European Commission

REPORT ON CRITICAL RAW MATERIALS FOR THE EU

Report of the Ad hoc Working Group on defining critical raw materials

May 2014

DG ENTR

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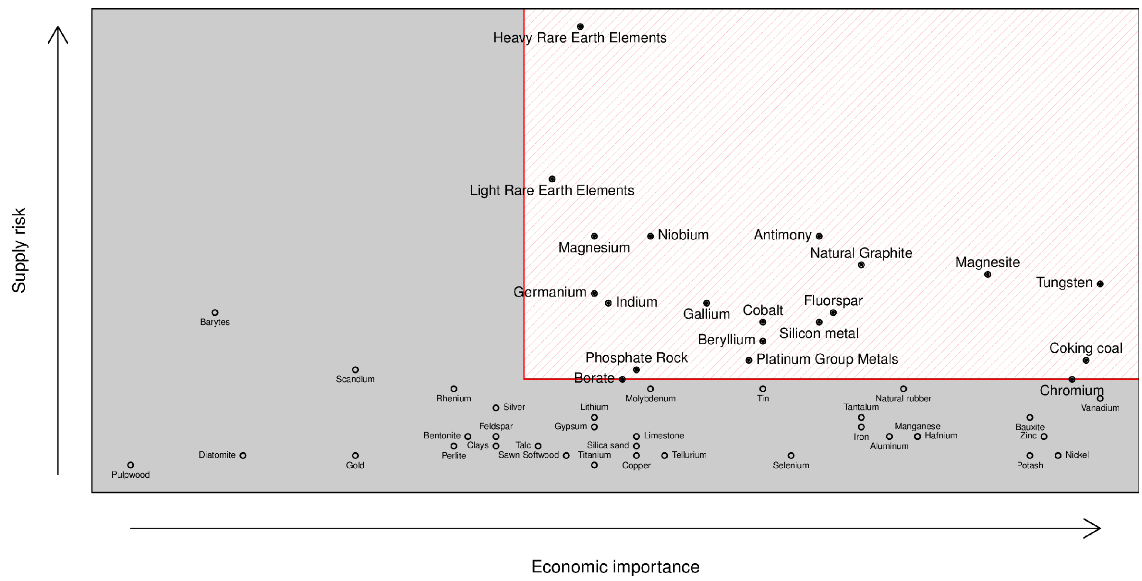
1. EXECUTIVE SUMMARY

Raw materials are fundamental to Europe's economy, growth and jobs and they are essential for maintaining and improving our quality of life. Recent years have seen a growth in the number of materials used across products. Securing reliable, sustainable and undistorted access of certain raw materials is of growing concern within the EU and across the globe. As a consequence of these circumstances, the Raw Materials Initiative was instigated to manage responses to raw materials issues at an EU level. At the heart of this work is defining the critical raw materials for the EU's economy. These critical raw materials have a high economic importance to the EU combined with a high risk associated with their supply.

The first criticality analysis for raw materials was published in 2010 by the Ad-Hoc Working Group on Defining Critical Raw Materials. Fourteen critical raw materials were identified from a candidate list of forty-one non-energy, non-agricultural materials.

In the 2013 exercise fifty-four non-energy, non-agricultural materials were analysed. The same quantitative methodology as in the previous 2010 exercise applies two criteria - the economic importance and the supply risk of the selected raw materials. The criticality zone is defined by the thresholds of 2010 to ensure comparability of the results. This extended candidate list includes seven new abiotic materials and three biotic materials. In addition, greater detail is provided for the rare earth elements by splitting them into 'heavy' and 'light' categories and scandium. The overall results of the 2013 criticality assessment are shown below; the critical raw materials are highlighted in the red shaded criticality zone of the graph.

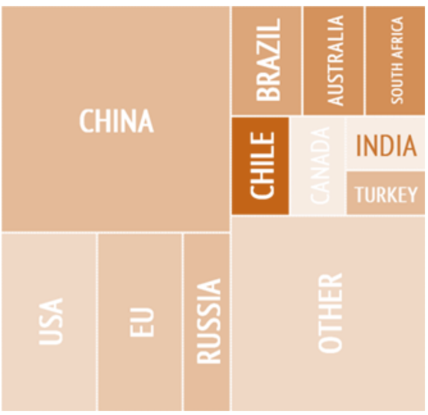


Twenty critical raw materials were identified as critical from the list of fifty-four candidate materials:

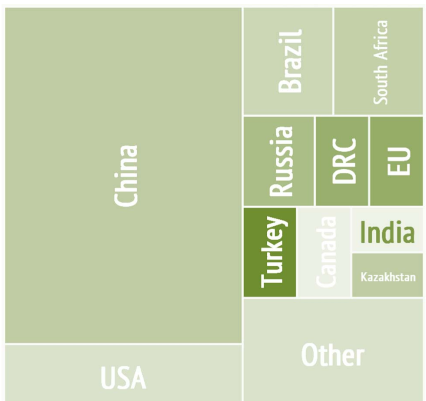
Antimony	**Beryllium**	**Borates**	**Chromium**	**Cobalt**	**Coking coal**	**Fluorspar**
Gallium	**Germanium**	**Indium**	**Magnesite**	**Magnesium**	**Natural Graphite**	**Niobium**
PGMs	**Phosphate Rock**	**REEs (Heavy)**	**REEs (Light)**	**Silicon Metal**	**Tungsten**	

This 2013 list includes thirteen of the fourteen materials identified in the previous report, with only tantalum (due to a lower supply risk) moving out of the EU critical material list. Six new materials enter the list: borates, chromium, coking coal, magnesite, phosphate rock and silicon metal. Three of these are entirely new to the report. None of the biotic materials were classified as critical. Whilst this analysis highlights the criticality of certain materials from the EU perspective, limitations and uncertainties with data, and the report's scope should be taken into consideration when discussing this list. It is worth recalling that all raw materials, even when not critical, are important for the European economy and therefore not being critical does not imply that a given raw material and its availability to the European economy should be neglected. Moreover the availability of new data may affect the list in the future; therefore the policy actions should not be limited to critical raw materials exclusively. In addition, information for each of the candidate materials is provided by individual material profiles, found in two separate documents attached to this report. Further analysis is provided for the critical raw materials within these profiles.

Analysis of the global primary supply of the fifty-four candidate materials identifies around 90% of global supply originated from extra-EU sources; this included most of the base, speciality and precious metals, and rubber. China is the major supplier when these materials are considered, however many other countries are important suppliers of specific materials; for instance, Russia and South Africa for platinum group metals. EU primary supply across all candidate materials is estimated at around 9%. In the case of critical raw materials, supply from the EU sources is even more limited. A comparison between supply of the candidate materials and the critical materials is shown below, showing that supply becomes more concentrated for the critical materials, particularly in China.

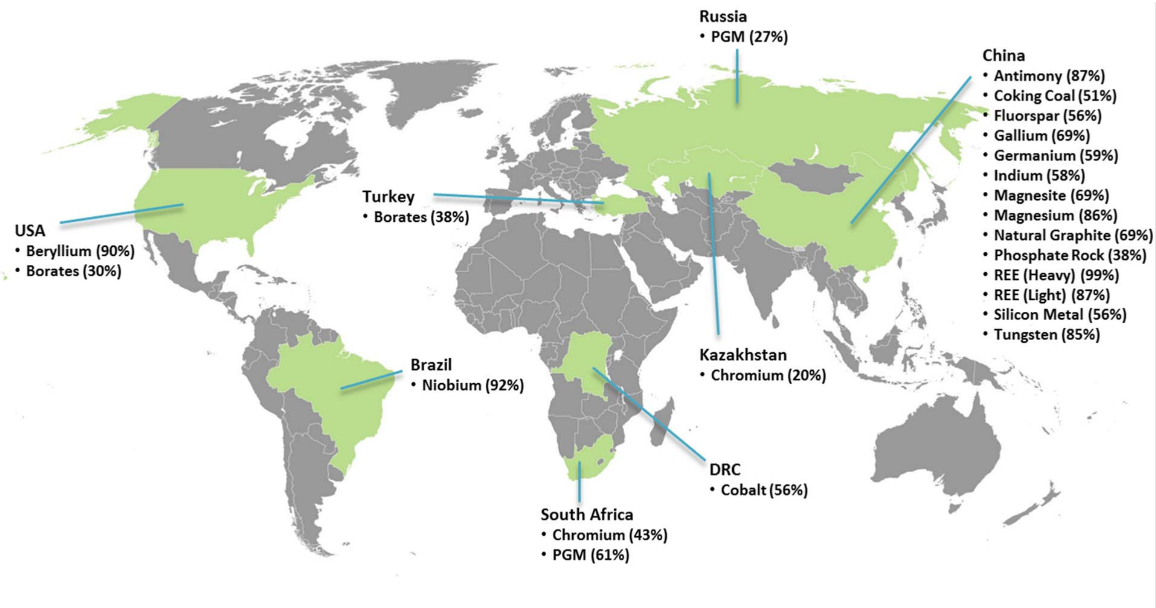


World primary supply of the 54 candidate raw materials



World primary supply of the 20 critical raw materials

The major producers of the twenty EU critical raw materials are shown below, with China clearly being the most influential in terms of global supply. Several other countries have dominant supplies of specific raw materials, such as the USA (beryllium) and Brazil (niobium). Supply of other materials, for example the platinum group metals (PGMs) and borates, is more diverse but is still relatively concentrated.



2. INTRODUCTION

2.1. Background information and purpose of the report

Although raw materials are essential for the EU economy, growth and jobs their availability is increasingly under pressure. Within the framework of the EU Raw Materials Initiative, it was decided to assess a number of raw materials at least every three years with a view to establish a list of raw materials at EU level that are deemed critical. In June 2010 the Commission published its first expert report, which established a methodology for the identification of critical raw materials. The report has put forward a list of fourteen critical raw materials. In its 2011 Communication the Commission formally adopted this list and proposed that it will monitor the issues of critical raw materials to identify priority actions, examine them with Members States and stakeholders and regularly update the list of critical raw materials. The present report further builds upon the work undertaken in the 2010 report. It should be noted that in the current report the same methodology has been used as in the 2010 in order to ensure comparability between the two lists.

