europa.eu/apps/rmp2/#/>

⁽³⁴⁾ https://ec.europa.eu/growth/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en

⁽³⁵⁾ <https://www.kimberleyprocess.com>

⁽³⁶⁾ <https://au.int/en/ti/amv/about>

⁽³⁷⁾ <https://www.mineralplatform.eu/about/the-platform/background>

⁽³⁸⁾ <https://ejatlas.org/about>

⁽³⁹⁾ <https://ejatlas.org/commodity>

sustainable way. In the **JRC report** on responsible and sustainable sourcing of battery raw materials, this topic has been studied and analyzed from different perspectives, focusing on potential social risks, using secondary data at country and corporate level and then exploring initiatives developed to respond to such criticalities (Mancini et al., 2020). The hotspot analysis conducted in this study showed that cobalt sourced from the Democratic Republic of Congo (DRC), which amounts to 60% of the global supply, has by far the highest risk when taking into account global indices on governance, conflicts, social risks and environmental performance. Based on this analysis it is predicted that the risks associated with sourcing of other raw materials such as nickel, graphite and lithium sourced from other countries will increase in the coming years. Furthermore, the report provides an assessment (social LCA) of various company disclosures and an analysis of various global initiatives, schemes or strategies implemented to mitigate the identified risks.

The **RMIS platform** has developed a tool to assess various aspects related to raw materials for battery and their relevance for the sustainable development of battery supply chains for Europe⁽⁴⁰⁾. This includes data (main trends and some key parameters) on supply, demand, stocks and flows, and reuse of batteries. Complementary to the dataset developed by the ProSUM project, RMIS provides a data viewer section in which accurate data on the global market of batteries per application, relevant materials, chemistry and sector are available.

<p>RMIS tile(s):</p> <p>‘Foresight, strategic value chains & material flows’, ‘Raw materials in batteries’</p>	<p>Data type and geographical focus:</p> <p>Analysis of supply chain challenges and an interactive data viewer.</p>
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For the **Urban Mine Platform**, which includes data on batteries, see the next section.

Material System Analysis (MSA) of five battery related raw materials, i.e. lithium, cobalt, nickel, manganese and natural graphite for five consecutive reference years between 2012 and 2016 (Matos et al., 2020) as well analysis of interlinkages between the flows of these materials using a multilayer system approach (Matos et al., 2022), revealed that the EU is strongly dependent on imports of lithium-ion batteries and the related raw materials. Low or non-existence of recycling of lithium or natural graphite in the EU hinders the sustainable supply of these materials.

2.3 CRMs for strategic technologies and sectors

Next to batteries and construction and demolition waste discussed above, other strategic sectors have been identified by the European Commission. The **EC/JRC foresight study** (Bobba et al., 2020) looks at the supply chains of nine technologies used in three sectors: renewable energy, e-mobility, and defense and aerospace in the EU in 2030 and 2050. The technologies studied include Li-ion batteries, fuel cells, wind energy, electrical traction motors, photovoltaic technology, robotics, drones (unmanned aerial vehicles or UAV), 3D printing and digital technologies. It attempts to provide a first answer to where future challenges lie and how competition for resources may evolve. The report identifies current bottlenecks and supply risks for the EU in the subsequent stages of processed materials, components and assemblies of the selected technologies. Moreover, the study highlights key recommendations for the EU to ensure a resilient and sustainable access to critical raw materials.

The RMIS highlights raw material needs for vehicles based, e.g., on data compiled in the Horizon project ProSUM⁽⁴¹⁾. This includes a **RMIS data viewer** based on the project “Sustainable and secure sourcing of Raw materials for future competitive and low carbon European strategic VALue chains (SureVAL)”⁽⁴²⁾ (Løvik et al., 2021).

The **Urban Mine Platform**⁽⁴³⁾ provides data on products put on the market, stocks, composition and waste flows for electrical and electronic equipment (EEE), vehicles and batteries for the EU-28 + Switzerland and Norway. Iceland is also included for vehicles. It has partly been integrated into the RMIS.

The EU CRM assessment provides detailed end-use information by raw material (linkage to NACE sectors in the economic importance calculation). This information is used in the **RMIS supply chain viewer**⁽⁴⁴⁾ using data from the 2017 EU CRM assessment to highlight the number of raw materials used in single sectors and cross-linkages between them (Nuss and Ciuta, 2018). However, it is unclear whether the supply chain viewer will be updated with more recent CRM data in the future.

⁽⁴⁰⁾ <https://rmis.jrc.ec.europa.eu/apps/bvc/#/>

⁽⁴¹⁾ <https://rmis.jrc.ec.europa.eu/apps/veh/#/p/intro>

⁽⁴²⁾ <https://rmis.jrc.ec.europa.eu/apps/veh/#/p/viewer>

⁽⁴³⁾ <http://www.urbanmineplatform.eu/homepage>

⁽⁴⁴⁾ <https://rmis.jrc.ec.europa.eu/apps/scv/#/>

2.4 Monitoring the performance of European (raw) materials use

The previous sections summarize a range of (new) information and data sources of potential interest to the RMIS. At the same time, various indicators related to the key building blocks highlighted above (i.e., efficient and circular use of materials, sustainable and responsible sourcing, and priority value chains) are also included, e.g., in the 2021 EU Raw Materials Scoreboard (EC, 2021a), the EU CE Monitoring Framework⁽⁴⁵⁾ (EC, 2018b; Eurostat, 2021), and the 2021 8th Environmental Action Programme (EAP) Monitoring Framework (EC, 2021b) – some of which have already been included in the RMIS.

Table 1 provides an overview of relevant indicators from these sources structured along the main themes of this chapter. Depending on the data source, indicators are available at EU-27 and/or individual member state (MS) level.

⁽⁴⁵⁾ Note that the new EC CE monitoring framework was not yet finalized at the time of writing, but some information on proposed new indicators were available, e.g., from: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13150-Sustainable-consumption-of-goods-promoting-repair-and-reuse_en

Table 1. Indicators of relevance to the topics discussed in this chapter. Data available at EU member state (MS) level are highlighted in green color.

Topic	Subtopic	Indicator name	Details	Desired trend	Geo	Temporal	Update frequency	Source	Underlying data	
Overarching	EU material flows and stocks	12. Material flows in the circular economy	Sankey visualization and data for each flow	↘*	EU-27 and MS	2010-2020	Annual	3rd RM Scoreboard	Eurostat Sankey data	
		6. Domestic production	Domestic extraction (DE) Domestic production (DP) of refined metals	-	EU-27 (DE also at MS-level)	1970-2017 (DE) 2004-2017 (DP)	Annual	3rd RM Scoreboard	UNEP IRP (MFA database).	
		Domestic material consumption (DMC)	Domestic material consumption (DMC) DMC per capita	↘	EU-27 and MS	1990-2021	Annual	2021 CEAP draft	Eurostat EW-MFA	
		Material footprint	Raw material consumption (RMC) RMC per capita	↘	EU-27 and selected MS	2011-2019	Annual	Draft 8EAP 2021 CEAP draft	Eurostat RME	
		Material stocks	Material accumulation	↘	EU-27 and MS	2010-2020	Annual		Eurostat Sankey data	
	Decoupling trends	Resource productivity	Gross domestic product (GDP)/domestic material consumption (DMC) Gross domestic product (GDP) / raw material consumption (RMC)	↗	EU-27 and MS (selected MS for RMC)	1990-2021 2011-2019	Annual	Draft 8EAP 2021 CEAP draft	Eurostat EW-MFA Eurostat RME	
	EU in the global context	8. Import reliance	Import reliance (IR) = Net imports/Apparent consumption	↘	EU-27 and MS (EW-MFA) EU-27 (CRM-list)	2000-2018 2013, 2016, 2019	Annual every 3 years	3rd RM Scoreboard 2021 CEAP draft	Eurostat EW MFA EU CRM assessment	
		7. EU share of global production	Share in global production for different material categories	↗	EU-27	1984-2017	Annual	3rd RM Scoreboard	World Mining Data and FAOSTAT	
	Efficient and circular materials use	Reducing waste management losses	Circular Material Use Rate (CMUR)	Share of material recycled and fed back into the economy in overall material use.	↗	EU-27 and MS	2010-2020	Annual	2021 CEAP draft	Eurostat Sankey data
			15. Recycling's contribution to meeting materials demand	End-of-life recycling input rate (EOL-RIR)	↗	EU-28 or -27	2013, 2016, 2019	every 3 years	3rd RM Scoreboard 2021 CEAP draft	Based on EU MSA study and informed estimates for the EU CRM assessment
Waste generation, excluding major mineral waste			Total waste generation	↘	EU-27 and MS	2004-2018	2 years	Draft 8EAP 2021 CEAP draft	Eurostat waste statistic	
Recycling limits		No indicator available	-	-	-	-	-	-	-	
Boosting secondary material markets		No indicator available	-	-	-	-	-	-	-	
Responsible sourcing	Environmental impacts of sourcing	21. Greenhouse gas emissions	Territorial GHG emissions from the EU RM sector and for individual RM industries	↘	EU-27, world	1970-2015	Periodically (less than annually)	3rd RM Scoreboard	JRC EDGAR	

Topic	Subtopic	Indicator name	Details	Desired trend	Geo	Temporal	Update frequency	Source	Underlying data
		22. PM and NMVOC emissions	Absolute PM10 and non-methane volatile organic compounds (NMVOC) emissions from the RM sector and for individual RM industries	↘	EU-27, world	1970-2015	Periodically (less than annually)	3rd RM Scoreboard	JRC EDGAR
		23. Water use	Water use for a selection of RM sectors	↘		2010-2019	Annual	3rd RM Scoreboard	Eurostat waste statistic
		Consumption footprint	LCA-based indicator to estimate 16 midpoint impacts associated with EU consumption	↘	EU-27 and MS	2010-2018	unclear	2021 CEAP draft	JRC D3
	GHG savings of CE	Contribution to climate neutrality and zero pollution	Placeholder indicator in the 2020 CEAP draft from 2021	↗	-	-	-	2021 CEAP draft	-
	Environmental impacts of CRMs in strategic sectors	Raw material environmental hazard potentials (EHP)	Semi-quantitative scores of environmental hazard potentials for 57 raw materials (available as factsheets)	↘	Global average	around 2014	Not foreseen	(Dehoust et al., 2020)	ÖkoRes project
	Social impacts of sourcing	25. Responsible sourcing	Issue description and box with case study. No quantitative indicator as of now	↗	-	-	-	3rd RM Scoreboard	various
26. Occupational safety		Incidence rate of accidents at work in selected economic sectors	↘	EU-27 and MS	2010-2019	Annual	3rd RM Scoreboard	Eurostat	
CRMs for priority technologies/sectors	Waste electrical and electronic equipment (WEEE)	13. Management of WEEE	Recycling of waste electrical and electronic equipment (WEEE)	↗	EU-27 and MS	2005-2018	Annual	3rd RM Scoreboard	Eurostat waste statistics
	Construction & demolition waste management	14. Construction and demolition waste	Recovery rate of construction and demolition waste	↗	EU-27 and MS	2010-2018	every 2 years	3rd RM Scoreboard CEAP	Eurostat waste statistics
	Battery raw materials	Recycling rate for batteries	Placeholder indicator in the 2020 CEAP draft from 2021	↗	-	-	-	2021 CEAP draft	-
	Textiles	Recycling rate for textile	Placeholder indicator in the 2020 CEAP draft from 2021	↗	-	-	-	2021 CEAP draft	-

*The goal is to reduce the overall flow magnitude of the Sankey diagram (to allow the EU to stay within a safe operating space) as increasing materials use and the maintenance of anthropogenic material stocks are associated with environmental implications.

