Study on the Competitiveness of the EU Primary and Secondary Mineral Raw Materials Sectors

Final Report for DG Internal Market, Industry, Entrepreneurship and SMEs

30th January 2015

Funded by the European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW)
Report for DG Internal Market, Industry, Entrepreneurship and SMEs

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Executive Summary

The Mineral Raw Materials Sector (MRMS), comprising the non-energy extractive industry (NEEI) and recycling industry (RI), provides many of the basic raw materials required by Europe’s manufacturing and construction industries. The purpose of this study is to provide the European Commission with a clear and up-to-date understanding of the current competitiveness of the EU NEEI and RI in respect of the MRMS. This study aims to provide a sound foundation of evidence that will enable the European Commission to support the sustainable growth of the industries.

It sets out to consider the competitiveness of the 28 Member States of the European Union (EU28) as a trading bloc relative to the rest of the world. It does not consider the individual Member States’ position, and in respect of trade, the focus is on trade between the EU and the rest of the world. In other words, the emphasis has been on performance of the EU28 as a trading bloc.

In order to focus the study, a set of representative materials and comparison countries has been agreed with the Commission. The selection of the representative raw materials aims (where possible) to represent variability in the market characteristics of raw materials within a specific sub-sector. In some cases, where there is significant variation within a sub-sector, a sub-group is utilised. Accordingly, in some situations, there are multiple representative materials for sub-sectors where there are diverse market characteristics. The comparison countries have been chosen on the basis of their high relative share in the production of the representative materials. These include Australia, Brazil, Canada, Chile, China, India, Indonesia, Japan, Mexico, Russia, South Africa and United States of America (USA).

The study has comprised of literature reviews, data analysis, interviews with operators, and workshops with trade associations and others within the NEEI and RI. The study has found that based on the data available, the EU28’s relative share of the global NEEI output appears to have been decreasing over the last 10 years. The causes of this decline are varied. The geology within the EU28 is a key factor, as the nature of the mineral endowment setting fundamentally impacts the ability to undertake mining and quarrying activity. Policy and legislation may, in some cases, also impact negatively. The legislative background is considered by some to be highly complex and often unevenly implemented and regulated within the EU28. This can discourage investment. The study has also found some positive aspects associated with the NEEI in the EU28. In respect of material supply, the EU28 has excellent transport networks and infrastructure which facilitate the movement of goods from places of extraction to locations where they are used. There is also strong support for R&I activity within the EU28 – especially from public funds.

For the RI, the EU28 has historically accounted for high volumes of traded recyclate. The study has found that the legislative framework of the EU28 provides strong support for the industry, and in environmental protection in general. However, some competitor countries have been able to provide a demand-side stimulus for their RI, by lowering

1 The representative materials are detailed within the Technical Appendix.
relative costs of products made with recycled content; a comparable initiative is not present in the EU28. Although capture rates are increasing, there is a still a considerable variation between Member States. Furthermore, some metallic waste streams produce low quality recyclate which impose additional costs on the EU28 RI.

Historic Performance of the EU28 NEEI and RI

Non Energy Extractive Industries

The EU28 possesses an active NEEI producing a wide range of minerals. For a small number of minerals the EU28 is the world leader in production, e.g. salt. However, this situation is not representative for the sector as a whole, and of the list of representative materials included within this report, only for gypsum and potash does the EU28 production account for over 10% of global production. The economic and market data appear to show the EU28 as having a declining importance in the global market since 2003, as evidenced by its declining share of the world production (Figure E1), whilst the trade data indicate large trade deficits for ores.

Figure E1: EU28 Share of Global Output by Sub-Group

Performance across the NEEI and EU28 is not uniform, and it should be recognised that there are significant variations between the sub-groups. For example, based on the representative materials selected for each sub-group, the data demonstrates that the EU28 trade balance is positive for semi-finished critical metals and for non-aggregate construction minerals (Figure E2).

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³ The nature of reported data is such that the non-ferrous metal sub-group cannot be split into constituent parts for this analysis.
In respect of cost structures, some parts of the EU28 have higher labour and energy costs than some of the key competitor countries, although reliable data on energy efficiency has not been identified. This is particularly challenging for the EU28 metal sub-group, when it is considered that the average depth of mining in the EU28 is significantly greater than the global average. Energy is required for mining and beneficiation of the ores and thus, the higher unit costs could place the sector at a significant competitive disadvantage. Much depends, however, on the extent to which innovation within industry has allowed for the higher unit costs to be offset by improved productivity with respect to these input factors.

In respect of the labour productivity and profitability, the data is of poor quality and it is therefore difficult to draw specific conclusions. From what little data is available, however, it appears to show the EU28 as a middle- to low-ranking performer. The best performers are countries which tend to have large open-pit mining operations, so the data may reflect, in part, the nature of the mineral endowment settings rather than a more fundamental structural problem of competitiveness. Furthermore, the ability to conduct mining by open-pit methods is also influenced by a wide range of other social, environmental and economic factors.

**Recycling Industries**

While the EU may not be a global leader in primary resource extraction (as outlined above), it is in a strong position to become a global leader in terms of resource recovery, at least insofar as that resource is available in the form of discarded products and packaging. In this regard, a telling point is the semantic shift which is occurring within the waste management industry away from talk of managing ‘waste’, and towards the desirability of making use of ‘resources’.

For the RI, availability of high quality data at the EU28 level is a significant barrier to being able to consider the performance of the industries. Waste recycling data is not...
captured at the level of detail needed for this assessment. However, the trade data does appear to capture parts of the industry relevant for this assessment. The trade data demonstrates that the EU28 currently has a high global share in the both the export, and import of metal recyclate (Figure E3 and E4).

**Figure E3: EU28 Share of Global Exports of Metal Recyclate (%)**

![EU28 Share of Global Exports of Metal Recyclate (%)](image)

*Source: UN Comtrade*

**Figure E4: EU28 Share of Global Imports of Metal Recyclate (%)**

![EU28 Share of Global Imports of Metal Recyclate (%)](image)

*Source: UN Comtrade*

This tends to show that the EU28 is highly active in the market, rather than giving a clear indication of competitiveness. Like the NEEI, some parts of the RI in the EU28 also has higher labour and energy costs than some of its competitors, though the use of energy and the impact of energy efficiency is uncertain. Again this, in general, can be considered a disadvantage when compared to comparison countries.

**Assessment of Competitiveness**

In order to assess the factors which impact on competitiveness of the EU28 MRMS the assessment has focussed on three key areas:

- Policy and Legislation;
- Raw Material Supply; and
Research and Innovation

Based on the research conducted, a summary of the key findings from each of the areas of assessment are provided for the NEEI and RI.

Key Findings - NEEI

Within the EU28 there are a number of strengths which bear favourably on the industry’s competitiveness. Policy and legislation within the EU28 generally provides a stable framework for investment, not least in comparison with some competitor countries. The relatively strong emphasis on social and environmental protection can also contribute to ensuring that the EU develops a sector that is sustainable in the long term. Additionally there is an increasingly strong appreciation, and political will, throughout the EU28 to seek to ensure a secure of supply of materials for industry, an aspect which should improve the outlook for the EU28 NEEI.

In respect of material supply, the EU28 has excellent transport networks and infrastructure which facilitate the movement of goods from places of extraction to locations where they are used. There is also strong support for R&I activity within the EU28 – especially from public funds. This combined with a wide range of diverse academic facilities provide a fertile environment for new innovative technologies to be developed within the EU28.

In the course of the assessment a number of weaknesses have also been identified. In relation to policy and legislation, although the stability of the investment climate is regarded as a positive factor, the legislative background is also highly complex and often unevenly implemented and regulated within the EU28 which can discourage investment. Additionally, whilst there is political will to ensure security of supply, political opposition, as well as public opposition, especially locally, can work to hinder the development of the extractive industries. Whilst comprehensive data is lacking, it is understood that some of the operators in the EU28 also experiences higher costs, specifically in regards to labour, when compared to competitor countries.

In respect of raw material supply, a key deficiency within the EU28 is a lack of knowledge of mineral endowment. This places the metals and industrial minerals sub-groups within the EU28 at a fundamental disadvantage to other comparison countries. Additionally, we have identified a number of countries which promote private sector investment in exploration. Such measures are rarely found in the EU28. In addition, it is notable that the mining depth for some metallic commodities in the EU28 is deeper than in many competitor countries and thus is likely to result in higher costs within the EU28. Although R&D activity in Europe receives strong public sector support and funding, current levels of private funding are higher in the comparator countries. ‘Leakage’ of R&I knowledge outside the EU28 is also a risk.

A schematic summary of the assessment of competitiveness of the NEEI is shown in Figure E5. The figure is based on a qualitative interpretation of the data identified and derived, at least in part, from the consensus of views and evidence obtained in this study.
Figure E5: Summary of the Assessment of Competitiveness of the EU28 NEEI

Notes:
1) The figure is based on a subjective assessment of the competitiveness based on the author’s views.
2) Lines nearer to the centre of the shape denote lower levels of competitiveness. Lines towards the outside of the shape denote higher levels of competitiveness.
3) RoW (Rest of the World) is based on the analysis of the representative countries presented in this research.

Key Findings - RI

The legislative framework of the EU shows a strong support for the industry and environmental protection in general, for example the EU legislation on waste. It would be further increased if EU legislators were to adopt the legislative proposal included in the Circular Economy Package. Alongside this, the EU28 has a skilled labour force and mature recycling market. Increasingly high capture rates of recyclable material in the EU28 are starting to provide consistent material supply to reprocessors and the Union’s proximity to global market and transport routes provide good trade links to neighbouring states. The future of the sector is strengthened by increased political support for recycling across Member States and increased demand for secondary materials as a substitute for primary materials.

In respect of material supply, the EU28 has excellent transport networks which facilitate competitive movement of goods. The EU28 places a strong emphasis on innovation. Accordingly, there is strong public sector investment in R&I activities with well-established programs in place such as Europe 2020 which position innovation as an important component of economic growth and key to competitiveness.

At the same time there are a number of weaknesses associated with the EU28 RI. Unfavourable trade policies of certain non-EU countries and apparent higher labour and energy costs in some parts of the EU28 (though reliable data on energy efficiency has not been identified) impact on the competitiveness of the EU28 RI. Additionally some competitor countries have been able to provide a demand-side stimulus for their RI, by lowering relative costs of products made with recycled content; a comparable initiative
is not present in the EU28. Although capture rates are increasing, there is a still a considerable variation between Member States. Furthermore, some metallic waste streams produce low quality recyclate which impose additional costs on the EU28 RI.

A schematic summary of the assessment of competitiveness of the RI is shown in Figure E6. The figure is based on a qualitative interpretation of the data identified and derived, at least in part, from the consensus of views and evidence obtained in this study.

**Figure E6: Summary of the Assessment of Competitiveness of the EU28 RI**

![Figure E6: Summary of the Assessment of Competitiveness of the EU28 RI](image)

**Notes:**
1) *The figure is based on a subjective assessment of the competitiveness based on the author’s views.*
2) *Lines nearer to the centre of the shape denote lower levels of competiveness. Lines towards the outside of the shape denote higher levels of competiveness.*
3) *RoW (Rest of the World) is based on the analysis of the representative countries presented in this research*

**Suggested Initiatives**

A series of suggested initiatives are recommended for consideration by policy makers to improve the competitiveness of the EU28 MRMS. These have been developed from a SWOT analysis undertaken during the course of this research.

**Non-Energy Extractive Industries**

By way of helping to improve the competitiveness of the EU28 NEEI, the following four suggested initiatives are recommended:

**Suggested Initiative 1: Improve knowledge of mineral endowment**

**Finding:** There has been a lack of investment in basic geological survey work. This means that the fundamental knowledge base is much weaker than it could be. This increases the risk of undertaking exploration activity, which, in turn, holds back the development of the EU’s indigenous resources.
**Suggested Initiative:** Although the measure might not enhance competitiveness per se, there is a suggestion that in order to develop to a greater extent than currently, more basic research is required to improve our understanding of Europe’s bedrock geology and thus to conduct more efficient and effective exploration. As identified in the research, other competitors have been able to incentivise exploration by the private sector via the use of tax breaks and other fiscal instruments. The EU should seek to improve the knowledge of mineral endowment using modern techniques and seek to incentivise relevant research.

**Suggested Initiative 2: Address costs of energy**

**Finding:** Energy costs in some parts of the EU28 appear to be higher than those in some competing nations. However, the use of energy must also be considered and there appears to be a lack of evidence which enables a full comparison of overall costs within the NEEI.

**Suggested Initiative:** Building on the efforts already made at an EU level at reducing the costs of energy, consideration should also be given to the amount energy used by processes. Operators within the EU28 could be incentivised to benchmark their energy consumption and engage in knowledge sharing activities that may help reduce energy consumption further.

**Suggested Initiative 3: Focus R&I on more efficient extraction methods**

**Finding:** For the metals sub-sector, the EU28 appears to have deeper deposits than other competing countries. This hinders competitiveness as more energy is required to extract minerals from deeper depths, when compared to the deposits at the sub-surface.

**Suggested Initiative:** The EU28 should look to focus and increase funding for R&I activity on helping to reduce the costs associated with the types of deposits found in the EU28. This includes deep deposits and recovering the value of materials contained in tailings from existing mining activity. This should be incorporated in research calls and effort should be made to promote the sharing of best practice across organisations within the EU28.

**Suggested Initiative 4: Simplify the regulatory framework**

**Finding:** Although the policy within the EU28 is stable and mature when compared to many of the competitor countries, the regulatory framework is regarded being time consuming, complex with quite unpredictable outcomes by industry. This may deter investment in the EU28 as the length of time from the commencement of permitting to starting extractive operations can be very long.

**Suggested Initiative:** Member States should be encouraged to review the legislation impacting on mining and quarrying activities and seek to simplify requirements by following better regulation principles. The EU could facilitate this process through the several instruments, starting from sharing of best practice. Additionally the EU can also ensure that Member States’ performances are calculating and monitoring the impact of legislation in line with best practice.

**Recycling Industries**

By way of helping to improve the competitiveness of the EU28 RI, the following four suggested initiatives are recommended:
Suggested Initiative 5: Provide demand-side stimuli for the RI

Finding: There is a lack of demand-side stimuli for recycled materials from within the EU28. Unlike competitor countries, products made from virgin and recycled products are treated equally within the EU28.

Suggested Initiative: In order to increase demand for recycled materials, the EU and its Member States should consider fiscal and other measures to incentivise the consumption of goods made from recycled materials.

Suggested Initiative 6: Address concerns associated with quality of recyclate

Finding: For some heterogeneous waste streams from the EU28, poor quality recyclate is captured. This impacts competitiveness as it means that the RI has to pay to remove contaminants.

Suggested Initiative: There is clear need for policies within the EU28 that standardise what the minimum level of quality of secondary material needs to be before it is traded in the internal market or in global markets. It is critical for the EU28’s RI that there is increased transparency globally regarding the quality of secondary material being traded and that standards are introduced to ensure consistency.

Suggested Initiative 7: Place stronger focus on the enforcement of existing legislation and increase its level of ambition

Finding: There appears to be inconsistent application of waste legislation within the EU28. This means that valuable feedstock for the EU28 RI is being discarded and not captured for recycling. As demonstrated in some EU Member States, current EU recycling targets do not represent the optimum level from an economic, social and environmental viewpoint.

Suggested Initiative: Regulation and policy in the RI is only as strong as the enforcement measures used within each Member State. Where enforcement is inadequate, the RI is undermined and thus the competitiveness is damaged. Member States should be required to ensure that adequate enforcement of existing legislation is undertaken, with a focus on ensuring that a suitable funding regime for enforcement activities is in place. Collaboration between Member States should also be encouraged through the sharing of intelligence on illegal activities and the sharing of best practice techniques in enforcement measures. In addition, current recycling targets should be updated to reflect progress made in the best performing Member States in recent years, while taking into account specific national circumstances.

Suggested Initiative 8: Establish better accounting of the RI within the EU28

Finding: Economic and market data relating to the RI is poor and the sector is not very well understood. Poor data availability undermines the ability to undertake a comprehensive assessment of the EU28 RI. The same problem could be faced by potential investors and therefore might limit the flow of capital to the EU28 RI.

Suggested Initiative: To improve the knowledge and awareness of the EU28 RI, the EU should consider collecting information and data on a regular basis that allows the sector to be better understood. For example, flows of waste intended to be recycled should be linked to locations where it is recycled so that the economic contribution of the EU28 RI can be best understood.
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# Glossary of Terms

<table>
<thead>
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<th>Term</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>BRIC</td>
<td>Brazil, Russia, India and China</td>
</tr>
<tr>
<td>CO₂e</td>
<td>Carbon Dioxide Equivalent</td>
</tr>
<tr>
<td>EAP</td>
<td>Environment Action Programme</td>
</tr>
<tr>
<td>EOL-RR</td>
<td>End-of-Life Recycling Rate</td>
</tr>
<tr>
<td>EOW</td>
<td>End of Waste</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EU28</td>
<td>The 28 Member States of the European Union</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse Gases</td>
</tr>
<tr>
<td>GOR</td>
<td>Gross Operating Rate</td>
</tr>
<tr>
<td>HS</td>
<td>Harmonised System</td>
</tr>
<tr>
<td>JORC</td>
<td>Australasian Joint Ore Reserves Committee</td>
</tr>
<tr>
<td>LME</td>
<td>London Metal Exchange</td>
</tr>
<tr>
<td>LP</td>
<td>Labour Productivity</td>
</tr>
<tr>
<td>MINT</td>
<td>Mexico, Indonesia, Nigeria and Turkey</td>
</tr>
<tr>
<td>M&amp;A</td>
<td>Mergers and Acquisitions</td>
</tr>
<tr>
<td>MRMS</td>
<td>Mineral Raw Materials Sector</td>
</tr>
<tr>
<td>MWD</td>
<td>Mining Waste Directive</td>
</tr>
<tr>
<td>NAICS</td>
<td>North American Industry Classification System</td>
</tr>
<tr>
<td>NEEI</td>
<td>Non-Energy Extractive Industries</td>
</tr>
<tr>
<td>NFM</td>
<td>Non-Ferrous Metals</td>
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<tr>
<td>OSR</td>
<td>Old Scrap Ratio</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>PGM</td>
<td>Platinum Group Metals</td>
</tr>
<tr>
<td>R&amp;I</td>
<td>Research and Innovation</td>
</tr>
<tr>
<td>RC</td>
<td>Recycled Content</td>
</tr>
<tr>
<td>REE</td>
<td>Rare Earth Elements</td>
</tr>
<tr>
<td>RES</td>
<td>Renewable Energy Sources Directive</td>
</tr>
<tr>
<td>RI</td>
<td>Recycling Industries</td>
</tr>
<tr>
<td>RTB</td>
<td>Relative Trade Balance</td>
</tr>
<tr>
<td>SA</td>
<td>South Africa</td>
</tr>
<tr>
<td>SGE</td>
<td>Share of Global Exports</td>
</tr>
<tr>
<td>SGO</td>
<td>Share of Global Output</td>
</tr>
<tr>
<td>SWOT</td>
<td>Strengths Weaknesses Opportunities and Threats</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>WFD</td>
<td>Waste Framework Directive</td>
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</table>
1.0 Introduction

The Mineral Raw Materials Sector (MRMS), comprising the non-energy extractive industry (NEEI) and recycling industry (RI) for the relevant materials, is the source of most of the basic raw materials required by Europe’s manufacturing and construction industries.

The MRMS is a key sector in driving growth in the European Union (EU). A wide range of metals, industrial minerals and construction minerals are utilised in Europe to build vital infrastructure, such as roads, homes and hospitals, and to help produce many of the industrial and consumer products consumed in the EU.

1.1 Background to the Study

The gathering momentum behind the EU’s 2020 strategy⁴ has led to clear priorities for achieving sustainable growth, and these have been given further substance through the Innovation Union flagship initiative, which identifies the critical role that the MRMS can play in driving real growth across the EU.⁵ Indeed, with the European Commission’s target of raising the proportion of GDP attributable to industry to 20% by 2020,⁶ there is a clear need for the EU to be confident that it has access to raw materials for the foreseeable future on terms which do not place its industry at a commercial disadvantage. One way of contributing to this, especially where geopolitical concerns affect the prospects for supply, can be through enhancing the competitiveness of its own NEEI. Another is through ensuring that recycling industries capture, in an efficient manner, materials from the waste stream that are suitable for use by industry.

The establishment of the Raw Materials Initiative and the European Innovation Partnership on Raw Materials have made it clear that the European Commission is determined to maximise the benefits that may be derived from the MRMS by increasing its competitiveness.⁷ Activities to enhance competitiveness will need to be based on a detailed understanding of the industries’ current performance, as well as a clear assessment of the challenges and opportunities faced by these industries in the global marketplace, some of which may be highlighted through examining recent trends.

It is also envisaged that manufacturing industries may increasingly adopt new business models which seek to retain the value in secondary materials through the transition to a circular economy. In January 2011, the European Commission’s Communication on a resource-efficient Europe⁸ was launched as one of the Europe 2020 flagship initiatives,

---

coordinating actions across many policy areas to secure sustainable growth and jobs through better use of resources. Building upon that initiative, the European Commission presented a Roadmap to a Resource Efficient Europe\(^9\) in September 2011, the ideas within which were further developed in the 7\(^{th}\) Environment Action Programme (EAP) "Living well, within the limits of our planet".\(^10\) This has, as a priority objective, the transformation of the EU into a resource-efficient, green and competitive low-carbon economy.

Figure 1 shows the changing shift in the location of all metal mining activity in the world since 1850 based on the value of the metals mined. The figure shows the decreasing share of European activity since the 1860’s, and the increase in share from a number of regions in the world. Notably, the figure shows that, since the 1990’s, all regions’ share in metal mining activity has decreased - apart from China.

*Figure 1: Location of World Metal Mining by Region (1850 to 2009)*

![Figure 1](image_url)

**Notes:** World mining is measured as the total value at the mine stage of all metals produced in all countries.

**Source:** ICMM (2012)\(^11\)

Generation of resource is not, however, limited to the extraction of minerals. The use of secondary materials as an additional (and in some cases alternative) source to primary resources through the process of recycling makes a significant economic and environmental contribution.

---

\(^9\) European Commission (2011) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Roadmap to a Resource Efficient Europe


1.2 Objectives

The purpose of this study is to provide the European Commission with a clear and up-to-date understanding regarding the current competitiveness of the EU NEEI and RI in respect of the MRMS. In doing so, the intention is to assist the European Commission, as well as Member States, industry and other stakeholders, in developing, implementing and assessing the policies and actions supporting the goals of EU Industrial policy to increase the share of industry on GDP to 20% as well as the goals of EU Raw Materials Strategy, and the European Innovation Partnership on Raw Materials.\(^{12}\)

Previous studies have identified that some of the NEEI industries face significant challenges associated with global competition, and they foresaw that this was likely to continue.\(^{13,14}\) Similar investigations have also concluded that Europe has a significant opportunity in the field of recycling, although the basis for this is not so clear. Additionally, the Commission emphasises the potential growth that could be realised by developing and enhancing ‘industrial symbiosis’ whereby waste materials from some firms are used as raw material inputs by other firms, as outlined in the Roadmap to a Resource Efficient Europe.\(^{15}\)

The combined assessment in this study of both the extractive and recycling industries aims, for the first time, to present a combined picture of the MRMS. It is hoped that this affords valuable insight as part of the Competitiveness and Innovation Framework Programme, helping to support the development of MRMS for the benefit of Europe.\(^{16}\)

1.3 Scope

1.3.1 Geographic Scope

The study sets out to consider the competitiveness of the 28 Member States of the European Union (EU28) relative to the rest of the world.\(^{17}\) It does not consider the individual Member States’ position, and in respect of trade, the focus is on trade between the EU and the rest of the world. In other words, the emphasis has been on performance of the EU28 as a trading bloc. In order to focus the study, a set of comparison countries has been agreed with the Commission, these being, by and large, the key players in the sectors under examination. These countries are shown in Table 1.

---


\(^{17}\) These comprise Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom. Note that where data is presented prior to the formation of the EU28 (i.e. prior to the 1st July 2013), it has been aggregated from the Member States to form EU28 data. It might be argued that this ‘distorts’ the view of what constitutes ‘the EU’. 

Competitiveness of the EU MRMS 3


Table 1: Comparison Countries

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<thead>
<tr>
<th>Comparison Countries</th>
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<tbody>
<tr>
<td>Australia</td>
</tr>
<tr>
<td>Brazil</td>
</tr>
<tr>
<td>Canada</td>
</tr>
<tr>
<td>Chile</td>
</tr>
<tr>
<td>China</td>
</tr>
<tr>
<td>India</td>
</tr>
</tbody>
</table>

Notes:
The comparison countries have been chosen on the basis of their high relative share in the production of the representative materials outlined in the Technical Appendix (Section A5.0).

In some cases, it has not been possible to find relevant information and data relating to some of the comparison countries. In such instances, therefore, the EU28 is compared to those comparison countries for which the data and information are available.

1.3.2 Defining Competitiveness

In order to assess the competitiveness of the European NEEI and RI industries it is necessary to define ‘competitiveness’ so that the relevant data required for its assessment can be collected, and analysed as appropriate.

A review of some relevant studies in respect of their approach to defining competitiveness is summarised in the Technical Appendix (Section A2.0). There is no clear definition of competitiveness which allows for a simple and straightforward assessment of it. Much of the analysis of competitiveness has been discursive. Consequently, there is no single, and readily quantifiable, indicator of competitiveness. Generally, studies have sought to understand competitiveness through reference to proxy indicators, supplemented by a discussion of competitiveness issues.

For the purposes of our assessment, we have been guided by the high level EU definition from the EU 2020 strategy, which we adopt as our principal definition. This suggests that the cornerstone of competitiveness for the EU is increased productivity with respect to its trading partners.\(^{18}\) This fundamental approach is echoed in the existing competitiveness studies that have been sponsored by the Commission. For example, the 2011 Commission Communication (COM (2011))\(^{19}\) noted:

> Ultimately, competitiveness is about stepping up productivity, as this is the only way to achieve sustained growth in per capita income — which, in turn, raises living standards.

This definition does not necessarily make assessment of competitiveness any more straightforward. Indeed, it raises a number of subsidiary questions as to how productivity should be measured for the NEEI and RI at the EU level.

In principle, it might be possible to do more to identify the most relevant variables using techniques from econometrics. This would require a dataset which captures measures of the characteristics one seeks to explore in the analysis so that their significance as independent variables could be explored. However, such a dataset is not readily available for the EU or its competitors in the sectors of relevance to this study, and as such, it has been necessary – as with other studies – to make use of proxy indicators.

In summary, in this study we aim to evaluate competitiveness by exploring a number of specific economic and market indicators, and related issues which impact on the indicators, so as to evaluate the performance of the MRMS in the EU in terms of how its productivity has developed relative to key trading partners in recent years.

1.3.3 Sectoral Classification

The NEEI can be divided in three main sub-sectors based on the different physical and chemical characteristics of the minerals produced, on their uses, and on the downstream industries they supply. The three main sub-sectors of the NEEI, as it has been classified in this report, are:

► Metallic minerals (Metals);
► Industrial minerals; and
► Construction minerals.

Each of these are described further in Section 2.0.

1.4 Method of Assessment

The analysis presented in this study is based upon a number of different methods, these include:

► literature review;
► analysis of economic and market data;
► interviews with operators within the NEEI and RI throughout 2014; and
► workshops with trade associations associated with the NEEI and RI throughout 201420

The MRMS is comprised of a number of tiers as shown in Table 2. This study focuses mainly at the most aggregated level of the NEEI and RI as a whole (Tier 1). However, recognising that there are likely to be differences within these sectors, additional analysis is provided at the lower tiers.

It would not have been possible to analyse all materials that form the MRMS in the scope of this study, so selected representative materials have been considered instead as a way of exploring the variation in performance within a sector. These are detailed within the Technical Appendix, alongside the justification for their selection.

20 Details relating to the stakeholders engaged during the course of the research are included in Section A9.0 of the Technical Appendix
This inevitably leads to some generalisation and masks potentially significant material-specific information that might be relevant to individual materials, for example; however, the strategic nature of this study aims to provide an analysis of the EU28 MRMS and the NEEI and RI as a whole rather than a detailed exposition for every sub-component of it.

**Table 2: Structure of MRMS Used in the Study, by Tiers**

<table>
<thead>
<tr>
<th>Tier</th>
<th>Term</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sectors</td>
<td>NEEI, RI</td>
</tr>
<tr>
<td>2</td>
<td>Sub-sectors</td>
<td>Metals, Industrial Minerals, Construction Minerals</td>
</tr>
<tr>
<td>3</td>
<td>Sub-group</td>
<td>Non-Critical Non-ferrous Metals, Construction Aggregates</td>
</tr>
<tr>
<td>4</td>
<td>Secondary Sub-group</td>
<td>Base Metals, Precious Metals</td>
</tr>
<tr>
<td>5</td>
<td>Representative Materials</td>
<td>Gypsum, Lead, Gold</td>
</tr>
</tbody>
</table>

**1.4.1.1 Who is Competing?**

It should be noted that the NEEI and RI are, in some cases, in competition with each other. Actors in the RI, for example, seek to sell materials into markets which are often largely shaped by the players in the MRMS, and they may be competing for custom from end users of material which could be of primary or secondary origin. At the strategic level, however, they might be considered as complementary sources of material for industry, and hence, the inclusion of both within the scope of this study.

Figure 2 illustrates the relationships between the EU NEEI and RI and the rest of the world (RoW) NEEI and RI, aiming to demonstrate which aspects of the EU28 economy competes and cooperates with. Each sector can be seen to be competing with one another to supply raw materials to potential users of those materials. The EU28 RI also competes with other waste management options within the EU28: the financial viability of recycling is shaped by the costs of disposal, or of treating waste as mixed, or unsegregated, waste.
1.5 Structure of the Study

This study is structured in to three distinct phases, these comprise of the following aspects:

1) **Describing the EU28 MRMS.** The first two sections of the study aim to explain to the reader how the EU28 NEEI and RI compare to key comparison countries;

2) **Explaining the factors that impact on competitiveness of the EU28 MRMS.** The following three sections aim to identify the key aspects which impact on the performance of the EU28 NEEI and RI.