The purpose of this present report is to revise and extend the work carried out in the previous report, taking into consideration feedback gathered from the previous exercise, and in doing so produce an updated list of critical raw materials for the EU.

The following items have been included within this report:

- Analysis of a wider range of abiotic raw materials, and disaggregated discussion on REE and PGMs;
- Extension of the assessment to a selection of biotic raw materials;
- Wider and more detailed analysis of the critical raw materials, including further consideration of supply chain risks and issues, and forward looking trends and forecasts for supply and demand;
- Use of higher quality data and greater transparency in the assessment.

The present report is the result of intense cooperation between the European Commission, the Ad hoc Working Group on Defining Critical Raw Materials and consultants from Oakdene Hollins, Fraunhofer ISI and Roskill. The Ad hoc Working Group is an expert sub-group of the Raw Materials Supply Group, comprising representatives from the Member States, from the extractive industries, intermediate user (e.g. steel), from downstream industries, from the recycling industry, from academia and from geological survey(s).

The purpose of the list of 20 critical raw materials is to contribute to the implementation of the EU industrial policy and to ensure that European industrial competitiveness is strengthened through actions in other policy areas. This should increase the overall competitiveness of the EU economy, in line with the Commission´s aspiration of raising industry’s contribution to GDP to as much as 20% by 2020. It should also help to incentivise the European production of critical raw materials and facilitate the launching of new mining activities. The list is also being used to help prioritise needs and actions. For example, it serves as a supporting element when negotiating trade agreements, challenging trade distortion measures or promoting research and innovation actions. It is also worth emphasising that all raw materials, even if not classed as critical, are important for the European economy and that a given raw material and its availability to the European economy should therefore not be neglected just because it is not classed as critical.

2.2. Concerns over Raw Materials

Raw materials are fundamental to Europe's economy, growth and jobs and are essential for maintaining and improving our quality of life. While the importance of energy materials such as oil and gas has often been highlighted, historically the indispensable role of metals, minerals, rocks and biotic materials has had lower profile. However, more recently securing reliable, sustainable and undistorted access to crucial non-energy raw materials has been of growing concern in economies such as those of the EU, US and Japan. Responses have been initiated in different nations, economic areas and companies, with the European Commission launching the "Raw Materials Initiative (RMI) - meeting our critical needs for growth and jobs in Europe" in 2008 to manage raw materials issues at the EU level. The original inception of the RMI stemmed from concerns over a combination of several complex factors linked to the importance of raw materials and changing supply conditions.

Irreplaceable role in industry and society

Non-energy raw materials are intrinsically linked to all industries across all supply chain stages, and consequently they are essential for our way of life – everything is made from materials. Sectors may rely on these materials as direct inputs, for instance metals refining relies on metallic ores as well as on industrial minerals. This primary industry underpins downstream sectors, which utilise processed materials in their products and services. For example, the healthcare sector uses equipment containing high performance magnets made from rare earth elements, electricity distribution relies on pylons and cables constructed of aluminium and copper respectively, and most vehicles are equipped with tyres which are comprised of natural rubber. As a society we rely on the availability of these goods to maintain our quality of life.

Further to established applications, future technological progress and improving quality of life are also reliant on access to a growing number of raw materials. The rapid development of hi-tech goods and environmental applications over recent decades has led to shifts in demand patterns for raw materials. The growth in use of flat panel televisions and touch screens is reliant on the supply of indium used in transparent conducting layers; previously this metal was only found in niche applications. The complexity and sophistication of these products is growing, leading to a corresponding increase in the number of materials used in their production; for instance the number of materials used in printed circuit boards has grown from a handful to sixty over the last three decades. This is coupled with increasing product complexity, for example a modern mobile phone may contain 500 to 1,000 different components. The same is true for countless other products. These changing needs have further highlighted the reliance on a wider group of raw materials.

Improving environmental performance is also closely linked to raw materials, both at present and in the future. Exhaust emissions from internal combustion engines are managed through catalytic converters containing platinum group metals; no other option is viable at present. Low carbon technologies also require that the correct resources are available. Many wind turbines designs use magnets containing rare earth elements, and solar panels rely on metals such as silicon, tellurium and indium amongst others. Similar cases are seen for electric vehicles and energy efficient lighting.

Only a few examples are provided above, however, it is apparent that if the quality and way of life within the EU Member States is to be maintained and improved, continued access to non-energy raw materials is essential.

EU resource dependence and concentration of supply

All countries are dependent on raw materials. This is particularly true for Europe which is highly dependent on non-energy raw materials to sustain businesses and the economy. It has been estimated that 30 million jobs in the EU are directly reliant on access to raw materials.[1] However, very little primary production occurs within Member States themselves, with the majority produced and supplied from third countries. Primary supply figures for the fifty four materials assessed in this report show that supply is dominated by non-EU countries, with no EU28 countries in the top ten producers (Table 1). The total EU28 contribution to overall materials supply can be estimated at around 9%, with France, Germany and Italy ranked the highest individually, largely due to industrial mineral production.[2]

Table 1: Countries supplying raw materials to the global market

Country	Materials Produced*	Total % of supply		Country	Materials Produced*	Total % of supply
China	48	30%		**South Africa**	26	3.9%
USA	36	10%		**Chile**	18	3.4%
Russia	42	4.9%		**Canada**	30	3.2%
Brazil	36	4.6%		**India**	30	2.5%
Australia	34	4.0%		**Turkey**	25	2.1%

** Supply data from the 54 materials assessed in this report, sources in Annex C*

In terms of materials, perlite (37%) and several other industrial minerals have the largest supply from within the EU, with hafnium refining (47%) also being important. By contrast there is no significant production of materials such as borates, indium, rare earths, and titanium within the EU, with many others produced in small quantities. The EU has many and uncharacterised and unexplored deposits; however, the existing economic and regulatory climate, combined with growing land use competition limits the exploitation. Secondary supplies can reduce the demand for primary materials. However, for many materials very little recycling and recovery occurs. In most of the cases it cannot completely replace primary supply even for materials with high recycling rates. Therefore much of Europe's industry and economy is reliant on international markets to provide access to essential raw materials.

1 COM(2008) 699 final Communication on the Raw Materials Initiative "Meeting our critical needs for growth and jobs in Europe"

2 Data sources are summarised in Annex B

Moreover, the production of many materials is reliant on a few countries outside of the EU. This concentration of supply can be observed for instances for the following cases: Brazil (niobium), USA (beryllium), South Africa (platinum) and China (rare earth elements, antimony, magnesium, and tungsten). Supply concentration has often been coupled with growing competition for materials from emerging economies, and proliferation of both economic and "resource nationalism". This is a reflection of many factors, such as growing economies in developing countries and evolving materials' markets. These have contributed to a restriction in supply from the World's most important suppliers, increasing risk across supply chains. The accompanying rises in the prices and price volatility of raw materials are of continuing concern to EU Member States, as this reduces the competitiveness of manufacturing compared with other economies. This clearly has an impact on the whole industrial value chain.

2.3. Raw Materials policies and initiatives

2.3.1. EU Raw Materials Policy

In order to address the complex and interrelated challenges described above, the European Commission formulated an integrated policy in 2008, called the EU Raw Materials Initiative (RMI). This is the major European Union strategy relating to raw materials. The RMI has been developed based on three pillars:

1. Ensuring a level playing field in access to resources in third countries
2. Fostering sustainable supply of raw materials from European sources
3. Boosting resource efficiency and promoting recycling.

The original RMI communication has been followed up further communications on "tackling the challenges in commodity markets and on raw materials" in 2011[3], and reporting on the progress of the RMI in 2013[4]. Together with the current report, the Commission has also published the list of critical raw materials through a Commission Communication on 26 May 2014 on the review of the list of critical raw materials and the implementation of the Raw Materials Initiative..

Raw materials are also an integral part of the Europe 2020 strategy to ensure smart, sustainable and inclusive growth and is closely linked to the flagship initiatives - "Industrial policy for the globalisation era"[5] and "Resource efficient Europe".[6] The list of critical raw materials helps defining the forward looking EU policies in different areas including research and innovation, industrial policy, trade, development and recently also in the communication on the Defence and Security Sector[7]. In this Communication the Commission committed to assess the criticality of raw materials for the defence sector, within the context of the overall RMI. This work will be carried out in cooperation with the European Defence Agency. The

3 EC COM(2011) 0025 Tackling the Challenges in Commodity Markets and on Raw Materials

4 EC COM(2013) 0442 On the implementation of the Raw Materials Initiative

5 EC COM(2010) 2020 "Europe 2020", and COM(2010) 614 "An Integrated Industrial Policy for the Globalisation Era".

6 EC COM(2010) 2020 "Europe 2020", and COM(2011) 21 "A resource-efficient Europe: flagship initiative under the Europe 2020 strategy".

7 EC COM(2013) 0542 Towards a More Competitive and Efficient Defence and Security Sector

Joint Research Centre has also taken a keen interest in many aspects of critical raw materials supply issues including in the defence sector and the energy sector.[8] [9]

In response to the Europe 2020 Flagship Initiative Innovation Union[10] and growing raw materials challenges, the Commission launched in 2012 the European Innovation Partnership on Raw Materials (EIP)[11]. Its aim is to ensure the sustainable supply of raw materials to the European economy whilst increasing benefits for society as a whole, by promoting innovation across the entire raw materials value chain. It does so by supporting technologies, improving the framework policy conditions for raw materials, and by promoting international cooperation. The European Innovation Partnership (EIP) on raw materials, brings together EU Member States and other key stakeholders - such as European companies, European researchers, and European NGOs.

In order to tap the full potential of primary and secondary raw materials and to boost the innovation capacity of the EU raw materials sector, a number of challenges along the entire raw materials value chain will be addressed in the Raw materials part of the Societal Challenge 5 of Horizon 2020. It focuses on non-energy and non-agricultural raw materials used in industry (metallic minerals, industrial minerals, construction materials, wood and natural rubber).

The European Parliament is also active in the raw materials area, with a cross-party group of MEPs for raw materials forming in 2011, and a series of reports discussing issues around raw materials supply.[12] In addition, the European Rare-Earth Competency Network (ERECON), a pilot requested by the European Parliament, carried out by the Commission, was launched in 2013. It should facilitate an open discussion among experts and create a network of excellence and cross-disciplinary exchange in order to enhance the knowledge of the most efficient use of rare earth elements, their mining, refining, recycling and substitution.