3 Country-level analyses (indicator dashboard)

3.1 Introduction

This chapter presents a streamlined analysis in the form of an indicator dashboard for individual countries for the following RMIS dimensions:

- Security of supply / sourcing
- Material and resource efficiency
- Priority value chains (WEEE, C&D waste, batteries, and vehicles)
- Environmental sustainability
- Social sustainability (responsible sourcing).

It is based on data and information identified in the previous chapter (mapping of available knowledge at EU-level), the existing RMIS country profiles⁽⁴⁶⁾, and inputs obtained from an EEA/JRC questionnaire sent out to four countries (Germany (DE), Ireland (IE), Portugal (PT), and Spain (ESP)) within the EIONET⁽⁴⁷⁾ in the spring of 2022. The results of the questionnaires are presented in detail in the country specific annexes of chapter 4. In these questionnaires, countries were asked, amongst others, to highlight data and information beyond the existing RMIS country profiles which (1) are available at national-level to further inform country profiles in RMIS and (2) are of additional interest if available for all EU countries (see Table 9 in chapter 4).

Furthermore, the indicator dashboard and report were presented in a deep-dive session entitled “The Resource Nexus” during the EIONET workshop on 16th September 2022. Key takeaways of this workshop session are incorporated into the conclusions (chapter 5).

3.2 Indicator dashboard

An initial screening of indicators was carried out taking indicators and data identified in chapter 2, from the RMIS country profiles, and from inputs to the country questionnaires. The dashboard includes indicators that are Relevant, Accepted, Credible, Easy and, Robust (RACER) to give answers to relevant policy questions related to the raw materials sector. For this, the simple RACER scoring highlighted in the following table was performed:

Table 2. RACER scoring to evaluate the indicators of the dashboard*

RACER	Details	Questions	1	2
RELEVANT (closely linked to related policy question)	R.1 Consistency with the thematic areas	Does the indicator report on non-food and non-energy raw materials in line with RMIS?	Yes	No
	R.2 Geography	Is the indicator available for all EU-27 countries?	Yes	No
	R.3 Comparability	Are comparisons between different countries possible?	Yes	No (e.g. hindered by use of different methodologies)
ACCEPTED (e.g. by policy makers and stakeholders)	A.1 Policy makers	Has the indicator been applied in a policy setting?	Yes	No
	A.2 Statistics	Is the indicator used by Eurostat or national statistical offices?	Yes	No
	A.3 Academia	Is the indicator accepted and used by academia?	Yes	No scientific agreement regarding methodology
CREDIBLE	C.1 Transparency	Is the underlying methodology	Yes	No

⁽⁴⁶⁾ <https://rmis.jrc.ec.europa.eu/?page=country-profiles>

⁽⁴⁷⁾ European Environment Information and Observation Network (Eionet) (<https://www.eionet.europa.eu/>)

RACER	Details	Questions	1	2
(unambiguous and easy to interpret)		transparently documented and are the results reproducible?		
	C.2 Methodology harmonization	Is the underlying methodology harmonized at EU-level or do multiple methods exist to calculate the indicator?	A commonly agreed methodology exists at EU level	Different methods exist to derive the indicator (not harmonized among countries)
EASY (e.g. data collection should be possible at low cost)	E.1 Data availability and technical feasibility	Are indicator data easily accessible and is the calculation possible at a reasonable time?	Yes	No
	E.2 Time resolution	Are data available for time series?	Yes	No
	E.3 Future reporting	Is the indicator updated at regular intervals?	Yes	No or unclear
	E.4 Communication	Is the indicator easy to communicate to a non-expert audience?	Yes	No
ROBUST (e.g. against manipulation)	RO.1 Data quality	Are the data and the methodology officially reported by governmental offices?	Yes	No

*RACER table based on (Nuss et al., 2021).

Selection criteria include data availability for all EU-27 member countries (spatial scope) and data points for multiple years to represent time trends (temporal scope). “Official” data sources such as from Eurostat were preferred over data coming from “non-official” sources such as, e.g., industry reports, non-governmental organizations, or research studies, while the latter sources sometimes had to be included to fill data gaps. In general, while the majority of indicators fulfilled the RACER requirements, there are a fair number of proposed indicators for which RACER-compliant data for all aspects are not yet available, but where the information/topic is deemed to be of high interest so that the indicators were still included (sometimes as placeholders). Only a first approximate RACER scoring could be undertaken in this project which should be refined in the future.

The initial screening list consisted of around 42 indicators and was reduced in an iterative process to the final dashboard consisting of 21 indicators. During this sorting process, indicators for which no data are yet available (e.g., recycling limits or material residence time in the economy) were removed and it was ensured that no more than 5-6 indicators are reported per theme to limit the overall size of the dashboard. The indicators are structured along the five RMIS themes of security of supply/sourcing, material and resource efficiency, priority value chains, environmental sustainability, and social sustainability. The final indicator dashboard is highlighted in Table 3 and in detail in the accompanying Excel file.

Note that in this study we did not account for additional uncertainties that might be associated with the data provided (and are sometimes discussed in accompanying documents, e.g., of Eurostat).

Table 3. Indicator dashboard to highlight raw material trends for individual EU-27 countries (see accompanying Excel-file).

#	Subtopic	Indicator	Details	Policy question answered	Desired trend	Temporal	Update frequency	Source	Unit
(Security of) supply/sourcing									
SU1	Material sourcing	Domestic extraction (DE)	Metal ores	Is the country a significant supplier of base metals, non-metallic minerals and wood?	-	1990-2021	Annual	ESTAT	tonnes per capita
			Non-metallic minerals		-	1990-2021	Annual	ESTAT	tonnes per capita
			Wood		-	1990-2021	Annual	ESTAT	tonnes per capita
SU2		Production of Critical Raw Materials (CRMs)	Number of CRMs mined (Stage 1). First indication of mining expertise/capacity.	Is the country a supplier of CRMs and has, therefore, production expertise/capacity?	↗	ca. 2018	3 years	EC CRM list 2020	Number of CRMs
			Number of CRMs refined (Stage 2). First indication of refining expertise/capacity.		↗	ca. 2018	3 years	EC CRM list 2020	Number of CRMs
SU3	Trade	Import dependency for raw materials	Total (biomass, metal ores, non-metallic minerals, and fossil energy carriers)	To what extent is the country reliant on raw material imports?	↘	1990-2021	Annual	ESTAT	Percentage
			Metal ores		↘	1990-2021	Annual	ESTAT	Percentage
SU4	Domestic mining industry	Mining Contribution Index (MCI)	The MCI is a composite indicator capturing mining's contribution to national economies	How significant is the mining sector's contribution to the national economy?	-	2012-2020	2 years	ICMM	Index score
SU5		Employment in mining sector	Number of persons employed in other mining and quarrying, mining of metal ores, and support activities for other mining and quarrying	To what extent does the mining sector contribute to jobs and employment in the country?	-	2005-2020	Annual	ESTAT	Number of people
Material / resource efficiency									
ME1	EU material flows and stocks	Domestic material consumption (DMC)	Metal ores	What amounts of raw materials does the country use?	↘	1990-2021	Annual	ESTAT	tonnes per capita
			Non-metallic minerals		↘	1990-2021	Annual	ESTAT	tonnes per capita
			Wood		↘	1990-2021	Annual	ESTAT	tonnes per capita
ME2		Material footprint (RMC)	Total (due to data gaps for individual materials for many countries)	What is the countries material footprint in the world (raw materials embedded in trade)?	↘	2011-2019	Annual	ESTAT	tonnes per capita
ME3		Material stock growth	Material accumulation comprising biomass, metal ores, non-metallic minerals, and fossil energy carriers	To what extent are material stocks growing?	↘	2010-2020	Annual	ESTAT	tonnes per capita
ME4	Circular use of materials	Circular Material Use Rate (CMUR)	Share of material recycled and fed back into the economy in overall material use	What fraction of raw material inputs is provided via secondary sources?	↗	2010-2020	Annual	ESTAT	Percentage
ME5		Waste generation, excluding major mineral waste	Total generation, excluding the major mineral waste, from households and industry	How much waste is generated in the country?	↘	2004-2018	2 years	ESTAT	tonnes per capita
ME6	Repair	Household expenditures on repair, hire and maintenance	Share of household spending on repair, hire, and maintenance compared to total spending	How much do households spend on repair and maintenance services?	↗	1988-2015	~5 years	ESTAT	Percentage
Priority value chains									
P1	WEEE	Recycling of waste electrical and electronic	Calculated from a combination of waste collection and recycling figures (see	How much WEEE is recycled?	↗	2005-2018, 2018->	Annual	ESTAT	Percentage

#	Subtopic	Indicator	Details	Policy question answered	Desired trend	Temporal	Update frequency	Source	Unit
		equipment (WEEE)	worksheet)						
P2	C&D waste	Recovery rate of construction and demolition waste	Percentage of construction and demolition waste prepared for re-use, recycled or subject to material recovery	How much C&D waste is recycled?	↗	2010-2018	2 years	ESTAT	Percentage
P3	Batteries	Recycling of batteries and accumulators	Percentage of other batteries and accumulators including the lithium ion batteries which are recycled as material	What amounts of Li-containing batteries/accumulators are recycled?	↗	2009-2020	Annual	ESTAT	Percentage
P4	Vehicles	Recycling & reuse of end-of-life vehicles (ELVs)	Percentage of ELVs recycled including also reuse after collection	How much of ELVs are recycled and reused?	↗	2005-2019	Annual	ESTAT	Percentage
Environmental sustainability (sustainable sourcing + sustainable use)									
E1	Domestic perspective	Greenhouse gas (GHG) emissions of the raw materials sector	Share of GHG emissions of the raw materials sectors compared to total GHG emissions	How much does the country's raw materials sector contribute to territorial GHG emissions?	↘	1995-2020	Annual	ESTAT	Percentage
E2		PM 2.5 emissions of the raw materials sector	Share of PM2.5 emissions of the raw materials sectors compared to total emissions.	How much does the country's raw materials sector contribute to territorial PM emissions?	↘	1995-2020	Annual	ESTAT	Percentage
E3	Footprint perspective	Consumption footprint	Aggregated environmental impact score using the PEF LCIA method	What are the country' consumption-based direct and indirect environmental impacts?	↘	2010-2018	unknown	JRC	nano-points per capita
Social aspects (responsible sourcing)									
S1	Governance	Worldwide Governance Indicators	Political Stability and Absence of Violence/Terrorism	Does the country have a stable governance structure?	↗	1996-2020	Annual	World Bank	Percentile rank (0-100)
S2	Country risks	INFORM index	Risk for humanitarian crises and disasters that could overwhelm national response capacity	Is the country at risk of suffering from humanitarian crisis and disasters?	↘	2013-2022	Annual	JRC	Risk index scale (0-10)
S3		Occupational safety	Mining and quarrying	Are accidents in the raw materials and other industries low?	↘	2010-2019	Annual	ESTAT	number of accidents
		Manufacturing	↘		2010-2019	Annual	ESTAT	number of accidents	

3.3 Security of supply / sourcing

This thematic area includes indicators examining a country's domestic extraction of metal ores, non-metallic minerals, and wood (in line with the RMIS scope) (SU1), a count of the number of critical raw materials (CRMs) mined or refined by the country (SU2), the import dependency for all raw materials and only metal ores (SU3), the mining contribution index as a measure of mining's contribution to the national economy (SU4), and the number of employees in the mining and quarrying as well as metal ore mining sectors (SU5). The color coding in Table 4 highlights the range of scores for each indicator from lowest (blue) to highest (red).

Table 4. Indicator dashboard: Security of supply / sourcing. Data shown for the last available year (see supplementary excel file). (-) No data reported.