3) **Providing a synthesis and assessment of competitiveness of the EU28 MRMS.** The final two sections aim to synthesise the information presented in the previous sections and provide an assessment of the competitiveness of the EU28 NEEI and RI, alongside suggested initiatives for improving the competitiveness.

Figure 3 provides a detailed breakdown of each of the sections associated with the study.
### Figure 3: Structure of the Study

<table>
<thead>
<tr>
<th>Describe</th>
<th>Explain</th>
<th>Synthesise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 2.0 - The EU industry in a global context</td>
<td>Section 3.0 - An economic and market assessment of the MRMS</td>
<td>Section 4.0 – An assessment of the Policy and Legislation Framework</td>
</tr>
<tr>
<td>This section aims to describe the NEEI and RI and highlight a number of key facts associated the sectors, including trends and patterns in production, price mechanisms and the costs structure of the different sub-sectors</td>
<td>This section provides a detailed description of economic and market indicators which are used to compare the EU28 alongside comparison countries</td>
<td>This section provides an assessment of the key impacts associated with policy and legislation in relation to the NEEI and RI</td>
</tr>
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<table>
<thead>
<tr>
<th>Section 5.0 - Raw Materials Supply</th>
<th>Section 6.0 - Research and Innovation</th>
<th>Section 7.0 – A SWOT Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>This section provides an assessment of the ability for the EU NEEI and RI to gain access and supply minerals</td>
<td>The section provides an assessment of the role of research and innovation in supporting activity within the NEEI and RI</td>
<td>A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis is provided for both the NEEI and RI in order to obtain a strategic view of competitiveness</td>
</tr>
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<table>
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<tr>
<th>Section 8.0 - Suggested Initiatives</th>
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</thead>
<tbody>
<tr>
<td>This section aims to provide the key recommendations relating to the EU28 NEEI and RI over the short, medium and long term</td>
</tr>
</tbody>
</table>
2.0 The EU Industry in a Global Context

It is necessary to have a general understanding of the nature of the NEEI and RI in order to develop a sound assessment of their competitiveness. This section provides a brief overview of the NEEI and RI in a global context, outlining an overview of price formation, the importance of value chains and the industry structure.

2.1 Non-Energy Extractive Industries

The EU28 possesses a dynamic NEEI producing a wide range of minerals. For a small number of minerals the EU28 is the world leader in production, e.g. salt. However, this situation is not representative for the sector as a whole, and of the representative materials included in this report, only for gypsum and potash does EU28 production account for over 10% of global production.

Table 3: Global Share of Representative Materials - 2012

<table>
<thead>
<tr>
<th>Representative Materials</th>
<th>EU28 Share of Global Production (2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum</td>
<td>13.2%</td>
</tr>
<tr>
<td>Potash</td>
<td>12.8%</td>
</tr>
<tr>
<td>Silver</td>
<td>7.0%</td>
</tr>
<tr>
<td>Zinc</td>
<td>5.6%</td>
</tr>
<tr>
<td>Copper</td>
<td>5.0%</td>
</tr>
<tr>
<td>Lead</td>
<td>4.2%</td>
</tr>
<tr>
<td>Fluorspar</td>
<td>2.4%</td>
</tr>
<tr>
<td>Nickel</td>
<td>2.3%</td>
</tr>
<tr>
<td>Cobalt</td>
<td>1.1%</td>
</tr>
<tr>
<td>Gold</td>
<td>1.0%</td>
</tr>
<tr>
<td>Iron Ore</td>
<td>1.0%</td>
</tr>
<tr>
<td>Bauxite</td>
<td>0.9%</td>
</tr>
<tr>
<td>PGM</td>
<td>0.2%</td>
</tr>
<tr>
<td>Graphite</td>
<td>0.0%</td>
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</tbody>
</table>

Furthermore, for some metals, such as the rare earth elements (REE), niobium, antimony and lithium, the EU28 is wholly reliant on imports for its industry. This situation is in part geologically determined, with some minerals not known to occur in deposits in the EU that are currently of economic interest. For some other minerals, including those of which resources may be present in the EU, supplies are derived from long-established overseas sources where the mines, processing plant, infrastructure and skills are located.

Global population growth and rapid industrial development in China and the other BRIC (Brazil, Russia, India and China) and MINT (Mexico, Indonesia, Nigeria, and Turkey) nations have been major drivers in global NEEI developments over the past 10 years. For China, this applies not only in respect of consumption, but also in respect of production. As well as supporting global market prices for materials such as iron ore through demand for use in its unprecedented infrastructural development, China has also developed its own extractive industries to the point where it dominates global production of several minerals.\(^{23}\)

Just as modern industrialisation in China and the other BRICs is linked to the development of mineral extraction, the relative depletion of many of Europe’s surface mineral resources is due to its historically anterior process of industrialisation. Having developed industrial infrastructure earlier than those nations now undergoing rapid economic growth, Europe has, for many minerals, already achieved many of its easy gains in terms of extraction, and there has been very little systematic modern exploration aimed at identifying new reserves.\(^{24}\)

A large proportion of the metal and industrial mineral mining activity in Europe is conducted underground, whilst in other regions open pit mining is the dominant method. Of the total number of metal mines in the world some 52% are open-pit operations, 43% underground operations and 4-5% are placer or tailings operations. Of total tonnages produced some 85% is derived from open pit operations (including placer operations) with 15% from underground mines.\(^{25}\)

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Technological developments have made it possible to mine ores of declining grades and more complex mineralogy without increasing costs. In most cases however, the technological progress has been made by small incremental developments rather than breakthroughs into entirely new processes.

The total number of mines in the world is huge. However, if small-scale mines are excluded, and only ‘industrial-scale’ operations are counted, there are some 2,500 metal-producing mines in the world.\(^{26}\) Additionally, metal mining activity is also undertaken by informal, and in some cases, illegal, operators. The World Bank estimates that there are 15 to 20 million artisanal and small scale miners operating in 30 countries, mainly focussed on mining Tantalum, Tin and Gold.\(^{27}\)

Examining the publicly available data, there were approximately 270 enterprises in the EU27 in 2010 operating with mining of metal ores.\(^{28}\) Around 42,000 FTEs were employed in the mining of metal ores in the EU27 in 2009, equivalent to 6.5 % of all persons employed in mining and quarrying (Section B).\(^{29}\)

In Europe there are approximately 700 industrial mineral mines and quarries and 750 plants throughout Europe.\(^{30}\) The industrial minerals sub-sector is made up of approximately 60% SMEs. For the construction minerals sub-sector, quarrying activity typically takes place in open pits, rather than underground. The sector consists mainly of SMEs operating over 20,000 extraction sites, generally supplying local and regional markets.

Examining the most available data, in 2010 the EU27\(^{31}\) industrial and construction mineral sub-sectors comprised of 18,000 enterprises and 214,000 FTEs.\(^{32}\)

Of the three main sub-sectors of the NEEI, as classified in this study, where construction minerals are concerned, for the majority of what is used, supply tends to be relatively localised. This is due both to the ready availability of these minerals, and also, the high costs of transporting minerals of high volume, but (for the most part) relatively low value. Consequently, international trade between the EU28 and other countries accounts for a relatively small component of the market activity of this the sub-sector: it follows that the issue of competitiveness – understood as the performance of the EU28 vis a vis its competitors – is less of an issue in this sub-sector other than for some more specialist materials.\(^{33}\)

\(^{26}\) Ibid
\(^{28}\) Data not available for Croatia
\(^{30}\) See [http://www.ima-europe.eu/about-industrial-minerals/industry-profile](http://www.ima-europe.eu/about-industrial-minerals/industry-profile)
\(^{31}\) Data not available for Croatia
\(^{33}\) This does not mean to say that countries within the EU28 do not trade in these materials. Rather, that when viewed as a trading bloc, analysis of competitiveness appears somewhat less relevant for this subsector than for the others.
The scope of this research includes the exploration, extraction and processing stages of the NEEI as shown in Figure 4. Those stages beyond the production of raw materials are excluded from this study.

**Figure 4: Scope of the Project by Lifecycle Stage - NEEI**

Source: Adapted from Resnick Institute (2011) 34

It is recognised that some minerals will not necessarily follow each stage of the lifecycle as outlined in Figure 4. For example, some minerals will be ready for sale on the market without much processing after extraction (for example aggregates). However, other minerals, such as aluminium derived from bauxite, require highly intensive processing to create the materials that are used in products.

2.1.1 **Metallic Minerals**

The EU metallic minerals sub-sector produces a wide range of ores which, following processing, yield metals or metallic substances. European metal mines compete in a global market and a significant number of metallic ores are imported to supply the European metallic industry. 35

Mines extracting metallic ores usually also undertake the mineral beneficiation to concentrate the valuable components of the ore before it is transported for further processing and/or refining at a dedicated production facility. This step often involves


smelting and/or electrowinning processing stages that are within the scope of this assessment. Processes beyond this stage are out of scope.

The metals industry is a diverse sub-sector comprising a number of sub-groups, each with its own characteristics. These are shown in Table 4.

**Table 4: The Metal Sub-Sector**

<table>
<thead>
<tr>
<th>Sub-Sector</th>
<th>Sub-Group</th>
<th>Secondary Sub-Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal</td>
<td>Ferrous</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Non-ferrous: Non-Critical</td>
<td>Base Metals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Precious Metals</td>
</tr>
<tr>
<td></td>
<td>Non-ferrous: Critical</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Non-ferrous metals, which comprise numerous individual metals, can be distinguished from ferrous metals by virtue of their enhanced resistance to corrosion. Non-ferrous metals may be classified as base, precious or critical metals.

Critical metals are typically used in low volumes in new and green technologies. They are labelled as critical when the risks of supply shortage and their impacts on the economy are higher compared with most of the other raw materials. In many applications the critical metals are not readily substituted and end of life recycling rates are low. Many critical metals are also distinct in that they are recovered only during the process of extracting other metals. Figure 5 aims to conceptualise this issue by showing relationships between interconnected metals in different ore types.

---

2.1.2 Industrial Minerals

The industrial minerals sub-sector comprises non-metallic, non-energy minerals used as feedstock for producing goods in a wide range of industries. The industries in which industrial minerals are used include chemical production, fertiliser production, paint, electronics, metal casting & foundry, paper, plastics, glass, ceramics, detergents and many more besides.

In contrast to the metals sector where there are a number of recognised grades (standard compositions) that are traded globally, this is not generally the case for industrial minerals, where grades and specifications are commonly defined for individual contracts for specific end uses. Thus, industrial minerals are often valued on their physical or chemical composition.\(^{38}\)

Like the metal sub-sector, the industrial minerals sub-sector can be divided into a number of sub-groups. For the purpose of this assessment, two sub-groups have been considered: the chemical sub-group, where the chemical composition determines the use (i.e. those used in the agriculture industry as fertiliser); and the physical sub-group where the physical characteristics determine what they are used for.

---


### Table 5: The Industrial Minerals Sub Sector

<table>
<thead>
<tr>
<th>Sub Sector</th>
<th>Sub-Group</th>
<th>Secondary Sub-Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Minerals</td>
<td>Physical</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Chemical</td>
<td>N/A</td>
</tr>
</tbody>
</table>

#### 2.1.3 Construction Minerals

The construction minerals sub-sector includes minerals such as sand and gravel used for civil engineering and building work. The consumption of construction minerals is closely related to the level of new house-building, maintenance and repairs of existing buildings and the scale and extent of civil engineering projects. Thus the production and use of construction minerals typically follows trends in the economic cycle.\(^{39}\)

In this assessment the construction minerals sub-sector is divided into two main sub-groups, aggregates and non-aggregates. The aggregates sub-group is further divided into crushed rock and sand and gravel as shown in Table 6.

### Table 6: The Construction Minerals Sub Sector

<table>
<thead>
<tr>
<th>Sub Sector</th>
<th>Sub-Group</th>
<th>Secondary Sub-Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Minerals</td>
<td>Aggregates</td>
<td>Crushed Rock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sand and Gravel</td>
</tr>
<tr>
<td></td>
<td>Non-aggregates(^1)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Notes:**

1) Includes, for example, Limestone not used for aggregate purposes.

#### 2.1.4 Mechanism of Price Formation

For each of the sub-sectors (metals, industrial minerals and construction minerals), the method of price formation is unique. Generally speaking, the prices of metals are set globally and trades are conducted through formal exchanges. Most notable of all is London Metal Exchange (LME), which is responsible for more than 80% of all non-ferrous metal futures business.\(^{40}\) As time has progressed the types of trades and the number of minerals has evolved. For example in 1869 the opening of the Suez Canal reduced the delivery time of tin from Malaya to match the three months delivery time for copper from Chile. This gave rise to the three month metal futures market which still exists to this day.\(^{41}\)

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Although metal mining operations are spread across the globe, local changes can impact on prices. For example, a recent change in environmental legislation in China has impacted on the global price of iron ore, as demand for lower grade ores has weakened.\footnote{Financial Times (2014) \textit{Iron Ore Price Hangs in the Balance}, http://www.ft.com/cms/s/0/841113bc-1ee6-11e4-9d7d-00144feabdc0.html}

In contrast to most metals, industrial minerals tend not to be marketed or sold as standardised products via centralised markets, such as the LME, but are sold directly to the formulator or end-user.\footnote{European Commission (2014) \textit{The EU Industrial Minerals Sub-Sector}, \url{http://ec.europa.eu/enterprise/sectors/metals-minerals/non-energy-extractive-industries/metallic-minerals/index_en.htm}} This also includes some metals, including, many of the EU’s critical raw materials, such as cobalt, gallium, indium and rare earths. The market for these materials is less transparent, and the volumes traded are very small in comparison to other materials. Mechanisms for price formation are, as a result, less transparent, and some markets may suffer from market failures in respect of asymmetric information.

Within Europe, construction minerals are typically the type of minerals most likely to be traded locally. As transport costs dominate the price of aggregates, most markets are local or regional and there is relatively little international trade, with the notable exception of north-west Europe (in particular Belgium and the Netherlands). The widespread occurrence of construction minerals, and the low costs of processing to make useable aggregates, means that prices are typically lower than for metals and industrial minerals.

For the non-aggregate construction minerals sub-group, the specialist nature of the minerals mean that the mechanism for price formation is more akin to industrial minerals sub-sector, where minerals are sold directly to the formulator or end-user.

\subsection*{2.1.5 Value Chains}

Although mining activities have become increasingly located in more remote and less developed regions of the world, smelter and refinery production is still located mainly in more developed regions, including the EU28. The existence of operators that function across the whole mining value chain for metals has hitherto been unusual. In recent years, however, there has been increased involvement in extractive activities by companies whose main focus has been downstream in the value chain – for example, smelters, refiners, manufacturers and even commodity traders.

The trend towards increased vertical integration is already visible in the number of steel companies seeking to enter mining to secure their supplies of iron ore and coking coal at reasonable cost.\footnote{The International Council on Mining and Metals (2012) \textit{Trends in the Mining and Metals Industry}, October 2012, \url{http://www.icmm.com/document/4441}} The drivers for such integration relate to a wide range of factors, including increased transport costs, and market dominance of large integrated companies.

A wave of mining industry mergers and acquisitions (M&A) has been sweeping the world since the beginning of 2005, and has resumed in 2010 with intensified force after the temporarily slowdown in 2008/09.\footnote{POLINARES (2012) \textit{Mining Industry Corporate Actors Analysis - POLINARES working paper n. 16}, March 2012, \url{http://www.polinares.eu/docs/d2-1/polinares_wp2_chapter4.pdf}}
For the industrial and construction minerals, integrated value chains are perhaps more commonplace, as the steps in the value chain are typically less complex, and therefore, the opportunity to add value at each stage of the chain is more limited.

2.1.6 Industry Structure

The NEEI spans a complex web of various private, publicly-traded and state-owned companies. These can be categorised by the size of the asset base, as shown in Table 7. While companies specialising in construction minerals are notably SMEs supplying local or national markets, most producers of industrial minerals and metallic minerals operate globally.\(^{46}\) Although the largest 150 companies represent a few per cent of the total number operating in the sector globally, these companies actually control about 85% of total global mineral production.\(^{47}\)

Table 7: Profile of the Formal\(^{48}\) Global Mining Sector

<table>
<thead>
<tr>
<th>Type of Company</th>
<th>Asset Base</th>
<th>Number</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>Exceeds €8 billion</td>
<td>50</td>
<td>Global and senior companies which have access to the largest portion of available capital</td>
</tr>
<tr>
<td>Seniors</td>
<td>€2 – €8 billion</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Intermediates</td>
<td>€0.8 – €2 billion</td>
<td>350</td>
<td>Companies often on a growth path to become seniors</td>
</tr>
<tr>
<td>Juniors (production)</td>
<td>€395 million – €0.8 billion</td>
<td>1,500</td>
<td>Companies which often have one mine</td>
</tr>
<tr>
<td>Juniors (exploration)</td>
<td>€4 – €395 million</td>
<td>2,500</td>
<td>Volatile and share market dependent; they are finders, not producers and their focus is on their exploration activities</td>
</tr>
<tr>
<td>Juniors - Juniors</td>
<td>Below €4 million</td>
<td>1,500</td>
<td>Focus is on accessing venture capital and enhancing their stock price</td>
</tr>
</tbody>
</table>

Notes: Values converted from US$ to € using exchange rate of 0.79.  
Source: ICMM (2013)

Table 8 shows the global share by value of production of the world’s top 10 metal-producing companies. In 2010 these companies accounted for 33% of global metal production by value. The activities and operations of these companies often span the globe and their headquarters may not always be in the same locality of their current mining and quarrying

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\(^{47}\) Ibid

\(^{48}\) ‘Formal’ refers to non-illegal, non-artisanal mining activity.
operations. Instead, the location may be more representative of their historic locality, thus two of the top ten companies are headquartered in the EU28.

In recent years there has been a shift in the exploration sector to the so called junior companies, i.e. companies which do not have a cash flow, but which are set up with the goal to explore for, and find, new ore bodies. These companies may be compared to the so called “high tech” companies in the biotechnology and IT sectors. They are small and flexible with capacity to make quick and risky decisions that larger companies often avoid. Furthermore, they can take greater political risks as they, in some cases, are not listed, but depend on private capital which is sometimes willing to go to countries where major established companies which are publicly listed are not able to operate due to their CSR (corporate social responsibility) undertakings and ethical guidelines.49

Table 8: Top Metal-producing Companies in 2010

<table>
<thead>
<tr>
<th>Rank world 2010</th>
<th>Company name</th>
<th>Headquarters</th>
<th>Share of value 2010 (%)</th>
<th>Cumulated share 2010 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vale SA</td>
<td>Brazil</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2</td>
<td>Rio Tinto plc</td>
<td>UK</td>
<td>5.5</td>
<td>13.5</td>
</tr>
<tr>
<td>3</td>
<td>BHP Billiton Group</td>
<td>Australia</td>
<td>5.5</td>
<td>19.0</td>
</tr>
<tr>
<td>4</td>
<td>Anglo American plc</td>
<td>UK</td>
<td>2.8</td>
<td>21.8</td>
</tr>
<tr>
<td>5</td>
<td>Freeport-McMoran Copper &amp; Gold</td>
<td>USA</td>
<td>2.2</td>
<td>24.0</td>
</tr>
<tr>
<td>6</td>
<td>Codelco</td>
<td>Chile</td>
<td>2.0</td>
<td>26.0</td>
</tr>
<tr>
<td>7</td>
<td>Barrick Gold Corp</td>
<td>Canada</td>
<td>2.0</td>
<td>28.0</td>
</tr>
<tr>
<td>8</td>
<td>Xstrata plc</td>
<td>Switzerland</td>
<td>1.8</td>
<td>29.8</td>
</tr>
<tr>
<td>9</td>
<td>Norilsk Nickel</td>
<td>Russia</td>
<td>1.8</td>
<td>31.6</td>
</tr>
<tr>
<td>10</td>
<td>Newmont Mining Corp</td>
<td>USA</td>
<td>1.5</td>
<td>33.0</td>
</tr>
</tbody>
</table>

Source: POLINARES (2012)50

2.2 Recycling Industries

Although EU production of key minerals may be, in some cases, relatively low or non-existent, the products consumed by households and businesses, particularly in the conurbations of the EU28 nations, may be considered to constitute a rich mineral resource which can be tapped through processes commonly known as recycling, and sometimes

referred to as ‘urban mining’ (though, of course, this activity is also already practiced in rural areas – the concentrations may be expected to be lower in these areas, however).

There is an ongoing debate regarding when specific waste materials should be considered to have been ‘recycled’. The Waste Framework Directive allows Member States to determine ‘end of waste’ standards, and some such standards exist at the EU level. When material ceases to be ‘waste’, it becomes a product and falls out of the normal controls applied to the management of materials defined as waste. In this study, we take the view that the ‘Recycling Industries’ relate primarily to the reprocessing of materials extracted from the waste stream into new materials which effectively replace, or compete with, those from primary raw materials. Given the preceding discussion, it will be appreciated that it is possible for materials to achieve an ‘end of waste’ status prior to the point at which they are reprocessed in the manner described. As such, ‘the recycling industry’ might more formally be described as those industries responsible for managing materials from the waste stream such that they are no longer fall under the waste definition: reprocessors may deal with materials which, though derived from the waste stream, have ceased to be ‘waste’. We do, in any case, also make reference to upstream processes, such as collection, dismantling and sorting, to the extent that they have a bearing on the competitiveness of the recycling industry, understood in this way.

While the EU may not be a global leader in primary resource extraction (see above), it is in a strong position to become a global leader in terms of resource recovery, at least insofar as that resource is available in the form of discarded products and packaging. In this regard, a telling point is the semantic shift which is occurring within the waste management industry away from talk of managing ‘waste’, and towards the desirability of making use of ‘resources’. Increasingly, products which have reached the end of their useful life are being viewed not as a problem to be disposed of, but as a source of material for the production of new goods and services.

The drivers for recycling include avoiding the costs of disposal (which is strongly influenced by national, or sometimes, regional policies), savings in material and energy costs, increasing security of supply, and other waste management policies. Because recycling is not always profitable based on material values alone, the costs of the alternative ways of managing waste, and hence, regulation, play an important role in promoting recycling measures.\(^{51}\) The guiding principles of waste management in the EU28 are largely reflected in the waste hierarchy, as set out in Article 4 of the Waste Framework Directive. This presents an order of general preference for waste management options serving as a broad normative guide, with environmental outcomes maximised as the hierarchy is ascended (see Figure 6).

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The top tiers, prevention of waste and preparation for reuse, have to date not been the focus of as much new policy as recycling, though this emphasis is shifting. Material recycling represents an area in which both environmental and economic gains can be attained, though it should be considered that such benefits may be even higher for activities higher in the hierarchy.

It should also be noted that in many economies, the recovery of scrap metals represents a potential source of income to populations, leading to considerable amounts of recyclate being collected informally. This informal collection bypasses the official collection, and hence, sometimes, the reporting channels. In such instances, nations may appear to have very low rates of material recovery, whereas in reality the rates may be much higher, simply because the true amounts recovered are not being captured—ironically because the materials are in fact being valued as a resource.

Alongside the NEEI, the scope of this report also includes the RI relating to the three sub sectors and their associated sub groups:

- Metallic Minerals (Metals)
- Industrial minerals; and
- Construction minerals

Figure 7 shows the scope of the RI by way of highlighting the lifecycle of commodities. The sector includes the capture and collection of recyclate within the EU28 and also the processing of the recyclate to form materials. This captures the recycling industry at a conceptual level, but we are aware that the industry can be more complex than shown in the figure. For example, we are aware that tailings from former mining operations in some countries are currently being re-processed with new technologies to produce commodities that were previously not economic to extract, thus supplying minerals from former waste deposits. Prominent examples of this practice include operations to recover cobalt, copper and chrome in Africa. We are also aware of an increasing number of operators looking to

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undertake activities similar to this, and in some cases these may be specific entities dedicated to this process.

**Figure 7: Scope of the Project by Lifecycle Stage - RI**

![Diagram showing the lifecycle stages of RI projects, including exploration, natural resources, mineral processing, raw material production, product manufacture, use, end of life, and additional processing stages.](source: Adapted from Resnick Institute (2011))

### 2.2.1 Mechanism of Price Formation

The scale over which RI markets operate determines the competitors with a given market. The scale of operation ranges from local to regional to global and is primarily dependent upon the value of the recyclate and the cost of transport. For example, aggregates operate under a local recycling market with competitors within the same region, within the private sector and other recycling firms. Industrial minerals bridge all scales with higher value materials traded globally, and competitors in global recyclers and primary production. The capture of materials and subsequent recycling activity competes with other treatment and disposal methods; if the disposal price is cheaper than the material will get directed towards that option.

### 2.2.2 Value Chains

The degree of vertical integration across recycling activities, from collection to treatment to end market use, can also have a strong impact on competitiveness.
A similar situation exists in the private sector, most noticeably where metal refiners and even end market consumers are looking to integrate vertically with re-melting and scrap collection operations.

### 2.2.3 Industry Structure

RI relates primarily to the reprocessing of material, however, in this section we make reference to upstream processes, such as collection, dismantling and sorting, due to a lack of available evidence directly focussed on the RI.

According to a report by the European Federation of Public Service Unions, in 2012 there were 16 major waste companies in Europe, with revenues ranging from €294 million to €7,099 million. Eurostat data shows that over 900,000 people are employed in the waste sector across the EU, including in materials recovery. This represents about 0.44% of the total numbers employed in the EU as a whole, but the percentage varies across countries.

In terms of the public / private split in waste management services, as far as municipal waste collection and processing are concerned, the pattern of ownership indicates roughly equal shares in the largest EU countries such as Germany, the UK and France.

The same European Federation of Public Services Union report (2012) states that in the EU, household waste constitutes only 8% of total waste generated. The rest is from industrial activities such as construction (33%), mining (28%) and manufacturing (13%).

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54 These companies are in descending order: Veolia; Suez Environnement; Remondis; Alba; FCC; Indaver; Urbaser; van Gansewinkel; Cespa; Biffa Group; Shanks Group; CNIM; Lassila & Tikanoja; Ragn-Sells; SAUR-Seche; and Saubermacher.

3.0 Economic and Market Assessment

As discussed in Section 1.3.2, there is no single indicator which defines competitiveness. In the section we provide information on key quantitative indictors of competitiveness. These indicators span a number of different elements:

► Production;
► Trade;
► Cost Structures;
► Profitability;
► Labour Productivity; and
► Location of New Investments and Mothballed facilities.

None of these indicators, in and of themselves, provides a clear assessment of competitiveness of the EU28. Rather the indicators all shed some light on the EU28’s performance, and together, help to give a more complete view of performance. The specific indicators used in the assessment are outlined in Table 9. These issues are examined in Sections 3.1 for NEEI and 3.2 for RI.
<table>
<thead>
<tr>
<th>ID</th>
<th>Theme</th>
<th>Indicator</th>
<th>Notes</th>
<th>Primary Data Source</th>
<th>Applicable to the NEEI?</th>
<th>Applicable to the RI?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Production</td>
<td>Share of Global Output = (EU28 Production)/(Global Production)</td>
<td>Production data in tonnes for representative commodities from 2003-2012 within the EU28 and the comparison countries</td>
<td>BGS production data</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>Production</td>
<td>Ratio of Production Share to Reserve Share = (((EU28 Production)/(Global Production)))/(EU28 Reserves)/(Global Reserves))</td>
<td>Production and Reserve data in tonnes for representative commodities from 2003-2012 within the EU28 and the comparison countries</td>
<td>BGS production data, USGS reserve data</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>3</td>
<td>Trade</td>
<td>Share of Global Exports = (EU28 Exports)/(Global Exports)</td>
<td>Export data by value for representative commodities from 2003-2012 within the EU28 and the comparison countries</td>
<td>UN Comtrade</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>4</td>
<td>Trade</td>
<td>Revealed Comparative Advantage</td>
<td>Export data by value for representative commodities from 2003-2012 within the EU28 and the comparison countries</td>
<td>UN Comtrade</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>5</td>
<td>Cost structures</td>
<td>Discussion of the % of operating costs relating to policy and legislation</td>
<td>Literature review of the impact of selected policy and legislation</td>
<td>Various sources</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>6</td>
<td>Profitability</td>
<td>Gross Operating Rate = ((Value added-wages &amp; salaries)/output)×100</td>
<td>Value added of the sector within the EU28 and the comparison countries from 2003-2012</td>
<td>Eurostat and other statistical organisations</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>7</td>
<td>Labour Productivity</td>
<td>Labour Productivity = Value added/Employees</td>
<td>Value added of the sector within the EU28 and the comparison countries from 2003-2012</td>
<td>Eurostat and other statistical organisations</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>8</td>
<td>Locations of New Investments /Mothballed Facilities</td>
<td>Map of new facilities</td>
<td>New investments in representative commodities within the EU28 and the comparison countries within the last 2 years</td>
<td>Various sources</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Map of mothballed facilities</td>
<td>Mothballed activities for the representative commodities within the EU28 and the comparison countries within the last 2 years</td>
<td>Various sources</td>
<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>
Whilst the nature of the analysis for the two industries (NEEI and RI) is similar, the available data upon which to base the analysis differs significantly between the two industries, with more data (albeit of varying quality) available for NEEI, but very significant data gaps for RI. As a result, the reliability of the conclusions that can be drawn for the two industries differ.

The analysis of each indicator is largely conducted without reference to the other indicators in these sections in order to provide clarity. However, a view on competitiveness can only be arrived at by building up a broader understanding of a number of different facets. At the end of each Section, therefore, we provide a synthesis that brings together the findings which emerge from considering all the indicators for that industry in so far as the data permits. This provides far greater insight than each indicator alone, although it will be appreciated that this synthesis does not account for the causes of the data, which are dealt with in Sections 4.0 to 6.0.

Additionally, whilst there is separation between the NEEI and RI, in some instances there is clear overlap between the two. In particular the trade indicators for commodities will account for exports of commodities from both extractive and recycling sources, and so, in such circumstances, the analysis is brought together to ensure that this interaction is captured.