2.3.2. Member States

In addition to European level initiatives, many of the individual Member States have produced studies and policies in the area of raw materials in order to identify materials that are important to their economies, actions to secure long term supply of raw materials or to place issues within the wider context of resource efficiency. As such the results, conclusions and outcomes from national studies differ from the European report. The following is a snapshot from selected countries:

French Strategic Metals Plan (2010) identifies areas where France is vulnerable to shortage of critical materials/metals and suggests options for the French Government to take concrete measures to secure future supply of critical materials.

Finland's Minerals Strategy (2010) outlines a strategy for Finland to exploit known and potential mineral resources to 2050. This aims to ensure that Finland's domestic mineral sector remains dynamic and globally competitive, as well as

8 EC JRC (2010 & 2013) Assessing metals as Supply Chain Bottlenecks in Priority Energy Technologies & Critical Metals in the Path towards the decarbonisation of the EU Energy Sector

9 http://lct.jrc.ec.europa.eu/assessment/assessment/assessment/ResourceSecurity-SecuritySupply

10 COM(2010) 546 final " Europe 2020 Flagship Initiative Innovation Union ".

11 COM(2012) 82 final "Making Raw Materials Available For Europe's Future Wellbeing Proposal For A European Innovation Partnership On Raw Materials".

12 For examples see: European Parliament Report (2011), Report on an effective raw materials strategy for Europe & STOA(2012), Study on Future Metal Demand from Photovoltaic Cells and Wind Turbines

ensuring access to minerals for Finish industry, particularly materials identified as critical.

German Government's Raw Materials Strategy (2010) aims to safeguard a sustainable supply for the German economy. Although ensuring the own supply of raw materials is still the task of the industry. Instruments of raw materials policy aim at improving the competitiveness and resource efficiency, while promoting research and innovation[13].

Dutch Policy on Raw Materials (2011) outlines three key aims: to secure availability and improve sustainability of raw materials, to restrict/reduce demand national demand for raw materials and to improve the efficiency and sustainability of raw materials consumption with the Dutch economy.

United Kingdom's Resource Security Action Plan (2012) is a joint strategy on natural resources. It details how the UK Government recognises these issues, provides a framework for business action to address resource risks, and sets out a plan-of-action to build on the existing partnership between Government and business on natural resource concerns. The Resource Security Action Plan was accompanied by a review of national resource strategies and research activities.

Sweden's Minerals Strategy aims at strengthening the country's position as one of the EU leading mining and minerals nations, and to create growth throughout Sweden by means of sustainable use of the country's mineral resources, in harmony with environmental, natural and cultural values.

2.3.3. International initiatives

Materials security and materials criticality has also been of growing interest internationally, leading to a number of studies and initiatives relating to raw material supply and criticality. Several countries, including both suppliers and users of raw materials have instigated studies and initiatives to develop national strategies for securing a stable supply of raw materials, linked to the most important materials for their economy. The goals, responses and relevant materials to the responses are highlighted from this US Department of Energy review.

Table 2: Materials Research and Development Policies of selected non-EU countries

Nation	Goal	Key materials identified for action	R&D Policy
Japan	Secure a stable supply of raw materials for Japanese industries	Cobalt, Nickel, Manganese, Molybdenum, REE, Tungsten, Vanadium	• Substitution research funded through METI & MEXT • Exploration, excavation, refining and safety research funded through JOGMEC
China	Maintain a stable supply of raw materials for domestic use through industry consolidation, mitigating overproduction &	Antimony, Tin, Tungsten, Iron, Mercury, Aluminium, Zinc,	• Rare earth separation techniques & exploration of new functional

13 http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm

	reducing illegal trade	Vanadium, Molybdenum, REEs	materials • Rare earths: metallurgy; optical, electrical, magnetic properties; basic chemical sciences
South Korea	Ensure a reliable supply of materials critical to Korean mainstay industries	Arsenic, Titanium, Cobalt, Indium, Molybdenum, Manganese, Tantalum, Gallium, Vanadium, Tungsten, Lithium, REEs	• Recycling end-use products • Designing for recyclability • Substitute materials • Production efficiency
Australia	Maintain investment in the mining industry & fairly taxing the depletion of national resources	Tantalum, Molybdenum, Vanadium, Lithium REEs	• Promote sustainable development practices in mining
Canada	Promote sustainable development & use of resources, protect the environment & public health, ensure attractive investment climate	Aluminium, Silver, Gold, Iron, Nickel, Copper, Lead, Molybdenum.	• Provide comprehensive geosciences information and infrastructure • Promote technological innovation in mining processes • Value-added mineral & metal products

Source: Adapted from US Department of Energy (2010), Critical Materials Strategy

Whilst this analysis focuses on R&D responses, it highlights the different stages of the supply chain where countries are placed and consequently the different approaches taken. For example, China focuses heavily on processing and metallurgy, South Korea on recycling, Australia on sustainable mining and Canada in exploration. Funding for some of these programmes can often be vast, for example South Korea is investing over 218 million EUR[14] over 10 years for its research into forty technologies covering refining, smelting, processing, recycling and substitution. Other strategies have also been adopted. Russia is also known to have an active programme on materials stockpiles and export restrictions, China has tightened the export quotas for rare earth elements ostensibly to secure internal supply, and the US has long had a stockpile for strategic defence materials.

In the broader context of raw materials supply concerns are also being raised over the origin and responsible sourcing of raw materials, leading to renewed concerns over supply for various materials such as cobalt and gold. Materials stewardship schemes and legislation have been put in place to provide greater confidence and traceability in various materials markets, for example, schemes such as the Extractive Industries Transparency Initiative (EITI) or the International Council on Mining and Metals" Materials Stewardship Scheme.

14 $300million: Converted at the exchange rate of 14.05.2014: http://www.ecb.europa.eu/stats/exchange/eurofxref/html/eurofxref-graph-usd.en.html

2.4. Materials Criticality and Previous EU Report

2.4.1. Criticality in context

Materials security issues have been of growing interest to researchers, governments, industry and other organisations alike due to increasing concerns over access to raw materials and the impact supply shortages may have. A central part of many initiatives identified above and elsewhere is to assess which materials are most "critical", allowing the most appropriate actions to be identified and taken. As a result a variety of criticality assessments have been published, each seeking to evaluate the criticality of a group of materials in relation to each other.

These studies may consider materials in different contexts:

- A specific economic zone or country, such as the EU report
- A technology focus, such as the work by the EU's JRC[15] or the US Department of Energy[16] on low carbon energy technologies, or sectors such as ICT and defence.[17]
- A company, such as analysis performed by General Electric[18]
- A more general view of supply risks or criticality for raw materials, often taking into account a longer term view.[19,20]

In addition, assessments may evaluate different set of materials chosen for context and use different criticality measures and methodologies. Whilst the aims and scopes of these analyses do vary, they all apply a selection of indicators to a group of materials to identify a list of critical materials, often combining a measure of supply risk against one of relative importance.

2.4.2. Critical raw materials for the EU in 2010

The rationale behind the **Report on Critical Raw Materials at EU Level**[21] in 2010 was prompted by the highlighted concerns over securing reliable, sustainable and undistorted access to non-energy raw materials, and the detrimental impact on the wider European economy to which supply issues may lead. To identify which raw materials can be considered critical to the EU, a methodology for assessing raw materials was developed by the AHWG, assessing economic importance to the EU against supply risk.[22] This methodology was devised to allow assessment of a diverse range of raw materials important to the EU's economy, allowing a pragmatic approach to the assessment of criticality that was broadly applicable. From an original list of forty one non-energy raw materials in scope, fourteen were identified as critical to the EU (Table 3).

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15 EC JRC (2010 & 2013) Assessing metals as Supply Chain Bottlenecks in Priority Energy Technologies & Critical Metals in the Path towards the decarbonisation of the EU Energy Sector

16 US Department of Energy (2011), Critical Materials Strategy

17 Annex D contains a brief discussion of these sectors from the EU perspective. These summaries highlight several raw materials, with those commonly identified across sectors including REEs (particularly dysprosium, erbium, neodymium, yttrium), indium and gallium.

18 General Electric (2010), Research Priorities for More Efficient Use of Critical Materials from a U.S. Corporate Perspective

19 Rosenau-Tornow et al, Resources Policy (2009), Assessing the long-term supply risks for mineral raw materials—a combined evaluation of past and future trends

20 Graedel et al, Environmental Science & Technology (2011), Methodology of Metal Criticality Determination

21 EC (2010), Critical Raw Materials at EU Level

22 An overview of this methodology is provided in Section 4.

Table 3: The 14 critical raw materials identified in the 2010 report:

Antimony	**Beryllium**	**Cobalt**	**Fluorspar**
Gallium	**Germanium**	**Graphite**	**Indium**
Magnesium	**Niobium**	**PGMs**	**REEs**
Tantalum	**Tungsten**		

However it is important to highlight that whilst these fourteen materials were identified as critical, concerns associated with other materials are also discussed by this work. As part of this report the Ad hoc Working Group recommended that this work was revised at regular intervals to ensure that it remained relevant and up to date, including revision of the criticality assessment. Therefore the aim of this report is to present the findings of the 2013 revision.

3. MATERIALS SCOPING

The scope of materials considered in this report includes fifty-four non-energy, non-agricultural abiotic and biotic materials which have been identified as important to the EU's economy (Table 4). These materials represent a diverse group, including materials that are mined or cultivated as well as some refined materials that are considered highly important to downstream sectors.