Subtopic	#	Indicator	Details	Unit	EU27	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE
Material sourcing	SU1	Domestic extraction	Metal ores	t/capita	0.49	0	4.66	0	0	0.01	0	0.50	0.36	0.39	0.00	0	0	0.59	0	0	0	0	0	0	0.43	0.83	0.91	0.16	0	0.01	5.01	8.4
			Non-metallic minerals	t/capita	7.1	5.1	7.9	7.7	11.8	7.1	13.5	11.8	4.8	4.6	5.6	6.0	3.7	14.3	9.3	10.0	0.70	9.5	4.2	1.6	10.8	8.7	10.8	20.9	7.0	6.6	16.2	10.6
			Wood	t/capita	0.65	0.19	0.51	1.7	0.70	0.36	4.7	0.38	0.07	0.24	0.39	0.87	0.07	0.01	4.9	1.6	0.92	0.37	0	0.11	1.5	0.67	1.3	0.56	1.3	1.1	6.9	4.7
	SU2	Production of CRMs	Num. of CRMs mined	Num. CRMs	-	0	1	0	0	4	0	0	1	3	2	1	0	0	0	0	0	1	0	0	2	1	2	1	0	0	2	1
			Num. of CRMs refined	Num. CRMs	-	3	0	0	0	6	1	0	0	3	6	0	3	0	0	1	0	2	0	2	2	4	0	0	0	1	5	2
Trade	SU3	Import dependency	Total raw materials	%	23	73	16	31	38	41	26	31	43	38	34	32	47	32	32	37	90	26	69	82	42	20	28	9	46	43	24	24
			Metal ores	%	48	100	13	100	100	99.5	100	76	59	65	100	100	100	87	100	100	100	100	100	100	100	83	48	47	79	100	99.6	21
Domestic mining industry	SU4	Mining Contribution Index	-	Index	-	31.3	58.4	19.5	19.1	32.4	30.8	35.9	63.8	47.9	35.6	28.1	23.7	29.9	19.3	23.2	25.4	24.9	18.5	30.5	43.2	51.8	42.7	34.3	20.8	37.2	59.4	54.7
	SU5	Employment in the mining sector	Mining and quarrying and metal mining	Num. people	2E+05	2423	10489	5000	1064	30923	1516	3136	4995	16743	13708	1782	12130	-	3191	2686	274	3916	123	2316	4987	18769	9056	12128	945	2894	5689	1689



For metal ore mining (SU1), Bulgaria, Finland, and Sweden are the main producers (on a per capita basis) while Romania, Finland, and Cyprus produce large quantities of non-metallic minerals. Wood is mostly produced by Finland, Sweden, Estonia and Latvia.

The production of CRMs (SU2) is captured by a simple count of the number of critical materials mined or refined within a country based on data from the EU CRM assessment (not considering production quantity). For example, the dashboard highlights that Germany and Spain produce four (barite (1%), coking coal (<1%), fluorspar (1%), natural graphite (<1%)) and three CRMs (fluorspar (2%), strontium (31%), and tungsten (1%)), respectively (numbers in brackets highlight the global production share). On the other hand, Germany, France, and Finland produce the largest numbers of refined CRMs.

Import dependency (SU3) is generally high for metal ores across EU-27 countries. Considering all materials (i.e., fossil energy carriers, biomass, non-metallic minerals, and metal ores), import dependency is high especially for Belgium, Luxembourg, Malta, and the Netherlands which rely heavily on the import of primary raw materials.

The mining contribution index (MCI) (SU4) captures the mining's contribution to the national economy and highlights Bulgaria, Greece, Poland, Finland, and Sweden – all of which are involved in the mining of minerals but also fossil energy carriers (e.g., coal) and biomass.

Employment in the mining sector is provided in indicator SU5 and shows the total number of people employed in the sector in 2019 across EU-27 countries

3.4 Material and resource efficiency

Indicators include the domestic material consumption (DMC) split into metal ores, non-metallic minerals, and wood (ME1), the material footprint (RMC) which considers raw materials embedded in trade (ME2), material stock growth as a measure of how much the physical economy is growing in the countries (ME3), the circular material use rate

(CMUR) to capture the share of recycling flows (including backfilling) as part of total material inputs (ME4), total waste generation (ME5), and household (HH) expenditures on repair, hire, and maintenance as a share of total spending (ME6) (Table 5).

Table 5. Indicator dashboard: Material and resource efficiency. Data shown for the last available year (see supplementary excel file).

Subtopic	#	Indicator	Details	Unit	EU27	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE
EU material flows and stocks	ME1	DMC	Metal ores	t/capita	0.75	0.99	4.85	0.42	0.18	0.47	0.20	1.36	0.53	0.72	0.29	0.22	0.24	1.16	0.06	0.18	1.59	0.31	0.30	0.46	0.95	0.92	1.08	0.40	0.31	0.47	5.09	6.14
			Non-metallic minerals	t/capita	7.2	4.9	7.8	7.6	12.5	6.8	14.7	12.2	4.0	4.1	5.8	5.9	3.7	13.1	9.6	10.7	10.9	9.9	6.5	2.3	10.8	8.9	10.4	21.0	7.2	6.1	16.2	11.1
			Wood	t/capita	0.64	1.04	0.43	0.59	1.41	0.32	1.45	0.28	0.14	0.21	0.40	0.41	0.26	0.13	1.14	1.33	1.61	0.37	0.06	-0.13	2.06	0.63	1.49	0.50	0.49	0.96	7.33	5.19
	ME2	RMC	Total raw materials	t/capita	14.6	11.9	22.9	17.5	24.0	15.1	27.8	24.1	11.5	9.8	13.6	14.2	10.9	23.2	18.0	20.9	27.5	16.6	17.3	7.4	24.4	18.2	17.1	28.2	15.4	14.0	29.5	24.2
ME3	Material stock growth	Total raw materials	t/capita	5.7	5.6	1.3	7.0	15.4	4.4	0.8	6.3	0.9	2.7	4.6	7.2	3.3	12.3	6.7	11.8	11.6	9.5	7.8	1.4	10.8	10.3	12.2	13.2	8.0	6.9	5.5	11.7	
Circular use of materials	ME4	CMUR	Total raw materials	%	12.8	23.0	2.6	13.4	7.7	13.4	17.3	1.8	5.4	11.2	22.2	5.1	21.6	3.4	4.2	4.4	13.6	8.7	7.9	30.9	12.0	9.9	2.2	1.3	12.3	6.4	6.2	7.1
	ME5	Waste generation, excluding major mineral waste	-	t/capita	1.8	3.5	3.1	1.5	1.8	1.9	9.7	1.6	1.5	1.5	1.5	0.9	1.9	0.9	0.7	1.4	2.3	1.1	1.1	2.6	1.9	2.1	1.3	1.1	1.5	1.6	2.6	2.1
Repair	ME6	HH expenditure on repair, hire and maintenance	Share of total spending	%	3.0	3.3	2.7	3.9	4.2	1.9	4.2	2.7	2.3	4.4	2.6	1.8	3.2	4.4	2.9	1.9	6.2	2.1	5.7	2.8	7.4	3.2	4.1	0.9	3.3	2.6	5.8	4.2



Per-capita use of metal ores (ME1) is highest in countries also with high domestic metal extraction such as Bulgaria, Finland, and Sweden. The same applied to the other material categories for ME1-indicator. The material footprint (ME2) is with >25 ton per capita highest in Estonia, Luxembourg, Romania, and Finland. The material footprint is a complex issue and reflects e.g. citizens’ consumption patterns, the structure and efficiency of the economy as well as levels of circularity⁽⁴⁸⁾.

More than a third of EU materials use is used for the expansion and maintenance of material stocks in the EU-27 (i.e., the accumulation of materials in buildings, infrastructure or durable goods) (ME3). Larger material stocks lock in energy and emissions for their operation. On a per-capita basis, material accumulation is highest in Denmark, Romania, and Lithuania, and lowest in Greece. Reasons might include enhanced construction and expansion in a year or maintenance and material replacements.

The circularity of the economy is captured with the CMUR (ME 4). In 2020, the EU-27 was around 12.8% circular and a number of countries exceeded this average rate. Especially, Belgium, France, Italy, and the Netherlands all reported a CMUR larger than 20%.

Waste generation (ME5) is at around 1.8 tons per capita in the EU-27 in 2018. Figures by country differ depending on national circumstances. For example, Estonia’s higher waste generation figure can be attributed to the country’s energy production partly based on oil shale⁽⁴⁹⁾. The share of household spending for repair-related activities of total spending (ME6) is highest in Austria, Luxembourg, Finland, and Malta. Increasing product repair can result in lower material extraction due to longer product lifetimes.

3.5 Recovery and recycling for selected priority value chains (WEEE, C&D waste, batteries, and vehicles)

This thematic area comprises the indicators waste electrical and electronic equipment (WEEE) recycling (P1), construction and demolition (C&D) waste recovery (P2), other batteries and accumulators recycling (used as a proxy for lithium-ion batteries) (P3), and end-of-life vehicle (ELV) recycling and reuse (P4) (Table 6).

⁽⁴⁸⁾ <https://www.eea.europa.eu/ims/europe2019s-material-footprint>

⁽⁴⁹⁾ https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics#Waste_generation_excluding_major_mineral_waste

Table 6. Indicator dashboard: Recovery and recycling for selected priority value chains.

Subtopic	#	Indicator	Details	Unit	EU27	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE
WEEE	P1	WEEE recycling	-	%	37.8	35.8	59.5	41.2	35.5	36.9	53.6	53.6	36.0	43.7	34.2	76.2	34.6	28.4	40.3	36.3	44.0	49.5	19.8	37.0	46.0	39.2	42.0	23.3	34.0	45.4	49.2	45.4
C&D waste	P2	C&D recovery	-	%	88	97	24	92	97	93	95	100	97	75	73	78	98	64	97	99	98	99	100	100	90	84	93	74	98	51	74	90
Batteries	P3	Other batteries and accumulators recycling	-	%	-	61.0	67.3	62.7	61.4	75.5	55.8	82.8	67.4	90.0	70.9	60.7	62.0	63.1	52.0	64.3	59.1	49.8	0.0	69.3	78.7	75.5	81.4	87.7	93.1	68.3	51.8	67.8
Vehicles	P4	ELV recycling and reuse	-	%	89.6	92.9	95.8	93.3	94.6	86.9	87.6	87.4	69.7	86.0	87.1	96.3	84.2	88.7	88.9	93.5	96.7	94.4	81.0	87.2	87.3	118.8	88.2	85.2	89.5	95.5	84.7	87.4



WEEE includes a large range of devices such as computers, refrigerators, and mobile phones which contain a complex material mixture including hazardous materials but also CRMs. WEEE recycling (P1) in the member states ranges between 20 and 76% in 2018 with Hungary and Bulgaria reporting the highest recycling rate.

C&D waste is one of the largest waste sources in the EU. The recovery rate of C&D waste (P2) accounts for the ratio of waste material prepared for reuse, recycling or is subject to material recovery (including via backfilling operations). Recovery rates vary across EU member states and can be influenced by factors such as building design, selective demolition of buildings and infrastructure, the price of waste materials, the fraction of hazardous materials present, or quality assurance systems for recycling systems (see Eurostat metadata for this indicator).

The current Battery Directive differentiates the following three battery types: lead-acid batteries and accumulators, nickel-cadmium batteries and accumulators, and other batteries and accumulators. The indicator P3 reports only the values for “other batteries and accumulators” to show the situation of recycling, e.g., of lithium-ion batteries, which is the key batteries type when the transport sector is electrified. These so called traction batteries also use significant amounts of CRMs such as cobalt and lithium. In the new proposal for the battery regulation⁽⁵⁰⁾ proposed by the European Commission in December 2020, lithium-ion batteries are extracted to an own category which is reported. Battery recycling is found to be highest in Ireland, Spain, Romania, and Slovenia.

