Deliverable D5.2

Development and application of the RMI-MATRIX

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Notice

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ACRONYMS AND ABBREVIATIONS

CE	Circular Economy
CEC	Circular economy concept
CRM	Critical raw material
DGD	Digital geological database
DMC	Domestic material consumption
EoL	End of life
EW-MFA	Economy-wide material flow accounts
GDP	Gross domestic production
GHG	Greenhouse gases
GIS	Geographic information system
LCA	Life cycle analysis
LUP	Land-use planning
MC	Mineral consumption
MCA	Mineral consumption analysis
MDoPI	Mineral deposit of public importance
MFA	Material flow analysis
MIA	Mineral inventory analyses
MP	Mineral policy
MPF	Mineral policy framework
MPP	Mineral planning policy
MS	Member State
MSs	Member States
MSS	Minerals supply security
Mt	Million metric tonnes
NE	National economy
NEEI	Non-energy extractive industry
RMD	Raw Materials Diplomacy
RMI	Raw Material Intelligence
RMI-M	RMI-MATRIX
SFA	Substance flow analysis

PURPOSE

Deliverable 5.1 *Report on the RMI tools and methods* (Falck *et al.* 2017) mapped key functions of RMI and their relevance for minerals policy development in particular future capacities needed at different levels – for industry, EU member states, regions, the EU and the role of the EU in international relations. Key aspects of mineral policies included: (a) clear definition of scope (primary, secondary, etc. minerals); (b) commitment to provide an appropriate materials regulatory and knowledge framework; (c) harmonisation between sectoral policies bearing on sustainable resource management; (d) appropriate supply and demand scenarios, including the feedback from corresponding (mineral) policies (cf. WP4); (e) SWOT (strengths, weaknesses, opportunities, threats) analyses of policy and regulatory options and their critical paths; (f) monitoring the effectiveness and impact of regulations and policies; (g) monitoring the status of mineral deposits of public importance.

Ideally, any minerals policy framework should consider equally primary and secondary materials when framing the objectives/actions. The scope and content of RMI is a function of stakeholder needs of existing long-term scenarios with relevance to RMI (see WP2, Erdmann *et al.* 2016, 2017). The mapping of D5.1 differentiated between operative tools (e.g. descriptive statistics) and strategic, long-term planning tools (e.g. scenario development and analysis). To develop a coherent and comprehensive minerals policy-making framework, the right tools, methods and RMI context are needed. While D5.1 assessed the different factors for the matrix, the actual RMI-matrix is subject of D5.2.

The minimum set of tools/methods needed to develop a coherent and comprehensive mineral policy-making framework providing a fast response are investigated in this deliverable (D5.2). The purpose of is to develop a RMI-MATRIX that allows the identification of strong, medium and worst cases for RMI development. The RMI status quo in Europe and how it influences the current mineral policy development will be analysed in D5.6 *Report on RMI implementation status quo and needs in EU-28*. The RMI-MATRIX for EU countries will be screened for the capacities, methods and tools employed (cf. WP4). Methods for correlating and transposing information from country reports will be developed for each EU member state.

EXECUTIVE SUMMARY

An intelligent management of the primary and secondary raw materials available within the territory of a country requires medium and long-term planning. Planning requires the collection and processing of data (WP3) (see Petavratzi *et al.* 2016, 2017) which translates into information and knowledge via tools and methods (WP4) (see Bide *et al.* 2017) according to the needs of stakeholders (WP2) (see Erdmann *et al.* 2016, 2017), inclusive of policy-makers. One key parameter underpinning raw materials intelligence (RMI) is mineral consumption analysis (MCA) that could be provided by one of its methods, e.g. minerals demand forecasting or material flow

analyses (MFA)[1]. Mineral consumption is related to the level of development of a country and allows the creation of forecasts of future minerals demand linked to proxy variables such as gross domestic product (GDP) or expected population growth. The mineral consumption analysis is the basis of any RMI approach; without mineral consumption (MC) forecast/foresight no detailed (future) demand/supply scenarios and thus no realistic mineral policies can be developed.

Another key issue is that a minerals policy is a cross-cutting topic with many links to other branches of politics (sectoral policies). Establishing a coherent minerals policy requires comprehensive and effective coordination and harmonisation between the mineral policy and other (related) policies. An isolated view of sectoral policies and a lack of coordination/ optimisation of policies (e.g. EU's separate energy and non-energy mineral policies) are counterproductive and will not result in a cost-effective contribution to the GDP of a state. The lack of sufficient MCA and the insufficient optimisation in the mineral policy design are underlying reasons for the screening and assessment of the current EU-28 policies.

With that aim an RMI-MATRIX was developed in this deliverable that allows the identification of strong, medium and weak mineral policies scenario for RMI development. For that, first, an 'ideal' RMI-MATRIX was developed containing a complete and comprehensive number of tools and methods which could be used to understand future demand and potential to optimise the portfolio of available resources within the territory of a country and guide policy-making activities.

The difference between different scenarios lies predominantly on whether mineral demand forecasts and other elements are implemented to guide policy-making:

- **Strong scenario**: an analysis is done of mineral demand forecasts via MCA/MFA, mineral inventory analysis, safeguarding of access to mineral resources via land-use planning, promoting the circular economy).
- **Medium scenario**: a MCA/MFA is implemented but without MC forecast (mid-term/long-term).
- **Weak scenario**: contains no MCA/MFA, no MC forecast. Any policy discussion is unrealistic. There is no realistic opinion possible on how the minerals development of a national economy has been and could be in the future.

These three scenarios will be used to screen the EU-28 mineral policies in D5.6.

[1] Material Flow Analysis is understood as a "systematic assessment of the flows and stocks of materials within a system defined in space and time" (Brunner and Rechberger 2004). In this sense is one of the methods how the Mineral Consumption Analysis (MCA) could be provided for the specific country in specific time (historical/future).

1. Introduction

The ultimate purpose of raw material intelligence (RMI) is to inform (mineral) policy makers at the various levels of government (see Erdmann *et al.* 2016, pp. 61-72) about MC trends, demand/supply scenarios, etc. An example could be the case of lithium exploration project in Czech Republic which could help to increase the demand for lithium-ion batteries for electric vehicles (The Financial Times (2017)). In order to be efficient and effective, both RMI and minerals (and related) policies have to be coordinated with each other. Thus, in this deliverable a multi-dimensional RMI-MATRIX (RMI-M) is developed in order to better understand interdependencies and cross-linkages. The RMI-M provides a simple guide for fast checking of the state of art of the mineral policy status in the Member States, identifying gaps and consequently allowing the determination of objectives and a strategy for improvement.

The main dimensions identified include *inter alia*:

- minerals policy framework and its governing principles at national, European, and global level;
- stakeholder needs and expectations;
- methods and strategies to predict future development in use, demand, and supply of minerals.

The investigation on the minimum set of tools/methods that are needed for a coherent and comprehensive mineral policy-making framework development has been provided in D4.1 *Fact sheets of methods* (Bide *et al.* 2017) (WP4) and D5.1 *Report on the RMI tools and methods* (Falck *et al.* 2017) (WP5). The methods have been divided into four categories. The D4.1 is containing the methodological fact sheets of 1) Methods to identify and assess geological and anthropogenic (urban) stocks; 2) Methods to assess society's metabolism and its environmental impacts and 3) Methods to assess the economic aspects of the use of resources. The last category: 4) Methods to estimate or assess the future use of resources, is the subject of D5.1. The RMI-M compiles and orders such RMI tools/methods to then discuss, develop and evaluate the mineral policy status at global/national/regional/local scale in D5.6 *Report on RMI implementation status quo and needs in European Member States*.

The following chapters provide the understanding of the RMI-M concept and the identification of strong, medium and weak cases for RMI development. First, an ideal RMI-M (policy) case scenario is presented. Secondly, based on the ideal scenario, the strong, medium and weak cases for RMI-M scenarios are derived and discussed.

This deliverable highlights the importance of **mineral consumption analysis (MCA),** given that <u>no policy scenario(s)/trends/strategies at all can be discussed and developed without such kind of analysis</u> (this statement has been discussed in D5.1, chapter 4). Therefore, the information about MC has to be included in the *ideal RMI-M* policy case scenario and the lack of MC consideration in mineral policy development can be related to the worst case for RMI. The RMI-M needs to reflect the internal and external aspects of mineral policy framework (MPF) (see the Chapter 3) that has already been communicated in the 3 pillars of the Raw Materials Initiative[2].

1.1 Methodology

This report complements D5.1 as it is using the knowledge obtained and the information collected in previous tasks. The overall starting point of the RMI-M is the MC discussion available in D5.1 (Falck *et al.* 2017, pp. 49-63).

The RMI-M concept is built on a two-dimensional framework that is based on the mineral policy (vs mining policy) paradigm (discussion on Scoping the RMI in D5.1; Falck *et al.* 2017, pp.17-19).