Table 4: List of candidate materials

Aluminium	**Antimony**	**Barytes**	**Bauxite**	**Bentonite**	**Beryllium**
Borates	**Coking Coal**	**Chromium**	**Clays (and kaolin)**	**Cobalt**	**Copper**
Diatomite	**Feldspar**	**Fluorspar**	**Gallium**	**Germanium**	**Gold**
Gypsum	**Hafnium**	**Indium**	**Iron ore**	**Limestone (high grade)**	**Lithium**
Magnesite	**Magnesium**	**Manganese**	**Molybdenum**	**Natural Graphite**	**Natural Rubber**
Nickel	**Niobium**	**Perlite**	**Phosphate Rock**	**Platinum Group Metals**	**Potash**
Pulpwood	**Rare Earth Elements – Heavy ***	**Rare Earth Elements – Light ***	**Rhenium**	**Sawn Softwood**	**Scandium***
Selenium	**Silica Sand**	**Silicon Metal**	**Silver**	**Talc**	**Tantalum**
Tellurium	**Tin**	**Titanium**	**Tungsten**	**Vanadium**	**Zinc**

* Rare Earth Elements are split in 3 categories: Light, Heavy and Scandium

Compared with the 2010 report, in which forty one materials were analysed, new abiotic materials have been added, and biotic materials are assessed for the first time. These newcomers are highlighted in blue in Table 4. In addition, the rare earth elements group has been split into three smaller groups. This reflects changing concerns over specific materials, as well as the desire to analyse criticality across a broader range of materials.

The materials under consideration include industrial minerals, ores, biotic materials, and processed or refined materials. Each of these may have different grades or types, particularly for industrial minerals and wood based materials. Additionally, a detailed description of the material assessed is provided in the individual material profiles.[23] However, the overall approach to the assessment remains consistent with the previous report, allowing comparison of results across the two studies. It is also to be noted that in certain cases products derived from a specific raw material cannot always be appropriately distinguished in the custom/NACE codes. The Ad hoc Working Group on Defining Critical Raw Materials will have a closer look at this issue for the next revision of the list.

An overview of the six 'newcomers'is given below. The 'newcomers' are those raw materials which were not deemed 'critical' in the previous report of the 'Ad hoc Working Group on defining Critical Raw Materials for the EU' but which became 'critical' in the 2013 report:

23 For instance in the case of Clays (and Koalin), kaolin and kaolinitic clays are assessed, and Limestone (high grade) refers specifically to ground calcium carbonate.

- Borates: The country production figures[24] show a higher level of concentration in comparison to the previous report leading to an increase in supply risk. The latter is now just over the threshold. The company concentration is low compared with other materials, though there is limited data available. The number of suppliers and/or supply distribution did not change compared to the critical raw materials report of 2010. The economic importance has increased due to changes in use patterns and megasector values. The recycling rate is low and there are limited options for substitution, particularly in its main application, i.e. in glass.

- Chromium: The supply risk increased due to greater concentration of supply in main producing countries, combined with more detailed statistics for the smaller producers. Chromium is just over the supply risk threshold; therefore it could be considered a borderline case. Recent changes in the market may alter this, and some producers indicate there is overcapacity within Europe. In addition the corporate concentration for chromium is relatively low, however it has increased over the past five years. There is a small decrease in economic importance, due to change in use patterns and megasector value. The recycling rate is low and there are limited options for substitution, particularly in its main application, i.e. in stainless steel

- Coking coal: The supply risk is high, linked to high concentration of supply in China and Australia. The economic importance is calculated as high due to use in the metallurgy sector. The recycling is non-existent for main uses. Some options for substitution are available. Coking coal is being assessed for the first time.

- Magnesite: The country production figures show a higher level of concentration than those used in the calculations in the previous report of 2010, with China's share increasing and Brazil's reducing.[25] There is small decrease in economic importance, due to change in use patterns and megasector values. The recycling is non-existent for main uses and only a few options for substitution are available in the main uses.

- Phosphate rock: There is a high supply risk due to concentrated production from three main countries, though it is close to the supply risk threshold. Corporate concentration for this material appears relatively high compared to other materials, rising over the past five years. The economic importance is moderately high, exceeding the criticality threshold. There is no recycled input and substitution is impossible in its main application as an input to fertilisers and other chemicals. Phosphate rock is being assessed for the first time.

- Silicon metal: There is a high supply risk due to high proportion of production from China, with the remainder spread out across other countries. The economic importance is calculated as high due to use in metallurgy and chemicals sectors. There is no recycled input and the options for substitution are limited, and none in its main application in aluminium production. Silicon metal is being assessed for the first time.

24 Please consult the fact sheets of the critical raw materials.

25 Idem

3.1. Abiotic Materials

The abiotic materials considered include all the forty one materials included in the 2010 report, with coking coal, gold, hafnium, potash, phosphate rock, selenium, silicon metal and tin added.

In line with the previous report, the abiotic raw materials consist of metals (or metallic ores) and industrial minerals using the following definitions:

- Metallic ore: a rock or sediment containing one or more minerals from which one or more metals can be extracted.

- Industrial mineral: mineral, which may be used in an industrial process directly due to its chemical/physical properties. Industrial minerals are used in a range of industrial applications including the manufacture of steel, chemicals, glass, fertilisers and fillers in pharmaceuticals and cosmetics, ceramics, plastics, paint, paper, and the treatment of gases and waste, etc. Industrial minerals include barites, bentonite, borates, clays, diatomite, feldspar, fluorspar, gypsum, limestone, silica sand, talc, and many others.

As before, a breakdown of certain material's value-chains is considered in order to analyse their specific supply risks. This was the case for bauxite/aluminium and magnesite/magnesium.

Two groups of materials, platinum group metals (PGMs) and rare earth elements (REEs) are included in this scope. The PGMs consist of six metals: palladium, platinum, rhodium, ruthenium, iridium and osmium. These have been grouped together for the purposes of the criticality analysis to allow comparison with the previous report. Additional information is provided for palladium, platinum and rhodium in the materials profiles to allow for a more nuanced understanding of influencing factors.

The REEs are a group of seventeen metals, which are often discussed together due to their similar properties (Table 5). In the previous report the REEs were considered as a single group. To provide greater insight in this report, and to reflect the different supply and demand issues faced by different REEs, this single group is been split into three in this analysis: light rare earth elements (LREE), heavy rare earth elements (HREE) and scandium.

Whilst a formal definition of which metals constitute the REEs exists, different sub-divisions may be used depending on context. For the purposes of this report scandium has been treated completely separately as its production and applications are not strongly linked to the other REEs. The remaining sixteen metals are split into light and heavy groupings. This distinction is commonly made, however different groupings are used depending on context, for instance from a technical or from an economic assessment. Within this report the REEs have been split into LREEs and HREEs between samarium and europium. This is the approach taken by several market reporters and mining companies. This division is partly based on respective chemical properties and geological availability, but also upon their different sources, supply demands, market values and end-markets. As with the

PGMs, more detailed information is provided within the profiles for each individual metal identified in Table 5.

Table 5: Classification of rare earth elements in EU Critical Raw Materials studies

2010 Report	2013 Report	Rare Earth Elements
Rare Earth Elements	Scandium	Scandium
	Rare Earth Elements -Light (LREE)	Lanthanum
		Cerium
		Praseodymium
		Neodymium
		Samarium
	Rare Earth Elements -Heavy (HREE)	Europium
		Gadolinium
		Terbium
		Dysprosium
		Erbium
		Yttrium
		Others (holmium, erbium, thulium, ytterbium, and lutetium)

3.2. Biotic Materials

Biotic raw materials are materials which are derived from renewable biological resources that are of organic origin but not of fossil origin. Biotic materials have been included within this criticality report as a result of concerns over limited supply and issues relating to responsible and sustainable sourcing, as seen for other raw materials. Three biotic materials have been included in the criticality assessment:

- Natural rubber
- Pulpwood
- Sawn Softwood

4. CRITICALITY ANALYSIS

4.1. Introduction

This section presents the updated criticality analysis for all raw materials. This assessment has used the same methodology, indicators and thresholds as the original 2010 criticality assessment at EU level, but with updated data and a wider range of materials. This enables a side-by-side comparison of both assessments (2010 and 2013) to understand how the criticality of materials has changed during this time. A review of the feedback and other studies indicated that the overall approach and methodology remains appropriate for the context and aims of the report, allowing various factors influencing criticality to be captured at a broad level. The scope of materials included in this analysis has been expanded compared to 2010; this has been described in Section 3.

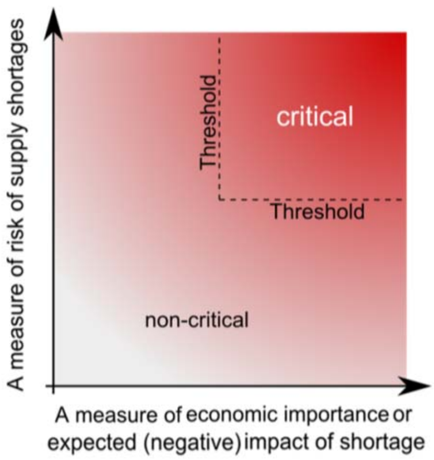
4.2. EU Criticality Methodology

The EU methodology used to assess criticality has a combination of two assessment components:

- Economic importance.
- Supply risk – Poor governance

Compound indicators are used for each of these two assessment components; therefore each takes multiple factors into account. The result is a relative ranking of the materials across the two assessment components, with a material defined as critical if it exceeds both the threshold for economic importance and the supply risk (Figure 1).

Figure 1: General scheme of the criticality concept projected into two dimensions.



Source: Sievers, Henrike; Buijs, Bram; Tercero Espinoza, Luis A. (2012): Limits to the critical raw materials approach. In: Proceedings of the ICE - Waste and Resource Management 165 (4), 201–208.

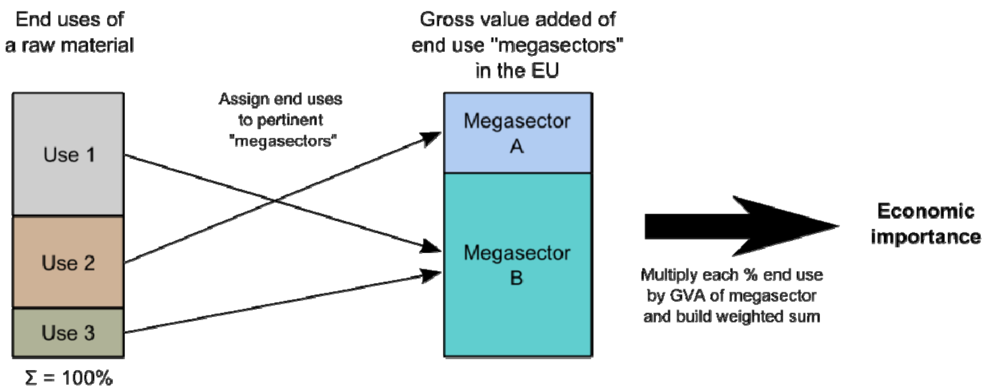
The general approach to calculating the Economic importance and the Supply risk assessment component for each of the materials is described below.

