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PART 1/3

COMMISSION STAFF WORKING DOCUMENT

Report on Critical Raw Materials and the Circular Economy

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1. INTRODUCTION

This report has been produced under the Action Plan on Circular Economy (see Section 1.2.1) in which the Commission set out to issue a report on critical raw materials and the circular economy in 2017, in order to ensure a coherent and effective approach, provide key data sources, promote best practices and identify possible further actions.

The report should be seen in the context of the political priorities of the Commission – especially relevant are the priorities on jobs, growth and investment, Energy Union and climate, the internal market, trade policy and global efforts on sustainable development.

More specifically, it supports implementation of the renewed EU Industrial Policy Strategy[1] presented by President Juncker in his State of the Union Address 2017. The renewed strategy highlights the importance of adapting to changes brought on by the transition to a low-carbon and more circular economy, as well as the strategic importance of raw materials for the EU manufacturing industry.

This report is based on a recently published JRC report[2], especially for the sectorial analysis presented in Section 5.

1.1. Critical raw materials

1.1.1. Background and definition

Raw materials are essential for the production of a broad range of goods and applications used in everyday life. They are intrinsically linked to **all industries across all supply chain stages**. They are crucial for a strong European industrial base, an essential building block of the EU's growth and competitiveness. The accelerating technological innovation cycles and the rapid growth of emerging economies have led to a steadily increasing demand for these highly sought after metals and minerals. The future global resource use could double between 2010 and 2030[3].

To address the growing concern of securing valuable raw materials for the EU economy, the Commission launched the European Raw Materials Initiative in 2008. It is an integrated strategy that establishes targeted measures to secure and improve access to raw materials for the EU. One of the priority actions of the Initiative was to establish a list of Critical Raw Materials (CRMs) at the EU level.

The fact that the most recent list of critical raw materials for the EU was adopted together with the renewed EU Industrial Policy Strategy on 13 September 2017 reflects the high importance that the Commission continues to attach to the list. The Commission is also engaged in a dialogue on critical raw materials with the US and Japan - the seventh annual meeting and conference took place in Pittsburgh on 12 October 2017.

CRMs are particularly important for **high tech products and emerging innovations** - technological progress and quality of life are reliant on access to a growing number of raw materials. For example, a smartphone might contain up to 50 different metals, all of which giving different properties such as light weight and user-friendly small size. CRMs are irreplaceable in solar panels, wind turbines, electric vehicles, and energy efficient lighting and are therefore also very relevant for fighting climate change and for improving the environment.[4] For example, the production of low-carbon technologies –

[1] Communication "Investing in a smart, innovative and sustainable industry", COM(2017) 479

[2] Critical Raw Materials and the Circular Economy. Background report. JRC Science-for-Policy Report. December 2017, EUR 28832 EN, http://dx.doi.org/10.2760/378123, JRC108710.

[3] Decoupling natural resource use and environmental impacts from economic growth. A Report of the Working Group on Decoupling to the International Resource Panel. UNEP.

[4] https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

necessary for the EU to meet its climate and energy objectives – is expected to increase the demand for certain raw materials by a factor of 20 by 2030[5].

The list of Critical Raw Materials contains raw materials which reach or exceed thresholds for both **economic importance** and **supply risk**.[6] The Commission established the first list in 2011 and committed to update it at least every three years to reflect market, production and technological developments.[7] The first assessment, conducted in 2011, identified 14 CRMs out of the 41 non-energy, non-agricultural raw materials assessed. In the 2014 exercise, 20 raw materials were identified as critical out of the 54 materials assessed.[8]

In the 2017 exercise, **27 CRMs** were identified using a revised methodology for an assessment of 61 raw materials (comprising 58 individual and 3 grouped materials, altogether 78 individual materials). [9]

Critical Raw Materials			
Antimony	Fluorspar	LREEs	Phosphorus
Baryte	Gallium	Magnesium	Scandium
Beryllium	Germanium	Natural graphite	Silicon metal
Bismuth	Hafnium	Natural rubber	Tantalum
Borate	Helium	Niobium	Tungsten
Cobalt	HREEs	PGMs	Vanadium
Coking coal	Indium	Phosphate rock	

Table 1: The 2017 List of Critical Raw Materials to the EU (HREEs = Heavy Rare Earth Elements[10], LREEs = Light Rare Earth Elements[11], PGMs = Platinum Group Metals[12])

The revised methodology[13] brought several improvements: systematic screening of the most critical points in the supply chain (mining/extracting and processing/refining); inclusion of an import reliance parameter and a trade-related parameter based on export restrictions and the EU trade agreements; considering also the actual sourcing of the material to the EU (domestic production plus imports), not only the global supply; inclusion of substitution in both supply risk and economic importance and improving the calculations, while the previous assessments only addressed substitution in the supply risk; more specific allocation of raw materials to the relevant end-use applications and corresponding manufacturing sectors, instead of mega sectors etc.