### 3.1 Non-Energy Extractive Industries

#### 3.1.1 Production – Share of Global Output

In any given market, if a country is gaining market share then that might indicate the country is becoming more competitive as it is expanding its share of the market at the expense of competitor countries. This holds true whether the market itself is expanding, contracting, or broadly stable, as, in all instances, a country is improving performance relative to competitors. Conversely, a country that loses market share might be doing so as result of a decline in its competitive position, with other countries gaining market share at the expense of the country in question. Primary minerals extraction might provide an exception to this rule since if the country has exhausted its economically viable reserves, then market share might be declining for reasons related to resource endowments.

Furthermore, depending on how elastic the supply is, then it may also be that countries could expand market share at times of higher prices since they are the marginal producers. In this context, it is useful to consider price evolution. Figure 8 presents the price index of selected metals over a 10 year period. The figures shows that the price of index rose between 2003 and 2008, before decreasing sharply during the financial crisis. From 2009 to 2011 the index rose once more. However, since 2011, prices have declined.
Global trade is most commonly traded in US dollars, thus for EU28 producers, the exchange rate is also an important consideration. Whilst it is noted that not all producers in the EU28 utilise the Euro, examining the relationship between the US dollar and Euro gives some indication of whether the trend observed in Figure 8 impacts EU28 producers. Figure 9 shows the changes in the exchange rate between the US dollar and the Euro since 2003.

**Figure 9: US dollar/Euro Exchange Rate (2003 -2014)**

Source: European Central Bank (2015)  

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56 International Monetary Fund (2015) *IMF Primary Commodity Prices*, January 2015,  
From 2003 to 2008, the Euro strengthened in value against the dollar, meaning that producers paid value in dollars earned less in 2008 compared to 2003. This could indicate that without successful hedging of the exchange risk, EU metal producers using the Euro may not have received the beneficial prices available in the market. From 2009 onwards there appears to have been significant volatility, however, generally the Euro has weakened against the dollar. Therefore, in the absence of hedging, metal producers using the Euro may have benefited during this time.

The share of global output can be explored by comparing the production of a country of interest (or group of countries) in a given industry, with the total global production to identify market share. This can then be traced over time to give an indication of how this is changing. This is defined as the ‘Trend in the Share of Global Output’ (SGO) which is calculated as follows:

\[
\frac{\Delta SGO \, (\%)}{\Delta t} = \frac{EU28 \, \text{Production in tonnes}}{Global \, \text{Production in tonnes}}
\]

Production data published by British Geological Survey (BGS) has been used to determine the SGO. This data has excellent coverage across the EU28 and key competitor countries, as well as excellent coverage of individual commodities.\(^58\) The source of the data and how it has been utilised is discussed in detail in the Technical Appendix (Section A5.0).

Complications arise for a few commodities due to the nature of their value chains. For example, data for gold are reported at one level only – that for gold extracted. However, for some metals, such as aluminium, cobalt, copper, lead and zinc, data are available for various forms, which essentially distinguish between production from mines, and production from smelters/refineries. For example, the aluminium production chain reports data at three levels:

- Bauxite;
- Alumina; and
- Aluminium.

The challenge associated with this is that the different products are not equivalent and therefore cannot be readily combined. Indeed the material flow through one will feed the next, so that would lead to double- and in some cases, triple-counting, as well as misrepresenting market shares. In this section the analysis therefore

58 Note: The only mineral for which data is not currently available for this analysis is niobium as this data has historically been collected with data for Tantalum
focusses, in the first instance, on the ore (i.e. mine production) where such a distinction proves possible.

The results of this analysis are shown in Figure 10. The results clearly show that for all of the sub sectors there has been a declining trend in the EU share of global output in the ten years to 2012. This could be an indication that the European industries are becoming less competitive than industries of competitor states. On the other hand, the indicator does not accurately reflect the productivity of industry, and could simply imply progressive utilisation of the available resource: because extraction of the ore presumes the existence of the ore, increases in productivity cannot always be reflected in expanding production (as might be the case in other markets for manufactured goods). Conversely, this is an industry where it might be possible to be increasing productivity, but where the ability to expand production (let alone market share in a market where demand may be growing) might be constrained.

**Figure 10: EU28 Share of Global Output by Sub-Group**

![Figure 10: EU28 Share of Global Output by Sub-Group](image)

*Source: British Geological Survey (BGS) World Mineral Statistics database*\(^{59}\)

It is instructive also to look at whether production has declined in absolute terms. Table 10 also indicates that the production of all but one of the 4 categories has seen a decline in production in absolute terms. Ferrous metals are the exception, and production has increased by 16%. That having been said, the Table also indicates that, because the overall market has increased in size, the EU28 has seen its market share of ferrous metals production halved, even despite this absolute increase in output.

Table 10 indicates that, whilst in all sub-groups the EU28 have lost market share, the global market has, in fact, grown, in many cases substantially, over the same period. This indicates that, whilst there have been opportunities for growth available, it has

---

\(^{59}\) The nature of reported data is such that the non-ferrous metal sub-group cannot be split into constituent parts for this analysis.
not been possible for the NEEI in Europe to respond to these opportunities to the same extent that industries in competitor countries have been able to. As identified in Figure 8 and Figure 9 between 2003 and 2008 producers using the Euro appear to have been at a disadvantage in respect of the prices it receives for its production compared to counterparts using the dollar. However, in the most recent period this situation has reversed. The question, therefore, that arises is whether that potential for increased market share has really been constrained by physical factors, or whether the decline reflects declining competitiveness.

**Table 10: Performance of EU28 Production Compared to Global Markets**

<table>
<thead>
<tr>
<th>Sub-Group</th>
<th>Change in Production¹</th>
<th>EU28 Share of Global Output</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EU28 (2003-12)²</td>
<td>Global (2003-12)²</td>
<td>Proportionate Change in Share (2003-12)⁴</td>
</tr>
<tr>
<td>Metals - Ferrous</td>
<td>16%</td>
<td>139%</td>
<td>-1.04%</td>
</tr>
<tr>
<td>Metals - Non-Ferrous</td>
<td>-17%</td>
<td>51%</td>
<td>-1.50%</td>
</tr>
<tr>
<td>Industrial Minerals - Physical</td>
<td>-31%</td>
<td>8%</td>
<td>-7.32%</td>
</tr>
<tr>
<td>Industrial Minerals - Chemical</td>
<td>-17%</td>
<td>17%</td>
<td>-4.46%</td>
</tr>
</tbody>
</table>

**Notes:**

1) *All rates are presented as compounded growth rates based on output in tonnes.*

2) *Percentage change in production where 0% indicates that EU28 or global production is the same size in 2012 as it was in 2003.*

3) *Change in Share (i.e. reduction in share of global output from 2% to 1% would be shown as -1% change).*

4) *Proportion of market share gained or lost (i.e. reduction in share of global output from 2% to 1% would be shown as -50% change).*

*Source: BGS Production Statistics*

There are two distinct patterns highlighted by Table 10:

- ▶ The ferrous metal sub-group exhibits growth in production, but a significant decline in share of global output due to much greater growth in global production; and

- ▶ The other sub-groups exhibit contracting production in the EU28 in a context of growing global production, also leading to a decline in share of global output.
3.1.2 Production – Ratio of Production Share to Reserve Share

The ratio of share of global output to share of global reserve could, in principle, give some indication of the competitiveness of an industry. This is based on the hypothesis that if an industry is more competitive, then it will be extracting more mineral relative to its reserves compared to the global average. The situations where this might not arise would be those where particular actors were able to exert market power.

Where the term “Reserve” is used here, it has originated from the use of the “Reserve” data quoted by the USA Geological Survey. Whilst it is acknowledged that USGS state that “Reserves” must be economically viable to mine, it is noted that the definition is not as strict as that required in reporting codes such as JORC. Therefore, the term “Reserve” does not necessarily equate to Reserves under JORC (or NI-43-101) reporting standards. The USGS definition of “Reserve” is provided in the Technical Appendix (Section A3.0.).

It is also noted that reserve data is a challenging dataset to utilise as reserves will always vary over time due to:

a) exploitation of the resource; and

b) the fact that most mining companies only have relatively few years of reserve on their balance sheet at any one time, and will carry out exploration to convert ‘inferred resources’ to ‘proven reserves’ on an ongoing basis.

This further adds to the dynamic nature of reserve data.

The calculation used to determine this for the EU28 is:

\[
\frac{\Delta \text{Ratio of Production Share to Reserve Share}}{\Delta t}
\]

Where:

\[
\text{Ratio of Production Share to Reserve Share} = \left( \frac{\text{EU28 Production in tonnes}}{\text{EU28 Reserves in tonnes}} \right) / \left( \frac{\text{Global Production in tonnes}}{\text{Global Reserves in tonnes}} \right)
\]

The same calculation can be performed for competitor countries. The figures can be converted into an index where a value of 1 indicates performance at the average level, and where values can be greater than, or equal to, zero. The meaning of the index values is shown in Table 11.
Table 11: Potential Results from Ratio of Production to Reserve Calculations

<table>
<thead>
<tr>
<th>Result</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha = 0$</td>
<td>That the EU28 (or competitors) produce none of the minerals for which data is available.</td>
</tr>
<tr>
<td>$0 &lt; \alpha &lt; 1$</td>
<td>The EU28 extract less of their reserves compared to the global average.</td>
</tr>
<tr>
<td>$\alpha = 1$</td>
<td>The EU28 extracts the same proportion of their reserves as the global average.</td>
</tr>
<tr>
<td>$\alpha &gt; 1$</td>
<td>The EU28 extract a greater proportion of their reserves than the global average.</td>
</tr>
</tbody>
</table>

The data used to determine this index is taken from the production data already addressed in Section 3.1.1 which is published by BGS, and reserve information published by the United States Geological Survey (USGS). Whilst the production data is generally accepted to be reliable and relatively consistent, the nature of the reserve data is thought to be of a relatively low quality, and there is far less certainty over the values reported. Indeed, the manner of reporting can lead to sudden jumps in index values from year to year. The major reasons for data uncertainty are the following:

► Reserve information is dependent on numerous factors including exploration data and a wide range of economic, market, social, legislative and regulatory factors. Reported reserves do not represent the total amount of a mineral commodity that may be available in any country because they are neither fixed, nor well known. In practice, reserves are commonly replenished as additional exploration is conducted to offset mined reserve;

► Reserve information will also vary significantly from country to country depending on the reporting systems, and the definitions, used in each jurisdiction;

► If a substantial new reserve is identified, then there will be a substantial jump in the reserve figure, leading to a very significant change in the index; and

► Reserve data is not available for all mineral commodities and this may lead to a distortion of the results in this analysis, therefore it has not been possible to present a complete picture of all of the selected representative commodities.

These issues mean that the analysis of this index needs to be carefully considered as there are a number of reasons why the index would change for reasons other than changes in a country’s competitive position. The results should be considered as less reliable than those derived from other indices.
The availability of reserve data is summarised in Table 12. The only sub-group for which data is available for all representative materials is the chemical industrial minerals sub-group. For two sub-groups, ferrous metal and physical industrial, it is not possible to calculate any values due to lack of data. The non-ferrous groupings can be calculated, but these are based on limited data and should therefore be used with caution.

Table 12: Availability of Reserve Data by Representative Commodity

<table>
<thead>
<tr>
<th>Sector</th>
<th>Sub-Group</th>
<th>Representative Commodity</th>
<th>Availability of Reserve Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ferrous</td>
<td>Iron Ore</td>
<td>Limited</td>
</tr>
<tr>
<td></td>
<td>Non-ferrous: Non-Critical</td>
<td>Aluminium</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nickel</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tin</td>
<td>Limited</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zinc</td>
<td>Limited only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silver</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gold</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cobalt</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indium</td>
<td>None</td>
</tr>
<tr>
<td>Metals</td>
<td>Non-ferrous: Critical</td>
<td>Niobium</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Platinum Group Metals</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rare Earths</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td>Physical Uses</td>
<td>Gypsum</td>
<td>Very Limited</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Graphite</td>
<td>Very Limited</td>
</tr>
<tr>
<td></td>
<td>Chemical Uses</td>
<td>Fluorspar</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potash</td>
<td>Available</td>
</tr>
<tr>
<td>Industrial Minerals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key:

- All data available
- Some data available
- No/very limited data available

Figure 11 provides a high-level representation of this index over the period 2003-2012. A very significant jump in index value between 2009 and 2010 is conspicuous. This is caused by a very significant readjustment in the estimated reserve available for potash in the EU28 between these two years, dropping from 752 million tonnes in 2009 to 192 million tonnes in 2010. This has the effect of significantly increasing the index value as the ratio of EU28 reserve to world reserve drops substantially whilst production does not change significantly between these groups. Such a jump highlights the issues already outlined regarding reserve data whereby indices can jump with no underlying change in competitiveness – which indicates that the
general trends are more relevant to this analysis rather than the step changes in the index caused by adjustments in estimated reserves.

Additionally it highlights the notable performance of the precious metals sub-group, which though declining moderately is relatively stable around a value of 8.0. This is largely driven by the production of silver in Poland. This high figure may indicate an industry which is highly competitive.

For all but non-ferrous precious metals (silver) and chemical industrial minerals, the ratio is <1. This could indicate:

a) A lack of competitiveness of the industry; or
b) A failure to adjust reserves over time as the resources available are exhausted (given the relatively low level of exploration activity in the sector – see Section 5.1.1.1); or
c) A combination of the two, with the lack of competitiveness of industry either explained by, or resulting in, a low level of exploration activity.

**Figure 11: EU28 Ratio of Production Share to Reserve Share – All Available Data**

![Graph showing EU28 Ratio of Production Share to Reserve Share](image)


### 3.1.3 Trade – Share of Global Exports

Whilst absolute and relative levels of production can be informative regarding the capacity of an industry, the level of exports, imports and the balance of the two can provide an indication of how production is meeting local demand and the extent to which the products are attractive to the international (export) market. These do not indicate competitiveness per se, but the trends over time can be revealing and may be indicative of a change in the competitive position.
The first indicator to be considered for trade is the Share of Global Exports (SGE) by value. This indicator compares the EU28 (or any country or region chosen for analysis) exports in a given industry, with the total global exports in that industry to identify market share. This is calculated as follows:

\[
SGE \, (\%) = \left( \frac{EU28 \, Exports \, by \, value}{Global \, Exports \, by \, value} \right)
\]

The data used to calculate this are taken from trade data published by UN Comtrade and takes the EU28 as a trading bloc – i.e. intra-EU trade is excluded from the analysis. The data within has been collected along standard lines for a significant period of time – data is available back to 1993 or earlier for the majority of representative commodities. As further discussed below, the trends in the data are concordant with those expected from a reliable dataset. The use of a single database for all input data also bypasses any data compatibility issues that might arise through using multiple data sources. The data source, extraction of data and nature of the data are all discussed in detail in the Technical Appendix (Section A5.0.).

It is important to consider that both supply and demand can influence trade, and that increasing Share of Global Exports (SGE) does not necessarily indicate enhanced competitiveness. For example, if a major exporter introduces export quotas, SGE may increase artificially. Nonetheless, it is clear that trade figures can provide valuable insight, especially when read in conjunction with production figures.

Where applicable, each representative material was divided into two categories: “ore” and “semi-finished materials” (e.g. iron ore and iron metal). For materials in which the “ore” and “semi-finished materials” are the same substance (e.g. gold, building stone etc.), these are only represented under the “semi-finished materials” category”. A separate “recyclate” sub-group was also used in our analysis, as discussed further in Section 3.2.2.

The limitations on availability of trade data are summarised in Table 13. The only sub-group for which data was not available for all representative materials is the critical metals sub-group. Within this group, data was patchy due to the way in which trade codes are specified and the small quantities that are traded. For example, the ores of indium, PGM and REE are captured together with that of “other metal ores”. Additionally, for semi-finished materials, the data for indium, niobium and REE is reported, but only as part of wider groups of metals from which their individual trade levels cannot be discerned. Due to this limitation, calculations for the critical metals sub-group should be treated with caution.

---

60 By ore, we mean both ores and concentrates
61 By semi-finished materials, we mean materials produced by chemical processing of ores and concentrates, including intermediate products for further processing, as well as powders and formed materials such as sheets, wires, and bars
Based on the available data, a high level overview of the imports and exports can be obtained for the representative material, grouped by sub sector, as shown in Table 14. The Table indicates that in 2012, for all those groupings where it makes sense to report in terms of “the ore”, the value of imports exceeds the value of exports. This tends to suggest that, subject to reserves being available, there is room for additional production of primary ores in the EU28. We noted above that only for ferrous metals has output increased (in absolute terms) in recent years. The picture for semi-finished materials is, however, somewhat more positive. For both critical metals and non-aggregate construction minerals, the value of export exceeds the value of imports. Generally, the trade in semi-finished materials appears more balanced, potentially indicating a more competitive industry in respect of this category of materials than is the case with primary ores.

### Table 13: Availability of Trade Data by Representative Material

<table>
<thead>
<tr>
<th>Sub-Sector</th>
<th>Sub-Group</th>
<th>Representative Commodity</th>
<th>Availability of Trade Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Iron Ore</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aluminium</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nickel</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tin</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zinc</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silver</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gold</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cobalt</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indium</td>
<td>Captured as part of other metals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Niobium</td>
<td>Part of group</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Platinum Group Metals</td>
<td>Captured as part of other metals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rare Earths</td>
<td>Captured as part of other metals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gypsum</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Graphite</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fluorspar</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potash</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limestone</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sand and Gravels</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Building Stone</td>
<td>Available</td>
</tr>
</tbody>
</table>

**Key:**
- All data available
- Some data available
- No data available
- Mineral does not have an ore

**Based on the available data, a high level overview of the imports and exports can be obtained for the representative material, grouped by sub sector, as shown in Table 14. The Table indicates that in 2012, for all those groupings where it makes sense to report in terms of “the ore”, the value of imports exceeds the value of exports. This tends to suggest that, subject to reserves being available, there is room for additional production of primary ores in the EU28. We noted above that only for ferrous metals has output increased (in absolute terms) in recent years. The picture for semi-finished materials is, however, somewhat more positive. For both critical metals and non-aggregate construction minerals, the value of export exceeds the value of imports. Generally, the trade in semi-finished materials appears more balanced, potentially indicating a more competitive industry in respect of this category of materials than is the case with primary ores.**
The data could also be indicative of an industry which is reasonably integrated vertically, with additional value being added prior to export. Note also that the value of exports is much higher for semi-finished materials. Evidently, such values are expected to be higher but this also indicates the relevance of access to raw materials for the material processing sectors.

**Table 14: Imports and Exports of EU28 Representative Material by Sub-Sector (2012)**

<table>
<thead>
<tr>
<th>Sub-Sector</th>
<th>Sub-Groups</th>
<th>Imports (US$m)</th>
<th>Exports (US$m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ore</td>
<td>Semi-Finished Material</td>
</tr>
<tr>
<td>Metals</td>
<td>Ferrous Metals</td>
<td>31,155</td>
<td>19,728</td>
</tr>
<tr>
<td></td>
<td>Base Metals</td>
<td>26,433</td>
<td>81,843</td>
</tr>
<tr>
<td></td>
<td>Precious Metals</td>
<td>351</td>
<td>107,237</td>
</tr>
<tr>
<td></td>
<td>Critical Metals</td>
<td>84</td>
<td>14,684</td>
</tr>
<tr>
<td>Industrial Minerals</td>
<td>Physical Industrial Minerals</td>
<td>N/A</td>
<td>354</td>
</tr>
<tr>
<td></td>
<td>Chemical Industrial Minerals</td>
<td>N/A</td>
<td>4,351</td>
</tr>
<tr>
<td>Construction Minerals</td>
<td>Aggregates</td>
<td>N/A</td>
<td>2,318</td>
</tr>
<tr>
<td></td>
<td>Non-Aggregates</td>
<td>N/A</td>
<td>6,550</td>
</tr>
</tbody>
</table>

*Source: UN Comtrade*

Figure 12 provides a high-level overview of the EU28 Share of Global Exports for the year 2012. It is evident that the share of global exports for metal ores is lower than for the corresponding semi-finished material, indicating that the majority of value generated through export from the EU28 is through the higher value semi-finished material rather than higher volume ores. Again, this might suggest that the EU is more competitive in respect of semi-finished materials than in ores, though equally, the share of exports of ores would be expected to be more strongly influenced by the geological endowment of a given country and access to its resources.
While this figure provides a snapshot of the share of global exports at a specific point in time, it does not enable an assessment of temporal trends. By calculating the change in the share of global outputs over a 10 year period, it was possible to assess whether the market share attributable to the EU28 is growing or declining – a growing market share would indicate a more competitive industry:

$$\Delta SGE (\%) = SGE_n - SGE_{n-10}$$

The results of this analysis are presented in Figure 13 and show that the EU28 share of global exports in most sectors has barely changed, when compared to the decrease in precious metals and increase in critical metals. Smaller decreases in share are observed for ferrous metals, physical and chemical industrial minerals and aggregates and non-aggregates. Base metals has increased its share for both ores and semi-finished material.

As already noted, however, this does not mean that the EU28 has necessarily become more or less competitive, as it is feasible that there is diminishing levels export of minerals from competitor nations due to their increasing internal demand means that the markets are contracting (increasing competitor consumption).
The export of precious metal ores falling steeply. At the same time, the share of exports of semi-finished precious metals has increased, whilst that for semi-finished ferrous metals has declined. This could suggest that for precious metals, more processing is happening than in the past, whilst for ferrous metals, market share has not been maintained.

Exports of both ores and semi-finished base metals have increased. The same applies to critical metals. The apparently “stellar” improvement in export of ores of critical metal needs to be considered against the very small change in absolute terms, whereby the value exported has changed from $0.5m in 2003 to $2.3m in 2012 (shown in part in Table 14) – this is most likely due to small changes in value of the critical metals alongside higher recovery.

There has been a small change in the share of exports accounted for by the physical industrial minerals. For aggregates, the change has been much more significant, but this might be set in context of the materials’ relatively low value. Both the chemical industrial minerals and the non-aggregates construction minerals have, however, experienced a significant decline in the share of global exports for which they are responsible.
3.1.4 Trade – Relative Trade Balance

Examining exports alone provides an indication of competitiveness, while the relative balance of exports and imports provides another perspective. In order to examine this, the Relative Trade Balance (RTB) is considered, which describes the amount of exports by value relative to imports (also by value) of materials from a given sector. It is measured as:

\[
\text{Relative Trade Balance} = \frac{X_i - M_i}{X_i + M_i}
\]

\(X_i\) and \(M_i\) are EU28 exports and imports of products of sector “i” to and from the rest of the World.

This index and any trends in its value over time sheds some light on the competitiveness of an industry. This is based on the assumption that if an industry is more competitive then net exports will increase over time as a proportion of overall trade. As for SGE, the interpretation is not quite so straightforward, as changes in the index will also be affected by supply and demand in competitor countries.

This index has a range of possible values from -1 to 1, as shown in Table 15.

Table 15: Potential Results from Relative Trade Balance Calculations

<table>
<thead>
<tr>
<th>Result</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha = -1)</td>
<td>The material is imported but not exported by the EU28</td>
</tr>
<tr>
<td>(\alpha = 0)</td>
<td>The material is imported and exported in equal quantities by the EU28</td>
</tr>
<tr>
<td>(\alpha = 1)</td>
<td>The material is exported but not imported by the EU28</td>
</tr>
</tbody>
</table>

The data used to determine this index is taken from the same trade database (UN Comtrade) used to calculate the share of global exports indicator (Section 3.1.3).

Figure 14 shows the RTB for the EU28 in 2012 and demonstrates that, for almost all semi-finished materials and ores, the EU28 currently imports substantially greater quantities than it exports. Exceptions to this rule are critical metals (semi-finished not ores), and non-aggregate construction minerals. Clearly this indicates that for both ores and semi-finished materials, whilst there has been growth in share of exports for some minerals, exports remain small relative to imports.

It may, perhaps, seem confusing that for some minerals, the SGE can rise, but that the RTB can worsen. However, in open economies, firms will look to buy and sell on the best terms. Hence, even if SGE may increase, imports might not be falling. Furthermore, in many cases importers of goods, wherever they are located, will have quality criteria when it comes to the ores, semi-finished materials or recyclates that they are purchasing. These criteria may be very broad, but they may also be quite specific and rigorous. Therefore, it is feasible that for higher value mineral products, the EU does not produce minerals of sufficient quality for the subsequent manufacturing industries and these are exported whilst these manufacturers import...
products of sufficient quality. Conversely it is also feasible that the EU can only economically produce minerals of higher quality, and the demand for these materials are located elsewhere, leading to exports at the same time as large imports of lower quality bulk minerals. It is not possible to provide details on which of these trends is being applied to the EU28 as comprehensive data on quality of minerals is not captured.

For many minerals there are a large number of different properties that will result in them being more or less desirable. It may be the case that the EU28, for example, produces only 3% of all of mineral A, but that this actually represents 50% of mineral A that has a highly desirable property. As a result the trade balance might be heavily weighted to imports, but this would mask the competitiveness of the EU within the high value segment, which may well have a trade surplus. This serves to highlight the challenges of analysis of RTB, and indicates that it is perhaps most powerful when individual markets can be assessed with a strong understanding of the different qualities of product available.

**Figure 14: NEEI - Relative Trade Balance (2012)**

![Graph showing Relative Trade Balance (2012)](source.png)

*Source: UN Comtrade*

Figure 15 to Figure 17 provide results of the Relative Trade Balance index calculations for a ten year period of data (2003 – 2012) for mineral ores and semi-finished materials respectively.
Figure 15: EU28 Relative Trade Balance of Ores - Metals

Source: UN Comtrade

Figure 15 demonstrates that the RTB for the ores of ferrous and non-ferrous base metals has been steadily improving but that for ores of precious metals, the RTB has worsened significantly. For critical metals, some small improvement from a position of almost complete import dependence has taken place.

Figure 16 and Figure 17 demonstrate the change in the relative trade balance of semi-finished materials over the last 10 years. As with the SGE data, the minerals for which the market is relatively small show greater volatility, with precious and critical metals showing particularly large variations in the metals sector. The chart shows that the RTB is improving for precious metals and base metals, and is more or less flat for critical metals and precious metals. No obvious trend is observable for the industrial and construction minerals, although all seem to have seen some improvement from 2008-2009, possibly reflecting effects of the economic crisis. Only for non-aggregate construction minerals, however, did this give rise to more sustained improvement.

This trade deficit in ores and semi-finished materials needs to be seen within a wider context. Given that these are the inputs to manufacturing industries, where significant value is added, it is perhaps not surprising that in an industrially advanced economy, there is a trade deficit in these input minerals. Therefore the trade deficit alone is not of particular concern. Where there are notable trade surpluses, however, this will very likely indicate relatively high-value minerals where the EU is able to add significant value. For example, the critical metal sub-group has the best overall trade balance, reflecting the availability of processing capabilities within the EU and thus indicating strong competitiveness. Another example is in non-aggregates where building stone that is exported will often be of very high value.
(with potential availability of stone in all territories, there is no need to import unless there is a need for a particular high-end material) and the EU sometimes operates a trade surplus, indicating the ability of the region to produce stone of high quality that can be exported.

**Figure 16: EU28 Relative Trade Balance of Semi-Finished Materials - Metals**

![Graph of EU28 Relative Trade Balance of Semi-Finished Materials - Metals](source)

**Source:** UN Comtrade

**Figure 17: EU28 Relative Trade Balance of Semi-Finished Materials – Industrial and Construction Minerals**

![Graph of EU28 Relative Trade Balance of Semi-Finished Materials – Industrial and Construction Minerals](source)

**Source:** UN Comtrade
3.1.5 Trade – Revealed Comparative Advantage

Revealed Comparative Advantage (RCA) is a well-known indicator, first proposed in the mid-1960s, used to assess the relative advantage or disadvantage of a certain country in a certain class of goods or services as assessed through relevance to trade flows. It is calculated as follows:

\[ RCA_i = \frac{\frac{X_{EU_i}}{\sum_j X_{EU_j}}}{\frac{X_{W_i}}{\sum_j X_{W_j}}} \]

This utilises the following:
- \( X_{EU} \): The value of exports from the EU to the world
- \( X_W \): The value of exports from a reference group of 106 countries to the world\(^{62}\)
- The subscript ‘i’ denotes the specific material or product in question
- The subscript ‘j’ denotes any material of product. Summing over all of these materials and products gives the total of all exports

The output of this indicator is a ratio of two ratios and can have values between 0 and infinity. It cannot be negative. The possible results are summarised in Table 16.

**Table 16: Possible Results from RCA Analysis**

<table>
<thead>
<tr>
<th>Result</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha = 0 )</td>
<td>The EU exports none of this mineral</td>
</tr>
<tr>
<td>( 0 &lt; \alpha &lt; 1 )</td>
<td>The exports of this mineral from the EU are lower as a proportion of total EU exports than they are for the group of reference countries</td>
</tr>
<tr>
<td>( \alpha = 1 )</td>
<td>The exports of this mineral from the EU are the same proportion of total EU exports as they for the group of reference countries</td>
</tr>
<tr>
<td>( 1 &lt; \alpha &lt; \infty )</td>
<td>The exports of this mineral from the EU are greater as a proportion of total EU exports than they are for the group of reference countries</td>
</tr>
</tbody>
</table>

Comparative advantage is not necessarily a strong indicator of ‘competitiveness’. Rather, it may simply indicate, for example, a lack of diversification in the export portfolio of a given country. Indeed, it would be possible for a country to have a RCA greater than 1, but for its productivity to be relatively low, though this would be

\(^{62}\) The choice of 106 countries is presented in the Technical Appendix (Section A5.1) – these account 99% of total world GDP.
expected to apply to relatively small exporters only. This needs to be borne in mind when assessing RCA.

Additionally, it should be noted that RCA can also be written in the following manner:

\[
RCA_i = \frac{X_{EU i}}{X_{W i}} \times \frac{\sum_j X_{W j}}{\sum_j X_{EU j}}
\]

This alternative form highlights a challenge in using the RCA. The first part of the equation is Share of Global Exports (SGE). If the second part of the equation (the ratio of world exports to EU28 exports of all commodities) remains largely constant over time, then this indicator simply becomes the SGE multiplied by a constant factor. In such situations, RCA will not provide significant additional insight save for the indication of whether the balance is above or below 1.0. Analysis of the ratio of world to EU28 exports across the period 2003-2012 shows that the differences are very small, meaning that the results are almost identical to those of share of global exports over time. The proportion of EU exports compared to the reference group remains consistently in the region of 12-13% in this period.