The **first dimension** is the interdisciplinary approach represented by different sectors and its relevant aspects as no mineral policy can be designed separately from other policies, e.g. economic, fiscal, environmental, land-use, etc. The whole supply chain was taken into account from exploration through extraction, processing and refining to product design, waste management and recycling in accordance with the circular economy concept (European Commission 2015), one of the strategic issues identified in WP2 (Erdmann *et al.* 2017). The cross-cutting mineral policy topic requires knowledge about trade and economy issues, environmental and development strategies and corresponds to demand for minerals. Thus, all these aspects were taken into account as well. Additionally, the social aspects are included.

The **second dimension** is based on the key features that should be monitored when screening the mineral policy-relevant aspects. These features are:

- Data (cf. D3.1 and D3.2, Petavratzi *et al.* 2016, 2017)
- Tools and Methods (RMI) (cf. D4.1, Bide *et al.* 2017; D5.1, Falck *et al.* 2017)
- Policies
- Stakeholders (cf. D2.1, D2.2, Erdmann *et al.* 2016, 2017)

The ideal RMI-M policy case scenario will be presented on the iron supply chain example. Consequently, the identification of strong, medium and weak cases is derived from that example.

1.2 Report Structure

Chapter 1 introduces this deliverable. *Chapter 2* discusses the relationship between RMI versus RMI-M. *Chapter 3* discusses the ideal RMI-M policy case scenario. *Chapter 4* discusses strong/medium/weak RMI-M policy case scenarios. *Chapter 5* includes the RMI-M for MICA's future D5.6. The (simplified) RMI-M for the MICA project is also discussed and the screening of the EU-28 mineral policies in D5.6 will be provided based on the RMI-M. *Chapter 6* concludes. *Chapter 7* lists references. Annex 1 includes minerals to be considered in MFA, as of regulation No 691/2011.

[2] https://ec.europa.eu/growth/sectors/raw-materials/policy-strategy_en

2. RMI versus RMI-MATRIX

Deliverable 5.1 has prepared a strong basis for the development of D5.2. It means that both reports are complementary to each other and should be considered that way. While D5.1 is offering a detailed and deep analysis of RMI Tools and Methods, including scope definition, the Circular Economy paradigm, resource efficiency scenarios, models for the development of a mineral policy framework, foresight tools and systemic minerals policy effect assessment, D5.2 is *compiling* this information for the elaboration of a Raw Materials Intelligence Matrix (RMI-M). The RMI-M provides the overview of all relevant aspects and their key features interrelated to the raw materials sector which are, thus, crucial to be considered for an ideal mineral policy framework (MPF) development.

2.1 Short summary of Deliverable 5.1

The ultimate purpose of RMI is to inform policy making at the various levels of government. In order to be efficient and effective, both RMI and minerals policies have to be tailored to each other. The main purpose of D5.1 was therefore to assess to what extent actual RMI is and has been used in the formulation of minerals policies and which methods and tools can be used.

2.2 Raw Materials Intelligence Matrix

Raw Material Intelligence Matrix is compiling the respective RMI tools of the MPF according to the concept visualized in Figure 1. Generally, the minerals policy development is consisting of several steps/phases (discussed in Falck *et al.* 2017):

1 MAIN OBJECTIVE
- Sub-objectives/strategic objectives

2 MAIN STRATEGY
- Sub-strategies - In line with objectives

3 CONCEPTION + ACTION PLAN
- Implement objectives + strategies (Actions - In line with objectives and strategies)

4 MONITORING PLAN
- Monitoring/assessment of policy implementation
- Review with respect to1+2

5 POLICY ADAPTION/REVISION
- Correction/revision of 1,2,3

The RMI-M aims to identify where the gaps of the current mineral policy status are and where the potential for improvement is. It can also serve for a fast SWOT analysis of RMI in selected member states. Such screening is able to guide the determination of the main objectives and the strategy which is leading to a proper action and monitoring plan. Finally, it is resulting in the successful policy adaptation/revision.

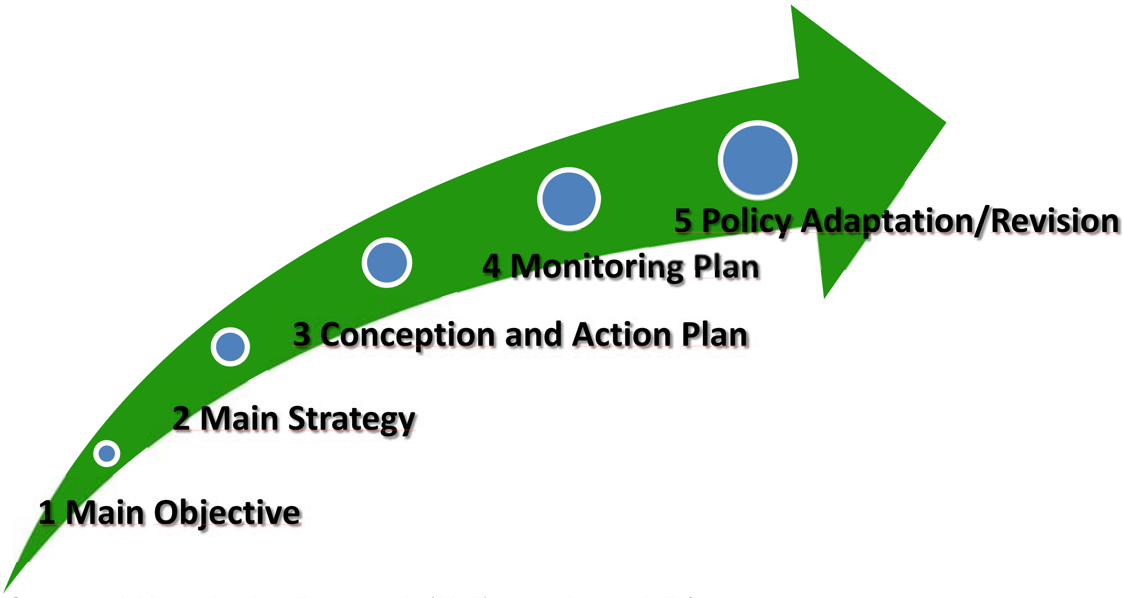

Figure 1 Conceptual Mineral Policy Framework (MPF) according to D5.1.

The starting point of consideration and screening is the MCA. The MCA is reflected in the MFA (MFA covers all materials used by a national economy; see below). The importance of MCA in mineral policy development has already been underlined in D5.1 (and WP4): to generate any (mineral) policy discussion we need to know the MC status of any country (or any other jurisdiction under investigation), i.e. the (current and future) need of minerals (commodities) along the supply chain, i.e. the input of minerals required for the development of any national economy.

The basic model of MC can be expressed as production plus imports minus exports minus waste as reflected in Equation 1.

$$M_C = M_{PR} + M_I - M_E - M_W \qquad \textit{Equation 1}$$

where M_C= minerals consumed; M_{PR} = production of primary and secondary raw materials (recycling); M_{PR} = $M_{PR(PRIM)}$ + $M_{PR(SEC)}$; M_I = minerals imported; M_E = minerals exported; M_W = Minerals going to waste, i.e. non-recoverable (see Falck *et al.* 2017).

Implicitly, from this equation it was concluded in D5.1 that when $\mathbf{M_C < M_{PR}}$, i.e. M_C is less than its output, then "*the country's economy is mainly oriented towards the development of mineral mining and exports and, as a rule, it is characterised by the absence of significant mineral imports*".

In the opposite, when $\mathbf{M_C > M_{PR}}$, the consumption is much higher than the domestic production and thus the country needs to take actions to secure its minerals supply by imports from outside its territory.

The **Mineral Consumption** (MC) concept is the differentiating element between mineral and mining policy. The mining policy is related (only) to domestic mining production and does not take into account the import and export part of MC.

Discussing the input of minerals needed for the development of a national economy (NE), however, requires the MC approach (which in most cases seems not reflected or not sufficient when framing mineral policy frameworks) (see Tiess 2011; Falck *et al.* 2017), i.e. including production/ imports/exports of commodities of any national economy. In a best scenario, the supply and value chain should be included as well; which would reflect the real contribution of mineral commodities to the NE status.

The MC status (and evolution) of a country is often reflected by the GDP status (evolution) (or vice versa) as indicated in D5.1 (Falck *et al.* 2017). Thus, the MC vs GDP relation is an important indicator regarding RMI-M. In order to analyse/discuss the MC including historical/future MC trends we need to have proper datasets/data base/statistics (and thus, collection of data) and models.

One major aim of any mineral policy would be to initiate the creation of a data pool/all categories of non-energetic minerals (following the MC approach)
In a best way, energetic mineral and non-energetic minerals should be jointly covered, thus avoiding the design of mineral and energy policies separately (e.g. compare the EU-RMI vs energy policies). A policy request would be to have a clear picture of collection/processing/updating the data (using appropriate tools) taking into account the relevant (responsible) stakeholders. Here we can refer to **Eurostat**. Eurostat collects **Economy-wide material flow accounts** (EW-MFA) from the national statistical institutes (NSI) of the EU Member States, Norway, Switzerland and the candidate countries under Regulation (EU) 691/2011 (amended by Regulation 538/2014) on European environmental-economic accounts[3].