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5 EU Raw Materials Scoreboard 2016. https://publications.europa.eu/en/publication-detail/-/publication/1ee65e21-9ac4-11e6-868c-01aa75ed71a1/language-en

6 The assessment is based on historical data rather than forecasts.

7 Communication "Tackling the challenges in commodity markets and on raw materials", COM(2011) 25

8 Communication "On the review of the list of CRM for the EU and the implementation of the Raw Materials Initiative", COM(2014) 297

9 Communication on the 2017 list of Critical Raw Materials for the EU, COM(2017) 490

10 dysprosium, erbium, europium, gadolinium, holmium, lutetium, terbium, thulium, ytterbium, yttrium

11 cerium, lanthanum, neodymium, praseodymium, samarium

12 iridium, platinum, palladium, rhodium, ruthenium

13 https://publications.europa.eu/en/publication-detail/-/publication/2d43b7e2-66ac-11e7-b2f2-01aa75ed71a1/language-en/format-PDF http://www.sciencedirect.com/science/article/pii/S0301420717300223?via%3Dihub

1.1.2. Global situation in supply and trade

The European industry is dominated by the manufacturing industry (i.e. the manufacture of end products and applications) and also the refining industry (metallurgy, etc.), compared to the extractive industry (mine and carriers). The value chain of CRMs is not fully and homogeneously covered by the European industry. Pronounced imbalance exists between the upstream steps (extraction / harvesting) and the downstream steps (manufacturing and use). Considering the very limited supply of CRMs from secondary sources[14] (see Fig. 5 and Fig. 7), the need for access to primary sources, including ores, concentrates, processed or refined materials is huge and crucial for the wealth – and even the survival – of European industries and their associated jobs and economic benefits.

The majority of these primary raw materials are produced and supplied from non-European countries.

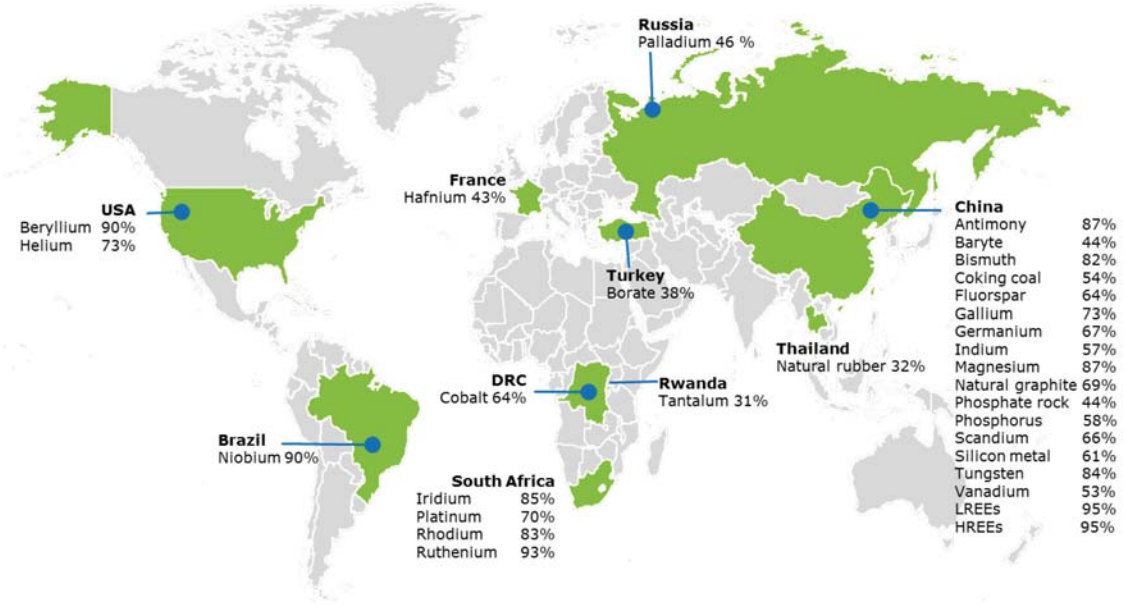

Figure 1: Contribution of primary global suppliers of critical raw materials, average from 2010-2014