4.2.1. Economic importance

Measuring the economic importance of a raw material for an economy is a complex task, presenting not only data but also conceptual and methodological difficulties. Because of this, a pragmatic approach was taken when developing the methodology to allow the comparison of non-energy raw materials in a relative ranking.

This analysis is achieved by assessing the proportion of each material associated with industrial megasectors at an EU level (Figure 2). These proportions are then combined with the megasectors' gross value added (GVA) to the EU's GDP. This total is then scaled according to the total EU GDP to define an overall economic importance for a material.

Figure 2: Visualization of the compound indicator for economic importance. GVA = Gross value added obtained from EUROSTAT's Structural Business Statistics for the EU27.



Source: Fraunhofer ISI.

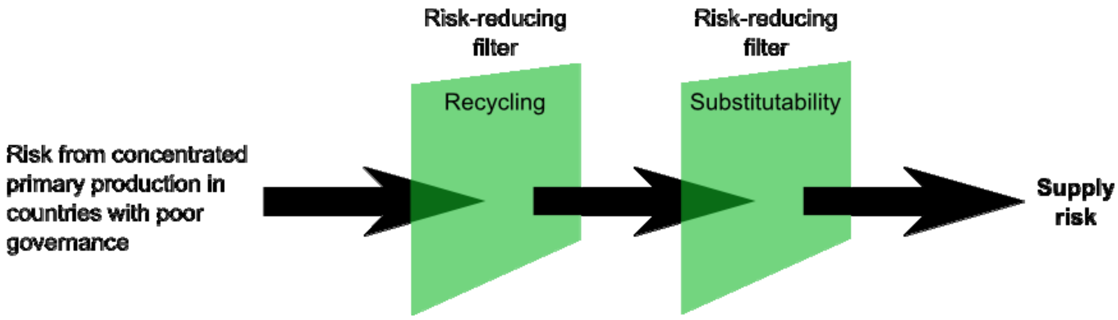
A key feature of the approach is that it is independent of both market size and price of the individual raw materials. Instead it focuses on the benefit these raw materials have for the European manufacturing economy, which can be viewed as more in line with a measure of "impact".

4.2.2. Supply risk (Poor governance)

Within the methodology, a large influence on supply risk is assumed to be concentrated primary supply from countries exhibiting poor governance because the supply may be interrupted e.g. through political unrest. It should be noted that no direct indicator of geological availability is included within this methodology due to the timescales considered.

However, the above mainly applies to primary production, because if any secondary production takes place it does not depend on geology. Therefore, the supply risk is seen to be reduced by the availability of secondary supply from end-of-life products. Furthermore, the risk is reduced by the existence of options for full substitution (price and performance). The interplay of these individual elements yield a composite indicator for supply risk as is shown graphically in Figure 3.

Figure 3: Visualisation of the compound indicator for supply risk as defined by Critical Raw Materials



Therefore the overall supply risks are considered to arise from a combination of several factors, namely:

1. substitutability;
2. end-of-life recycling rates;
3. high concentration of producing countries with poor governance..

'Substitutability Index' is a measure of the difficulty to substitute the material, scored and weighted across all applications. Values are between 0 and 1, with 1 being the least substitutable.

'End-of-life Recycling Input Rate' measures the proportion of metal and metal products that are produced from End-of-Life (EoL) scrap and other metal-bearing low grade residues (only EoL scrap) worldwide.

Factors of concentration are taken into account through Herfindahl-Hirschman-Index.[26] This Index has been modified to take into account country-level production with an indication of poor governance. Country-level data on production is provided quantitatively from the various sources in Annex B. Poor governance is indicated by the World Governance Index (WGI) This index takes a variety of influences into account. The WGI includes voice and accountability, political stability, government effectiveness, regulatory quality, rule of law and control of corruption. The Ad hoc Working Group on Defining Critical Raw Materials raised the concern that not all parameters of the complex Environmental Performance Index (EPI), which was initially part of the "supply risk" assessment component, are relevant for the assessment of the criticality of raw materials. In certain cases the EPI did not reflect the reality in the mining sector of certain countries resulting in an artificial move in the supply risk calculation. This is further explained in section 4.3 and 4.4.

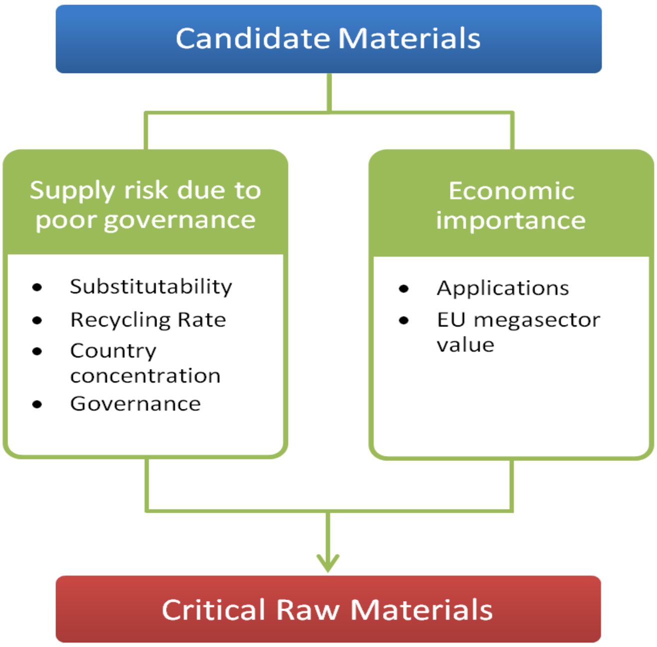
Within this methodology, increased recycling is assumed to be riskless and to reduce overall supply risk, as it can provide an alternative to primary production. This factor is included by the use of a total end-of-life recycling rate for each material. Therefore this assessment only considers recycling from old scrap in the calculation of supply risk. Substitution is assumed to influence risk in a similar way. If a raw material can be substituted, the risk to supply is lowered. To include this in

26 This index is more usually used to measure the size of a company in relation to the whole industry, providing an indication of competition within a sector.

the assessment, difficulty of substitution is estimated for each application of a material through expert judgment. These scores are then scaled according to the proportion of material used in the application and are then aggregated to provide an overall factor for each material. It shall be noted that the data base on secondary raw materials is relatively poor as also pointed out by another EU study on data availability of primary and secondary raw materials within the EU.

A scheme of the overall EU criticality assessment methodology for raw materials is shown in Figure 4.

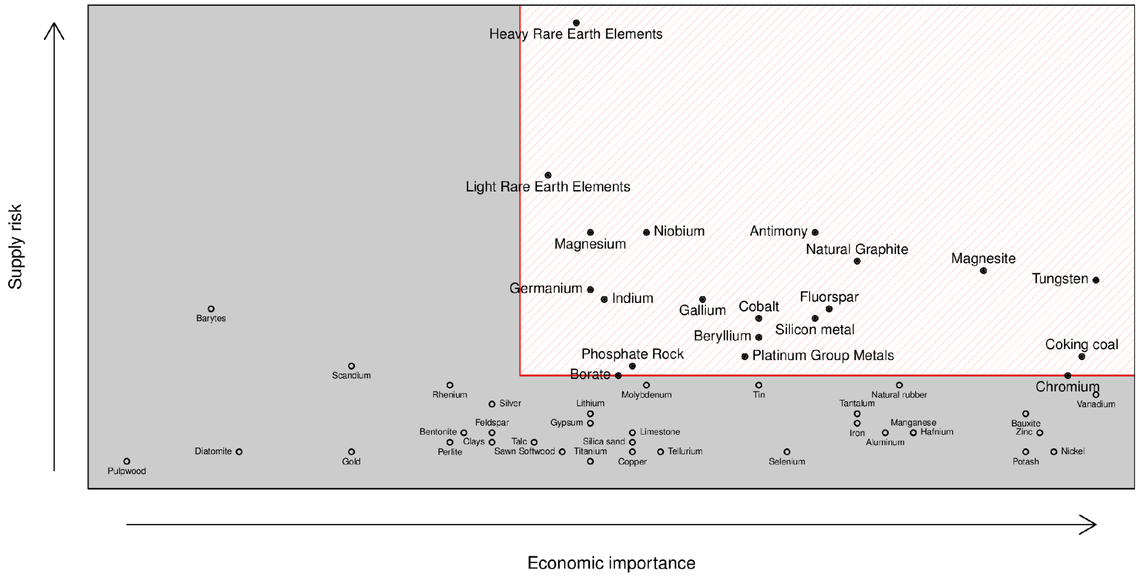
Figure 4: Scheme of EU criticality methodology



4.3. Results of Criticality Analysis

When the EU criticality methodology is applied to the list of fifty four candidate raw materials twenty materials are classified as critical (Figure 5 & Table 6).

Figure 5: Updated criticality assessments for the EU for 2013



The methodology and thresholds are the same as those used in the previous report which identified fourteen critical raw materials from a candidate list of forty one, though in the former analysis REEs are presented as a single group rather than separate groups.

Table 6: EU Critical raw materials (2013)

Antimony	**Beryllium**	**Borates**	**Chromium**	**Cobalt**	**Coking coal**	**Fluorspar**
Gallium	**Germanium**	**Indium**	**Magnesite**	**Magnesiu m**	**Natural Graphite**	**Niobium**
PGMs	**Phosphate Rock**	**REEs (Heavy)**	**REEs (Light)**	**Silicon Metal**	**Tungsten**	

Lithium exceeds the threshold for economic importance; however the supply risk is non-critical using the poor governance indicator, but critical using the EPI indicator. Due to inconsistencies between the environmental performance in the mining sector of relevant producing countries and the EPI indicator values, the Ad hoc Working Group on Defining Critical Raw Materials decided to use the WGI indicator for assessing the supply risk of all raw materials assessed including lithium. This is the only difference to the previous report. A lithium material profile is provided in the fact sheets of the non-critical raw materials.

