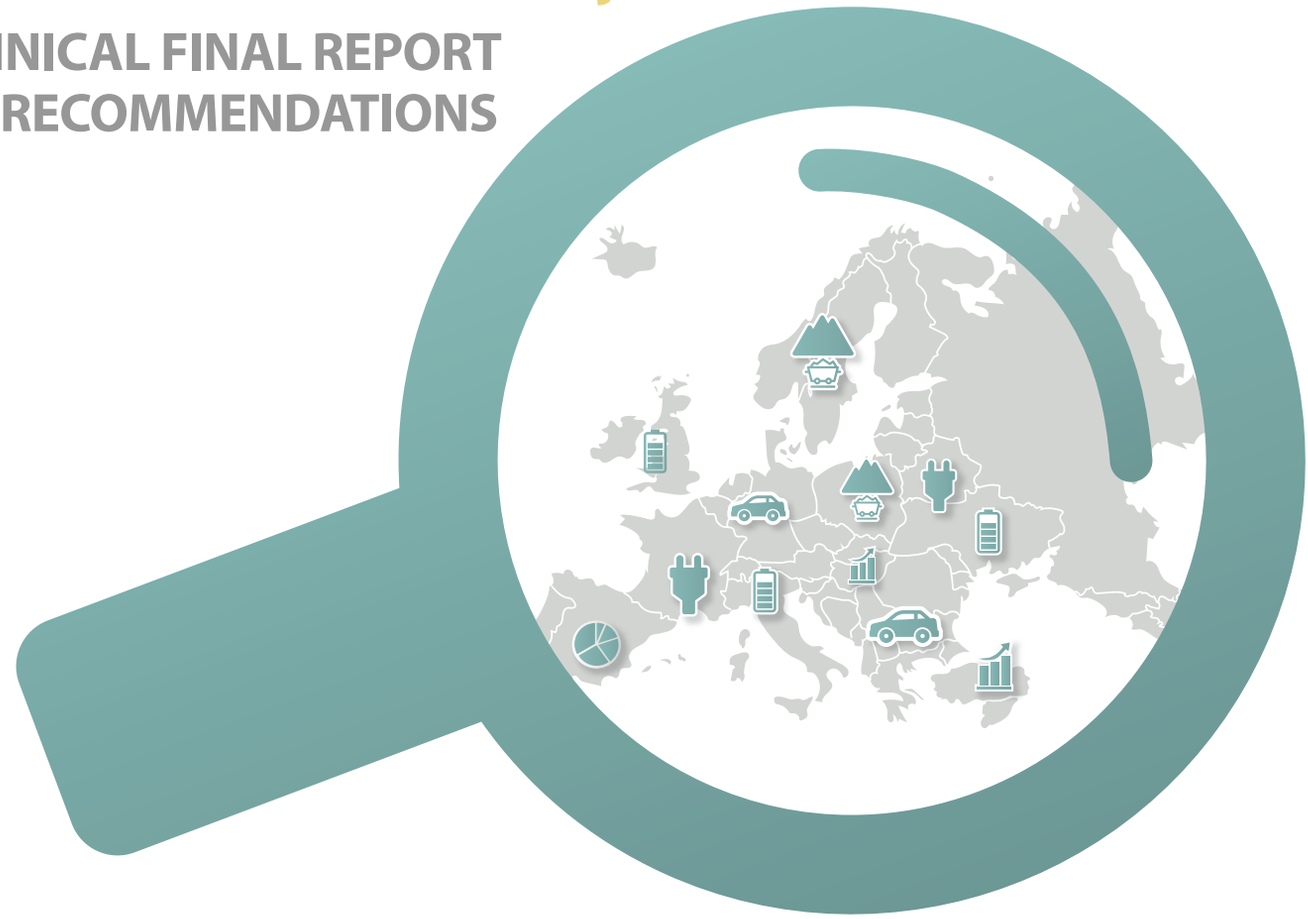
Optimising quality of information in RAw MAterials data collection across Europe

FINAL REPORT - ORAMA Project

TECHNICAL FINAL REPORT AND RECOMMENDATIONS



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Disclaimer

This document summarises the key findings from the ORAMA project. Individual project deliverable reports provide more detail and can be found at www.orama-h2020.eu. See Appendix 1 for list of key deliverables.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Acronyms

BGS: British Geological Survey

Batt: Batteries

BEV: Battery Electric Vehicle

CGI: Commission for the Management and Application of Geoscience Information

CRIRSCO: Committee for Mineral Reserves International Reporting Standards

CRM: Critical Raw Materials

D: Deliverable Report one of the official reports of the project that have been submitted to the EC. Published Deliverable Reports are available at: https://orama-h2020.eu/downloads/

EC: European Commission

EEE: Electrical and Electronic Equipment

ELV: End of Life Vehicles

e-MYB: e-Minerals Yearbook

ERML: EarthResource Markup Language

EU: European Union

GeoSciML: GeoScience Markup Language

GTK: Geological Survey of Finland

HEV: Hybrid Electric Vehicle

IUGS: International Union of Geological Sciences

INSPIRE: Infrastructure for Spatial Information in the European Community

MIN: Mining Waste

MS: Member States

NGU: Geological Survey of Norway

PERC: Pan-European Reserves and Resources Reporting Committee

PGI: Polish Geological Institute

PHEV: Plug-in Hybrid Electric Vehicle

POM: Placed on market

PRM: Primary Raw Materials

PRO: Producer Responsibility Organisation

PRODCOM: "PRODuction COMmunautaire" (Community Production) for mining, quarrying and manufacturing.

PV: Photovoltaic

RMIS: Raw Materials Information System (from EC DG JRC), http://rmis.jrc.ec.europa.eu/?page=country-profiles#/

SRM: Secondary Raw Materials

Tukes: Finnish Safety and Chemicals Agency

UMP (previously known as: EU-UMKDP): Urban Mine Platform - for prospecting secondary raw

materials in the Urban mine and Mining wastes, ProSUM.

UNECE: United Nations Economic Commission for Europe

UNECE EGRC: United Nations Economic Commission for Europe - Expert Group on Resource Classification

UNFC: United Nations Framework Classification for Resources

UNRMS: United Nations Resource Management System (the successor of the UNFC from the second half of 2018).

UNU: United Nations University

WEEE: Waste Electrical and Electronic Equipment

(W) EEE: Electrical and Electronic Equipment and Waste Electrical and Electronic Equipment

WP: Work Package (a section of work in the ORAMA project)

xEV: Electric Vehicles (BEV, HEV, and PHEV)

Executive Summary

Securing the sustainable access to and supply of raw materials, and particularly of Critical Raw Materials (CRM), is of high importance for the European economy. Complex primary and secondary resources contain many different raw materials. The inability to easily produce reliable statistics about reserves, resources, stocks, and flows of raw materials limits the understanding of global trends in resource availability and hampers formulation of mineral and waste policies. This ultimately affects supply chain security and strategic decisions by industry. Hence, it is an issue of great concern for the European Commission (EC) and many other stakeholders. The ORAMA project (Optimising quality of information in RAw MAterial data collection across Europe) seeks to contribute to better supply of raw materials by improving the quality of harmonised raw materials data collection and information sharing among the different levels within the European Union (EU).

Data collection practices for primary and secondary raw materials (PRM and SRM) face specific challenges in EU Member States (MS). For PRM data, the main concerns are related to data availability, geographical coverage, accessibility, harmonisation, interoperability, quality, and thematic coverage. The reporting of primary mineral resources and reserves statistics is currently carried out by a wide variety of systems, standards or codes which are not directly comparable. Hence, it is currently impossible to produce reliable pan-European figures for resources for any mineral commodity. ORAMA addresses these issues by recommending a single standard for reporting of resource data, the United Nations Framework Classification (UNFC), a framework for reporting mineral resource data developed by the UN. To enable and encourage data providers to adopt this standard for European PRM data, the ORAMA project has developed resources in the form of a range of training materials and good practice examples.

The ORAMA project demonstrates that the analysis of various classifications and reporting systems that sit within the INSPIRE (Infrastructure for Spatial Information in the European Community) concept and data services, are not opposing but rather integral elements of the proper European level data collection and production of information for PRM and SRM. The use of UNFC/UNRMS (United Nations Resource Management System) in the framework of the INSPIRE compliant data service can significantly contribute to sustainable resource management taking into account not only geological knowledge and raw materials potential but also environmental and social issues, based on using the national/regional legislative elements for exploration and exploitation as well.

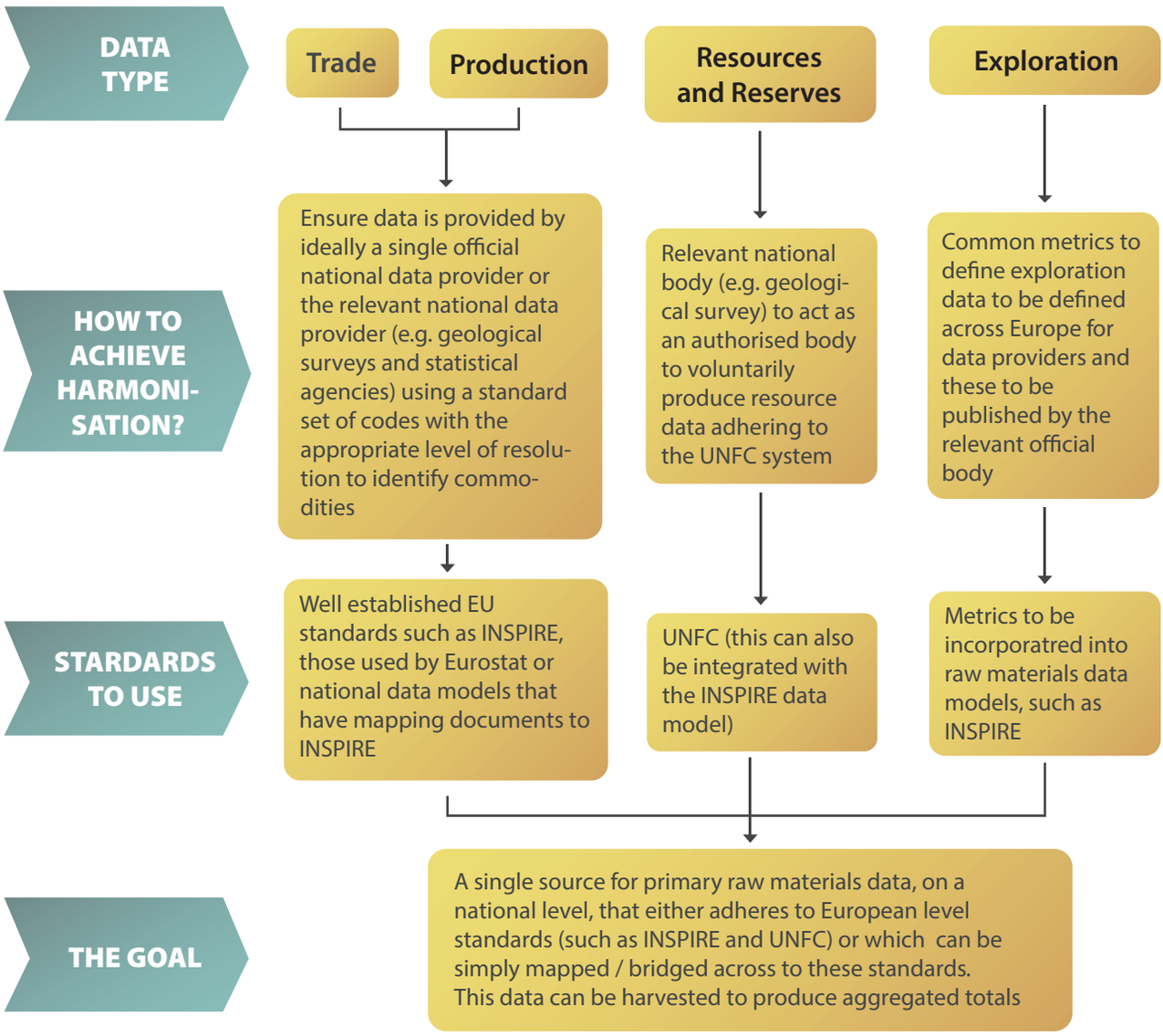


Figure 1 *Overview of EU flow status and best practices applied by PRM*

In the case of SRM, the challenges are somewhat different. Regarding mining waste (MIN), the lack of information on deposit characteristics (composition, volumes, and suitable processing technology) is a huge barrier in the identification of recovery potential of the valuable materials that remain in the waste. Furthermore, the lack of a single reporting standard commonly accepted at EU level has created a dispersion of existing information in various systems and project deliverables. In the case of electrical and electronic equipment (EEE) and batteries, beyond the lack of harmonisation, substantial data gaps exist for the market inputs, materials consumption and stocks, and for waste electrical and electronic equipment (WEEE) for unaccounted flows ending up being scavenged, metal scrap and export channels. For vehicles, huge amounts of data, both on stocks and flows and on composition, are systematically collected by authorities and the manufacturing industry, but are only publicly available in a somewhat too aggregated form (placed on market (POM), stock, waste flows) or not at all (composition data).

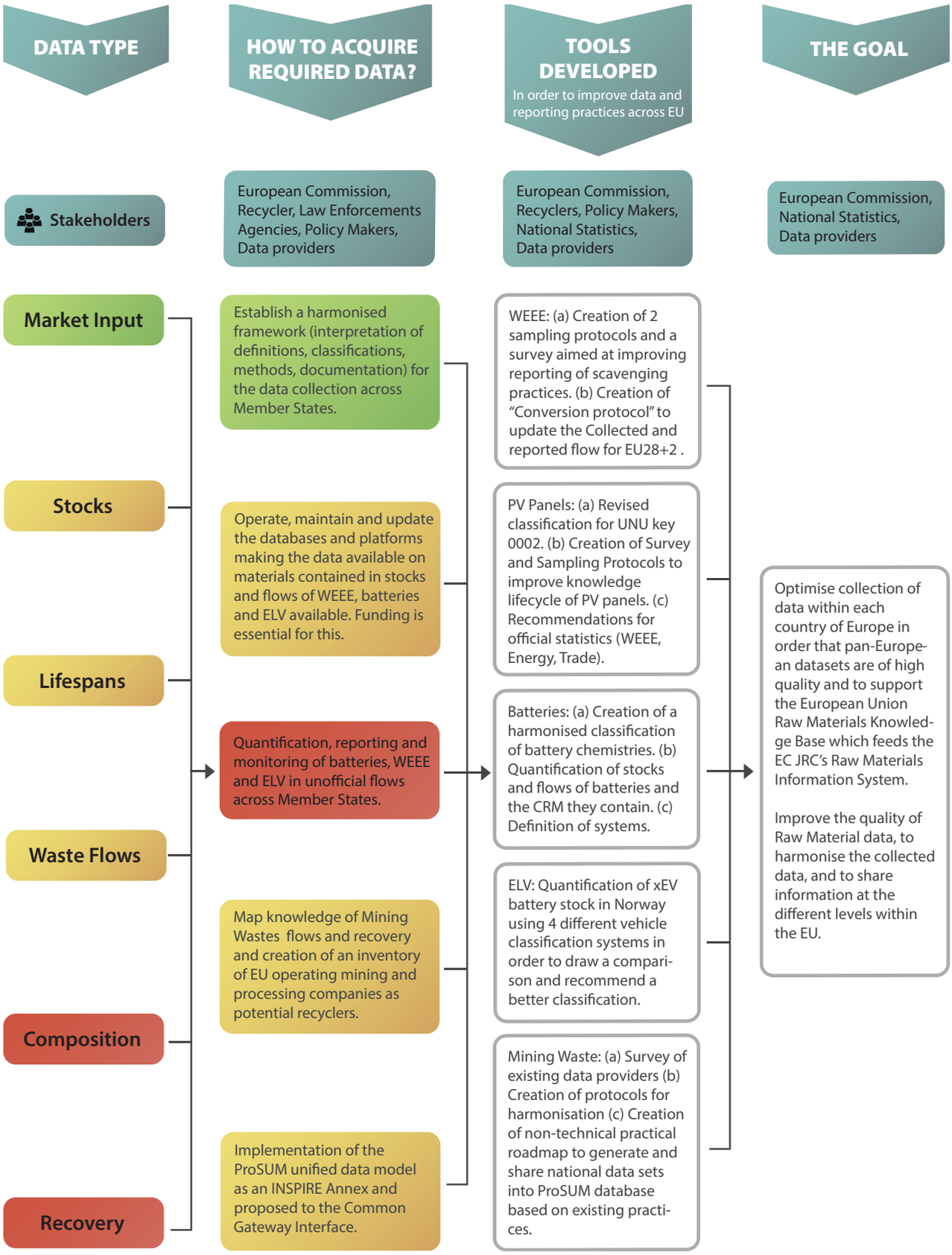


Figure 2 *Overview of EU flow status and tools applied by SRM with traffic light colour, meaning (Red – Urgent need for improvement, Orange – Moderate need for improvement, Green – No immediate need for improvement) from research analysis.*

Even when collected, the reporting of the composition of these flows on a product, component and materials level are currently poorly described across all MS, and when actually ending up in recycling processes, the recovery efficiency for all elements and CRMs, in particular, is disappointing. In order to improve the data collection and reporting practices for SRM a structured review and inventory were made followed by a data gap analysis which resulted in the developments of recommendations and subsequently the selection of 6 case studies. The SRM case studies tackle the main data gaps encountered in the analysis and developed tools that will enable the improvement and harmonisation of collection and reporting practices in MS, treatment facilities, data providers, academia among others.

The ORAMA project recommends to establish more structured and continuous funding for realising and maintaining a European data infrastructure for tracking both PRM and SRM. The current project-by-project based financing is insufficient and not sustainable to properly track and understand Europe's strengths and weaknesses in the early resource intensive stages of global supply chains.

1 Introduction

In order to secure the well-being of its population and the competitiveness of its manufacturing industry, the European economy requires sustainable access to raw materials. However, statistics about reserves, resources, stocks and flows of products, components and materials are unreliable and hence of poor quality, data are not available or not accessible, insufficiently harmonised and not interoperable.

For example, the *primary* mineral resources and reserves statistics are reported in accordance with a wide variety of systems, standards or codes which are not directly comparable. It is therefore impossible to produce reliable pan-European figures for resources for any mineral commodity.

Compared to PRM, the challenges related to SRM materials are of a different nature. As well as there being a variety of codes used for reporting purposes, there are substantial data gaps as regards the identity and tonnages of products POM, materials consumption and stocks of WEEE, end of life vehicles (ELV) and batteries. Furthermore, there are unaccounted flows of WEEE that end up being scavenged, treated as metal scrap and exported. In addition, significant amounts of batteries and WEEE end up in municipal solid waste and the reporting of the composition of these flows on a product, component and materials level is poor, to put it mildly.

The ORAMA project has sought to address these serious problems by improving the quality of harmonised raw materials data, improving data collection and stimulating the exchange of information among MS. The project thereby has contributed to the development of the EU knowledge base on PRM and SRM.

Figure 3 provides an overview of the structure of this Technical Final Report. Chapter 2 provides an overview of data collection and reporting methods in the EU, followed by, in Chapter 3, an overview of data collection and reporting methods for SRM. Chapter 4 selects and implements a number of best practices for data collection and reporting methods in the EU. Chapter 4 zooms in on tools designed to harmonise data collection. Chapter 5 offers a range of recommendations and next steps to consider, followed by Chapter 6 where policy briefs for different aspects of PRM data management and SRM waste groups compiled on the material presented are included.

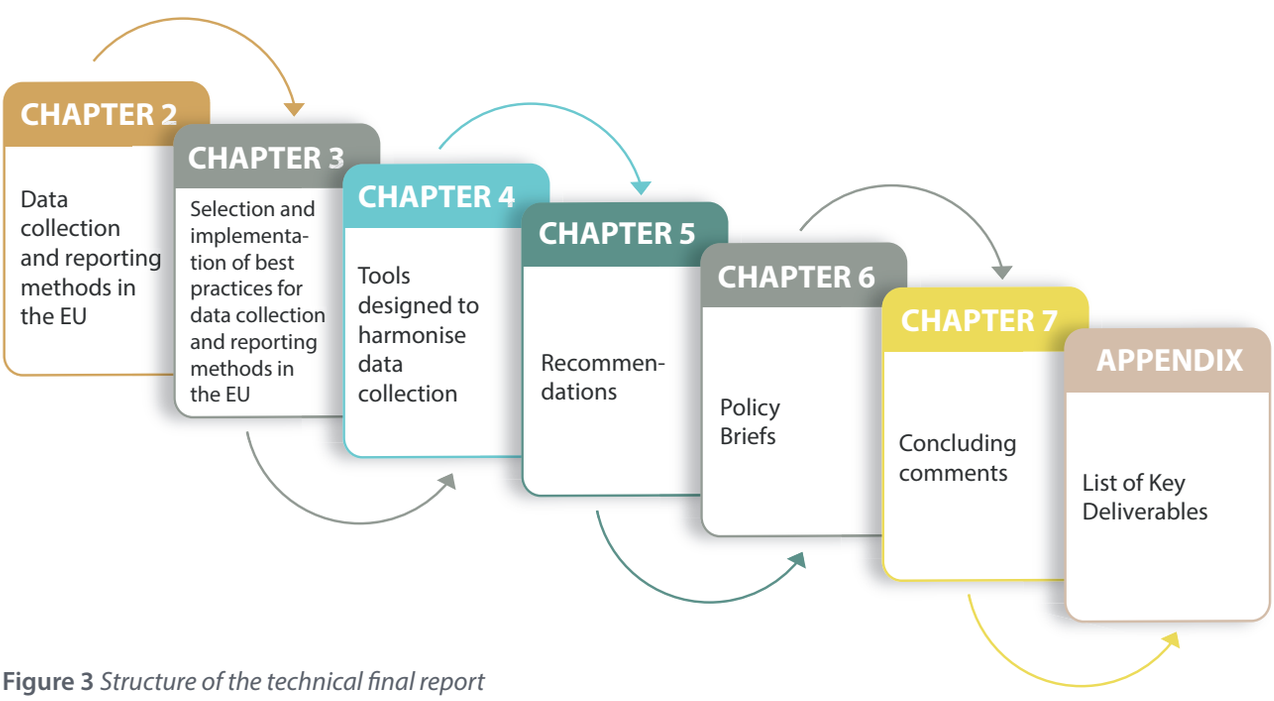


Figure 3 *Structure of the technical final report*

2 Data collection and reporting methods in the European Union

2.1 Data models: the INSPIRE MR / ERML data model, the ProSUM unified data model

The ORAMA study conducted in Work Package (WP)3 reviews the different implementations of the INSPIRE Mineral Resources (MR) data model (INSPIRE Thematic Working Group Mineral Resources, 2013) via two main projects, the EU-FP7 Minerals4EU project (Cassard et al., 2014; Schubert et al., 2014) and the H2020 ProSUM project. ProSUM was essentially centered on the urban mine (WEEE, end of life vehicles (ELV) and batteries) and this necessitated the development of a new data model (the ProSUM Unified data model), but at the same time, ProSUM was also in charge of improving the management of mining waste (MIN) data. Originally, MIN were not included in the INSPIRE core data model but in the INSPIRE MR extension data model. The implementation made in the M4EU data model needed to be refined, which was done in the frame of ProSUM.

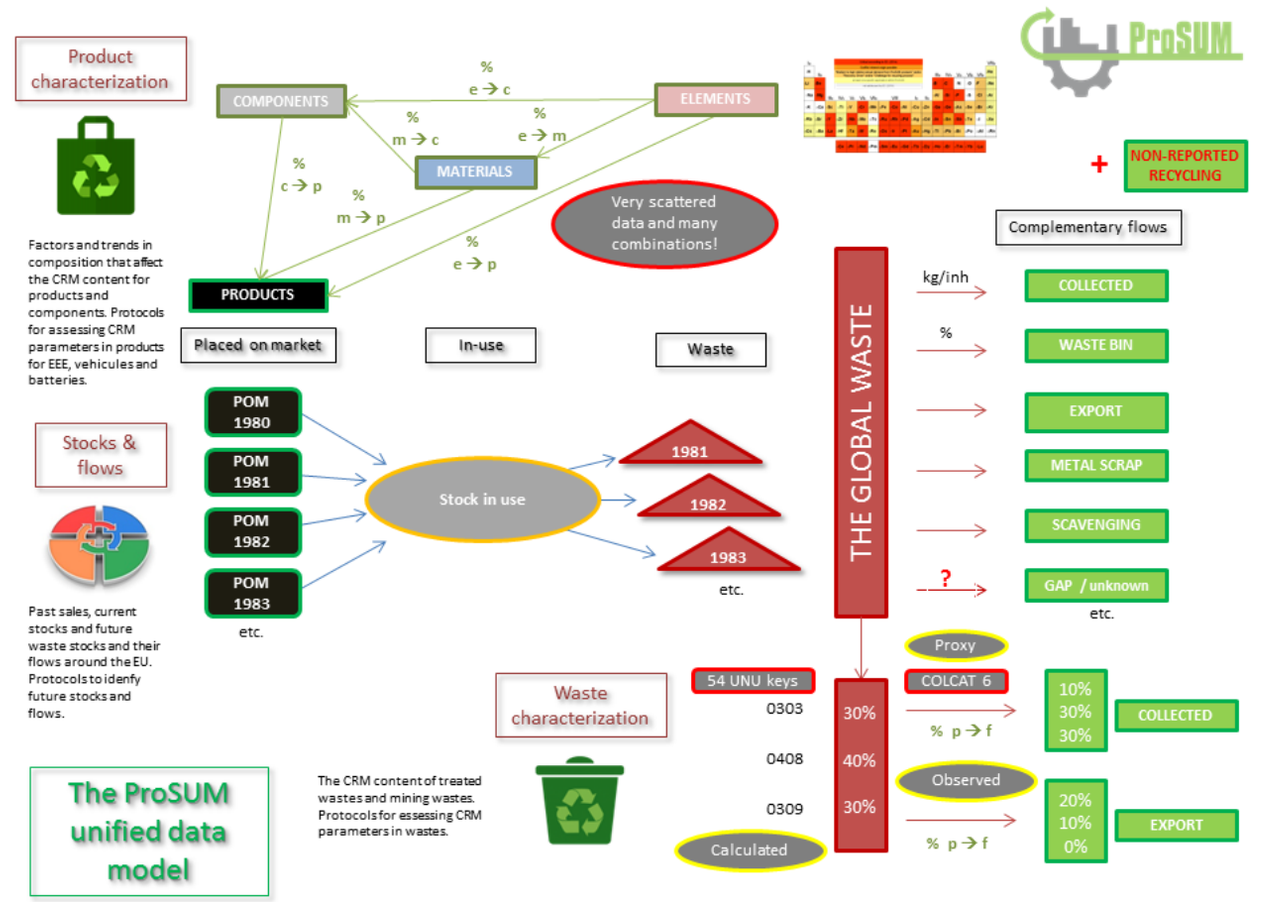
Both data models are robust, perform their roles effectively and are not more complex than needed. Their level of detail is relatively high (hence a certain complexity) but in return, it allows the correct processing of data and information.

Future changes will, therefore, not focus on the structure of the models but more on the vocabulary part (i.e. the code lists) in order to follow the improvements of the classifications and in particular the integration of more detail in order to better characterise stocks and flows[1] (Cassard et al., 2019).

The INSPIRE MR / ERML (EarthResourceML) data model has been improved since the publication of the original version in 2013. **Additions, corrections and improvements made in the frame of the Minerals4EU and ProSUM projects have been submitted to, and accepted by, the IUGS/CGI/ ERML Group** (the process is still ongoing for some code lists). They will have to be 'pushed' into the INSPIRE validation process following the submission procedures described in collaboration with the Directorate-General Joint Research Centre (DG JRC). Modifications can be seen at: https://www.seegrid.csiro.au/subversion/xmml/GGIC/trunk/doc/ERML_3_Doc/index.htm.

The INSPIRE MR / ERML data model is more focused on metal substances than on industrial rocks and minerals, and some key parameters/properties such as volume (m^3) and bulk density, among others are not provided by the current data model. The solution could be to complete EarthResourceDimension for raw materials, similar to what has been done for WasteDimension. Physical properties, essential to characterising industrial rocks, define their use(s) and classify them; these are obviously important but missing. This is probably manageable through GeoScience Markup Language (GeoSciML) 3.0 Package 'PhysicalProperties', available at: http://geosciml.org/doc/geosciml/3.0/documentation/html/, and a new code list will be needed.

The ProSUM Unified data model (see Figure 4 a and b, versions extracted from Cassard et al., 2017 and Heijboer et al., 2017), for its part, will have to be submitted to the Commission for the Management and Application of Geoscience Information (CGI) in order to get the opportunity to become a recognised standard. As this data model is intended to quantify flows and stocks of metals (including CRM), an option could be to make it an extension of ERML.