Taking together high-quality data, appropriate methods/tools and responsible stakeholders for related sectoral policies we are able to frame the mineral policy. For the RMI-M different features/ areas were considered and grouped into several sectors/areas:

- Demand for Raw Materials (including mineral consumption analysis, data management and structure of industry)
- Minerals demand forecast based on the MC approach
    - It needs to be distinguished between long-term (foresight) and mid-term demand forecast (as well short-term i.e. regional estimates of minerals demand (construction minerals)). We know different tools used for foresight and forecasting (e.g. system dynamics, scenarios exploration, back-casting, future wheels, etc., see Falck *et al.* 2017, Martins and Bodo 2017a, Martins and Bodo 2017b. Minerals forecasting (and foresight) requires the (historical) analyses of MC

[3] For more details on the material flow accounts data collection, see the reference metadata of the EW-MFA. http://ec.europa.eu/eurostat/statistics-explained/index.php/Material_flow_accounts_-_flows_in_raw_material_equivalents#Data_sources_and_availability.

(primary and secondary raw materials), and as such, the analyses of the economical and (mining and related (i.e. supply chain)) industrial structure of any nation/country.

- Supply chain in volume and monetary terms (from exploration, through extraction, processing and refining, product design and manufacturing, waste towards recycling and including stockpiling as well).
- Trade and economic issues (import/export, prices of raw materials, economic growth and investment).
- Environmental and development issues (nature protection, energy and environment, infrastructure development, mineral deposits of public importance assessment and technology and innovation).
- Social aspects (stakeholder engagement, demography and employment analysis).

All these areas are complementary to the broad vision of a mineral policy concept and context and provide the frame for the RMI-M.

To approach the MC of a country a good proxy indicator is the **"domestic material consumption"** (DMC) as collected and compiled by Eurostat. The DMC measures the total amount of materials directly used by an economy and is defined as the annual quantity of raw materials extracted from the domestic territory of the focal economy, plus all physical imports minus all physical exports. The indicator DMC is based on the EW-MFA[4]. The theory of EW-MFA includes compilations of the overall material inputs into national economy, the changes of material stock within the economy and the material outputs to other economies or to the environment. Economy-wide material flow accounts covers all solid, gaseous, and liquid materials, except water and air (EUROSTAT 2017).

The three main components of the DMC are:

- the raw materials domestically extracted (domestic extraction);
- the total imports;
- the total exports.

The DMC data is collected in four categories of interest:

- Biomass
- Metal ores (gross ores)
- Non-metallic minerals
- Fossil energy materials/carriers

An examination of the DMC of metal ores and non-metallic minerals across selected large EU consuming countries shows that, in general, the DMC levels have been decreasing over the last 15 years (Figure 2). While Germany and France (Europe's largest consumers) and the UK have gradually reduced consumption levels, Italy and Spain (Europe's third and fourth largest

[4] http://ec.europa.eu/eurostat/web/environment/material-flows-and-resource-productivity

consumers) have shown a drastically drop in consumption since the crisis of the years 2007-2008. The reduction since the year 2000, and especially after the global financial crisis of 2007-2008, can be explained due to the slowdown in the construction sector and the lower demand for non-metallic minerals which make up around 90% of the total consumption (of metal ores and non-metallic minerals).

In contrast, Poland has shown a steady increase in consumption until the year 2011 and then a continued drop. Austria and Sweden have shown rather more stable consumption levels over the whole period.

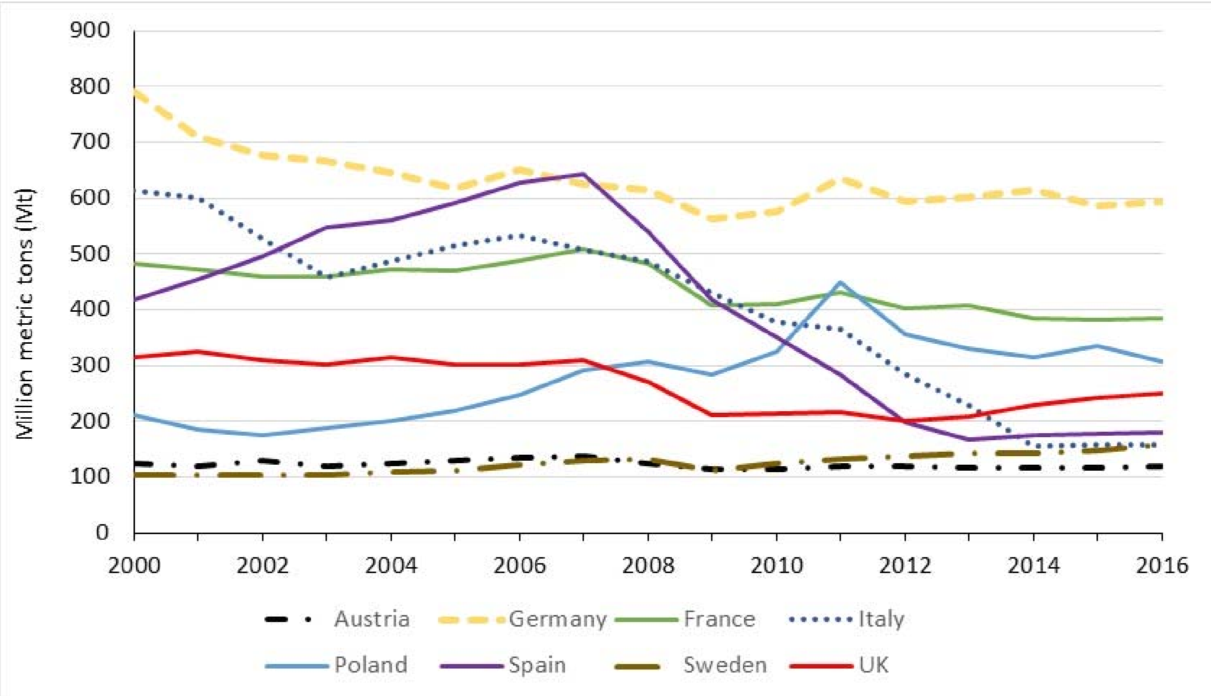

Figure 2 Annual domestic material consumption (metal ores and non-metallic minerals) for selected countries (Eurostat, env_ac_mfa).

<u>Schematic description of estimation of country level raw material equivalents by an adjusted coefficient approach</u>

Another way of measuring material flows employed by Eurostat includes the **raw material equivalents (RME[5]) units**. This tool allows the user to estimate country-level estimates of flows in raw material equivalents, such as imports and exports in RME, raw material input and raw material consumption (RMC). The tool implements one methodology with the "simple coefficient

[5] The concept of RME was created due to an asymmetry between the concept of domestic extraction and the recording of trade in EW-MFA. The asymmetry occurs because the value of DMC depends strongly on the origin of the input. If e.g. metal ore is extracted domestically the total amount of ore is accounted for, but if metals are imported only their imported mass (product weight) is used. Consequently, all imported semi-finished and finished goods used by Eurostat are expressed in raw material equivalents (RME).
http://ec.europa.eu/eurostat/documents/1798247/6874172/Handbook-country-RME-tool

approach" as an interim step and the "adjusted coefficient approach" providing the final results (see Figure 3). The adjustment takes into account differences regarding electricity mix and primary metal ratios between the EU and the country under review.

As per regulation No 691/2011 (amended by Regulation 538/2014), the EC requires each member state (MS) to deliver consistent compilations of MFA data[6]. It requires to consider certain minerals (see *Table 4* in Appendix 1). The last update of material flow accounts dates back to 04 July, 2017 and includes the metallic (metallic ores) and non-metallic consumption of MSs; from 2007 to 2016[7].

The country-level estimates of flows in RME, such as imports and exports in RME, raw material input (RMI) and raw material consumption (RMC) could be improved / detailed with the MC approach as discussed in D5.1 (Falck *et al.* 2017 and included in D5.3 Martins and Bodo 2017a). For instance, this could be done by publishing MC information per metal, and not at an aggregated level. This would provide a more **detailed approach of the minerals consumption scenario** when developing the MFA (i.e. minerals versus other materials) which is important for discussing different MC trends when framing mineral policy strategies. In other words, mineral policy design requires the detailed knowledge of future demand at the national level per metal, e.g. forecasts of iron demand.

[6] The REGULATION (EU) No 691/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 July 2011 on European environmental economic accounts (http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02011R0691-20140616&from=EN) is requiring the MSs to take into account certain minerals (see ANNEX I).