The analysis also shows that both light and heavy sub-groups of REEs fall into the critical region. This is not the case for scandium. None of the three biotic materials included in this analysis are considered critical using this methodology.

This new list of twenty includes the majority of the previous fourteen minus tantalum. Six new materials are included, three of which were included in the 2010 analysis (borates, chromium and magnesite) and three of which are new to the analysis (coking coal, phosphate rock and silicon metal). Figure 6 highlights the differences in critical raw materials between each analysis. A comparison of scores for the 2013 and 2010 report is provided in Annex C.

Figure 6: Comparison of EU critical raw materials from 2010 and 2013.

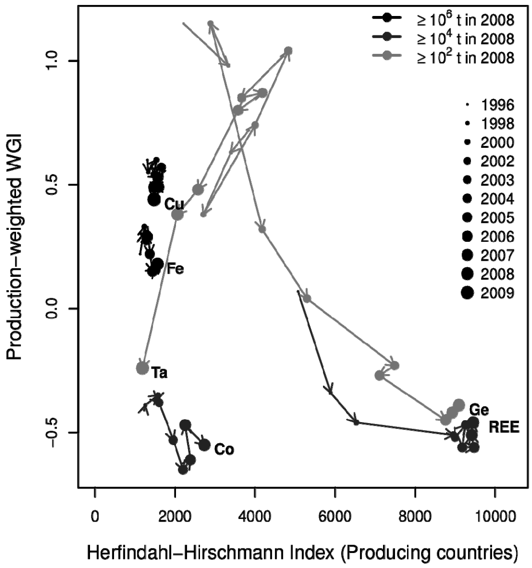
2010 Assessment only	Common to both Assessments	2013 Assessment only
Tantalum	Antimony Beryllium Cobalt Fluorspar Gallium Germanium Indium Magnesium Natural Graphite Niobium PGMs Rare Earths (Heavy) Rare Earths (Light) Tungsten	Borates Chromium Coking coal* Magnesite Phosphate Rock* Silicon Metal*

2010 Critical Raw Materials **2013 Critical Raw Materials**

**denotes new material in scope*

Perhaps the most notable change is tantalum leaving the list of critical raw materials. This is due to the reduced supply risk indicator, resulting from changes in the concentration of tantalum primary production. Australia (with excellent governance rating) and D.R. Congo (with poor governance rating) have historically been major tantalum producers and their respective shares in world supply are known to vary strongly from year to year, depending on the price of tantalum (Figure 7). At the time of the previous exercise, Australian mines had closed down due to low tantalum prices, therefore D.R. Congo had a very large role in world supply. In the meantime, Brazil has emerged as an important tantalum supplier. Nevertheless, it is worth pointing out that reliable tantalum production figures for conflict regions are very difficult to obtain.

Figure 7: Changes in concentration and production-weighted World Governance Indicator (WGI) for selected metals grouped by 2008 tonnage. The values of the WGI vary modestly year to year therefore the large variations seen are due to changes in the relative (country) concentration of production.



Source: Buijs, Sievers and Tercero Espinoza (2013): Proceedings of the ICE - Waste and Resource Management, 165 (4) 201-208. http://dx.doi.org/10.1680/warm.12.00010

Comparison of Figure 5 with the previous analysis reveals that most raw materials have changed their relative positions. This is due to changes in one or more of the variables. On the side of economic importance, these changes are in part due to actual changes in the distribution of end uses and in part because the new data applies to a different geographical area (see Annex B and C). Moreover, the economic importance of raw materials varied from year to year due to the changes in Gross Value Added (GVA) of several megasectors (see Annex B and C). For instance the Metals megasector GVA dropped by €24bn or 13%, Electronics by €18bn and ICT by 15%. Megasectors showing the largest growth in GVA terms are Pharmaceuticals showing a growth of €15bn or 22% and Food growing by €11bn or 7%.

4.4. Availability and Quality of Data

One of the key challenges in performing a large scale comparison of the criticality of raw materials is the access to pertinent data of adequate quality. Some of the issues known from the previous exercise remain, for instance the accuracy and reliability of the estimates and forecasts. Factors such as prices and regulatory requirements are subject to change.

A summary of data sources for production and end use data is presented in Annex B and C. Data for each material can be found in the individual fact sheets of the raw materials assessed.

4.4.1. Economic importance

Distribution of end uses

The key issue here lies in the different geographical regions to which end use data apply, with data for Europe, USA and World being used as they are available. In many cases, there are no significant differences between these geographical regions, but this is not a rule. Figure 8 shows the geographical distribution of end-use data, showing the majority is for Europe or worldwide.

Figure 8: Distribution of data sources for end use data.

European data	Aluminium, Antimony, Bentonite, Beryllium, Borates, Clays (and kaolin), Copper, Iron ore, Limestone, Magnesite, Magnesium, Manganese, Natural Rubber, Nickel, Pulpwood, Sawn Softwood, Silica Sand, Silicon Metal, Talc
World data	Cobalt, Coking Coal, Fluorspar, Gallium, Germanium, Gold, Hafnium, Indium, Lithium, Molybdenum, Natural Graphite, Niobium, Platinum Group Metals, Potash, Rare Earth Elements – Heavy, Rare Earth Elements – Light, Rhenium, Scandium, Selenium, Silver, Tantalum, Tellurium, Tin, Tungsten, Vanadium, Zinc
US data	Barytes, Bauxite, Chromium, Diatomite, Feldspar, Gypsum, Perlite, Phosphate Rock, Titanium

Value added of the megasectors

The most recent data from EUROSTAT has been used for 2010, this compares well with the data from the 2010 report which used 2006 data. However, changes to the NACE coding in this timeframe means that remapping between the two was required (see Annex B). However, this exercise allowed good alignment between the data sets; therefore this should not influence the comparability of the two studies.

4.4.2. Supply risk

Production data

Production data is generally available and of good quality for metals, natural rubber and for some industrial minerals. The data for some industrial minerals is of lower quality, in terms of location, grades and/or market segments. Compared to the previous exercise, this assessment profits from access to data from Roskill and Raw Materials Group (licensed as the database Raw Materials Data). Nevertheless, it was decided that the best available data will be used, even if it was not the latest data. This led to the use of a combination of data ranging from 2010 for World Mining Data up to 2012 for Raw Materials Data. Data for the biotic materials is of variable quality, and is discussed further in Section 4.6.

World governance Indicator

This indicator is available and considered of good quality. The data used is for 2011.

Recycling rates

Data is available but of varying quality. The main source for abiotic materials is the UNEP report on recycling (2011), a draft of which was also used for the previous assessment. Moreover, the sources behind the UNEP report vary in quality and timeliness. Data for biotic materials is of good quality for both wood types, but less reliable for natural rubber.

Substitutability

The inherent weakness in this variable is the difficulty in assessing substitutability itself: an issue of judgement as much as of data. The issue is relevant especially for the materials close to the threshold of the supply risk (i.e. borates, phosphate rock, PGM, cobalt, coke, chromium, vanadium, bauxite, tin, tantalum and lithium). It should be noted that the substitutability used in the supply risk assessment is linked to the distribution of end uses coming from the assessment of economic importance. Therefore, regional differences also affect this variable.

Environmental performance Index

This indicator is available for all countries assessed. However, the Ad hoc Working Group on Defining Critical Raw Materials raised the concern that not all parameters of the complex EPI index are relevant for the assessment of criticality of raw materials. In certain cases EPI does not reflect the reality in the mining sector of certain countries resulting in an artificial move in the supply risk calculation.

4.5. Analysis of Global Supply

Analysis of the primary supply data used in this report allows the twenty largest producing countries of biotic and abiotic materials to be identified, based on the percentage contribution across the fifty four materials in scope,

Table *7*.[27] Figures in this table were calculated using the supply data across all fifty four raw materials. This data was aggregated using the percentage production of each material for each country both for 54 candidate materials as well as separately for the 20 critical raw materials. Therefore each material contributes equally for the purposes of the analysis below.[28]

The twenty countries highlighted supply approximately 82% of the fifty four materials in scope for this report when primary production is considered.

Table 7: Countries with the largest contributions to global primary raw material supply. Their contribution to the supply of critical raw materials is also shown

Country	Materials supplied (Out of 54)	Overall % contribution	Critical raw materials supplied (Out of 20)	% Contribution to CRM supply
China	48	30%	18	49%
USA	36	10%	9	9%
Russia	42	5%	16	4%
Brazil	36	5%	11	6%
Australia	34	4%	10	1%
South Africa	26	4%	9	6%
Chile	18	3%	2	1%

27 Data from sources in Annex C, individual material data is available in the materials profiles

28 The range of tonnages and values for the materials means that analysis using these measures would be dominated by a few materials, therefore a percentage based approach was used.