[14] I.e. from recycling of waste

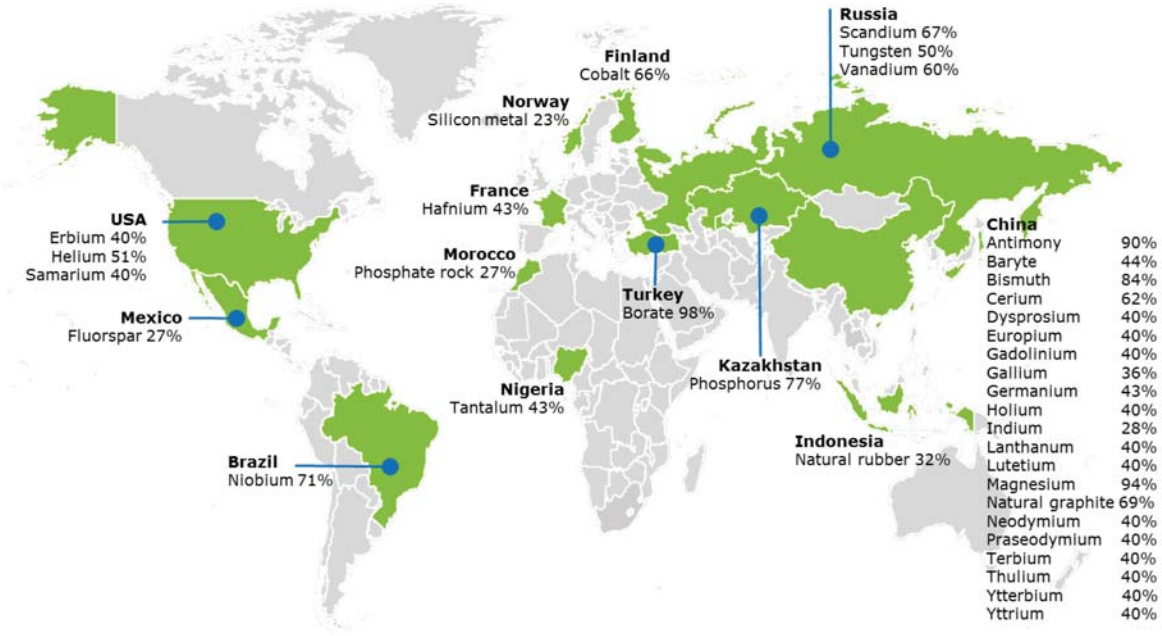

Figure 2: Contribution of countries accounting for largest share of supply of primary CRMs to the EU, average from 2010-2014

Although China is also the principal supplier of CRMs to the EU, the analysis highlights several other countries that represent important shares of the EU supply for specific CRMs, such as the USA (beryllium and helium), Russia (cobalt and scandium) and Mexico (fluorspar and tungsten). The revised methodology incorporates actual sourcing to the EU, therefore allows for a more realistic picture of Europe's supply of the raw materials assessed.

For many CRMs the upstream steps of the value chain are not present in the EU: antimony, beryllium, borates, magnesium, niobium, PGMs, phosphorus, rare earths, scandium, tantalum and vanadium. This is due either to the absence of those materials in the European ground or to economic and societal factors that negatively affect the exploration (for deposit discovery and characterisation, estimation of resources and reserves) or the extraction (closure of existing mines, reluctance to open new mines, etc.). In addition to abiotic raw materials, natural rubber is also grown and harvested entirely outside the EU.

To access those primary CRMs, the EU has currently no other choice than importing the ores and concentrates or the refined materials from other countries to feed its industries and markets.

Hafnium is the only CRM for which an EU Member State (France) is the global main producer. For hafnium and indium, the Member States produce enough primary materials to avoid significant extra-European imports.