[7] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_mfa&lang=en

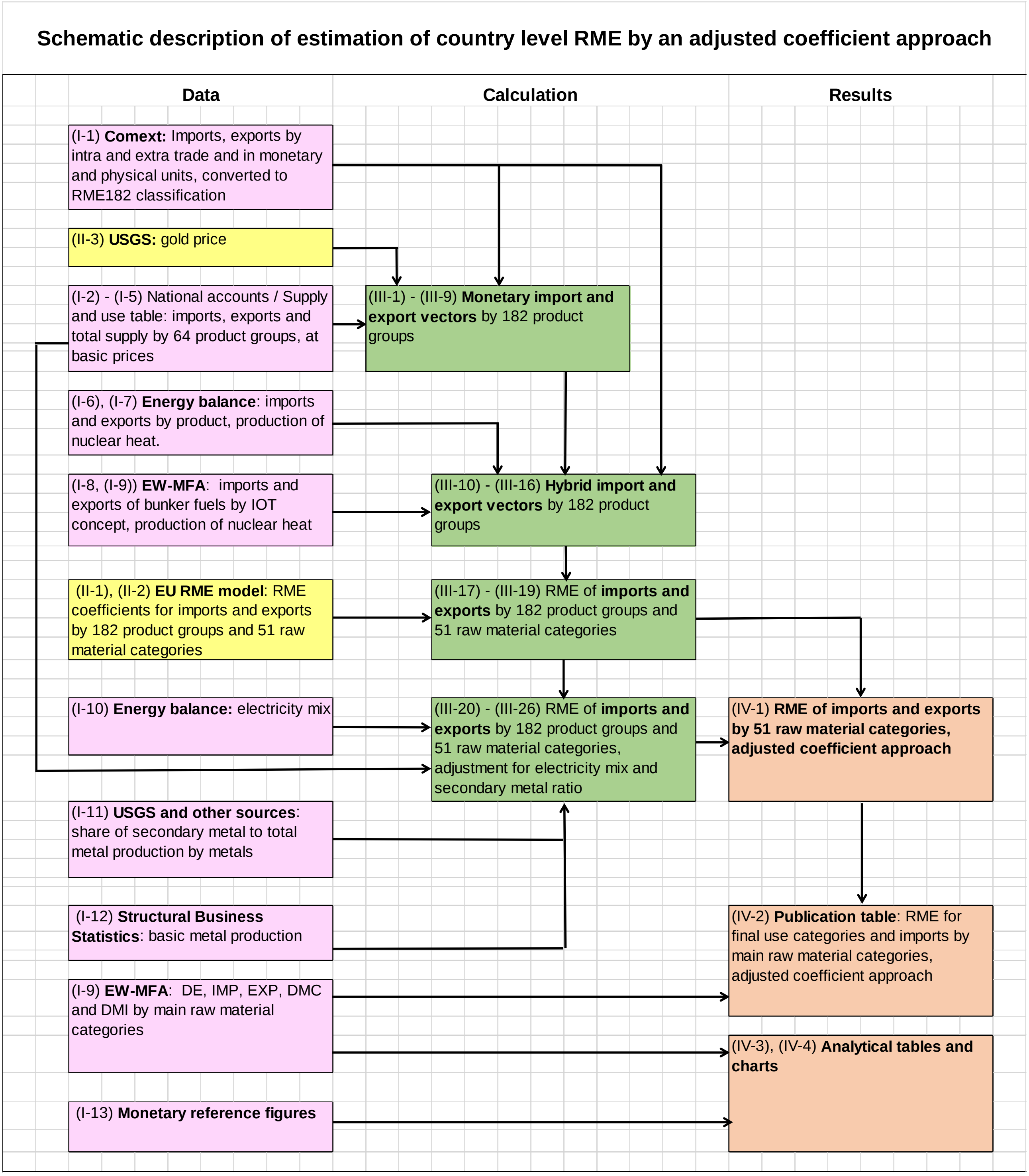

Figure 3 Schematic description of estimation of country level RME by an adjusted coefficient approach (EUROSTAT 2017).

3. Ideal RMI-Matrix policy case scenario

3.1 The need of an ideal RMI-Matrix and its options

A policy design is a complex, dynamic and costly process which requires its time and cooperation of different stakeholders from different sectors. Moreover, it is driven by number of factors such as elections cycle (government's priorities), availability of financial resources and skilled human resources, as well as overall status of socio-economic development. It is not realistic that positive development of all the factors would be met at the same time, thus, the ideal policy scenario will probably never exist.

However, it is always needed to have in mind where and how the improvement could be done, in which direction would be more effective to move and which indicators would enable monitoring/screening of an improvement/status-quo in corresponding sectors. This is the reason, why the idealised RMI-M is indispensable part for the raw materials sector development.

When discussing the ideal RMI-M policy scenario both mineral policy framework (MPF) dimensions – internal and external – should be considered (also in relation to the 3 pillars of the Raw Material Initiative).

- ***Internal Policy Options*** are providing possibilities on how the internal minerals market could be managed. This includes a clear statement of government expectations towards mining activities and it provides legislative framework and regulatory bodies with a broad guidance (Falck *et al.* 2017). National mineral policies are supported by land-use planning policies that encourage a mineral planning policy (i.e. exploration and protection of deposits in the context of land-use planning) and research and technology policies that aim to increase resource efficiency.

- ***External Policy Options*** aim to have an impact on external factors that are influencing the mineral sector, i.e. the trends and development in the international trade on raw materials. The policy options in this case could be covered by foreign policies based on diplomatic dialogues with main suppliers outside the country and setting objectives of trade and development policy, as well as trade policies aimed at securing access to minerals from non-member countries, for example through multi-lateral contracts (Falck *et al.* 2017).

A *realistic* minerals policy must take into account the basic geological and economic facts as well as the internal/external conditions. Appropriate RMI tools are needed to balance internal and external factors, to identify main challenges and objectives that could help secure the sustainable supply of minerals. A detailed MC analysis (historical/forecast, including the supply chain) requires a detailed analysis of the industry structure (energetic vs non-energetic minerals) and application of products through the supply chain. This requires an appropriate dataset/structures and data processing of past vs future MC development. A rule of thumb establishes that the minimum requirement for mineral consumption data analysis is a 10 year period; however, an optimal timeline would be 30-50 years (past vs future).

3.2 Example of iron MC Austria (import-dependent) vs Sweden (self-sufficient)

Iron is one of the metals of the highest economic importance and globally the largest traded non-energetic mineral commodity in tonnage with around 1.5 billion tonnes produced yearly (Reichl *et al.* 2017). It is crucial for the economic development of any country as many related industries are dependent on the supply of iron and its added-value products (i.e. steel), e.g. steel and machinery industry, construction sector, etc. The share of the EU member states production of iron ore is negligible at global scale: Sweden 1.01%, Austria 0.06% (Reichl *et al.* 2017).

A mineral consumption discussion could be (for example) based on the tool system dynamics, for instance applied to the iron supply chain (primary and secondary, see Figure 4) with a focus on the steel industry (globally around 98% of iron ore is used in steel-making). Other sectors of the economy are dependent on the supply of iron/steel, i.e. automotive, electrical, house and construction engineering, processing and energy industry, where the steel products are used.