ELVs can represent an important source of CRMs and recycling rates are generally above 85% for all EU member states (indicator P4).

3.6 Environmental sustainability

Dashboard indicators related to environmental sustainability include the share of greenhouse gas (GHG) emissions from raw materials-related activities⁽⁵¹⁾ compared to total territorial GHG emissions in a year (all NACE activities) (E1), the share of particulate matter (PM) emissions from raw materials-related activities⁽⁵²⁾ compared to total territorial PM emissions in a year (all NACE activities) (E2), and the JRC Consumption Footprint as an indication of a country’s environmental impacts triggered globally by consumption (E3) (Table 7).

⁽⁵⁰⁾ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020PC0798>

⁽⁵¹⁾ i.e., the sum of NACE activities consisting of: B-Mining and quarrying; C16-Manufacturing of wood and products of wood and cork, except furniture, manufacturing of straw and plating materials; C17-Manufacturing of paper and paper products; C-22 Manufacturing of rubber and plastic products; C-23 Manufacturing of other non-metallic mineral products; C-24 Manufacturing of basic metals.

⁽⁵²⁾ i.e., the sum of NACE activities consisting of: B-Mining and quarrying; C16-Manufacturing of wood and products of wood and cork, except furniture, manufacturing of straw and plating materials; C17-Manufacturing of paper and paper products; C-22 Manufacturing of rubber and plastic products; C-23 Manufacturing of other non-metallic mineral products; C-24 Manufacturing of basic metals.

Table 7. Indicator dashboard: Environmental sustainability. Data shown for the last available year (see supplementary excel file).

Subtopic	#	Indicator	Details	Unit	EU27	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE
Domestic perspective	E1	GHG emissions of the raw materials sector	Share of RM sectors compared to total	%	15	15	10	16	6	15	4	10	11	17	14	19	14	21	12	6	16	10	1	7	37	15	16	19	16	29	17	24
	E2	PM 2.5 emissions of the raw materials sector	Share of RM sectors compared to total	%	17	32	20	20	1	8	14	26	3	12	23	9	18	29	27	8	12	22	1	14	22	25	46	37	35	28	34	32
Footprint perspective	E3	Consumption footprint	Endpoint impact score	nano-points per capita	0.135	0.146	0.089	0.120	0.176	0.161	0.148	0.177	0.112	0.124	0.136	0.107	0.158	0.166	0.134	0.120	0.200	0.117	0.180	0.140	0.136	0.105	0.149	0.086	0.125	0.141	0.141	0.153



With regards to inland GHG-emissions (E1), the share attributed to the raw materials sectors ranges between 1 – 37% in 2019 with the largest shares found for Austria, Slovakia, and Sweden. This can be due to the structure of the industrial sectors within the country where energy intensive industry present larger share compared for example to the other manufacturing or transport sector⁽⁵³⁾. The PM 2.5 emissions of the raw materials sector (E2) make up between 1 – 46% of all PM 2.5 emissions in 2019. The largest share is occupied by Portugal, Romania, Slovenia, and Finland. This can be due to the higher shares in manufacturing of paper and paper-, non-metallic mineral products and basic metals in relation to other manufacturing, transport and waste management activities⁽⁵⁴⁾.

Finally, the JRC Consumption Footprint (E3) captures the life-cycle-wide environmental impacts of national consumption by looking at five different product baskets. On a per-capita basis, the highest consumption-based impacts are found for Luxembourg, followed by Malta, Ireland, and Denmark. For example, for Luxembourg impacts are largely due to food consumption (beef meat, cheese and pig meat) and mobility (passenger vehicles and two/wheelers)⁽⁵⁵⁾.

3.7 Social sustainability (responsible sourcing)

The thematic are of social sustainability and responsible sourcing of the indicator dashboard consists of indicators including the Worldwide Governance Indicator (WGI) looking at the political stability and absence of violence and terrorism in a country as a proxy of a well-functioning trade partner (S1), the INFORM index which examined possible risks within a country for humanitarian crises and disasters which might overwhelm national response capacities (S2), and data on occupational safety within the sectors mining and quarrying and manufacturing (S3) (

Table 8).

⁽⁵³⁾ <https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer>

⁽⁵⁴⁾ <https://www.eea.europa.eu/data-and-maps/dashboards/air-pollutant-emissions-data-viewer-4>

⁽⁵⁵⁾ <https://eplca.jrc.ec.europa.eu/ConsumptionFootprintPlatform.html>

Table 8. Indicator dashboard: Social sustainability / responsible sourcing. Data shown for the last available year (see supplementary excel file).

Subtopic	#	Indicator	Details	Unit	EU27	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE
Governance	S1	Worldwide Governance Indicators	Political Stability and Absence of Violence/Terrorism	Percentile rank (0-100)	-	64.6	60.9	79.3	81.6	68.9	70.3	83.0	51.4	58.0	56.6	65.6	59.9	56.1	60.4	75.5	93.9	75.0	82.6	74.1	74.5	63.2	85.9	63.7	69.8	67.5	82.1	85.4
Country risks	S2	INFORM index	Risk for humanitarian crises and disasters	risk index (0-10)	1.7	1.7	2.5	1.1	1.1	1.9	0.8	1.5	2.8	2.1	2.2	2.3	2.4	2.9	1.4	1.2	0.9	1.8	1.9	1.3	1.7	1.6	1.6	2.4	1.2	1.5	0.9	1.4
	S3	Occupational safety	Mining and quarrying	number of accidents	8428	75	126	488	23	1598	43	34	51	1346	542	14	393	6	12	6	11	12	5	77	178	2365	575	46	135	151	12	104
			Manufacturing	number of accidents	586907	9602	642	17860	6430	200434	1899	1526	998	82364	79090	2609	63042	377	703	1443	662	9096	409	12204	13353	27721	32968	1702	4540	3863	6246	5123



All EU countries are found in the upper half of the WGI percentile rank highlighting a relatively high political stability and the absence of violence and terrorism (S1). Some countries such as Luxembourg, Sweden, Ireland, Finland, Sweden, and the Czech Republic show particularly high scores for this indicator. The lower scores in some countries might be related to various variables used to construct this measure such as international tensions, government stability, security of risk rating, intensity of internal conflicts (ethnic, religious or regional) or intensity of social conflicts.

Similarly, the INFORM index highlights generally low risks from humanitarian crises and disasters that could overwhelm countries to cope with them in the EU (S2). On the overall scale from 0 to 10, all EU countries are found in the very low or low risk categories. Slightly higher index scores are observed, e.g., for Cyprus, Bulgaria, Romania, Italy, and Greece which is due to a combination of slightly higher scores for variables measuring e.g. natural hazards, vulnerable groups (Cyprus) and lack of institutional coping capacity (Bulgaria, Romania).

Finally, occupational safety as expressed by the number of accidents (S3) depends on the magnitude of the mining or manufacturing industry in the country under investigation and absolute figures are provided with the indicator dashboard.

4 Country inputs to the EEA/JRC questionnaire

Questionnaires were sent to four EIONET⁽⁵⁶⁾ countries, namely Germany (DE), Ireland (IE), Portugal (PT), and Spain (ESP (abbreviated as 'ES' in the indicator dashboard)), in which the countries were asked, amongst others, to highlight data and information beyond the existing RMIS country profiles⁽⁵⁷⁾ which (1) are available at national-level to further inform country profiles in RMIS (data availability), and (2) would be of additional interest if available for all EU countries (data needs) (Table 9). The detailed country responses are provided in the annex.

4.1 Additional data availability at country-level

A wide range of additional information and data sources available at country-level were highlighted in the questionnaire. Responses varied by country and included, e.g., detailed mining and materials trade data based on information from national geological surveys, information on the national regulatory framework and exploration investments, environmental data with regard to land cover, pollutant inventories, water bodies (e.g., relevant for foreseen mining operations), or material stock data. Data on accidents, occupational safety, and public acceptance of mining / raw materials activities were also reported. Some countries highlighted the availability of national data on materials use in raw material equivalents (i.e., for material footprint calculations).

These additional data sources provide a rich source of information and could be increasingly incorporated into the RMIS country profiles and indicator dashboard. They can be classified into the following categories:

- Mining, supply, and trade data / statistics

Data from national geological surveys and information systems provide a detailed assessment of the country's mining situation, data on reserves, and in some cases trade data for materials and products. While some of these data and information have already been incorporated into the RMIS (e.g., data on resources/reserves currently come from the Minerals4EU⁽⁵⁸⁾ project) and are also partly reported to Eurostat, the country-level data provides more detailed and up-to-date information.

The RMIS could increasingly utilize such information and thereby fill an important knowledge gap in bringing EU country-level information on supply and trade together under one platform.

However, countries also commented that reporting on supply- and trade-related data can be outside the scope of EIONET (with a focus on Europe's environment) and, therefore, national geological surveys would need to be explicitly involved in such a data collection exercise in the future.

- Information on mining investments and the regulatory (mining) framework

The questionnaire highlighted some of the detailed knowledge available at country-level with regard to exploration/mining investments and the national regulatory mining framework. Such information is useful in capturing the national policy framework including possible future mining operations.

This knowledge could directly inform the section "Investment and regulatory framework" in the RMIS country profiles and the separate tile "Member States Legislation" in order to ensure that the latest knowledge is displayed. For this, regular questionnaires (e.g., once a year) seem useful to ensure that the RMIS provides up-to-date information for all EU-27 member countries.

As highlighted above, looking at mining policy touches on information partly outside the area of expertise of EIONET (depending on the institutional structure of member countries) and further discussions on how to involve national geological and economic ministries/agencies in such a data gathering exercise in the future might be required.

- Indicators and data sets (environment, social and governance, circular economy and resource efficiency)

A range of detailed data sets and existing indicators were highlighted by countries. Examples include, e.g., data on land use and land cover, emissions data by sectors/industries (sometimes aligned with the System of Economic-Environmental Accounting (SEEA)), waste generation and treatment, environmental footprint indicators, maps on water bodies, data on occupational safety and public acceptance, energy consumption of extractive sites, or fatal and serious accidents in the extractive sector (not a complete list).

Examining each available data and indicator highlighted by countries was beyond the scope of this ETC project. However, the data and knowledge highlighted could be readily used by the countries to complement the RMIS indicator dashboard (section 3.2, Table 3) at national level. Furthermore, future studies should examine which

⁽⁵⁶⁾ <https://www.eionet.europa.eu/>

⁽⁵⁷⁾ <https://rmis.jrc.ec.europa.eu/?page=country-profiles>

⁽⁵⁸⁾ <http://www.minerals4eu.eu/>

indicators would be of wider interest to EU countries and whether the underlying data are available for all EU-27 countries and are regularly reported (prerequisite for inclusion in the indicator dashboard).

- Pilot studies on emerging topics

Countries are carrying out various pilot studies examining policy-relevant topics at national level. For example, recent studies examining the environmental criticality of raw materials or the collection of data and information on anthropogenic material stocks were highlighted by Germany in the questionnaire.

Such national-level studies can be of interest to the wider EU landscape, while the underlying data of such pilot studies might not yet be sufficiently RACER-compliant to be included in the indicator dashboard (e.g., because data have only been collected for a single year or are only available for one country).

Nevertheless, the RMIS could encourage countries to actively share such knowledge by linking to it via the “RMIS Knowledge Gateway” or by providing content space in the RMIS country profiles.

4.2 Data & knowledge needs of countries

Knowledge needs of countries included specific indicators, data sets, the sharing of best practices and methods, and additional knowledge on policy instruments. Only aspects related to indicators and specific data could be taken up when developing the indicator dashboard, while more qualitative information, e.g., on specific policies or best practices might be integrated into the RMIS country profiles or corresponding RMIS tiles in the future.