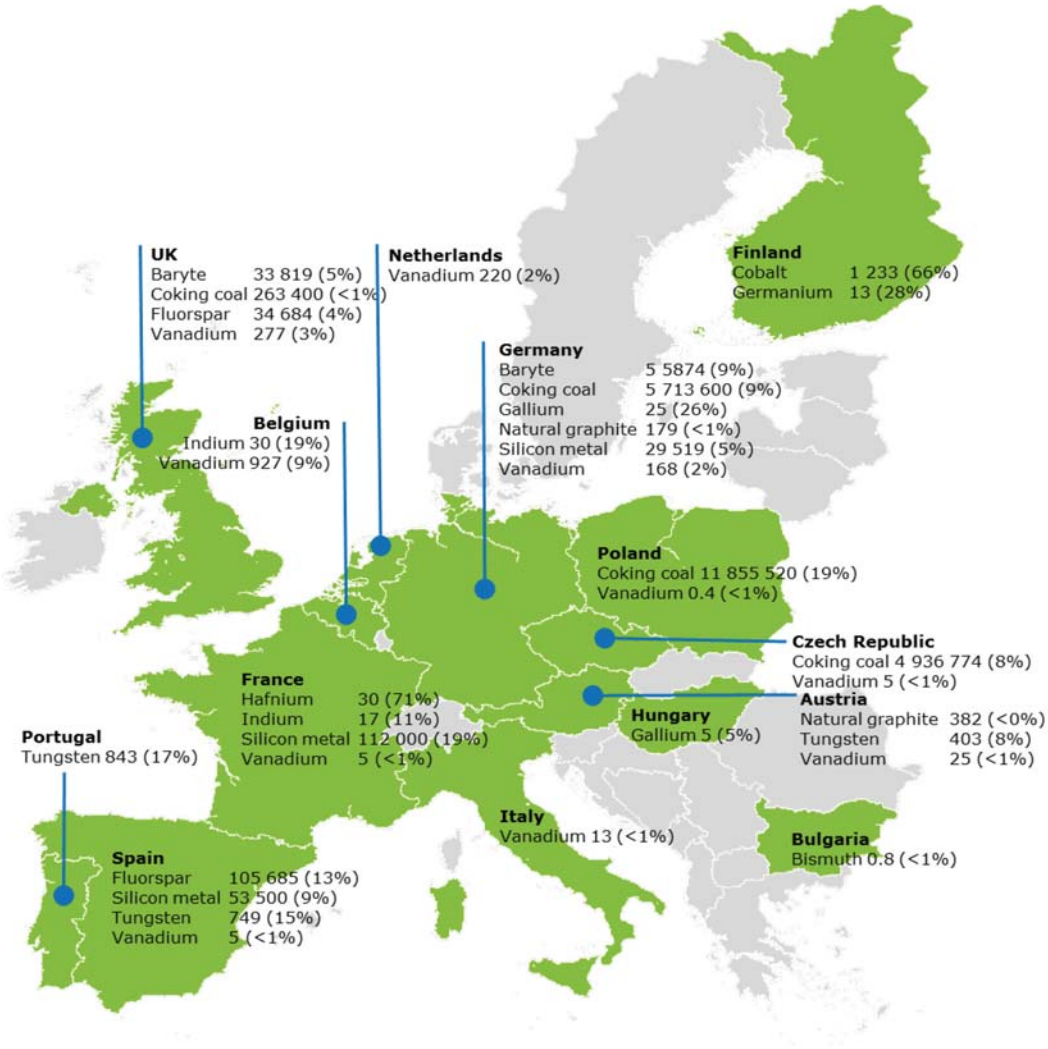

Figure 3: EU production of primary CRMs in tonnes (and share of supply to EU), average from 2010-2014

1.2. Circular economy

1.2.1. Background and definition

On 2 December 2015, the Commission adopted a Circular Economy package consisting of a Communication and an action plan[15] and proposals for revised legislation on waste[16]. It indicated that 'the transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy.'

The actions support the circular economy in each step of the value chain – from production to consumption, repair and remanufacturing, waste management, and secondary raw materials that are fed back into the economy.

15 COM(2015) 614

16 COM(2015) 593, COM(2015) 594, COM(2015) 595 and COM(2015) 596

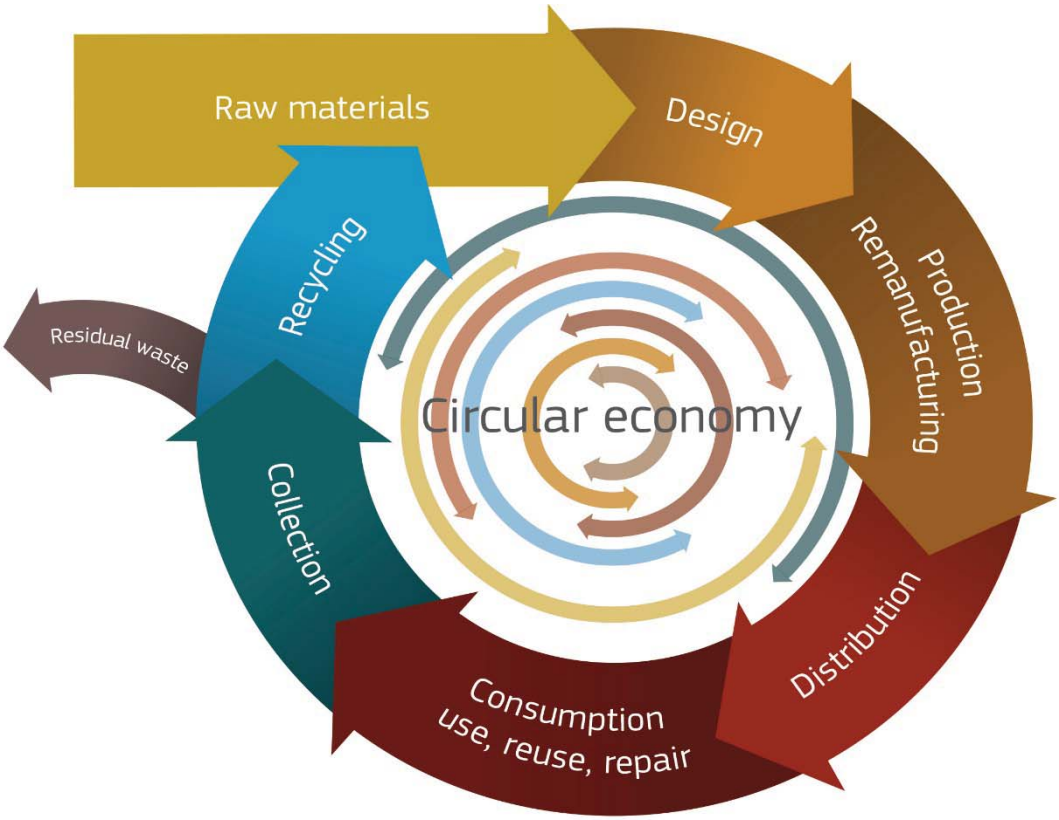

Figure 4: Conceptual diagram illustrating the Circular Economy in a simplified way