Canada	30	3%	11	3%
India	30	3%	8	2%
Turkey	25	2%	7	3%
Japan	18	2%	2	1%
France	13	2%	1	0%
Germany	17	1%	3	1%
Indonesia	16	1%	2	0%
Kazakhstan	23	1%	7	2%
Mexico	24	1%	5	1%
Peru	17	1%	3	0%
DRC	9	1%	3	3%
Italy	11	1%	0	0%
Thailand	20	1%	4	0%

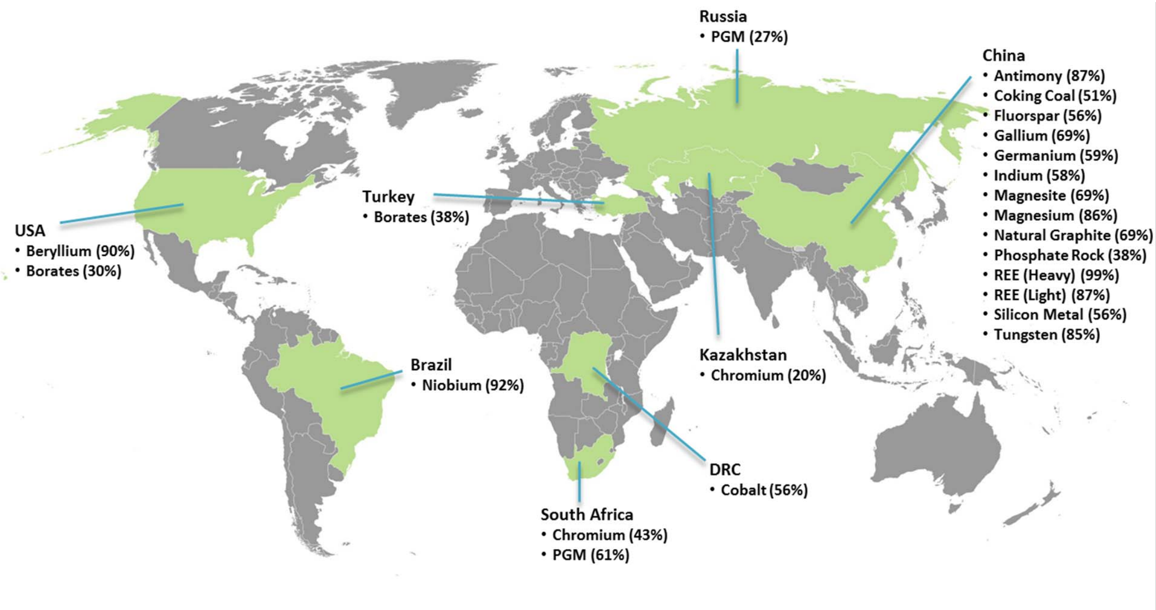
Source: Based on primary global supply figures, sources in Annex C

Table 8: Percentage of primary supply of critical raw materials from the twenty most significant producing countries

Critical raw material	% Supply	Major suppliers (>20%)	Critical raw material	% Supply	Major suppliers (>20%)
Antimony	93%	China (87%)	Magnesite	86%	China (69%)
Beryllium	99%	USA (90%)	Magnesium	96%	China (86%)
Borates	88%	Turkey (38%) USA (30%)	Natural Graphite	93%	China (69%)
Chromium	88%	South Africa (43%) Kazakhstan (20%)	Niobium	99%	Brazil (92%)
Cobalt	82%	DRC (56%)	PGMs	93%	South Africa (61%) Russia (27%)
Coking Coal	94%	China (51%)	Phosphate Rock	66%	China (38%)
Fluorspar	84%	China (56%)	REE (Heavy)	100%	China (99%)
Gallium	90%	China (69%)	REE (Light)	100%	China (87%)
Germanium	94%	China (59%)	Silicon Metal	79%	China (56%)
Indium	81%	China (58%)	Tungsten	91%	China (85%)
			Total	**90%**	**China (49%)**

These twenty countries are also the largest suppliers of the critical raw materials. Table 8 shows the contribution of these countries to the supply of the critical raw materials, with around 90% of supply coming from these twenty countries. All major suppliers of the individual critical raw materials fall within this group of twenty countries. Other significant producers not in this group include Morocco (Phosphate rock 15%).

Figure 9: Major supplying countries of the EU Critical Raw Materials



In terms of EU supply, around 9% of raw material supply is indigenous to the EU according to the data gathered. This is includes large supplies of hafnium (47%, linked to refining), clays (37%), perlite (37%), silica sand (35%), feldspar (35%), diatomite (28%) and sawn softwood (26%). For the critical raw materials the supply situation is more limited. Total supply across all twenty critical raw materials can be estimated at under 3%, with over half having no or very limited production within the EU (Figure 10). The critical raw materials with the highest production in the EU are gallium (12%), magnesite (12%), silicon metal (8%) and germanium (6%).

Figure 10: Primary production of the candidate raw materials. The 'EU supply' row shows the proportion of global supply derived from the EU

Critical Raw Materials		Gallium Magnesite	Silicon Metal Coking coal Fluorspar Germanium Indium	Chromium Tungsten	Antimony Beryllium Borate Cobalt Magnesium Natural Graphite Niobium PGMs Phosphate Rock REEs (Heavy) REEs (Light)
EU Supply	**>20%**	**<20%**	**<10%**	**<3%**	**<1%**
Non-Critical Raw Materials	Clays (& Kaolin) Diatomite Feldspar Hafnium Limestone Perlite Sawn Softwood Silica sand Tellurium	Bentonite Gypsum Potash Pulpwood Selenium Talc	Aluminium Copper Rhenium Silver Zinc	Barytes Bauxite Iron Lithium Nickel	Gold Manganese Molybdenum Natural Rubber Scandium Tantalum Tin Titanium Vanadium

4.6. Criticality Analysis of Biotic Materials

Three biotic materials have been assessed using the same criticality methodology as implemented for abiotic materials: natural rubber, sawn soft wood and pulp wood. In order for the scope to be consistent with abiotic materials, only non-energy, non-agricultural biotic materials are under consideration. Whilst the selection of natural rubber was simple, the selection of a wood type was more complex.

4.6.1. Criticality of biotic materials

In the instance of biotic materials, a raw material is considered critical when the risks of supply shortage and their impact on the economy are higher compared to other raw materials.

Several relevant studies which investigate the materials usage of biomass have been identified. The motivation and focus of these studies is however slightly different to that of the present report.

4.6.2. Suitability of existing methodology

Before conducting the criticality assessment of biotic materials it was necessary to determine the suitability of the existing methodology. For biotic materials the data sources are different to those used for abiotic materials. Where possible, external stakeholders and members of the AHWG have been used to verify the data sources. For natural rubber the data required for the assessment is available or can be easily approximated. As a raw material, wood is complex and many of the specific issues which its supply faces are not fully addressed by the existing methodology, which has been used.

The supply of renewable biotic materials, such as wood and natural rubber, is fundamentally different to that of abiotic materials. For example, biotic resources regenerate over time with a limited stock at any one time. In the examples used there is significant wood production within the EU and no natural rubber production.

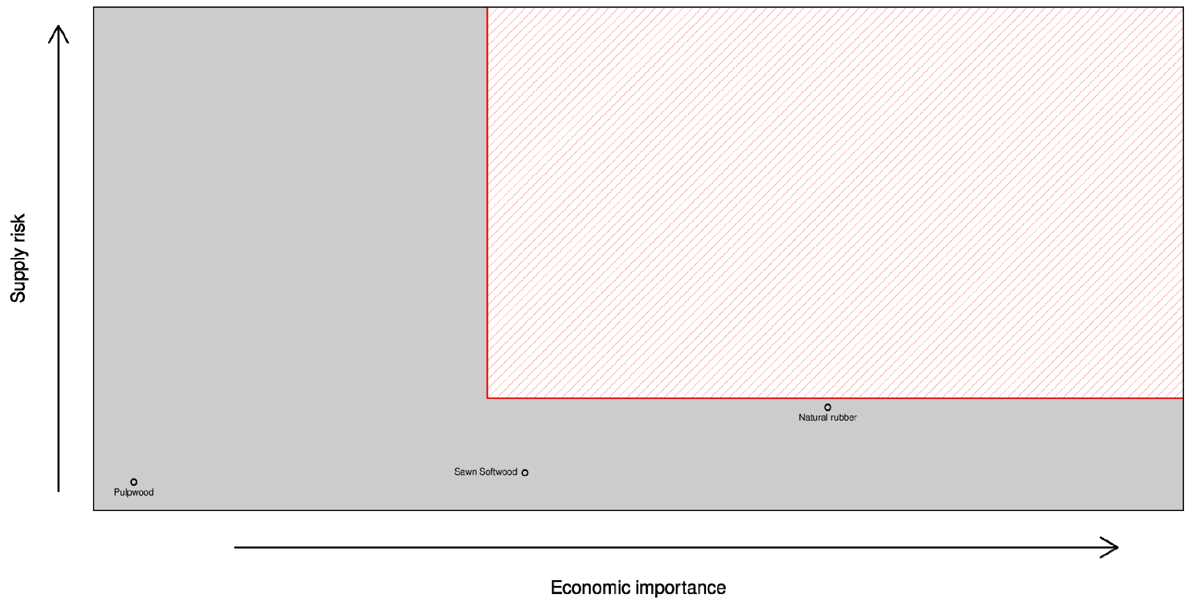
For natural rubber the most significant end-user is the tyre industry, accounting for around 75% of annual consumption. Unfortunately, detailed data is not readily available on the end-sector uses of natural rubber other than tyres. For soft sawnwood, the following megasectors are of economic importance: construction materials, wood and other final consumer goods. For pulpwood, the only megasector of economic importance for this report is paper.

Taking into account the differences between biotic materials and abiotic materials the AHWG agreed that at the high-level of the current assessment, the criticality framework is suitable for both abiotic and biotic materials.

4.6.3. Results of the criticality analysis of Biotic Materials

The results of the criticality analysis for natural rubber, pulpwood and sawn softwood are summarised in Figure 11. None of the three biotic materials under investigation can be classified as critical. Of the three materials in focus, natural rubber was found to be the closest to the criticality thresholds. This is due to its use in tyres for road transport coupled with its lack of suitable substitutes and minimal recycling. In contrast pulpwood and sawn softwood scored lower on the criticality scale, due to higher recycling rates and low concentration of producing countries.