With regard to indicator and data needs, countries highlighted that additional data on material inputs and uses as well as the efficiency with which raw materials are used should be ideally included in an indicator set. Footprint indicators highlighting the materials or environmental implications embedded in trade were also mentioned. Therefore, the proposed indicator dashboard includes data on domestic material consumption (ME1) and the material footprint (ME2) as well as on territorial GHG (E1) and air emissions (E2) and the consumption footprint (E3). Resource productivity was not included as an individual indicator in order to limit the overall number of indicators.

The contribution to EU’s security of supply of CRMs was mentioned as another piece of essential information by countries. The dashboard therefore includes an indicator capturing the number of CRMs mined or refined in EU-27 countries (SU2) (based on a simple count of CRMs using data from the EU CRMs assessment).

Data on material stocks were also mentioned as relevant information. While data on absolute in-use stocks in EU countries could not be identified, Eurostat provides annual data on material accumulation (Eurostat MFA Sankey data) which provides a first indication of the extent to which EU stocks are growing (ME3).

Information on repair could be included via indicator ME6, while other relevant pieces of information with regard to, e.g., CE skills profiles, the residence time of materials within the economy, or information on royalties and success cases in communication with the public on new mining projects, could not be identified.

Additional data needs related to the sharing of best practices or knowledge on the successful implementation of policy instruments could not be considered in the indicator dashboard, but such information could be increasingly displayed in the RMIS country profiles and discussed in RMIS workshops. For example, Portugal highlighted the relevance of knowledge on success cases in communication with communities with strong mining opposition or best practices from the mining sector in implementing policies.

Table 9. Overview of selected country responses to the EEA/JRC questionnaire. Empty fields (-) indicate missing response. Color indicates suggestions taken up in the indicator dashboard (cases where data were available).

Topic	Which additional* information are available from country-level data?				Which additional* insights/indicators would be of interest?			
	Germany	Ireland	Portugal	Spain	Germany	Ireland	Portugal	Spain
1: Key indicators	Mining and trade data from DERA ROSYS (https://rosys.dera.bgr.de/)	Exploration Expenditure on early stage mineral projects aggregated from national or commercial sources	Mineral resources production (value and tonnes), imports, exports, jobs, mining potential (www.dgeq.gov.pt)	Mining Statistics of Spain ⁽⁵⁹⁾	Material efficiency and productivity indicators, material and environmental footprints (e.g., carbon footprint)	Contribution to EU's security of supply of CRMs and addition to early stage of the value chain	Information on royalties, success cases in communication with communities with strong mining oppositions, success cases in mining acceptance from local communities, other mining regulations, best practices from the mining sector, enforcement of best practices from competent authorities	-
2: Investment and regulatory framework	Exploration expenditure aggregated into gold, CRMs and industrial minerals	-	Additional details on the national regulatory framework; Amount of investment (€) per year in exploration	Mining ⁽⁶⁰⁾ ; Mining and environment ⁽⁶¹⁾ ; Regulatory framework - Compilation ⁽⁶²⁾ ; CE strategy ⁽⁶³⁾	Environmental Governance Performance	Source of exploration funding – e.g. Australia, UK, Canada. Stock market location of publicly traded companies for each country	-	-
3: Supply	Data on anthropogenic stocks (Schiller et al., 2017)	-	Statistical data on geological resources and mineral sector data on www.dgeq.gov.pt	Mining Statistics of Spain	Material stocks data	Production normalized to EU/EAA ⁽⁶⁴⁾ demand/consumption	-	-
4: Trade	DERA ROSYS (https://rosys.dera.bgr.de/)	-	Statistical data on imports and exports ⁽⁶⁵⁾	Exports and imports by main raw materials and countries (UN Comtrade)	Imports and exports in RME	-	Trade statistics	-

⁽⁵⁹⁾ <https://energia.gob.es/mineria/Estadistica/DatosBibliotecaConsumer/2020/Estadistica-Minera-Anual-2020.pdf>

⁽⁶⁰⁾ <https://energia.gob.es/mineria/Mineria/Legislacion/Paginas/OrdenacionMinera.aspx>

⁽⁶¹⁾ <https://energia.gob.es/mineria/Mineria/Legislacion/Paginas/Medioambiente.aspx>

⁽⁶²⁾ https://www.boe.es/biblioteca_juridica/codigos/codigo.php?id=196_Codigo_de_la_Mineria_&modo=1

⁽⁶³⁾ <https://www.miteco.gob.es/en/calidad-y-evaluacion-ambiental/temas/economia-circular/estrategia/>

⁽⁶⁴⁾ European Economic Area (EU countries and also Iceland, Liechtenstein, and Norway).

⁽⁶⁵⁾ <https://www.dgeq.gov.pt/pt/estadistica/geologia/publicacoes-estatisticas/statistical-data-information-mining-industry>

Topic	Which additional* information are available from country-level data?				Which additional* insights/indicators would be of interest?			
	Germany	Ireland	Portugal	Spain	Germany	Ireland	Portugal	Spain
5: Environment	National Corine Land Cover dataset (5 ha resolution) ⁽⁶⁶⁾ ; Data on environmental criticality (Dehoust et al., 2020); DERA mine site maps ⁽⁶⁷⁾ ; Carbon footprints by CPA classification ⁽⁶⁸⁾	-	Various sources for map layers, coastal/riverine flooding hazard maps, etc. ⁽⁶⁹⁾ ; GHG and other pollutant inventories ⁽⁷⁰⁾ ; water bodies ⁽⁷¹⁾ .	Data for maps ⁽⁷²⁾ ; air pollution emission maps ⁽⁷³⁾ ; Energy consumption (fuel, electricity) in extractive sites ⁽⁷⁴⁾	Environmental footprint perspective essential to avoid burden shifting	EPD ⁽⁷⁵⁾ for individual extractive products compared to other countries	-	-
6: Social & Governance	Government revenue from the extractive sector, taxes and subsidies (from D-EITI ⁽⁷⁶⁾)	-	Data on occupational safety and public acceptance	Fatal and serious accidents in the extractive sector	-	Fraser Rankings (sourcing countries)	Royalties policies, mining legislation, communities mining acceptance	-
7: Circular Economy and Resource efficiency	RME-figures (material footprint) calculated by Destatis		RMC in the INE database; Indicators from the national CEAP	-	Waste treatment data could be provided in addition to waste generation data	Residency time (of material) in the economy is a better measure of CE performance for raw materials than recycling indicators	DMC, RMC, resource productivity , CRM flows (production, trade, domestic consumption, waste quantities (generated and imported), indicators on eco-design, households expenditures in maintenance and repair services CE policy instruments	-

⁽⁶⁶⁾ <https://gdz.bkg.bund.de/index.php/default/digitale-geodaten.html>

⁽⁶⁷⁾ <https://rosys.dera.bgr.de/mapapps49prev/resources/apps/rosys2/index.html?lang=en>

⁽⁶⁸⁾ <https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/UGR/energiefluesse-emissionen/Publikationen/Downloads/direkte-und-indirekte-energiefluesse-emissionen-pdf-5859006.html>

⁽⁶⁹⁾ <https://www.dgeq.gov.pt/pt/servicos-online/informacao-geografica/>; <https://sniamb.apambiente.pt/content/diretiva60ce2007-2%25C2%25BA-ciclo?language=pt-pt>

⁽⁷⁰⁾ <https://apambiente.pt/clima/inventario-nacional-de-emissoes-por-fontes-e-remocao-por-sumidouros-de-poluentes-atmosfericos>; <https://apambiente.pt/clima/distribuicao-espacial-de-emissoes-nacionais-2015-2017-e-2019>

⁽⁷¹⁾ <https://snirh.apambiente.pt/>

⁽⁷²⁾ <https://inspire-geoportal.ec.europa.eu/results.html?country=es&view=details&theme=none>; <https://sig.mapama.gob.es/geoportal/>

⁽⁷³⁾ <https://sig.mapama.gob.es/geoportal/>

⁽⁷⁴⁾ https://energia.gob.es/mineria/Seguridad/Guias/Siniestralidad/Informe_Siniestralidad_Minera_2020.pdf

⁽⁷⁵⁾ Environmental Product Declaration (EPD)

⁽⁷⁶⁾ <https://rohstofftransparenz.de/en/daten/>

Topic	Which additional* information are available from country-level data?				Which additional* insights/indicators would be of interest?			
	Germany	Ireland	Portugal	Spain	Germany	Ireland	Portugal	Spain
							(regulatory and economic) aiming at eco-design, secondary materials use, biologic material use and biologic products; Circular Economy skills profiles	

* Beyond indicators already included in the RMIS country profiles.

5 Conclusions

The Joint Research Centre (JRC) and the European Environment Agency (EEA) as well as individual European countries all compile raw materials information. The JRC Raw Materials Information System (RMIS) is the European Commission's web-based knowledge platform on non-fuel, non-agricultural raw materials from primary and secondary sources (hosted at the JRC) which aims to make information at EU- and country-level more widely accessible (e.g., via the RMIS country profiles).

This report carried out a pilot investigation on raw materials data and knowledge available both from EU (JRC, EEA, Eurostat, etc.) and national data sources within the scope of the RMIS. This included a screening of available knowledge from EU sources with a specific focus on EEA and JRC products. Furthermore, four EIONET-countries (i.e., Germany, Ireland, Portugal, and Spain) were consulted via a questionnaire by EEA/JRC in spring 2022 to obtain insights on available national data and knowledge going beyond the RMIS country profiles and also specific data/knowledge needs by countries. Based on this, the ETC project team developed an indicator dashboard for the RMIS.

Data availability at national level:

Results from this study highlight that a wide-range of high-quality data and information are already available to monitor the raw materials situation of individual EU countries. Countries hold detailed information with regard to: (1) mining, supply, and trade, (2) investments and the regulatory (mining) framework, (3) indicators and data about environmental, social and governance, and circular economy/resource efficiency aspects, and (4) pilot studies on emerging topics (e.g., environmental criticality or material stocks). Such national data and knowledge could be increasingly taken up by the RMIS as follows:

Data on reserves, mining activities, or trade from national geological surveys provide detailed assessments of the country's raw materials supply situations. To date, such information is only partly available at EU-level (e.g., from EU-projects such as Minerals4EU or via selected geological surveys (often outside the EU) such as, e.g., the British Geological Survey (BGS) or United States Geological Survey (USGS)). The RMIS could start filling this knowledge gap by more actively engaging with European countries to bring relevant supply information together in the RMIS country profiles or via an annual geological yearbook.

Knowledge regarding the national investment and regulatory framework could be highlighted under the RMIS tile "Member state legislation"⁽⁷⁷⁾ and in the country profile section "Investment and regulatory framework"⁽⁷⁸⁾. Furthermore, pilot studies on emerging issues could be displayed via the "RMIS Knowledge Gateway" or the RMIS country profiles.

However, supply data and information are often outside the scope of EIONET (with a focus on Europe's environment) and, therefore, national geological surveys would need to be involved in future data collection exercises (e.g., by creating an RMIS country network or by inviting relevant institutions to join related EIONET meetings).

The detailed indicators and data sets highlighted by countries⁽⁷⁹⁾ could not be examined in depth in this study. While some of these data sources are reported to Eurostat, they can provide additional layers of information and might already be collected against the specific policy needs of a country. Future work should examine whether such data and indicators are available for all EU-27 countries and are regularly reported (prerequisite for inclusion in the indicator dashboard).

Data needs:

The exchange with the four countries highlighted that data needs relate to specific indicators, data sets, sharing of best practices and methods used, and knowledge on policy instruments. Quantitative aspects related to aspects such as materials stocks, footprint indicators, spending on repair, or the production of CRMs could be taken up when developing an RMIS indicator dashboard. Future research is required for data needs such as on circular economy skills profiles or the residence time of materials in the economy.