As a result of these issues, detailed examination of the RCA is limited here as it would largely duplicate the analysis for share of global exports.

3.1.6 Cost Structures

As an energy intensive sector, electricity and fuel costs comprise a substantial proportion of the NEEI’s cost structure. Although this will affect some sectors more than others, variations in the cost of energy will influence competitiveness across all the materials considered in this study.

Energy costs are formed from two aspects:
   
a) The overall use of energy; and
b) The price paid for the energy.

Interviews with operators within the NEEI in EU28 have yielded a variety of estimates of the percentage of the operating costs which relate to the cost of energy, ranging from less than 10% to over 20%. Our discussions with operators found that energy requirements differ considerably, depending on the type of mineral being extracted, whether it is mined underground or on the surface and the extent to which it is processed.

Research conducted by the European Commission in 2007 found similar findings. The research found that the energy costs in the EU, as a proportion of the overall site operating cost for minerals extraction, were up to approximately 20% (Table 17).
Table 17: Comparison of the Relative Costs of Energy (electricity and fuel) as a Proportion of Overall Operating Costs

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>Estimated energy costs in the EU as a proportion of overall site operating cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallic minerals (copper and zinc)</td>
<td>15%-17%</td>
</tr>
<tr>
<td>Construction minerals (aggregates)</td>
<td>3%</td>
</tr>
<tr>
<td>Industrial minerals</td>
<td>11%-19%</td>
</tr>
</tbody>
</table>

Source: European Commission (2007)63

More recent research has also been conducted by the Commission into the proportion of production costs relating to energy for the metals manufacturing sector – a sector not within scope of this research. This research has estimated that the Basic Metals sector shows an average energy share of 19%. The Other Metals and Mineral Products sector has an average energy share of about 30%.64

From the limited information available, it is clear that energy costs within the EU28 can represent a sizeable proportion of overall operating costs for some operators. However, due to a lack of reliable and up to date data, it has not been possible to identify differences between comparable operators within and outside of the EU28. Further research, aimed on the price of energy, is presented in Section 4.1.2.

3.1.7 Profitability

The profitability of an industry gives an insight into its competitiveness. A profitable industry is able to produce goods or services with sufficient margin to generate revenue that exceeds the costs of production. If prices were to fall, the companies with greater profit margins will be more able to survive, owing to a lower production cost. In addition companies with greater profit margin have more money available to reinvest in the business to continue to develop products and services to maintain a competitive advantage and to potentially grow the industry and gain market share. Therefore regions or countries with greater profitability are likely to be more competitive than those with low profitability, both in terms of survival and development and growth of a sector.

Direct measures of profits are difficult to gain in a form in which the data are readily comparable. Profits declared by a company will be affected by accounting practices and by corporate strategies. The measure of profitability utilised in this assessment is the Gross Operating Rate (GOR). It is calculated using the following formula:

\[
GOR (%) = \left( \frac{\text{Value added} - \text{wages & salaries}}{\text{output}} \right) \times 100
\]

Where:

\[ \text{Value Added} = \text{Output Value} - \text{Expenses} \]

This is a useful measure of profitability, but is limited by the following two aspects:

► Where an organisation/sector has some vertical integration, this will make comparisons of GOR difficult; and

► Where capital can easily be substituted for labour, wages and salaries will be significantly reduced leading to a substantially higher GOR. As a result it is anticipated that more industrialised economies would exhibit higher GOR values.

The data utilised to calculate this ratio does not form a uniform dataset, but originates from national/regional statistical or mining bodies from each comparator country and from Eurostat for the EU28. Consequently, the results may have been derived in slightly different ways. In each instance, however, the values that most closely matched the Eurostat definitions were utilised in an attempt to ensure comparability of data. Nonetheless, the following analysis should be read with an understanding that the data are not uniform, and comparability is not assured. The source and nature of the information for all of the countries represented is provided in the Technical Appendix (Section A5.0).

Whilst for some countries there is detailed data available regarding structural business statistics at semi-finished material, sub-group and sector level, in many countries there is no data available or very limited data at only one specific level (mostly sector). As a result, only the following levels of analysis have been possible:

► Metals – Total
  o Metals – Ferrous
  o Metals – Non-Ferrous

► Non-Metals – Total (Excluding Energy Extractive Industries)
  o Non-Metals – Industrial Minerals
  o Non-Metals – Construction Minerals

A summary of the data availability for key competitor countries is shown in Table 18. This table highlights that there are relatively few complete datasets and that, even for complete datasets, there are often limitations regarding the time series of data available. It is worth noting that the nature of the data used to calculate GOR is very similar to that used to determine Labour productivity (LP), and so this table is also relevant for the analysis in Section 3.1.8.
### Table 18: Availability of data for Gross Operating Rate and Labour Productivity

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Sub-Sector Level</th>
<th>Sub-Group Level</th>
<th>Mineral Level</th>
<th>Time Period</th>
<th>Additional Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU28</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>Only aggregated for 2010</td>
<td>Mining data only included in reporting since 2008</td>
</tr>
<tr>
<td>Australia</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Full coverage</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>Full coverage</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Reporting discontinued from 2007</td>
<td></td>
</tr>
<tr>
<td>Chile</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>Data only reported in index form which prevents analysis</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>Data only presented at all mining level</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>Mining data not included in business statistics reporting</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>Full coverage back to 2005</td>
<td>Data only reported for top 10 commodities with no summary of groupings or total sector</td>
</tr>
<tr>
<td>Japan</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>No data 2006-2011</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>Every five years (2003 &amp; 2008)</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>2008-2011 with some 2010 data missing and some 2012 data</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>Whilst some data is available at sector level, it is incomplete and prevents analysis of indicators</td>
<td></td>
</tr>
</tbody>
</table>

In what follows, it is important to note that because the value of output will vary with rises and falls in commodity prices, the GOR for different countries is best compared within a given year. Both the general trend in GOR in EU28 relative to

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65 Full coverage at sub-group level, no data for individual raw materials between 2008 and 2011
other countries, and the GOR value in a given year compared to that which prevails in others, are of greatest interest.

3.1.7.1 Metals

The calculated GOR values (in %) for the total metals sector are shown in Figure 18. The different time periods over which data is available for each country, or group, is clear and highlights that there is only one year for which data is fully aggregated for the EU28.

The GOR reported for the EU28, whilst being for a single point in time, still provides useful insight. At just above 30%, the GOR is low compared to almost all the other data points available for competitors. Indeed only six other data points are below 30%, five of which are for Brazil and South Africa. This GOR figure is much lower than those reported by Canada and Australia, and for the majority of those reported by Japan, all of which are highly industrialised economies with the ability to substitute capital for labour. The fact that the EU28 is reporting a GOR that is closer to those reported for countries with lower labour costs indicates that the EU28 are potentially less profitable in the extraction of metals. Note that for most countries, GOR has been increasing in recent years as output values for many commodities have been increasing over the period examined.

This analysis is clearly severely restricted by the lack of trend data for the EU28, and so it is not possible to determine the broader trend in performance, and the extent to which this data point is representative. Nonetheless, it is possible to draw some conclusions for the broader competition, which is that except for South Africa, there is a clear upward trend in GOR in this sector. Unless the EU28 is increasing GOR at a similar rate, then one might have reason to believe that the profitability of its metal extraction industry is declining, at least in relative terms.
Figure 18: Gross Operating Rate – Total Metals (%)

Notes: Where data points are beyond five years apart, a dotted line is denoted.

The metals sector comprises the ferrous and non-ferrous sub-groups. There is no reported aggregated data for the EU28 ferrous industries, but two consecutive years of data are available for the non-ferrous sub-group (Figure 19). For this analysis there is no data available at the equivalent level for Japan and Mexico.

This chart shows that the performance of the EU28 in the non-ferrous sub-group is perhaps superior to the broader metals sector (and hence by inference, to the ferrous sub-group). The rates reported are marginally higher than for metals as a whole, but perhaps more notably they are much closer to the GOR values available for Australia and substantially outperform Brazil and South Africa. The non-ferrous subsector in the EU28 appears more profitable than the metals sector as a whole.
The values available for GOR in the ferrous sub-group among competitors are shown in Figure 20. If one considers the figures for all metals and for non-ferrous metals, the EU28 figure would be just below 30 for the year 2009. All countries for which a figure is available fare better than this in 2009. It seems likely that Canada would also have a figure in excess of the EU28 one.

This emphasises that within the EU28 metals sector, the ferrous sub-group appears to be somewhat less competitive than the non-ferrous sub-group.
3.1.7.2 Non-Metals

Whilst the sectoral classification used in this project splits the MRMS by metals, industrial minerals, and construction minerals, the nature of structural business statistics is that reported data is often in the form of metals and non-metals, with non-metals comprising both industrial minerals and construction minerals. It is at the level of non-metals that the best data are available, and more are presented here.

The results of the analysis of GOR for non-metals are shown in Figure 21. This shows that more data points are available for the EU28 with values for 2008-2011, inclusive, being available. The EU’s performance is clearly at the lower end of the spectrum and had dipped below the rates in both Brazil and South Africa by 2011. As worrying is the hint – the statistics are not good enough for us to be confident of this – that GOR has not shown much sign of increasing, even though competitors’ GOR has increased since 2009.

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66 It is important to note that the data for non-metals does not include energy minerals.
Figure 21: Gross Operating Rate – Non-Metals (%)

Notes: Where data points are beyond five years apart, a dotted line is denoted.

As shown in Figure 22, the data availability at sector level is very poor, with only Brazil, Canada and South Africa providing data alongside four years of aggregated data for the EU28. The data limitations for the industrial mineral sector are similar. This amount of data does not provide significant insight beyond that already identified.

The EU28 exhibits similar GOR values to those of South Africa and Brazil, but substantially below Canada. This may well be related to the scale of operations in Canada which facilitate significant capital investment thereby reducing the labour costs, which can be identified from the Labour Productivity described in Section 3.1.8. Despite this, the advantage of capital intensive industry should be experienced to some extent by the EU28 industries. However, this appears not to be the case, reinforcing the sense that the competiveness of these industries, at least in terms of this indicator, is poor. As already described, the industrial mineral results follow a very similar pattern and so are not presented here.

### 3.1.8 Labour Productivity

As with GOR, Labour Productivity (LP) is an indicator populated by structural business statistics. It is calculated as the amount of value added by each employee, and therefore provides an insight into how productive workers are in a country/region. Value added, net of labour costs, gives an indication of profitability. It is represented by the formula:
\[ LP = \frac{Value\ added}{Employees} \]

As with GOR, there are caveats to the use of this indicator:

- When capital is substituted for labour, the LP figure could be expected to rise. The extent of the rise could be affected by the approach to accounting for capital investment in calculating value added;

- Where an industry has a large number of part-time employees this will reduce the LP significantly unless the indicator for ‘employees’ takes this into account; and

- Where an industry contracts in a considerable amount of labour, this may affect the LP. The impact of this will be dependent on the LP of the support industries, meaning that it could be skewed in either direction.

As already described, the data availability for this indicator is the same as for GOR and is summarised in Table 18 and described in detail in the Technical Appendix (Section A5.0.).

### 3.1.8.1 Metals

The analysis for LP of the EU28 and key competitors is shown in Figure 23. The results suggest that the LP of the EU28 is relatively low, though only one point of aggregated data is available. The LP is similar to that of South Africa, Mexico and Japan. The highest performers are countries which tend to have large, open mining operations, so the data may reflect the nature of the mineral endowment rather than a more fundamental structural problem of competitiveness.

The LP in the EU28 is substantially lower than for Australia, Brazil and Canada, which all displayed upward trends in LP over the period 2002-2012. In fact the most recent values for Australia and Canada show LP over ten times the level of the EU28. The single data point for the EU could, of course, be atypical, although the GOR analysis for the non-metals indicated that the results were broadly similar over four years. As this data point is part of the same dataset, it would appear that it is reasonable to assume that the single EU28 LP value shown here gives a fair reflection of current performance (which does not seem especially encouraging).
In this case there is a clear indication that the productivity in the industry is weak when compared to the majority of other countries for which data are available.

Splitting out the labour productivity figures by sub-group, there is no data for the EU28 for ferrous metals, so the analysis is focussed on non-ferrous metals. The results are shown in Figure 24, and portray a different scenario compared to the metals group as a whole. Once more, the performance for the EU28 non-ferrous industry is better than for the metals sector as a whole, implying also that the LP of the ferrous industry is somewhat lower than that for the non-ferrous metals. The one data point available is far below the values available for Australia and Canada, but not by the same proportion as was the case for metals overall, indicating better relative performance. Additionally it is above, if only marginally, the values reported for Brazil and South Africa.

Despite this, the performance still appears to be weaker than might be expected for a heavily industrialised economy such as that of the EU. As with all the indicators for which only one data point is available, the reliability of any derived conclusions should be treated with caution. However, for the same reason that the metal sector figure is deemed to be reasonably reliable, this one is also considered to be a reasonable indicator of performance also.
As for the GOR analysis, it is instructive to assess the ferrous metal sub-group results, despite the lack of aggregated data for the EU28 itself. This analysis is shown in Figure 25.

The values displayed clearly show that LP in the ferrous metals sub-group are far higher than for the non-ferrous sub-group. For example, values reported for Brazil are about three times that of the equivalent non-ferrous LP figures. Given the EU28 figures for all metals and for non-ferrous metals it is clear that the EU28 figure will be lower than €100,000 in 2009. This would imply that it has the lowest productivity of any country in the Figure, just below the figure for South Africa. Also of note is that the LP of Canada in respect of ferrous metals is below that reported for non-ferrous metals. It should be noted that ferrous metals comprises only c.11% of metal mining by value in Canada. This indicates that, unlike many countries, this is not the key focus of the metals mining sector.
3.1.8.2 Non-Metals

Due to data limitations, the results can only be presented at the aggregated level for all non-metals as was the case for GOR data Figure 26 shows that the LP values are, in general, far lower for this aggregated grouping than for the metals sector, indicating that the industries in question generally exhibit lower productivity. On the other hand, the EU28 figures are only marginally lower than the figures for its metal sector, indicating that this aggregated group is performing significantly better than the metal sector as a whole.

The LP of the EU28 is above those of all competitors apart from Australia and Canada, which again indicates a better performance compared to the metal sector. However, these two competitors exhibit LP performance that far exceeds that of the EU28, showing that the productivity of the EU28 is substantially lower than for these two industrialised countries.

Splitting the group into the two sectors gives much the same results as for GOR, with very similar results for both sectors. The construction mineral sector of the EU28 is performing substantially better than Brazil and South Africa, but well below Canada in respect of this measure (Figure 26).

This indicates that the EU28 industrial mineral and construction mineral sectors are more productive than the metal sector, in relative terms, but that this productivity is below that of major industrialised competitors.
Figure 26: Labour Productivity – Non-Metals (€’000 / employee)

Notes: Where data points are beyond five years apart, a dotted line is denoted.

Figure 27: Labour Productivity – Construction Minerals (€’000 / employee)

In summary, this analysis suggests a relatively unsatisfactory performance in respect of labour productivity in the sectors we are examining in the EU28. Although the sub-sectoral data is not of high quality, and lacks a quality time series basis, data provided by the European Commission tends to confirm this view, with trends in labour productivity for most of the sectors of interest to this study being in decline in the period 2007 to 2012 (Figure 28). Within all EU manufacturing and construction sectors, mining and quarrying activities have shown the greatest decline in labour productivity over the period. Annual rates of decline in labour productivity in excess of 2% are clearly not indicative of an increasingly competitive industry.

**Figure 28: Average Annual Labour Productivity Growth in EU Manufacturing Sectors, Construction and Mining, 2007–2012**

Source: European Commission (2014)\(^{67}\)

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3.1.9   Locations of New Investments and Mothballed Mining Facilities

A review of technical and trade publications and numerous company websites has been conducted to identify the location of new investments in, and closures, both temporary and permanent, of mining facilities in the EU and worldwide in the three-year period 2012 to 2014 inclusive. This has allowed a reasonably comprehensive list to be developed that captures the majority of openings and closures. Nevertheless, it is inevitable that some of these activities have been missed in this rapid global review. The full list of openings and closures identified in this study is shown in Technical Appendix Section (A5.2).

Figure 29: Locations of Expansion, Opening and Re-Opening of Mining Facilities (2012-2014)

Source: Various sources outlined in the Technical Appendix

Figure 29 shows the location of sites where new or additional capacity has opened or where an existing facility has re-opened between 2012 and 2014. Projects for which regulatory approvals are incomplete, or funding has not been secured, have not been included in our list. New mining activity since 2012 was recorded in many places in the world, including Australasia, North America, South America, Africa and the EU.

Figure 30 shows the location of sites where facilities have been closed or mothballed. The main reasons for mothballing across all regions have been cost related, such as falling commodity prices or high operational costs, with two mines being shut down due to operating illegally or causing excessive harm to the environment. The highest level of mothballing since 2012 was recorded in Australia and Africa, with slightly lower amounts in Asia and North America.
3.1.9.1 Mining Activity in Comparator Countries

One of the EU’s main comparator countries with a strong historic mining sector is Australia, which since 2012 has seen one mine expand or increase its production, two that have re-opened, and four which have been newly developed. Conversely, the country has also witnessed a number of closures with one mine permanently closed down, and six which have been mothballed.686970

A number of the closures are related to the appreciation of the Australian dollar and the low price of commodities, which led to big after-tax losses for some mining companies. The mothballed mines were extracting a range of raw materials—aluminium, copper, nickel, cobalt and gold— but no reason has been elicited for their mothballing beyond those already mentioned. Many of the newly developed mines are for iron ore, and the mines re-opening are for gold and tin following refurbishment of older mines.

Since 2012, Canada has had five new mines open (covering a range of raw materials, namely gold, copper, nickel, precious metals, iron ore and zinc). One iron ore mine in Canada was mothballed in 2014 due to the falling commodity price and escalating running costs.717273

In other comparator countries, four new openings have occurred in the USA.\textsuperscript{74, 75} South Africa has had five mines mothballed, all relating to platinum.\textsuperscript{76, 77, 78} The mothballing has been the result of a number of labour disputes. A similar trend has also been observed in Indonesia, with two mothballed mines in 2014, for gold-copper and gold-silver respectively.\textsuperscript{79, 80}

Based on review of comparator countries it appears that there are a variety of reasons why activity is ceasing, including political instability, movements in the exchange rate, changes in prices and regulatory issues. Several of these factors are explored further in Sections 4.0 to 6.0.

### 3.1.9.2 Mining Activity in EU28

Based on our review we have identified a significant amount of new mining activity recorded within the EU28 since 2012. In total, ten mines have opened, re-opened or expanded, covering a range of minerals including iron ore, nickel, copper, platinum-group metals, tungsten, gold, fluorspar, lead, silver and zinc. Only one mothballed operation was identified, an iron ore mine in Sweden\textsuperscript{81} whose operations are understood to have been suspended in October 2014 because of financial problems, in part, at least, due to low iron ore prices.

### 3.2 Recycling Industries

The analysis in this section is limited compared to that for NEEI in Section 3.1 due to the poor quality of data for RI. For many representative material under consideration, there is a complete absence of global recycling data, possibly

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\textsuperscript{74} Rice, X. (2014) Zinc producers eye resuming operations, http://www.ft.com/cms/s/0fb04d92-cbcd-11e3-a934-00144feabcd0.Authorised=false.html?_i_location=http%3A%2F%2Fwww.ft.com%2Fcms%2Fs%2Fs%2F0%2F0fb04d92-cbcd-11e3-a934-00144feabcd0.html%3Fsiteedition%3Duk&siteedition=uk&_i_referer=#axzz30GrMRN1Y
\textsuperscript{75} Prairie Business (2014) In waste rock, mining companies find opportunity, http://www.prairiebizmag.com/event/article/id/18981/
\textsuperscript{78} Eastplats - Mareesburg, http://www.eastplats.com/projects/mareesburg/
\textsuperscript{81} http://www.infomine.com/index/properties/Kaunisvaara_Iron_Concentrate_Project_(Sahavaara).html
indicating an absence, or very limited extent, of recycling industries for some of these minerals.

### 3.2.1 Production

The amount of recycling undertaken over a ten year period could be a good indicator in understanding the performance of the RI EU28 and how it is changing. However, there is very little published data on the amount of material actually recycled, rather much of the data describes how much waste is sent for recycling and therefore intended to be recycled. Additionally there is no clear global definition of waste and therefore the information included in data sets is often based on different interpretations. This causes issues with comparability and analysis.

Additionally, rather than being focussed on specific minerals, data for recycling are often focussed on the producer of the waste, for example the commercial and industrial sector. The differing interpretations of ‘end of life’ status also means that some ‘waste’ that is recycled does not feature in waste or recycling statistics as it is not considered to be waste. Consequently it is not possible to provide comparable data on the amount of recycling taking place.

### 3.2.2 Trade – Share of Global Exports

Using an identical methodology as for the NEEI (Section 3.1.3), it is possible to calculate the EU28 share of global recyclate exports for a number of representative commodities, using trade data published by UN Comtrade. Unlike the NEEI, if the EU28 RI experience high levels of exports of material intended to be recycled, this would not necessarily indicate that the sector is competitive. Therefore within this section, the imports of material intended to be recycled in to the EU28 is also considered.

Data is presented in UN Comtrade for a range of commodities, but the available data from this source is limited for some sub-groups and individual commodities (Table 19). The only sub-groups with full data coverage are ferrous metals and base metals, where data for waste and scrap materials is provided. Figures for critical metals can be calculated, but only based on data relating to waste and scrap cobalt and PGM. This means that the results for the critical metals sub-group need to be treated with caution, as they reflect only two commodities. No data is available for either the industrial mineral, or construction mineral, sectors so these are excluded from our analysis. The lack of data is not entirely surprising, at least for construction minerals, as the recycled material generally has even lower value than the primary source.
Table 19: Availability of Recyclate Trade Data by Representative Commodity

<table>
<thead>
<tr>
<th>Sub-Sector</th>
<th>Sub-Group</th>
<th>Representative Commodity</th>
<th>Availability of Trade Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Ferrous</td>
<td>Iron</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td>Non-ferrous: Base Metals</td>
<td>Aluminium</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nickel</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tin</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zinc</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td>Precious Metals</td>
<td>Silver</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gold</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cobalt</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td>Non-ferrous: Critical</td>
<td>Indium</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Niobium</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Platinum Group Metals</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rare Earths</td>
<td>None</td>
</tr>
<tr>
<td>Industrial Minerals</td>
<td>Physical Uses</td>
<td>Gypsum</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Graphite</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Chemical Uses</td>
<td>Flourspar</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potash</td>
<td>None</td>
</tr>
<tr>
<td>Construction Minerals</td>
<td>Aggregates: Crushed Rock</td>
<td>Limestone</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Aggregates: Sand &amp; Gravel</td>
<td>Sand and Gravels</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Non-aggregates</td>
<td>Building Stone</td>
<td>None</td>
</tr>
</tbody>
</table>

Key:

- All data available
- Some data available
- No data available

Based on the available data, a high level overview of the imports and exports can be viewed for the metals sub-sectors by the representative material, as shown in Table 20.
Table 20: Import and Exports of EU28 Representative Material in the Metals Sub-Sector (2012) - Recyclate

<table>
<thead>
<tr>
<th>Sub-Sector</th>
<th>Sub-Groups</th>
<th>Imports (US$m)</th>
<th>Exports (US$m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Ferrous Metals</td>
<td>20,253</td>
<td>33,121</td>
</tr>
<tr>
<td></td>
<td>Base Metals</td>
<td>21,312</td>
<td>24,795</td>
</tr>
<tr>
<td></td>
<td>Precious Metals</td>
<td>8,926</td>
<td>11,885</td>
</tr>
<tr>
<td></td>
<td>Critical Metals</td>
<td>5,303</td>
<td>2,421</td>
</tr>
</tbody>
</table>

*Source: UN Comtrade*

As detailed in Table 21, the EU28 accounted for a substantial share of global recyclate exports in 2012. These results are not surprising as compared to most other countries, EU28 Member States have relatively advanced waste collection systems, and collect relatively large quantities of recyclate.

Relatively high exports of recyclate might suggest that the EU28 is exporting materials that could, instead, be utilised by European recycling industries (which would lead to increased production of materials from recyclate, potentially reducing the demand for primary materials).

However, this assumes that all recyclate exported and imported is of the same quality, which will not be the case. The quality of recyclate will have a significant impact on exports and imports, as does quality of minerals as discussed in Section 3.1.1. Where the quality of recyclate is poor, it may well be that the costs associated with processing are too high for the EU to be competitive, whilst for labour-intensive economies, it makes sense to import these materials. Therefore it maybe that the EU28 are exporting lower quality recyclate and, where it is available, importing higher-quality recyclate to provide the relatively advanced recycling industry with the quality of feedstock that it requires.

Table 21: EU28 Share of Global Exports of Recyclate in 2012

<table>
<thead>
<tr>
<th>Sub-Group</th>
<th>Share of Global Exports (%)</th>
<th>Share of Global Imports (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous Metals</td>
<td>58.7</td>
<td>39.0</td>
</tr>
<tr>
<td>Base Metals</td>
<td>55.6</td>
<td>41.0</td>
</tr>
<tr>
<td>Precious Metals</td>
<td>51.7</td>
<td>49.7</td>
</tr>
<tr>
<td>Critical Metals</td>
<td>54.3</td>
<td>69.9</td>
</tr>
</tbody>
</table>

*Source: UN Comtrade*

Figure 31 provides an overview of the change in the EU28 share of global recyclate exports of the last 10 years. Critical minerals and precious metals exhibit significant
fluctuation over time. Due to the much lower trading volumes of critical metals, small changes in export shares can have a large impact, and this is likely to account for the observed year-on-year changes.

**Figure 31: EU28 Share of Global Exports of Metal Recyclate (%)**

![Graph showing EU28 Share of Global Exports of Metal Recyclate](image)

*Source: UN Comtrade*

By way of comparison Figure 32 includes the share of global imports for metal recyclate between 2002 and 2012. The figure shows lower volatility than for the export figure, but a decreasing shares of imports over time. This suggests that the EU processing industries may be losing their competitive edge as competition increases for these materials.
3.2.3 Trade – Relative Trade Balance

The relative trade balance enables a comparison of the relative size of the EU28 export and import markets for a specific sector or mineral. While the exact methodology used is outlined in 3.1.4, it is useful to remind the reader of the implications of this index. Values of between -1 and 1 are possible, and should be understood to mean the following:

- -1: Imports only (no exports)
- 0: Equal quantities of export and imports
- 1: Exports only (no imports)

As detailed in 3.2.2, unlike the ore and semi-finished material markets (with the exception of critical metals), the EU28 exports more metal recyclate than it imports.

In interpreting these figures, it is worth considering what a change in RTB implies: an increase in the value effectively means that the EU28 is increasing exports relative to imports. This means that more of the materials that could be processed in the EU28 are being exported for processing outside the EU. As such, an increase in the RTB of recyclate effectively indicates a worsening in the performance of the processing industries which are the central focus of our study.

The change in the relative trade balance of metal recyclate over the last ten years is shown in Figure 33. An upward trend is observed for ferrous and precious metals demonstrating an increase in exports relative to imports. The increases in exports for these sub-groups probably indicates the effect of a growth in the amount of material

Source: UN Comtrade
captured for recycling within the EU28, and a growing demand for these materials from the RI outside the EU28.

For critical metals there has been a steady increase in the value of the RTB, but as data are only available for cobalt and PGM, no meaningful analysis can be made or significant conclusions drawn.

**Figure 33: EU28 Relative Trade Balance of Metal Recyclate**

![Graph showing the EU28 Relative Trade Balance of Metal Recyclate](image)

*Source: UN Comtrade*

### 3.2.4 Trade – Revealed Comparative Advantage

Our appraisal of the relevance of the Revealed Comparative Advantage (RCA) indicator is provided in Section 3.1.5. The same assessment holds true for the Recycling Industry figures and therefore this indicator is not considered further here.

### 3.2.5 Profitability

The profitability of the RI is measured by the Gross Operating Rate (GOR) and is derived from the same calculations and datasets as the profitability of the NEEI. The methodology is described in Section 3.1.7 and the dataset is discussed in detail in the Technical Appendix (Section A5.0).

Whilst the data availability for the NEEI was limited, there is even less data available for the RI. This is in part due to the classification of RI activities within the activities of “other industry”. For example, parts of RI are likely to fall into the metal and mineral manufacturing sectors, while other aspects may fall under municipal services. As a result, it is rare to find a distinct ‘recycling’ or ‘waste recovery’ category in structural business statistics. Even where it may have been reported, sometimes it may be deemed as an obsolete category. For example, this occurred in the North American Industry Classification System (NAICS) code revisions, which split
the recycling category out of manufacturing into other disparate categories, thereby preventing the assessment of the RI from what little data are available.

As a result, the only available data are for the EU (via Eurostat) and South Africa (from Statistics South Africa) (Table 22).