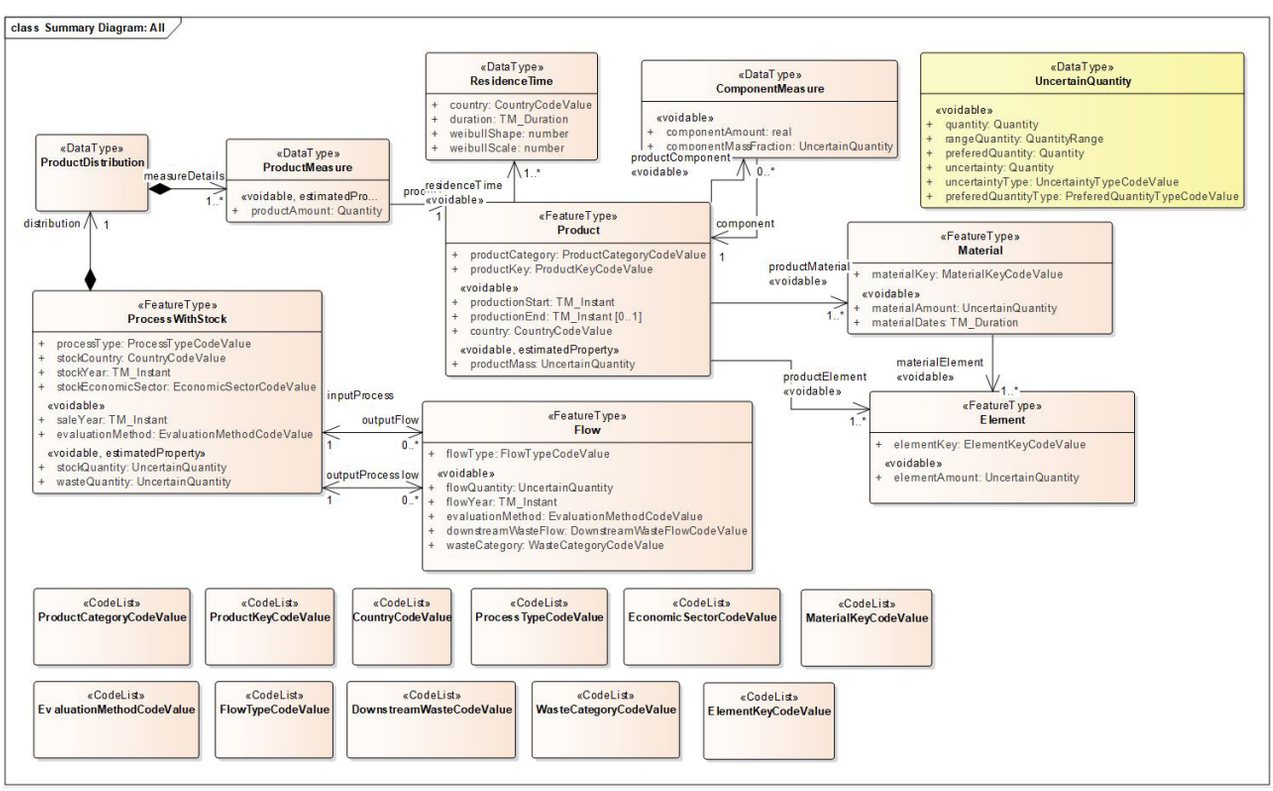


Figure 4 a & b *The ProSUM Unified data model: a) conceptual (above) and b) UML (below)*

The partial automation of the e-Minerals Yearbook (e-MYB) initially developed in the Minerals4EU project will require the harvesting of resources and reserves (if any) and production data aggregated at the national level. Several options (ERML, ERML-Lite and O&M (ISO 19156, Observations and Measurements)) have been evaluated in terms of data model for the building of the web services and harvesting database. It was concluded that the best option (saving time, ease of implementation) was to build on ERML by extending the Minerals4EU MineralProducingCountry feature class that was adapted from the EuroGeoSource project and fitted into the M4EU model. The extension will notably include the following properties: (i) Exploration (number of active licences, number of licences issued, number of companies exploring, the area covered by exploration licences, the amount of expenditure incurred), (ii) Trade (data not harvested, only provided by British Geological Survey (BGS) for diffusion - import data and export data), and (iii) Mineral-based waste flows issued by Eurostat (Cassard et al., 2019; see Figure 5).

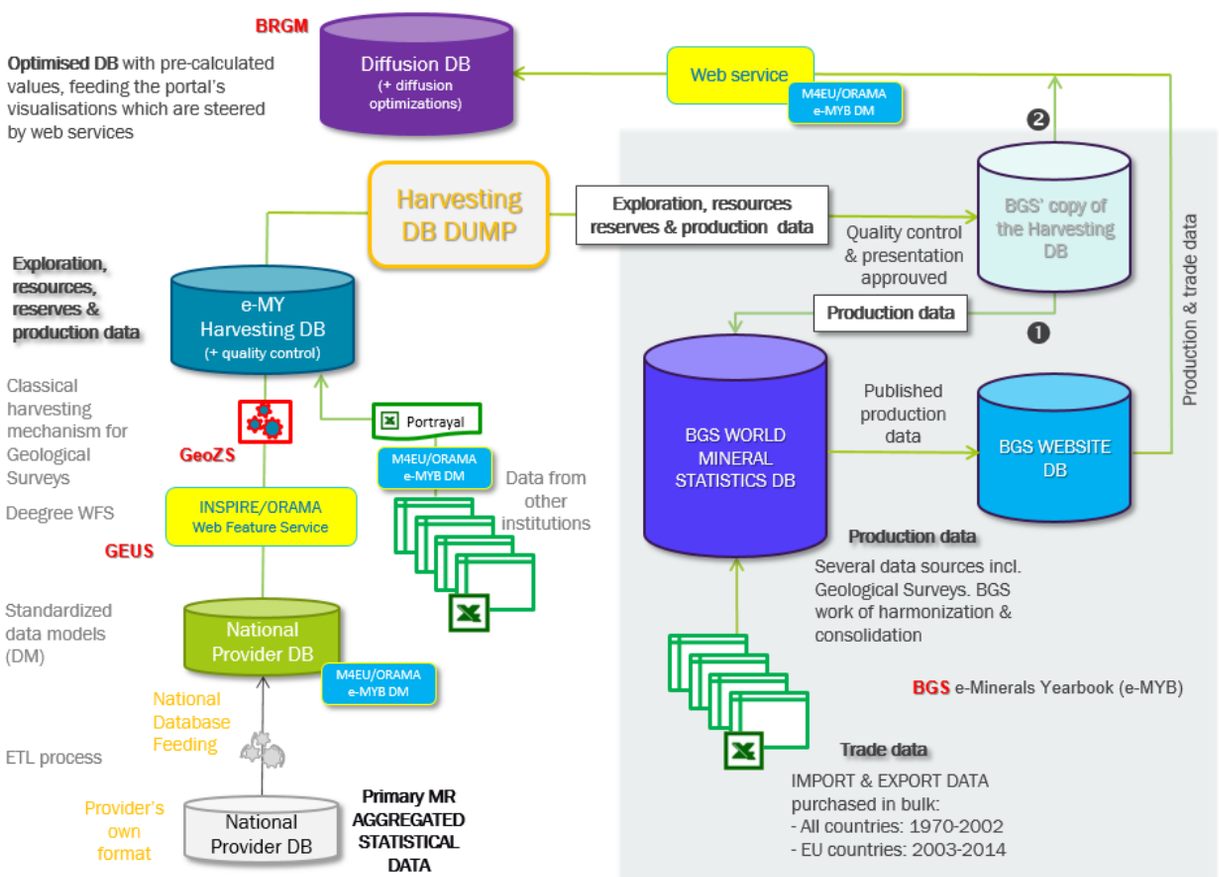


Figure 5 *The e-MYB feeding data flow*

Regarding 'Commodities', the mapping between the INSPIRE MR/CGI CommodityCodeValues and the BGS list of commodities used for the e-MYB has been re-evaluated. The two code lists are alternatively more detailed for some commodities/products in connection with their original objectives that were not the same, more metallogenic for the first, more industrial and commercial for the second. The solution finally adopted was to extend/complete the ERML code list with the 'BGS e-MYB existing commodity/products codes into a **hierarchical code** list which will preserve the compliance with the 'INSPIRE/ERML' list and avoid the loss of information generally occurring during a mapping. This review was also the opportunity for an update regarding a few missing terms or concepts (Heavy Rare Earth Oxides & Light Rare Earth Oxides notably). Also the needs expressed by some ongoing projects regarding the lack of details for certain commodities (e.g. graphite), will also inevitably lead to regular updates of this new common commodity code list.

2.2 Data collection and reporting methods for Primary Raw Materials (PRM)

2.2.1 Production data

Many national data providers deal with mineral production data, it is the most common data type regarding PRM published by national geological surveys, national statistical agencies, mining authorities etc. A survey of data providers, conducted by the ORAMA project, published in Deliverable 1.2, showed that over 80% of national data providers produce data on mineral production. This is predominantly for mine production, although a significant number also publish data for sold production (Figure 6) and some organisations publish data on the downstream end of the value chain.

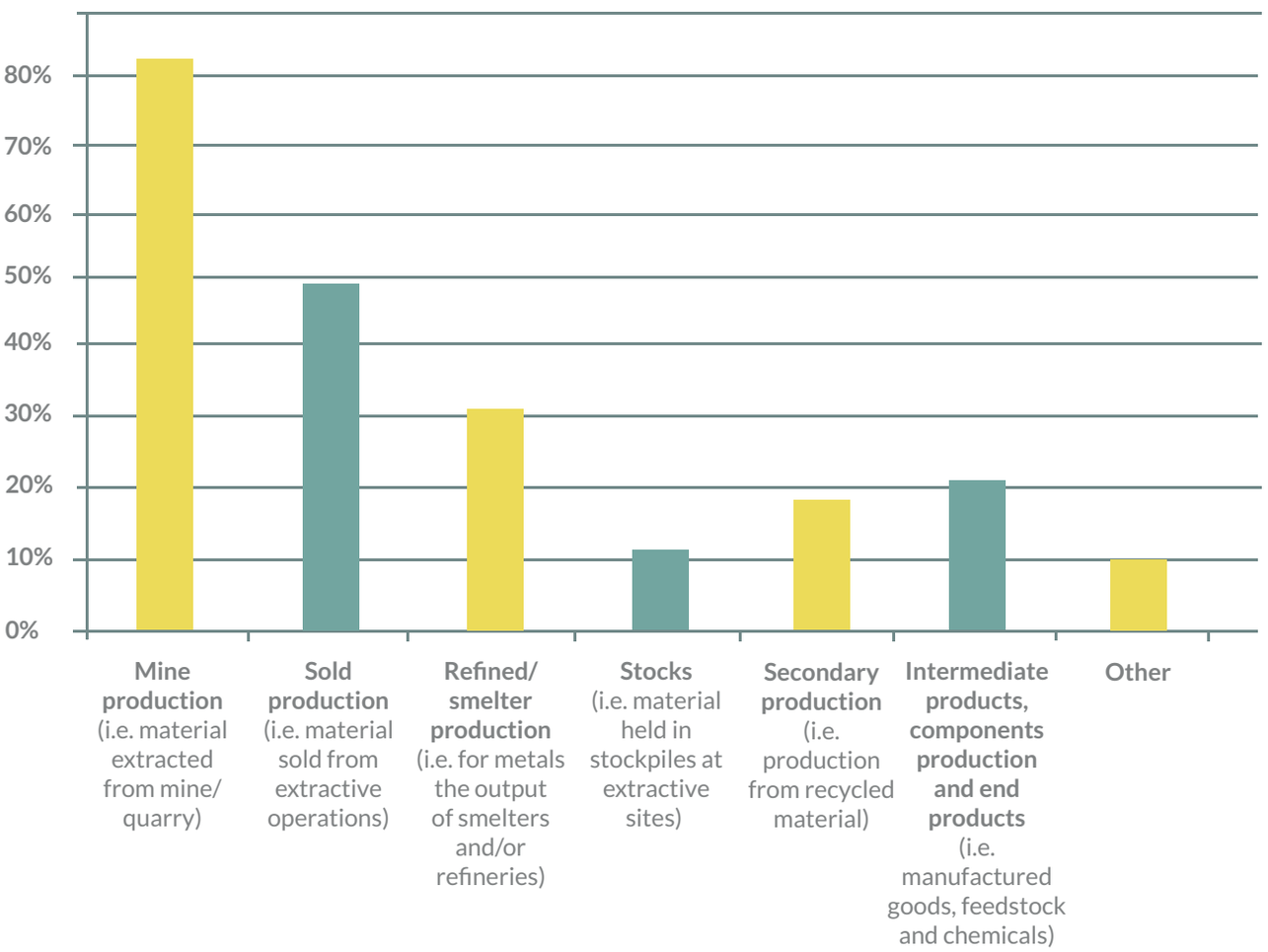


Figure 6 *Collection of mineral production stages by lifecycle stage*

Over 80% of national data providers, that deal with production data, collect data predominately from companies extracting/processing and recycling mineral resources as shown in Figure 7. Two thirds of data providers gather data from a single source type (e.g. from companies) and the rest use multiple source types, which shows the collection of production data can be complex. It is positive that the majority of sources are companies as producers will always ultimately be the source of all mineral production data and the more data that comes from primary sources the less scope there is for misunderstandings to occur.

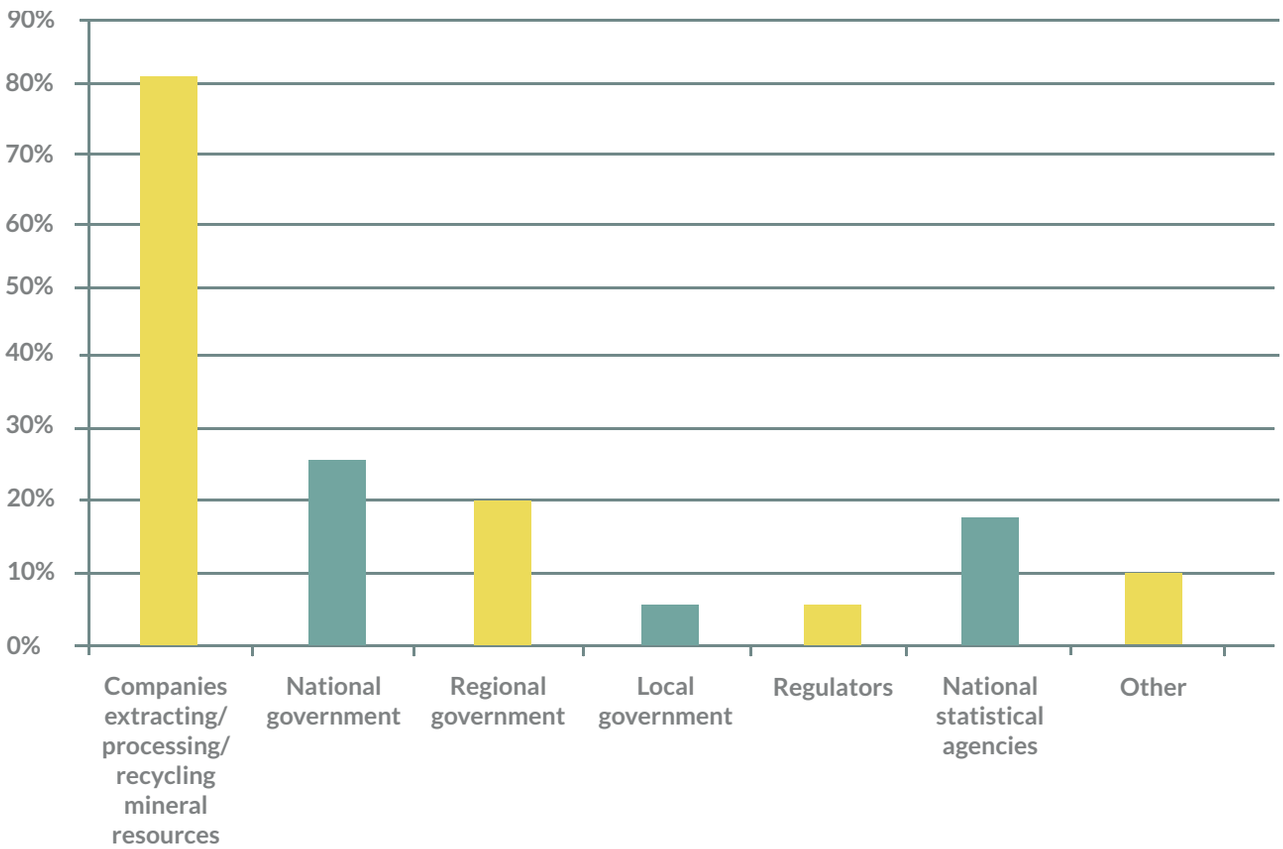


Figure 7 *Data sources for production data*

Organisations collect this data for a variety of reasons, the main reason being because they are statutorily/legally obliged to do so (Figure 8), this emphasises that data are rarely collected if there is no specific reason or incentive for it. However, that reason could be that organisations are required to collect them due to legislation, even if there is not a full understanding of the subsequent uses they might be put to.

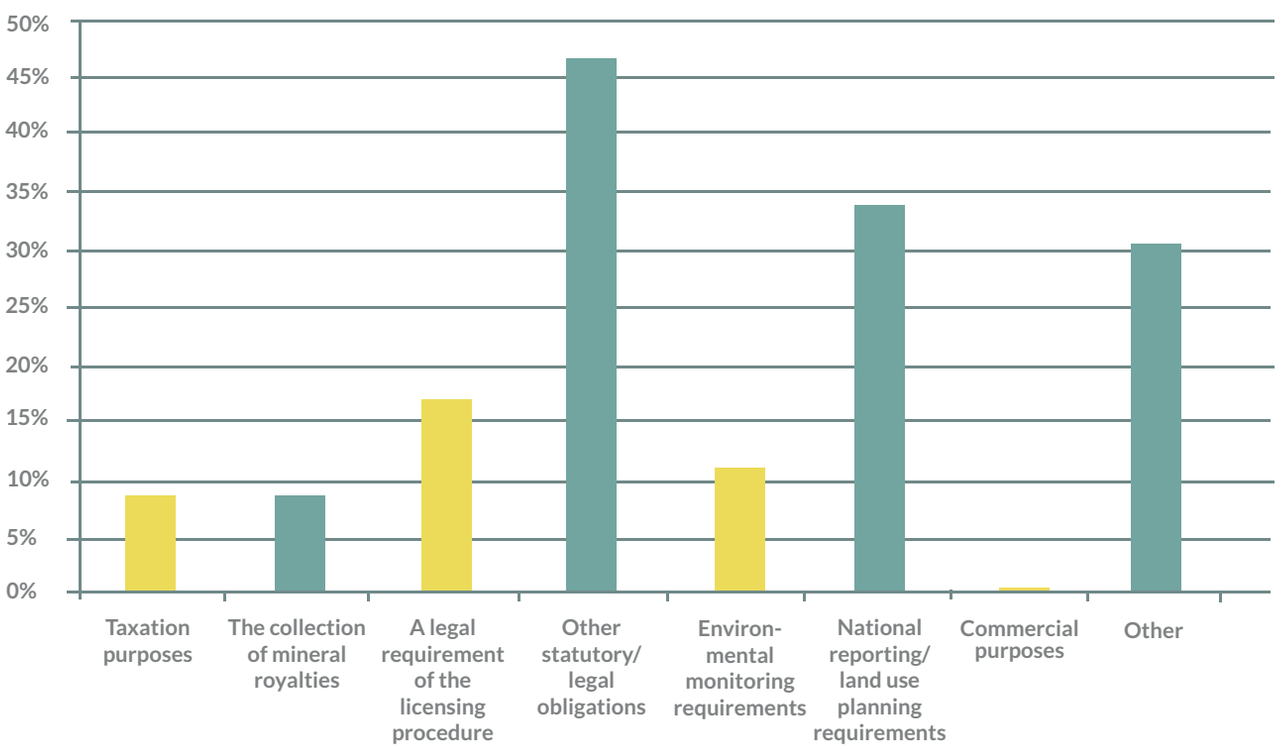


Figure 8 *The reasons for collection of production data*

An analysis of the types of production data available also shows potential data gaps and causes of uncertainty. Data is often not collected for metal content or grade, only gross weight of ore extracted, this demonstrates that it is necessary for some assumptions to be made when publishing data for metal content, which is usually the way figures for most metals are presented. This adds a degree of uncertainty to the final numbers.

Several third party organisations also publish data on a national level on European mineral production, these include BGS (which are included in electronic European Minerals Yearbook) the Austrian Federal Ministry for Sustainability and Tourism and the United States Geological Survey. These figures are compiled from a variety of sources including data from geological surveys, statistical agencies and the minerals industry.

2.2.2 Trade data

All countries will collect trade data as part of taxation and customs procedures. There is also a legal requirement for all EU countries to submit trade data, this includes all trade including primary minerals. This is achieved through the Intrastat system (Regulation (EC) No 638/2004 and Regulation (EC) N 471/2009) for internal EU trade and customs declarations for external trade. For countries outside the EU, there is no international legal basis for trade data to be publically reported but almost all countries report customs returns which allows these data to be collected by the United Nations (UN), which is assessed, via the UN Commodity trade database (UN Comtrade). A survey of data providers shows that raw data are collected predominantly by both customs declarations and the Intrastat survey. This is to be expected because the former collects data for extra-EU trade while the latter collects data for intra-EU trade. It should be noted however that much data reported by Intrastat and Comtrade are often either confidential or aggregated at such a level that splitting out individual commodities can be difficult or impossible.

Like mineral production statistics of the amount of available data decreases rapidly along the value chain, data for the metal content of metallic ores are often absent and the metal contents of refined or manufactured products are usually not known or not reported.

2.2.3 Exploration data

The majority of countries do not publish any data regarding mineral exploration and there are no standard metrics for reporting this data type. In the survey of data providers, very few respondents answered questions regarding exploration data, reflecting the scarcity of available data across Europe.

Where exploration data is collected, for all mineral commodity groups (i.e. metals, industrial minerals, construction minerals and dimension stone) it appears to be because there is a legal obligation for companies to provide data. This is either the result of mineral licensing procedures or in response to a request that encompasses all the relevant companies. Details are given in Figure 9.

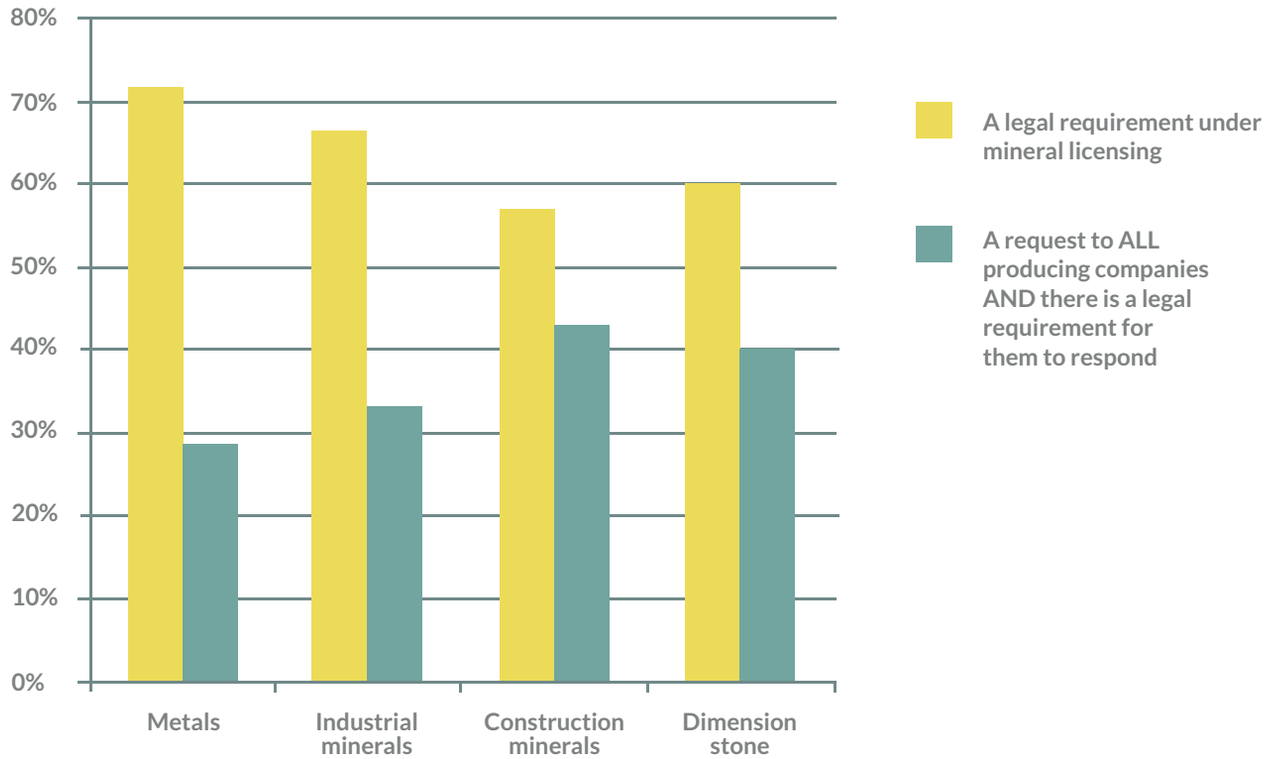


Figure 9 *Collection methods for exploration data*

The most common metric used for recording exploration data is the number of exploration licenses issued in a year, with over two-thirds of respondents stating they had this data. This is followed by the number of active exploration licenses in a year, the area covered by active exploration licenses and the number of companies exploring. The metrics that are less likely to be collected, are the number and length of boreholes drilled, company expenditure, government/public sector expenditure. The majority of data are aggregated to protect confidentiality before they are published. Perhaps unsurprisingly, this demonstrates that confidentiality is a significant issue for mineral exploration data.

2.2.4 Data for the environmental and social aspects of extraction

There are no real minerals industry-focused data for the environmental and social aspects of extraction that are published on a national level consistently across Europe. Data are available in some countries, for some sectors, for a wide variety of metrics in this area. The methods used to collect this type of data are therefore also disparate. The ORAMA project attempted to collate a list of possible data sources in this thematic area and identified a list of possible metrics that can be used to illustrate how mineral extraction impacts social and environmental factors (Deliverable 1.3). For many themes identified in this area, additional research and development of metrics are required in order to portray the full picture of the impacts of mining and quarrying.

2.2.5 Resources and gaps reserves data

Comprehensive harmonised national mineral resource and reserve data on a European level can be created by either taking a top-down or bottom-up approach. The bottom-up approach is to build a database defined on a deposit by deposit basis (as opposed to starting with nationally aggregated data). The ProMine project was a first attempt to produce a dataset where harmonised data on resources and reserves could be calculated on a European level using a bottom-up deposit based approach.

However, whilst ProMine produced some good results on the spatial locations of deposits in many countries, it is currently not possible to compile statistical information in this way because these data are simply not available on a deposit-by-deposit basis. In many countries either no data exists or spatial data does not have statistics attached to it. Many MS do not have datasets for individual deposits prepared that can the used on a European level. The vast majority of records of deposits identified through ProMine (and subsequently through Minerals4EU) do not have resources or reserve figures attached to them. Often these figures at individual deposit scale are confidential. In other cases, deposits have not yet been quantified sufficiently to enable figures to be reported.

The top-down approach is aimed at constructing an inventory of mineral resources by asking experts or the relevant authorised national body within each country to supply, calculate or estimate mineral inventories for each country on an aggregated national scale. This is done in many central and eastern European countries that use a national resource code based on the Russian standard or a variant of this. This requires some level of national resource management and collection of data for resources. This type of data exists, for example, in Slovenia, Hungary, Poland, the Czech Republic to name a few. Data within these databases, however, are normally to national standards and may not be comparable to each other.

On a larger European scale this top-down approach was used by the Minerals4EU project for the electronic European Minerals Yearbook. This data was compiled via a one-off survey of European countries albeit without any attempt at harmonisation between countries. This was done to assess accurately the scale of harmonisation issues. Although this project succeeded in producing national totals for countries where good data provision exist, significant gaps were present for countries that did not respond, or that did not have access to the data. Also, it was not possible to produce European aggregated totals due to the numerous, incomparable reporting codes, standards and classification schemes used in different countries. Harmonisation could be achieved by the adoption of a single standard or classification scheme, such as the UNFC, albeit with appropriate levels of guidance, training and support.

In terms of how and why data is collected within Europe, the survey of national data providers conducted by ORAMA showed the majority of countries that report data do use a national reporting code followed by CRIRSCO (Committee for Mineral Reserves International Reporting Standards) compliant codes (Figure 10). The survey revealed that if a country uses either a national code, the Russian code or a variant of the Russian code, they are unlikely to use any other code. However, if a country is using CRIRSCO compliant codes they are likely to use a mixture of these. No respondents stated they are currently using UNFC. The survey also showed that data providers were generally not very aware of tools to harmonise data, like UNFC, which could be a barrier in the short term to the adoption of a standard method of reporting for this data.

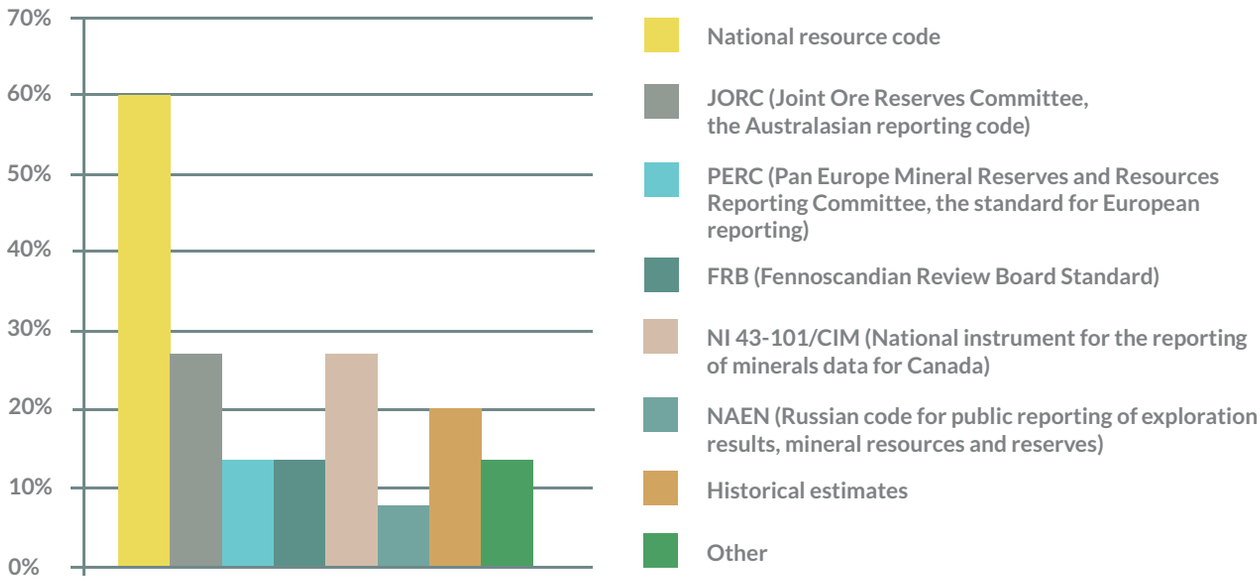


Figure 10 *Systems of reporting used by organisations that responded to the ORAMA survey (note, systems that were not used are not shown)*

This finding is also reflected when considering the reporting codes and standards that are required by national laws or regulations. This shows that no country covered by the ORAMA project (EU 28, Norway and Switzerland) requires the use of UNFC. This is a major barrier when considering it as a tool for harmonisation (Figure 11). However, this barrier can be overcome with suitable training.