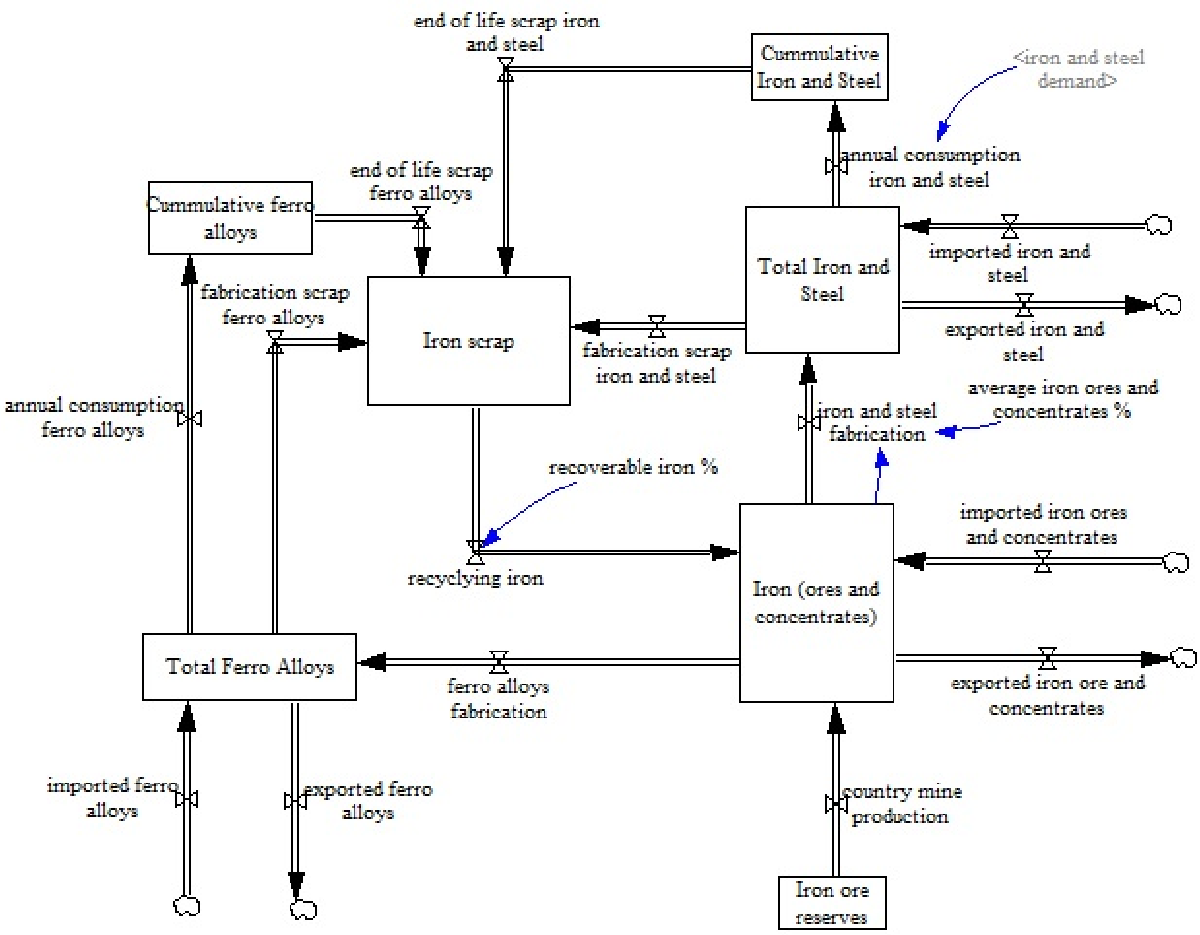

Figure 4 Iron supply chain presented by a System Dynamics Model (MinPol database 2017).

Figure 4 is describing the simplified iron supply chain and relations between primary iron ore production, imports and exports at different steps of the upstream ferroalloys, iron and steel industry, production of scrap and recycling. All these variables enter to the final total and cumulative production of ferroalloys, iron and steel that need.

For understanding the mineral supply chain (iron in this case) we need to take into account these variables and its relationships as they are directly or indirectly entering into calculation of MC. The analysis of the MC is then forming a base for the analysis of the mineral industry and identification of the main challenges. The difference between import and export dependence based on simple MCA is briefly explained on examples of Austria and Sweden.

The only iron ore producer in **Austria** is an open-pit siderite mine Erzberg at Eisenerz (Styria) with a yearly production of around 2 to 3 million metric tonnes (Mt) (Vaerzberg.at 2017). However, it only covers less than half of the domestic demand: e.g. in 2014 the total Austrian iron ore production (British Geological Survey 2016) counted more than 2.4 Mt while iron ore imports were close to 6.3 Mt. In Austria the largest steel producer is Voestalpine and Böhler, a subsidiary of Voestalpine. The main part of the steel production is exported (Germany 36%, Italy 12%, Czech Republic 6% of exports in 2016). Austrian steel exports averaged 6.9 Mt between 2010 and 2015. Steel and its products was counting for 4.6 % of total exported goods in 2015 (International Trade Administration 2017).

It is clear that the steel industry in Austria is highly dependent on imports of iron ore and there is a need for a policy that would minimize the supply risk as a potential supply disruption could endanger the economic and industrial development of the country. The question arises of how to secure the supply of raw materials using internal or external policy options.

<u>Examples of questions towards internal policy options:</u>

- Has the geological potential for deposits been fully explored within the country's territory? If not, are there sufficient basic pre-requisites (e.g. security of tenure, low risk of being unable to transfer the discovery rights) and incentives for exploration companies to invest in exploration?
- Which policies are needed to secure the access to land for the minerals industry? Is there any extension of the mine possible? Are there regular estimations (and updates) of the mineral resources and reserves per project/deposit in the entire country indicating production potential? Are primary and secondary raw materials (e.g. recyclable and recoverable minerals from tailings) included?
- Is it possible to increase the mining/processing output? How does the government contribute to the technological development (R&D)?
- What instruments are used/necessary to increase resource efficiency? How effective is the recycling and use of secondary raw materials? How is the country applying and advancing towards aims set in the Raw Materials Initiative's 3rd pillar?
- Are policies promoting the domestic exploration/extraction, aligned and designed together with resource efficiency policies? How are they coordinated?
- How are other internal policies and strategies (e.g. commitments or targets to progress towards a low-carbon economy, to protect biodiversity, to generate employment)

coordinated with mining promotion policies? Are they well-coordinated? Are they being effective?

Examples of questions towards external policy options:

- Which external policies are needed to identify other (non-domestic) supply possibilities?
- In the case of the EU: steel production vs CO_2 emissions which could limit the search in EU (restrictive environmental policies), although the supply potential is limited in EU-28; therefore > outside of Europe, e.g. South America.
- What are the diplomatic relationships with the main supplying countries? In this way, is the government assisting with raw material diplomacy (RMD) (first pillar of EU-Raw Materials Initiative)? (which then would increase the supply security for steel production – mid/long-term view)

In the case of metallic minerals, this implies an international dimension – which is different in the case of construction minerals having a regional scope (transport costs forbid transportation across long distances). For the latter, a separate mineral policy is needed as extraction is (usually) done at local/regional level (access vs transport). The need of non-energetic minerals determines different supply options/possibilities and thus, specific mineral policies. As in the case of metallic minerals, as well for some/several of the industrial minerals (dependent from the geological potential) the international context is visible and we need to apply the RMD-policy in correspondence with companies requiring this material.

The MCA including minerals forecast and the industrial structure (of any country) determines the mineral policy context and is closely interrelated. E.g. in the case of **Sweden**, the domestic iron ore production (35.7 Mt in 2014) is sufficient to secure the industry's demand for iron. There is low import – 0.26 Mt in 2014 in comparison with large exports 23.7 Mt (British Geological Survey 2016). Mineral consumption in turn is influenced by technical development, especially green technology. Therefore, the questions for the mineral policy framework development and its internal and external policy options will be oriented more to export policies, technological, environmental and social issues. The security of supply is not in the focus as it is covered by domestic resources.

3.3 RMI-M related to iron

$$M_{C,Fe} = M_{PR} + M_I - M_E - M_W \qquad \textit{Equation 2}$$

where $M_{C,Fe}$ = minerals (iron) consumed; M_{PR} = production of primary and secondary raw materials (recycling); $M_{PR} = M_{PR(PRIM)} + M_{PR(SEC)}$; M_I = minerals imported; M_E = minerals exported; M_W = Minerals going to waste, i.e. non-recoverable.

Table 1 provides a comprehensive overview of the aspects, data, sources and methods which might be employed for the creation of an ideal RMI-M which allows an intelligent identification of current and future raw material needs and how a country best can aim to cater for that demand balancing primary and secondary raw materials supply (inclusive of imports/exports, and along the different stages of the value chain).

Table 1 Aspects to be considered when applying an ideal RMI-MATRIX related to iron.

Sector	Relevant aspect	Data / source[8]	Tools/methods (RMI)	Policies	Stakeholders	Notes /data needs
	GDP (present and forecasts)	National statistics or international ones (e.g. World Bank)	GDP forecasting methods	Request/mandate of national government	Competent ministry/ authority or World Bank	Status and evolution of the national economy; MC vs GDP (in general strong correlation[9])
Demand for mineral raw materials	**MCA, historical analyses**	Ore/concentrates /refined/unwrought; (primary + secondary)	Time series analysis and compilation, system dynamics	Request to conduct MCA;	Competent ministry/ authority	
		>10 years data set; statistics, domestic consumption imports, exports	Raw material consumption database	Request for data collection/ processing	National statistics authority	Data for production, import and export (if available) along value chain needed
	MFA material flow analysis	All material (data) used in the national economy	Material flow accounting, MFA, SBA, LCA, environmental extended input-out analysis	Request for MSs to conduct MFA; Regulation (EU) 691/2011	Mix of competent authorities, research institutes	(MCA needs to be correlated with MFA) Eurostat undertakes annual data collections which are covered by Regulation (EU) 691/2011 consolidated version (Annex III). The MINFUTURE (www.minfuture.eu/)

[8] The MICA project has collected an inventory on data sources. The project published and regularly updates its online metadata inventory available at: http://metadata.bgs.ac.uk/mica/srv/eng/catalog.search#/home (cf. D3.2).