Table 22: Data Included in GOR and LP Analysis

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Dataset Name</th>
<th>Commentary on Inclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU28</td>
<td>Waste Collection</td>
<td>This has been included. Whilst the processing of recyclate into materials is perhaps the major component of the competitiveness of the RI, collection of recyclate is the equivalent of extraction from the ground in NEEI, and is therefore an important aspect to address.</td>
</tr>
<tr>
<td>EU28</td>
<td>Waste Treatment and Disposal</td>
<td>This has been included. Once more, whilst disposal of residual wastes is not what will comprise the majority of operations, it is equivalent to the disposal of mining wastes that the NEEI process and is an important part of the recycling operation.</td>
</tr>
<tr>
<td>EU28</td>
<td>Remedial Waste Activities</td>
<td>This has not been included. This largely relates to decontamination of land, which is not primarily concerned with obtaining resources.</td>
</tr>
<tr>
<td>South Africa</td>
<td>Recycling – Metals</td>
<td>This has not been included as there is a break in the dataset</td>
</tr>
<tr>
<td>South Africa</td>
<td>Recycling – Non-Metals</td>
<td>This has not been included as there is a break in the dataset</td>
</tr>
<tr>
<td>South Africa</td>
<td>Recycling – Metals and Non-</td>
<td>This has been included. Whilst not all non-metals recycling is directly relevant to this study, the majority of the South African industry is metal recycling and so the figures are dominated by the performance of this element. This dataset is more complete than the above two constituent parts.</td>
</tr>
<tr>
<td></td>
<td>Metals</td>
<td></td>
</tr>
</tbody>
</table>

For both the GOR and LP analyses, the equivalent values for metal mining and non-metal mining for the EU28 have been included for comparison purposes. The metal mining industry for South Africa has been included for comparison. The results of the analysis of GOR are shown in Figure 34.
The chart shows that EU waste treatment is more profitable than waste collection operations, which is perhaps unsurprising as the transformation of recyclate into materials offers a greater scope for adding value, depending on the quality of the output materials.

Both of these elements of the EU industry perform well compared to the South African recycling industry, which has a substantially lower GOR, which has declined over the period for which data is available. This is perhaps unsurprising as the nature of the industries in each region will potentially be substantially different – the EU28 industry will be more capital intensive and the SA industry more labour intensive. It is also likely that the South African results will be affected by a large proportion of recycling occurring in the informal sector. Such figures will not be captured by the statistics body, but if they were captured there could be substantial increases in the GOR due to the low costs associated with this method of recycling.

It is clear that the EU28 RI is performing better relative to the mining industries than in South Africa. Whilst the EU indicator for metal mining is substantially larger than for the RI indicators, this is largely driven by the ferrous metal sub-group which provides substantial opportunities for added value. It is the relative performance that is perhaps therefore more helpful and, with the South African metal mining indicator at similar values to the EU28’s indicator, this shows that the RI is performing far better relatively in the EU28.

The final point of comparison is that the waste treatment indicator outperforms the mining of non-metals. This does not reveal any particular detailed insights, but rather

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82 Includes all forms of waste treatment, not just limited to RI.
indicates that RI treatment is generally performing at a level that is similarly profitable to NEEI activities. Unfortunately without data for more competitors it is not possible to draw more substantive conclusions regarding the profitability of the RI in Europe.

3.2.6 Labour Productivity

Labour Productivity (LP) as an indicator is described in Section 3.1.8, and the supporting dataset is discussed in the Technical Appendix (Section A5.0.). There are far less data available for this indicator than for the NEEI, sources being the same as discussed in Table 22 for the GOR. The results of the analysis are shown in Figure 35.

Figure 35: Labour Productivity – Recycling Industries (€’000 / employee)

In terms of labour productivity the performance of the EU’s waste treatment industry appears to be performing better than in profitability terms as the values for the indicator are very similar to the metal mining indicator. Compared to South Africa’s recycling industry figures, it is far superior, but this would be expected for a more capital intensive industry. Once again the collection indicator shows less productivity, and hence less competitiveness. However, it is not possible to draw more substantive conclusions as a proper international comparison cannot be made due to the lack of data for competitor countries.

3.3 Summary of Findings

3.3.1 Non-Energy Extractive Industries

The situation is summarised in Table 23. We first discuss the performance by class of material before giving a more general overview.
For ferrous metals, the picture is not a positive one. Although production has increased, the share of the global market has fallen, and the index for the relative comparative advantage is moving in the wrong direction. Only the relative trade balance shows some sign of improving, and then only for ores, and labour productivity is below that of competitors.

For non-ferrous metals, the picture is somewhat better, even though output and the share of global production are both falling. The share of global exports is increasing for all but the precious metal ores, and the index for the RCA exhibits the same pattern. The relative trade balance is also improving for the critical and base metals sub-categories, but for precious metals, the trend is down for both ores and for semi-finished materials. Nonetheless, the performance in respect of the gross operating rate and labour productivity does not appear to be as strong as for some competitors. Note, however, that this is for the class of non-ferrous metals as a whole, and so comparative performance may be skewed by the structure of the non-ferrous metals industries in the comparator countries. Generally, though, the picture for non-ferrous metals appears somewhat better than for ferrous metals.

For industrial physical minerals, the availability for data is a major constraint on what can be said about the sector’s performance. However, what data is available does not indicate a thriving sector, with output falling, and the overall share of production in decline. In addition, the non-metals as a group have a relatively low gross operating rate, and at best, moderate labour productivity relative to competitors.

There is a little more information for the chemical industrial minerals, and like the physical ones, this indicates output falling, and the overall share of production in decline. Data also show a declining share of global exports and a worsening position in respect of the relative trade balance. Again, given that for the non-metals group as a whole, these have a relatively low gross operating rate, and at best, moderate labour productivity relative to competitors, then the overall picture is not an encouraging one.

For the construction minerals, as we have already noted, the notion of competitiveness is not as meaningful given the limited extent to which the materials, especially construction aggregates, are traded. However, what data does exist for the non-aggregate construction minerals tends to suggest that a declining share of global exports, a falling index of the revealed comparative advantage, though moderate performance in respect of gross operating rate and labour productivity.
**Table 23: Summary Performance of NEEI Sector**

<table>
<thead>
<tr>
<th>Sub-sectors</th>
<th>Sub-Groups</th>
<th>Secondary Sub-group</th>
<th>Output</th>
<th>Share of Global Production</th>
<th>Share of Global Exports</th>
<th>RCA</th>
<th>RTB</th>
<th>GOR</th>
<th>LP</th>
<th>Reserve Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ferrous Metals</td>
<td>n/a</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>↔</td>
<td>↓</td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td></td>
<td>Non-ferrous Metals</td>
<td></td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td></td>
<td>Precious Metal</td>
<td></td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>↔</td>
<td></td>
<td>&gt;1</td>
</tr>
<tr>
<td></td>
<td>Critical Metal</td>
<td></td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑/↔</td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td></td>
<td>Industrial Minerals, Physical</td>
<td>n/a</td>
<td>↓</td>
<td>↓</td>
<td>n/a</td>
<td>↓</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Industrial Minerals, Chemical</td>
<td>n/a</td>
<td>↓</td>
<td>↓</td>
<td>n/a</td>
<td>↓</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td></td>
<td>Construction Minerals, Aggregates</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>↓</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Construction Minerals, Non-aggregates</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>↓</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
<td>n/a</td>
</tr>
</tbody>
</table>

**Notes:**

1) N/A denotes gaps in the data
For the NEEI, the economic and market data show the EU28 as having a declining importance in the global market since the start of our data assessment (2003). The production data demonstrates a declining share of world production, whilst the trade data indicate large trade deficits for ores. Performance across the NEEI and EU28 is not homogenous, and it should be recognised that there are significant variations between the sub-groups. For example, based on the representative materials, the data demonstrates that the EU28 trade balance is positive for semi-finished critical metals and for non-aggregate construction minerals.

In respect of the labour productivity and profitability, the data is of poor quality and it is therefore difficult to draw general conclusions. From what data is available, it appears to show the EU28 as a middle- to low-ranking performer. The best performers are countries which tend to have large open-pit mining operations, so the data may reflect in part the mineral endowment rather than a more fundamental structural problem of competitiveness. However, the ability to conduct mining by open-pit methods is also influenced by a wide range of other social, environmental and economic factors. Figure 36 provides an illustrative representation of the assessment of economic and market assessment with respect to NEEI. The figure is based on a qualitative interpretation of the data identified and derived, at least in part, from the consensus of views and evidence obtained in this study.

**Figure 36: Economic and Market Competitiveness - NEEI**

![Diagram showing economic and market competitiveness assessment]

**Notes:**

1) The figure is based on a subjective assessment of the competitiveness based on the author’s views.

2) Lines nearer to the centre of the shape denote lower levels of competiveness. Lines towards the outside of the shape denote higher levels of competiveness.

3) RoW (Rest of the World) is based on the analysis of the representative countries presented in this research.

### 3.3.2 Recycling Industries

For the RI, availability of high quality data is also a significant barrier to the assessment of the performance of the industries. Waste recycling data is not
captured at the level of detail needed for this assessment. However, some of the trade data is informative and relevant to this assessment.

The trade data demonstrates that the EU28 currently have a high global share in the both the export, and import of metal recyclate. Examined at a sub-group level, the EU28 is a net exporter of base, ferrous and critical metals. The relative trade balance for base metals has been relatively stable, but for ferrous and precious metals there is an increasing trend of a higher net percentage of export. For critical metals the EU28 is becoming less dependent on imports.

This tends to show that the EU28 are highly active in the market, rather than giving a clear indication of competitiveness. Like the NEEI, the RI in the EU28 also has higher labour and energy costs, which is considered a disadvantage when compared to comparison countries.
4.0 Assessment of the Regulatory Framework

In the previous Section, we have tried to analyse available data with a view to shedding light on the matter if competitiveness. This chapter explores the impact on the NEEI and RI, of various aspects of policy and legislation, seeking to understand how this varies across the key competitor countries. The intention is to explore some factors which might explain the observed changes in performance highlighted above.

In the context of this research, a policy is considered to be an action taken by a government which ‘changes the rules’ in some way, thereby affecting, or potentially affecting, the way in which all actors targeted by the policy behave. Under this definition, we do not include ‘soft’ approaches which rely upon voluntary commitments with no threat of any sanction. ‘Legislation’, on the other hand, refers to a specific, identifiable law.

Whilst the metals, industrial minerals and construction mineral sub-sectors for the NEEI and RI are the focus of the analysis, legislation and policy is rarely focussed at the sub-sector level. More typically, it is focused on mining and process activities for the NEEI, and collection and reprocessing activities for the RI. Therefore it is not always possible to identify specific impacts at a sub-sector level. Additionally, due to a lack of data, it has not always been possible to provide an assessment of all of the comparison countries used in this assessment.

Finally, to the extent that this analysis is focused on the EU28 as a bloc, then we have not investigated the specifics of policy and regulation at Member State level. This would be beyond the scope of this work. It is important to note, therefore, that our assessment glosses over what may be significant variations in the policy and legislative landscape at the Member State level (and, possibly, regionally within some of these). In order to provide a framework for this analysis we have divided policy and legislation into the following categories:

- Economic;
- Energy;
- Environmental;
- National Mining Policies; and
- Health and Safety.

4.1 Non-Energy Extractive Industries

In Sub-Sections 4.1.1-4.1.5 we have aimed to outline the key legislation and policies relating to the NEEI.
4.1.1 Economic Policy and Legislation

Economic policy and legislation comprises a number of components relating to the NEEI including taxation, trade policies, different forms of economic incentives and fiscal policy. This section aims to identify and assess the impacts of key policies and legislation within the EU28 and competitor countries. It should be noted that a full and detailed explanation of all such policies would constitute a major undertaking is its own right, and that the analysis is a relatively high level one.

4.1.1.1 Mining Taxes

It has been suggested that the principal role of a government’s mining tax system should be to ensure the greatest possible benefit to the public whilst also encouraging investment. This requires a careful balancing of the objectives of mining companies and government. The overall level of tax (including royalties) will have a direct influence on an individual company’s incentive to invest in a particular locality: higher tax rates may increase government revenue in the short term, but can discourage investment, and thus, reduce tax revenues over the long term.

Operators involved in mining and quarrying activities are liable to pay a variety of taxes. PricewaterhouseCoopers (PwC) summarise these as follows:

- Corporate Income Tax;
- Mineral Taxes or royalties; and
- Other taxes and payments.

With respect to corporate tax rates, given the fact that major global companies dominate the world NEEI (especially in respect of the metals sub sector), it could be argued that corporate tax rates are of limited relevance, as such companies may be able to influence their exposure to such taxes through various forms of transfer payments.

For the industrial and construction minerals sub groups, on the other hand operators are more likely to be impacted by differential corporate tax rates within the EU28, as the extractive activities are more localised in character, and commonly, restricted to operations within a small number of countries. The implicit corporation tax rates within the EU28 exhibit wide variation (6% to 29%).

Whilst royalty systems differ widely amongst nations, the range of types amongst private parties with negotiated agreements is even larger. A review of selected

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86 The Technical Appendix outlines the implicit corporation tax rates within the EU28 (Section A6.4).
mining taxes and royalties extracted from the PwC summary report for the EU28 and selected comparator countries is provided in the Technical Appendix (Section A6.0.).

Understanding the impact of royalties and mining taxes alone is difficult. Whilst they can influence the attractiveness of the investment climate, and the probability of production, it has been suggested that their significance should not be overstated. The World Bank holds that mineral royalties, and by association, mineral taxes, are just one variable that affect competitiveness in terms of new investment. A country’s geological landscape and potential, political stability and overall taxation regime are likely to be of equal or greater importance. Evidently, the issue is likely to be the magnitude of royalty payments relative to expected margins, and where taxes on corporate income are concerned, both their level and the ease with which they may be avoided.

A lack of publically available information on all rates has meant that it was not possible to provide a comprehensive synthesis of the mineral taxes and royalties relevant to the EU28 and comparator countries, as there are major variations in the rates applied to the minerals considered in this study. Despite this, some insight into understanding the impact of the taxation regimes is available. For example, the Fraser Institute’s 2013 Annual Survey of Mining and Exploration Companies aims to assess how a country’s overall taxation regime affects exploration investment. The survey solicited around 700 responses from exploration, development, and other mining-related companies around the world.

Although the specific issue of mining taxes was not directly tested by the Fraser Institute survey, a broader question relating to the taxation regime in general was asked. Taxes in this context include personal, corporate, payroll, capital and others, while the complexity of tax compliance was also included. The results of the survey question are shown in Table 24 and Table 25 and highlight that the selected Member States score well compared to key comparison countries. It shows that 56% of respondents stated that the taxation regime in selected European Member States either ‘encourages investment’ or is ‘not a deterrent to investment’. This compares to countries like Chile and Canada, where the investment landscape with regards to taxation was deemed highly favourable, and Russia and China, where it was markedly less so. Table 25 also highlights the wide variations of perceptions of the various EU28 member states selected within the survey.

89 Fraser Institute (2014) Survey of Mining Companies 2013, Accessed 7th October 2014,
It should be noted, however, that this type of survey might not always take into account the treatment of companies based within the country being considered. So, for example, the attractiveness of the existing regime to incumbent investors based in Russia and China might differ notably from the attractiveness of these locations as perceived by foreign investors. This is likely to be influenced by the perceived stability of the regime in respect of treatment of foreign investment in exploration.

Table 24: Perceived Influence of Taxation Regime on Exploration Investment – Non EU

<table>
<thead>
<tr>
<th>Country</th>
<th>Encourages investment</th>
<th>Not a deterrent to investment</th>
<th>Mild deterrent to investment</th>
<th>Strong deterrent to investment</th>
<th>Would not pursue investment due to this factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile</td>
<td>8%</td>
<td>71%</td>
<td>16%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>Canada</td>
<td>17%</td>
<td>58%</td>
<td>22%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>USA*</td>
<td>16%</td>
<td>50%</td>
<td>28%</td>
<td>6%</td>
<td>1%</td>
</tr>
<tr>
<td>Australia</td>
<td>12%</td>
<td>47%</td>
<td>34%</td>
<td>6%</td>
<td>0%</td>
</tr>
<tr>
<td>Brazil</td>
<td>4%</td>
<td>46%</td>
<td>38%</td>
<td>13%</td>
<td>0%</td>
</tr>
<tr>
<td>Mexico</td>
<td>5%</td>
<td>42%</td>
<td>39%</td>
<td>12%</td>
<td>2%</td>
</tr>
<tr>
<td>South Africa</td>
<td>6%</td>
<td>41%</td>
<td>33%</td>
<td>16%</td>
<td>4%</td>
</tr>
<tr>
<td>India</td>
<td>0%</td>
<td>43%</td>
<td>29%</td>
<td>19%</td>
<td>10%</td>
</tr>
<tr>
<td>Russia</td>
<td>14%</td>
<td>18%</td>
<td>46%</td>
<td>18%</td>
<td>5%</td>
</tr>
<tr>
<td>China</td>
<td>0%</td>
<td>19%</td>
<td>66%</td>
<td>9%</td>
<td>6%</td>
</tr>
</tbody>
</table>

Notes:

*The USA encompasses the following states only: Alaska, Arizona, California, Colorado, Idaho, Michigan, Minnesota, Montana, Nevada, New Mexico, Utah, Washington and Wyoming.

Source: Fraser Institute (2014) ⁹⁰

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### Table 25: Perceived Influence of Taxation Regime on Exploration Investment - EU

<table>
<thead>
<tr>
<th>Country</th>
<th>Encourages investment</th>
<th>Not a deterrent to investment</th>
<th>Mild deterrent to investment</th>
<th>Strong deterrent to investment</th>
<th>Would not pursue investment due to this factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>29%</td>
<td>54%</td>
<td>17%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Finland</td>
<td>31%</td>
<td>51%</td>
<td>14%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>Sweden</td>
<td>32%</td>
<td>50%</td>
<td>16%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Poland</td>
<td>0%</td>
<td>69%</td>
<td>31%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Portugal</td>
<td>9%</td>
<td>55%</td>
<td>27%</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>Spain</td>
<td>9%</td>
<td>50%</td>
<td>41%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>France</td>
<td>21%</td>
<td>26%</td>
<td>37%</td>
<td>16%</td>
<td>0%</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>18%</td>
<td>24%</td>
<td>47%</td>
<td>12%</td>
<td>0%</td>
</tr>
<tr>
<td>Romania</td>
<td>0%</td>
<td>20%</td>
<td>60%</td>
<td>15%</td>
<td>5%</td>
</tr>
<tr>
<td>Greece</td>
<td>0%</td>
<td>15%</td>
<td>55%</td>
<td>25%</td>
<td>5%</td>
</tr>
<tr>
<td>Average of Selected European Member States*</td>
<td>15% (Range 0% to 32%)</td>
<td>41% (Range 15% to 55%)</td>
<td>34% (Range 14% to 44%)</td>
<td>8% (Range 0% to 25%)</td>
<td>1% (Range 0% to 5%)</td>
</tr>
</tbody>
</table>

Notes:

*The EU28 was not considered within the survey. Selected Member States include Bulgaria, Finland, France, Greece, Ireland, Poland, Portugal, Romania, Spain and Sweden.

Source: Fraser Institute (2014) 91

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4.1.1.2 Trade: Extraction of Minerals

This section examines trade policies with regards to metals and industrial minerals. Construction minerals are typically sourced locally and regionally, and are only traded internationally in exceptional cases (due to their wide availability and relatively high transportation costs relative to their value). Therefore they are not included within this aspect of the assessment.\textsuperscript{92} Customs duties, also known as tariffs, relevant to the raw materials within the scope of this project are considered below.

Imports Duties Issued by the EU28 for Imports from Comparison Countries

For the vast majority of ores and concentrates, the EU applies no duties on the import of such minerals, thus ensuring that processors of such minerals within the EU28 have unrestricted access to raw materials.

For a few ores and concentrates (specifically aluminium bauxite – unwrought, not alloyed; indium – unwrought or powder; and caustic potash), import duties are applied, but exemptions exist for ores and concentrates imported from Chile, Mexico and South Africa. Further details on import duties are provided in the Technical Appendix (Section A6.0.).

Imports Duties Issued by the Comparison Countries for Imports from the EU28

In the case of imports into the comparison countries, preferential trade agreements, translating into 0% import duties for imports of primary raw materials from the EU28 to the comparator countries, apply only to some minerals. This contrasts to most of the imports of these raw materials from the comparator countries into the EU28. The import duties into the comparator countries are charged as ad valorem duties, unless otherwise stated, and are listed the Technical Appendix (Section A6.0.).

It is clear that the competitor countries examined in this study apply more tariffs on imports than the EU28. There is significant variation in the rates applied by individual countries. These vary from zero rated import duties on all or most raw materials arriving from the EU28, to import duties on all raw materials, typically of the order of 2%. A summary of the rates of import duties for selected comparison countries is shown in Table 26.

Table 26: Summary of Import Duty Rates Charged by Comparison Countries

<table>
<thead>
<tr>
<th>Typically Charging Zero Rated Import Duties on all Raw Materials</th>
<th>Charging some Import Duties and some Zero Rated Import Tariffs on Raw Materials</th>
<th>Typically Charging Import Duties on all Raw Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>China</td>
<td>Brazil</td>
</tr>
<tr>
<td>Canada</td>
<td>Indonesia</td>
<td>India</td>
</tr>
<tr>
<td>Chile</td>
<td>Russia</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In principle, this affords producers in the comparison countries some protection vis-à-vis EU28 producers, assuming that the duties are not used as compensating measures for policies applied locally.

Furthermore, countries such as India and China have introduced high import duties on a large number of primary (and secondary) raw materials entering their markets in order to support the development of extraction, processing and recycling activities domestically, by protecting them from foreign imports (shown in the Technical Appendix Section A6.0). The extent to which these countries’ industries have already developed suggests, on the other hand, that the ‘nascent industry’ argument for maintaining tariffs is losing its credibility. The effect is likely to be to maintain a larger industry than would prevail in the absence of the tariffs.

4.1.1.3 Promotion and Restriction Mechanisms

Customs duties are one way of promoting or restricting trade in certain raw materials or products. There are also a number of non-tariff related issues which may affect trade, including:

► customs procedures and policies;
► restrictions on exports of primary raw material to third countries;
► state support and competition policy; and
► intellectual property rights.

Customs Procedures and Policies

In Russia and China some custom procedures and policies add to the cost of imported products, thus tending to favour local producers over their international

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competitors. Such policies can involve complicated and costly verification of performance criteria for standards in third countries which inevitably hinder exports to these countries. Furthermore legislation such as the REACH Directive as it relates to the import of raw materials and other such legal policies may lead to delays and make imports to the EU28 more costly (see Section 4.1.5.1 for further discussion of the REACH Directive).

Restrictions on Exports of Primary Raw Materials in Third Countries

Restricting the export of natural resources may enable domestically located downstream producers to compete internationally, as is the case in Indonesia, which is a major supplier of many metallic ores to international markets (e.g. nickel, copper and bauxite). Such measures restrict access of competitors to ores and concentrates, and increase prices for them. They can also lead to inefficiencies in the allocation of resources, as they may protect sectors that are uncompetitive, whilst any benefits could be offset if comparator countries impose their own export restrictions.

State Support and Competition Policy

State support and competition policies may also become problematic. Subsidies offered by foreign governments are increasingly indirect (i.e. not overtly directed towards the NEEI) and put the NEEI in a disadvantaged position vis-à-vis non-EU industry, causing unfair competition with the EU market by restricting imports from abroad. In Russia, for example, export-oriented non-ferrous metal smelters have access to energy at a lower cost than industrial users producing for the domestic market, thus creating a form of export subsidy.

In China there have been extensive public investments in clean energy technology in recent years, which support upstream activities, such as photovoltaic panels or rechargeable batteries manufacturer, thus indirectly encouraging production and technological development for domestic NEEI producers as well. As a result their EU counterparts are at a disadvantage.

In combatting such infringements, the EU28 supports fair and open trade and therefore utilises trade defence instruments, such as anti-dumping or anti-subsidy duties, based on rules set out by the World Trade Organisation. Therefore, to some extent, the impacts of such practices can be mitigated.

Intellectual Property Rights

Intellectual property rights (IPR) infringement issues may also impact on competitiveness. This may involve patent infringement and violation of technology issues, or counterfeiting of trademarks and the piracy of work protected by copyrights. China, for instance, has developed industrial policies to encourage and

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speed up, the transfer of technology from foreign-based companies if, and when, they choose to invest in the country (e.g., it requires detailed information on installations, including design and technological specifications). This creates a risk of imitation, and loss of firm-specific assets and forms a barrier to investment.

**Trade: Processing**

The EU has introduced its own customs procedures to promote processing trade in the form Outward Processing Relief (OPR) and Inward Processing (IP) relief.

Outward Processing Relief (OPR) is a customs procedure that allows EU traders to export goods outside the EU for processing or repair in a non-EU country, and then re-import them, whilst claiming full or partial duty relief. This enables traders to gain advantage from cheaper labour costs, or processes that are not available within EU countries, without incurring duties on export and import.

OPR was established under Council Regulation (EEC) No. 2913/92 and implementing Commission Regulation 2454/93 (amended) and enables businesses to take advantage of cheaper labour outside of the EU.\(^{97}\) The extractive and recycling industries benefit from OPR through the ability to cheaply outsource processing, be that on the NEEI or RI. There is currently no publically available information on the impacts of OPR or its implementation throughout the EU, although in principle, it could, depending on how it is applied, undermine processing industries in the EU.

Inward Processing (IP), established under Council Regulation (EEC) No 2913/92 establishing the Customs Code, and Commission Regulation (EEC) No 2454/93 as amended, which lays down the provisions for its implementation (the Customs Code Implementing Regulations),\(^{98}\) allow imported raw materials or semi-manufactured goods to be processed for re-export within the EU by EU manufacturers without a requirement that the manufacturers have to pay a customs duty or VAT on the goods being used. By reducing the cost of imported inputs, IP places EU businesses on an equal footing with businesses outside the EU. IP either allows the duty to be suspended (suspension), or for it to be paid, and later repaid (drawback).\(^{99}\)

Being able to obtain relief from paying import duty and VAT can be extremely beneficial to companies, especially for reasons related to cash-flow. The EU processing industries are a significant beneficiary of IP through the ability it affords them to import raw materials and goods, process them within the EU, and export them again without being affected by various duties.

**4.1.1.4 R&D Tax Incentives**

In the EU, investment in R&D follows the Lisbon Strategy (2000) and the Lisbon target, which requires investment in European R&D to be increased to 3% of GDP, and the level of business funding of R&D to be increased to two-thirds of total R&D


\(^{98}\) HM Revenue and Customs (2014) Notice 221 - Inward Processing

EU corporate investment in R&D increased by 8.1% in 2008, despite the economic crisis. In its drive to make the EU economy a knowledge based one, the European Commission also recommended that any tax incentives which Member States might introduce in order to meet the Lisbon target should be transparent. For example, this could be done by issuing the tax in the form of a tax credit or a reduction in the tax rate, so that it can be more easily identified by competitors and other Member States.

R&D tax incentives in a sample of EU Member States are set out in the Technical Appendix (Section A7.0). Those incentives currently in force in some of the comparator countries included in this research, namely Australia, Brazil, Chile and the USA, are also shown. These are outlined in the OECD report on R&D tax incentive schemes for OECD countries and selected economies. It is significant to note that the definition of R&D, and what activities are considered to fall under the scope of the definition, vary from one nation to the next.

In the selected EU Member States considered in Technical Appendix (A7.0), R&D tax incentives for industry range from 20% to 30%, depending on the size of the company and/or the amount of taxable profit. Tax incentives can take many forms:

a) Wage tax reductions and reductions on tax rates on royalties deriving from patents for the Netherlands;
b) Relief for R&D spending and tax credits if companies are making a loss in the UK; and
c) Tax credits for R&D spending and activities resulting in innovation as well as exemption from taxation in Spain.

The Member States also have varied provisions with regards to the location of R&D, and the ability to carry forward tax incentives. In the Netherlands, R&D must be conducted in the EU, relevant activities must be organised in the country to be eligible, and the company cannot carry forward any tax incentives it is eligible for if it incurred a loss. By contrast in the UK, any benefits that a company may be eligible for can be settled without time limitation as a retroactive tax refund for preceding periods, and eligible R&D activity is not confined to either UK or EU territory. In Spain, unused credits may be carried forward for a maximum of 15 years and no specifications are provided with regards to where R&D activities must take place to be eligible.

In the comparator countries considered in Section 4.1.1.4 the type of R&D tax incentive schemes range from tax credits and allowances (in Australia, Brazil and the

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103 Ibid
USA) to accelerated depreciation for R&D capital (in Chile). The tax incentives for industry range from 20% to 80% (incremental/volume based) depending on the size of company and/or turnover. They take the form of refunds and deductions from taxable income, as well as accelerated depreciation for machinery, equipment and buildings. In Australia and Chile there is an indefinite carry forward of any benefits that apply. In the USA benefits can be carried forward for up to a maximum of 20 years, and back for up to a year, whereas Brazil does not specify any time restrictions that relate to benefits.

Due to the complexities of the various R&D tax incentive schemes, is unclear which policies afford the greatest support to mining industries. Nor is it clear to what extent mining-based R&D is readily appropriable (though IPR, or other forms of protection), and where it is, how this can be confined to the EU28 (given the global reach of some companies in the NEEI). If R&D investment qualifies for incentives irrespective of where it occurs, then this clearly does allow mining R&D to be treated favourably irrespective of location, perhaps limiting the development of the activity in the EU28.

Further insights are offered in Section 6.0, which considers R&D activity in further detail.

4.1.2 Energy Policy and Legislation

Energy plays an essential role in the extraction and processing of minerals and raw materials. Whether it is used to power ventilation systems, water pumps, crushing and grinding machinery or haulage and transport, energy consumption is an inevitable part of the NEEI supply chain, although its importance varies considerably by type of raw material, and with the level of processing. For example, a report in 2007 suggested that for construction minerals in the EU, energy costs account for 3% of overall site operating costs. For industrial minerals, the figure was estimated at 11-19%, and for metallic minerals it was 15-17%. For alumina production, a report in 2004 noted that the cost structure was broadly as follows: bauxite (34%), labour (13%), electricity (3%), other energy (fuel costs (oil, gas, and coal) incurred for the digestion, precipitation and calcinations phases of the refining process) (22%), caustic soda (13%), and other operating costs (15%). These estimates are supported by our interviews with operators within the EU28, but it is noted that no comprehensive survey of energy costs exists for the NEEI.

DG Enterprise has funded two important studies which have sought to assess the cumulative cost of EU legislation on the steel and aluminium industries. However, these cover the processing side of the primary industry, whereas this study focuses on the extraction and preliminary processing side for the NEEI. The work’s observations are relevant to the steel industry, and for the RI as defined in this work.

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The following sub-sections provide a description of some of the key policies relating to energy. It is noted that this is not exhaustive, and there are many policies which can impact on the price of energy.