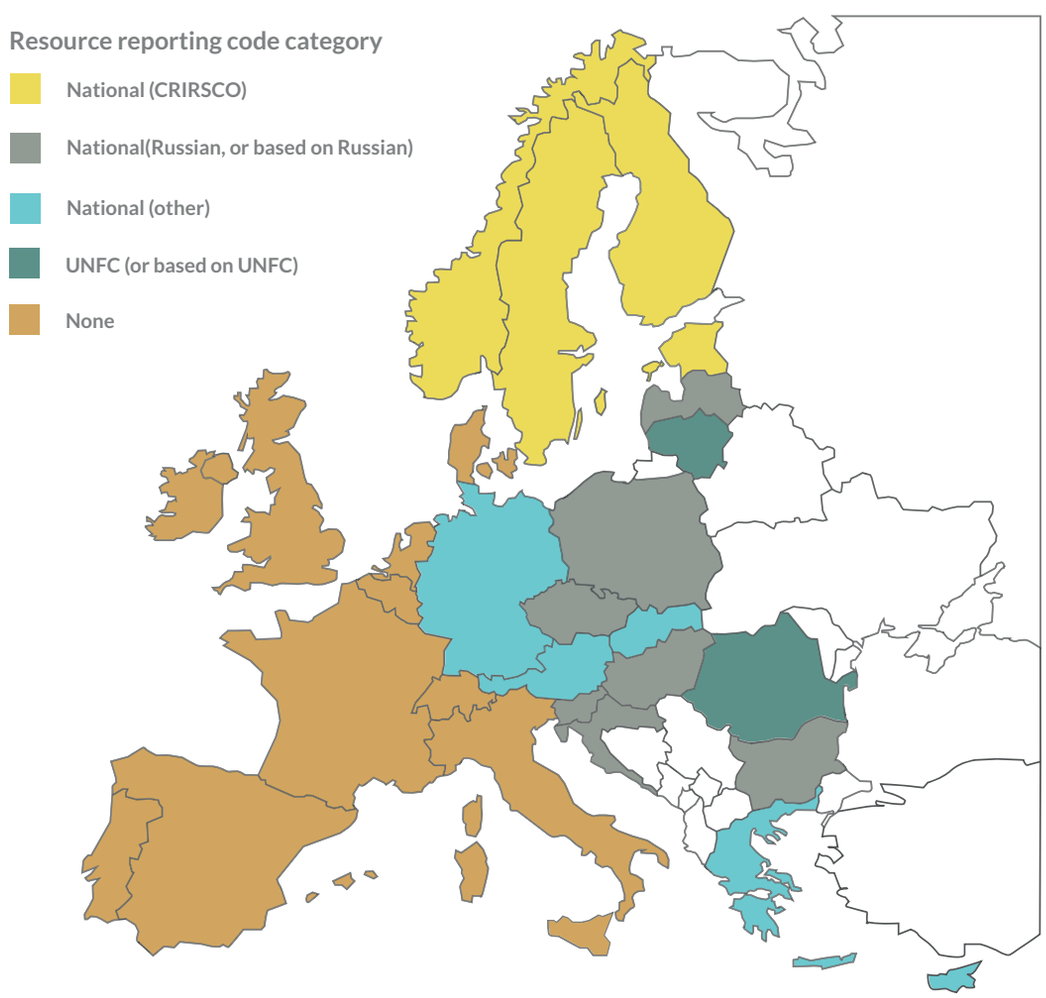


Figure 11 *National resource reporting codes in countries covered by the ORAMA project*

When looking at why data is produced the survey results also suggest that a country is more likely to use a single system/code if their legislation requires it. Where there is no legislation requiring a specific system/code then multiple systems/codes are likely to be used. If legislation is put in place that requires a single system to be used across Europe, to ensure harmonisation via a common code like UNFC, this will have to be in addition to what is already used, not instead of existing systems/codes. This is because individual countries have other specified purposes that require particular styles of reporting, for example, international stock exchanges.

2.3 Data collection and reporting methods for Secondary Raw Materials (SRM)

2.3.1 Waste Electrical and Electronic Equipment (WEEE) and Photovoltaic (PV) Panels

Member States report to Eurostat their EEE and WEEE data on an annual basis either to the Ministry of Environment or Environment Agencies via the Edamis portal. This being the result of Article 16 (4) and (5) of Directive 2012/19/EU of the European Parliament and of the Council on WEEE (hereinafter "the Directive") and the Commission Decision 2005/396/EC (Eurostat 2017d). Information on EEE categories that are POM is, due to reporting obligations in general reported directly from producers or through their producer responsibility organisation (PRO) to national registers. However, often the obligations of a producer are linked to the amount the producer reportedly placed on the market, meaning that he will not overestimate his POM but maybe underestimate it (Wagner et. al., 2018). In addition, online free-riding, the phenomenon whereby companies, often based outside Europe, sell their products online but do not register their EEE and hence do not take back WEEE, imposing an unfair cost on other producers and retailers, distort the market, make compliant companies less competitive and result in an overstatement of WEEE collection rates. According to the OECD Extended Producer Responsibility and the Impact of Online Sales report, online free-riding accounts for 5-10% of all sales.

In the case of WEEE collected, treated, prepared for reuse and recycled or recovered, official statistics report to Eurostat the 6 (formerly 10) collection categories defined in the WEEE Directive. Eurostat then publishes EEE and WEEE ((W) EEE) data in this aggregated manner, since they do not aggregate the data more than is already provided by MS. As a result, the methodology in data collection and reporting may vary from MS to MS. Incoherent and incomplete information (timescale, classification, and spatial coverage) affect material flow analysis when mapping potential SRM. Furthermore, there is no obligation to report composition of products being placed on the market or collected as waste nor data on waste generated. Therefore this type of data is only provided by country research studies or by projects such as ProSUM and eco-design studies. However, the way the data is provided is not harmonised and therefore difficult to transfer into inventories like the European Union Raw Materials Knowledge Base (EURMKB) and the Raw Materials Information System (RMIS).

Regarding complementary or unreported WEEE flows, MS do not provide data quantifying how much WEEE is being disposed of in solid waste nor on the quantity that has likely been scavenged (whole appliances as well as parts of appliances). The information from such practices are a result of various European studies and projects such as those undertaken in the United Kingdom by WRAP, and Horizon 2020 projects CWIT and ProSUM (CWIT 2015, ProSUM 2017).

In addition to the general research on EEE and WEEE, a special focus was directed towards photovoltaic (PV) panels. The amount POM is expected to increase due to the transformation of the energy supply systems and thus the amount of waste PV panels will also increase. Consequently, PV panels will become a significant share of total (W) EEE in many countries. But it is not only the quantity that is

relevant, also material content, especially metals like silver, indium, and gallium, is relevant with a view to the availability of SRM. Therefore, within the ORAMA project a closer look was taken at data and data collection methods (see D2.2, chapter 4.5.2 and D2.3 chapter 4.3 for details) with the aim to derive specific recommendations for PV panels. Since PV panels were not included in the scope of the first WEEE Directive (2002/96/EC), no data is available concerning POM, PV panel waste collected, treated, recovered, and recycled in tonnes as it is for other (W) EEE since 2005. However, due to PV panels not being a separate category under the WEEE-Directive, data on them is included within other categories. In order to obtain information on PV panels, Eurostat's Guidance on WEEE reporting asks for voluntary reporting of PV panels as a sub-category. So far, this was only done by less than half of the MS.

POM data for PV panels cannot be obtained from production and trade statistics (as it can be for other EEE) since the respective PRODCOM (PRODuction COMmunautaire) code contains also other technologies. To enable the calculation of PV panel flows, data from energy statistics of totally installed capacities can be used to calculate POM. However, the information corresponds to the nominal power in Megawatt peak (MWp) and conversion to tonnes has to be done. This is not straightforward due to change of power-to-weight ratios over time.

Concerning the share of the different PV technologies, none of the official statistics contains this type of data. This information is only available from other types of literature, such as that from industry and private organisations and only as a worldwide figure. With regard to the composition, as was found in the ProSUM project, there are also no official statistics. This information has to be taken from scientific articles and research reports as well as from reports of industry associations. The available data is not harmonised and therefore difficult to compare, especially since the share of some elements, such as silver, changes over time.

2.3.2 Batteries

Data collection and reporting methods revolving around waste batteries and batteries POM vary across each MS in Europe. Eurostat provides MS with a set of guidance documents in an effort to assist them on their battery data reporting[1]. However, these documents leave plenty of room for different interpretations of the reporting requirements, which, according to Hogg et al. (2017) might be one reason for the lack of harmonisation and resulting in inconsistencies of reporting between MS.

Furthermore, the Battery Directive does not provide legally binding requirements on data collection methods, for instance on the level of detail in the reported data to Eurostat. The reporting obligation under the current Directive 2006/66/EC distinguishes only between three types of portable batteries: LeadAcid, NiCd and 'other batteries'. The distinction between primary and secondary batteries is, however, important since most of the CRMs, such as cobalt, can be found in secondary batteries. The same is true for chemical types. The level of detail in the data reporting is crucial for the assessment of the CRM flows in the urban mine. Providing information on the different chemical types of batteries will give a good indication of which CRMs are embedded information which is not only valuable to potential recyclers but also to other stakeholders like policymakers. Harmonisation in battery reporting is missing, thus a battery classification tool will be presented in Chapter 5.2.2 in an effort to move towards an improved information base in the future. The lack of a mandatory verification process and minimum data check-up requirements at MS level before submitting the data also remains a problem for reliable battery data across the EU. Eurostat does not publish data on battery composition, on aggregated battery weights nor on battery residence times, all of which are necessary for conducting

1 *'How to report Data for Directive 2006/66/EC and Commission Regulation 493/2012 on batteries and accumulators', which outlines general practical advice on deadlines and how to use the web portal eDAMIS and 2) 'How to report for Directive 2006/66/EC and Commission Regulation 493/2012 on batteries and accumulators' on the methods used to gather the data.*

reliable calculations on CRM flows over time. Stakeholders interested in this information are dependent largely on industry data that is often confidential (see ORAMA Deliverable 2.1 for more details).

2.3.3 End of Life Vehicles (ELV)

Data on new vehicles POM and generated ELV are published by Eurostat but under two different and non-unified sections and for different purposes. The number of vehicles in stock and new registrations are part of the transport statistics, with data collected annually through "the Common Questionnaire for Transport Statistics", voluntary reporting using the Eurostat classification system for vehicles, based on type, mass, engine size and motor energy type (fuel type). Data on ELV are part of waste statistics, with required annual reporting to assess MS compliance with the ELV Directive. The Directive only encompasses vehicles below 3.5 tonnes, thus excluding heavy-duty vehicles. The minimum required reporting includes the number and mass of generated and collected ELV, the total mass of materials and components dismantled, mass of shredder outputs and exports of ELV and materials from ELV treatment. Some MS only report the minimum while others add more detailed data. However, there are no cases in which the data contain any information on the type of vehicles, such as drivetrain types or the ages of vehicles, which makes it impossible to align it with data on new registrations and in-use stock vehicles. While the extent and level of detail of reported data on ELV and their treatment are the result of the requirements defined in ELV Directive, the data on vehicles in transportation statistics is collected for other purposes than the prospection of SRM.

A number of gaps can be pointed out in relation to the needs for mapping and estimating the flows of SRM in vehicles and ELVs. Transport statistics have been updated to distinguish between different types of electric and hybrid vehicles but do not contain information about the maximum power of electric traction motors or the battery capacity, which are key parameters for estimating the content of SRM. Nor do transport statistics contain information on the EEE contained in vehicles in which significant shares of SRM are contained. The mass and engine size classifications are quite broad, resulting in a very large number of cars belonging to the same category. Similarly, vehicles in use are classified according to a few broad age groups. As regards the data on collected ELVs, it is difficult to assess their quality and completeness since the quality reports that MS are obliged to submit to Eurostat are not made public.

Besides information at the vehicle level, information on the composition of vehicle components, and on materials and elements are required for SRM estimates, but the public availability of such data is limited to primarily disparate investigations with different scopes, levels of detail and/or significant uncertainties. At present, only the vehicle manufacturers have access to such information, primarily through the International Material Data System (IMDS), with information mainly related to hazardous substances available to dismantlers through the International Dismantling Information System.

2.3.4 Mining Waste (MIN)

EU collection practices for deposit level MIN information, which have been applied in the scope of the Directive 2006/21/EC, were used in the ProMine and the ProSUM projects. The ProSUM MIN group coordinator, as well as the Geological Survey of Slovenia harvesting team, were interviewed with the intention of identifying any weaknesses in the ProSUM collection framework.

Another aim was to elaborate on the potential of SRM in MIN and highlight the lack of data on chemical composition in the shared datasets. In most cases, the reason for this is that chemical data does not exist or are confidential. The lack of chemical waste characterisation is one of the main reasons for the undefined secondary potential of waste.

In general, it was shown that future work for identification of MIN recovery is related to:

1. Collection of new data that would enable estimation of resource potential/research of MIN (deposit characterisations).
2. Investigation of MIN stocks and flows.
3. Identification of recycling system for MIN (processing sites).
4. Creation of a functional database for MIN related information.
5. Development of a classification system for MIN resources.
6. Development of guidelines for MIN characterisation.

Obstacles for data providers (DP) (national geological surveys):

1. Have new information on composition, but no funding to update the database.
2. The compositional data they serve had not yet been successfully harvested.
3. Several DPs were of the opinion that the process of sharing the data is complicated and time-consuming.
4. The guidelines for data harmonisation were not clear.

The current status of countries providing mining waste information is CZ (10), DK (1), HR (46), IE(12), NO(137), SE(676), SI(4), and UA(12) (status of May 2019).

3 Selection and implementation of best practices for data collection and reporting methods in the EU

3.1 Primary Raw Materials (PRM) best practices

ORAMA conducted a review of data collection and reporting practice across Europe for PRM in order to identify examples of good practice. This focused on examples that were widely used and contained the most up-to-date and comprehensive data. It is hoped that these examples can be used to aid organisations responsible for data collection and provision in improving methods as well as to understand the current limitations of this data within Europe.

3.1.1 Production data

There are many good examples of mineral production data provided by national data providers that are clear and concise with appropriate metadata. A sample of these are given below:

- UK mineral production: https://www.bgs.ac.uk/mineralsUK/statistics/ukStatistics.html
- The balance of mineral resources deposits in Poland: http://geoportal.pgi.gov.pl/surowce
- Finnish webpages on mining and mineral production: http://en.gtk.fi/informationservices/mineralproduction/
- Mineral Commodity Summaries of the Czech Republic: http://www.geology.cz/extranet-eng/publications/online/mineral-commodity-summaries

As well as data collected nationally, good examples for data provision within Europe can be seen in data collected by third-party organisations. For example for mineral production by BGS in its publication 'World Mineral Production' (https://www.bgs.ac.uk/mineralsUK/statistics/worldStatistics.html) or by the Austrian Government in its publication 'World Mining data' (http://www.world-mining-data.info/). Considerable amounts of data can also be found in the electronic European Minerals Yearbook produced by the Minerals4EU project (http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html).

On a European level, the data produced by Eurostat in the form of the PRODCOM production database is a good example of a single point source of data, compiled from submissions from individual MS. However, data is often aggregated making specific commodities hard to identify, and much of the data is confidential.

These studies are excellent sources of aggregated, easily accessible statistical data. However, they rely on funding from third-party organisations and also require considerable resources in data collection and quality assurance, often from a wide variety of sources. For these types of publication, harmonisation is achieved through a review of the data by expert staff when compiling the figures. Much less effort would be required if some level of harmonisation was already in place in the data received from the data providers.

3.1.2 Trade data

Most countries provide some form of an online portal where trade statistics can be obtained. However, much of this data is also reported centrally for Europe via Eurostat, the statistical office of the European Union.

The Eurostat data portal is a clear example of harmonised, accessible data on an EU scale. With regards to primary minerals data, the Eurostat trade database provides a comprehensive single point of entry source for European minerals trade information. These data are collected according to a system of commodity codes (known as Combined Nomenclature) which is compatible with the Harmonised System, an internationally recognised system for defining traded commodities. Also, there is a legal basis for this data to be provided by MS to Eurostat. Improvements could be made to this data by inclusion of metadata relating to metal contents of ores and compounds and improving resolution for commodities, such as industrial minerals and products further along the value chain.

3.1.3 Exploration data

There are many examples of good practice of systems for the collection of exploration data within Europe. One particular example noted by this study was data for mineral exploration produced by Ireland; this provides a large amount of publically available data for a wide range of metrics.

Mineral exploration in Ireland is regulated and licensed by the Exploration and Mining Division (EMD) of the Department of Communications, Climate Action and Environment (DCCAE). Publications from DCCAE give a complete breakdown of annual exploration expenditure for the previous year, broken down by commodity and expenditure type, as well as total distance drilled, number of licences, area of land under licence and various other things such as industry news, etc. This data is collected every January by EMD and is made available publicly on an aggregated, anonymised basis.

Mineral exploration from Finland is another example of good practice, Turvallisuus- ja kemikaalivirasto - Tukes - is the public body in Finland given a broad range of responsibilities including mining and mineral exploration. Every March it publishes a brief review of exploration expenditure in the previous calendar year. This review typically takes the form of a short, 300-400 word summary on the previous year's activities, including data highlights. These updates are only available on the Finnish website. In addition, there are English language resources presenting this and additional data in tabular and graphical form. Information published includes the amount spent on exploration, number of prospectors, number of applications, the area being explored and distance drilled.

It perhaps is no coincidence that both Finland and Ireland are ranked very highly in the influential Fraser Institute report on mineral investment attractiveness, demonstrating how provision for good data collection and provision can promote investment in minerals. This metric is determined using two criteria: geological prospectivity and its policy perception index. The latter is a way of quantifying a country's mining regulatory regime and how favourable their government is towards mining investment.

3.1.4 Data for the environmental and social aspects of extraction

There are few data sources that deal with the environmental and social aspects of mineral extraction. The ORAMA project has added some of these to the new edition of the European Minerals Yearbook. The vast majority of the data that may be suitable and that are available without any requirement for further processing, analysis or harmonisation is generally (with some exceptions) statistical data from Eurostat. Data on public perceptions of mining and waste emissions due to mining and employment in the mining sector are two examples of the relevant data contained within Eurostat databases. This data is already harmonised at a European level and has pan-European coverage. Some good examples of data for the environmental and social aspects of mineral extraction can also be found in the country summaries of the RMIS as well as the Raw Materials Scoreboard[1] sourced from third party data, such as Eurostat and the European Environment Agency.

3.1.5 Resources and reserves data

There are two main issues regarding European resource and reserve data. The first is data collection and provision, as some countries produce excellent detailed and comprehensive data whereas others publish no data at all. The second is harmonisation of published data, where data may be available at a national level, it may not be comparable with other national datasets due to different standards being applied.

3.1.5.1 Provision of resource and reserve data

Data collection and provision is variable between the different countries of Europe. Some have very comprehensive procedures and strict regulations on what is required, while others tend to rely more on the extractive industries themselves and on voluntary schemes. The European countries with the most comprehensive data provision tend to be those of central and eastern Europe that have a strong history of central record collation and state ownership of mineral resources. There are also other examples of European countries with strong systems for data collection, including Ireland, where the DCCAE has a direct involvement with mineral licensing, and Finland where Tukes, the Finnish Safety and Chemicals Agency, has a statutory role in the collection of minerals data. Both Sweden and Norway also have extensive databases for mineral resources managed by the countries' respective geological surveys.

In the Czech Republic, the majority of minerals are owned by the state and are categorised as 'reserved minerals'. In Poland, the majority of minerals are owned by the state and exploration and mining licenses are issued by a central body, the Ministry of Environment. These types of systems create a statutory requirement for collecting resource or reserve data and are commonly linked to the collection of mining royalties or taxes. For example, in countries such as Slovenia and Poland, there is a statutory requirement for all 'concession holders' to send resources data to a central body; for deposits that are being worked this is an annual requirement and for non-exploited deposits it is mandatory to send these data on a regular basis.

1 *Raw materials scoreboard 2018,* https://op.europa.eu/en/publication-detail/-/publication/117c8d9b-e3d3-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-107337027

Poland also has, as part of its regulations for mineral extraction and exploration, a requirement for central records to be kept on any new discoveries of mineral deposits (Państwowy Instytut Geologiczny). This allows the national reporting standard of Poland to be followed and total reserve and resource estimates for the country to be calculated. In turn, these data can feed into important planning and policy decisions that reflect which mineral deposits need to be developed in order to better serve local markets and support the national economy.

An example of where a different approach has been taken is an inventory known as the Fennoscandian Ore Deposit Database. This is a database, with an associated web-based mapping application that details metal deposits and potential future metal discoveries in the Fennoscandian Shield. The database was compiled by a joint project between the geological surveys of Finland, Norway, Sweden and Russia based on known minerals occurrences, a compilation of mineral exploration records, mine locations and mineral prospectivity analysis. This comprehensive database is only made possible due to the strong role of the geological surveys involved in mineral exploration, a wealth of available historical data on mineral deposits (all countries involved have robust resource management systems and have a regularly updated database of mineral deposits and their properties) and a significant investment in combining several extensive datasets. This database covers metallic and industrial minerals, but no data are available for construction minerals.

3.1.5.2 Harmonisation of resource and reserve data

There is currently a serious issue regarding harmonisation of European resource and reserve data where much of the available data are reported to non-comparable standards and reporting systems. The ORAMA project recommends the use of the UNFC as a tool for resource data harmonisation. Several countries have undertaken case studies to convert data to UNFC and these can be used as good examples of how this can be achieved. The Mining and Geological Survey of Hungary has undertaken a detailed exercise mapping the Hungarian national mineral resource corresponding code to UNFC. This produced conversion algorithms between the national (Russian type) and international systems including the CRIRSCO type reporting codes and the UNFC as well as a set of case studies to test the conversion algorithms. Key elements of the data harmonisation procedure were established in a national project. The alignment between national classification and reporting systems having international reporting codes (like CRIRSCO), UNFC and UNRMS level that contributes to European level developments are the following on national:

1. Collection and translation of relevant standards and UNFC documents.
2. Understanding potential links between different systems that is called bridging.
3. Stakeholder consultation between relevant players like experts, authorities, companies and decision makers.
4. Publication of results on national and international forums, integrations of feedbacks.
5. Development of guidance.

The involvement of the national geological survey or other responsible authority is important.

Similar exercises have also been undertaken in Slovenia by GeoZS and in Poland by the Polish Geological Institute (PGI). The latter compiled a detailed case study converting the Polish classification system to UNFC in their publication 'The Mineral Resources of Poland'[1]. This outlines in detail how

1 *POLISH GEOLOGICAL INSTITUTE.Polish Geological Institute. 2017. Mineral Resources of Poland. (Warsaw).* http://geoportal.pgi.gov.pl/css/surowce/images/2017/pdf/mineral_resources_of_poland_2017.pdf

the Polish classification system can be bridged across UNFC and explores some of the issues such as definition for 'reserves' in the Polish system.

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

A team from the Geological Surveys of Finland (GTK), Norway (NGU) and Sweden (SGU), the Swedish Association of Mines, Minerals and Metal Producers (SveMin) and Petronavit a.s., have worked on the application of the UNFC for mineral resources in Finland, Norway and Sweden. The group has published "Draft guidance for the application of the UNFC for mineral resources in Finland, Norway and Sweden"[1]. The purpose of the document is to provide guidance on the application of UNFC, incorporating specifications for its application (as set out in ECE Energy Series No. 42) to mineral resources in Finland, Norway and Sweden. The draft document is intended to assist in producing UNFC inventories and support users by clarifying how UNFC can be used to facilitate policy and strategy formulation, Government resource management, industry business processes and capital allocation. Part of the motivation has been to explore how the application of UNFC will provide better harmonisation of mineral resource data across projects from uncertain reconnaissance stage and under-explored prospects to well characterised and well-assessed resources and reserves. This work acknowledges that industry recognised reporting standards are mostly employed in developing or on-going mining projects and are required only for listed companies. These industry standards are not used, nor intended to be used, comprehensively, and are therefore not suitable tools for comparing and aggregating resource, and potential resource, inventories.

3.2 Secondary Raw Materials (SRM) best practices

3.2.1 Waste Electrical and Electronic Equipment (WEEE) and Photovoltaic (PV) Panels

Two projects have been identified as best practices for quantifying WEEE flows and, in particular, for assessing the methods to monitor unofficial flows; these are: "Prospecting Secondary Raw Materials in the Urban Mine and Mining Wastes (ProSUM)" and "Countering WEEE Illegal Trade (CWIT)". The ProSUM project is one of the most relevant projects as it producing data on SRM from 2015 to 2017. It identified and compiled more than 800 sources containing data on the stocks, flows and composition of products and wastes for batteries, WEEE and ELVs. In addition, the project produced a dedicated set of recommendations to improve the knowledge on the urban mine in Europe and identified specific data gaps (Downes et al. 2017). The CWIT project received funding from the European Union's Seventh Framework Programme and concluded in 2015. CWIT provided a set of recommendations to support the EC, law enforcement authorities, and customs organisations, in countering the illegal trade of e-waste in and from Europe.

The CWIT and ProSUM projects provided **estimated** data of WEEE flows at MS level, including Switzerland and Norway. There is no official data on complementary WEEE flows. One of the main shortcomings identified in the inventory work performed in ORAMA on WEEE reporting, is that

1 *Draft guidance for the application of the UNFC for mineral resources in Finland, Norway and Sweden. 2017.* https://www.unece.org/index.php?id=45992

there is no clear connection between reported collection and actual treatment volumes. Treatment volumes include complementary recycling flows and excludes items lost to scavenging practices of both components and products with relatively high reuse and recycling values. The former come from unreported collections and the latter are lost after reported collections are made. Some indirect Eurostat data is provided intermittently regarding the volumes of metal scrap and household waste containing WEEE, but the totals do not possess sufficient granularity to enable the characterisation of waste flows.

Another useful source of information is the I4R (Information for Recyclers) platform, recently delivered by industry bodies in the frame of Art. 15 of the WEEE Directive, which provides treatment and recycling facilities and preparation for re-use operators access to WEEE recycling information in line with the requirements of Directive 2012/19/EU. This includes information on hazardous components, mixtures and substances in EEE.

The separate data reported under the WEEE Directive for PV POM, collected, and treated is a good starting point for determining the stocks and flows of PV panels. However, recently performed comparisons with estimates and forecasts show significant differences in the results, especially for waste PV panels collected. This emphasises the need remains to improve data collection for PV panels.

Data on PV panels collected and published by industry associations is quite extensive. However, data is often not suitable for stock and flow modelling. One report of IRENA, which is explicitly dealing with future waste amounts of PV panels, provides a summary of a lot of valuable data.

It is noticeable that research projects dealing with the development of treatment and recycling technologies for PV panels do not deal with data collection methods nor publish comprehensive data e.g. on POM and composition. Furthermore, reports like the Eunomia report on Waste Statistics, do not deal with the special challenges of PV data and treatment facilities do not yet have a lot of experience with PV panels and, as a result, do not have collection data helpful for stock and waste flow modelling as done in ProSUM.

3.2.2 Batteries

Belgium and Luxembourg distinguish between primary and secondary batteries for batteries POM and gather data on the chemical types and whether a battery is sold contained in EEE or separately. Most countries report batteries collected in chemical types, however, the range of chemical types varies between 3 (e.g. UK) and 11 (e.g. Lithuania)[1]. In order to assess the level of detail in the information passed to Eurostat, the reported data were classified into high, moderate and low level of detail. The level of detail in the data reporting is crucial for the assessment of the CRM flows in the urban mine.

1 *Hogg, Dominic; Elliott, Tim; Corbin, Mark; Hilton, Mark; Tsiarta, Christina; Hudson, Joe et al. (2017): Study on Waste Statistics – A comprehensive review of gaps and weaknesses and key priority areas for improvement in the EU waste statistics. Final Report for DG Environment under Framework Contract ENV.C.2/FRA/2013/0023. Hg. v. Eunomia Research & Consulting. Available online:* https://publications.europa.eu/en/publication-detail/-/publication/565a7df0-bd25-11e7-a7f8-01aa75ed71a1.

Table 1 *Level of detail of battery reporting in the EU MS*[1]

COUNTRY	LEVEL OF DETAIL	POM REPORTING DETAIL	COLLECTION REPORTING DETAIL
AUT	low	volume	volume
BEL	high	prim/sec, ChemTypes, Batt sold in EEE	prim/sec, ChemTypes, Batt sold in EEE
BGR	medium	ChemTypes	ChemTypes
HRV	low	n.a.	n.a.
CYP	medium	units, weight groups	ChemTypes
CZE	medium	ChemTypes, BattType	ChemTypes
DNK	medium	ChemTypes, BattType	ChemTypes
EST	high	BattType, prim/sec	prim/sec, ChemType
FIN	medium	ChemTypes	ChemTypes
FRA	medium	ChemTypes	ChemTypes
GER	high	(detailed) ChemTypes, prim/sec, BattType	(detailed) ChemTypes, prim/sec, BattType
GRC	low	prim/sec	n.a.
HUN	high	peim/sec, ChemTypes	prim/sec, ChemTypes
ICE	low	n.a.	n.a.
IRL	high	ChemTypes/BattType	ChemTypes/BattType?
ITA	medium	ChemTypes, prim/sec	volume
LVA	medium	ChemTypes/BattType?	ChemTypes/BattTypes?
LTU	medium	11 ChemTypes, EWC	EWC
LUX	high	ChemTypes, Batt sold in EEE, BattType	prim/sec, ChemTypes, BattType
MLT	low	ChemTypes, prim/sec	volume
NLD	medium	ChemTypes, BattWeight	volume
NOR	low	BattTypes	volume
POL	medium	ChemTypes	volumes, EWC
PRT	low	n.a.	EWC codes
ROU	high	BattType, ChemTypes	BattType, ChemTypes
SVK	high	ChemTypes (EWC), BattType (Port&Ind)	Units, ChemType, BattType (ind)
SVN	medium	prim/sec, ChemTypes	prim/sec
ESP	low	volumes	volumes
SWE	high	ChemTypes, Batt sold in EEE	ChemTypes/BattTypes?
CHE	high	ChemTypes (7), Batt sold in EEE	ChemTypes (7)
GBR	medium	ChemTypes (3 groups)	ChemTypes (3)

1 *Perchards study on behalf of EPBA (2017): The collection of waste portable batteries in Europe in view of the achievability of the collection targets set by Batteries Directive 2006/66/EC. August 2013, update December 2016: European Portable Battery Association (EPBA)*

3.2.3 End of Life Vehicles (ELV)

Data included in vehicle classification systems used to report on the number of vehicles in use (stock), new registrations or trade flows are provided by MS to Eurostat, which in turn makes these data available to the public in an aggregated form. The aggregated form means that cars are grouped into different categories, depending on their fuel type, mass and engine size and the number of vehicles within each category is the only information that is published. This aggregation has implications for subsequent use of these data, for example as input to material flow models that are used to quantify future SRM potentials. ORAMA investigated how the classification systems used for aggregation may influence the results when calculating total material stocks and flows, in particular for rechargeable batteries (mainly lithium-ion based) used to power battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), and hybrid electric vehicles (HEV).