Additional more qualitative knowledge needs related to the sharing of best practices or knowledge on the successful implementation of policy instruments (e.g., success cases in communication with communities with strong mining opposition or best practices from the mining sector in implementing policies) could not be

⁽⁷⁷⁾ <https://rmis.jrc.ec.europa.eu/?page=member-states-legislation-08b84e>

⁽⁷⁸⁾ <https://rmis.jrc.ec.europa.eu/?page=country-profiles/>

⁽⁷⁹⁾ For instance, data on land use and land cover, emissions data by sectors/industries, waste generation and treatment, environmental footprint indicators, maps on water bodies, data on occupational safety and public acceptance, energy consumption of extractive sites, or fatal and serious accidents in the extractive sector.

considered in the quantitative indicator dashboard, but such information could be increasingly displayed in the RMIS country profiles and discussed in RMIS workshops.

Indicator dashboard (see also the accompanying Excel-file):

The final indicator dashboard consists of 21 indicators related to the themes (1) security of supply / sourcing, (2) material and resource efficiency, (3) priority value chains (WEEE, C&D waste, batteries, and vehicles), (4) environmental sustainability, and (5) social sustainability (responsible sourcing). The indicator dashboard highlights that a wide range of high-quality (RACER-compliant) data are already available to monitor Europe's raw materials situation.

The dashboard allows capturing essential raw materials aspects in a single year across EU-27 countries. For example, the production of CRMs is captured by a simple count of the number of critical materials mined or refined within a country highlighting that Germany and Spain mine four and three CRMs, respectively (but in small quantities). On the other hand, Germany, France, and Finland produce the largest numbers of refined CRMs. Per-capita use of metal ores is highest in countries also with high domestic metal extraction such as Bulgaria, Finland, and Sweden. Territorial GHG and air emissions vary by country, e.g., depending on the industries present and consumption patterns. High environmental footprints (consumption-based) for some countries are, e.g., driven by differences in food consumption (beef meat, cheese and pig meat), differing modes of mobility, or housing and heating. All EU countries score high in term of country governance highlighting a relatively high political stability and the absence of violence and terrorism, but some smaller differences exist between countries.

However, in the course of the project the geopolitical situation changed with Russia's invasion of Ukraine which is also affecting the EU's raw materials situation. Therefore, knowledge in the RMIS and indicators of the indicator dashboard need to be frequently reviewed against the background of the changing global situation (considering next to geopolitical changes also threats due to climate change (heat waves, floods) or pandemics).

EIONET deep dive session insights:

The report and indicator dashboard were presented during the EEA EIONET workshop on 16th September 2022 (with participation of several EIONET member countries). The attendants welcomed the report and resulting indicator dashboard, and it was recommended to expand the study by conducting more country-surveys.

Countries highlighted that there is a need for availability and accessibility of the MFA data from the JRC MSA studies at country level. Furthermore, some member States have collected the data for their own use, but these are not publicly available for the other countries. However, the type and quality of data collected at national level might not be comparable with the data collected at the EU level. Harmonization, compatibility, and comparability of the data collected should be taken into consideration. It was recommended to use assessment tools such as the RACER criteria as a mean to identify the quality of data and indicators.

Considering the current geopolitical shifts, the importance of conducting foresight studies (incl. alternative future scenarios, outcomes, and impacts) to support policy makers in making better-informed decisions were highlighted. This would require high quality and harmonized data. However, RMIS is not intended to be a day-to-day data analysis tool. Other platforms and tools are needed for real-time analysis of data.

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Annex 1: EEA/JRC country questionnaire



Towards More Sustainable Management of Material Resources in Europe

Joint JRC-EEA project

Questionnaire for participating countries

February 2022

Background

The contribution of raw materials to achieving a prosperous, modern, competitive, circular and climate-neutral economy is widely acknowledged. Raw materials – and in particular Critical Raw materials (CRMs) – form the basis for today's and tomorrow's European economy, and serves to ensure jobs and competitiveness. They are essential for maintaining and improving quality of life, and are recognized contributions, directly or indirectly, to practically all Sustainable Development Goals (SDGs).

Raw material supply chains and industrial value chains along critical raw materials in strategic sectors are fundamental to several priorities of the European Commission. They are essential to jobs and growth. Their secure and sustainable supply is important to the competitiveness of the single market. They are essential in the "strong, open, and fair trade agenda", in the "comprehensive strategy on Africa", as well as to European strategic autonomy and security. Raw materials are key for Europe to deliver on the ambitions of the European Green Deal European Green Deal (COM(2019) 640) and become a "world leader in circular economy and clean technologies".

Responding to a specific action in the 2015 Circular Economy Action Plan (CEAP) (COM(2015) 614), the Raw Materials Information System (RMIS) acts as the EC's reference knowledge platform on non-energy, non-food raw materials from primary to secondary sources, along the entire raw materials value chains. The RMIS provides the core basis for raw materials knowledge and analyses required to support EU policy, such as the European Green Deal, the 2020 CEAP (COM(2020) 98) and the 'Industrial Strategy for Europe' (COM(2020) 102). The RMIS supports EC policy needs through data management and a web interface, in particular addressing knowledge needs identified by the EC related to the secure and sustainable raw materials systems and value chains.

Resource efficiency and circular economy are key topics in the agenda of the EEA. The issue of resource supply and its environmental consequences and circularity as a means to modulate these impacts while contributing to Europe's wellbeing, is of increasing priority. Over the next years, EEA will develop projects on these areas, in particular on sustainable sourcing, criticality and environment, boosting secondary raw material markets and the monitoring of the circular economy.

This project deals with non-energy, non-food material resources, with special focus on Critical Raw Materials (CRMs) and priority value/supply chains identified by the Commission. In particular, its scope includes aspects related to the secure (ref. to the concept of "supply risk"), sustainable (i.e. environment), and responsible (i.e. social) sourcing and management of raw materials.

With a view to provide EU and national Authorities with relevant knowledge and tools to strengthen resource-governance, this project ultimately aims to facilitate more informed decisions in the areas of secure, sustainable and responsible resource management. Towards this goal, and building upon the available knowledge (i.e. data, indicators, analysis and any other type of knowledge output), specific objectives include:

Increase visibility and accessibility of relevant knowledge/tools to policy/decision makers at EU and national levels;

Increase the coherence of such knowledge/tools, identify most important knowledge needs/gaps, overall making this knowledge more useful for better management/governance of material resources at EU/national level;

Gradually refine such knowledge/tools and underlying datasets to better reflect national differences in performance and with a view to integrate such knowledge into the JRC's Raw Materials Information System (RMIS);

Develop streamlined analytical tools that can:

Help assess the countries' performance towards a more secure, efficient/circular and sustainable management of (non-energy, non-food) raw materials.

Help national authorities to make concrete decisions in resource management/governance areas under their competence. Provide countries with relevant knowledge that can help taking more informed decisions related to e.g.:

Security of Supply of critical raw materials (economic interest)

Certification of supply (environmental and social interest)

Possible trade-offs (management and governance interest)

Purpose of the exercise

The purpose of this exercise thus is twofold:

First, to identify whether / where countries hold data/knowledge covering aspects that are not (or not exhaustively) addressed in the RMIS, but which may be used to support the further development of certain RMIS' outputs, such as the EU Country Profiles⁽⁸⁰⁾. Furthermore, to identify if data at the country level have a higher level of disaggregation (than currently used in the RMIS), or if data are collected via a different methodology, leading to potential discrepancies with existing RMIS data sets.

Secondly, to identify if/how countries see these data elements being of interest to other countries, and if/how policy development would benefit from knowing such data from other EU countries.

The following section will run through some of the existing and possibly forthcoming data/knowledge elements in the RMIS and as for reflection on the two above questions. For reference, it may be useful for look at the existing country profiles in the RMIS (both for EU & African Countries).

[In particular, the EU Country Profiles in the RMIS are being thoroughly revised during Q2/Q3 2022. This revision will include not only an update of the underlying data, but a systematic reconsideration of the indicators and visualization options too. The outcome of this survey will help derive a mapping of existing/available data at country level for specific topics/areas. Such mapping, in turn, will facilitate the process of revision of the current profiles' structure/content.](#)

⁽⁸⁰⁾ [Raw Materials Information System \(europa.eu\)](http://europa.eu)

Questionnaire

1: Quick facts (key indicators)

Possible indicators include:

- Competitive Industrial Performance Index (UNIDO)
- mining as % in value added (Global source UN)
- Value added of selected industrial sectors (Eurostat)
- Number of employees in selected industrial sectors (Eurostat)
- Labour productivity of industry (NACE Rev.2 sections (B-E), (Eurostat)
- Mining contrib. index (ICMM)
- Natural resources rents indicator (new, World Bank)

Q1.1: Considering the topics/areas touched upon by the above list of indicators, does your country have specific data that could provide additional insight/info? If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q1.2: Is there any additional relevant information/indicator that you would suggest for inclusion in this section? (i.e. indicators that are used as key indicators in policy making in the raw materials field in your country). If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q1.3: Which information do you consider would be relevant to know from other countries in elaborating national policies?

2: Investment and regulatory framework

Possible indicators include:

- Flows and stocks of foreign direct investment in mining and quarrying sector (International Trade Center)
- Annual exploration budget (by material, over time) (S&P Global)
- Business environment (World Bank)
- Regulatory framework (EC-DG GROW)
- Gross domestic expenditure on R&D (Eurostat)
- Business expenditure on R&D by relevant NACE Rev.2 sector (Eurostat)

Q2.1: Considering the topics/areas touched upon by the above list of indicators, does your country have specific data that could provide additional insight/info? If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)?

Q2.2: Is there any additional relevant information/indicator that you would suggest for inclusion in this section? (e.g. indicators that are used as key indicators in policy making in the raw materials field in your country). If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q2.3: Which information do you consider would be relevant to know from other countries in elaborating national policies?

Q2.4: In your country, which national companies (if any) are investing in exploration in the EU? Where (geographically) are they investing – inside the country and/or abroad?

Q2.5: With respect to your country's Regulatory Framework as included in the RMIS ^(^{B1}), could you confirm that it is complete and up to date? If not, what is missing /outdated?

Q2.6: With respect to the regulatory framework on circular economy and environment (governance, national/regional policies, etc..) – which is currently not included in the RMIS – could you provide links to the relevant national documents?

3: Supply

Possible indicators include:

- Domestic extraction by main category, (Eurostat)
- Production value of relevant sectors, (Eurostat)
- Production of primary minerals/global share of production, (World Mining Data)
- Resources and reserves, (World Mining Data)

^(B1) See the Regulatory Framework section in the EU country profiles available at: <https://rmis.jrc.ec.europa.eu/?page=country-profiles#/>

Q3.1: Considering the topics/areas touched upon by the above list of indicators, does your country have specific data that could provide additional insight/info? If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q3.2: Is there any additional relevant information/indicator that you would suggest for inclusion in this section? (e.g. indicators that are used as key indicators in policy making in the raw materials field in your country). If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q3.3: Which information do you consider would be relevant to know from other countries in elaborating national policies?

Q3.4: Are Resources and Reserves data available for your country? With respect to the Resources and Reserves section included in the RMIS EU country profiles, data are sourced from Minerals4EU project, and S&P Global. Are you aware of these sources? Do you find these data aligned with the national data you have available? If not, why?

4: Trade

Possible indicators include:

- Export of mining equipment, (UN Comtrade)
- Exports and imports by main raw materials and countries (UN Comtrade via WITS)

Q4.1: Considering the topics/areas touched upon by the above list of indicators, does your country have specific data that could provide additional insight/info? If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q4.2: Is there any additional relevant information/indicator that you would suggest for inclusion in this section? (e.g. indicators that are used as key indicators in policy making in the raw materials field in your country). If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)?