### 4.1.2.1 Renewable Energy Policy and Energy Prices

The EU Directive 2009/28/EC[^107^], also known as the Renewable Energy Sources (RES) Directive, was adopted in April 2009 and came into effect in June 2009. It focuses on the promotion of the use of energy from renewable sources. The Directive requires Member States to submit national renewable energy action plans and national overall targets for the share of energy from renewable sources in 2020 by end of June 2010, and to have implemented it nationally by December 2010.

Through this Directive the EU has committed itself to reach a 20% share of renewable energy in final energy consumption over all sectors by 2020. In line with EU climate and energy policy, the aim of this high level target is to:

- contribute to the reduction of greenhouse gas emissions (a reduction of 20% by 2020 in relation to 1990 levels);
- promote the security of energy supply;
- promote technological development and innovation; and
- provide opportunities for employment and regional development, especially in rural and isolated areas.[^108^]

Member States are free to adopt their own strategies to meet the targets under the Directive. The effect on the NEEI is not entirely clear. The cumulative cost study for steel carried out on behalf of DG Enterprise noted:

*The costs of support schemes in general and for steelmakers in particular depend on member states’ implementation of the RES directive and the national context. It is important to emphasise that RES support schemes do not necessarily lead to higher costs for steelmakers, but may even lead to lower electricity supply costs due exemptions and the merit-order effect. There is, however, a risk that steelmakers will have to shoulder a greater burden of RES support scheme costs in the future if politicians give in to public opinion which tends to see exemptions for industry critically.*

In respect of steel, the study sought to understand the effect of renewable energy schemes on electricity prices, and whilst the study indicates some uncertainty in this, it concluded:

> ‘Although the weighted average is in the area of 5-5.5 €/MWh, in the sample there are countries where RES costs are in the area of 1€/MWh; countries close to the average; and countries in the area of €10/MWh;’


The sister study, relating to aluminium, found:

*On average, RES tariffs amount to 2.2 €/MWh, that is 4.9% of total electricity costs. The distribution is however skewed, as only one smelter pays RES tariffs in excess of 2 €/MWh. Indeed, the median value is 0.50 €/MWh, and the mean value without the outlier is 0.58 €/MWh.*

As this suggest, the average figure was heavily skewed by the report from one plant of the nine facilities reporting, which gave a figure of 10.70 €/MWh.

It is clear from the above that the Directive can, via the medium of Member State implementation, impact on the operating cost structures of the NEEI. Even so, the exact cost is not always easy to estimate (as the costs of the schemes are often met by industry and households, with the burdens not always being shared proportionately). In Germany, for example, the law protects energy intensive sectors from the added costs of electricity and gas owing to preferential grid access for renewables. These sectors pay a reduced rate on their electricity consumption. The majority of energy intensive industries also qualify for a complete reimbursement of energy taxes.

As part of the national renewable energy action plans that Member States have to submit, governments of all 28 EU States have set renewable energy policy targets, along with another 40 countries globally. For example, the USA has a national target of 20% whereas Canada has 9 provincial targets but no national target. Targets typically relate to the share of electricity production, but some are defined by primary energy supply, installed capacity or otherwise.

### 4.1.2.2 Energy Taxation

The Energy Taxation Directive (Directive 2003/96/EC), which was implemented in January 2004, effectively establishes minimum excise duty rates for energy carriers, with some exemptions also applied. The Directive widened the scope of the EU's minimum rate system for energy products, previously limited to mineral oils, to include all energy products (i.e. coal, natural gas and electricity) aimed at increasing energy efficiency.

The effect of energy taxes upon industrial sectors is complicated by reimbursements and exemptions which may be available in some countries to specific sectors in conjunction with the Environmental and Energy State Aid Guidelines (EEAG) that entered into force in 2014. More fundamentally, however:

1. Article 4(b) excludes from the scope of the Directive ‘dual use of energy products’, this being defined as ‘when it is used both as heating fuel and for purposes other than as motor fuel and heating fuel. The use of energy

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products for chemical reduction and in electrolytic and metallurgical processes shall be regarded as dual use.’

2. Article 4(b) also excludes from scope:

- electricity used principally for the purposes of chemical reduction and in electrolytic and metallurgical processes,

- electricity, when it accounts for more than 50% of the cost of a product. "Cost of a product" shall mean the addition of total purchases of goods and services plus personnel costs plus the consumption of fixed capital, at the level of the business, as defined in Article 11. This cost is calculated per unit on average. "Cost of electricity" shall mean the actual purchase value of electricity or the cost of production of electricity if it is generated in the business,

- mineralogical processes


This clearly indicates exemptions for the bulk of the NEEI.

In addition, Article 17 provides the option for Member States to fully exempt energy-intensive industries from any duties subject to certain conditions. This effectively means that the extent to which the NEEI is affected by energy taxation depends on decisions taken at the Member State level, and cannot be attributed to the EU framework itself, albeit that such duties could be used as means to meet objectives which have been set at the EU level (for example, with respect to carbon, or in respect of incentivising renewable energy generation).

Comparison Country Energy Legislation and Policy

In the following sections, a brief description of selected comparison countries energy legislation and policy is presented. The brief analysis is supported by a summary of all of the available renewable energy polices from the IEA presented in the Technical Appendix. For some comparison countries a synopsis has not been able to be presented due to a lack of reliable analysis on the NEEI, however, as demonstrated in the Technical Appendix that does not equate to a lack of policy and regulation.

Brazil

Alongside the EU and Japan, Brazil has some of the highest costs of electricity in the world. The government is now taking steps to reduce the Brazilian energy bill by, on average, 20% given that in 2011 the cost per MWh in Brazil was 53% higher than the average cost of power in 27 countries, including Argentina, China, France, Germany, India, Japan, Russia and the USA. Such high electricity costs can affect competitiveness of industry, and can negatively affect the domestic NEEI. As a result,
many of the taxes have been removed or reduced, and bills are now reportedly 32% lower.\textsuperscript{111}

**Canada**

Canada has one of the lowest energy prices globally, both for electricity and for gas.\textsuperscript{112} Prices differ between provinces, with some benefiting from lower generation costs and favourable interest rates compared to others. Furthermore there are lower levels of energy taxation, higher energy intensity and fewer environmental policies than is typical in the EU.\textsuperscript{113} As a result the Canadian raw materials sector can benefit from low energy rates.\textsuperscript{114} It remains to be seen how the various policies on renewables might affect energy prices in future.

**China**

On-grid (electricity sold by generators to the grid) and retail electricity prices are determined and capped by the National Development and Reform Commission (NDRC) in China. Additionally, the NDRC also raises a surcharge on renewable energy use to all end-users apart from the residential and agriculture sectors. These measures are designated to encourage more investment in renewable energy infrastructure and to facilitate a greater shift towards using alternative fuels. This can act negatively on the competitiveness of the Chinese NEEI. China's natural gas prices, similar to retail oil prices, are regulated and generally below international market rates. China has typically favoured manufacturing and fertilizer gas users by regulating the price these sectors pay, whereas residential and transportation sectors pay higher, unregulated prices.\textsuperscript{115}

**Japan**

As a net importer of most of its fossil fuels, Japan also has some of the highest energy prices globally. As with the EU this is the result of higher taxation and of unfavourable trading conditions, making raw material prices and the fuel mix cost high. The high prices may also be due to its energy market not being fully liberalised and of the regulatory environment in the country.\textsuperscript{116}

\textsuperscript{112} Wilson, L. (2014) *Average electricity prices around the world: $/kWh*, http://shrinkthatfootprint.com/average-electricity-prices-kwh
USA

In contrast to Japan, the USA has relatively low retail energy prices for industry, partly due to the country’s historic reserves of fossil fuels and partly due to political opposition to raising energy prices. These have translated into ready access to cheap gas and coal, keeping raw material prices down. Furthermore, the perceived ‘right’ of the USA to cheap energy, the positioning of climate change low on the agenda of environmental concerns of USA citizens, and the lobbying power of the fossil fuel companies have led to historically low energy taxes, and have been fundamental in keeping energy prices to about half the levels of those in the EU28. As a result, these low energy prices may have contributed to keeping the cost base of the USA NEEI low relative to prevailing levels in the EU28.

Observations Regarding Energy Prices

Figure 37 outlines the average retail electricity prices for industrial consumers in 2012 and Figure 38 outlines the average retail gas prices in 2012 as presented in a report published by the European Commission on Energy Prices and Costs in Europe (2014). In the context of this study, however, such aggregated estimates of electricity prices have to be treated with caution, not least because various exemptions may apply to specific industries (as noted in Section 4.1.2.2 in respect of the Energy Tax Directive). This applies both to the EU and to competing countries.

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Figure 37: Average Retail Electricity Prices (€/MWh) for Industrial Consumers (2012)

Notes: EU28 price is presented as a weighted average. The price ranges from €75/MWh to €225/MWh

Source: European Commission (2014)

Figure 38: Average Retail Gas Prices (€/MWh) for Industrial Consumers (2012)

120 EU electricity prices for industry refer to consumption band IC, exclusive of VAT and other recoverable taxes. Electricity prices for industry for Canada refer to 2010 and for Korea to 2009. ECB annual exchange rates have been used. Industrial prices exclude taxes as reported by ERRA for Nigeria, Russia and Ukraine, by ANEEL for Brazil, by the IEA for Japan, Canada (2010) and New Zealand. IEA reports zero taxation of industrial prices for Mexico; ERRA reports zero taxation for Saudi Arabia and UAE. No data on taxation of industrial prices in South Korea (IEA); until 2009 natural gas prices reported by South Korea indicated 12-14% taxation of industrial natural gas prices. Prices reported by CEIC for China are actual averages of industrial use electricity prices in 36 cities; no consumption taxation on industrial retail prices in China, but prices include production tax (17% for electricity, 13% for gas, note that these are production taxes). Australian values are exclusive of general sales tax (GST). EIA numbers for the USA include state and local taxes; electricity consumption is not taxed at the federal level in the United States, but it is taxed in some states.
Notes: EU28 price is presented as a weighted average. The price ranges from €25/MWh to €70/MWh

Source: European Commission (2014)\textsuperscript{121}

Of the three elements of energy prices (energy, network costs and taxes and levies), the energy cost element is generally the largest, though its share is diminishing. Although there are many factors that contribute to the higher energy prices in Europe, such as the market domination of the suppliers in the EU, the marginal pricing system, the partially liberalised internal market and mandatory renewable energy targets are also playing a role. The effect of the Emissions Trading Scheme is considered below.

The impact of energy prices affects some mineral sub-groups more than others. Energy prices will have a greater impact on the competitiveness of more energy intensive industries such as some of the non-ferrous, non-critical base metal industries, mainly aluminium, zinc and copper producers. In fact the average industrial energy purchase costs related to total production costs in 2010 in the EU were \textasciitilde4\% for the non-ferrous metal industry and \textasciitilde8\% for the iron and steel industry.\textsuperscript{122} On the other hand, to the extent that recycling saves on energy use, then the RI will not be so strongly affected. This also implies that to the extent that the RI and NEEI compete for custom, then in situations where energy prices are higher, one would expect the RI to become more competitive relative to the NEEI.

As identified in Section 3.1.6, energy costs are comprised of two components, the price of energy and the quantity of energy utilised. Real Unit Energy Cost (RUEC) is an indicator which measures the energy cost per unit of value added in a given sector, thus taking in to account both factors.\textsuperscript{123} An analysis conducted by the European Commission compared the EU RUEC to a number of competitors including China, Japan, Russia and the USA.\textsuperscript{124} The study revealed that the EU\textsuperscript{27}\textsuperscript{125} had more competitive values for RUEC than all of the countries except the USA for the ‘Other Non-Metallic Minerals’ and ‘Basic Metals and Fabricated Metals’ within the

\textsuperscript{121} Australia refers to prices paid under new contracts by large industrial consumers, respectively and is based on information on standing offers (default tariffs, exclusive of general sales tax). Prices for Korea and Japan refer to 2011. Prices for Japan, Ukraine, China, Turkey, New Zealand, Russia, Canada and the EU exclude VAT (in the case of EU and Turkey also other recoverable taxes, if any). Prices for Korea (2011) and the USA include taxes. No data on taxation in India. The price for Brazil includes federal taxes as PIS and COFINS (social contribution taxes) and state taxes such as ICMS (tax on circulation of goods and services; no value-added or general sales tax in Brazil) which has different rates for each state. In June 2013 the government of India approved a new pricing formula for gas proposed by the Rangarajan Committee, which is expected to double natural gas prices starting from April 2014.


\textsuperscript{124} \textit{Ibid}

\textsuperscript{125} Data for Croatia was not presented.
manufacturing sector. Whilst neither of these sectors are within the scope for NEEI they do point to the EU28 having relatively competitive energy costs when energy efficiency is accounted for.

4.1.3 Environmental Policy and Legislation

Environmental policy and legislation for the NEEI comprises a number of aspects focusing on mitigating climate change and environmental protection. The following section aims to identify and assess the impacts of key policies and legislation within the EU28 and comparison countries within these key areas.

4.1.3.1 Emissions Trading Scheme – EU28

The EU Emissions Trading Scheme (EU ETS) was launched in January 2005 as a core instrument for compliance with the Kyoto Protocol in the EU. It is the largest cap-and-trade scheme in the world, covering around 12,000 industrial installations and 45% of the EU’s greenhouse gas emissions. Since the scheme’s inception, the price of carbon has fluctuated significantly, dropping to zero in 2007 due to an over-allocation of emissions allowances relative to demand. In 2013, the average price was €4.31/tCO$_2$ e. Three key impacts relating to the competitiveness of the NEEI have previously been highlighted:

- Direct impacts: an increase in production costs, associated with the purchase of allowances, compared to those of producers outside the EU;
- Indirect impacts: costs associated with CO$_2$ as a result of higher electricity prices and cost of burden of self-generation; and
- Administrative costs (i.e. the costs associated with reporting on performance under the scheme, etc.).

The last of these is relatively insignificant. For reasons explained below, the indirect impacts (associated with electricity use) are considered first, followed by the direct impacts.

According to the cumulative cost studies in respect of steel and aluminium, the key lessons appear to include, in respect of indirect impacts (i.e., the cost of electricity use) that the ETS can have a significant impact on costs where:

a. the operator is a major electricity user;

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b. the operator is not purchasing electricity through long-term contracts is not generating its own supplies;
c. the energy intensity of the operation is high;
d. one assumes a high pass through of the costs of allowances into electricity prices; and
e. importantly, the allowance price itself is high.

It should be noted that these reports worked with historic figures in respect of allowance prices since they were reviewing the impact of the first 2 Phases of the ETS. The average price of EUAs was much higher than the price of EUAs over recent years. Furthermore, in the first 2 Phases of the ETS, a high, though (slowly) declining proportion of the EUAs was allocated free of charge. Notwithstanding this fact, the assumed level of pass through of the allowance price by electricity producers was assumed to vary from a low of 60% to a high of 100%. There is some uncertainty about what these pass through rates should be, but given the volume of allowances being issued free of charge, then these rates might be considered quite high.

In Phases I (2005-2007) and II (2008-2012) of the EU Emissions Trading Scheme (EU ETS), the Member States (MSs) could auction up to 5% and 10% of allowances, respectively, as they saw fit. For the first trading period of the EU ETS (2005-2007) only 4 countries (Denmark, Hungary, Ireland and Lithuania) used auctioning or direct selling, as opposed to grandfathering, for allocating EU allowances (EUAs) to the companies covered by the scheme. Although only Denmark chose to auction the full 5% allowed, it finally decided to sell them directly on the market. In Phase II, a larger number of countries auctioned or sold allowances. These are shown in Table 27, along with the total sold or auctioned over the Phase II period. The sale of allowances by year is shown in Table 28.

Table 27: Auctioned or sold Allowances in Phase II of the EU-ETS, ‘000 emission units (kt CO₂-eq), all stationary sectors (1-9 and 99)

<table>
<thead>
<tr>
<th>Country</th>
<th>Allowances Auctioned / Sold in Phase II ('000 EUAs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>2,000</td>
</tr>
<tr>
<td>Belgium</td>
<td>9,565</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>130</td>
</tr>
<tr>
<td>Cyprus</td>
<td>0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>2,569</td>
</tr>
<tr>
<td>Denmark</td>
<td>2,837</td>
</tr>
<tr>
<td>Estonia</td>
<td>0</td>
</tr>
<tr>
<td>Finland</td>
<td>0</td>
</tr>
</tbody>
</table>

Competitiveness of the EU MRMS
<table>
<thead>
<tr>
<th>Country</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0</td>
</tr>
<tr>
<td>Germany</td>
<td>220,181</td>
</tr>
<tr>
<td>Greece</td>
<td>18,750</td>
</tr>
<tr>
<td>Hungary</td>
<td>7,675</td>
</tr>
<tr>
<td>Iceland</td>
<td>0</td>
</tr>
<tr>
<td>Ireland</td>
<td>557</td>
</tr>
<tr>
<td>Italy</td>
<td>0</td>
</tr>
<tr>
<td>Latvia</td>
<td>0</td>
</tr>
<tr>
<td>Liechtenstein</td>
<td>0</td>
</tr>
<tr>
<td>Lithuania</td>
<td>3,331</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>4</td>
</tr>
<tr>
<td>Malta</td>
<td>0</td>
</tr>
<tr>
<td>Netherlands</td>
<td>16,000</td>
</tr>
<tr>
<td>Norway</td>
<td>35,019</td>
</tr>
<tr>
<td>Poland</td>
<td>210</td>
</tr>
<tr>
<td>Portugal</td>
<td>0</td>
</tr>
<tr>
<td>Romania</td>
<td>638</td>
</tr>
<tr>
<td>Slovakia</td>
<td>0</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0</td>
</tr>
<tr>
<td>Spain</td>
<td>0</td>
</tr>
<tr>
<td>Sweden</td>
<td>0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>122,819</td>
</tr>
</tbody>
</table>

Table 28: Auctioned or Sold Allowances by Year, ‘000 emission units (kt CO₂-eq), all stationary sectors (1-9 and 99)

<table>
<thead>
<tr>
<th>Year</th>
<th>Allowances Auctioned / Sold in Phase II ('000 EUAs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>0</td>
</tr>
<tr>
<td>2006</td>
<td>6,782</td>
</tr>
<tr>
<td>2007</td>
<td>1,730</td>
</tr>
<tr>
<td>2008</td>
<td>53,130</td>
</tr>
<tr>
<td>2009</td>
<td>79,315</td>
</tr>
<tr>
<td>2010</td>
<td>91,862</td>
</tr>
<tr>
<td>2011</td>
<td>92,943</td>
</tr>
<tr>
<td>2012</td>
<td>125,034</td>
</tr>
</tbody>
</table>


In 2013 over 40% of all allowances were expected to be auctioned, and the ETS legislation sets the goal of phasing out free allocation completely by 2027. Regular auctions take place in accordance with Commission Regulation (EU) No. 1031/2010 (the "Auctioning Regulation").

For the power generation sector, the rule is that operators no longer receive any free allowances but have to buy them. However, eight of the Member States which have joined the EU since 2004 - Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Poland and Romania - have made use of a derogation (under Article 10c of the revised EU ETS Directive) which allows them to allocate, free of charge, a decreasing number of allowances to existing power plants for a transitional period. Latvia and Malta were also eligible to use this derogation but chose not to. The derogations require that the number of free allowances allocated declines progressively to reach zero no later than 2020. In exchange, the eight Member States concerned are required to implement national plans to modernise their electricity sectors and diversify their energy mix through investments worth at least as much as the value of the free allowances.

By way of comparison, the quantity sold or auctioned in the last year of Phase II of the ETS was 125 million across the EU (see Table 28 above). In 2014, the quantity to be auctioned was around 926 million (almost eight times the number in 2012). At the same time, the allowance values have not been particularly high. For UK allowances, in 2013, the average value of allowances was €4.31 per EUA.

The prices for non-critical non-ferrous metals (and some non-critical) are determined globally on the London Metals Exchange. Costs, conversely, are locally determined.
European non-ferrous metal producers cannot easily pass the costs of the EU ETS on to downstream consumers in markets where they are largely price takers (and their declining share of the market for most materials suggests this is the case). As a result, only if they are able to take cost effective measures to reduce emissions to offset higher electricity prices would they be able to avoid some impact on their competitive position. At the same time, it should be recognised that competitors are, increasingly, implementing similar schemes of their own (see below) in response to the threat of global climate change.

The impacts outlined above can also be applied to iron. The cumulative cost study on steel suggests, regarding pricing:

'Iron ore is sold to steel makers on the basis of long-term contracts based on quarterly prices (Datamonitor, 2011). Customarily, the price negotiated by Japanese steel makers was the benchmark for contracts worldwide. Since the second quarter of 2012, contract pricing has been reportedly shifting towards an index-based mechanism (based on spot price in China). Consequently, a growing tendency toward monthly pricing mechanisms would be unfolding.'

The direct and indirect effects associated with the EU ETS are felt across all of the sectors within the scope of this study, particularly by processing activities. An ex-ante study by the Carbon Trust on the impacts of the scheme on trade in the UK highlighted the costs of some metal raw materials. Paying £20/tCO$_2$e would increase production costs of copper by 3.9%. Aluminium was found to be the non-ferrous metal for which cost increases were greatest, with a cost increase of around 12% of GVA.

As regards indirect impacts, where costs of production are expected to increase as a result of the ETS, the potential for carbon leakage arises, whereby businesses transfer production to other countries which have laxer constraints on greenhouse gas emissions (unless a suitable border tax adjustment mechanism could be implemented). The revised ETS makes provision for listing sectors at risk of carbon leakage where one of the provisions of Articles 10(15) and 10(16) apply, and subject to Articles 10(17) and 10(18).

The Commission has addressed this potential for leakage in a Commission Decision (COM 2010/2/EC). This recognises that the direct costs of the EU ETS pose a potential risk to certain industries and allows the Union to allocate allowances free of charge to sectors deemed to be exposed to a significant risk of carbon leakage. It should also be noted that higher electricity prices are included in the methodology to determine the list of sectors eligible for assistance, so that indirect costs are effectively taken into account in identifying the sectors at risk. These sectors can

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132 Article 10a (1) of Directive2003/87/EC
therefore be compensated for the passing down of these costs from utilities companies.

The European Commission has proposed a list of sectors which it believes to be at risk of carbon leakage. These are shown in the Technical Appendix (Section A6.0), and include many of the sectors of interest to this study, including some which — by common consent — are not seriously exposed to industrial competition (because of the costs of haulage relative to the value of the material), such as aggregates. Even so, the list is of interest to this study in that it identifies, relative to defined benchmarks, the extent to which sectors are thought to be exposed to a competitive threat owing to the additional burden implied by the EU-ETS. The indication from the assessment is that several of the sectors of interest to this study are deemed to be sufficiently affected by the ETS for there to be a risk. Additionally, in 2014 the Commission consulted on post-2020 carbon leakage provisions of the ETS in order to canvass opinions on different options for a system to avoid carbon leakage after 2020.

4.1.3.2 Emissions Trading Schemes - Competitor Countries


Canada

In Québec, the cap-and-trade system, launched in 2012, is the main instrument for achieving reductions in greenhouse gases. It was largely designed by the Western Climate Initiative (WCI) which Québec joined in 2008. Initially the Québec ETS covers just the electricity and industrial GHG emissions. From 2015 it will be extended to include emissions from fossil fuels distribution, thus covering 85% of the province’s GHG emissions.

For the electricity and fossil sectors the allowances are sold at auctions with a minimum and a maximum price set, which will rise annually by 5% plus inflation, thus guaranteeing a strong carbon price signal to the Québec economy. Purchase limits also apply to avoid hoarding of allowances. Some allowances are freely distributed to companies whose products face national or international competition (they amount to about 80% of the allowances they receive). To avoid carbon leakage, however, and to provide an incentive for emissions reductions, the number of freely available allowances will decrease by 1-2% annually from 2015 onwards.

The first compliance period runs from January 1st 2013 to December 31st 2014. The Quebec cap-and-trade regulation set as a minimum price for allowances sold at the

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134 See: http://ec.europa.eu/clima/consultations/articles/0023_en.htm
first auction on December 2013 10.75 CAD (~7.25 Euro). The price will rise annually by five percent plus inflation until 2020, to guarantee a progressively strong carbon price signal to the economy. The following two periods will last three years each (i.e. 2015-2017 and 2018-2020).

Since January 2014 Québec and the California Air Resources Board have linked their respective schemes allowing for a joint auction of emission allowances. The link between the two systems creates the largest carbon market in North America and the first transnational cap-and-trade system run by sub-national governments in the world.

**China**

China’s **Shenzen ETS** was launched in June 2013 and is the first carbon market in China. In the first compliance period (i.e. 2013-2015) the trading system covers 635 companies (fulfilling certain criteria regarding added value and energy consumption) and 197 public buildings (with more than 20,000 square metres of floor space). The plan is to expand the scope gradually with the transport sector being considered for the next phase. The allocation methodology differs according to the sector. Power and water supply sectors received allowances based on benchmarking. For manufacturing industries a carbon intensity allocation method was used based on carbon emissions per unit of industrial added value. Companies were divided into groups and a reduction target was set for each group. The companies of the same group then compete with each other to apply for the allowances based on their respective estimated industrial added value and projected emissions for the years 2013-2015.

Strict guidelines exist for monitoring, reporting and verification. The program is guided by two specifications – the Specification of Guidance for Quantification and Reporting of the Organisation’s GHG Emissions and the Specification of Guidance for Verification of the Organisation’s Greenhouse Gas Emissions. Verification bodies are also supervised and cannot be used by a company for more than three consecutive years. Since June 2013 when the ETS became active, prices of allowances have risen from 30 CNY to more than 100 CNY, with an average price of ~63 CNY (~7.60 Euro).

China has also launched (or is in the process of launching) ETS in six other regions between 2013 and 2014: Beijing; Guangdong; Shanghai; Tianjin; Chongqing; and Hubei.

**Japan**

The Tokyo cap-and-trade program is the world’s first city wide ETS targeting urban facilities, including office and public buildings and commercial and industrial facilities. It was launched in April 2010 and covers ~1,400 large facilities, which can reduce emissions themselves or buy credits to meet their obligations. The first compliance period (i.e. FY2010 - FY2014) has a 6% cap below base-year (i.e. the year 2000) emissions requiring a reduction of 8% for the commercial sector including office buildings, and 6% for the industrial sector including factories. The second

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136 ‘CNY’ is the Chinese Yuan, the basic unit of the renminbi
compliance period (i.e. FY2015 - FY2019) has a cap of 15% below base-year emissions (i.e. the year 2000) for the industrial sector including factories and 17% for the commercial sector including office buildings. Facilities owners must submit their reduction plans and emissions reports annually and these must be verified by third-party verification agencies. It forms part of the Tokyo Climate Change Strategy, which has a target of reducing GHG emissions by 25% below 2000 levels by 2020. In general the Tokyo program does not control carbon prices, however the supply of credits available for credits may be increased in case of excessive price evolution.

By 2011, emissions in the city had been reduced by 23% compared to the base-year due mainly to electricity savings. The program’s success is due to a good understanding and support of the involved facilities including how owners and tenants can co-operate to comply. Following the Fukushima nuclear power plant accident due to the earthquake in East Japan, Tokyo faced a major power crisis but power facilities were able to implement electricity saving measures quickly and effectively due in large to the Carbon Reduction Reporting Program’s energy conservation system, in force since 2002, and the ongoing cap-and-trade program, in force since 2010.

USA

The Regional Greenhouse Gas Initiative (RGGI) is the first USA mandatory market-based emissions trading program to reduce greenhouse gases. It was launched in January 2009 and applies to 168 electricity generation facilities in nine states (i.e. Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont). These facilities account for approximately 95% of CO₂ emissions from electricity generation in the region. To reflect current market conditions in 2014, the RGGI states agreed to reduce the cap by 45% in 2014 to lock in the CO₂ pollution reductions achieved to date. The RGGI cap is also being reduced from 165 million to 91 million which is approximately the level of the current emissions. Furthermore the cap will decline by 2.5% each year from 2015 to 2020, and unsold allowances from 2012 and 2013 will not be re-offered. The RGGI proves that cost effective emission reductions can be achieved while creating economic benefits and jobs in the region, and provides a successful blueprint for a national emissions trading system.

California’s cap-and-trade program was adopted in October 2011 in order to give effect to the California Global Warming Solutions Act of 2006 (AB 32) which requires the greenhouse gas (GHG) emissions in California be reduced to 1990 levels by 2020. The relevant provisions took effect on January 1, 2012. The first compliance period under the program begins on January 1, 2013. After 2015 the cap-and-trade program will cover 85% of California’s GHG emissions. ¹³⁷

Other Schemes

Other ETS in force or currently being implemented include New Zealand (launched in 2008); Kazakhstan (launched in 2013); Switzerland (launched in 2008 but mandatory from 2013); and Korea (to be launched in 2015).

¹³⁷ http://www.c2es.org/us-states-regions/key-legislation/california-cap-trade
All active ETS cover the power sector, with the majority also covering industry, but only a handful covering transport and buildings, and one or two covering waste and forestry. Similarly all ETS cover carbon dioxide (CO$_2$), the most common greenhouse gas. A handful cover the other five main greenhouse gases, namely nitrous oxide (N$_2$O) perfluorocarbons (PFCs), methane (CH$_4$), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF$_6$).