ORAMA compared estimates of the current battery stock in use in Norway (which has a significant stock of electric vehicles) using four different classification systems, ranging from a very simple distinction between three categories (BEV, HEV and PHEV) to a detailed model-specific classification with 194 different models. Given the current availability of statistics, the best possible practice for estimating battery stocks in European countries would be to rely on the current Eurostat classification as this is the only classification with harmonised statistics for all EU MS. A clear weakness of the current classification system is that it does not provide distinction between different vehicle masses above 1500 kg, although around half of all vehicles have a larger mass than this. A significant improvement over the existing Eurostat classification could, therefore, be achieved by expanding the Eurostat classification with additional mass categories for vehicles. Such an expansion (including mass categories up to 2500 kg at 250 kg intervals) is recommended and should be eminently feasible given the level of detail of information in central vehicle registries in MS.

For studies focusing on individual countries, it is recommended to obtain less aggregated data (from national offices for statistics, the roads/transport administration or other national organisations) and to use a more detailed classification based on individual models and fuel types. This can lead to an estimate of battery stocks and flows with very low uncertainty. Data on battery sizes and types employed in BEV, PHEV and HEV currently on the market, which would need to be combined with data on stocks and flows of vehicles, are available in the Deliverable 2.3 report from the ORAMA project.

In addition to an expansion of the mass categories, we recommend introducing reporting of vehicle power, either instead of engine size or in addition to it. A more accurate estimate of battery stocks and flows could be enabled if battery capacity or battery mass was reported in addition to existing data, i.e. including this as a new attribute in the vehicle classification. Information on battery mass or capacity is, however, to our knowledge, currently not recorded in national vehicle registries.

3.2.4 Mining Waste (MIN)

In the ProSUM project the INSPIRE MR extension data model for MIN was established to enable reporting of MIN information in greater detail at EU level. Detailed MIN data was requested from EGS members but due to some issues, data were not collected successfully. Consequently, INSPIRE compliant collection practices were addressed in ORAMA and issues were resolved resulting in waste site datasets being successfully reported and analysed with the help of, and collaboration with, existing data providers and harvesting teams. This allowed ORAMA to synthesise and present existing best practices for sharing of MIN data according to INSPIRE compliant protocols, which are described in detail in ORAMA D2.3.

In summary, examples of reported ProSUM MIN secondary resource datasets, which were shared to the common harvested database, were included along with demonstrations of examples of national (Slovenia, Hungary) MIN data harmonisation.

It is hoped that the examples presented will reduce the effort and provide a boost to the motivation of existing and new data providers for harmonising and sharing datasets with INSPIRE compliant framework developed within previous projects (ProMINE, Minerals4EU, ProSUM). Taking this in mind also a new guideline has been developed for MIN for data providers within the ORAMA project:

- G4.1.02.03 Mining Waste Extension insert data guidelines

Presented best practices together with the new guidelines improves the understanding and knowledge on how to provide quality-controlled MIN data to the M4EU database.

4 Tools designed to harmonise data collection

The following sections present the tools developed by ORAMA as a result of the different case studies implemented for PRM and SRM.

4.1 Tools designed to harmonise Primary Raw Materials (PRM) information

4.1.1 INSPIRE, EarthResoureML

One obstructive factor in the harmonisation of these data types is a lack of consistent terminology. To overcome this issue, standard dictionaries or glossaries must be developed and used when reporting figures. There are several internationally recognised examples, such as that set out by the INSPIRE directive or EarthResourceML (a XML-based data transfer standard for the exchange of digital information for mineral occurrences, mines and mining activity). These, however, need regular updating and input from end users to ensure sufficient resolution exists and therefore require clearer definitions for terms used in metadata.

Within the European Union, the INSPIRE Directive (2007/2/EC) is an important tool for harmonisation. The Directive aims to establish a uniform infrastructure for spatial information in the European Community. The Directive does not require the collection of new spatial data but it builds upon infrastructures for spatial information established and operated by the MS. Spatial data themes regulated by the INSPIRE Directive include information on mineral resources.

Within INSPIRE, the mineral resources data theme is defined as “Mineral resources including metal ores, industrial minerals, etc., where relevant including depth/height information on the extent of the resource”. This data scope definition is specified in the "INSPIRE Data Specification on Mineral Resources – Technical Guidelines" as data that refers to the description of natural concentrations of very diverse mineral resources of potential or proven economic interest.

The Mineral resources data model is organised around two major categories of information:

- Description and location of mines and mining activities; and
- Description and location of “earth resources” including their classification, estimates of the amount and a description of the main market commodities.

Despite the fact that the INSPIRE compliant data service is being processed at an EU-level, the quality of the data service still requires development (not all countries provide the same datasets for raw materials and not with the same frequency). Different approaches to the consideration of confidentiality may also contribute to the heterogeneity of the INSPIRE compliant data service that needs to be improved.

However, the collation of INSPIRE compliant mineral resource information at European level does reveal several issues regarding: spatial data coverage; links between spatial and statistical data; and quality of data. Data coverage problems are a major issue as they prevent the development of other applications like statistical studies.

The reasons for this include the availability of data not being the same for all countries or some data providers not being allowed to disseminate information related to single deposits. There are also some countries where data exists, but there are problems in harmonising and serving data according to the required specifications or just a lack of staff or financial resources to implement the EarthResourceML data model.

4.1.2 United Nations Framework Classification for Resources (UNFC)

The use of the UNFC system as a standard way of classifying mineral resources is a solution to the lack of harmonised data at European level. Use of UNFC overcomes the issue of multiple non-comparable resources and reserves reporting codes and standards in use across Europe by producing data that is harmonised for resources and reserves at the EU level. It is not suggested that individual countries should change their current systems of working, many of which have a legal foundation. At the national level, all countries would be able to continue with other systems of reporting to suit their internal purposes, but when figures are reported to a central point for EU level compilation (e.g. European Minerals Yearbook) and in order for them to be consistent and comparable they would need to be converted to a harmonised system such as UNFC.

The UNFC for Fossil Energy and Mineral Resources (UN, 2010) is a global classification system developed under a mandate from the UN Economic and Social Council and serviced by the Expert Group on Resource Classification (EGRC) of the United Nations Economic Commission for Europe (UNECE). The UNFC is a flexible classification system that is capable of meeting the requirements for application at national, industrial and institutional level, as well as to be successfully used for international communication and trans-national assessments. It should be emphasised that UNFC is a classification and not a full reporting standard. It provides no guidance on data quality or validation, or on methods or formats of reporting.

In the UNFC system quantities are classified using a numerical coding scheme for three fundamental criteria: economic and social viability (E); field project status and feasibility (F); and uncertainty, mostly related to geological knowledge (G). Combinations of these criteria can be displayed and visualized in three dimensions, or in two dimensions (Figure 12 and Table 2).

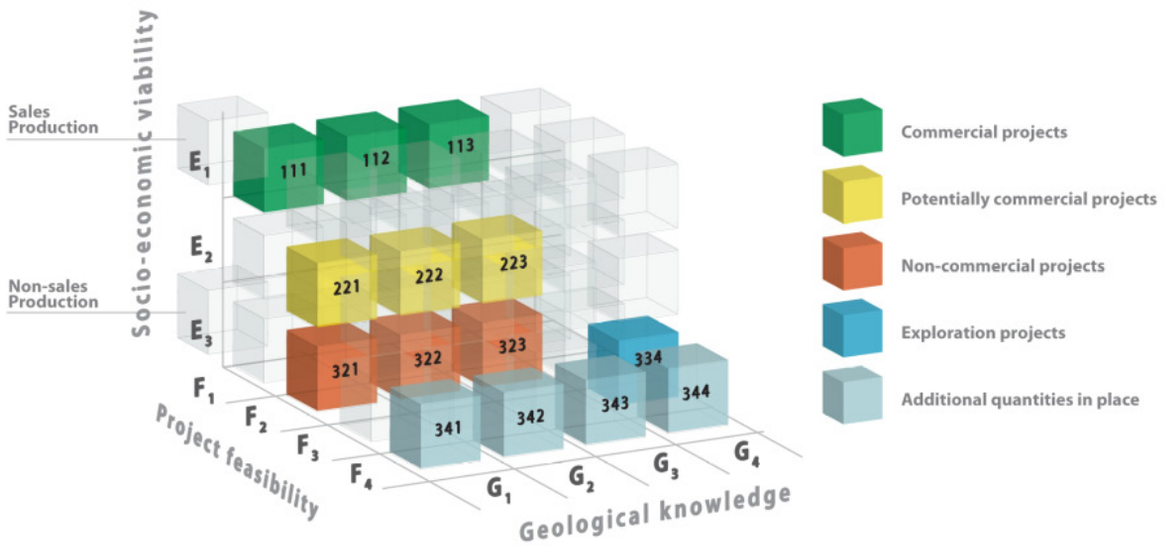


Figure 12 *Abbreviated version of UNFC-2009, showing the primary classes. Source: Adapted from UNFC*

Table 2 *Abbreviated version of UNFC-2009, showing the primary classes. Source: Adapted from UNFC*

	EXTRACTED	SALES PRODUCTION / NON-SALES PRODUCTION			
		Class	Categories		
			E	F	G
Total commodity Initially in Place	Future recovery by commercial development projects or mining operations	Commercial Projects	1	1	1, 2, 3
	Potential future recovery by contingent development projects or mining operations	Potentially Commercial Projects	2	2	1, 2, 3
		Non-Commercial Projects	3	2	1, 2, 3
	Additional quantities in place associated with known deposits		3	4	1, 2, 3
	Potential future recovery by successful exploration activities	Exploration Projects	3	3	4
	Additional quantities in place associated with potential deposits		3	4	4

The UNFC system has been designed to create mineral inventories in harmonised ways that can be easily combined across regions and national borders for the purpose of developing mineral policies and planning. Unlike the CRIRISCO template, UNFC can accommodate resources that are not economic to extract under current market conditions. The UNFC system does not use the term 'reserves', rather all categories are considered 'resources'.

Various documents, known as 'bridging documents,' exist to convert between different systems of defining resources, which have been developed by governments and the minerals industry to enable comparisons (Figure 13). However, not all commonly used definitions have bridging documents. This highlights that resource harmonisation can be a very challenging task.

1) Post 2011 the NAEN standard become aligned to the CRIRISCO template, a bridging document was produced in 2010 to ensure harmonisation prior to this.

2) For data in a national reporting code or historic estimates a considerable amount of re-analysis, possibly involving new ground investigations and sampling, overseen by a CRIRSCO qualified 'competent person' would be required.

3) Bridging documents have been produced enabling conversion between UNFC and CRIRSCO and vice-versa.

4) Depending on the level of data available for national reporting codes and historic estimates a suitable qualified person could potentially convert these into the UNFC classification using the UNFC guidelines. Finland and Hungary are countries that have undertaken such an exercise.

5) This would depend on the code in question. No examples of this are known.

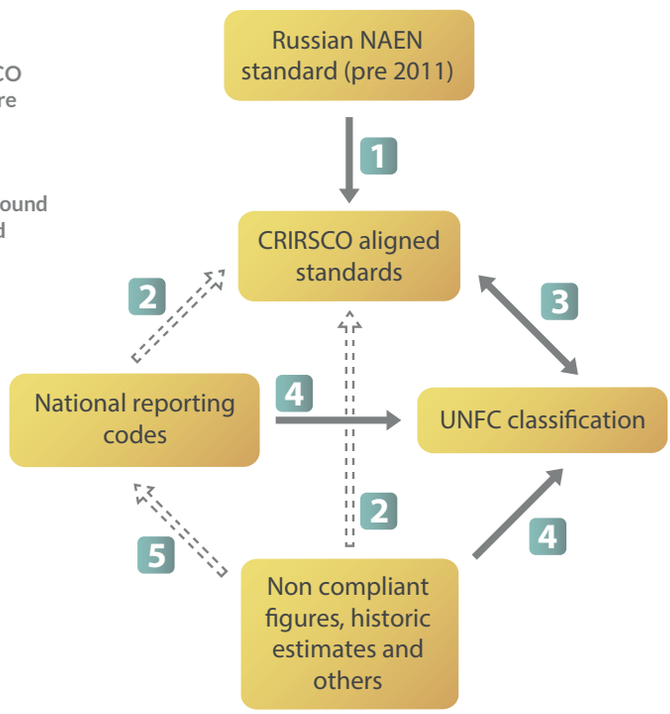


Figure 13 *Bridging documents between different reporting codes and classifications. Solid arrows indicate existing bridging documents, dotted arrows indicate where bridging may be possible but little or no official documents exist.*

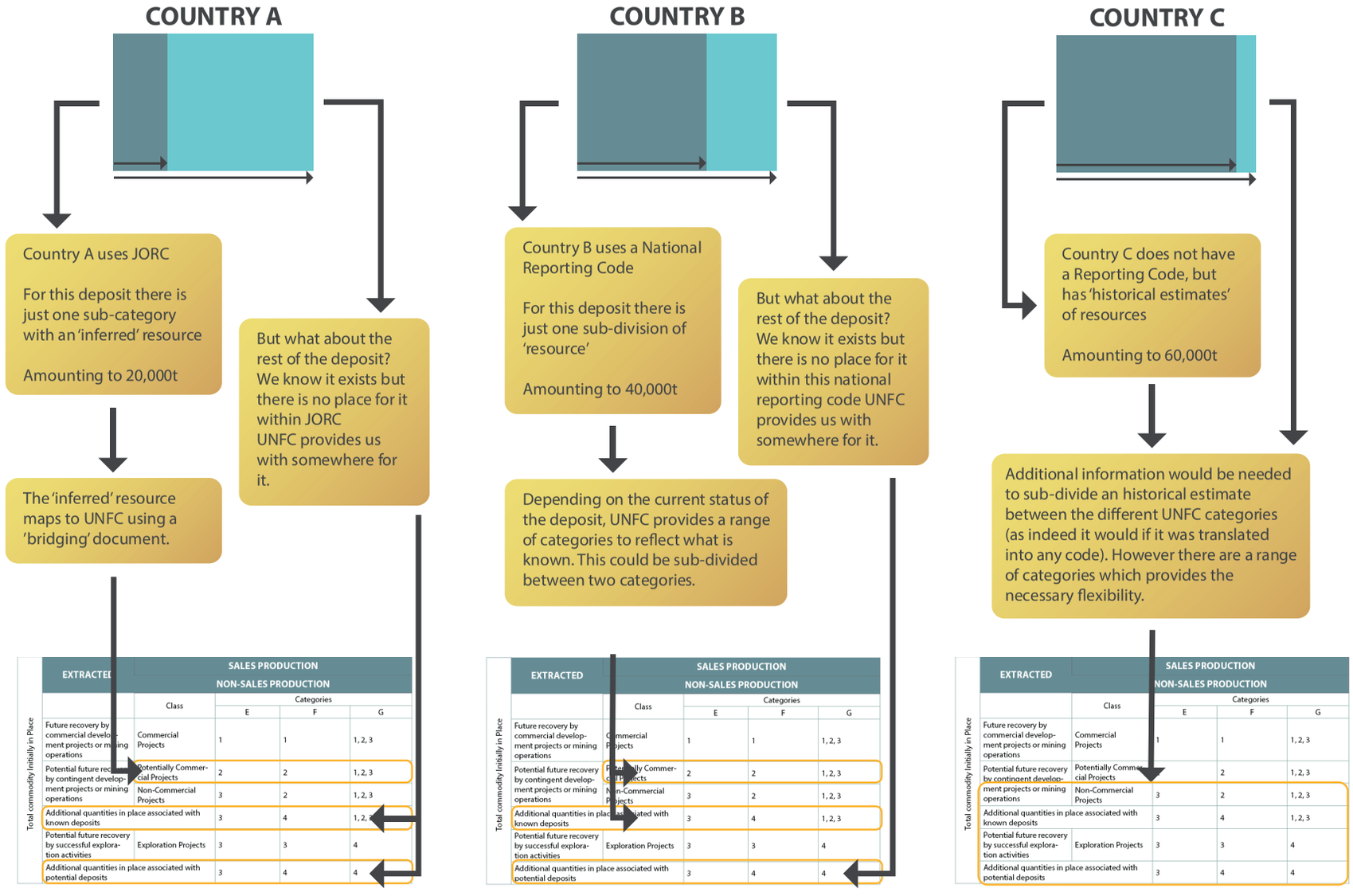
On account of its flexibility, together with the fact it has been designed to be used at a national level and is already being used or considered for use in several European countries, UNFC appears to be the best tool for harmonisation.

The following hypothetical example, as outlined in Figure 14, is provided to summarise the challenges of harmonising resource data in Europe and to highlight how UNFC can help with harmonisation. This uses a theoretically identical deposit located in three different countries that utilise three different systems of reporting. By using UNFC the three resource figures in the example, which were previously incompatible, can be compared in a consistent manner. This allows aggregated totals for separate categories under UNFC to be produced.

For none of these countries does the reported 'resource'represent "all there is".
If you add these together the figure of 120,000 tonnes is meaningless.

Reported quantity

Total goelogically available resource



Total commodity Initially in Place	EXTRACTED	SALES PRODUCTION / NON-SALES PRODUCTION	Class	Categories E	F	G
	Future recovery by commercial development projects or mining operations		Commercial Projects	1	1	1, 2, 3
	Potential future recovery by contingent development projects or mining operations		Potentially Commercial Projects	2	2	1, 2, 3
			Non-Commercial Projects	3	2	1, 2, 3
	Additional quantities in place associated with known deposits			3	4	1, 2, 3
	Potential future recovery by successful exploration activities		Exploration Projects	3	3	4
	Additional quantities in place associated with potential deposits			3	4	4

Figure 14 *How UNFC can help in harmonisation (NB the tables in this Figure are replicates of Table 2 on p39; refer to this for a more legible version)*

4.2 Tools designed to harmonise Secondary Raw Material (SRM) information

4.2.1 Waste Electrical and Electronic Equipment (WEEE) and Photovoltaic (PV) Panels

A description is given below of the different tools developed and applied in the different case studies aimed to harmonise and quantify the different type of (W) EEE products in the urban mine.

- **UNU Keys classification:** The classification of 'UNU keys' envelops all possible EEE that are currently POM. It was created in such a way that product and waste groups share comparable average weights, material composition, end of life (EoL) characteristics and lifespan distributions. The UNU key classification was used in the ProSUM project and proved to be ideal when linking with other types of classifications, quantifying product flows and establishing composition in the urban mine.

- **Officially collected and reported 'Conversion protocol':** From the 15th of August 2018 the recast Directive 2012/19/EU classifies WEEE in 6 collection categories and consequently MS are using a new classification from this date. Therefore, harmonisation when using different aggregations of products is needed for information to be comparable and to define recovery targets to ensure resources in the future. Using the systematic and harmonised methodology created in ProSUM a conversion protocol, to calculate both WEEE officially collected and reported flows, and to convert existing information in a harmonised manner with the alignment between UNU Keys to EU-10 and EU-6 categories, was applied. It was developed by using volumes reported by Eurostat, WEEE Forum Key Figures and national statistics in Europe for 2016 (see D2.3 of ORAMA for more details).

- **Sampling protocol on scavenging:** Currently there are no sampling protocols used to report and measure scavenging of components and products across MS. In the ORAMA project, two sampling protocols were developed in MS Excel (.xls) format aimed at measuring scavenging practices at collection points, logistics and treatment facilities. In each sampling protocol, key components of key products per collection category were identified and included. The protocol seeks to measure the amount of SRM that does not enter formal treatment facilities (see D2.3 of ORAMA for more details). In addition, to facilitate an evaluation of the data quality of the sample, the origin of the sample (municipal waste collection point, scrap dealer, retailer and municipal + retailer) is defined as well as the location (treatment, collection and logistics facility) of the sampling for each data record provided in the protocol. Both sampling protocols are constructed in a way that is compatible with the UNU Key product classification system. Two protocols have been developed the "Simple Sampling Protocol" and the "Detailed Sampling Protocol". The "Simple Sampling Protocol" would allow PRO and treatment facilities to collect the minimum required information to report to MS, and for the Urban Mine Platform (UMP) to analyse it without any complications. In the case of the "Detailed Sampling Protocol", the information would allow MS to have a clearer overview of SRM in this flow and would allow the EU to map how much material is currently not being reported due to scavenging and to gather information on the composition and weight of relevant products and components.

- **Market Survey on scavenging:** The scavenging survey resulted from a literature review and research on scavenging data collection practices in Europe. The survey is aligned with the work performed by previous initiatives, and results similar to those noted by this survey can be seen in the report published by UNU and the European Electronics Recyclers Association, WEEE Recycling Economics (Magalini F., et al 2018). The survey can be accessed online in Google Forms (see D2.3 of ORAMA for more details). This market survey allows different PRO and recycling facilities to provide information on scavenging practices in the areas where they operate. The survey allows treatment facilities to provide information in a harmonised manner and covers key products and components from

different collection categories that they are currently treating. This harnesses all information in one .xls or .csv file which facilitates further quantification and analysis.

In order to improve data for PV panel stocks and flows, four tools were developed that aim to increase the quantity and quality of information and data. The tools are:

- **Use of classification for UNU key 0002 PV panels:** In the frame of the ProSUM project the classification of the UNU key 0002 for PV panels lacked detail and thus it was improved in the ORAMA project with respect to the composition of the materials in PV panels. This classification should be used by producers, researchers, and waste treatment plants in order to provide composition data for PV panels that can be used in, for example UMP and RMIS.

- **Data collection protocol for PV panels:** A systematic literature review of 35 sources was conducted and showed that data is not displayed in a harmonised way nor is it described well. The data collection protocol provides a detailed approach on how to structure data according to the different steps in the life cycle of PV panels and explains which type of information/ metadata is needed in order to display data in a transparent manner.

- **Sampling protocol for PV panels:** Currently the amount of PV panels entering waste treatment facilities is not that large meaning there is little or no information available concerning the proportion of the different PV panel technologies in the waste stream, their age, the reason for disposal, the treatment undertaken, missing and accompanying parts, etc. Therefore, this protocol can be used to systematically collect these types of data and information.

- **Survey for PV panels' data and data collection methods:** The survey aims to evaluate what information is available for each stage of the life cycle of PV panels. Thus, information for the different life cycle steps can be obtained and an assessment on data collection methods can be performed.

4.2.2 Batteries

The following table presents a harmonisation tool for future battery reporting and referencing. The battery types cover the six current main electrochemical systems based on lithium, zinc, nickel-cadmium, nickel-metal hydride, lead and others with corresponding applications. Further battery tools developed in the project can be found in Deliverable 4.1 and training materials in Deliverable 4.2.

Table 3 *Battery classification list with battery keys and applications*

BattKey	Short name	Applications	BattCode
Lithium Rechargeable	LCO	Portable PC	LCOportablePC
		Cell phones	LCOcellphones
		Camera/games	LCOcameras_games
		e-bikes	LCOebikes
		Industrial excl mobility	LCOindustrial
		Tablets	LCOtablets
	LMO	Cameras/games	LMOcameras_games
		Others portable	LMOothers_portable
		e-bikes	LMOebikes
		PHEV	LMOPHEV
		BEV	LMOBEV
		Industrial excl mobility	LMOindustrial
		SLI	LMOSLI
	NMC	Portable PC	NMCportablePC
		Tablets	NMCtablets
		Cell phones	NMCcellphones
		Cameras/games	NMCcameras_games
		Cordless tools	NMCcordless_tolls
		Others Portable	NMCothers_portable
		e-bikes	NMCebikes
		HEV	NMCHEV
		PHEV	NMCPHEV
		BEV	NMCBEV
		Industrial excl mobility	NMCindustrial
	NCA	BEV	NCABEV
		Industrial excl mobility	NCAindustrial
	LFP	Others portable	LFPothers_portable
		e-bikes	LFPebikes
		Industrial excl mobility	LFPindustrial
		SLI	LFPSLI
		e-bus	LFPebus
		e-truck	LFPetruck
Lithium Primary	Li-Primary	Primary	Liprimary
	LMO	Primary	LMOprimary
	LCF	Primary	LCFprimary
	LSO	Primary	LSOprimary
	LTC	Primary	LTCprimary
	LFS	Primary	LFSprimary

BattKey	Short name	Applications	BattCode
NiCd	NiCd (sealed)	Cordless tools	NiCdcordless_tools
		Others portable	NiCdothers_portable
	NiCd (vented)	Industrial excl mobility	NiCdindustrial
NiMH	NiMH (sealed)	Portable PC	NiMHportable_PC
		Cordless tools	NiMHcordless_tools
		Others Portable	NiMHothers_portable
		HEV	NiMHHEV
	NiMH (vented)	Industrial excl mobility	NiMHindustrial
Pb	Pb (sealed)	Others portable	PbAothers_portable
		SLI	PbASLI
		e-bikes	PbAebikes
	Pb (vented)	Industrial excl mobility	PbAindustrial
Zn	Zn	Primary	ZnPrimary
Other	Other	Industrial excl mobility	Otherindustrial

4.2.3 End-of-Life Vehicles (ELV)

Based on the results of the case study on batteries in electric vehicles (xEV) in Norway, it is recommended to revise the vehicle classification system used by Eurostat and others to compile statistics on vehicle registrations. The proposed new classification system, which includes new categories of mass, is shown in Table 4.

Table 4 *Proposed new classification system for vehicles. Categories that are new (displayed with a red font) compared to the current Eurostat classification are shown in red.*

TYPE	MOTOR ENERGY	ENGINE SIZE	MASS
unknown	unknown	unknown	unknown
car	petrol	< 1400 cm3	< 1000 kg
van	diesel	1400-1999 cm3	1000-1249 kg
	LPG	> 2000 cm3	1250-1499 kg
	NG	no cylinder	1500-1749 kg
	HEV		1750-1999 kg
	PHEV		2000-2249 kg
	BEV/fuelcell		2250-2499 kg
	other		>2500 kg

To improve the characterisation of xEV it would be desirable to include another characteristic, e.g. power, as a replacement for, or in addition to engine size. For xEV and hybrid-xEV it would also be useful to include a measure of battery size (e.g. capacity). However, these characteristics are not necessarily well documented in the national vehicle registries meaning their inclusion in international statistics is not currently possible.

4.2.4 Mining Waste (MIN)

Mining waste differs from other SRM groups as there is no European wide data collection mechanism. Data on MIN is often limited in terms of chemical composition and volume thus making the harmonisation of meaningful data the main challenge. Work began on data harmonisation using INSPIRE compliant protocols during earlier projects such as ProSUM and has been extended during this project.

Actions aimed at improving data collection and reporting were developed in the ORAMA Deliverables 2.1 and 2.2.

A new technical guideline has been produced in WP4 describing data harmonisation tools for the collection of MIN data. This guideline has been produced from information collected in WP2.

The extended data model enables the characterisation of MIN in terms of amount, composition, type, storage and environmental impact using specific classification codes. These codes are found here: https://geusgitlab.geus.dk/m4eu

At the end of this project, over 1,200 mining waste sites have been harmonised across 9 European countries.

5 Recommendations

Based on the structured inventory produced for the identification of data collection methods, the data gap analysis and the case studies developed for the improvement of PRM in WP1 and SRM in WP2, the following recommendations are made.

5.1 Recommendations for the improvement and harmonisation of Primary Raw Materials (PRM) statistical datasets

ORAMA has identified a clear set of issues regarding barriers to harmonisation:

- Heterogeneous policy, legislation and regulation across Europe;
- Heterogeneous data quality and comparability (in terms of both what data is collected and the standards used to collect data) across Europe; and
- Heterogeneous data infrastructure, provision and accessibility across Europe.

These three issues are all intrinsically linked, as shown by the data providers' survey. In the vast majority of cases the type of data, quality of data and standards used to collect data are controlled by national legislation (although good examples exist of good voluntary provision of data, these are rare). This is a serious issue for the harmonisation of raw materials information across Europe as MS are unlikely to be willing to change from systems that have suited their needs, and for which there may be a legal basis. They are also unlikely to welcome additional burdens of having to use new ways to classify data, such as UNFC, alongside what they already use. However, the benefits of harmonisation are clear and these should be explained fully in order to encourage progress towards this end.

A clear theme of common elements can be seen across good practice examples that facilitate the harmonisation of primary minerals data:

- An organisation with clear responsibility for data collection, ideally with a legal basis to do so;
- A robust legal system to ensure data is provided by the industry; and
- A clear set of standards for data to ensure interoperability between different countries and bodies responsible for data collection.