[9] In advanced countries (e.g. Italy, Spain, France) the GDP does not show a strong correlation with the MC levels, i.e. decoupling of economic growth (measured by GDP) from material needs (measured by DMC levels) has taken place due to an increasing participation of the services sector in the GDP.

						project aims identify, integrate, and develop expertise for global material flow analysis and scenario modelling
	MC, forecast	>10 years data set; statistics	e.g. system dynamics (SD), demand foresight (long-term approach)	Request to conduct MC forecast;	Competent ministry/ authority	The DMC indicator is a good proxy to estimate MC evolution (at least according to Eurostat´s available data), but needs to be disaggregated at the metal level
	Data management	Type of data needed, terminology and labelling used in practice, metadata	Harmonization of data collection	National reporting standards	Competent authority responsible for standardization	each step of the value chain
	Industrial structure, value chain	flows of goods from each sector (as producers) to the rest of the sectors (as buyer)	Input-Output Analysis	National economy	Chamber of Commerce, National statistics authority, Ministry of Economic affairs	metallic/industrial /construction industry
		Share of GDP of the sector (%)	GDP analysis	National economy	National statistics authority, national bank	
		economic importance + supply risk	strategic/critical raw materials definition, criticality assessment	CRM and “strategic” raw materials management	competent ministry (Economy, Industry)	
Value chain	**Product design and manufacturing**	Environmental footprint of products; economic, financial and environmental data in monetary terms	Footprint at micro-, meso- and macro level; Whole life costing (WLC), LCA, MFA, SBA	Eco design, minimize the footprint, partnership public-private to apply cradle-to-cradle approach, improve efficiency	competent ministry, manufacturing industry and end-user product design industry	This is the first step in the value chain
	Identification of mineral resources	Prospecting and exploration data	Digital geological database and thematic online maps application (GIS software - INSPIRE compatible)/	Creation/maintenance of a geological database, online thematic maps, prospecting/exploration	geological survey, exploration companies	e.g. OneGeology portal, minerals4EU, ASGI – Automatized System of Geological

			geological mapping, remote sensing, geochemical analysis, ground investigation, resource estimation mineral exploration	programme/project, reporting of exploration work to a government agency		Information (Czech Republic), national exploration programme Tellus projects (IRELAND)
		Active exploration permits	GIS, online map application with active exploration permits (INSPIRE compatible)	Legal basis for exploration permitting procedure Policy supporting investment security (security of tenure)	EIB, national bank, permitting authorities	MINLEX (Study on legal framework for mineral extraction and permitting procedures for exploration and exploitation in the EU)
		Inventory / Mineral deposits, Mineral Resources/reserves (primary + secondary)	3D models, deposit modelling, deposit assessment (prefeasibility, feasibility study)	Inventory of mineral resources/reserves/deposits, online map application with designated areas of mineral deposits, estimation of minerals contained in in-use stocks (urban mines)	National or regional statistical authorities; Geological Survey, exploration companies, research institutes	E.g. the MINVENTORY project, the ProSUM database (for secondary raw materials) CRIRSCO, the PERC Reporting Standard
	Extraction (production)	Mines in operation, how much is being produced and is expected according to the mines in different phases	GIS, online map application with designated areas of mines in operation, (INSPIRE compatible)	Balanced mining and other related policies (e.g. environmental) Streamlined permitting procedures	mining policy makers	MINLEX project indicates drawbacks in EU permitting procedures
		Mineral recovery potential from ore tailings (e.g. iron from slimes)	Methods to calculate recovery potential from tailing dumps	Waste management policy (prevention and recycling)	Competent ministry (Environment, Mining)	
	Processing, Refining	Processing/refining production	Processing and refining technological methods	R&D, Increasing effectiveness in processing and refining	Industry	Increasing iron output

	Waste	mining/processing waste production, fabrication and EoL scrap production	waste management, effective collection and separation	Waste management policy (prevention and recycling)	Competent ministry	
	Recycling	Secondary materials use rate	Substitution of primary raw and effective use of secondary raw materials	Circular economy, R&D policies	Competent ministry	Increasing resource efficiency
Trade and Economy	**Import**	Commodities, different forms / UN COMTRADE, Eurostat, etc.	System Dynamics, Input-output analysis	RMD-policy Raw material diplomacy; identification of sources outside of EU	Ministry of Foreign affairs, Ministry of Economy	Supports companies dealing with iron
		Importing countries, mayor producers	bilateral (multilateral) trade agreements	Foreign policy	Ministry of Foreign affairs	
	Export	Commodities, different form, / UN COMTRADE, Eurostat, etc.	encouraging domestic consumption	Trade policy, National economic strategy	Ministry of Economy	>concentrates, refined products (added value)
	Prices	Market prices (historical, forecasts)	market price analysis and forecasts	Trade policy	Warehouses, Price regulation authority, Producers and consumers associations	
	Economic growth	GDP (total, % growth, per capita), historical, forecasts	National economy development	National economic strategy	Government, National Bank	
	Investment	FDI, Investment attractiveness index and its factors, expected investments in the sector	Investment attractiveness assessment	Fiscal policy, Legal framework, Transparency, Justice, Geopolitical stability, etc.	Government	e.g. Fraser Institute survey
Environment and development	**Nature protection**	data on relevant legislation and implementation	Fitness Check of implementation of the legislation	Nature protection legal framework	Competent ministry (Environment)	MINLEX
	Energy and environment	energetic consumption and GHG emissions in mineral industry	method for GHG emissions monitoring, LCA	Low carbon and Green Economy	Competent ministry (Environment and Energy)	monitoring of energetic consumption, GHG emissions limits
	Infrastructure	infrastructure availability (highways, rails, water, electricity, energy supply)	GIS, Smart cities	National/Regional development strategy	Competent ministry (Infrastructure and Transport)	INSPIRE compatibility

	MDoPI securing	Mineral deposits assessment results	GIS, MDoPI, Land use planning, conflicts of interest management	LUP-policy, Mineral planning policy	Responsible ministers for Environment; natural resources and mineral (planning) policy; authorities responsible for land use planning	Land use planning (LUP), See project MINATURA 2020 (www.minatura2020.eu)
	Innovation and technology	skilful workforce available, technological advance	investment in R&I and development; education system corresponding to economy´s needs	State policy on Education; Research, Innovation and Development Funding Programmes	competent ministry (education, research and innovations)	Research
Social aspects	**Stakeholder engagement**	public awareness, level of social acceptance of mineral development projects	Social Licence (to Operate), early involvement and communication with public (e.g. focus groups)	Communication with the public, stakeholder engagement policies /principles	Companies, Local government	
	Demography and employment	population growth, population structure (economically active population, unemployment rate), contribution of mining to employment generation	demography analysis, policy impact analysis	Social policy	competent ministry for social issues	Population and mineral demand often show a strong correlation for forecasting future MC
Defense aspects	**Contributions to national defense goals (military)**	Importance of the metal for national security purposes	Criticality assessment	Defense policies	Ministry of Defense in cooperation with Ministry in charge of minerals (e.g. Ministry of Economic affairs)	
	Stockpile	raw materials in stocks	stockpiling of critical/strategic raw materials	Raw Materials Security policy	Ministry in charge of minerals (e.g. Ministry of Economic Affairs)	

The interrelationships between the elements are shown in Figure 5. Again, the objective of an RMI-M is to guide policy-making towards the right steps to ensure that the future demand by the national economy is supplied in an optimal way combining domestic and imported primary and secondary mineral resources. The starting point for advanced economies like that of the EU countries is the MC approach, i.e. estimations per metal (not an aggregated level) of the future demand of one country. This can be done using proxy indicators like forecasts of GDP, GDP per capita or population growth rates which show a correlation with MC (see Falck *et al.* 2017). Material flow analysis indicators like DMC can be used for historical analyses which are ideally conducted as a way to calibrate and validate modelled forecasts (though care should be taken as DMC is only provided at an aggregated level by Eurostat).