Economic actors, such as business and consumers, are key in driving this process. Local, regional and national authorities are enabling the transition, but the EU also has a fundamental role to play in supporting it. The aim is to ensure that the right regulatory framework is in place for the development of the circular economy in the single market, and to give clear signals to economic operators and society at large on the way forward with long term waste targets as well as a concrete, broad and ambitious set of actions, to be carried out before 2020. Action at EU level will drive investments and create a level playing field, remove obstacles stemming from European legislation or inadequate enforcement, deepen the single market, and ensure favourable conditions for innovation and the involvement of all stakeholders.

1.2.2. Current circular use of critical raw materials

While there is no universally agreed definition of 'circular use' of raw materials, the share of secondary sources in raw material supply is one of several simplified approaches to assess circular use.

Although several CRMs have a high technical and real economic recycling potential, and despite the encouragement from governments to move towards a circular economy, the recycling input rate (a measure of the share of secondary sources in raw material supply) of CRMs is generally low (see Fig. 5). This can be explained by several factors: sorting and recycling technologies for many CRMs are not available yet at competitive costs; the supply of many CRMs is currently locked up in long-life assets, hence implying delays between manufacturing and scrapping which negatively influences present recycling input rates; demand for many CRMs is growing in various sectors and the contribution from recycling is largely insufficient to meet the demand.

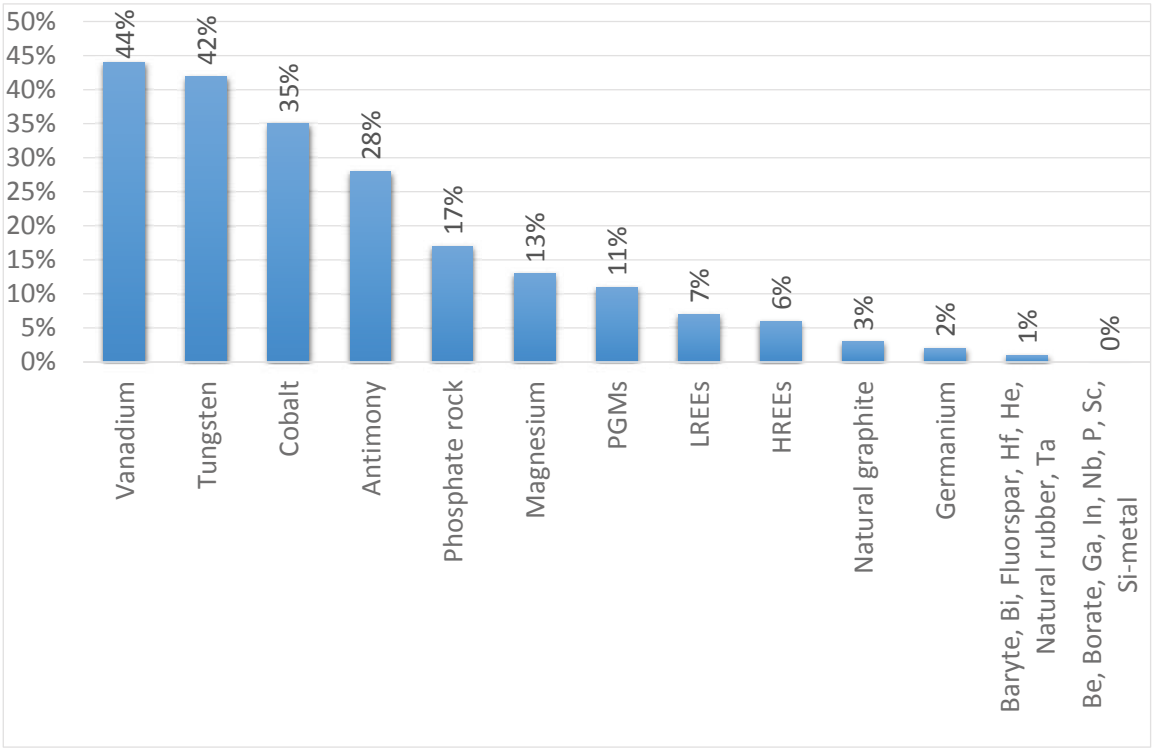

Figure 5: Current contribution of recycling to meet EU demand of CRMs: End-Of-Life recycling Input Rate (EOL-RIR) (JRC elaboration based on the 2017 CRM study and on the MSA study 2015)

A few CRMs, namely Vanadium, Tungsten, Cobalt and Antimony have a high recycling input rate. Other CRMs have a good rate of recycling at end-of-life (e.g. recycling rates for PGMs reaches up to 95% for industrial catalysts and 50-60% for automotive catalysts) but this gives a contribution that is largely insufficient to meet the growing demand and thus the recycling input rate is low (e.g. 14% for PGMs).