Q4.3: Which information do you consider would be relevant to know from other countries in elaborating national policies?

Q4.4: Do you know the share of imports of primary commodities into your country?

5: Environment

In the RMIS, the possible indicators in this section will be divided into two sets of indicators: a map with different layers of interest, and pollution data at country level (graphs).

5.1 Maps:

- Mining site location (S&P Global)
- Protected and Conservation Areas (WDPA)
- Water Risk Index (WRI)
- Flood Hazard (WRI)
- Land use (Corine Land Cover – Copernicus)

Q5.1.1: Would you suggest other relevant layers of information for this field? Is the “national geoportal” accessible (open web link)?

Q5.1.2: Is a map displaying mines (active and inactive) locations available? In case of active mining sites, is the associated production known (materials extracted and quantities)?

Q5.1.3: Are coastal/riverine flooding hazard (flooding area) maps available?

Q5.1.4: Are air pollutant emissions maps from specific stages/sectors (extraction, manufacturing/productions,...) available?

5.2 Graphs:

- Greenhouse gas emissions intensity by raw material sector, Eurostat
- Absolute greenhouse gas emission by raw material sector, Eurostat

- PM2.5 emissions intensity by raw material sector, Eurostat
- Absolute PM2.5 emissions by raw material sector, Eurostat

Q5.2.1: Considering the topics/areas touched upon by the above list of indicators, does your country have specific data that could provide additional insight/info? If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q5.2.2: Is there any additional relevant information/indicator that you would suggest for inclusion in this section? (e.g. indicators that are used as key indicators in policy making in the raw materials field in your country). If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q5.2.3: Which information do you consider would be relevant to know from other countries in elaborating national policies?

Q5.2.4: Are data on water pollution (in connection to mining activities in your country) accessible?

6: Social & Governance

Possible indicators include:

- Worldwide Governance Indicators, (JRC inform-index)
- Country risk: Inform index, (JRC inform-index)
- Occupational safety: rate of fatal accidents at work, (Eurostat)
- Public acceptance (Raw Materials Scoreboard Indicator 2)

Q6.1: Considering the topics/areas touched upon by the above list of indicators, does your country have specific data that could provide additional insight/info? If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q6.2: Is there any additional relevant information/indicator that you would suggest for inclusion in this section? (e.g. indicators that are used as key indicators in policy making in the raw materials field in your country). If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q6.3: Which information do you consider would be relevant to know from other countries in elaborating national policies?

Q6.4: What is the process for the engagement of the local population in opening a new mine on the territory? Is there a participatory process? Are social impact studies/surveys planned in the process?

Q6.5: Are information on accidents/spills/social in relation to mining/refining/recycling processes available/accessible?

Q6.6: Could you suggest any relevant data and source of information on specific social and governance issues in your country?

7: Circular Economy and Resource efficiency

Possible indicators include:

- Domestic material consumption by main category, (Eurostat)
- Generation of waste by raw material sector Hazardous/Not hazardous, (Eurostat)
- Waste of Electrical and Electronic Equipment (WEEE) management, (Eurostat)
- Secondary and waste trade (source: COMTRADE) – see African country profiles

Q7.1: Considering the topics/areas touched upon by the above list of indicators, does your country have specific data that could provide additional insight/info? If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q7.2: Is there any additional relevant information/indicator that you would suggest for inclusion in this section? (e.g. indicators that are used as key indicators in policy making in the raw materials field in your country). If so, which? What data sources? Level of disaggregation (e.g. number of industrial sectors, time series, etc.)

Q7.3: Which information do you consider would be relevant to know from other countries in elaborating national policies?

Q7.4: In relation to the following indicators of the Circular Economy Monitoring framework endorsed by EUROSTAT:

- Recycling rate of e-waste (%)

- Recovery rate of C&D waste
- Recycling rate of overall packaging
- Circular material use rate
- EoL-RIR

Which of these indicators do you consider more relevant (for your country)? Why?

For your country, beyond these indicators, are there other indicators in use for CE-monitoring?

Annex 2: Country inputs to the EEA/JRC questionnaire

Germany (DE): Questionnaire inputs

Data availability: What kind of information are countries holding that could be of interest to other countries in planning more sustainable and circular management of raw materials?

Key indicators:

The IRP developed a modeling/allocation approach to express only the impacts of raw materials production and processing (results available for G20 countries) (<https://www.resourcepanel.org/reports/natural-resource-use-group-20>).

Investment and regulatory framework

This topics might be outside the area of expertise of EIONET and might be better addressed at national geological services (e.g., at DERA/BGR in case of Germany).

Circular Economy: Overarching legal framework for waste management is the Circular Economy Act (KrWG) <https://www.bmuv.de/en/law/circular-economy-and-safeguard-the-environmentally-compatible-management-of-waste> .

The coalition agreement of the current Federal Government (<https://www.bundesregierung.de/breg-de/aktuelles/koalitionsvertrag-2021-1990800>) foresees the development of a Circular Economy Strategy to bundle existing material related government strategies such as the Raw Materials Strategy (2020) (<https://www.bmwi.de/Redaktion/DE/Artikel/Industrie/rohstoffstrategie-bundesregierung.html>) and the [German Resource Efficiency Programme](https://www.bmuv.de/en/topics/water-resources-waste/resource-efficiency/german-resource-efficiency-programme-progress-an-overview) (2020) (<https://www.bmuv.de/en/topics/water-resources-waste/resource-efficiency/german-resource-efficiency-programme-progress-an-overview>).

Supply

ROSYS, the Datahub of the German Raw Materials Agency DERA could be a relevant data source for this and other questions: <https://rosys.dera.bgr.de/>

More information could be provided by directly contacting DERA/BGR.

Trade

Imports and exports considering the material footprint perspective (using EW-MFA data in raw material equivalents (Eurostat))

Environment

The national Corine Land Cover dataset is derived on the basis of the “LBM-DE” dataset (<https://www.bkg.bund.de/DE/Ueber-das-BKG/Geoinformation/Fernerkundung/Landbedeckungsmodell/landbedeckungsmodell.html>). Based on LBM-DE, Germany in addition derives a “national Corine Land Cover dataset” in 5 ha resolution which can be accessed here: <https://gdz.bkg.bund.de/index.php/default/digitale-geodaten.html>

National land use and land cover data will be included in the new EEA CLC+ dataset in future. Includes data for hazards posed by:

storms (Global assessment report on disaster risk reduction),

landslide (Global assessment report on disaster risk reduction),

earthquakes (Global Seismic Hazard Assessment Program).

See indicator 6 of the assessment scheme developed within the UBA research projects OekoRes I (<https://www.umweltbundesamt.de/publikationen/eroerterung-oekologischer-grenzen-der>) and OekoRes II (<https://www.umweltbundesamt.de/publikationen/environmental-criticality-of-raw-materials>).

The Copernicus Emergency Management Service can be used to access information on major damaging events / hazards in the EU. However, this requires that the mapping service is activated by the member states (<https://emergency.copernicus.eu/mapping/ems/emergency-management-service-mapping>).

German DERA produces maps of mine sites as part of the ROSYS information system: <https://rosys.dera.bgr.de/mapapps49prev/resources/apps/rosys2/index.html?lang=en>

Additionally, the EU project FINEPRINT seems to be developing comprehensive information on mine site locations globally (<https://www.fineprint.global/resources/>)

UBA is about to publish the results of the OekoRess III research project, an interactive map showing the world's 100 (in total) largest mine sites for iron ore, bauxite and copper ore, including assessment of environmental hazards and some additional governance information for each site. (Link presumably available in May 2022).

The emissions data highlighted above (GHGs, air pollutants) are also available by Destatis in the SEEA datasets. As such they should be similar to the data reported by Eurostat.

Carbon footprint data are available by CPA classification for various sectors (incl. industrial ones): <https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/UGR/energiefluesse-emissionen/Publikationen/Downloads/direkte-und-indirekte-energiefluesse-emissionen-pdf-5859006.html>.

The D-EITI portal provides additional data for the extractives sector on water, dealing with human intervention in nature and landscape, etc.. <https://rohstofftransparenz.de/en/rohstoffgewinnung/>

Social and governance

The environmental justice atlas documents and catalogues social conflict around environmental issues including extractive activities. <https://ejatlas.org/about/>

Circular economy and resource efficiency

Germany reports in addition to DMC also raw material equivalents (material footprint perspective). This is fed into Eurostat data:

https://ec.europa.eu/eurostat/databrowser/view/env_ac_rme/default/table?lang=en. Eurostat work seems to be ongoing to estimate RME figures for all member states via their country tool.

In addition to the "Generation of waste by raw material sector Hazardous/Not hazardous, (Eurostat)", the amount of treated waste (preparing for reuse, recycling, energy recovery, etc) could also be a possible indicator. Such data is reported by Germany to Eurostat every year.

"Municipal waste by waste management operations":

https://ec.europa.eu/eurostat/databrowser/view/ENV_WASMUN_custom_2388804/default/table?lang=en.

Each of the Eurostat circular economy monitoring indicators is important on its own, so that developments in their specific subject can be shown and appropriate measures for improvement can be derived. The primary goal should be to reduce the amount of waste, because waste that is not generated does not cause any environmental impacts and saves the most resources.

The total amount of waste generated in Germany is dominated by building waste which makes up around 55%. The total amount of waste therefore primarily reflects the economic situation in the building industry. In addition to the total amount of waste generated in Germany, the amount of municipal waste is just as important. It mainly covers the types of waste collected by municipal waste management companies. The main waste generators are households, administration and commercial companies. The amount of municipal waste therefore reflects the behavior of a wide spectrum of waste generators.

A central policy with regard to resource efficiency and circular economy is the German Resource Efficiency Program (ProgRess) which includes indicators related to resource productivity, material footprints, circular materials use and anthropogenic stocks. <https://www.bmuv.de/en/topics/water-resources-waste/resource-efficiency/german-resource-efficiency-programme-progress-an-overview>

Furthermore, UBA is in the process of elaborating on resource indicators (but with a focus on all natural resources, i.e., raw materials, water, land, environmental media, ecosystems) <https://www.sciencedirect.com/science/article/pii/S0921344921004675?via%3Dihub>

Data needs: What kind of information would countries be interested in from other countries in order to be able to better coordinate the extraction and management of raw materials?

Key indicators:

The efficiency with which different countries convert primary materials into GDP (or alternative measures of wellbeing) is central to EU policy (Green Deal, CE action plan, RMI, etc.), also against the background of supply security. Materials productivity could be calculated based on Eurostat EW-MFA statistics for each MS (env_ac_mfa) and also considering the material footprint (RMC) for countries (ENV_AC_RME).

Lowering GHG emissions (and other impacts) across all sectors (including raw materials and related industries) is essential to achieve the EU's climate (and other environmental) goals. Data on GHG emissions could perhaps stem from indicator 21 (GHG emissions) of the RM scoreboard or SEEA accounts for CO₂ / GHG footprints (e.g., Destatis).

Investment and regulatory framework

Environmental Governance Performance

Supply

Information on in-use anthropogenic material stocks (e.g., raw materials in buildings, appliances, automobiles, etc.) can provide an alternative source of future materials supply. Data are collected at UBA via research projects: <https://www.umweltbundesamt.de/publikationen/kartierung-des-anthropogenen-lagers-in-deutschland> (in German).

Trade

These indicators/topics seem outside the area of expertise of EIONET and might be better addressed at national geological services (e.g., at DERA/BGR in case of Germany).

Environment

It would be good if RMIS could increasingly also include a footprint perspective (e.g., carbon footprint, water footprint, etc.) as not doing so can lead to burden shifting between geographical regions. For example, Eurostat provides such data for the EU-27 as a whole (not yet at MS-level) which could be further disaggregated for relevant industrial sectors (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Greenhouse_gas_emission_statistics_-_carbon_footprints#Carbon_dioxide_emissions_associated_with_EU_consumption). Such data are also available for Germany for CO₂ and energy demand (see above).