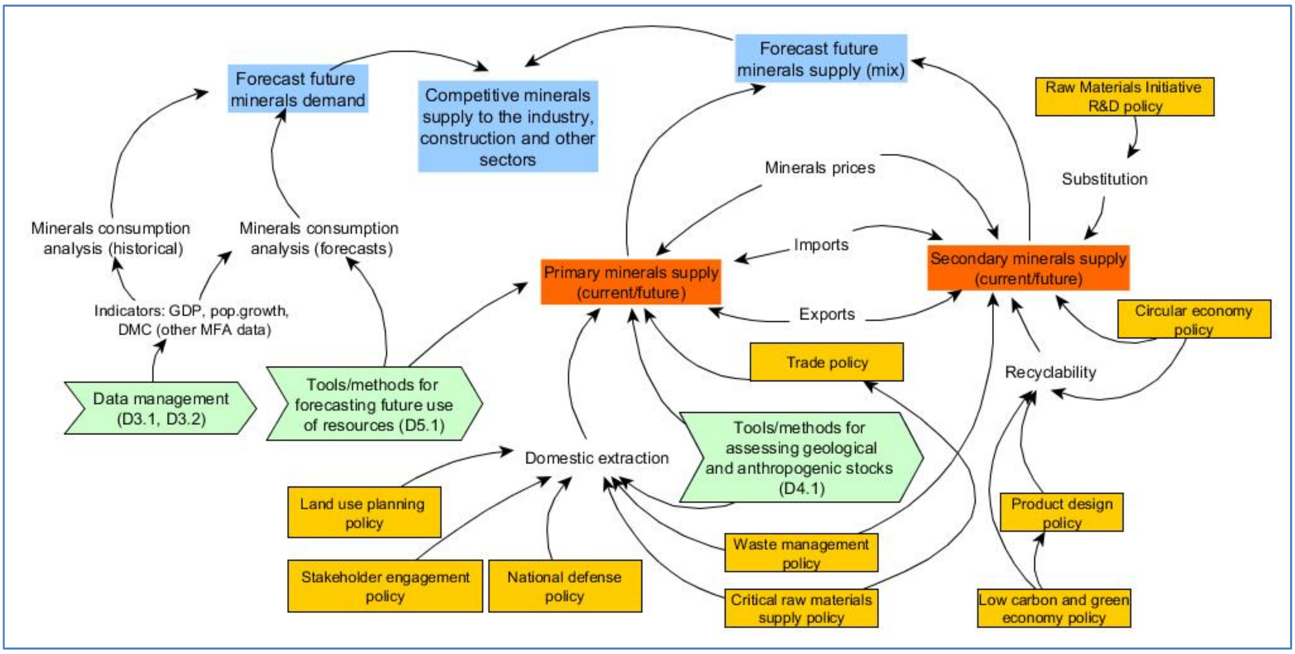

Figure 5 Interrelationships among the elements composing an ideal RMI-M (MinPol database 2017).

The necessary future supply to cover such demand needs to be estimated in advance and the future supply needs to be managed combining the potentially available primary and secondary raw materials. Primary mineral raw materials supply can be approached via indicators like "domestic extraction" (MFA, Eurostat), yet it should include not only minerals extracted from the natural environment (geological deposits) but also from waste dumps/tailings and other man-made concentrations (e.g. abandoned mines). The supply of secondary raw materials needs to foresee available anthropogenic stocks (in-use stocks, dormant ones, etc.) via stock-and-flow models. A central consideration in this ideal case requires an effective coordination among policies and regulations, i.e. policies are designed strategically analysing their synergies.

Well-guided MC analysis determines the current mineral policy context and issues like e.g. critical minerals which then would influence the policy decision as well. The MC discussion thus determines (finally) the domestic and non-domestic mineral policies – which should be included in a policy matrix (internal vs external policy dimension) to have the best impact (i.e. supply security of a national economy). The RMI-M is a compilation of RMI tools/methods in a proper way – to fulfil the policy request. Summarised, the policies are determining the RMI-M discussion. Table 1 (example iron) lists data, sources and methods which might be employed for the creation of a detailed RMI-M. This idealised model allows for an intelligent identification of current and future raw material needs and how a country can best aim to cater for that demand for mineral raw materials supply (inclusive of imports/exports, and along the different stages of the supply chain).

An ideal RMI-M should not only identify the important sectors/dimensions but also determine/provide options as to how different sectoral policies and strategies need to be integrated and optimised to achieve the desired targets making trade-offs between different objectives. For instance, ensuring the iron supply security can be well aligned with economic and social policy seeking to promote economic and social development of (primary and secondary) mineral-rich regions and with low-carbon targets as long as resource efficient production methods are deployed, i.e. ensuring a (relative) decoupling of economic growth from resource use.

An RMI demand forecast tool like scenario development (see Falck *et al.* 2017, Appendix 1) can be employed to guide policy making seeking to achieve such aims (promoting iron extraction but reducing greenhouse gases (GHG) emissions). A good example is given by the model developed by Milford *et al.* (2013) in which they explored the roles of energy and material efficiency in attaining (global) steel industry CO_2 targets by 2050. The authors modelled the global supply chain (global MFA combined with process emissions intensities) and potential future steel sector emissions under different scenarios. The scenarios are of a normative character as they explore different pathways the industry should undergo to reach global steel emission targets by 2050. Their results show that global capacity for primary steel production is already near to a peak and that if sectoral emissions are to be reduced by 50% by 2050, the last required blast furnace will be built by 2020. They also concluded that emissions reduction targets cannot be met by energy and emissions efficiency alone, but deploying material efficiency provides sufficient extra abatement potential. Moreover, the authors present alternatives for policy makers while concluding that "*Material efficiency would lead to reduced steel production and policy-makers could support this transition through promoting opportunities for new businesses, for example through deconstruction and reuse, maintenance over longer product lives, and diverting scrap into other uses. Policy-makers could also challenge existing consumer behavior, for example, promoting product life extension over disposal, or promoting shared ownership over single-ownership*".

This means that, at a national scale, extraction of iron ore can be compatible with GHG emission reduction targets. Similar analysis needs to be done to examine how poverty and inequality reduction targets (and other goals, e.g. United Nation's Sustainable Development Goals) can be attained while at the same time ensuring clean water and the protection of life on land and in the water.

Modelling of policy and their expected impacts is necessary so that differences in their interrelations can be modelled and trade-offs can be identified, maximising the overall impact of all policies together. Despite the potential, this is only an "ideal" case as often mineral policies are designed and implemented on a sectoral level, and the interrelations with other policies is often not optimised (e.g. EU's separate energy and non-energy mineral policies). In other words, under an ideal policy case scenario the mineral policies should be coordinated with each other and also with other ones (e.g. environmental, land-use planning, etc.).

4. Strong versus medium versus weak RMI-Matrix scenarios

Chapter 4 discusses different *simplified* cases in relation to the ideal RMI-M policy scenario from *Chapter 3* (delivering validity of minerals supply) taking the MC approach into account. The overall mineral policy target in the case of EU/EU-28 is a sustainable minerals supply security (MSS). Minerals supply security can be influenced by the set of RMI tools/methods. For instance, we can optimize the MSS with a full set of RMI-M. For the right economic development, the MSS is an important target.

Using the MC approach, we can differentiate between strong (optimal scenario) RMI-M (MC is taken into account including forecast), medium RMI-M (MC without forecast) and weak RMI-I (no MC approach at all).

We are using a *simplified RMI-M approach in order to have the option to screen the RMI-status of EU-28 in an efficient way* as we want to derive a broad picture; and thus, be able to generate the mineral policy status including gaps. In other words: to apply the ideal RMI-M would even require a setting of detailed RMI-M methodology and deep analysis of the policies in every member state (MS) which is not within the scope of this report. It would require a separate study.

4.1 Strong RMI-Matrix

For the best scenario case the following (*simplified*) approach could be taken into account – apart from identifying the GDP (status of national economy) the following elementary parameters (required for framing the MPF) are listed:

1) MCA (minerals)/MFA (minerals / all materials)
2) MIA (mineral inventory analyses)
3) Identification and safeguarding of access to mineral resources (mineral deposit of public importance (MDoPI)/land-use planning (LUP))
4) Circular economy
5) Minerals consumption forecast

ad 1) Mineral consumption analysis (MCA) and Material flow analysis (MFA)

The MCA needs to be correlated with the **material flow analyses** (MFA) approach (MC input for MFA; identifying/*weighting* different mineral flow e.g. critical minerals). Production, import and export are all considered for both primary and secondary raw materials. Substance flow analysis is also worth considering. This, in relation to **any other materials** used in (any) national economy.

Whereas regulation No 691/2011 takes certain minerals into account, the MC scenario as discussed in D5.1 (Falck *et al.* 2017) takes the **whole MC scenario** of a national economy into account (so called raw materials mix including value chain).

Mineral flow analysis needs information (knowledge) input related to production, import and export; for example, the mining (and related) industry (i.e. the supply chain). Input means for example, data input. In turn, this means the request of data collection/compilation/processing (e.g.

mineral year books). And finally, it needs the analyses of all non-energy extractive industry (NEEI) producers, producers along the supply chain and recyclers, cp. the iron example of Austria (Steirischer Erzberg company/Voest Alpine, steel producer). A special focus should be put on critical raw materials (CRMs) (and their supply and value chains).

ad 2) Mineral inventory analyses (MIA)

The Mineral inventory analyses explore the (mineral exploration and) domestic mining potential (MC – production). The main reason is to identify the national mineral/mining potential in relation to the MC approach; taking into account all possible occurring mineral resources vs critical minerals as well the secondary raw materials potential. Mineral inventory analyses require the establishment of comprehensive digital geological database (DGD) and secondary raw material database as well a transparent methodology for identifying mineral resources. The development of DGD can be managed by digital geological mapping, remote sensing, geochemical analysis, ground investigation and resource estimation techniques for primary (deposits on the ground) and secondary stocks (e.g. municipal waste, mining waste, pre-fabrication manufacturing stocks). Any transparent methodology for identifying mineral resources (vs other natural resources) can be based (for example) on geographic information system (GIS) which is a tool using different (digital) features.

ad 3) Identification and safeguarding of access to mineral resources (MDoPI/LUP)

Under the frame of a strong RMI-M approach, MIA and GIS will be used for the identification and protection of domestic minerals resources, e.g. implementing the MDoPI approach of the MINATURA2020 project (taking into account other land uses by using appropriate land use planning tools). This will provide the basics for the mineral planning policy (MPP) decisions (MPP is part of a national mineral policy).

ad 4) Circular economy

Aspect of resource efficienc, needs to be incorporated in the RMI-M concept. There are different tools, e.g. life cycle analysis (LCA) approach, i.e. there needs to be coordination in the amount of minerals available for use via primary extraction and the material available via re-use/recycling. This needs to be done with a medium and long-term perspective.

ad 5) Minerals consumption forecast

It needs to be distinguished between long-term (foresight) and mid-term demand forecast (as well short-term i.e. regional estimates of minerals demand (construction minerals)). We know different tools used for foresight and forecasting (e.g. time series, system dynamics, back-casting, scenario development, etc.; see Falck *et al.* 2017).