**Discussion**

The key aspects of the ETS examples described are summarised in Table 29.
Table 29: Comparison of the ETS Examples Considered

<table>
<thead>
<tr>
<th>ETS</th>
<th>EU</th>
<th>California</th>
<th>USA RGGI</th>
<th>Québec</th>
<th>Tokyo</th>
<th>Shenzen (China)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sectors covered</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Power</td>
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<td>✓</td>
<td>✓</td>
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<tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Buildings</td>
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<td>✓</td>
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<td>✓</td>
</tr>
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<td>Forestry</td>
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<td></td>
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</tr>
<tr>
<td><strong>GHGs covered</strong></td>
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</tr>
<tr>
<td>CO₂</td>
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<td>✓</td>
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<tr>
<td>N₂O</td>
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<td></td>
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<tr>
<td>CH₄</td>
<td>✓</td>
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<tr>
<td>HFCs</td>
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</tbody>
</table>

*Source: Based on sources review outlined in previous section*

**Exemptions and Carbon Leakage**

Carbon pricing takes place in a number of competitor countries, and like the EU28, exemptions are given to the NEEI. Table 30 summarises some of the exemptions and offsetting measures offered in other competitor countries.
Table 30: Policies to Address Competitiveness and Leakage in the NEEI in Comparison Countries

<table>
<thead>
<tr>
<th>Policy</th>
<th>Exemption</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa¹</td>
<td>Iron and steel and aluminium will receive 10% uplift on tax-free threshold for high process emissions and a further 10% uplift for trade exposure. Offsets can be used for up to 5% of liability. Other sectors deemed to be highly trade exposed can receive 10% uplift on their tax-free threshold.</td>
</tr>
<tr>
<td>Quebec ETS</td>
<td>Activities identified will receive benchmarked free allowances. Revenue recycling will include some allocation to energy efficiency technologies in the industrial sector.</td>
</tr>
<tr>
<td>British Columbia Carbon Tax</td>
<td>General corporate tax reductions.</td>
</tr>
<tr>
<td>California ETS</td>
<td>Mining and manufacturing of soda ash and diatomaceous earth mining will receive free allowances in line with highly emissions intensive activities. Secondary smelting and alloying of aluminium, secondary smelting, refining and alloying of non-ferrous metal (except copper and aluminium), iron foundries will receive free allowances in line with moderately emissions-intensive activities</td>
</tr>
</tbody>
</table>

Notes:
1) Yet to be implemented

Source: ICMM (2014)¹³⁸

The modelled impact of the exemptions on the cost of aluminium, as calculated by the ICCM, are shown in The figure shows that whilst exemptions are offered by the EU28, the impacts of such exemptions are not as pronounced as in other nations. That having been said, the ICMM report does not include any Member State specific measures which might be implemented under State Aid approvals, and considers only the impact of free allowances allocated through the scheme (it is not clear how the issue of leakage has been dealt with). Furthermore, it should be noted that as schemes develop and as carbon pricing becomes more harmonised, it seems likely that pressure will increase to remove any measures that effectively imply that implicit subsidies are awarded to the mining and other energy intensive sectors. As the comparative cost studies note, whether or not schemes impose costs on a given industry does not constitute an indication of the validity, or otherwise, of the policy itself. Where carbon pricing is concerned, those schemes offering the greatest exemptions to energy intensive users are those which engender greater economic inefficiency.

Figure 39. The figure shows that whilst exemptions are offered by the EU28, the impacts of such exemptions are not as pronounced as in other nations. That having been said, the ICMM report does not include any Member State specific measures which might be implemented under State Aid approvals, and considers only the impact of free allowances allocated through the scheme (it is not clear how the issue of leakage has been dealt with). Furthermore, it should be noted that as schemes develop and as carbon pricing becomes more harmonised, it seems likely that pressure will increase to remove any measures that effectively imply that implicit subsidies are awarded to the mining and other energy intensive sectors. As the comparative cost studies note, whether or not schemes impose costs on a given industry does not constitute an indication of the validity, or otherwise, of the policy itself. Where carbon pricing is concerned, those schemes offering the greatest exemptions to energy intensive users are those which engender greater economic inefficiency.

Figure 39: Carbon Cost Impacts on Aluminium Production

Notes:

Australia repealed their system in 2014

South Africa has delayed the implementation of their system until 2016

Source: ICMM (2014)
It is of interest to note that other ETS under consideration include Russia, North America Pacific Coast, Turkey, Ukraine, Brazil, Chile, Mexico, Japan and Thailand. Eight new schemes commenced in 2013 alone. Australia had its own ETS known as the Carbon Pricing Mechanism from July 2012 but it was repealed by the new government in 2014 and is no longer in force. Hence, over time, it might be expected that more countries will be implementing measures which are intended to place a price on carbon. There is also considerable interest in making these schemes ‘linkable’ so that a unified market across a large number of countries may be a possibility in years to come. The recent exception to this rule in Australia has been a major topic of political debate. Therefore, in respect of the costs associated with accounting for emissions from the NEEI, it appears that the EU28 is slightly less competitive than other comparison nations.

A recent World Bank report mapped the schemes either in place, or under consideration. These are shown in Figure 40. The same publication notes the prices at which carbon is taxed or traded under different schemes already in place (see Figure 41). This highlights the fact that the ETS is not pricing carbon at an abnormally high level. Hence, the competitiveness effects are likely to depend, increasingly, on the extent to which jurisdictions a) implement carbon pricing b) allow exemptions to persist for the sectors under consideration. The first of these shows clear signs of increasing in likelihood, whilst the persistence of exemptions seems most likely to be threatened by the increased prevalence of schemes.

Figure 40: Summary Map of Existing, Emerging, and Potential Regional, National and Sub-national Carbon Pricing Instruments (ETS and Tax)

### 4.1.3.3 Permitting Requirements – EU28

The Industrial Emissions Directive (2010/75/EU) (IED) is a recast of seven previously existing pieces of legislation, the aim of which is to reduce harmful industrial emissions across the EU. The IED is the successor to the Integrated Pollution Containment System (IPCS) and is designed to bring consistency to the way these emissions are managed across the EU. The directive builds on the existing framework by introducing additional provisions to address specific challenges such as fugitive emissions and the use of carbon capture and storage (CCS) technologies.
Prevention and Control (IPPC) Directive and requires operators of industrial installations with a major pollution potential (defined by Annex 1 of the IED) to obtain an integrated permit from the relevant authorities. The IPPC encompassed around 50,000 installations in the EU and, as the IED covers a wider range of activities, this figure is likely to be somewhat higher for the IED.\textsuperscript{142} The Directive came into force on 6\textsuperscript{th} January 2011 and was required to be transposed into Member State legislation by 7\textsuperscript{th} January 2013.\textsuperscript{143}

As of the date of this study, no formal implementation report has been published for the IED and thus it is unclear as to whether all of the requirements of the IED have been fully incorporated within the Member State legislation. However, despite the lack of a formal implementation report, the European Commission appears to have undertaken some analysis of the implementation of the IED and has reported that the majority of Member States have transposed the Directive into national law. As of the 6 May 2014, the only states remaining to do so fully were: Austria, Luxemburg, Poland, Slovenia and Sweden.\textsuperscript{144}

It was not possible to identify any ex-post studies related to the cost impacts associated with the IED, not least given that it has only recently taken effect and will impact upon different sectors on different timescales (pending revisions of the relevant documents setting out Best Available Techniques by the Joint Research Centre of the European Commission). The Europe-wide Impact Assessment of the Directive, published in 2007, provides estimates of the operating costs associated with the Directive’s transposition into Member States. It estimated that there were a total of 2,006 installations operating in the mineral industry and 4,237 operating in the production and processing of metals industry within the EU (note that figure is likely to have increased since Romania, Bulgaria and Croatia have joined the EU since the time of the study).\textsuperscript{145}

The IA applied an administrative cost regarding the permitting of installations per installation of €20,000 for combustion plants (20-50 MW), wood preservation and wood-based panel production, taken as the average figure from previous studies by Defra (2007) and Rambøll (2005).\textsuperscript{146,147} This was based on the assumption that a new

\begin{itemize}
\item\textsuperscript{142} European Commission (2014), \textit{Summary of Directive 2010/75/EU on Industrial Emissions (integrated pollution prevention and control)}, available at: \url{http://ec.europa.eu/environment/air/pollutants/stationary/ied/legislation.htm}
\item\textsuperscript{143} European Commission (2014), \textit{Summary of Directive 2010/75/EU on Industrial Emissions (integrated pollution prevention and control)}, available at: \url{http://ec.europa.eu/environment/air/pollutants/stationary/ied/legislation.htm}
\item\textsuperscript{145} European Commission (2014), \textit{Transposition of Directive 2010/75/EU on Industrial Emissions (integrated pollution prevention and control)}, available at: \url{http://ec.europa.eu/environment/air/pollutants/stationary/ied/transposition.htm}
\item\textsuperscript{148} Defra (2007) \textit{Mid-term Review of the UK’s Implementation of the Pollution Prevention and Control Regulations}, April 2007.
\end{itemize}
permit application would be needed every 20 years. The Commission states that the technical work involved in assessing environmental impacts, etc. (which allows the operator to decide on how to comply with the legislation) is likely to be 2-4 times these figures. A separate value for mineral and metal industries was not estimated.

The UK Department of Environment, Food and Rural Affairs also calculated a one-off compliance cost of £350,000, of which the majority (£307,000) is made up of capital investment.\textsuperscript{148} It should, however, be noted that this figure was reportedly influenced by a particularly high investment required at a single installation.

Costs associated with reporting and monitoring were estimated to be €3,000 and €2,800, respectively (also derived from Defra and Rambøll figures). It was also assumed that the reconsideration of a permit for the purpose of bringing an installation in line with the Directive, in the minerals and metal production and processing industries would have administrative costs of €3,175 and €1,975 respectively. The costs outlined above are presented in Table 31.

Table 31: Operating Costs Associated with the Industrial Emissions Directive (2007)\textsuperscript{149}

<table>
<thead>
<tr>
<th>Associated Cost</th>
<th>Time period</th>
<th>Cost per Installation (EUR)</th>
<th>Minerals Sector</th>
<th>Metals Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permitting</td>
<td>Every 20 years</td>
<td>20,000</td>
<td>20,000</td>
<td></td>
</tr>
<tr>
<td>Technical work associated with permitting</td>
<td>Every 20 years</td>
<td>40,000 – 80,000</td>
<td>40,000 – 80,000</td>
<td></td>
</tr>
<tr>
<td>Compliance costs</td>
<td>One-off</td>
<td>350,000</td>
<td>350,000</td>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
<td>Annual</td>
<td>2,800</td>
<td>2,800</td>
<td></td>
</tr>
<tr>
<td>Reporting</td>
<td>Annual</td>
<td>3,000</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>Permit Reconsideration</td>
<td>Case dependent</td>
<td>3,175</td>
<td>1,975</td>
<td></td>
</tr>
</tbody>
</table>

Source: European Commission (2007)

The IED will have an impact on each of the sectors within the scope of this study: the metals, industrial minerals and construction minerals industries will all incur costs associated with the Directive.


As with the IPPC Directive before it, Annex 1 of the IED does not expressly mention activities related to the extraction of non-energy minerals. It is therefore processing operations (which require a permit to operate) that will bear additional costs related to the IED.\footnote{150} Despite this, reports from Euromines and the Commission have indicated that some Member States applied the IPPC Directive to some mining installations (e.g. Austria, Spain, the Netherlands and Slovakia).\footnote{151,152} The extent to which this is likely to be done for the IED cannot be truly assessed until the respective Implementation Report has been published.

**Best Available Technology – Competitor Countries**

**China**

A best available techniques determination system was established by China’s Ministry of Environmental Protection (MEP) in 2006 in order to provide technical support across industrial sectors. The iron industry, as a key polluter, were, among others, chosen as test industries for the application of the new BAT system.\footnote{153} Although China’s MEP continues to work to develop a robust framework of environmental law, the scope of its legislation is still narrower than that of the EU in some significant areas. For example, air pollution prevention and control is still notably absent.\footnote{154} Furthermore, there is no overarching methodology for determining BAT in China, with assessments based on the personal experience of those conducting them.\footnote{155}

**USA**

In the USA, facilities, operations or industrial processes which emit contaminants to air are required to implement Best Available Control Technologies (BACT) as part of their construction permitting approval process for both new constructions and modifications to existing constructs. This requirement is enshrined in the New European Commission (2010) *Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial Emissions (integrated pollution prevention and control)*, November 2010.


Source Review (1977) amendment to the Clean Air Act\textsuperscript{156}, this act being the key piece of legislation in USA air pollution control policy. Although the requirement to implement some such standard is universal, each facility, operation or process has its own individual standard determined on a case by case basis by the USA Environmental Protection Agency (USA EPA).

The USA EPA determines these bespoke standards through the Prevention of Significant Deterioration (PSD) permitting program. The principle of the program is that, starting with the lowest, subsequently increasing emission rates are considered based on energy, environmental and economic factors, until one is found for which there are no good alleviating reasons on these grounds for why it should not be implemented. In addition to establishing this limit, the EPA also determines the technology to be used in achieving the limit. By establishing standards as and when they are needed, up-to-date technological factors can be built into the assessment, meaning that progress in BACT should be achieved over time.

Owing to the fact that economic factors are considered in the PSD process, BACT should in theory not hamper the economic competitive of USA businesses. Whilst primarily aimed at establishing the best possible technology and standards, competing alternatives are in part considered with the objective being the avoidance of unnecessarily high costs.

4.1.4 National Mineral Policies

National mineral policies, tailored to reflect the individual requirements of a nation, can have direct impacts on the operating cost structure of the NEEI through their influence on the way mineral resources are managed. Although it is not possible to attribute a precise figure to the impact they have on the sector, this section outlines some of the key policies in place across the EU28 and the comparator countries and provides some discussion of the associated effects.

4.1.4.1 European Policy and Legislation

The Raw Materials Initiative, launched by the Commission in November 2008, sets out targeted measures to secure and improve access to raw materials for the EU\textsuperscript{157}. To tackle these issues, the Commission proposed an integrated raw materials strategy for the EU, focused around three ‘pillars’. These were refined further in a later communication to:

- Pillar 1: Ensure level playing field in access to resource in third countries
- Pillar 2: Foster sustainable supply from European sources


Pillar 3: Boost resource efficiency and recycling

Pillar 2 encourages Member States to define a national policy for minerals to ensure that they are exploited in an economically viable way and harmonised with other national sustainable development policies. These generally define a list of action points for government and industry, depending on the situation of the country. For example, more technologically advanced and resource rich Member States may outline measures to maintain and expand operations, whilst resource poor Member States plan to focus on resource efficiency to maintain supplies of critical raw materials.

Some of the actions stemming from these national strategies that are likely to have an effect on the operating costs of extractive processes are described below. These are based on a review of Member States that have produced national mineral strategies. The Commission lists the following Member States that have produced national mineral strategies:

- Austria
- Denmark
- Finland
- France
- Germany
- Greece
- Netherlands
- Portugal
- Sweden
- United Kingdom

Accordingly, costs associated with the Commission’s Raw Material Initiative will not be felt universally. Further to this, not all Member States have outlined actions that will have obvious impacts on the minerals sector, with many of the proposed measures being the responsibility of government that have no clear impact on the NEEI. This issue if inconsistency between Member States was raised by stakeholders and may also explain the wide differences in perceptions of the selected Members States identified in the Fraser Institute Survey (shown in Table 25).

Although the impacts are not quantifiable at this stage, they provide an indication of the types of costs associated with the strategies.

---


Example Actions likely to Increase Operating Costs

Environmental Management and Sustainability

► Finland: Companies will be required to create water management plans for mines. All existing mines in Finland are required to conduct a water review, with more attention being paid, at the planning stage, to the water management of new mines. 161

► Portugal: Promotion of environmental and social responsibility in the mining industry. 162

► Portugal: Elimination or minimisation of security risks regarding abandoned mines and quarries or perceived as potentially dangerous. 163

Health and Safety

► Finland: Companies will be required to implement development measures to improve the safety of individual mines and quarries. Mining companies will also have to actively participate in the activities and developments of an advisory council. 164

► Portugal: Promotion of adequate working conditions and social protection to be provided by companies holding exploitation rights of geological resources. 165

Education

► Sweden: The mining sector has been offered the opportunity to co-finance a project aiming to increase knowledge about the role of geology in society. The project, funded by the Geological Survey of Sweden (SGU), would stretch over a number of years and highlight the sector as a workplace. 166

Example Actions likely to Decrease Operating Costs

Supporting Efficient Production Techniques

► Finland: Further improvement to the energy efficiency of machinery, equipment and processing technologies within the sector. The introduction of incentives for the recycling and re-use of stockpiled waste materials, tailings,

163 Ibid
mineral products and earth materials associated with construction industries.  

► Germany: Promotion of the development of materials efficiency through the Federal Economics Ministry. The Ministry makes substantial funding available for research into the use of resource-efficient technologies and materials.  

Funding Research and Development  
► Finland: Plan to establish a research programme under the Finnish Funding Agency for Technology and Innovation (Tekes), aimed at developing innovative solutions, products and services in all areas of the mineral utilisation chain to facilitate reduced consumption of energy and material resources.  
► Germany: Germany’s Federal Research Ministry’s Framework Programme entitled “Research for sustainable development” cites the issue of “sustainable business activity and resources” as one of five central fields of action. Support is given to measures including enhancing raw materials productivity in high input industries and innovative SMEs.  
► UK: the Natural Environment Research Council (NERC) is funding a programme “Security of Supply of Mineral Resources” which aims to understand the processes responsible for the mobilisation and concentration of metals used in ‘environmental’ technologies and to predict the environmental impacts of low-carbon extraction and recovery of critical minerals. The first aim will contribute to improving the efficiency and effectiveness of exploration for a range of minor and critical metals thus contributing to the identification of additional resources.  

Administrative Efficiencies  
► UK: The government will look for opportunities to streamline the working of REACH across the EU, reducing costs to businesses.

4.1.4.2 Competitor Country Policy and Legislation and Discussion

Table 32 summarises the priorities of the comparator countries’ national mineral strategies. More detailed descriptions are provided in the Technical Appendix (Section A6.0).

Table 32: Summary of the Priorities of Comparator Countries National Strategies

<table>
<thead>
<tr>
<th>Country</th>
<th>Sustainable development</th>
<th>Health &amp; Safety</th>
<th>Education</th>
<th>R&amp;I</th>
<th>Increase Investment</th>
<th>Economic assistance</th>
<th>Sustainable extraction/increased efficiencies</th>
<th>Stable national supply</th>
<th>Enhance Regulatory framework</th>
<th>Increase production/exports</th>
<th>Improve administration</th>
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</tr>
</tbody>
</table>

Notes:

1) Only relates to those Member States that have produced a National Minerals Policy: Finland, France, Germany, Netherlands, Portugal, Sweden and the UK.

Sources: The National Mineral Strategies discussed in Section 4.1.4
Fundamentally, all the mineral policies assessed from the comparator countries address a similar theme. The most in-depth mineral policies come from Canada and USA, while other countries such as Brazil and Chile require further development. China’s policy, as far as we understand, is yet to be finalised.

Political opposition to exploration, alternative pressures on land and negative public attitudes towards the NEEI can hinder its development in the EU28. These factors, amongst others, could threaten the development of the industry, and thus domestic supply, in the long term. In contrast, mining makes an important contribution to the economic and social fabric of Canadian society. There is, therefore, a generally positive attitude in Canada towards mining and its benefits, with the main emphasis of the mineral policies on environmental protection and Health and Safety. The USA takes a similar stance on environmental issues. However, from information collected from interviews with regard to mining in the USA, although the national policies are encouraging, each State appears to have its own mining policy. NGOs play a forceful role in the mining industry especially on environmental issues in the USA (e.g. in California and Alaska).

It is difficult to compare the policies of the comparator countries with those of the EU28, as they vary at Member State level, with some states yet to introduce a national policy. The lack of tangible evidence relating to the impact of policies on operating cost structures compounds this difficulty, and it therefore difficult to determine whether the EU28 is better or worse off in terms of competitiveness as a result of the Raw Materials Initiative and the national mineral policies already in place. The recurring themes present in the policies of EU Member States and comparator countries suggest there are unlikely to be significant variations in terms of cost implications between nations and therefore competitiveness.

Where EU28 Member States have national mineral policies in place, they are not always effectively linked to the relevant industrial policies. It has been recommended that, since the majority of countries are yet to introduce such a policy, they do this to ensure that they remain attractive for inward investment. 173 The Ad Hoc Working Group on the exchange of best practices on minerals policy and legal framework, information framework, land-use planning and permitting has identified gaps and made recommendations to improve future and current policies. 174

4.1.5 Health and Safety Laws and Labour Costs

The unique nature of mining and its associated hazards has led the development of a substantial suite of related health and safety legislation over a period of several years. Mines can be hazardous environments and the possibility of fire, flood, explosion and collapse has the potential to cause damage to individuals and the wider environment. In the following sections we have aimed to summarise the key pieces of legislation relating to the EU28 and a selection of the comparison countries. 175

173 Ibid
174 Ibid
175 Note that information for all countries has not been made available.
4.1.5.1 European Policy and Legislation

Waste Management

Directive 2006/21/EC on the Management of Waste from Extractive Industries (the Mining Waste Directive - MWD) stemmed from a Communication adopted by the European Commission entitled, "Safe Operation of Mining Activities: a follow-up to recent mining accidents". The document was a response to two high profile environmental accidents within the mining sector in the EU and the communication made a recommendation for legislation to be produced for mining waste.

The MWD provides measures, procedures and guidance to properly manage waste from the extractive industries, minimising any adverse effects to the environment and human health. It came into force on 1 May 2006 with requirement for transposition in Member States by 1 May 2008.

Within its scope, Member States are required to ensure that operators engaged in the extractive industry compose a waste management plan for the minimisation, treatment, recovery and disposal of extractive waste. This includes, inter alia:

► The characterisation of the type(s) of waste processed;
► The development of preventative measures in place to minimise environmental impact of the site;
► The development of control and monitoring procedures; and
► The development of proposed plans for site closure.

Further requirements are demanded of riskier ‘Category A’ facilities, defined as such if they meet one or more of the following criteria:

► A failure or incorrect operation at the mining waste facility has the potential (based on a risk assessment) to cause a major accident; or
► The mining waste facility contains hazardous waste above a certain threshold; or
► The facility contains dangerous substances above a certain threshold.

These operations must also prepare a major accident prevention policy and external Emergency Plan as part of the waste management plan.

At the time of writing, a formal implementation report, that would provide an insight into the extent that Member States are compliant with the MWD, has not been published, although one is currently being prepared.

178 Ibid
Within the non-energy extractive industry, the MWD impacts both extraction and processing operations: it includes materials that need to be removed to gain access to minerals (such as topsoil), as well as tailings remaining after minerals have been extracted from ore. Its requirements therefore fall on all the raw materials within the scope of this study.

The transposition of the directive into Member State legislation has introduced additional operating costs on businesses, principally through the requirement for a waste management plan. The costs are not distributed equally as some industries will bear greater costs than others depending on whether they are classed as a Category A facility. These facilities are classed as having large quantities of hazardous waste, dangerous substances or where incorrect activities could give rise to a major accident, and so for the most part do not relate to the raw materials within the scope of this study. The scale of the additional costs will also be dependent on whether operators would have undertaken the requirements of the MWD prior to its implementation.

The clearest example of the estimated impact on operating costs was made by the UK Government in their Impact Assessment (IA) associated with implementing the EU Mining Waste Directive in England and Wales. The impact assessment highlights the following average costs per operator within the NEEI associated with the transposition of the Directive:

► **Average cost of preparing a major accident policy**: estimated to be a one-off cost of £12,500;
► **The average cost of preparing an external emergency plan**: estimated to be a one-off cost of £0.5 million; and
► **Average cost of financial guarantees**: estimated to be an annual cost of £0.78 million.

The IA notes that some expenditures were difficult to quantify and were thus excluded. For example, the time taken from mining and quarrying operators to become accustomed to a new operating framework. As such the true costs associated with the MWD are likely to be higher. It is important to note that the assumptions and methodology behind the figures are not provided in the document and the original source of the figures is not publically available. As such, these estimates should be treated with caution as clearly there could be wide variations in costs between different activities.

Additionally, research has also been commissioned by the European Commission in respect of improving mine waste. The study found that the costs of managing mining waste vary considerably from mineral to mineral, and for a single mineral they vary significantly from mine to mine. For both zinc and copper mines, waste management typically accounted for

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about 1.5-2.0% of total cash costs. For industrial minerals, the study found that the cost of waste management seldom if ever exceeds 2% of the sales value of the mineral being sold.

**Chemicals**

Regulation (EC) No 1907/2006 is the Regulation on the Registration, Evaluation, Authorisation and Restriction of Chemicals, or REACH, which came into force on 1st June 2007. It was brought in to improve the legislative framework on chemicals within the EU.  

The purpose of the regulation is to ensure a high level of protection of human health and the environment from the risks that can be posed by chemicals, including metals and metal compounds. At the same time it strives to increase competitiveness and innovation within the EU chemicals industry.  

As REACH relates to the chemicals industry, both the metals and minerals sectors fall within its scope. REACH stipulates that all manufacturers of chemical substances in the EU in excess of one tonne per year are required to submit a registration dossier to the European Chemicals Agency. This should contain detailed information on the substance, including a full chemical safety assessment and proposals for classification.

The principal impact of the regulation is the administrative burden associated with the development of registration dossiers. A report by ECORYS Research and Consulting on the competitiveness of the EU Non-ferrous metals industries summarises the additional costs incurred:

- Costs incurred by the industry due to extra administration of hazardous properties;
- Costs for registration (i.e. testing, registration fees, dossier costs);
- Costs for testing and back testing of products produced;
- Investments in alternative production processes: manufacturers of non-ferrous metal products are not allowed to use certain chemical substances and manufacturers have to adapt, change and/or restructure their processes accordingly; and
- Constraints on production and supply of certain compounds like chromium salts (used in the production of catalysts) due to the REACH authorisation process.

The nature of these costs means that they are borne by processing rather than extractive industries. Those affected by the costs have formed consortia so as to cooperate efficiently and to facilitate the sharing of costs. For example, the nickel sector consortia has spent approximately €12 million in the preparation of 11 registration dossiers of chemical substances and two for intermediates (defined as a substance that is manufactured for and

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consumed in or used for chemical processing in order to be transformed into another substance). Similarly, the copper sector consortia has spent a total of €11 million.

A study conducted by the Centre for European Studies estimated the cost to the aluminium industry per tonne of metal produced. The study estimated that the administrative burden of REACH had a cost impact of €1.34 per tonne of aluminium produced.

ECORYS, in 2011, suggest that 25-30 REACH consortia have been formed within the non-ferrous metal industry to cover around 750 chemical substances. They also estimate that approximately €25,000 is spent per substance, depending on the nature of the substance and the availability of existing data. Based on this information, ECORYS estimates that the overall cost to the non-ferrous metals industry is in the range of €150-200 million. At the time of writing no estimates have been made for the ferrous metals industry or the industrial and construction minerals sectors.

4.1.5.2 Competitor Country Policy and Legislation

Waste Management

Our desk-based research did not identify any counterparts to the Mining Waste Directive in the comparator countries. Given the substantial costs associated with the Directive, this would seem to put the EU28 at a significant disadvantage in terms of competitiveness. However, that being said, there are undoubtedly many pieces of waste management legislation in each of the competitor countries that aim to prevent adverse environmental impacts. It is our understanding that there has not been an assessment of the regulatory costs of waste management within the EU or in the comparison countries, nor of the benefits of the legislation (e.g. avoided clean-up costs, improved public image).

Chemicals

China

In 2010, China introduced a new chemical substance notification regulation and system heavily modelled on EU REACH; in fact, China’s regulation is known as China REACH. This is a revised version of Order. No.7 of the Provisions on Environmental Administration of New Chemical Substances, and comes from the Ministry of Environmental Protect (MEP) of China. Although influenced to a great extent by EU REACH, China REACH has some important differences in scope and administrative structure.

Whereas EU REACH applies to all chemical manufactured in excess of a 1 tonne limit, China REACH has no such lower limit for inclusion. However, the scope of China Reach is limited to new chemical products—and new chemicals to be used as ingredients in products—additional to those 45,000 or so substances currently listed on the Inventory of Existing Chemical Substances Produced or Imported in China (IECSC). Accordingly the costs associated with compliance are likely to be significantly less than REACH within the EU.

Although inclusion under China REACH is not based on a production minimum, there are greater notification requirements on those producing over a threshold of 1 tonne of

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187 Ibid
product. In such cases, regular notification must be made to the Chemical Registration Centre (CRC) of the MEP.

USA

The Toxic Substances Control Act (1976) was intended to give the USA Environment Protection Agency (EPA) the authority to require testing and reporting on chemical products potentially hazardous to human health, and if necessary to enforce restrictions. For example, the Act provides that new chemical substances must be reported to the EPA before going to market. However, due to overly heavy burdens of proof upon the EPA in instigating enforcement, the measures in the Act effectively favour industry over the regulator, meaning that the application of the EPA’s powers under the Act have been severely limited in the near to 40 years of its history.

The EPA is now planning to introduce new, up-to-date legislation up to the task of controlling the movement of chemical products to market and protecting human and environmental health. Since 2010, Senator Frank R. Lautenberg has been attempting to reform the 1976 Act by proposing a series of bills under the title of the Safe Chemicals Act. A senate committee advanced the bill in 2012, but it has yet to become law. If made into law, the new Act would swing the burden of proof onto industry, requiring producers to prove a ‘reasonable certainty of no harm’, rather than the ‘reasonable certainty of harm’ which the EPA must currently prove under the 1976 Act.

4.1.5.3 Labour Costs

Labour costs in the EU28 are amongst the highest in the world, and this is thought to be no different for the NEEI. The poor availability of international data means it is not possible to draw comparisons between the NEEI labour costs in the EU28 and overseas. The following section looks at the individual sub-sectors within the industry in 2008, the last year Eurostat conducted a Labour Market Survey that collected comprehensive data on the industries in all EU28 countries. Figure 42 presents the average labour costs, defined as the total expenditure borne by employers in order to employ workers, for the NEEI and supporting sectors in 2008. Across the five industries, the average cost per employee in the NEEI was €42,779, although there are significant differences between the sub-sectors, ranging from €53,293 for the manufacture of chemicals and chemical products to €33,494 for mining and quarrying.

The European Commission has calculated that the mining and quarrying sector had an annual growth rate for labour costs of 7.2% for the period 2008 to 2013. Whist on its

References:


Competitiveness of the EU MRMS 123
own, this does not imply a loss of competitiveness, without a corresponding growth in value added; this would reduce the gross operating rate within the sector.

It has been argued that, to an extent, these high labour costs are offset by higher productivity and higher value added through a more skilled work force.\textsuperscript{194} High labour costs can potentially pose a greater problem when in competition with emerging markets, such as China and India, where labour costs are significantly lower. In some way this may reflect a less skilled labour force, but also less regulation and therefore fewer associated compliance costs.