Examples of good practice suggest there are two pathways for the harmonisation of raw materials data across Europe. One option is that new legislation is created at a European level that requires data to be collected from specific points in the value chain of raw materials production, and in accordance with specific standards and classification schemes, such as UNFC in the case of resource data. This approach has worked very well in the case of spatial data using the example of the INSPIRE directive, however, this is probably unrealistic to expect for the foreseeable future. The more realistic option is for a voluntary process through projects, such as ORAMA, to persuade geological surveys and other data collection agencies of the merits of a unified approach across Europe and the importance of obtaining high quality harmonised data on raw materials on a European level. It is hoped that training materials, outreach, training events and advances in how these data are collected and displayed which will be produced by the ORAMA project can go some way to achieving this goal whichever route is chosen. Deliverable 1.5 contains a range of training materials aimed to help with resource data harmonisation.

A recommendation that cuts across all themes is also the need for a permanent funding mechanism for data provision. Currently, data is produced by specific projects (such as Minerals4EU, which produced the European Minerals Yearbook and subsequently Mintell4EU, which is producing an update). A more long-term funding mechanism is required for these data to be continually updated and improved in the future. Similarly, such a body must also have a strong mandate to continue to monitor data harmonisation for PRM.

5.1.1 Production data

Although the provision of mineral production data is the most established of all PRM data types across Europe, there is still some ambiguity over the form of the materials produced by the minerals industry (such as metal content vs gross weight of ore) and also there are significant data gaps for many downstream products. This highlights significant issues for many industrial minerals and many metallic mineral commodities that require several steps of processing. Extra effort is required to both educate data collectors in the complex value chains of these commodities and to ensure these data are captured where they are needed. Important metadata is also often absent, metadata regarding uncertainty and/or confidence, degree of rounding and revisions made to the data would greatly improve datasets. Ideally, these data need to be reported within a system context (i.e. taking into account the full life cycle of the mineral or commodity). It is important to pinpoint the place in the system that the data supplied correspond to, presently this is not done, and analysts are required to make assumptions regarding the data provided.

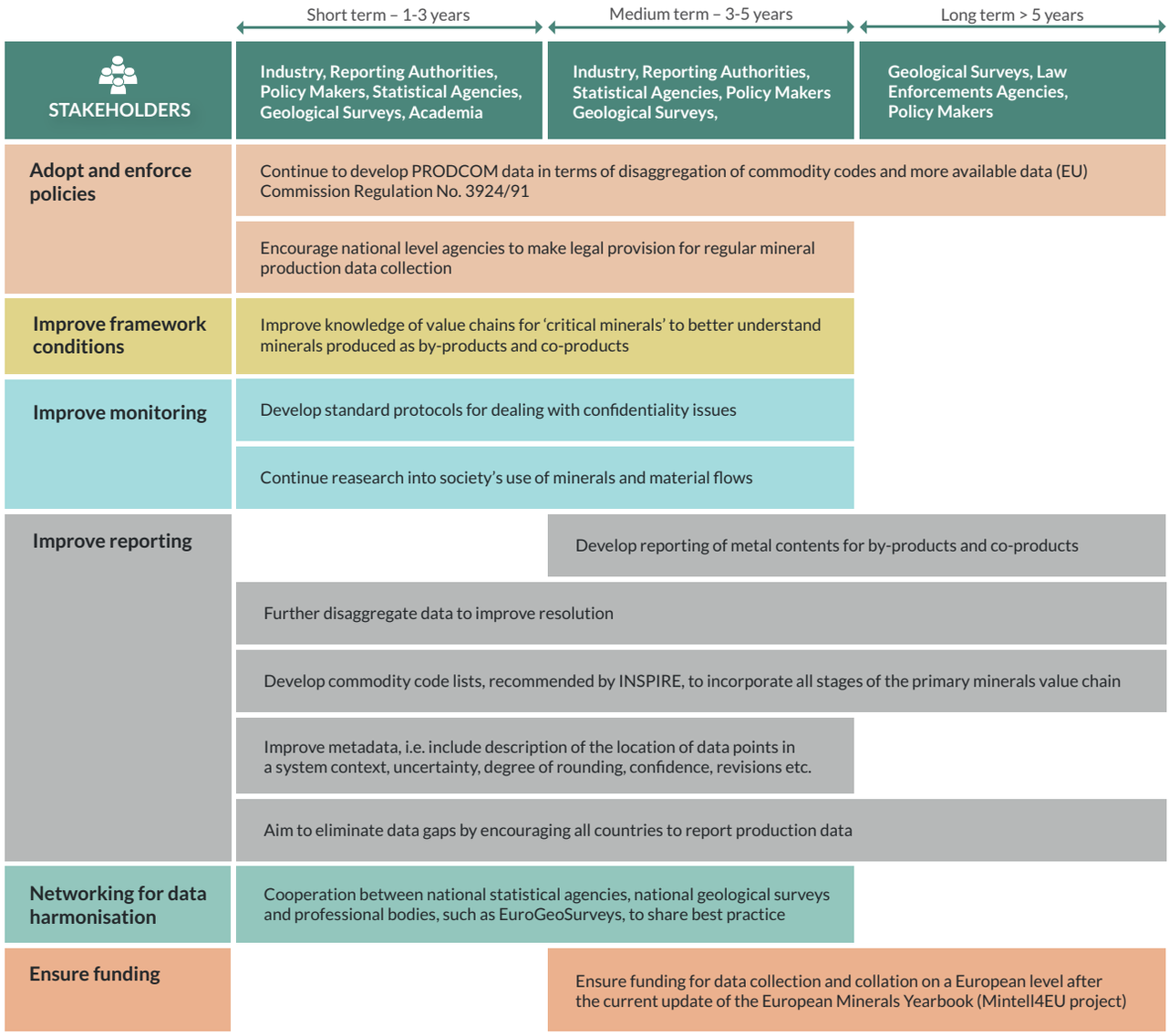


Figure 15 *Prioritised recommendations for the harmonisation of production data*

The European PRODCOM dataset is heavily used by data providers. This may seem unusual in some respects as these data are collected by national governments and supplied to the EC. However, this may highlight that datasets which are to some extent harmonised and easily accessible (even if they may have significant data gaps) may be more attractive to data users than more fragmented raw data, which they may be able to obtain from other sources. Nevertheless, disaggregation of certain commodity codes within PRODCOM is desirable to enable individual minerals to be isolated when required by data users.

Funding is required for a consistent source of production data at a European level. These data are currently being produced by individual projects, such as Minerals4EU and Mintel4EU, which are then not updated after project completion.

The collection of statistical data for by-product commodities is often more difficult than for main products. This is of particular concern for CRM because often these occur, or are produced, as by- or co-products. Greater transparency would clearly be very helpful and options requiring this should be examined.

5.1.2 Trade data

Trade data is one of the most well-established forms of PRM data and follows long-established internationally recognised protocols and standards. However there is still scope for improvements because complexities in trade data can lead to errors, such as the incorrect trade codes being attributed to commodities or goods being traded, then re-traded (triangular trade) between countries. Training is required for data providers to reduce these issues for data users and to make sure they understand the data and use them correctly.

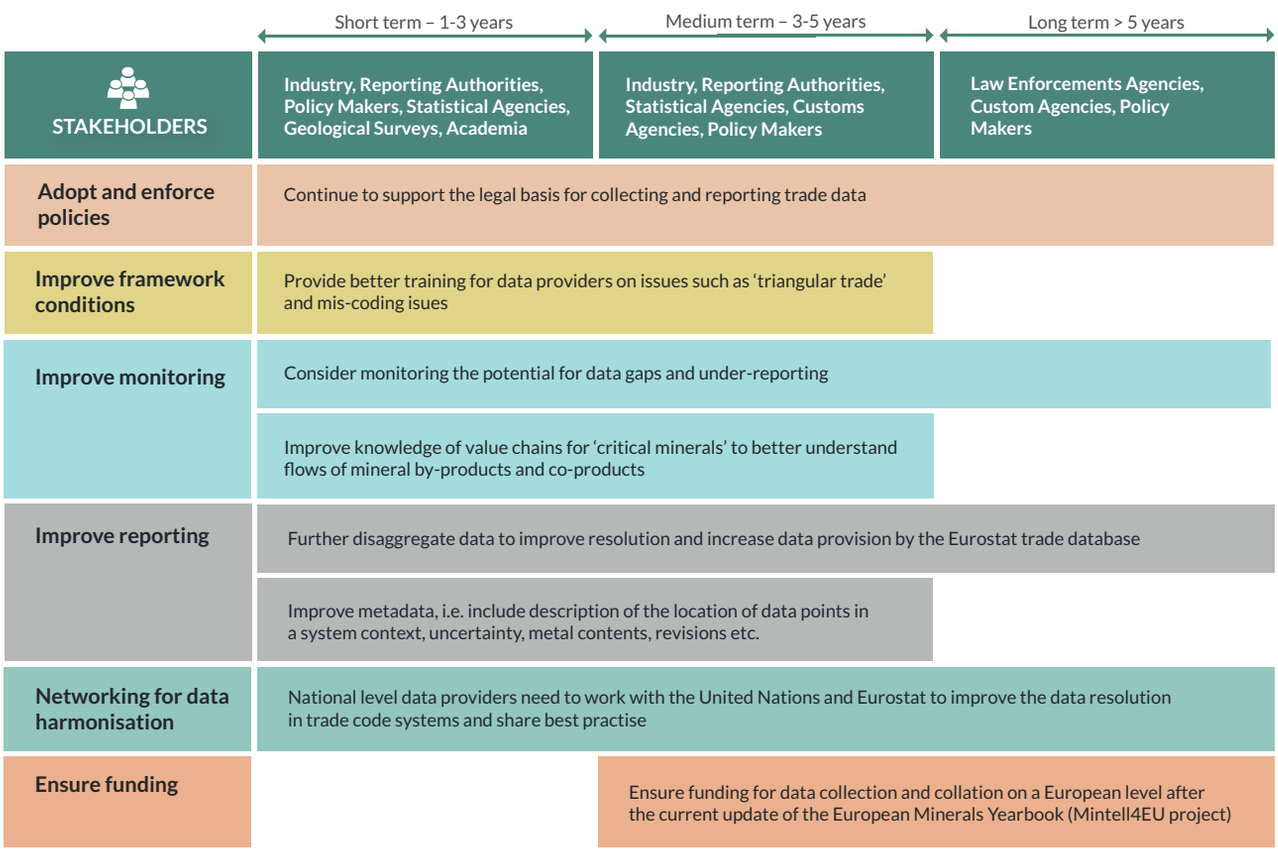


Figure 16 *Prioritised recommendations for the harmonisation of trade data for PRM*

Important metadata is also often absent. Metadata regarding uncertainty and/or confidence levels, metal contents of ores and compounds, and revisions made to the data would greatly improve datasets. Ideally, these data need to be reported within a system context. It is important to pinpoint the place in the system that the data supplied correspond to; presently this is not done and analysts are required to make assumptions regarding the data provided.

Funding is required for a consistent and regular compilation of trade data at a European level. These data are currently being compiled by individual projects, such as Minerals4EU and Mintel4EU, which are then not updated after project completion. Although data are published by Eurostat and UN Comtrade they are often confidential or will be aggregated at such a level that many commodities cannot be differentiated. As a result, work needs to be undertaken to disaggregate these data and ensure a comprehensive, minerals specific source of trade data is available for Europe (such as the European Minerals Yearbook).

5.1.3 Exploration data

Exploration data is poorly reported and understood when compared to other PRM data. The metrics available vary greatly. If a harmonised approach is to be taken, a first step would be to decide upon the most useful metrics. If current availability is used as an indicator of what may be most useful, these metrics could be:

- Number of licences issued;
- Number of active licences;
- Areas these licences cover; and
- Number of companies involved in exploration.

If, however, other metrics are required then more effort needs to be made to encourage their collection.

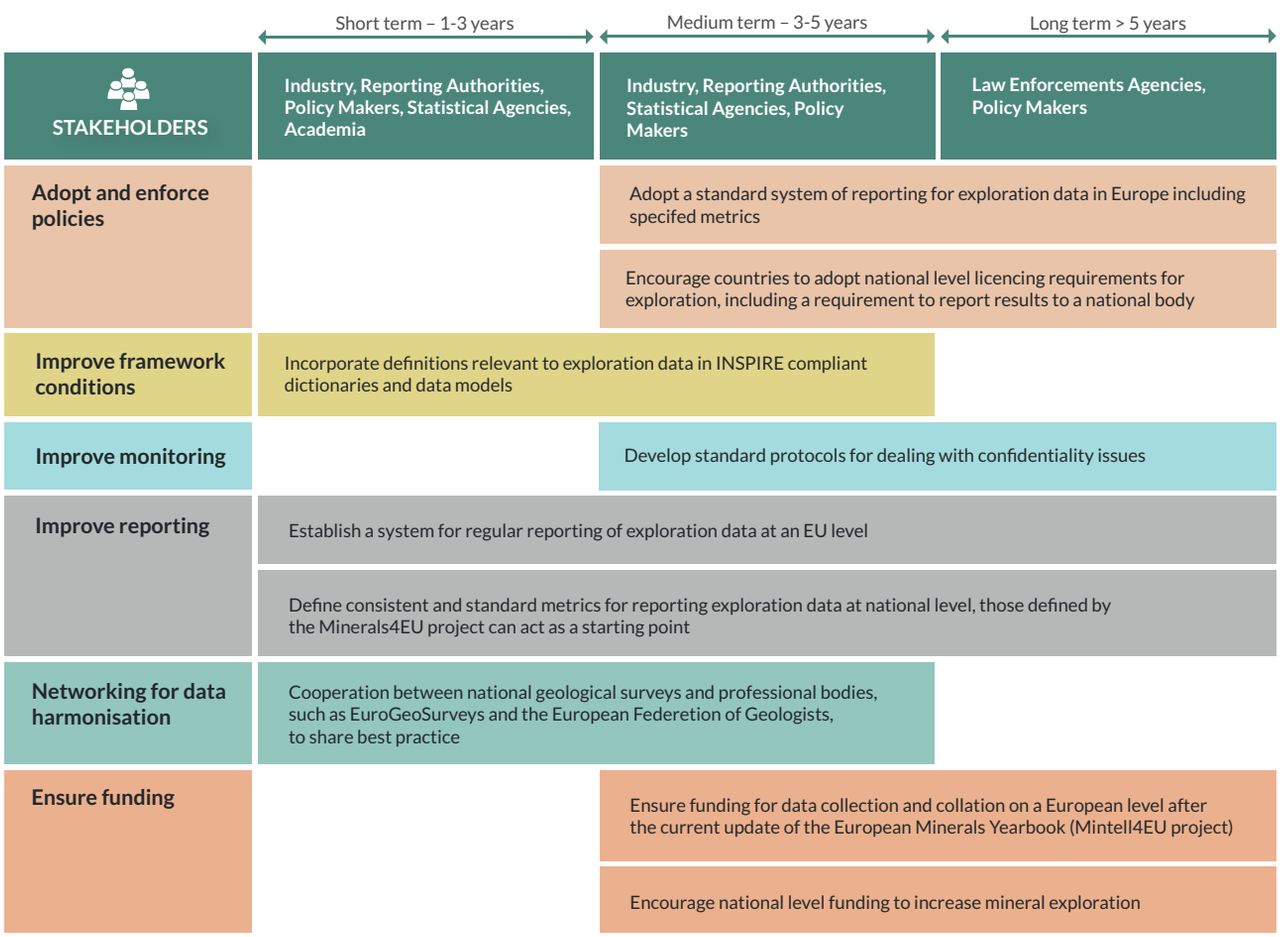


Figure 17 *Prioritised recommendations for the harmonisation of exploration data*

There are some good examples of data collection for exploration data within Europe. However, most countries do not have the same processes in place and exploration activity levels vary widely. Each country can decide for itself whether it wishes to encourage more or less exploration and will develop its own policies to achieve that end. However, in general, more exploration will usually lead to the discovery of more deposits.

Not all of Europe has been explored to the same degree. Exploration in the past has not always considered the commodities that are now important for modern technology and past exploration may not have used the more modern techniques now available. Exploration is an important part of

the extractive industry but it requires investment and support. A system of exploration licencing is more likely to generate data relating to the amount of activity that is taking place. Where there is no licensing system for exploration then it is hard to gather the accurate data that is required. The presence or absence of mineral licensing systems is often related to mineral ownership and/or land ownership. However, even where minerals are owned by local landowners (and not the state), if exploration requires some kind of permit then data can be collected.

5.1.4 Resources and reserves data

Within Europe, some countries have a legal basis for collecting data relating to resources and reserves, while other countries do not. Some countries have good quality data (albeit not always for all commodities), while data quality in other countries is highly variable. Even where data are provided, the figures are not always complete, i.e. additionally known deposits do not have quantities associated with them and are therefore not included. In some instances, deposits may be too small to be considered economic in the current market but these may become economic in future. Other deposits may be at too early a stage to have been sufficiently evaluated for a resource quantity to have been developed.

It is also important to remember that quoted figures for 'resources' or 'reserves', or even 'endowment' or 'inventory', do not represent 'all there is' in the Earth because even in Europe undiscovered deposits remain.

International codes aligned with the CRIRSCO template do not have classes available that allow the inclusion of sub-economic deposits, early-stage exploration, historical data or probabilistic estimates of resources. The classification systems that are aligned with the CRIRSCO template are only concerned with resources that are economic to work now or in the very near future. The UNFC system is, however, more flexible and includes classes that can be utilised for all these types of deposit and thus allows a longer-term view of mineral supply. Data provided in accordance with UNFC can be much closer to 'all there is', or at least as close as it is possible to be bearing in mind the uncertainties associated with certain types of estimate and the fact that some deposits are completely unquantified. It is therefore recommended that the UNFC should be adopted for longer-term studies at the more strategic scale. However, there are consequences arising from this recommendation, such as the need to provide guidance and training for people who are responsible for transforming the figures between classification systems.

No countries covered by the ORAMA project have so far adopted UNFC as a national system of reporting. This is not surprising when national legalisation often dictates a specific system or a specific code must be used. However, this is a situation that could be changing as shown by the numerous case studies, published by the ORAMA project, which highlight that some countries are beginning to use UNFC, and also the high awareness of UNFC amongst data providers reported by the survey conducted by ORAMA. However, if UNFC, is to be used for harmonisation purposes this will need to be in addition to what is currently being used, not instead of. Countries will need to be encouraged to voluntarily bridge their resource data to UNFC for harmonisation purposes. This is a difficult task but is more realistic for the foreseeable future than calling for legislation at a EC level requiring MS to produce harmonised data.

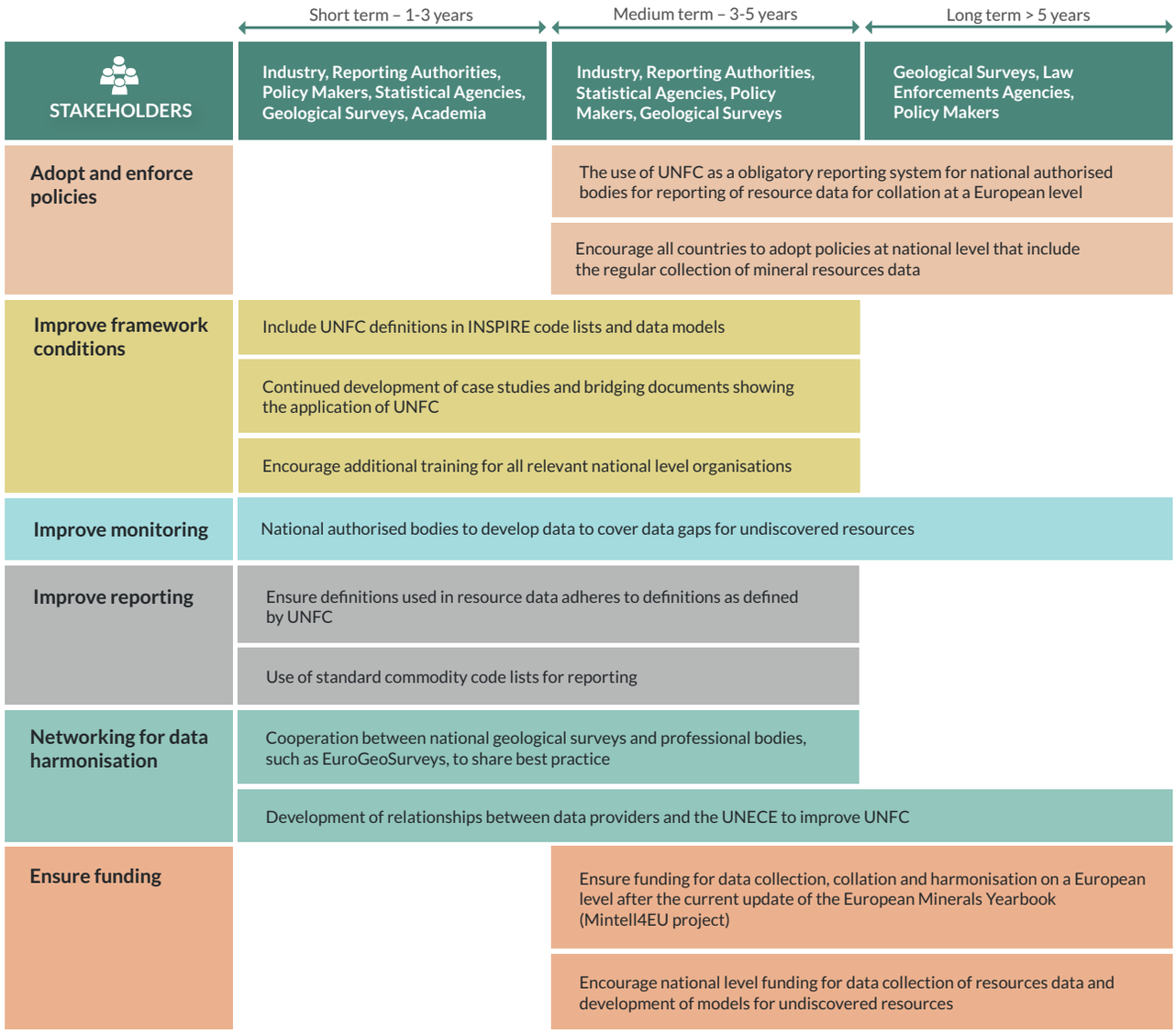


Figure 18 *Prioritised recommendations for the harmonisation of resources and serves data*

For many European countries that have mineral resource management procedures and the related classification systems in place that are based on, or developed from, the Russian system (e.g. Hungary Czech Republic, Poland, etc.), long term datasets are available for mineral resources and these are appropriate for the harmonisation process. For these examples, where data is readily available, harmonisation can be achieved with international reporting standards and the UNFC classification framework by using bridging procedures associated with these codes and classifications. However, the heterogeneity of mineral deposits needs to be indicated clearly and the role of a competent expert (e.g. Competent Person) is important. It is also critical that further bridging documents are developed for those countries that have not already undertaken this exercise.

For countries that do not have a history of resource management and do not have minerals inventories or experience of using standard codes and classifications, it may be more challenging to develop data suitable for harmonisation at European level. However, bridging documents also exist between other codes/systems aligned with the CRIRSCO template (e.g. JORC, PERC, NI 43-101, etc.) and work is underway in several countries to explore how other resource figures could be aligned with UNFC.

The process of bridging between codes is complex due to the difference in national resource codes as well as the inherent complexities surrounding geological, technical, environmental and socio-economic factors at individual sites. Therefore, the most appropriate body to convert data is the

owner of national resource data (normally the national geological survey) as they will have the most experience and understanding of their data and mining industry.

The use of UNFC will require help with training and expert input to the relevant government bodies, which is what an EU project, such as ORAMA, can provide, along with resources to aid in the bridging from other national and international codes and standards to UNFC (see Deliverable 1.5). It must also be recognised that although one of the strengths of UNFC is its ability to incorporate uneconomic resources and deposits that have not been fully evaluated, for many countries these data do not exist. As a result, care needs to be taken when comparing across countries, even when using a consistent standard. A data gap may mean an absence of data not an absence of resources.

5.1.5 Recommendations for improving available datasets related to social and environmental dimensions of extraction

The provision of datasets specifically relating to environmental and social aspects of mining and quarrying is highly variable. For some thematic areas datasets already exist that directly report on, or act as good proxies for, assessing impacts of the extractive sector on social and environmental issues. Eurostat data, using the NACE (Nomenclature of Economic Activities) codes, provide a wide range of easily accessible data with some degree of quality assurance. For many published datasets there is a suitable resolution to be able to specifically disaggregate the extractive sector from the rest of the data. However, in many cases, it is not always possible to split energy and non-energy minerals, link downstream activities of the extractive sector, such as smelting and processing, to mineral extraction, or get breakdowns for specific mineral sectors. Depending on the user requirements, this may or may not be sufficient.

However, a common theme for this data is that either no data are available, or much of the available data cannot be related to specific impacts of mineral extraction. For example, data are available across Europe for soil quality, water use, the movement of heavy goods vehicles, dust emissions etc. but there is often no way of separating the extractive sector's contribution to these from other economic sectors. If the extraction sector-specific datasets are required at a European level, further disaggregation by industrial sector is required when collecting data. This may not be a realistic prospect given the high administrative burdens of collecting the existing data. Alternatively, it may be possible to integrate existing datasets in innovative ways to link the extractive sector to other datasets such as linking land use maps with known locations of mineral extraction sites. However, to develop these ideas into published datasets significant additional research is required. Consequently, there needs to be a strong desire for particular datasets, combined with the necessary resources to enable them to be created. It is hoped that the examples given by the ORAMA project show what could be possible should more detailed or more specific datasets of the impacts of mineral extraction be required.

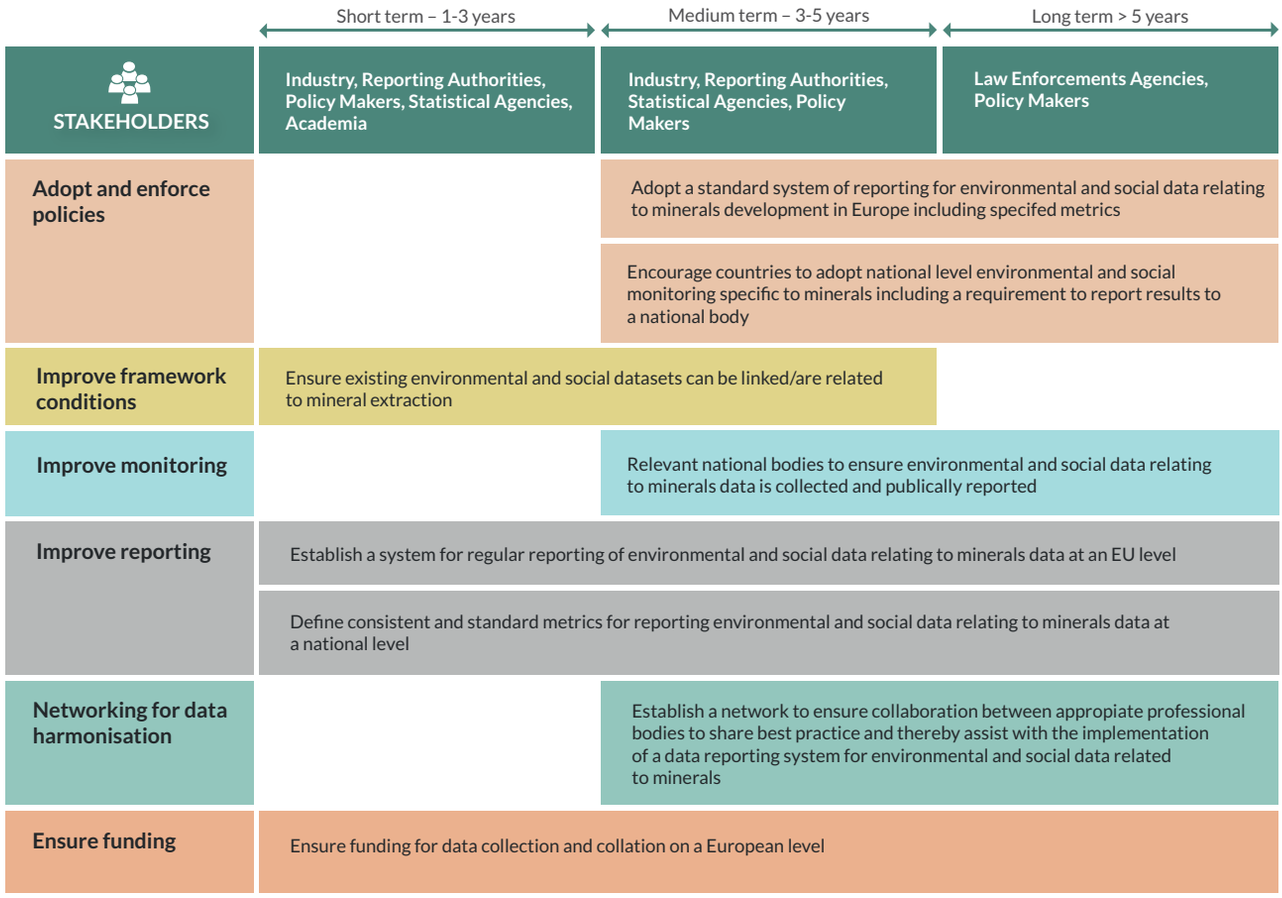


Figure 19 *Prioritised recommendations for the improvement of available datasets related to social and environmental dimensions of extraction*

5.2 Recommendations for the improvement and harmonisation of Secondary Raw Material (SRM) statistical datasets

In this section prioritised recommendations for the improvement and harmonisation of SRM will be described using the following criteria:

- Adopt and enforcement of policies;
- Ensure funding; and
- Improve reporting and monitoring.

The time frame suggested for each recommendation was analysed in the following way: short term strategies involve a timeframe of implementation between 1-3 years, medium-term strategies involve strategies with implementation time between 3-5 years and long term strategies involve strategies which implementation is meant to take > 5 years. Further information can be found in D2.2 Recommendations for improving SRM datasets and harmonisation.

5.2.1 Waste Electrical and Electronic Equipment (WEEE) and Photovoltaic (PV) Panels

As a result of the inventory of collection and reporting practices along with the identification of data gaps and best practices performed for WEEE, prioritised recommendations for the improvement of data collection methods were drawn up and are illustrated in Figure 20.