Minerals forecasting (and foresight) requires the (historical) analyses of MC and as such, the analyses of the economic and (mining and related (i.e. supply chain)) industrial structure of any nation/country. As long as data enables it, *primary and secondary raw materials should be considered in a coordinated way* as they are both part of the minerals supply and minerals supply potential within the country.

Minerals forecast will provide different demand and supply scenarios for (primary and secondary) mineral commodities in relation to time (short/mid/long-term). An optimal scenario would be: demand forecast for all mineral commodities and foresight approach (long-term future scenario) treating jointly non-energy and energy minerals. This way, a realistic mineral policy scenario and thus, strategy could be developed.

Minerals forecast based on the MC approach would provide the basics for any mineral policy decisions.

4.2 Medium RMI-Matrix

The medium scenario case includes (MCA or at least) MFA, but no MC forecast (mid-term/long-term). The MC approach including MFA provides the historical MC. Historical trends (but no future trends) of different mineral commodities can be discussed[10], for example the increasing need of REE, or the (still) remaining high level of iron demand. However, *without MC forecast/foresight no detailed (future) demand/supply scenarios and thus, no realistic mineral policies can be developed.*

4.3 Weak RMI-Matrix

The weak scenario case contains no MCA, no MFA, no MC forecast. Any policy discussion is unrealistic. There is no realistic opinion possible on how the minerals development of a national economy has been and could be in future due to the lack of concrete mineral policy scenarios in the absence of reliable production statistics, import and export, the absence of reliable (historical/future) mineral consumption analyses.

Regulation No 691/2011[11] requires each MS to conduct a MFA: thus, this scenario is in principal not relevant for EU-28. Although the question remains if MSs have designed mineral policies/strategy based on their MFA; but this is task D5.6.

[10] cp. http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do, 2007-2016 DMC data
[11] http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

5. RMI-Matrix for MICA D 5.6

This chapter discusses the development of RMI-M for MICA to be applied for D5.6 (screening of MSs) taking into account the output of *chapter 4*; again, the central focus is MC. The matrix includes various parameters (*tools/methods*) i.e. **MC/MFA, MIA/DGD, MDoPI/LUP, Circular economy (CE), MC/forecast**. These parameters are selected as they represent **key parameters** for designing mineral policies; also because they enable the screening/comparison of EU-28 in an effective way.

It is suggested to use the matrix in Table 2 for the policy screening of EU-28. Such screening matrix is simply adding attribution of strong/medium/weak scenario for each parameter depending if the parameter is fully/partly or not applied in the selected country.

Table 2 RMI-M to applied for screening of EU-28 (x – the parameter is applied at the level of strong/medium/weak scenario, - – the parameter is not applied at the level of strong/medium/weak scenario).

RMI (policy) scenarios/value	MCA	MFA	MIA/DGD	MDoPI/LUP	CE	MC/Forecast	Mineral policies/ strategies
Strong	x	x	x	-	-	x	Name of the strategy
Medium	-	-	-	x	x	-	
Weak	-	-	-	-	-	-	

For a more detailed analysis, this simple version could be potentially extended by adding several possibilities representing strong, medium or weak scenarios. For instance, a strong scenario for access to mineral resources (column MDoPI/LUP) represents a) efficiently working implementation of MDoPI into LUP or b) efficiently working minerals safeguarding via other mechanism. A medium scenario could be understood as a) the access is restricted to selected minerals (e.g. reserved minerals), b) the access is secured via land-use planning for all minerals but not working properly, c) the access to minerals is limited by other elements. A weak scenario would mean that the country is not securing the access to minerals by any tool or instrument.

However, this extension would require definition of different possibilities of interpretation for each element, which could result in complex assessment. For the purposes of MICA (especially D5.6) it is suggested to use a simple and quick screening like the scheme in the Table 2.

The structure of the Table 2 applied in the case of Finland can be seen in Table 3. Finland could be related to the medium/strong RMI-M scenario. The country has developed the Finnish minerals strategy[12] in 2010. The objectives are to promote domestic growth and prosperity, to develop solutions for global mineral chain challenges and to mitigate environmental impacts, CRMs are also considered. Raw material intelligence tools applied are i.a. MFA, MIA/DGD, MDoPI/LUP, CE is included; (to be checked in D5.6). Exploration and mining companies are required to report data to

[12] http://projects.gtk.fi/export/sites/projects/minerals_strategy/documents/FinlandsMineralsStrategy_2.pdf

an international standard code but the mining law does not specify which code (Parker *et al.* 2015). No evidence is found on the use of future mineral demand estimates: Finland's Mineral Strategy only presents information on global scenarios of future demand.

Table 3 Example – RMI-M to be applied for screening of Finland (x – the parameter is applied at the level of strong/medium/weak scenario, - – the parameter is not applied at the level of strom/medium/weak scenario).

RMI (policy) scenarios/value	MCA	MFA	MIA/DGD	MDoPI/LUP	CE	MC/Forecast	Mineral policies/ strategies
Strong		x	x	x	x		x
Medium						x	
Weak							

6. Conclusions

An intelligent management of the primary and secondary raw materials available within the territory of a country requires medium and long-term planning. Planning requires collecting and processing of data (see Petavratzi *et al.* 2016, 2017) which translates into information and knowledge via tools and methods (see Bide *et al.* 2017) according to the needs of stakeholders (see Erdmann *et al.* 2016, 2017) including policy-makers. One key parameter underpinning raw materials intelligence (RMI) are mineral consumption (MC) analysis, linked to minerals demand forecasting (MDF) and material flow analyses (MFA). Mineral consumption is related to the level of development of a country and allows the creation of forecasts of future minerals demand linked to proxy variables such as gross domestic production (GDP) and expected population growth.

Mineral consumption analyses is the basis of any raw material intelligence (RMI) approach; without MC forecast/foresight no detailed (future) demand/supply scenarios and thus, no realistic mineral policies, supported by data can be developed. In this deliverable an ideal RMI-MATRIX has been developed containing a comprehensive number of tools and methods which could be used to understand future demand and potential to optimise the portfolio of available resources within the territory of a country and guide policy-making activities. Based on such RMI-M three different options (strong, medium or weak) were developed and proposed to be used to screen the EU-28 mineral policies in D5.6.

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Appendix 1

REGULATION (EU) No 691/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 July 2011 on European environmental economic accounts – http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02011R0691-20140616&from=EN

Requires each MS do deliver a MFA. It requires to consider the following minerals:

Table 4 List of minerals to be considered in the MFA of MSs.

2	**Metal ores and concentrates, raw and processed**
2.1	Iron ores and concentrates, iron and steel, raw and processed
2.2	Non-ferrous metal ores and concentrates, raw and processed
2.2.1	Copper
2.2.2	Nickel
2.2.3	Lead
2.2.4	Zinc
2.2.5	Tin
2.2.6	Gold, silver, platinum and other precious metals
2.2.7	Bauxite and other aluminium
2.2.8	Uranium and thorium
2.2.9	Other n.e.c.
2.3	Products mainly from metals
3	**Non-metallic minerals, raw and processed**
3.1	Marble, granite, sandstone, porphyry, basalt and other ornamental or building stone (excluding slate)
3.2	Chalk and dolomite
3.3	Slate
3.4	Chemical and fertiliser minerals
3.5	Salt
3.6	Limestone and gypsum
3.7	Clays and kaolin
3.8	Sand and gravel
3.9	Other n.e.c.
3.10	Excavated earthen materials (including soil), only if used (optional reporting)
3.11	Products mainly from non-metallic minerals
4	**Fossil energy materials/carriers, raw and processed**
4.1	Coal and other solid energy products, raw and processed
4.1.1	Lignite (brown coal)
4.1.2	Hard coal
4.1.3	Oil shale and tar sands
4.1.4	Peat
4.2	Liquid and gaseous energy products, raw and processed
4.2.1	Crude oil, condensate and natural gas liquids (NGL)
4.2.2	Natural gas
4.3	Products mainly from fossil energy products