As a summary, the circular use of CRMs depends on many parameters. It should be pointed out that circularity is very much influenced by the sectors in which CRMs are used: the demand and the duration of the use of the CRMs is strictly dependant on the products that the CRMs are embodied in, recycling rates usually depend on the nature of the end-of-life products the CRMs are embodied in; moreover, circularity of several CRMs strongly benefits from take back-scheme that are implemented in various sectors. (See Section 5 of this report for key sector overviews.) The need to adopt a sectorial analysis for the analysis of flows of CRMs, including considering circularity aspects, was confirmed by a recent report of the SCRREEN project (see Section 3.4).[17]

1.2.3. *Benefits of a more circular use*

Just as extraction of primary CRMs in Europe helps to ensure **security of supply** of raw materials to European industry, so does their resource efficient management throughout the lifecycle and the recycling of waste into secondary CRMs. Consequently, substitution and recycling are considered as risk reducing measures in the methodology for establishing the EU list of Critical Raw Materials[18].

[17] Report on the current use of critical raw materials. http://scrreen.eu/wp-content/uploads/2017/01/SCRREEN-D2.1-Report-on-the-current-use-of-critical-raw-materials.pdf

[18] http://publications.europa.eu/en/publication-detail/-/publication/2d43b7e2-66ac-11e7-b2f2-01aa75ed71a1/language-en/format-PDF/source-32064602

Energy use (and associated CO_2 emissions and other emissions to air) and **water use** are typically much lower for secondary CRMs than for primary CRMs. Some examples are given in Table 2.

Metal	**Energy use** (MJ per kg of metal extracted)		**Water use** (m^3 per tonne of metal extracted)	
	Scrap	Ores	Scrap	Ores
Magnesium	10	165-230	2	2-15
Cobalt	20-140	140-2100	30-100	40-2000
PGM	1400-3400	18,860-254,860	3000-6000	100,000-1200,000
Rare Earths	1000-5000	5500-7200	250-1250	1275-1800

Table 2: Energy and water consumption in production of metals from scrap and ores (range given is high to low grade)[19]

Other environmental benefits of a more circular use may include for instance lower impacts on the biosphere (rainforests, arctic regions, ocean floors etc.) and/or less waste produced per tonne of material extracted.

2. GENERAL POLICY MEASURES

2.1. Waste Framework Directive

The Waste Framework Directive[20] provides for a general framework of waste management requirements and sets the basic waste management definitions for the EU. As for its future direction, the 7th Environment Action Programme sets the following priority objectives for waste policy in the EU:

- To reduce the amount of waste generated;
- To maximise recycling and re-use;
- To limit incineration to non-recyclable materials;
- To phase out landfilling to non-recyclable and non-recoverable waste;
- To ensure full implementation of the waste policy targets in all Member States.

Following a review of the Directive, the Commission adopted a proposal for changes to the Directive in December 2015 as part of its Circular Economy package. Of particular relevance are the proposed provisions on CRMs i.e. that Member States should take measures to achieve the best possible management of waste containing significant amounts of CRMs, taking economic and technological feasibility and environmental benefits into account, prevent products constituting the main sources of CRMs from becoming waste and include in their waste management plans nationally appropriate measures regarding collection and recovery of waste containing significant amounts of CRMs. The present report should help Member States implement the proposed provisions on CRMs.

[19] Sverdrup and Koca, "*A short description of the WORLD 6.0 model and an outline of elements of the standard parameterization*", 2016

[20] Directive 2008/98/EC of the European Parliament and of the Council on waste

2.2. Circular Economy Finance Support Platform

The European Fund for Strategic Investments (EFSI) is an initiative to help overcome the current investment gap in the EU. Jointly launched by the European Investment Bank (EIB) Group and the Commission, it aims to mobilise private investment in projects which are strategically important for the EU.

Linked to EFSI, a platform to support the financing of circular economy was launched together with the Commission's first report on the implementation of the Circular Economy Action Plan[21]. The platform brings together the Commission, the EIB, financial market participants and businesses to increase awareness of the circular economy business logic and improve the uptake of circular economy projects by investors.

The platform has a three-pillar structure:

- The coordination and awareness raising pillar will share best practices amongst potential project promoters and other stakeholders. It will analyse the characteristics of circular economy projects and their particular financing needs, advice on improving their bankability, as well as coordinate activities regarding financing of the circular economy. In this context, a Support to Circular Economy Financing Expert Group has been set-up. The first meeting of this expert group was held on 2 October 2017.
- The advisory pillar will be used to develop circular economy projects and to improve their bankability prospects.
- The financing pillar will explore whether a dedicated financing instrument for circular economy projects is needed.