Figure 11: Results of the criticality assessment of biotic materials with world governance indicators

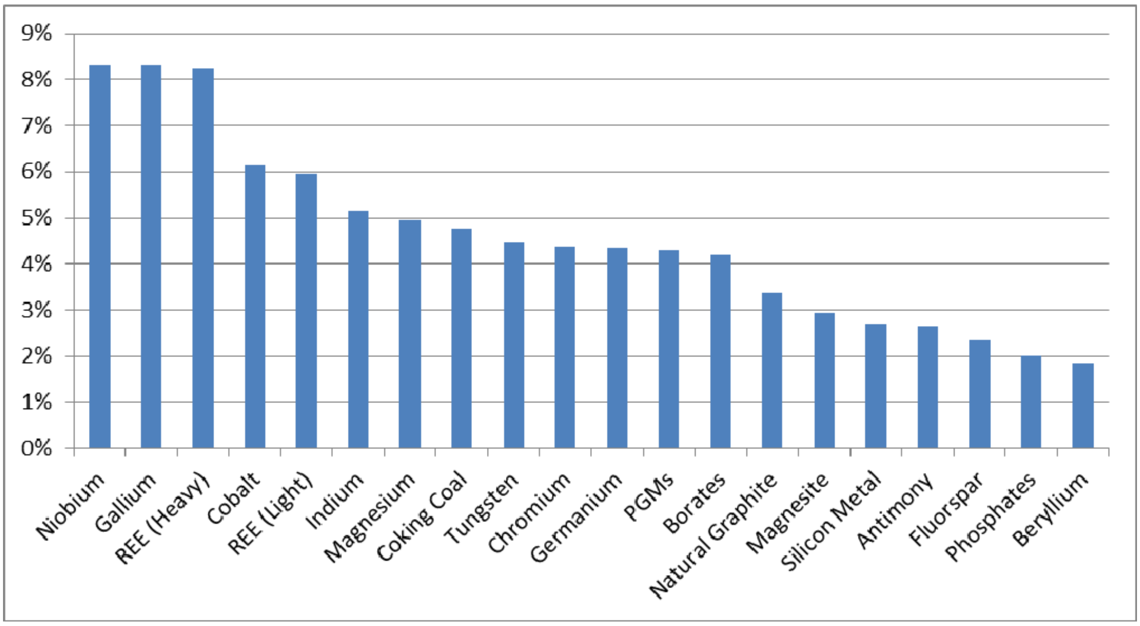


4.7. Outlook for the Critical Raw Materials

For each of the raw materials identified as critical within this report, extended analysis has been compiled to assess any additional risks or mitigating factors that may influence future policy considerations. For example developing primary supply may be appropriate for some materials but not others, similarly for secondary supply. Moreover, due to the dynamic character of the global market and on technology developments some raw materials which are currently not identified as critical might become critical when new data become available. This analysis includes supply chain analysis, some assessments of ore quality/by-product dynamics and EU trade patterns. This information is included in the profiles for the critical raw materials.

A part of the extended analysis was dedicated to long-term forecasts for the supply and demand of each of the critical raw materials. Figure 12 summarises the annual demand forecasts for each of the critical raw materials. The demand for all the critical raw materials is predicted to grow, with niobium, gallium and heavy rare earth element forecast to have the strongest rates of demand growth, exceeding 8% per year for the rest of the decade. Table 9 categorises each of the critical raw materials by their corresponding rate of demand growth forecast.

Figure 12: Forecast average annual demand growth to 2020 for critical raw materials (% per year)



Source: Roskill Information Services (September 2013) and other data in the extended profiles

It should be noted that a supply deficit/surplus does not necessarily imply a change in criticality of these materials. Many of the critical materials could experience a future supply surplus. For example factors such as supply concentration, country risk, and substitutability are taken into consideration within the methodology, while supply deficit/surplus of materials is not directly measured. This analysis is a useful tool for understanding the linked issue of current and future supply and demand and changes thereof, rather than a direct reflection of criticality.

Table 9: Forecast average demand growth to 2020 for critical raw materials (% per year)

Very Strong (>8%)	Strong (4.5%-8%)	Moderate (3%-4.5%)	Modest (<3%)
Niobium	Cobalt	Tungsten	Magnesite
Gallium	Light Rare Earths	Chromium	Silicon Metal
Heavy Rare Earths	Indium	Germanium	Antimony
	Magnesium Metal	Platinum Group Metals	Fluorspar
	Coking Coal	Borates	Phosphates
		Natural Graphite	Beryllium

Source: Roskill Information Services (September 2013) and other data presented in the extended profiles

The evolving market balance situation for each of the critical raw materials is summarised in Table 10 and Table 11. This has been colour-coded according to whether a surplus, deficit or market balance is forecast for a particular year (although for some of the critical raw materials only supply capacity forecasts are available). Roskill data have been used for the forecast in this report; however it has to be noted that for some of the critical raw materials the data has been challenged by different stakeholders, such as for silicon metal or coking coal.

The result of these supply-demand forecasts is that certain critical raw materials have been identified as having a risk of market deficit. These include antimony, coking coal, gallium, indium, platinum group metals, heavy rare earths and silicon metal (Table 10 and Table 11). However, care is required when interpreting these results, and readers are directed towards the material profiles for a more complete and specific understanding of the circumstances for each critical material.

Table 10: Forecast market balance for critical raw materials to 2020[29][30]

Critical Raw Material	2012	2015	2020
Antimony	Small deficit	Large deficit	Large deficit
Borates	Large surplus	Large surplus	Small surplus
Chromium	Balance	Balance	Balance
Cobalt	Small surplus	Small surplus	Small surplus
Coking Coal	Small deficit	Small deficit	Balance
Fluorspar	Balance	Large surplus	Small surplus
Gallium	Large surplus	Small deficit	Large surplus
Germanium	Small surplus	Balance	Balance
Indium	Small surplus	Small deficit	Small deficit
Magnesite	Large surplus	Small surplus	Balance
Magnesium	Large excess capacity	Large excess capacity	Large excess capacity
Natural Graphite	Small surplus	Large surplus	Large surplus
Niobium	Large excess capacity	Large excess capacity	Large excess capacity
Phosphates	Small surplus	Small surplus	Large surplus
Platinum Group Metals	Small deficit	Small deficit	Small deficit
Rare Earth Elements - Light	Large surplus	Large surplus	Large surplus
Rare Earth Elements - Heavy	Large deficit	Balance	Small deficit
Silicon Metal[31]	Small deficit	Balance	Balance
Tungsten	Balance	Small surplus	Balance

Key: Balance: +/- 1%;Small <10%; Large: >10%

Source: Roskill Information Services (September 2013) and other data in the extended profiles

29 Differences in views over future supply and demand mean that there are differing opinions over the future markets, for instance assumptions over new mining capacities or developments may have an impact on the forecasts presented in table 10. Therefore these results are only indicative. Further details and descriptions on the forecasts are provided in the relevant factsheets. New mining capacities or developments may have an impact on the forecasts presented in table 10.

30 The magnitude of the expected small deficit for indium in 2020 will depend also the availability and accessibility of indium from the Chinese market. The same applies also to germanium for which a balance is forecasted in 2020 in the current report.

31 It has to be noted that for some of the critical raw materials the data has been challenged by different stakeholders, such as for silicon metal.

Table 11: Summary of forecasted market balance for critical raw materials to 2020

Risk of deficit	Balanced market	Surplus
Antimony	Beryllium*	Borates
Coking Coal	Chromium	Magnesium Metal
Gallium	Cobalt	Natural Graphite
Indium	Fluorspar	Niobium
Platinum Group Metals	Germanium	Light Rare Earth Elements
Heavy Rare Earth Elements	Magnesite	Phosphates
	Tungsten	
	Silicon Metal	

Source: Roskill Information Services (September 2013) and other data in the extended profiles
**no quantitative supply forecast was possible*

5. Recommendations

The AHWG adopts the revised list of twenty critical raw materials for the EU which replaces the list of fourteen materials as published in 2010 and recommends:

- To disseminate the CRM study results and findings, accompanied by an introductory guidance on the intended purpose of the list.
- To initiate all the necessary specific actions to ensure undistorted and reliable access to critical raw materials given the combination of their economic importance and supply risk, as well as for non-critical raw materials where appropriate.
- To promote the outcome of the study not only across the EU Institution and the Member States where the study results could be used in relevant policies and initiatives, but also amongst relevant stakeholder, including manufacturers, designers and waste processors, who may benefit from it.
- To regularly update the list. Updating it every three years seems time being appropriate.
- To continue the activities of the Ad-Hoc Working Group into place. Appointment of additional members from relevant sectors may be considered, taking into account the representativeness.
- Keeping the scope on non-energy, non-agricultural raw materials, to review the list of candidate materials for the next update ensuring it remains appropriate for the purpose of the study.
- To review the quantitative methodology and carefully consider possible modifications while maintaining comparability over time.
- To draw lessons from the CRM work regarding the assessment of resources and reserves of critical and other raw materials in the EU. This should, where possible, include the assessment of EU mineral resources, internal EU flows of raw materials, including secondary resources such as tailings, waste rocks and spoiling heaps; internal supply, capacity, imports and exports of different grades of materials; the supply chain stage materials that are required in the EU; as well as detailed trade statistics for the raw materials.

Glossary

AHWG	Ad hoc Working Group on Defining Critical Raw Materials
BGR	German Federal Institute for Geosciences and Natural Resources
BGS	British Geological Survey
BRGM	Bureau de Recherches Géologiques et Minières
CRM	Critical Raw Materials
DRC	Democratic Republic of the Congo
ECHA	European Chemicals Agency
EIP	European Innovation Partnership on Raw Materials
EITI	Extractive Industries Transparency Initiative
EPI	Environmental Performance Index
GDP	Gross Domestic Product
GVA	Gross Value Added
HHI	Herfindahl-Hirschman-Index
HREEs	Heavy Rare Earth Elements
ICT	Information and Communication Technology
LREEs	Light Rare Earth Elements
PGM	platinum group metal
REE	Rare Earth Elements
RMI	Raw Materials Initiative
UNEP	United Nations Environmental Programme
WGI	World Governance Index

Abiotic: Metals (or metallic ores) and industrial minerals. These are derived from static reserves.

Biotic: Materials which are derived from renewable biological resources that are of organic origin but not of fossil origin. Only non-energy and non-agricultural biotic materials are under consideration in this report.

Deposit: A concentration of material of possible economic interest in or on the earth's crust.

Reserves: The term is synonymously used for "mineral reserve", "probable mineral reserve" and "proven mineral reserve". In this case, confidence in the reserve is measured by the geological knowledge and data, while at the same time the extraction would be legally, economically and technically feasible and a licensing permit is certainly available.

Resources: The term is synonymously used for "mineral resource", "inferred mineral resource", "indicated mineral resource" and "measured mineral resource". In this case, confidence in the existence of a resource is indicated by the geological knowledge and preliminary data, while at the same time the extraction would be legally, economically and technically feasible and a licensing permit is probable.

Units: Conventional SI units and prefixes used throughout: {k, kilo, 1,000} {M, mega, 1,000,000} {G, giga, 10^9} {kg, kilogramme, unit mass} {t, metric tonne, 1,000 kg}.

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