Similarly, the UNEP SCP-Hat provides detailed data and visualizations of countries' raw materials use (using UNEP IRP MFA data), GHG emissions, water use, water pollution, air emissions, etc.) which can be broken down also by individual sectors. This might be linked to by RMIS. (<http://scp-hat.lifecycleinitiative.org/>)

Social and governance

Government revenue from the extractive sector as well taxes and subsidies could be of interest. Data provided by D-EITI: <https://rohstofftransparenz.de/en/daten/>

Circular economy and resource efficiency

See above

Ireland (IE): Questionnaire inputs

Data availability: What kind of information are countries holding that could be of interest to other countries in planning more sustainable and circular management of raw materials?

Key indicators:

- N/A

Investment and regulatory framework

- N/A

Supply

- N/A

Trade

- N/A

Environment

- Maps of mining activities
- Coastal/riverine flooding hazard maps

Social and governance

- EPA, IGI, GSI websites

Circular economy and resource efficiency

- N/A

Data needs: What kind of information would countries be interested in from other countries in order to be able to better coordinate the extraction and management of raw materials?

Key indicators:

- Exploration expenditure on early stage mineral projects aggregated from national or commercial sources
- Contribution to EU's security of supply of CRMs and addition to early stage of value chain.

Investment and regulatory framework

- Exploration expenditure aggregated into gold, CRMs and industrial minerals
- Source of exploration funding – e.g. Australia, UK, Canada. Stock market location of publically traded companies for each country

Supply

- Production normalized to EU/EAA demand/consumption

Trade

- N/A

Environment

- EPD (environmental product declarations) for individual extractive products compared to other countries

Social and governance

- Fraser Rankings

Circular economy and resource efficiency

- Residency time in the economy is a better measure of CE performance for raw materials than the above measures.

Portugal (PT): Questionnaire inputs

Data availability: What kind of information are countries holding that could be of interest to other countries in planning more sustainable and circular management of raw materials?

Key indicators:

- DGEG: Portugal has data for mineral resources production (value and tonnes), imports, exports, jobs, mining potential. All data may be found at www.dgeg.gov.pt
- Portugal also provides several statistical mining data for Eurostat.
- DGEG: Portugal has a stable and coherent legislative framework, which has been recently updated in 2015 and 2022, aiming at the sustainable mining principles. We are now updating Portugal profile mining data in RMIS

Investment and regulatory framework

- Detailed information about the Regulatory Framework, at national level:
 - [Law 54/20155, 22th June](#)
 - [DL 30/2021, 7th may](#)
 - [Law 10/2022, 12th january](#)
 - [DL 270/2001, 6th October](#)
 - [DL 340/2007, 12th October](#)
- Amount of investment (€) per year, in exploration in Portugal.

Supply

- Statistical data on geological resources and mineral sector data on www.dgeg.gov.pt

Trade

- DGEG: Statistical data on imports and exports. See: www.dgeg.gov.pt
<https://www.dgeg.gov.pt/pt/estatistica/geologia/publicacoes-estatisticas/statistical-data-information-mining-industry/>

Environment

- National geo-portal: <https://www.dgeg.gov.pt/pt/servicos-online/informacao-geografica/>
- Flooding area maps: <https://sniamb.apambiente.pt/content/diretiva60ce2007-2%25C2%25BA-ciclo?language=pt-pt>
- Portugal compiles national inventories on GHG and other pollutants that are annually reported in the framework of the international and EC agreements such as the UNFCCC, the CLRTAP and NECD. This information is available at CRF and NFR categories levels since 1990 until the year-2.
- This information can be downloaded from the APA 's internet site: <https://apambiente.pt/clima/inventario-nacional-de-emissoes-por-fontes-e-remocao-por-sumidouros-de-poluente-atmosfericos>
- Spatially disaggregated emissions are also compiled and available for some years at: <https://apambiente.pt/clima/distribuicao-espacial-de-emissoes-nacionais-2015-2017-e-2019>
- System with information about all the water bodies <https://snirh.apambiente.pt/> .

Social and governance

- Data related with occupational safety and public acceptance.

Circular economy and resource efficiency

- The CEAP for Portugal considered the following set of indicators that are being used for monitoring purposes.

AREA		Indicator
RESOURCES	PRODUCTIVITY	Resource productivity (€/kg) Defined as gross domestic product (GDP) divided by domestic materials consumption.
		Productivity of artificial areas (PPP (purchasing power parity) millions per km²) [2009 (corresponds to just 23 countries, not including BG, CY, HR, MT, RO); 2012] Defined as a country's gross domestic product (GDP) divided by its total artificial areas. Artificial areas: urbanised areas (surfaces covered with buildings and greenhouses) except towns (roads and sealed surfaces). Shows whether the productivity of built artificial areas is used efficiently to generate added economic value.
ENVIRONMENTAL IMPACT	MATERIALS	Domestic materials consumption (ton/ capita) Defined as the total amount of materials used directly in the economy and is equal to direct material input (domestic extraction plus imports) less exports.
	ENERGY	Energy productivity (€/kg of oil equivalent) Defined as GDP divided by gross domestic energy use in a certain calendar year. Share of renewable energy (%) Percentage of renewable energy compared to total energy consumed
	EMISSIONS	GHG intensity in energy use (Index 2000=100) [-; 2015] Ratio of energy-related GHG emissions (carbon dioxide, methane and nitrous oxide) to gross domestic energy use. Per capita GHG emissions (tons of CO₂ eq per capita) [-; 2015]
TRANSFORMING THE ECONOMY	TRANSFORMING WASTE INTO A RESOURCE	Waste production excluding mineral waste, dredging waste and contaminated soils (kg/capita) [2004;2014]
		Landfilling rate with the exclusion of mineral waste, dredging waste and contaminated soils (%) [2010; 2014] Defined as the volume of waste sent to landfill (directly or indirectly) divided by the volume of treated waste (exclude mineral waste, dredging waste and contaminated soils).
		Urban waste production (kg/capita) [-; 2014]
		Urban waste landfilling rate (%) [2010; -]
		Urban waste recycling rate (%) [-; 2014]
		Packaging waste recycling rate (%) [-; 2014]
SUPPORTING RESEARCH AND INNOVATION		Electrical and electronic waste recycling rate (%) [2008; 2014]
		Eco-innovation index (EU=100) [2010; -] Index with 16 indicators (e.g. green investment, jobs, patents)

Data needs: What kind of information would countries be interested in from other countries in order to be able to better coordinate the extraction and management of raw materials?

Key indicators:

- DGEG: Royalties applied to mining, success cases in communication with communities with strong mining oppositions, success cases in mining acceptance from local communities, other mining regulations, best practices from the mining sector, enforcement of best practices from competent authorities.

Investment and regulatory framework

- N/A

Supply

- N/A

Trade

- N/A

Environment

- N/A

Social and governance

- Royalties policies, mining legislation, communities mining acceptance

Circular economy and resource efficiency

- Regarding indicators related to Material Flow Accounts, namely: 1. Domestic material consumption (DMC); 2. Raw material consumption (RMC); 3. Resource productivity, we think they are justified within this framework.
- It is considered to be simultaneously maintaining the Domestic Material Consumption (DMC) and Raw Material Consumption (RMC) indicators. This indicator (RMC = material footprint) is already available in the INE database (Material Footprint (1000 t); Annual) and will be updated annually.
- Despite the inclusion of two indicators that measure the same event, we believe that this is a justifiable option, given the still limited use of the RMC by member states and the existence of some uncertainty in terms of the quality of the data necessary for its preparation from outside the EU.

- Indicators that support the mapping and policy making in the area of critical raw materials: production; imports and exports; domestic consumption; quantities in waste (generated and imported)
- Taking a broader perspective, we suggest that indicators related with eco-design and Private consumption could be considered. For Private consumption behavior it is suggested to include the indicator “households expenditures in maintenance and repair services” (per capita; share in total expenditures).
- Circular Economy specific policy instruments (regulatory and economic), aiming the promotion of eco-design, secondary materials use, biologic material use and biologic products; Circular Economy skills profiles
All of the listed indicators from the CE monitoring framework (Eurostat) are relevant to monitoring waste policy and circular economy performance.
- With regard to the Generation of Packaging Waste, it is considered necessary to harmonize the methodology for calculating the data in the different Member States

Spain (ESP): Questionnaire inputs

Data availability: What kind of information are countries holding that could be of interest to other countries in planning more sustainable and circular management of raw materials?

Key indicators:

- Mining Statistics of Spain (“Estadística Minera de España, 2020: <https://energia.gob.es/mineria/Estadistica/DatosBibliotecaConsumer/2020/Estadistica-Minera-Anual-2020.pdf>)
- Possible indicators covered:
 - mining as % in value added (Global source UN)
 - Value added of selected industrial sectors (Eurostat)
 - Number of employees in selected industrial sectors (Eurostat)

Investment and regulatory framework

- Data sources (mining): Mining Statistics of Spain (“Estadística Minera de España, 2020: <https://energia.gob.es/mineria/Estadistica/DatosBibliotecaConsumer/2020/Estadistica-Minera-Anual-2020.pdf>)
- Mining <https://energia.gob.es/mineria/Mineria/Legislacion/Paginas/OrdenacionMinera.aspx>
- Mining and environment <https://energia.gob.es/mineria/Mineria/Legislacion/Paginas/Medioambiente.aspx>
- Regulatory framework – Compilation https://www.boe.es/biblioteca_juridica/codigos/codigo.php?id=196_Codigo_de_la_Mineria_&modo=1
- <https://www.miteco.gob.es/en/calidad-y-evaluacion-ambiental/temas/economia-circular/estrategia/>

Supply

- Mining Statistics of Spain (“Estadística Minera de España, 2020: <https://energia.gob.es/mineria/Estadistica/DatosBibliotecaConsumer/2020/Estadistica-Minera-Anual-2020.pdf>)
- Possible indicators covered:
 - Domestic extraction by main category, (Eurostat)
 - Production value of relevant sectors, (Eurostat)
 - Production of primary minerals/global share of production, (World Mining Data)

Trade

- Exports and imports by main raw materials and countries (UN Comtrade via WITS)
- Data sources: Partially, Mining Statistics of Spain (“Estadística Minera de España, 2020: <https://energia.gob.es/mineria/Estadistica/DatosBibliotecaConsumer/2020/Estadistica-Minera-Anual-2020.pdf>)

Environment

- Data sources (EU level): See Spain: <https://inspire-geoportal.ec.europa.eu/results.html?country=es&view=details&theme=none>
- <https://sig.mapama.gob.es/geoportal/>
- Maps with air pollutants industrial emissions from pollutant compound. <https://sig.mapama.gob.es/geoportal/>
- Energy consumption (fuel, electricity) in extractive sites.
- Data sources: Mining Statistics of Spain (“Estadística Minera de España, 2020: <https://energia.gob.es/mineria/Estadistica/DatosBibliotecaConsumer/2020/Estadistica-Minera-Anual-2020.pdf>)

Social and governance

- Fatal and serious accidents in the extractive sector
 - Data sources: Estadística de Siniestralidad Minera de España (https://energia.gob.es/mineria/Seguridad/Guias/Siniestralidad/Informe_Siniestralidad_Minera_2020.pdf)

Circular economy and resource efficiency

- N/A

Data needs: What kind of information would countries be interested in from other countries in order to be able to better coordinate the extraction and management of raw materials?

Key indicators:

- N/A

Investment and regulatory framework

- N/A

Supply

- N/A

Trade

- N/A

Environment

- N/A

Social and governance

- N/A

Circular economy and resource efficiency

- N/A

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