2.3. Horizon 2020

Horizon 2020 has been instrumental in implementing the EU Raw Materials Initiative and the European Innovation Partnership (EIP) on Raw Materials (See Section 3.1). Particularly the Societal Challenge 5 on climate action, environment, resource efficiency and raw materials (SC5) has helped to respond to the challenge of securing the sustainable access to raw materials, particularly CRMs. Other major contributing parts of Horizon 2020 include the SPIRE Public Private Partnership on energy efficient raw materials production and the Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing work programmes.

More than €200 million has so far been invested in R&I actions under the SC5 developing and demonstrating sustainable production of primary and secondary raw materials, including CRMs, in the EU. The Commission already funded at least 26 research projects and policy support actions related to CRMs (see further in Section 3). All the actions should help to consolidate a growing raw materials R&I community in Europe and outside. The started or planned large innovation actions are expected to contribute to achieving the EIP target of launching at least ten innovative pilot plants for the production of raw materials and finding at least three substitutes of CRMs. Raw materials topics under the SC5 are successfully attracting industrial participation: 43% of funding goes to private companies, compared to an average 28% in SC5 as a whole.

In the last period of 2018-2020, more than €250 million will be dedicated to the actions on raw materials, including more than €100 million under a Circular Economy Focus Area. The actions should contribute to improving access to CRMs and increased recovery

[21] COM(2017) 33 final

rates in the EU, to reduced EU dependency on imports of CRMs and to strengthening the expert community in the EU.

2.4. Best practices

- France: *Le Comité pour les Métaux Stratégiques* (COMES) seeks to strengthen the security of supply of strategic metals. Its activities include work on specific recycling targets for strategic metals as part of certain extended producer responsibility (EPR) schemes.[22] The French agency ADEME also commissioned and published a study on research and development priorities for the recycling of critical metals.[23]
- The Netherlands: A Government-wide Programme for a Circular Economy[24] addresses critical mineral raw materials by promoting their substitution, efficient use, re-use and recycling. The Ministry of Economic Affairs has also commissioned the development of a "resource scanner", a method and IT tool to map out business risks.
- ERA-MIN 2: Through the Horizon 2020 programme, the Commission is co-funding ERA-MIN 2 which is the largest network of R&I funding organisations in the mineral resources field. It is a public-public partnership of 21 research funding organisations from 11 Member States, two regions and five non-EU countries[25]. In February 2017, a joint call, "Raw materials for the sustainable development and the circular economy", was published, including a topic on design of products: efficient use or substitution of critical materials in products and components, product durability, facilitation of recycling.[26]

2.5. Possible further actions

- The Commission could hold a workshop for Member States in 2018/2019 on approaches to implement the proposed provisions on CRMs under the Waste Framework Directive.

3. KEY ACTORS AND PROJECTS IN THE EU

3.1. The European Innovation Partnership on Raw Materials

The 2012 Communication proposing a European Innovation Partnership (EIP) on Raw Materials[27] asked EU and national industry, institutional stakeholders, academia, research organisations and NGOs to come up with a plan to contribute to the mid- and long-term security of the sustainable supply of raw materials in Europe. A strategic implementation plan was adopted in 2013.

Two calls for commitments from external stakeholders to implement the plan were launched in 2013 and 2015. As a result, there are currently some 105 ongoing recognised 'raw materials commitments'.[28] Several of these address CRMs and circular economy

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22 http://www.mineralinfo.fr/page/comite-metaux-strategiques

23 http://www.ademe.fr/sites/default/files/assets/documents/competences-recyclage-metaux-201706-rapport.pdf

24 'A Circular Economy in the Netherlands by 2050', September 2016, https://www.government.nl/documents/policy-notes/2016/09/14/a-circular-economy-in-the-netherlands-by-2050

25 Finland (Tekes), France (ANR and ADEME), Germany (Juelich/BMBF), Ireland (GSI), Italy (MIUR), Poland (NCBR), Portugal (FCT), Romania (UEFISCDI), Slovenia (MIZS), Spain (CDTI and MINECO) and Sweden (Vinnova); Flanders (FWO and Hermesfonds) and Castille y Léon (ADE); Turkey (TUBITAK), Argentina (MINCyT), Brazil (Finep), Chile (CONICYT) and South Africa (DST).

26 https://www.era-min.eu/system/files/call_text_era-min_joint_call_2017_0.pdf

27 COM(2012) 82, 29.2.2012

28 See https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en/call-commitments

aspects. Calls for commitments offer an opportunity for stakeholders to receive a guarantee that their initiative is in line with the objectives of the EIP, get visibility and identify potential synergies with other initiatives in this area. In 2017, the memberships of the high-level steering group and the operational groups have been renewed.

3.2. The Ad hoc Working Group on Critical Raw Materials

The Ad hoc Working Group (AhWG) on Critical Raw Materials is a sub-group of the Commission expert group called the Raw Materials Supply Group[29]. It is composed of representatives from EU Member States, European Economic Area countries, candidate countries and organisations representing industry, research and civil society stakeholders.