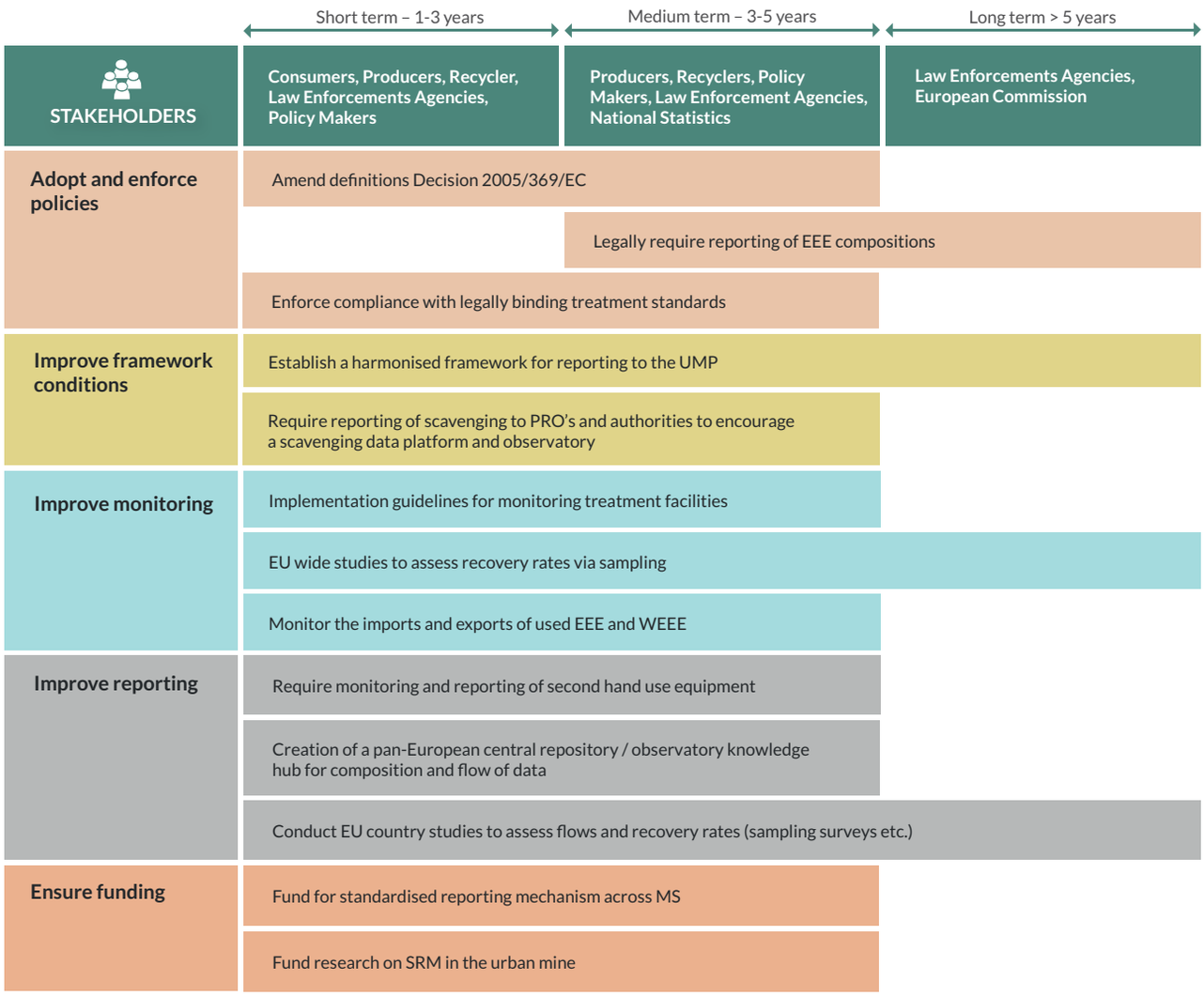


Figure 20 *Prioritised recommendations for better SRM reporting on WEEE*

When adopting and enforcing policies, it is important that an amendment of the definitions in Decision 2005/369/EC is made and in doing so includes harmonised definitions which should make an explicit differentiation. See Deliverable 2.2 of the ORAMA project (Huisman et. al., 2018). Harmonised SRM knowledge/data base is critical for the economic growth of the manufacturing sector in the EU, therefore new policies should be made where legally binding declarations of composition content of EEE be reported to the corresponding authority. MS should work with the industry sector to develop a compatible architecture system, where information on raw materials can be easily exchanged in a secure way (aligned to Digital Europe's 'Declaration to ensure the EU is a world leader in Digital Manufacturing'). The aforementioned could only be achieved if all parties have a common understanding of legal disclosures and of when the necessary resources are met. The composition declaration should be made in a harmonised manner preferably using product level (product types) in order to have more knowledge of SRM in the urban mine.

In addition, by improving the reporting methods, knowledge on unaccounted flows in the urban mine, such as WEEE being scavenged or ending up in metal scrap, could be improved. In doing so, quantification and composition flow mapping of (W) EEE can provide valuable insights on recovery rates per MS and an overview of SRM in the urban mine could be achieved. This information would greatly contribute to the calculation of substantiated estimates accountable for meeting collection targets. Moreover, the EU should adopt concrete actions to enhance trade and political relationships with third-country producers of CRMs in order to mitigate supply risks. There is a need to promote industrial cooperation initiatives between the two shores of the Atlantic and better coordination among the "national champions" of individual MS in an effort to lock-in and develop key R&I advantages (aligned to the Italian IAI - Istituto Affari Internazionali).

Monitoring should play a very important role in order to guarantee proper standardised and harmonised data collection and reporting of information across MS. This could be achieved by performing country studies in a form of standardised sampling campaigns or via surveys in collection/segregation points and treatment facilities in order to quantify the final recovery rates of SRM from WEEE in MS. Moreover, MS should have in place and should implement monitoring of standardised guidelines of treatment facilities to ensure the proper treatment of fractions is performed in an environmentally sound manner.

Member States should secure yearly funds to promote a standardised reporting mechanism. This could be done within the UMP and in doing so, they would guarantee that all MS report information in a harmonised manner making information comparable, allowing the mapping of SRM in the urban mine, making information accessible to stakeholders and to the public, and improving the quality of the information.

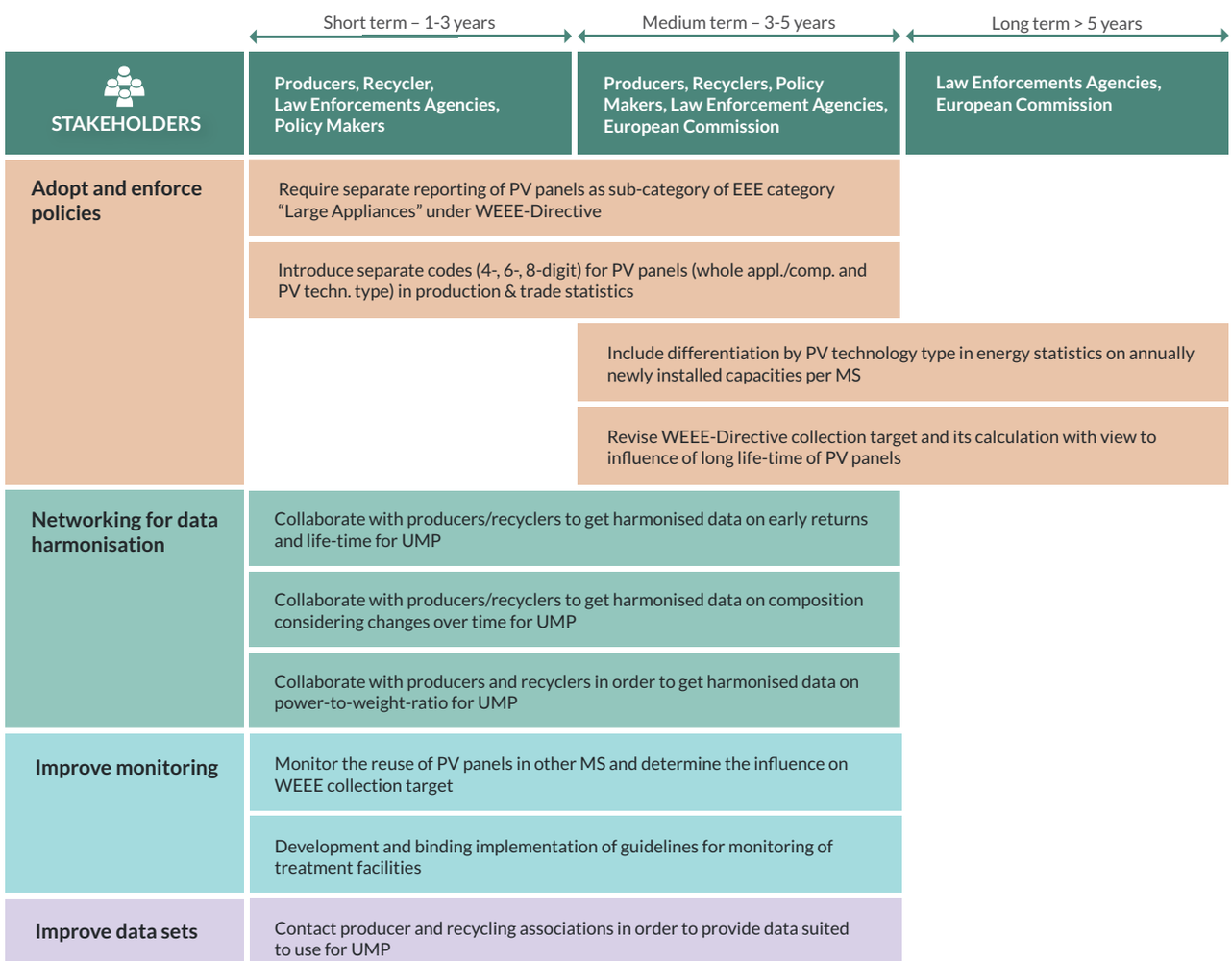


Figure 21 *Prioritised recommendations for PV panels*

Concerning PV panels, it should be emphasised that the recommendations for (W) EEE (see above) also apply for PV panels. The following recommendations deal, however, with aspects particular to PV panels (see chapter 4.3 and 4.5 of Deliverable 2.2 and the Technical Guideline Tools for harmonisation of data collection on WEEE/PV panels for details, revised according to results of the PV panel case study (Deliverable 2.3) and further discussions in the frame of an expert workshop (D4.2).

First of all, concerning the monitoring according to the WEEE Directive, it should become mandatory for the MS to report data on PV panels POM, waste collected, treated, prepared for reuse and recycled, recovered, and exported as separate figures (so far voluntary according to Eurostat Guideline on WEEE Reporting, (Eurostat 2017). Regulation (EU) 2019/290 already requires that producers have to report PV panels separately to the national registers. Now, the Commission Decision 2005/369/EU that lays down the format for the reporting of the MS to the EU still has to be amended (this Commission Decision is already under revision as far as the authors of this report understand).

Furthermore, statistics to be revised are the energy statistic (annually installed capacities additional to cumulative installed capacities as well as distinction between different PV technologies) and the production and trade statistics (codes for PV panels without the inclusion of LED; separation of PV panels' components and modules; differentiation between different PV technologies).

Since neither waste nor energy or production and trade statistics do, so far, distinguish between different PV panel technology types and a revision of statistics would only be possible in the medium or long run, if it is at all enforceable to change them concerning this issue, industry associations (such as IRENA, SolarPower Europe, ITRPV) should publish the shares of the different technology types per country for POM as well as waste collected.

The more detailed UNU sub-key classification that was developed within the ORAMA project should be implemented in the UMP as well as being used by producers/ industry associations, researchers, and treatment plants to display PV panel composition data (see Deliverable 2.3 of ORAMA project).

Producers and operators of PV power stations should collect and publish data on early returns (damages due to transport, mounting, early failure PV panels, etc.) in order to discuss/ verify the lifetime distribution methodology used for prospecting future waste streams of PV panels and contribute the data itself. This should go hand-in-hand with the determination of the age of PV panels becoming waste regularly after usage.

Research on time series concerning the composition of the different PV panel technology types should be undertaken and harmonised data should be published (e.g. regarding silver in crystalline silicon (c-Si) PV).

In the case study conducted in Deliverable 2.3 it was pointed out that, since data from official statistics is rare/ not available, industry associations that already publish different data could improve their voluntary reporting by including data on:

- Annual installed net maximum electrical capacities per country (already done by the International Energy Agency Photovoltaic Power Systems Programme (IEA-PVPS), should be continued and data further improved);
- Power-to-weight-ratios on annual basis, differentiated by PV technology type;
- Share of different PV technologies per country and region;
- Share of BIPV and portable PV in comparison to "classical" PV;
- Data on lifetime, especially early failures; and

- More complete data on composition as needed for UMP (see also D4.1 of ORAMA)

Further, a harmonised nomenclature and classification system for the output fractions of PV panel treatment and recycling should be developed and binding guidelines for the monitoring be developed and implemented. A monitoring guideline/ fact sheet should be developed that contains a comprehensive methodological description of how to collect data in order to calculate (material specific) recycling and recovery rates (corresponding with the PV panel classification). This monitoring guideline, defining minimum requirements, should be applied by treatment/ recycling facility operators as well as by researchers who develop recycling options (tools developed within the ORAMA project and published within this deliverable should be considered and integrated).

5.2.2 Batteries

Recommendations on how to improve future data availability of batteries flow aim to establish a harmonised framework encompassing interpretation of definitions, classifications, methods, and documentation for battery data collection across MS. This would be supported by the development of a common classification system that would allow all MS to categorise the electrochemical battery (sub-) systems and the corresponding applications to better monitor the stocks and flows of batteries. This entails amending the definitions in the revised Battery Directive 2006/66/EC. A centralised data platform to provide harmonised data on battery types POM, including xEV batteries, that is accessible to the wider public is one crucial step. It would be important to operate, maintain and update the databases and platforms making the data available on materials contained in stocks and flows of batteries. Furthermore, the extension of reporting requirements to better monitor second-life batteries from xEV would enable stakeholders and policymakers to monitor the stock level and ages of xEV batteries in the future. More detailed information can be found in ORAMA Deliverable D2.3 and Technical Guideline Tools for harmonisation of data collection on batteries.

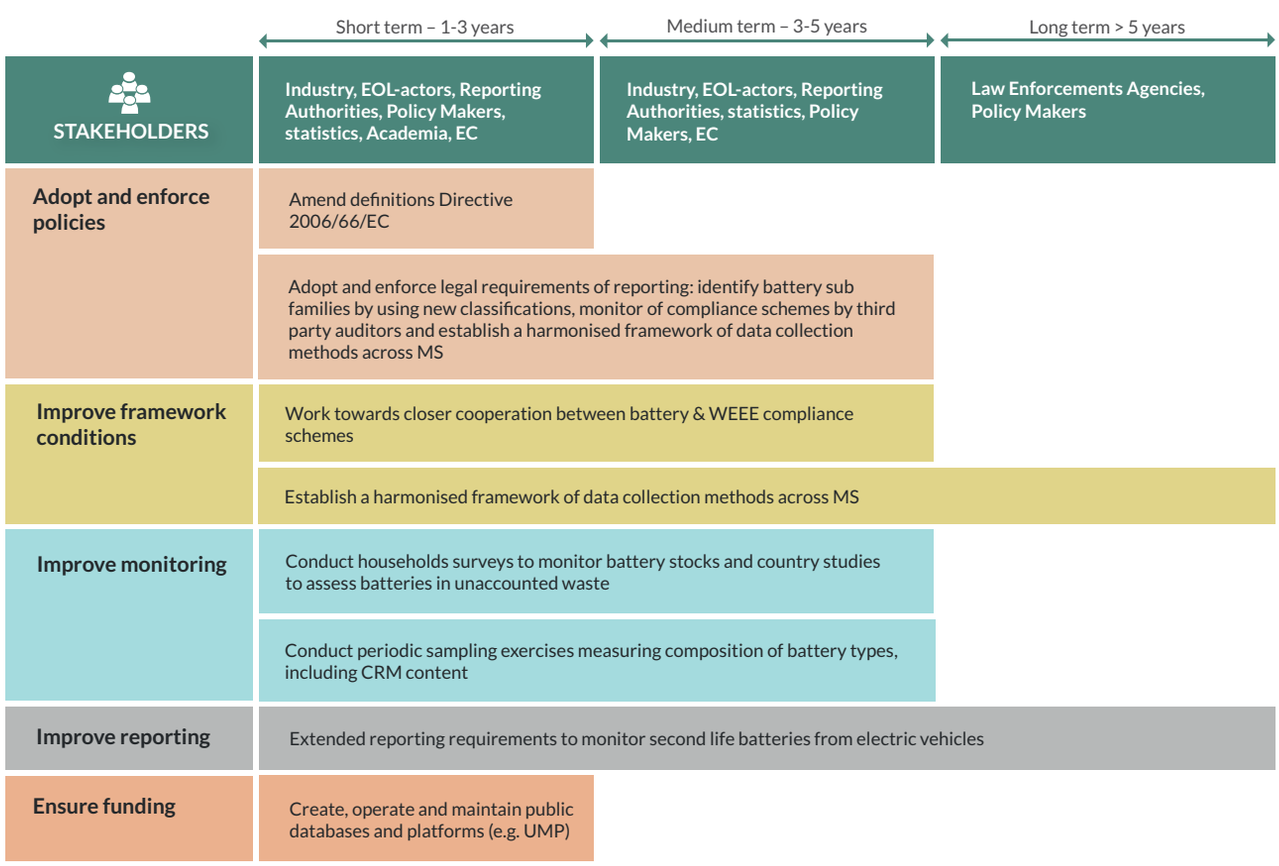


Figure 22 *Prioritised recommendations for batteries*

In order to quantify the high battery flows which currently fall under "unknown whereabouts", information on batteries in municipal solid waste, as well as batteries in household stocks, is much needed. The results of sampling in several MS show that there are examples of good practices that could be extended to other countries[1]. One key issue is the standardisation of methods, including the sampling origin and size and the classification of the batteries found in the sorted samples. It is important to monitor the stock levels and ages of batteries in households or institutions/ industry e.g. through surveys to generate reliable knowledge on the return flows of CRM in batteries. Promoting close cooperation between batteries & WEEE compliance schemes could ensure that EEE producers report correctly through an improved knowledge transfer.

5.2.3 End of Life Vehicles (ELV)

A number of recommendations can be given in order improve data management of SRM in vehicles, selected on the basis of being of high priority and above reasonable feasibility.

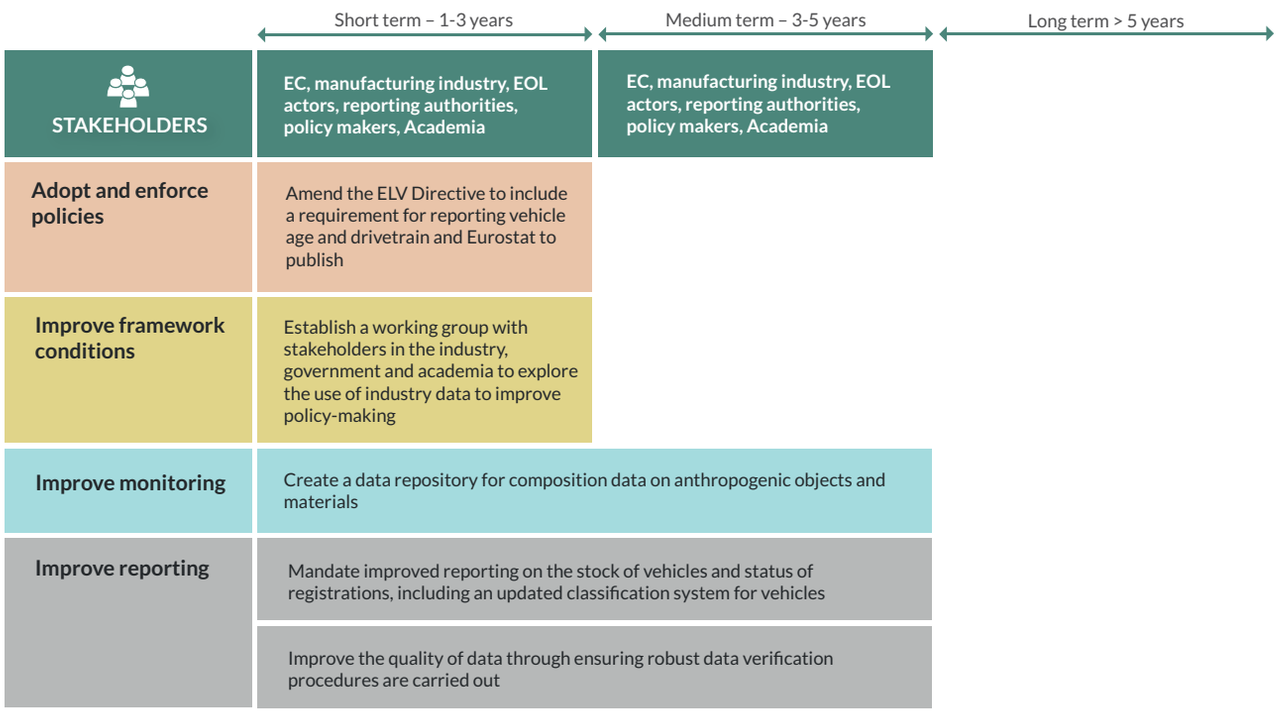


Figure 23 *Prioritised recommendations for ELV*

A working group involving vehicle manufacturing and recycling industries could be established with support from reporting authorities and the SRM research community. The aim would initially be to explore possibilities to best utilise the already existing information and information infrastructures within the vehicle industry to identify and communicate components to be dismantled for SRM recovery. The working group could also serve as a stakeholder forum for the development of ELV management policy in general.

1 *Eucobat (2017): How battery life cycle influences the collection rate of battery collection schemes.*

The current classifications used for reporting statistics on new vehicles and vehicles in use should be further diversified with additional mass categories and information related to the electric drivetrain. This requires such data being collected by the national authorities. Specific recommendations include:

1. More mass categories are needed to better distinguish between (increasingly common) heavy cars (above 1500 kg); and
2. Include a performance-related characteristic that is more suitable for electric (and hybrid) vehicles than the current "engine size", for example power or capacity of electric drive batteries and motors.

Information about collected ELVs is already less detailed than that of new vehicles and vehicles in use. Alignment of data representing the full vehicle lifecycles is thus not possible. This also affects the uncertainty of estimated SRM composition available for recycling, since SRM contents vary over time and type of vehicles. The ELV directive could mandate reporting of the vehicle model year and drivetrain available in the certificates of destruction issued for all recycled vehicles. Overall, it is important to capture changes over time in vehicle technologies since it affects quantities and compositions of SRM.

A data repository where information can be collected, sorted and easily retrieved could be established. Information about the composition of components and materials is increasingly generated by researchers but is scattered in various locations and formats.

The reliability of data collected and published in Eurostat varies as quality control procedures vary. Uncertainty levels are in general difficult to assess and must often be based on assumptions. It is recommended that EC and Eurostat collaborate to develop and implement robust data verification procedures.

The issue of a large number of vehicles of 'unknown whereabouts' is without doubt of high priority but is not included as a recommendation in this report since its feasibility is assessed as low and since it is part of issues in the revision of the ELV directive to be finalised in 2020.

5.2.4 Mining Waste (MIN)

The main general recommendations to improve the quality of MIN data are to combine and harmonise data collected in earlier projects into a single source, perform detailed research on reported interesting waste sites to obtain necessary information for valuation of recovery potential as well as to improve knowledge on certain topics (recycling technologies, permits for recovery) An overview of the final recommendations is shown in Figure 24.

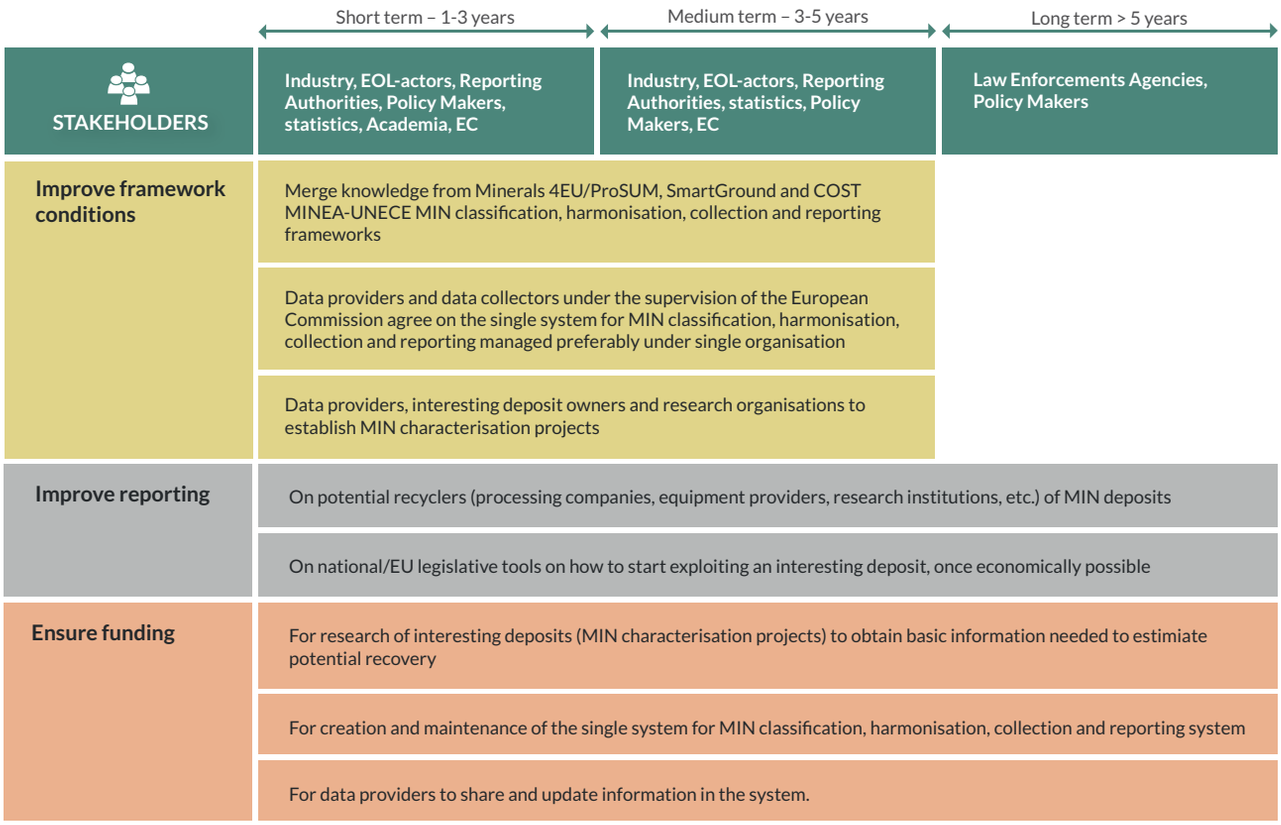


Figure 24 *Prioritised recommendations for MIN*

6 Policy Briefs

6.1 Policy Briefs for Primary Raw Materials (PRM)

6.1.1 Production data

Production data for PRMs are established in Europe with all countries reporting some form of production data (they are legally obliged to do so under EU Commission Regulation No. 3924/91, to supply data to the PRODCOM database). As well as providing data to the EU for PRODCOM, many, but not all, countries produce easily accessible national statistics for a range of commodities as reported in publications such as World Mineral Production (from BGS, United Kingdom) or World Mining Data (from BMNT, Austria).

However, data gaps still exist, very little data is available for instance for minor metals and many raw materials that are considered 'critical'. It can be problematic using PRODCOM data due to confidentiality issues and the level of aggregation, which means many commodities cannot be differentiated. If PRODCOM data are to be used further for reporting of European production data, protocols on how confidential data can be handled and reported need to be developed.

PRINCIPLES	BOTTLENECK	Industry, Reporting Authorities, Policy Makers, Statistical Agencies, Academia, European Commission	TOOLS AND ACTIONS
Adopt and enforce policies	Some data requires further disaggregation, data gaps exist for some countries	• Continue to develop PRODCOM data in terms of disaggregation of commodity codes and increasing availability of data (EU Commission regulation No. 3924/910) • Encourage national level agencies to make legal provision for regular mineral production data collection	• Continue to develop communication between PRODCOM and data users • Encourage data providers to adopt good practice
Improve framework conditions	Lack of understanding of 'value chain' and where or how data fits within it	• Improve knowledge of value chains for 'critical minerals' to better understand downstream products and minerals produced as by-products and co-products	• Encourage the use of lifecycle analysis by data providers
Improve monitoring	Some data are confidential, data gaps for by and co-products	• Develop standard protocols for dealing with confidentiality issues • Continue to develop understanding of the use of PRM and materials flows	• Review of data resolution and confidentiality. Develop studies on commodity specific materials flows
Improve reporting	Some data require further disaggregation, data gaps exist for some countries and downstream products, metadata are often lacking	• Develop commodity code lists, recommended by INSPIRE, to incorporate all stages of the primary minerals value chain • Improve metadata, i.e. include description of the location of data points in a system context, uncertainty, degree of rounding, confidence, revisions, metal content etc. • Aim to eliminate data gaps by encouraging all countries to export production data	• Continued development of INSPIRE and relevant data models • Application of life cycle analysis to statistical data. Use of good practice examples to improve data provision
Ensure funding	No funding mechanism for long term data collation	• Ensure funding for data collection and collation on a European level after the current update of the European Minerals Yearbook (Mintel4EU project)	• Establishment of a permanent programme for European PRM data collation

Figure 25 *Analysis of challenges in the reporting of production data and suggested tools to improvement*

It is important that, to improve data provision, countries are encouraged to follow best practice examples and national data providers facilitate the sharing of production statistics (as outlined in D1.2) by publically reporting data.

In addition, important metadata for production data are often not available. Clarity of the data could be improved if it was considered in a 'system context' (i.e. taking into account the full lifecycle of the mineral or commodity). This allows data to be pinpointed within the production/processing/consumption lifecycle. The vast majority of data, including PRODCOM, does not include such information. Presently this is not done and analysts are required to make assumptions regarding the data provided. Consideration of the entire lifecycle in a system context could also help to reduce data gaps that currently exist, including for by- and co-products as well as products from intermediate manufacturing stages.