The AhWG assists the Commission in the regular updates of the list of the CRMs and contributes with relevant expertise. It was also consulted on the outline of the present report.

3.3. The European Institute of Innovation and Technology: Raw Materials Knowledge and Innovation Community (EIT Raw Materials)

EIT RawMaterials, initiated by the EIT (European Institute of Innovation and Technology) and co-funded under Horizon 2020, is the largest consortium in the raw materials sector worldwide. It aims to boost competitiveness, growth and attractiveness of the European raw materials sector via driving and fostering innovation and empowering students, education partners and entrepreneurs toward the circular economy. This will result in the introduction of innovative and sustainable products, processes and services, as well as talented people that will deliver increased economic, environmental and social sustainability to European society.

EIT RawMaterials unites more than 100 partners – academic and research institutions as well as businesses – from more than 20 EU countries. They collaborate on finding new, innovative solutions to secure the supplies and improve the value chain of raw materials, including CRMs, from extraction to processing, manufacturing, reuse and recycling. There are six regional hubs ("co-location centres) in Belgium, Finland, France, Italy, Poland and Sweden that promote bridging between business, research and education.

3.4. SCRREEN: the European Expert Network on Critical Raw Materials

SCRREEN (Solutions for CRitical Raw materials - a European Expert Network)[30] is a new Coordination and Support Action funded under Horizon 2020. It aims at gathering European initiatives, associations, clusters, and projects working on CRMs into a long-lasting European expert network on CRMs with stakeholders, public authorities and civil society representatives. This network builds on the previous experience of the ERECON network (see below) and combines forces to address key CRM issues including circular economy aspects in relation with policy/society, technology, standards and markets.

SCRREEN will contribute to the CRM strategy in Europe by (i) mapping primary and secondary resources as well as substitutes of CRMs, (ii) estimating the expected demand of various CRMs in the future and identifying major trends, (iii) providing policy and technology recommendations for actions improving the production and the potential substitution of CRMs, (iv) addressing specifically waste electrical and electronic equipment (WEEE) and other relevant end-of-life products with regard to CRM contents and treatment standards and (vi) identifying the knowledge gained over the last years and easing the access to these data beyond the project. The knowledge gathered within the

[29] http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=1353

[30] http://scrreen.eu

project will be maintained in the EU Raw Materials Information System (see Section 4.1.1).

3.5. ERECON: The European Rare Earths Competency Network (2013-2015)

The former European Rare Earths Competency Network (ERECON)[31] brought together experts from industry, academia and policy-making to specifically look at ways to improve the security of Europe's **rare earth** supply. Three Working Groups of ERECON were focused on primary supply of rare earths in Europe; European rare earths resource efficiency and recycling; and European end-user industries and rare earths supply trends and challenges. Key findings of the network were compiled into a final report[32].

3.6. Other Horizon 2020 and LIFE projects

Together with the SCRREEN coordination and support action a number of **Horizon 2020** research and innovation actions are currently investigating the potential substitution of CRMs. **INREP**[33] and **INFINITY**[34] are working towards indium-free transparent conducting oxides. **Flintstone2020**[35] deals with the next generation of superhard non-CRM materials and solutions in tooling substituting tungsten and cobalt.

In the area of industrial symbiosis, **SCALE**[36] aims to develop a European supply chain for scandium through the development of technological innovations which will allow the extraction of scandium from bauxite residues, the **CHROMIC**[37] project aims to develop a new recovery process for critical by-product metals (niobium and vanadium) from complex and low-grade secondary industrial waste, **CABRISS**[38] aims at the recovery and preparation for reuse of key photovoltaic raw materials including silicon and indium, to be used for the manufacturing of photovoltaic cells and panels or as feedstock for other industries and **REslag**[39] is addressing, among other things, CRMs to be extracted from steel slag.

The **LIFE Programme** (2014-2020) also contributes to sustainable use, recovery and recycling of raw materials. It is currently funding a cluster of projects dealing with CRMs such as indium, platinum group metals and magnesium. Examples of such projects are the **CRM Recovery**[40] that is demonstrating viable approaches to increase the recovery of target CRMs found in waste electrical and electronic equipment through trials in Italy, Germany, the UK and the Czech Republic and the **RECUMETAL** project[41] that is demonstrating the recycling of flat panel displays to recover plastics, indium and yttrium and their reuse in new applications.

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31 https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/erecon_en
"*Strengthening of the European Rare Earths Supply Chain - Challenges and policy options*", http://ec.europa.eu/DocsRoom/documents/10882/attachments/1/translations

33 http://www.inrep.eu

34 https://infinity-h2020.eu

35 http://flintstone2020.eu

36 http://scale-project.eu/

37 http://www.chromic.eu/

38 https://www.spire2030.eu/cabriss

39 http://www.reslag.eu

40 http://www.criticalrawmaterialrecovery.eu/

41 https://life-recumetal.eu/en/