6.1.2 Trade data

Trade data are a very well established type of PRM data and are collected in some form by all countries within well-established European and international frameworks. However, there are still improvements that can be made. Issues sometimes arise with mis-coding of commodities and complex trade arrangements where material is imported and re-exported. A better understanding by national statistical agencies of PRM specific issues, as outlined in D1.2, will help with this. There are also significant issues around lack of disaggregation of trade codes meaning data for many minor or critical metals cannot be resolved. As with production data, these data could be improved by consideration within a system context that identifies precisely where, in the lifecycle of a specific commodity, reported data are being captured. This may help with current data gaps, particularly for some CRM.

PRINCIPLES	BOTTLENECK	Industry, Reporting Authorities, Policy Makers, Statistical Agencies, Custom Agencies, Academia, European Commission	TOOLS AND ACTIONS
Improve framework conditions	Lack of understanding of 'value chain' and where or how data fits within it	• Improve knowledge of value chains for 'critical minerals' to better understand downstream products and minerals produced as by-products and co-products	• Encourage the use of lifecycle analysis by data providers
Improve monitoring	Data can be mis-reported due to mis-reported and complex trade flows, there are also data gaps for by and co-products	• Consider monitoring the potential for data gaps and under-reporting • Improve knowledge of value chains for 'critical minerals' to better understand flows of mineral by-products and co-products	• Training for data providers on issues such as 'triangular trade' and miscoding • Develop studies on commodity specific materials flows
Improve reporting	Some data require further disaggrega-tion, data gaps exist for some downstream products, metadata are often lacking	• Improve trade codes to incorporate all stages of the primary minerals value chain • Improve metadata, i.e uncertainty, revisions, metal content etc.	• Work with Eurostat and UN Comtrade to ensure appropriate data disaggregation • Application of lifecycle analysis to statistical data
Ensure funding	No funding mechanism for long term data collation	• Ensure funding for data collection and collation on a European level after the current update of the European Minerals Yearbook (Mintel4EU project)	• Establishment of a permanent programme for European PRM data collation

Figure 26 *Analysis of challenges in the reporting of trade data and suggested tools to improvement*

6.1.3 Exploration data

Data for mineral exploration are disparate and inconsistent across Europe. If they are collected or not, and what type of data are collected will be dependent on specific national legislation with regard to how mineral extraction is licensed within a specific country. A first step in better provision of exploration data is for countries to agree upon common metrics to be reported across Europe. The Minerals4EU project began this process by collecting data for a range of metrics and the ORAMA project has recommended some metrics that may be achievable for harmonised European data (D1.2). Regardless of the metrics used there are significant data gaps across Europe where exploration data are not collected. Countries need to be informed of the value of collecting these data and encouraged to collect them by the use of good practice examples, or, alternatively, through policy incentives from the EU that ensure data is collected.

PRINCIPLES	BOTTLENECK	Industry, Reporting Authorities, Policy Makers, Statistical Agencies, Custom Agencies, Academia, European Commission	TOOLS AND ACTIONS
Adopt and enforce policies	No consistency in data collection across Europe, many countries do not collect / report data	• Adopt a standard system of reporting for exlporation data in Europe • Encourage countries to adpot national level licencing requirements for exploration, including a requirement to report results to a national body	• Define what knowledge is required at a European level • Policies and training to ensure data collection
Improve framework conditions	Definitions are poorly defined	• Incorporate definitions relevant to exploration data in INSPIRE compliant dictionaries and data models	• Continued development of INSPIRE and relevant data models
Improve monitoring	Many countries have no monitoring	• Revelant national bodies should ensure exploration data are collected and publically reported	• Encourage countries to collect data via the provision of good practice case studies
Improve reporting	There are no standard metrics for reporting or system for data collection at a European level	• Establish a system for regular reporting of exploration data at an EU level • Define consistent and standard metrics for reporting exploration data at a national level	• Metrics and data collection practices used by the Minerals4EU project
Ensure funding	No funding mechanism for long term data collation	• Ensure funding for data collection and collation on a European level after the current update of the European Minerals Yearbook (Mintell4EU project)	• Establishment of a permanent programme for European PRM data collation

Figure 27 *Analysis of challenges in the reporting of exploration data and suggested tools to improvement*

6.1.4 Environmental and social data

There is no systematic collection of data relating to environmental and social data regarding PRMs across Europe and there are no standard metrics. A significant issue with the available data is that, although there are many datasets across Europe which deal with a range of social and environmental issues, few can be directly related to PRMs. This is to be expected as the purpose of existing environmental and social data is prevention, protection and compliance rather than monitoring the performance of the mining sector in Europe. This needs to change if the impacts of extraction are to be quantified and understood. It may be possible to link PRM datasets to social and environmental datasets, or improve social and environmental datasets by further disaggregation of industry sectors involved etc. However, this requires significant resources and the first step needs to be a decision by the user community as to what would be the most effective metrics for measuring the social and environmental impacts of mineral extraction across Europe. As detailed in D1.3, the ORAMA project has recommended metrics which could be used immediately, that are already harmonised and have full European coverage, but other metrics may be more useful.

PRINCIPLES	BOTTLENECK	Industry, Reporting Authorities, Policy Makers, Statistical Agencies, Custom Agencies, Academia, European Commission	TOOLS AND ACTIONS
Adopt and enforce policies	No consistency in data collection across Europe, many countries do not collect or report data	• Adopt a standard system of reporting for environmental and social data relating to minerals development in Europe including specified metrics • Encourage countries to adpot national level licencing requirements for exploration, including a requirement to report results to a national body	• Define what knowledge is required at a European level • Policies and training to ensure data collection
Improve framework conditions	Environmental and social datasets are often not linked to mineral extraction	• Ensure existing environmental and social datasets have sufficient resolution to enable mineral extraction to be isolated from other industrial sectors	• Define datasets required for reporting and ensure they are integrated with PRM datasets
Improve monitoring	Monitoring is heterogeneous across Europe and often not linked to mineral extraction	• Revelant national bodies to ensure environmental and social data relating to minerals are collected and publically reported	• Encourage countries to collect data via the provision of good practice case studies
Improve reporting	There are no standard metrics for reporting or system for data collection at a European level	• Establish a system for regular reporting of environmental and social data relating to minerals at an EU level • Define consistent and standard metrics for reporting environmental and social data relating to minerals at a national level	• Metrics used by the ORAMA project and the RMIS
Ensure funding	No funding mechanism for long term data collation	• Ensure funding for data collection and collation on a European level after the current update of the European Minerals Yearbook (Mintell4EU project)	• Establishment of a permanent programme for European PRM data collation

Figure 28 *Analysis of challenges in the reporting of environmental and social data and suggested tools for improvement*

6.1.5 Resource data

Much resource data exist within Europe and many countries report some form of data. However, these data conform with many different standards, which are not directly comparable. This issue can be resolved with the adoption of UNFC for reporting of resource information at a European level. Countries will have to continue to report data in accordance with their own national standards (for national level legal reasons) but should bridge their data across to UNFC using standard practices (outlined in D1.5). This can be a complex task and it is hoped that the training materials and technical guidance delivered by ORAMA (D1.5) can aid in this.

There is also a separate issue of data gaps. Even where data are provided, the figures are not always complete, i.e. uneconomic resources or resources that are not associated with currently producing mines may or may not be included. It is therefore also important to be mindful of these data gaps, even when comparing data using the same reporting standards (like UNFC) and to continue to invest in mineral resource studies and exploration to fully understand European mineral endowment. One long-term solution for these data gaps and harmonisation issues is for European policy to require reporting of resource data.

PRINCIPLES	BOTTLENECK	Industry, Reporting Authorities, Policy Makers, Statistical Agencies, Custom Agencies, Academia, European Commission	TOOLS AND ACTIONS
Adopt and enforce policies	Different countries will be required by law to use different reporting standards	• The use of UNFC as an obligatory reporting system for national authorised bodies for reporting of resource data for collation at a European level • Encourage all countries to adopt policies at national level that include the regular collection of mineral resources data	• Adoption of UNFC for EU level data reporting • Encourage countries to collect data via provision of good practice case studies
Improve framework conditions	Resource data are often misunderstood. It is difficult to compare different types of data	• Include UNFC definitions in INSPIRE code lists and data models • Continued development of case studies and bridging documents showing the application of UNFC • Encourage additional training for all relevant national level organisations	• Continued development of INSPIRE and revelant data models • Case studies, and training materials, as produced by ORAMA, showing how UNFC can be used
Improve monitoring	Many countries do not collect these data, most countries have some form of data gaps	• National authorised bodies need to be defined and develop mechanism to fill data gaps including for undiscovered resources	• Data gaps across Europe need to be fully understood
Improve reporting	There is no standard way of reporting data across Europe	• Ensure definitions used in resource data adheres to UNFC • Use of standard commodity code lists for reporting	• Adoption of UNFC for data reporting and ensuring that commodity definitions used are to established standards
Ensure funding	No funding mechanism for long term data collation	• Ensure funding for data collection and collation on a European level after the current update of the European Minerals Yearbook (MintelI4EU project)	Establishment of a permanent programme for European PRM data collation

Figure 29 *Analysis of challenges in the reporting of resource data and suggested tools to improvement*

6.1.6 Issues for all data types

Funding is required for a consistent source of PRM statistical data, aggregated at both a European and national level. There is no funding mechanism for long-term data collation. These data are currently being produced by individual projects, such as Minerals4EU and Mintel4EU, which are then not updated after project completion. For continued provision of these data, a permanent programme for European PRM data collation needs to be established.

6.2 Policy Briefs for Secondary Raw Materials (SRM)

The economies and welfare of the citizens in the European Union are highly dependent on raw materials. This causes a lot of environmental pressure – also in other regions of the world where e.g. a lot of metals are mined. The strategic planning of the raw materials supply chain needs high quality, independent, and up-to-date statistics and projections that are available at different levels within the European Union.

Comprehensive and up-to-date data and information on the stocks and flows of batteries, (W) EEE, and vehicles in Europe and their composition is essential both for the design of good recycling-oriented policies and for recycling-oriented decisions by individual actors in end-of-life management, such as dismantlers. Thus, design of policies presently relies on highly aggregated data on stocks and flows (such as from Eurostat) and a small set of studies on product composition that rely on costly independent chemical analysis.

The ORAMA project has identified state-of-the-art reporting procedures, harmonisation strategies, bottlenecks, and implementation processes to improve the reporting on WEEE, ELV, batteries, and MIN in the European Union. The following section presents comprehensive analysis of the current situation and improvements that could be made by improving and implementing strong policies on European Statistics in order to quantify SRM in the urban mine.

6.2.1 Waste Electrical and Electronic Equipment (WEEE) and Photovoltaic (PV) Panels

Electrical and electronic equipment contains many crucial raw materials, such as base and precious metals, high-quality plastics, and CRM. These materials are essential in shaping a future carbon-neutral, and resource-efficient society. In order to substitute PRM, SRM have to be recovered in high quality and quantity.

WEEE statistics indicate that more than 60% of SRM found in WEEE are part of unofficial flows (i.e. waste bin, exports, metal scrap, scavenging etc.) and as a result the treatment and recycling/ recovery technologies, as well as further uses in the value chain, are unknown. The current inability to accurately and easily produce timely and reliable statistics and projections about raw materials in WEEE stocks and flows is therefore of major concern to the European Union. Unfortunately, producers do not provide composition information of products POM which makes estimations of recovery rates very challenging. This type of information is scattered among European projects that have limited funding dependent to the projects duration, eco design studies and research institutes among others. Normally this information is not harmonised and is outdated.

In addition, reporting methodologies are very much country dependent as they have their own internal guidelines and procedures and even in some cases, their own classification of products

which may result in inconsistencies and underestimations. Furthermore, reporting obligations linked to Extended Producer Responsibility and lack of regulations and monitoring on e-commerce may lead to underestimation of products placed on the market.

Among the main challenges identified for collection and reporting of WEEE in MS within ORAMA were:

1) Composition data of EEE/WEEE

2) Recovery of SRM in WEEE by material type

3) Undocumented flows: most notably, transboundary movement of used-EEE and WEEE, WEEE mixed with other waste streams and scavenging of WEEE

4) Lack of centralised and funded platforms to inform public, stakeholders and industry on WEEE management in the EU, such as the UMP that covers all WEEE flows in EU

5) Online free riders as they represent an unfair burden to take back systems because they do not fulfil their take-back obligations and since they do not report product POM cause underestimation in WEEE statistics

PRINCIPLES	BOTTLENECK	RECOMMENDED ACTIONS	TOOLS
Adopt and enforce policies	Unclear definitions, too generic categories/ codes, no composition data	• Amend definitions in Decision 2005/369/EC and add sub-category for PV panels • Legally required reporting of EEE compositions • Improve PV panel data in energy statistics as well as production and trade statistics	• Guidelines to monitor used EEE and WEEE • Legally binding agreements on harmonised data format • Define codes for different PV panel technologies
Improve framework conditions	No existing platforms with harmonised data	• Establish a harmonised framework for reporting composition • Set up an independently monitored data platform and observatory for scavenging	• ProSUM and ORAMA methodology (especially UNU-key characterisation) and protocols
Improve monitoring	No harmonised data on used EEE & WEEE Flows, reporting of unofficial flows composition, recovery available	• Improve provision of data from producers/PROs, researchers, and treatment facilities ensuring harmonised data • Monitor the imports and exports of used EEE and WEEE • Implementation of guidelines for monitoring of treatment facilities • EU studies and treatment facility batch tests to assess actual recovery rates	• Implement monitoring guidelines, sampling protocols, surveys • Set up a working group to assess product lifetimes, composition of (W)EEE
Improve reporting	Data gaps concerning used EEEE, stocks, waste flows, composition, recovery on MS level	• Require monitoring and reporting of second-hand equipment and online free-riding • Conduct EU country studies to assess WEEE flows and recovery rates • Creation of a pan-European central repository hub for composition and flow of data	• Implement sampling, surveys • Increase reporting obligations on the recovery of secondary raw materials in WEEE by material type, and quality • UMP
Ensure funding	Lack of continuous financing for data collection	• Standardised reporting mechanism across MS • Research on SRM in the urban mine	• Allocate yearly funding to support WEEE statistics and research

Figure 30 *Analysis of challenges in WEEE reporting and suggested tools to improvement*

Since PV panels are one of the main technologies for decarbonising future energy supply systems, amounts POM are expected to increase. This will eventually lead to an increase waste PV panels. Consequently, PV panels will become a significant share of total (W) EEE in many countries. But it is not only the quantity that is relevant, it is also the materials they contain that are of interest, especially metals like silver, indium, and gallium, which have the potential to be extracted as SRM.

Currently, there is no reliable data available concerning stocks and flows of PV panels; the few data that are available contradict each other. Data on composition and life-time are only available from a few sources and it is not harmonised. Further, the change of composition and power-to-weight-ratio over time is not sufficiently reported and taken into account.

Recommendations regarding PV panels developed within the ORAMA project deal with the following three main issues:

1) Improve existing waste, energy and production & trade statistics in order to obtain data solely for PV panels. Therefore, legal requirements, as well as statistical systems and reporting practices, have to be amended (i.e. Commission Decision 2005/369/EU, categories of energy statistics, PRODCOM codes). In a second step, different PV panel technologies should be distinguished between.

2) Activate data collection by producers/ PROs, researchers and treatment and recycling facilities. In order to produce harmonised data, the tools developed within ORAMA should be applied (usage of UNU key classification, data collection protocol, sampling protocol, survey).

3) Improve collaboration with industry associations and encourage them to enhance their regular industry reports by including the data needed for the purpose of stock and flow analysis of PV panels (i.e. data on annual installed net maximum electrical capacities per country (already done by IEA-PVPS, should be continued and data further improved), power-to-weight -ratios on annual basis and differentiated by PV technology type, share of different PV technologies per country and region, share of building integrated (BI) PV and portable PV in comparison to "classical" PV, data on lifetime and especially on early failures, more complete and harmonised data on composition as needed for UMP and RMIS – taking into account changes over time).

6.2.2 Batteries

Batteries represent an interesting product group for proposing more harmonisation in European reporting legislations due to their content of CRMs and their increasing market extension especially looking at lithium-based rechargeable batteries and the xEV market. The trend towards xEV is expected to provide the largest share of the demand for Li-ion batteries in the coming years. Growing concerns on global warming and air pollution will give the eco-friendly xEV a great push. Next to environmental benefits, xEV contribute to long-term economic growth through the introduction of new technologies and infrastructure. However, the compositions of Li-ion batteries vary considerably regarding CRM content and reliable information on market numbers are of high strategic importance, not only to policymakers but also to industry and recyclers. The relevance of reliable battery data is likely to increase even more with second life scenarios in mind. NiMH batteries which are among other applications also found in xEV contain rare earth metals which are also of high strategic importance for the EU.

Current reporting obligations are lagging behind and do not provide reliable information on CRM flows and expected waste generation and thus need to be improved. In order to conduct valid estimations

on the magnitude of SRM contained in the xEV battery system, to estimate valuable return flows for EoL actors, data collection along the intermediate steps of the battery value chain are crucial. Little knowledge is available for instance on the lifetime of xEV batteries that will determine the timeframe for when batteries move from stock in use to their end of first life, where several second use scenarios may happen. A key recommendation from the ORAMA project is, therefore, to extend the reporting obligations along the battery value chain towards improved composition data from manufacturers (CRM content) and set legally binding reporting requirements that allow stakeholders to estimate the CRM flows in Europe. Policies supporting this approach and working towards an improved and harmonised data collection system around batteries in Europe is highly recommended.

PRINCIPLES	BOTTLENECK	RECOMMENDED ACTIONS	TOOLS
Adopt and enforce policies	Unclear definitions, too generic categories/ codes, no composition data	• Amend definitions in Decision 2006/66/EC and add sub chemistries • Legally required reporting of more detailed battery data for batteries placed on the market and waste collected	• Battery classifications list • Legally binding agreements on harmonised data format across MS
Improve framework conditions	No existing platforms with harmonised data	• Establish a harmonised framework for reporting to the UMP • Improve cooperation of WEEE and battery compliance schemes	• ProSUM and ORAMA methodology (e.g. battery classification) & protocols
Improve monitoring	No harmonised data on used battery flows lack of reporting of unofficial flows, no composition data available	• Improve provision of data from producers/PROs, researchers, and treatment facilities ensuring harmonised data • EU studies / scientific papers and treatment facility batch tests to assess actual return	• Implement monitoring guidelines, sampling protocols, surveys
Improve reporting	Data gaps on high numbers of unknown whereabouts, battery stocks, waste flows	• Require monitoring and reporting of second-hand batteries from EV sector • Conduct EU country studies to assess battery stocks, and improve lifetime data of batteries and applications • Creation of central database for reliable data	• Implement/finance reliable data platform • UMP
Ensure funding	Lack of continuous financing for data collection	• Standardised reporting mechanism across MS	• Allocate annual funding to support battery statictics and research

Figure 31 *Analysis of challenges in reporting of batteries and suggested tools to improvement*

6.2.3 End of Life Vehicles (ELV)

Vehicles represent one of the major application areas for a wide range of raw materials, including CRM such as rare earth elements, cobalt, niobium and platinum group metals, and are an important source of SRM. Current practice for the treatment of ELV is mainly aimed at recovery of their major constituent materials such as steel, aluminium, copper and to some extent plastics. Most elements that are used in relatively small quantities (e.g. in specialised car electronics and steel alloys) are not functionally recycled at end-of-life, although their material flows on a national or European level are substantial and highly relevant for the overall circularity of the economy. With the introduction of new technologies such as electric drivetrains and autonomous driving, the use of speciality materials in vehicles is expected to increase further.

Although huge amounts of data on vehicles are collected and stored by government institutions (i.e. central vehicle registries of the individual MS) and the automobile industry (compositional data needed for compliance with various regulations), these data are not available to the public or the relevant actors in their primary form. Thus, design of policies presently relies on highly aggregated data on stocks and flows (such as from Eurostat) and a small set of studies on vehicle composition that either rely on costly independent chemical analyses of vehicle parts, or on very limited access to the IMDS (the information system used by the automobile industry to track material compositions through the supply chain).

The main challenge in the sector will be to find ways in which existing data and information systems can be used or transformed to support recycling-oriented policies and actions, both on a high level (rules and regulations) and for individual actors (e.g. dismantlers). Considering the possible synergies with reporting for compliance reasons, the potential for improvement is huge, especially in the domain of compositional data. A key recommendation from the ORAMA project is, therefore, to establish a working group involving vehicle manufacturing and recycling industries, with support from reporting authorities and the SRM research community. The aim could initially be to explore possibilities to best utilise the already existing information and information infrastructures within the vehicle industry to identify and communicate components to be dismantled for SRM recovery. The working group could also serve as a stakeholder forum for development of ELV management policy in general. In addition, it is recommended to expand the existing vehicle classification systems to better represent current variation in vehicle mass and new drivetrain technologies in statistics on registered vehicles and to include information on drivetrain and cohort year in ELV statistics.

PRINCIPLES	BOTTLENECK	RECOMMENDED ACTIONS	TOOLS
Adopt and enforce policies	Level of detail in primary data from authorised treatment facilities	• Amend the ELV Directive to include a requirement for reporting vehicle age and drivetrain type of treated ELV and Eurostat to publish	• Vehicle classification
Improve framework conditions	Composition data not available to policy-makers and recyclers	• Establish a working group with stakeholders in industry, goverment and academia to explore the use of industry data to improve policy-making	• Recycling-oriented digital information systems (to be developed)
Improve monitoring	No harmonised way of storing composition data	• Create a data repository for composition data on anthropogenic objects and materials.	• EU urban mine data models and code lists
Improve reporting	Data gaps on unknown whereabouts and waste flows; vehicle classification not representative of current technology	• Mandate improved reporting on the stock of vehicles and status of registrations, including an updated classification system for vehicles • Conduct EU country studies to assess ELV stocks, and improve information on unofficial flows • Imrove the quality of data through ensuring robust data verification procedures are carried out	• Updated vehicle classification • Country studies
Ensure funding	Lack of continuous financing for data collection	• Standardised reporting mechanism across MS	• Allocate annual funding to support battery statictics and research

Figure 32 *Analysis of challenges in reporting of ELV and suggested tools to improvement*

6.2.4 Mining waste (MIN)

EU Collection practices of deposit level MIN information have been applied in the scope of the Directive 2006/21/EC, but this has not yet been implemented in the core of INSPIRE directive. This is one of the ORAMA project recommendations.

The lack of information on deposit characteristics (composition, volumes, and suitable processing technology) is a huge barrier in the identification of recovery potential of the valuable materials, which remained in the waste. Furthermore, the lack of a single reporting standard commonly accepted at EU level created a dispersion of existing information in various systems and project deliverables.

The main general recommendations to improve the quality of MIN data are to combine and harmonise data collected in earlier projects into a single source, perform detailed research on reported interesting waste sites to obtain necessary information for valuation of recovery potential as well as to improve knowledge on certain topics (recycling technologies, permits for recovery) to cover the whole of Europe.

PRINCIPLES	BOTTLENECK	RECOMMENDED ACTIONS	TOOLS
Adopt and enforce policies	Lack of legislative tools for MIN resources valuation and recovery	• Establish legislative tools covering all aspects of MIN recovery • Develop official guidelines for valuation of MIN resources • Obligatory reporting of chemical composition of registered MIN	• Directive 2006/21/EC • Legally binding agreements on harmonised data format
Improve framework conditions	Multiple classifications and platforms with harmonised data	• Unite competent stakeholders into a single network • Establish a single classification for reporting to the EU • Establish a single harmonised framework for reporting to the EU	• SmartGround, ProSUM, ORAMA and UNFC for anthropogenic resources methodologies, practices • INSPIRE compliant protocols
Improve monitoring	No harmonised data on MIN flows, composition, recovery available	• Monitor all flow processes from extraction to final processing (identify MIN streams) • Monitor progress in existing MIN reporting systems • EU case studies on MIN recovery projects	• Elaborate the monitoring of MIN secondary resources, implement monitoring guidelines, surveys
Improve reporting	Data gaps concering MIN composition, flows, recovery at MS level	• Valuation of composition of reported MIN sites • Registration of existing MIN processing companies • Mapping of available technologies for MIN recovery • Creation of a single pan-European central repository for MIN data	• Implement characterisation studies, surveys, etc. • EU mineral intelligence network structure
Ensure funding	Lack of continuous financing for data collection	• Standardised reporting mechanism across MS • Research on SRM in MIN	• Allocate annual funding to support battery statictics and research

Figure 33 *Analysis of challenges in reporting of mining waste and suggested tools to improvement*

7 Concluding comments

7.1 Primary Raw Materials (PRM)

The continent of Europe contains more than 40 independent, sovereign countries that are heterogeneous due to their long and varied evolution. However, there are times when groups of countries need to work together towards common goals because more can be achieved in this way. The Raw Material Initiative was established in part to assist with collaboration between countries in order to improve the security of supply of materials to all European countries.

An important step towards improving the security of supply of materials is to know what is available within Europe, what materials are produced within its borders and what is imported or exported. Exploration is ultimately a means to improve the available knowledge of what materials are available within Europe. Data for resources and reserves are a quantification of past exploration, but it is important to remember they do not represent "all there is" within the continent. Additional exploration is still likely to find more deposits worth evaluating and this evaluation may lead to additional resources.

In order to move forward with harmonisation of reserve and resource data for PRM, to facilitate the creation of an adequate knowledge base for the formulation of policy decisions relating to raw materials, relevant EU public authorities need to come to an agreement about using a single system of reporting at European level.

Although there are several options for different systems of reporting, all with advantages and disadvantages regarding the compilation of statistics at a European level, the ORAMA project recommends the use of UNFC. This classification system seems best suited for the task as it is designed for national scale resource management, has several guidance documents and case studies linked to it bridging other systems of reporting to UNFC and has the flexibility to include a variety of different resource types. The ORAMA project has attempted to enable the use of UNFC by producing training materials and cases studies showing how it is already used in Europe.

It is not being suggested that countries abandon their already well-established systems of reporting, which serve national needs and may have requirements in national law, only that the use of UNFC or conversion to UNFC be considered for reporting at a European level to allow comparison and aggregation with other European data. Similarly, it is not suggested that UNFC can, or should, replace CRIRSCO compliant systems of reporting which serve a different purpose, principally aimed for protection of investors and the specific needs to the minerals industry. At the national level, all countries would be able to continue with other systems of reporting to suit their internal purposes. However, when figures are reported to a central point for EU level compilation (e.g., European Minerals Yearbook) and in order for them to be consistent and comparable they would need to be converted to a harmonised system such as UNFC.

The following infographic provides a summary of prioritised recommendation resulting from the inventory, data gap analysis and case study outcomes for PRMs.

	Short term – 1-3 years	Medium term – 3-5 years	Long term > 5 years
STAKEHOLDERS	Industry, Reporting Authorities, Policy Makers, Statistical Agencies, Custom Agencies, Academia	Industry, Reporting Authorities, Statistical Agencies, Customs Agencies, Policy Makers	Law Enforcements Agencies, Custom Agencies, Policy Makers
Adopt and enforce policies		The use of UNFC as a obligatory reporting system for national authorised bodies for reporting of resource data for collation at a European level	
	Encourage national level agencies to make legal provision for regular mineral production data collection		
	Continue to support the legal basis for collecting and reporting trade data		
	Continue to develop PRODCOM data in terms of disaggregation of commodity codes and increasing availability of data		
		Adopt a standard system of reporting for exploration data and for environmental and social data relating to minerals development at a national level within Europe including specified metrics	
		Encourage all countries to adopt policies at national level that include the regular collection of mineral resources data and the collection of mineral exploration data	
Improve framework conditions	Cooperation between national statistical agencies, national geological surveys, professional bodies, and European and international bodies such as the United Nations and Eurostat to share best practice		
	Development of relationships between data providers and the UNECE to improve UNFC		
		Establishment of a working group on data harmonisation at EU level	
Improve monitoring		National authorised bodies to develop raw materials knowledge to cover data gaps for undiscovered resources	
	Continue research into society's use of minerals and material flows		
	Improve understanding of trade data colection		
	Improve knowledge of value chains for 'critical minerals' to better understand flows of mineral by-products and co-products		
	Develop standard protocols for dealing with confidentiality issues		
		Revelant national bodies ensure exploration data and environmental and social data relating to minerals is collected and publically reported	
Improve reporting	Ensure definitions used in resource data adhere to definitions as defined by UNFC		
	Further disaggregate production and trade data to improve resolution and increase data provision by the Eurostat trade database		
	Develop commodity code lists, recommended by INSPIRE, to incorporate all stages of the primary minerals value chain		
	Aim to eliminate data gaps by encouraging all countries to report production data		
	Improve metadata, i.e. include description of the location of data points in a system context, uncertainty, metal contents, revisions etc.		
	Establish a system for regular reporting of exploration data and environmental and social data relating to minerals at an EU level		

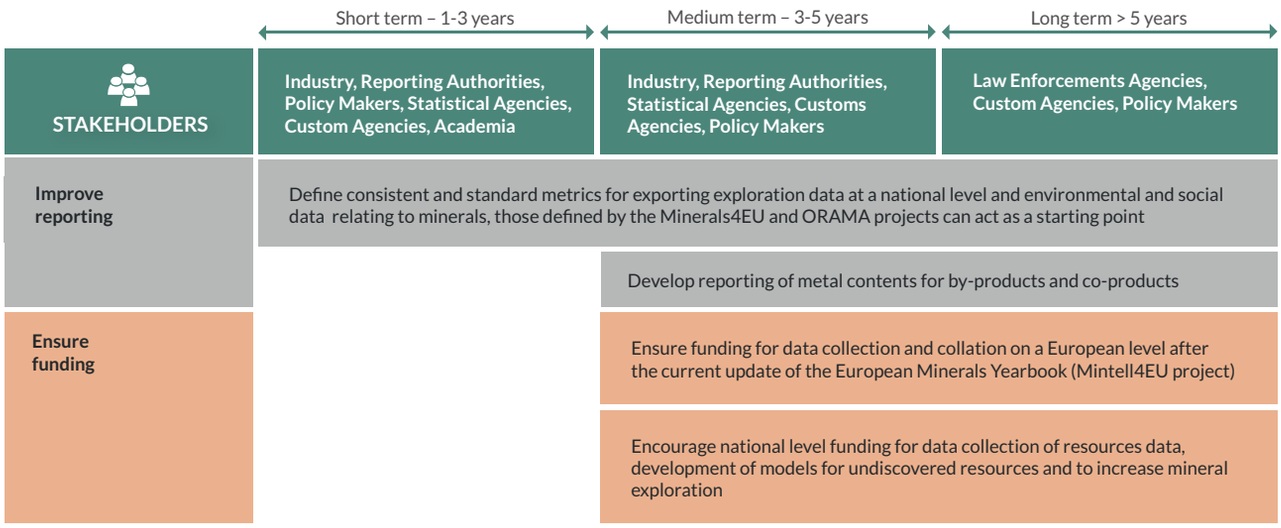


Figure 34 *Prioritised recommendations for PRM*

7.2 Secondary Raw Materials (SRM)

The inventory of data collection methods currently used in national registries across MS provided an overview on how reporting for product waste like batteries, ELV, (W) EEE/PV panels and MIN is being reported and collected and who the key data providers are.

Data on the amounts of EEE, PV panels, batteries and vehicles POM are generally available for the EU MS due to the reporting obligations. However, the data quality and completeness of this data need to be improved in order to be able to produce data for SRM in the EU.

The SRM content in WEEE is difficult to calculate with the currently available data sets, due to the fact that current collection data is reported (as averages) per collection category and not at a product level. This is a clear obstacle for quantifying material losses since, in many cases, valuable components from products are missing before being treated and thus not reported. The value of the output fractions (material, composition, flow) before and after the treatment of products cannot currently be determined due to this data gap. ProSUM highlighted the relevant impact of scavenging in WEEE data reported. Of course, more detailed reporting is costly, however, the economic relevance is equally high[1]. The unclear boundaries between various stages and actors within waste management systems make it difficult to monitor the full whereabouts of the WEEE streams.

In addition, complementary flows form a very relevant data gap, since it includes all waste flows that are not reported at national level under official compliance systems and potentially represent both a significant leakage as well as a source for recovery of SRM. By quantifying and reporting these flows, better material flow analysis and monitoring of circular economy and collection indicators can be made. This, in turn, supports identification of potential gains and losses and interventions where needed most. MS, in turn, can then develop measures to make stakeholders active in the non-reported flows become part of the legal system and to adhere to the treatment requirements as well as to avoid an uneven economic playing field.

PV panels are still an emerging product group and, consequently, an emerging waste stream. Comparisons of past forecasts for future quantities of waste PV panels show significant differences to initial data reported under the WEEE Directive; reported amounts have been seen to be significantly

1 *Magalini, F., et. al., 2018 WEEE Recycling Economics - The shortcomings of the current business model,* https://www.eera-recyclers.com/files/unu-eera-brochure-online-v5-002.pdf*, DOI 10.13140RG.2.2.24945.53608, 2018/1/31, Bonn, Germany*

lower than forecasted amounts. This emphasises the need to research the "disposal routes" of waste PV panels. Separate and, for SRM forecasts, applicable data is still barely available. In order to improve data, statistics (WEEE, energy, production and trade statistics) need to be amended. Further, industry associations already publish some helpful data and should be encouraged to extend their reports to cover other data types needed for SRM stock and flow modelling. Data on composition should be represented in a harmonised way by producers, researchers and treatment plants according to the systems developed in the ORAMA project. Treatment plants also play an important role concerning the determination of type and age of PV panels entering the waste stream. In order to collect harmonised data, a sampling protocol was developed by ORAMA.

Batteries represent a relevant product group for proposing harmonisation of reporting because of their high CRM content and their increasing market extension (this is especially at the case with lithium-based rechargeable batteries) and the increasing trend towards xEV. Varying compositions of Li-ion batteries coupled with extended user-profiles, diversification of applications and product lifetime extension will make reliable predictions of CRM (return) flows from batteries important in helping policymakers and industry actors making strategic decisions.

In comparison to other product categories, very large amounts of highly detailed data on vehicles are collected by MS authorities and the manufacturing industry. Every MS maintains a database with detailed information about every vehicle registered for use on public roads. To ensure compliance with various regulations (e.g. REACH - Registration, Evaluation, Authorisation and Restriction of Chemicals), vehicle manufacturers collect and store huge amounts of data on the composition of vehicle components. Despite the extensive collection of primary data, the availability of data to support the development of policies for recovering SRM remains relatively low, due, inter alia, to confidentiality issues (industry data is not open to the public) and the degree and method of aggregation in publicly available statistics such as those available from Eurostat. The ability to provide better information to the public can in part be explained by lack of harmonisation and limitations of the primary data collection (e.g. no performance-related information on xEV). Some suggestions for relatively low-effort improvements to data reporting, e.g. revision of the vehicle classification used by Eurostat, have been provided in this report. Still, the main challenge in the sector will be to find ways in which existing data and information systems can be used or transformed to support recycling-oriented policies and actions, both on a high level (rules and regulations) and for individual actors (e.g. dismantlers). Considering the possible synergies with reporting for compliance reasons, the potential for improvement is huge.

Data on MIN sites, which are interesting for recovery, became more prevalent in recent years owing to various national and international projects or networks aimed at identification, sharing and reporting of existing MIN information at EU level. However, the existing information is still fragmented, reported national information exists in different formats due to the use of different unofficial MIN classification templates and most importantly the quality of data reported is not sufficient for estimation of recovery potential. The latter is a consequence of the fact that most interesting sites have not yet been characterised in detail. Rather the existing information for the sites was gathered at national level from mine archives, scientific/ expert studies, etc. Therefore, mostly only basic information (site location, commodity, time of deposition, environmental impact) exists, while volumes, composition and potential processing techniques remain unknown. Site investigations are key to obtaining the lacking information and improving the quality of reported data, while existing sources of reported information should unite under a single network and system for classifying, collecting and reporting of MIN information.

The following infographic provides a summary of prioritised recommendations resulting from the inventory, data gap analysis and case study outcomes for SRMs.

	Short term – 1-3 years	Medium term – 3-5 years	Long term > 5 years
STAKEHOLDERS	**Producers, Recyclers, Law Enforcements Agencies, Policy Makers, European Commission**	**Producers, recyclers, Policy Makers, Law Enforcements Agencies, European Commission, Data providers**	**Law Enforcements Agencies, European Commission**
Adopt and enforce policies	Amend definitions decision in Directive 2005/369/EC for WEEE, 2006/66/EC for Batteries and ELV Directive to include reporting of vehicle age and drivetrain details to be published in Eurostat		
	Require separate reporting of PV panels as sub-category of EEE category 4 "Large Appliances" under WEEE-Directive		
		Adopt legal requirements for reporting at higher level of detail SRM recovered during the waste management supply chain (i.e. composition of products)	
		Include differentiation by PV technology type in energy statistics on annually newly installed capacities per MS	
		Revise WEEE-Directive collection target and its calculation with view to influence of long life time of PV panels	
		Encourage all countries to adopt policies at national level that include the regular collection of mineral resources data and the collection of mineral exploration data	
	Enforce compliance with legally binding treatment standards and third party audits		
Improve framework conditions	Establish a working group with stakeholders in industry, government and academia to explore the use of data (lifetime of products, composition, time series etc.) and improve policy-making		
	Work towards closer cooperation between battery & WEEE compliance schemes		
	Set up an independently monitored scavenging data platform and observatory		
	Data providers, interesting deposit owners and research organisations to establish MIN characterisation projects		
	Data providers and data collectors under the supervision of the European Commission agree on a single system for MIN classification, harmonisation, collection and reporting managed preferably under single organisation		
	Merge knowledge from Minerals4EU/ProSUM, SmartGround and COST MINEA-UNECE MIN classification, harmonisation, collection and reporting frameworks		
	Enforce compliance with legally binding treatment standards and third party audits		
Improve monitoring	Monitoring treatment facilities using certified standards		
	Contact producer and recycling associations in order to request data suited for UMP		
	Conduct households surveys to monitor WEEE and battery stocks and country studies to assess unaccounted waste flows		
	Conduct periodic sampling exercises measuring composition of (W) EEE and battery types, including CRM content		
	Monitor the imports and exports of used EEE and WEEE		
	Conduct country studies to assess flows and recovery rates for all waste groups		
	Monitor the reuse of PV panels in other MS and determine the influence on WEEE collection target		

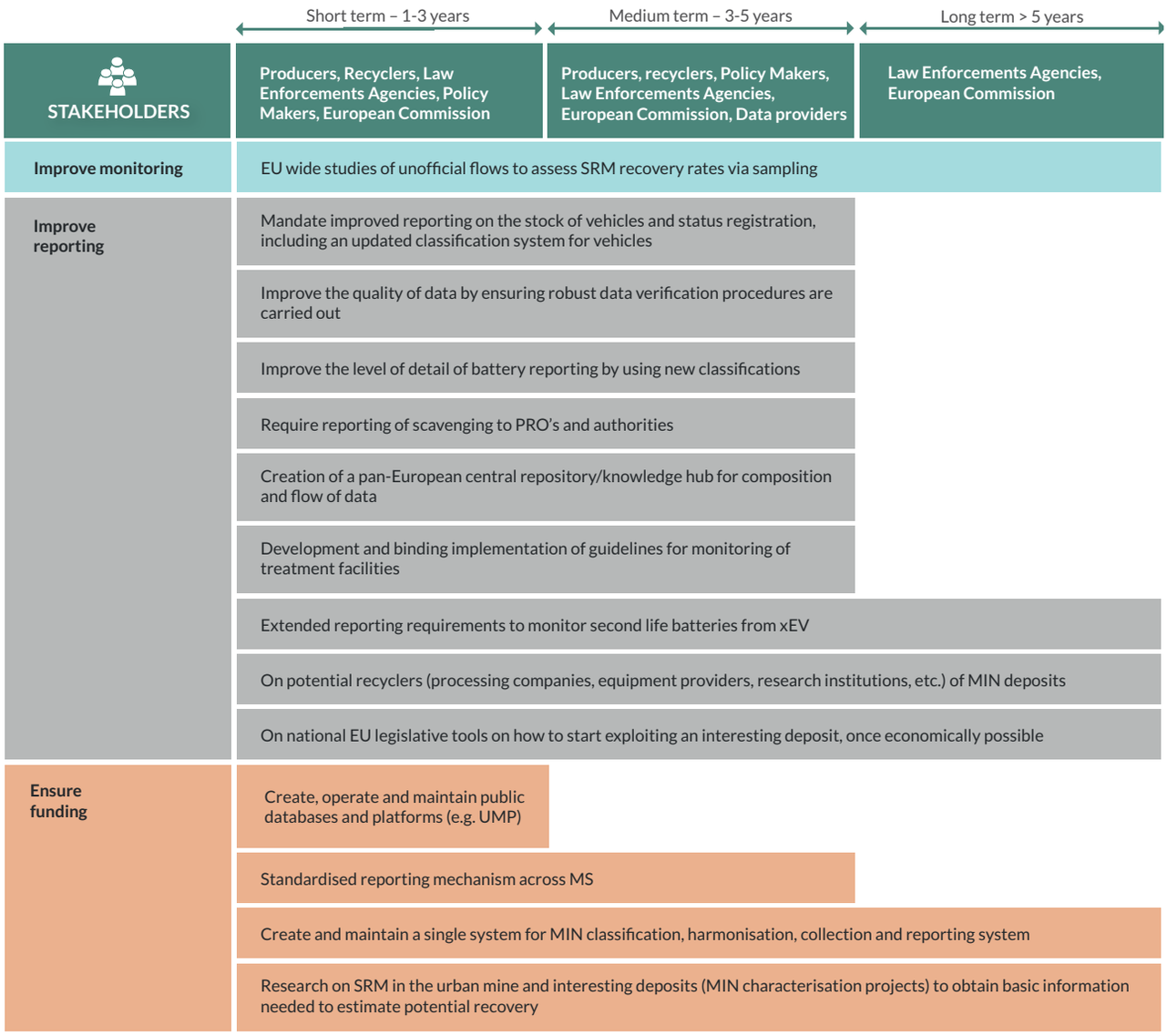


Figure 35 *Prioritised recommendations for SRM from WEEE, PV panels, batteries, ELV and MIN*

8 About us

8.1 The ORAMA consortium

Figure 36 *Members of the ORAMA Project Consortium in Ispra, Italy*

BGS – British Geological Survey

The British Geological Survey (BGS) is responsible for advising the United Kingdom government on all aspects of the geosciences, as well as providing impartial geological advice to industry, academia and the public. It is the UK's premier provider of objective and authoritative geoscientific data, information and knowledge for sustainable use of natural resources. BGS is also a world leader in the compilation of mineral statistical information and analysis, with one of the largest databases in the world on the production and trade of minerals. It is the custodian of a historical dataset containing mineral production and trade data, by commodity and country, from 1913 to present. It also publishes a highly-respected Mineral Profile series includes detailed reviews and analysis of the market dynamics and end-uses for number of raw materials and these are available on our dedicated minerals web portal (www.mineralsUK.com). BGS published a risk index, which provides an indication of the relative risk to supply of chemical elements we need to maintain our economy and lifestyle.

Contact: tode@bgs.ac.uk
Website: http://www.bgs.ac.uk/

BRGM - Bureau de Recherches Géologiques et Minières

BRGM, the French Geological Survey, is a French Public Institution responsible for mobilising the Earth Sciences in the sustainable management of geo-resources and the subsurface domain. BRGM's research and development programs, financed by the Ministry of Research, support innovation and work towards advancing the Earth Sciences in strategic areas, both on a national and international scale. BRGM is involved in a high standard of research activities under the supervision of the Research Division, which ensures the quality of the undergoing research projects. BRGM activity covers the whole spectrum of the management of mineral resources, from fundamental research (e.g. ore-forming processes, metallogenic syntheses, predictive mapping, etc.), including exploration, expertise, development of geological and mining data infrastructures, management of after mine problems, to

raw material economy. In the same way, BRGM has international expertise in information systems, being part of leading European drafting teams and working group of the INSPIRE directive. At national level, it is in charge of the development and hosting of the National Environment Portal and of the National Geo-catalog (national catalogue for INSPIRE), and of the "National Portal about Environment". Promoting interoperability in geosciences and environmental information, BRGM is contributing to OGC development and to GeoSciML and ERML (through IUGS/CGI).

Contacts: d.cassard@brgm.fr ; u.clain@brgm.fr
Website: http://www.brgm.eu

Chalmers University of Technology

Chalmers University of Technology focuses on research and education in technology, natural science, architecture, maritime and other management areas. The Division of Environmental Systems Analysis conducts research to find more sustainable technology solutions to better meet environmental and resource constraints faced. Among other, technology assessments in the fields of vehicles, materials and end-of-life management are carried out, often in collaboration with industry. Examples of recent research topics are circular economy measures for manufacturing industries, policy for recycling of scarce metals in vehicles and life cycle environmental impacts of electrified vehicle components.

Contact: info.tme@chalmers.se
Website: http://www.chalmers.se

Empa – Swiss Federal Laboratories for Materials Science and Technology

Empa is the interdisciplinary research and services institution for material sciences and technology development of the ETH Domain. Empa's R&D activities are oriented to meeting the requirements of industry and the needs of society, and link applications-oriented research with the practical implementation of new ideas. Safety, reliability and sustainability of materials and systems form a common thread running through all Empa activities. The priorities of Empa's research are structured in five Research Focus Areas with the following topics: Nanostructured Materials, Sustainable Built Environment, Health and Performance, Natural Resources and Pollutants, and Energy. Empa's Technology and Society Laboratory (TSL) aims at creating and transferring knowledge for the transition to a more sustainable society, with a focus on the analysis and evaluation of material and energy stock and flows associated with novel materials and emerging technology applications.

Contact: portal@empa.ch
Website: https://www.empa.ch/

IGME - Instituto Geológico y Minero de España

Instituto Geológico y Minero de España (Geological Survey of Spain. IGME). Founded in 1849. It is a Public Research Organisation and an autonomous institution attached to the Ministry of Economy, Industry and Competitiveness. It is the main Earth Sciences Research Centre of Spain, with a total of 350 employees, 185 graduated. Specialised in various fields of activity such as geology, environment, hydrogeology, mineral resources, natural hazards and land use planning. IGME facilities, including its headquarters, project offices in several places around the country, laboratories, warehouses, drill core repository, library and museum, are equipped with advanced technology and technical resources.

IGME is the national centre for the creation of knowledge infrastructure, information and R&D in Earth Sciences.

Contact: p.delgado@igme.es
Website: http://www.igme.es/

GSI – Geological Survey of Ireland

Geological Survey of Ireland, founded in 1845, is the National Earth Science Agency. It is responsible for providing geological advice and information, and for the acquisition of data for this purpose. GSI produces a range of products including maps, reports and databases and acts as a knowledge centre and project partner in all aspects of Irish geology.

Contact: eoin.mcgrath@gsi.ie
Website: https://www.gsi.ie/en-ie/

GeoZS - Geological Survey of Slovenia

The Geological Survey of Slovenia (GeoZS) is a public research institute (90 employees) established by the Government of the Republic of Slovenia. Scientists, researchers, technicians and project managers, among them 64% with high education, contribute to production of geological maps, assessment of natural and anthropogenic geological hazards to living environments, expertise in fields of groundwater, mineral resources, geothermal energy resources and natural geological heritage. All activities are supported by Geological information Centre, responsible for the collection, processing, storage and dissemination of geological data within the framework of a single information system.

Contact: info@geo-zs.si
Website: http://www.geo-zs.si

GEUS

GEUS has worked intensively with the development and operation of databases and exchange-formats for geological, geophysical and mineral resources data for more than 25 years. GEUS runs nation-wide databases for boreholes, geochemistry, geophysics, geological samples, digital reports, digital maps and geological models integrated with a large number of web-services for query and update of these data used on-line by local and regional administrations throughout Denmark. GEUS has the long-term responsibility of collecting basic geoscientific information about natural resources in Greenland and Denmark, as well as the experience in resource assessments and evaluation.

Contact: geus@geus.dk
Website: http://www.geus.dk

GTK – Geological Survey of Finland

Geological Survey of Finland (GTK) is a national geological research centre operating under the Ministry of Employment and Economy. GTK is an internationally known and recognized expert organisation in applied earth sciences. The geological earth resources of strategic and economic importance are in the

core of GTK's research mission and GTK has long history and extensive knowledge in all areas of data management from definition of database structures to building services based on these databases. As a result of this work Finland constantly ranks in top positions in Fraser Institute's annual surveys to mining companies with respect to quality and coverage of available data.

GTK contributes to a wide range of international geosciences, mapping, mineral resources and environmental monitoring projects as well as projects concerning eco-efficient mining and mineral processing. International references of GTK cover a wide spectrum of undertakings in about 40 countries on all continents. GTK is active in the European Innovation Partnership on Raw Materials and one of the core partners in EIT Knowledge and Innovation Community Raw MatTERS. The total staff of GTK is about 435, annual turnover totals about 44 million €, of which 8 million € is invoicing.

Contact: gtk@gtk.fi
Website: www.gtk.fi

JRC - Joint Research Centre - European Commission

The Joint Research Centre (JRC) is the European Commission's in-house science service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy. The mission of JRC Directorate D "Sustainable Resource" is to provide independent scientific evidence to support the development, implementation, evaluation and coherence of EU policies, mainly in the areas of agriculture and rural development, development cooperation, environment and climate change, blue growth and fisheries, the bio-economy, industry and trade and raw materials.

The goal of the Land Resources Unit (JRC.D.3) is to provide scientific knowledge to balance competing for land-use demands whilst securing access to natural resources and maintaining ecosystem services. In particular, the Unit is developing the Raw Materials Information System (RMIS) and gives particular attention in its activity to resource scarcity, resource conflicts and to the sustainable management of resources such as (critical) raw materials.

Contact: simone.manfredi@ec.europa.eu
Website: https://ec.europa.eu/info/departments/joint-research-centre_en

MBFSZ - Mining and Geological Survey of Hungary

The Mining and Geological Survey of Hungary is a public research institute and responsible to advance geoscientific knowledge of Hungary's landmass by systematic acquisition, interpretation, management and dissemination of geoscientific data including data on mineral resources and INSPIRE compliant data service. The strong co-operation with the supervisor government body the Hungarian Office for Mining and Geology ensures the appropriate data harmonisation and data service for mineral resources. Beside classical tasks of a geological survey MFGI is dealing with the modernization of mineral resource inventory based on internationally recognized reporting standards (CRIRSCO/PERC) and United Nations classification framework (UNFC-2009) and the improvement of the INSPIRE compliant data service environment for primary (e.g. aggregates, ores and energy resources) and secondary resources (mining waste). Based on many mineral resources related to EU-funded projects MFGI has relevant experience to organise stakeholder consultations and to build network of experts and stakeholders and to prepare guidance and training materials.

Contact: horvath.zoltan@mbfsz.gov.hu
Website: https://mbfsz.gov.hu/en

NGU - Geological Survey of Norway

Geological Survey of Norway, founded in 1858, is a government agency under the Ministry of Trade, Industry and Fisheries (NFD). NGU shall actively contribute to ensuring that geoscientific knowledge is utilised for the effective and sustainable management of the nation's natural resources and environment. NGU provide services and information within a large range of subjects within geoscience, such as mineral resources (metals, industrial minerals, natural stone and aggregate), geological hazards, environmental issues, marine geology, regional geophysics and land use planning. NGU provides databases on mineral and aggregate resources to Norway's national information infrastructure and to the European mineral resource data platforms. NGU has 200 employees, of which approximately 65% are scientists.

NGU operates the national databases for mineral resources and aggregate, among the most comprehensive ones in Europe. NGU has a mandate from the Norwegian Government to establish criteria for public importance of mineral deposits in Norway and the assessment of such, and also works in developing tools for improved visualization of mineral resources and the potential in land use planning. Other relevant tasks include region-wise assessment of construction aggregate resources and material flows as decision-aiding tools for sustainable planning. http://www.tu-berlin.de/

Contact: henrik.schiellerup@ngu.no
Website: https://www.ngu.no/en

TUB - Technische Universität Berlin

The Technische Universität Berlin (TUB) is a public research and education institution with 30,000 students, 6,000 academic staff members and 300 professors. Research activities under the Chair of Circular Economy and Recycling Technologies (CERT) include the transition of waste management towards a circular economy for selected product systems. Recycling-oriented characterisation methodologies have been developed and adapted to the need of new recycling systems in particular for strategic raw materials for example for WEEE and waste batteries. Within the ORAMA project CERT dealt with data and data collection methods for metal scrap (only D 2.2) and PV panels. The Research Centre "Forschungsschwerpunkt Technologien der Mikroperipherik" (TMP) at the Technische Universität Berlin was responsible for the collection and consolidation of the data on batteries and brought expertise on technologies established and in development.

TUB CERT
Contact: vera.rotter@tu-berlin.de; kristine.sperlich@campus.tu-berlin.de
Website: http://www.circulareconomy.tu-berlin.de

TUB TMP
Contact: Johanna.emmerich@tu-berlin.de
Website: https://www.tmp.tu-berlin.de

UNU - United Nations University

UNU is an autonomous organ of the UN General Assembly dedicated to generating and transferring knowledge and strengthening capacities relevant to global issues of human security, development, and welfare. The University operates through a worldwide network of research and training centres and programmes. The Bonn (Germany) based Sustainable Cycles (SCYCLE) Programme hosted by UNU's Vice Rectorate in Europe is providing world-class research and action on e-waste. SCYCLE aims to enable societies to reduce the environmental burden caused by the production, consumption and disposal of ubiquitous goods. SCYCLE is leading in global quantification and qualification of e-waste flows, authoring the2014 and 2016 Global E-waste Monitors, with more detailed e-waste generated/ arising analyses carried out in individual EU MS, such as e.g. the Netherlands, Belgium, France, Italy, Romania, Ireland and the Czech Republic.

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Website: http://www.unu.edu

WEEE Forum

The WEEE Forum, set up in 2002, is a Brussels-based international not-for-profit association speaking for 36 not-for-profit electrical and electronic equipment waste (WEEE) producer compliance schemes – alternatively referred to as 'producer responsibility organisations' (PRO). The 36 PROs are based in Europe, Australasia and North America: Australia, Austria, Belgium, Bosnia, Canada, Czechia, Cyprus, Denmark, Estonia, Italy, Greece, France, Iceland, Ireland, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom. It is the biggest organisation of its kind in the world. In 2016, its member organisations reported collection and proper de-pollution and recycling of 2,100,000 tonnes of WEEE. Members in 2017: Amb3E, ΑΝΑΚΥΚΛΩΣΗ ΣΥΣΚΕΥΩΝ, ASEKOL, Australia New Zealand Recycling Platform, Ecodom, Eco-systèmes, Ecotic, ECOTIC, Ecotrel, EES-Ringlus, EGIO, Electrocyclosis Cyprus, ElektroEko, Elektrowin, El-Kretsen, elretur, Environ, EPRA, Fotokiklosi, Norsirk, Recipo, Recupel, Remedia, RENAS, Repic, Retela, RoRec, SENS e-Recycling, SWICO, UFH, Úrvinnslusjóður, Wecycle, WEEE Ireland, WEEE Malta, WEEE Recycle and Zeos. See also 15 Years on brochure.

Contact: info@weee-forum.org.
Website: www.weee-forum.org

8.2 The Advisory Board

The project consortium was supported by an external Advisory Board made up of experts in their sectors who helped us to steer the project direction. We would like to express our most sincere gratitude to:

- PERC, Pan-European Reserves & Resources Reporting Committee
  The organisation responsible for setting standards for public reporting of exploration results, mineral resources, and mineral reserves by companies listed on markets in Europe
- NTNU, Norwegian University of Science and Technology
  Expert in secondary raw materials sector and MSA related to it
- Tukes, Finnish Safety and Chemical Agency
  Responsible for exploration and mining licencing plus related data transfer from private sector to public databases in Finland
- Eurostat
  Responsible for the collection and processing of data in order to publish official EU-wide statistics, to be used by policymakers and by scientists. Also responsible for work of further development of European statistics
- UNECE EGRC, The United Nations Economic Commission for Europe, Expert Group on Resource Classification
  Responsible for the promotion and further development of the United Nations Framework Classification for Resources
- EGS, EuroGeosurveys
  As the umbrella organisation of European geosurveys representing important stakeholder group related to resources and reserves of primary raw materials.

9 Appendix

9.1 List of key Deliverables

Deliverables are available at: https://orama-h2020.eu/downloads/

NUMBER	DELIVERABLE NAME	WP NUMBER	LEAD PARTICIPANT
D1.2	Final report on the analysis of data collection methods and implementation of the recommendations for improvments to the relevant data sets.	WP1	BGS & MB FSZ
D1.3	Report on the datasets available telating to social and environmental dimensions of extraction	WP1	BGS & JRC
D1.5.1	Technical Guidance Note: United nations Framework Classification (UNFC)	WP1	BGS
D1.5.2	Technical Guidance Note: Bridging document between CRIRSCO and United Nations Framework Classification	WP1	BGS
D1.5.3	Technical Guidance Note: Decision flow tools for classifying resource data according to the United Nations Framework Classification (UNFC)	WP1	BGS
D1.5.4	Technical Guidance Note: Practical Exercises in Reporting Resource and Reserve Data according to the United Nations Framework Classification (UNFC)	WP1	BGS
D1.5.5	Technical Guidance Note: Worked example for conversion of UK polyhalite resource data to UNFC D	WP1	BGS
D1.5.6	Technical Guidance Note: Worked example for conversion of Spanish copper resource data to UNFC	WP1	IGME & BGS
D1.5.7	Technical guidance note: Raw materials import reliance and associated data uncertainties	WP1	BGS
D1.5.8	Technical guidance note: The challenges of assessing European critical metal resources: Insights from data availability and quality in the UK	WP1	BGS
D1.5.9	A minerals inventory for the UK using the United Nations Framework Classification system for 2018	WP1	BGS
D1.5.10	Technical guidance note: Country summaries for national legal and regulatory frameworks for resource and reserve data	WP1	BGS
D2.2	Final report on the analysis of data collection methods and implementation of prioritised recommendations for improving SRM datasets.	WP2	JRC, UNU & GeoZS

NUMBER	DELIVERABLE NAME	WP NUMBER	LEAD PARTICIPANT
D2.3	Draft Good Practice guidelines for the collection of SRM data, improvement potential, definition and execution of case studies.	WP2	UNU & GeoZS
D3.1	INSPIRE compliance of improved dataset	WP3	BRGM
D3.2	Serving aggregated data	WP3	GeoZS
D3.3	Producing flows & Sankey diagrams	WP3	CML
D3.4	Serving environmental & social spatial data	WP3	BRGM
D3.5	Navigating environmental & social knowledge	WP3	BRGM
D4.1	Technical guidelines	WP4	GEUS
D4.2	Training material	WP4	GEUS
D4.3	Report on feedback and other outcome of training sessions	WP4	GEUS
D5.1	Mapping of relevant EU funded projects and initiatives	WP5	WEEE-Forum
D5.2	Analysis of the mapping of EU funded projects, initiatives and identification of synergies	WP5	JRC
D5.3	Organisation of clustering activities	WP5	GEUS
D5.4	Final report of Mapping of relevant EU funded projects and initiatives, analysis and organisation of clustering activities	WP5	GEUS
D6.4	Information roadmap for potential investors	WP6	GTK
D6.5	Exploitation plan	WP6	MGFI
D6.6	Final Technical and Recommendation report	WP6	UNU

PROJECT COORDINATOR:

GTK

ORAMA PROJECT PARTNERS:

brgm – Géosciences pour une Terre durable

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Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
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Empa
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GeoZS

GEUS

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European Commission

MBFSZ
MINING AND GEOLOGICAL SURVEY OF HUNGARY

BGS 1835

GEOLOGICAL SURVEY OF NORWAY
- NGU -

Technische Universität Berlin

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