Taking everything into account, it is not clear to what extent higher labour costs are offset by a better skilled workforce, and it is likely that the labour costs of less developed nations will increase as they come under greater political pressure to introduce further policy and legislation (e.g. health and safety regulations) to improve working conditions.

4.2 Recycling Industries

Since the adoption of the first Directive on Waste (Directive 75/442/EEC) in 1975, the EU has developed an extensive body of legislation including the revised Waste Framework Directive, rules on shipments of waste, Directives regarding specific waste management operations (landfilling and incineration), and a number of Directives aimed at implementing producer responsibility mechanisms.

Much of the policy and legislation developed around the world is aimed at promoting better management of waste, with the RI being a beneficiary of such legislation. Such legislation has the effect, generally, of enhancing the security of supply of certain secondary raw materials.

4.2.1 Economic Policy and Legislation

In the following section the impact of taxation, trade policies, different forms of economic incentives and fiscal policy on the competitiveness of the RI is discussed.

4.2.1.1 Taxes

Organisations operational within the RI are not exposed to the same level of taxation at the NEEI through the individual forms of mineral tax and royalty. They are liable to pay corporate income tax and the rates for the EU28 and comparator countries are presented in the Technical Appendix (Section A6.0), which show that the EU28 mean is three percentage points lower than the comparator country average. As noted in the Technical Appendix, caution should be applied when assessing competitiveness by corporation tax as companies, particularly the larger conglomerates, can employ methods to avoid higher tax jurisdictions.

In contrast, an aspect that is perhaps more pertinent is the application of tax breaks or exemptions for the RI. Within the EU28, much of the policy and legislation is focussed on
bans and targets, rather than incentives. Taxation, and in particular VAT, has been an area of focus within the EU28. In 2013 the European Commission consulted on a review of existing legislation on VAT reduced rates which included waste as specific consultation question. The response to the consultation noted that many respondents to the consultation had highlighted the benefits associated with reduced VAT but application of any differentiation of tax rates may cause problems of interpretation. It is not understood that any further developments in this field have been made.

In contrast, other competitors have in some instances utilised tax incentives to promote RI. In China revenue derived from the manufacture of products that are in line with state industrial policy and involve “synergistic use of resources” may be reduced to 90 percent of actual in calculating the taxable income of enterprise.

In 2011, China reduced or eliminated VAT on goods produced from recycled materials in order to promote the circular economy. VAT refunds range between 50 and 100 percent. Qualifying goods include sand produced from construction waste.

In USA twenty-five states around the country use some type of tax incentive or credit to promote recycling market development. The large majority of states offer tax incentives for purchasing recycling equipment—either income, sales, or property tax credits. These tax credits range from 10 to 50 percent of equipment costs. Tax incentives can take several other forms, as well. Some states offer sales, real, or property tax exemptions on construction and renovation of recycling facilities.

In Brazil manufacturers benefit from a tax credit on the acquisition of certain waste materials if they are to be recycled into new products. Eligible waste materials include plastic, paper, glass and various metals. The tax credit is calculated according to a defined percentage of the IPI (federal sales tax) rate.

Other notable tax instruments applicable to material resource conservation and waste reduction include South Africa’s Section 37B of the Income Tax Act. This provides an allowance for costs incurred in acquiring new environmental treatment, recycling or waste disposal assets.

4.2.1.2 Trade: Recycling

Table 33 lists a range of secondary raw materials, and the way they are referred to in trade policies.

198 http://www.epa.gov/wastes/conserve/tools/rmd/bizasst/tax-ince.htm
Table 33: Secondary Raw Materials as Listed in Trade Policies

<table>
<thead>
<tr>
<th>Secondary Raw Materials</th>
<th>Full Name as Listed in Trade Policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron Ore</td>
<td>Granulated slag from the manufacture iron or steel</td>
</tr>
<tr>
<td></td>
<td>Slag, dross (other than granulated slag), scalings and other waste from the manufacture of iron or steel</td>
</tr>
<tr>
<td>Aluminium (Bauxite)</td>
<td>Aluminium waste and scrap</td>
</tr>
<tr>
<td>Copper</td>
<td>Copper waste and scrap</td>
</tr>
<tr>
<td>Lead</td>
<td>Lead waste and scrap</td>
</tr>
<tr>
<td>Nickel</td>
<td>Nickel waste and scrap</td>
</tr>
<tr>
<td>Tin</td>
<td>Tin waste and scrap</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zinc waste and scrap</td>
</tr>
<tr>
<td>Silver</td>
<td>Silver ores and concentrates</td>
</tr>
<tr>
<td>Gold</td>
<td>Gold ores and concentrates</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Cobalt waste and scrap</td>
</tr>
<tr>
<td>Indium</td>
<td>Indium waste and scrap</td>
</tr>
<tr>
<td>Niobium</td>
<td>Niobium waste and scrap</td>
</tr>
<tr>
<td>Platinum Group Metals / Non-ferrous Non-critical Metals</td>
<td>Waste and scrap of precious metal or of metal clad with precious metal; other waste and scrap containing precious metal or precious-metal compounds, of a kind used principally for the recovery of precious metal: Of platinum, including metal clad with platinum but excluding sweepings containing other precious metals.</td>
</tr>
</tbody>
</table>

Imports
The EU28 has established preferential trade agreements with all of the selected comparator countries for some secondary raw materials, and there is no customs duty (0%) for imports of these specific raw materials into the EU28.

The Technical Appendix (Section A6.0) lists the customs duties for imports of the listed secondary raw materials into the EU28 from the selected comparator countries. The customs duties are expressed in ‘ad valorem’ terms.
Exports
In the case of exports, preferential trade agreements, translating into 0% import duties for exports of secondary raw materials from the EU28 to the comparator countries, only apply to some raw materials. This is in contrast to most of the imports of these raw materials from the comparator countries into the EU28. As with imports, the customs duties, expressed in ad valorem terms, unless otherwise stated are listed in the Technical Appendix (Section A6.0).

4.2.1.3 Promotion and Restriction Mechanisms
Customs Procedures and Policies
As is the case with primary raw materials, a number of pieces of legislation are relevant for the import and export of secondary materials. Waste shipment regulations (Regulation (EC) No 1013/2006 on shipments of waste) requires Member States to check and verify whether waste exported to third countries is recycled in a socially and environmentally sustainable way.

In May 2014, the Commission released Regulation 660/2014 to strengthen inspections on waste shipments through an amendment of the Waste Shipment Regulations as there is a high number of illegal waste shipments, for example from EU Member States to countries in Africa and Asia. Whilst it is not possible to provide a definitive estimate of the scale and value of the illegal activity, the Commission has highlighted that inspections and controls of waste shipments appear to vary significantly between Member States and in some countries only very few and insufficient controls are carried out. This damages the competitiveness of the EU28, as material that could be recycled in the EU28 is instead exported.

Restrictions on Exports for Secondary Raw Materials in Third Countries
Secondary materials such as aluminium, copper, nickel and zinc scrap, are becoming increasingly more valuable globally in response to higher prices, less secure access to primary raw materials and environmental policies and regulations. Restricting access to secondary raw materials puts upward pressure on costs as well as potentially threatening the development of new technologies and the retention of value chain segments within the EU.

Russia, for example, has severely restricted the export of scrap metals to ensure supply for domestic industries and to facilitate the upgrading of production along the value chain to higher value added products. Russia’s export taxes are up to 50% for aluminium and copper scrap, meaning that such exports are virtually non-existent today. Ukraine had also imposed a complete ban on exports of scrap for non-ferrous metals between 2003 and 2008, when it joined the WTO.

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Illegal Dumping of Waste

Another issue for the EU which can act to undermine the position of the RI located in the EU, is the *illegal exports of waste* and of end-of-life products outside the EU labelled as ‘for re-use’. The effect is to reduce the availability of material in recycling within the EU, even though there is a strong demand for scrap in the EU and the EU’s recovery rates for metals are probably amongst the highest in the world.\(^\text{203}\) As outlined in Section 4.2.1.3, the EU has recently strengthened inspections on waste shipments through an amendment of the Waste Shipment Regulation. The Commission has also commissioned work to consider the feasibility of introducing a certification scheme/standard for recycling treatment facilities.\(^\text{204}\)

R&D Tax Incentives

Section 4.1.1 discusses R&D tax incentives for the raw materials sector, encompassing both NEEI and RI, in that the same policies apply to both industries. Technical Appendix (Section A7.0.) summarises R&D tax incentives in selected EU Member States and summarises R&D Tax incentives currently in force in selected comparator countries.

### 4.2.2 Energy Policy and Legislation

Section 4.1.2 provides an analysis of the effects of energy policy on the RI, specifically discussing the effects of the Renewable Energy Sources (RES) Directive and energy taxation and the extent to which they have raised consumer energy costs. The core principle of the discussion translate to the RI in that EU Members States tax natural gas and electricity more heavily than other global competitors and have set mandatory renewable energy targets for 2020 which many of the competitor countries have not.

It should be noted that because the energy used in recycling is generally less than that used in primary materials production, then increases in energy prices tends to favour the use of secondary materials rather than primary materials in manufacturing. For example, recycling aluminium uses 95% less energy than producing aluminium using raw materials.\(^\text{205}\) Process scrap and residues as well as old scrap (from end-of-life products) enter the value chain at the refining and processing stages which results in significant energy and resources savings, environmental benefits and increased competitiveness.


4.2.3 Environmental Policy and Legislation

4.2.3.1 European Policy and Legislation

Emissions Trading Schemes

As discussed in Section 4.1.3.1, electricity generators face increased production costs through their ETS compliance cost. To the extent that they can (and given low demand elasticities, by and large, this is possible), they pass these costs on to their customers. Industry therefore faces an extra cost because of the cost of CO\textsubscript{2}e embedded in electricity prices.

A report by the Centre for European Policy Studies assessed the impact of these indirect costs on the secondary aluminium industry.\textsuperscript{206} It was found that the indirect costs were in a different order of magnitude compared to primary aluminium production. This is mainly due to lower electricity intensity in their production process. Primary smelters consume around 14 to 15 MWh per tonne, whereas secondary producers consume around 0.15-0.20 MWh per tonne.

The secondary aluminium sector is also impacted by the direct costs (i.e. the purchase of allowances) of the EU ETS, although this was not assessed in this study. It is important to note that producers of secondary aluminium, where combustion units with a total rated thermal input exceeding 20MW are operated, do not have to purchase allowances and are thus not affected by the direct costs of the scheme. This highlights the influence of free allowances on the cost burden implied by the ETS.

Best Available Technology

Enacted by the European Parliament, Directive 2006/12/Ec\textsuperscript{207} on waste (the Waste Framework Directive or WFD)—the overarching piece of EU legislation on waste and recycling—states at the highest level, in Article 13, that Member States shall ensure that waste management operations are carried out without endangering human health or harming the environment.

Supplementing the WFD, the WEEE Directive makes provisions for the recovery, recycling, and reuse of waste electric and electronic equipment. The purpose of the WEEE Directive is to minimise the environmental impact of electronic and electrical goods by managing them at the end of their product life in line with the waste hierarchy.

The Directive was updated in the Waste Electrical and Electronic Equipment (WEEE) Recast Directive 2012/19/EU\textsuperscript{208}, which came into force in August 2012, with a deadline for Member State transposition into national WEEE regulations by February 2014.


The WEEE Directive provides specific standards for WEEE recycling operations, including Best Available Technology (BAT) guidance. Many of the key minerals covered in this report (e.g. rare earths) occur in the component parts of electronic and electrical goods, and in large amounts in the case of materials such as steel and aluminium. The WEEE Directive therefore has an important role in ensuring the recovery of this secondary resource (it does not have an effect on the competitiveness of the industrial or construction minerals sectors). It does this by stipulating that systems for the treatment of WEEE must make use of best available treatment, recovery and recycling techniques (BATRRT). The Directive points to the procedures contained in the Industrial Emissions Directive (IED) (2010/75/EU) as providing a definition of BATRRT.

The IED Directive defines the constituent parts of the ‘best available techniques’ formation as such:

► ‘Techniques’: the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.
► ‘Available techniques’: techniques that have been developed on a scale such as that they are economically and technically viable in the relevant industrial sector, regardless of whether they are currently produced or used in the Member State in question.
► ‘Best’: The most effective in achieving an overall high level of environmental protection.

The IED also stands to impose costs on the recycling industry through best available technique requirements. Following a recent review of industrial activities, ‘metal shredding’ was brought into integrated control under the Directive, although it does not apply until 7 July 2015. 209 Metal shredders are used for extracting both ferrous and non-ferrous metals. As an example of the extent to which they are used in recycling operations, data collected from 24 of the UK’s 45 shredders shows that these installations process up to 30% of the 13 million tonnes of ferrous and non-ferrous metals handled each year in the UK. 210 Amec, in an Impact Assessment of the IED in the UK, estimated the sum of administrative and compliance costs to UK shredder operators to be between £1.1 million and £3.3 million per annum for all operations in the UK – equivalent to approximately £0.30 to £0.85/tonne, a relatively small cost. 211

**Recycling Targets**

The Waste Framework Directive (WFD) enshrines the waste hierarchy into EU law Recycling sits in the middle of the order of preference, and policy and targets on recycling will sit in the context of associated policies and targets around other options. For example, Directive

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1999/31/EC\(^{212}\) on the landfill of waste (the Landfill Directive) sets targets for the diversion of biodegradable municipal waste from landfill.

Two legally binding waste management targets for Member States are given in the WFD:

- 50% recycling and reuse of municipal and municipal type waste by 2020; and
- 70% recovery, recycling and reuse of construction and demolition waste by 2020.

In June 2014, the European Commission proposed a new package of targets based on the results of a Eunomia led review of the existing waste targets. The proposal, which will be voted on by the European Parliament and Council of Ministers\(^{213}\), includes a 70% municipal recycling target by 2030, and an 80% packaging recycling target—which would include glass, steel and aluminium packaging—by 2030. Based on the results of the Bio Intelligence Service report, this would stand to increase cost savings and thus competitiveness of the sector even further.

It should be noted that there is a small threat that higher targets could create a perverse incentive to decrease the quality of recyclate in order to meet them. This can be mitigated by strong enforcement of waste legislation.

**End of Waste Criteria**

The concept of End of Waste (EoW) criteria is enshrined in Directive 2006/12/EC\(^{214}\) on waste (the Waste Framework Directive or WFD) which was enacted by the European Parliament in November 2008. EoW criteria define when a waste material, following treatment, ceases to be waste and can be treated as a product on the European open market. The aim of EoW is to promote high quality recycling while reducing the administrative burdens associated with the reprocessing and sale of secondary materials. As such, EoW policy is intended to deliver both environmental and economic benefits.

Article 6 of the WFD provides four conditions in accordance with which material specific EoW criteria should be developed:

- the substance or object is commonly used for specific purposes;
- a market or demand exists for such a substance or object;
- the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
- the use of the substance or object will not lead to overall adverse environmental or human health impacts

The first two of these conditions ensure the economic viability of classifying the material as a product, guaranteeing that market conditions preclude the material simply being discarded—i.e. the material being treated as waste.

The third condition ensures that the material meets the legal requirements covering the product type which the waste is to be reclassified as—i.e. that the material is as fit for

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\(^{213}\) Possibly on the basis of a revised proposal as announced by the European Commission in December 2014.

purpose as virgin material. The fourth condition ensures that the material would not be better regulated under waste legislation.

Thus far the European Commission has legally enacted two EU EoW regulations that are relevant to this study. Notably these are focused on metals rather than construction or industrial minerals, although the commission may develop EoW criteria for these raw materials in the future.

- Regulation (333/2011)\textsuperscript{215}, which was adopted in March 2011 and provides criteria for iron, steel, and aluminium scrap; and
- Regulation (715/2013)\textsuperscript{216} which was adopted in July 2013 and provides criteria for copper scrap.

As EU legislation enacted by the European Parliament, EoW criteria have application across the EU 28, and replace any national EoW criteria of the same or similar scope which individual Member States may have had in place.

A certain lack of ex-ante or ex-post research on quantified impacts of the implementation of EoW criteria means that it is in several cases not possible to quantify the impacts on competitiveness that occur as a result of their transposition. Nonetheless, it is possible to comment on and infer possible impacts, which are borne principally by the recycling industry. For example, one effect of EoW criteria is that classified material can move more freely across Member State borders as it is no longer subject to the waste transportation and shipping laws contained in Regulation (EC) No 1013/2006.\textsuperscript{217} Therefore, there should be a reduction in the administrative costs incurred by importers / exporters in acquiring necessary shipping documentation. Conversely, extra costs may be incurred where scrap metal recycling have to upgrade or purchase new equipment to adhere to higher recyclate standards stemming from EoW criteria. Survey research conducted on behalf of the EU found almost no evidence that end-of-waste has caused any negative impacts on the market, whether that be to scrap quality, availability/trade or on the environment. On the contrary, quite a number of the survey participants, both from industry and Competent Authorities highlighted the perceived benefits of the introduction of end-of-waste for metal scrap. These perceived benefits include: creating a simplified regulatory framework and offering companies greater flexibility and legal certainty. Some companies identified improved scrap quality and increased sales prices.\textsuperscript{218}


EoW criteria may also remove some of the administrative barriers which have made trade of scrap metal from the EU to non OECD countries difficult. This should increase the competitiveness of EU suppliers and, although it may result in a drop in the amount of scrap material available within the EU, it is hard to gauge the exact impact EoW would have on the complex global flow of scrap metal.\(^{219}\) Furthermore, some countries (for example, China) implement their own screening parameters to accept or reject shipments of waste, and material bearing EU EoW status would be treated no differently in such cases.

In the case of aggregates recovered from construction and demolition waste, there would be both savings to be made and possible costs to be incurred through the application of EoW criteria. There are significant administrative burdens associated with the trade of aggregates bearing waste status, with one estimate putting these up to 1% of the turnover of the recycling sector.\(^{220}\) EoW application would therefore result in significant cost savings. However, as is the case for metals, some expense would be incurred where existing recovery procedures are insufficient for generating aggregates which meet EoW standards. For example, processes of selective demolition are optimal for achieving source separation of materials, but are between 17–25% more costly than non-selective demolition measures. In addition, costs will be accrued in most cases through the need to carry out leaching tests on aggregate materials.

### 4.2.3.2 Comparator Countries Policy and Legislation

#### Best Available Technology

Europe is a world leader in establishing best available technology legislation for recycling. As such, it is not possible to draw comparisons between the EU and other nations in this regard, as no comparable policies to be found on the world stage.

#### Recycling Targets

**China**

In June 2012 China released The 12\(^{th}\) Five-Year Plan for Waste Recycling Technology\(^{221}\), which contains waste treatment targets for municipal solid waste and industrial waste for the period 2011–2015\(^{222}\). China’s targets are noticeably different from those found in EU legislation in important respects.

Firstly, the emphasis on the recycling of municipal solid waste (MSW) which is so prominent in EU policy is altogether absent, with no specific recycling target given for this waste source. Rather, targets for MSW treatment capacity are given, with aims to move from 77% landfill in 2010 to 59% in 2015, and from 20% incineration to 35% over the same time period. The remaining 6% capacity in 2015 (up from 3% in 2010) is listed as ‘other’, and any MSW recycling capacity must be assumed to fall into this category.

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\(^{220}\) Ibid.  
\(^{222}\) J.P.Morgan (2012) *China Waste Treatment Centre, Two sweet spots in environmental protection*, Asia Pacific Equity Research, November 2012, available at: [https://mm.jpmorgan.com/EmailPubServlet?h=c3256o68&doc=GPS-983209-0.pdf](https://mm.jpmorgan.com/EmailPubServlet?h=c3256o68&doc=GPS-983209-0.pdf)
Recycling rate targets are given, however, for industrial waste, for which a 10% increase from 40% in 2010 to 50% in 2015 is envisaged, equating to a rise from 1.1 billion to 1.6 billion tonnes of material recycled. Economic output from industrial waste recycling is also targeted to rise from 300 billion RMB in 2010 to 500 billion RMB in 2015.

**Japan**

Japan has effectively adopted the concept of the waste hierarchy into its national waste policy as part of the Fundamental Law for the Establishment of a Sound Material-Cycle Society (SMC)\(^{223}\), which came into force in 2000. However, the Fundamental Law also contains prescriptions based on concepts of resource efficiency and environmental economic sustainability, with the waste hierarchy feeding into a wider picture of circular economy-type thinking.

The holistic approach of Japan’s environmental economic policy is well illustrated by the package of targets contained in the First Fundamental Plan for the Establishment of an SMC, which sets out actions required for the fulfilment of the Fundamental Law. Quantitative targets are set for three key aspects of material flows in Japanese society.\(^{224}\) The current targets, to be met by 2015, are:

- Resource productivity\(^{225}\) of 420,000 yen/ton
- A cyclic use rate of 14–15%
- A final disposal amount of no more than 23,000,000 tons.

The cyclic use rate is the quantity of resources consumed by society which are reused or recycled resources. Although Japan does set more conventional recycling rate targets, the cyclic use rate target represents a novel policy concept by which progress towards a more resource efficient society can be measured.

**Brazil**

The first ever national waste management legislation: Política Nacional de Residuos Solidos n.12305 (PNRS) came into force at the end of 2010, following 20 years of discussion.\(^{226}\) PNRS sets a target collection of 17 per cent in weight of all WEEE products released on the market in 2012.

**End of Waste Criteria**

**USA**

The USA differs from the EU in that there is no default categorisation of scrap metal as waste; i.e. scrap metal is considered in the first instance as a product, not as waste.\(^{227}\)

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\(^{225}\) Resource productivity is the amount of GDP divided by the amount of natural resources and the like input.


Therefore, clearly there is no need for a comparable EoW type policy framework in relation to this material.

Quality standards for scrap are provided, however, by the Institute of Scrap Recycling Industries (ISRI), a USA trade association which publishes yearly specification updates for a range of materials and material grades, including ferrous and non-ferrous metal scrap, electronic scrap and glass cullet.228

India

India does not have a comparable system in place for classifying waste and non-waste materials. What it does have is strict orders on the production of steel. The Indian Ministry of Steel’s Joint Plant Committee (JPC), throughout 2012–2013, issued a first and second order and subsequent amendments constituting the Steel and Steel Products Quality Order. The effect of the order is to limit the legal manufacture of nine categories of steel products to those which have obtained an official certificate from the Bureau of Indian Standards (BIS). The order has application to production involving virgin and secondary material and to imports of steel scrap.

Under the order, foreign importers are required to pay 1% of the cost of inspection of their shipment by the BIS. This added cost could be viewed negatively by importers, who make instead take their scrap elsewhere, putting India at a competitive disadvantage.

4.2.4 Health and Safety and Labour Laws

4.2.4.1 European Policy and Legislation

Chemicals

REACH Regulations also apply to the recycling industry, but with very limited obligations. With regards to recycled aggregates, the latest European Chemical Agency (ECHA) guidance clarifies that recycled aggregates, produced according to a set of criteria equivalent to the requirements of the Quality Protocol for the production of aggregates from inert waste do not in general require registration.229

Section 4.1.5 discusses the impact of REACH and similar schemes on the NEEI in both the EU28 and abroad.

Labour Costs

According to Eurostat, the labour costs for full time employees that work in ‘waste collection, treatment and disposal activities and materials recovery’ were €32,914 per year, less than the labour costs for the extractive and processing industries (see Figure 42).230

The poor availability of international data means it is not possible to draw comparisons between the RI labour costs in the EU28 and abroad or across time (Section 4.1.5 gives a more detailed discussion on labour costs and the availability of data), nor is it possible to compare labour intensity.

4.3 Summary of Findings

Many of the policies and legislation used to regulate the sectors have been developed over many years, often in response to specific incidents, such as mining accidents, but also to minimise the specific environmental and health effects of activities. This iterative process of policy making has created, in many localities, a policy environment which has diverse and far reaching impacts on the activities of the NEEI and the RI.

4.3.1 Non-Energy Extractive Industries

Although the extent and type of the impacts due to taxation, trade policies and tax incentives varies according to material and country, the overarching message is that the structure of import and export customs duties in the EU28 and comparator countries places Europe at a slight economic disadvantage. Compounding this, the comparator countries examined provide a wide-ranging set of incentives (chiefly through tax allowances and reliefs) that act to further reduce the cost structure of their domestic operations, though it is noted that some of these impacts can be mitigated via trade defence instruments.

The limited analysis available on mining specific taxes relevant to the extractive industries suggests that the EU is not at a significant disadvantage in relation to the comparator countries. Additionally, no significant impacts associated with the corporation taxes have been identified.

In respect of energy policy, the EU28 typically has higher retail energy prices than comparator countries. However, the impact of this may not be as significant as might be expected because there are a number of exemptions given to the NEEI in the EU28. A more detailed investigation would be required to understand the effects of these exemptions in individual countries. The EU28 does, however, have higher wholesale costs of electricity and gas when compared to the majority of the comparison countries. This indicates that energy costs in the EU28 are likely to be higher than most countries, even taking into account the effect of exemptions. To some extent, part of the cost differential is compensated by the higher efficiency of European plants.

In principle, higher prices for imported energy or fuel might be expected to induce some further innovation in respect of energy efficiency, either in respect of energy use, or the efficiency of self-generation from higher priced fuels. Indeed, to the extent that competitiveness relates to productivity, then one would expect some improvement in productivity with respect to energy and fuel use as energy and fuel prices increase. The question is whether the response of industry in this respect is sufficiently elastic to offset any increase in prices through the uptake of cost-effective measures to increase energy efficiency. It might reasonably be argued that this becomes more likely where efforts in respect of R&D and innovation are focused on addressing – through efficiency measures – any cost increase implied by taxes, and other policies aimed at reducing the carbon intensity of energy generation and use. However, given that mining and quarrying activities are energy intensive, higher energy costs will inevitably impact on competitiveness.

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The research demonstrates the position of the EU as a key player in the development of policy designed to minimise the negative environmental and health and safety impacts associated with mining and quarrying activities, alongside Canada and Australia. Some developing nations, such as China, are, however, following the EU in establishing a body of policy designed to integrate consideration of environmental protection within industry practice and therefore this competitive edge is unlikely to be long lasting.

Waste management, in the form of the MWD, reportedly imposes substantial overhead costs in the form health and safety reporting obligations on extractors; however the benefits of such policies are often not quantified. The research revealed that such regulations are not present in the comparator countries and therefore they are unlikely to experience the costs and the benefits of such measures.

As to assessing the impacts of these policies on competitiveness, our research has pointed to some increased costs on operators in relation to implementing the policies within the EU28. However, the key impact raised by industry during discussions, was not the overall cost, rather the lack of coherence between some regulations. Additionally, inconsistency associated with the application of some policies within the EU28 was also referred to. The net impact of these is difficult to assess. Based on a small number of discussions with members within industry, there might be a small amount of frustration associated with the complexity of the regulatory environment; however, the evidence presented in Section 3.1.9 suggests that investment has flowed to the EU28. It should also be noted that where complexity is perceived to be a barrier, it may be possible to rationalise and simplify existing legislation using the ‘Smart Regulation’ tools.232

Additionally, many interviewees also highlighted the political stability within the EU28 – noting that fundamental changes to the policy and legislation environment were unlikely to occur. However, it was also noted that other areas of the world also continue to demonstrate such stability.

An illustrative summary of the assessment of policy and legislation competitiveness of the NEEI is shown in Figure 43. The figure is based on a qualitative interpretation of the data identified and derived, at least in part, from the consensus of views and evidence obtained in this study.

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4.3.2 Recycling Industries

For some activities, especially those in the RI, policy and legislation are fundamental to creating the market conditions for activities to take place. Additionally, the presence of a fair and reasonable legal system and state adherence to the rule of law both have economic implications in that they offer investors some surety of an entity’s investment against national expropriation by a host state.\(^{233}\)

The trade in secondary raw materials is affected by customs duties in an almost identical manner to primary raw materials. As far as customs duties for imports into the EU28 are concerned, most of these tariffs are 0%, meaning that the European Union is enabling the free flow of secondary raw materials into the EU28 without requiring any additional costs to be paid by the exporting nation.

As with the exports of primary raw materials, the exports of secondary raw materials from the EU28 to the selected comparator countries have customs duties associated with their trading. Contrary to the situation in respect of the primary materials, however, duties applied by competing countries might be seen as helping to ensure that more of the secondary materials remain in the EU than might otherwise be the case. In essence, the duties in third countries could be said to help to protect the users of secondary materials in the EU, and increases the costs of acquiring such materials to industries in the countries where the duties are in place. On the other hand, it also makes it more likely that the RI in

the countries applying duties will make use of the material collected in their own country in preference to other materials. In that respect, those selling collected materials for reprocessing may find export markets more difficult to penetrate.

As a less energy intensive sector, the RI is less exposed to the cost burdens that are associated with high energy usage, and the associated environmental impacts. Fewer subsectors fall under the remit of the EU ETS, and often, where they do, only companies over a certain size are affected. However, like the NEEI, where complexity is perceived to be a barrier, it may be possible to rationalise and simplify existing legislation using the ‘Smart Regulation’ tools.²³⁴

Figure 44 provides an illustrative summary of the assessment of policy and legislation with respect to RI. The figure is based on a qualitative interpretation of the data identified and derived, at least in part, from the consensus of views and evidence obtained in this study.

**Figure 44: Policy and Legislation Competitiveness - RI**

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**Notes:**

1) The figure is based on a subjective assessment of the competitiveness based on the author’s views.

2) Lines nearer to the centre of the shape denote lower levels of competitiveness. Lines towards the outside of the shape denote higher levels of competitiveness.

3) RoW (Rest of the World) is based on the analysis of the representative countries presented in this research.

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5.0 Raw Material Supply Assessment

The supply of and access to raw materials are important considerations for understanding the competitiveness of the EU28.

5.1 Non-Energy Extractive Industries

Europe is highly dependent on imports of many raw materials which are increasingly affected by growing global demand and by an increasing number of national policy measures that can disrupt the normal operation of global markets. Moreover, the production of many metallic raw materials is concentrated in a small number of countries, e.g. more than 90% of rare earths and antimony, and more than 75% of germanium and tungsten are produced in China; 90% of niobium comes from Brazil; and 77% of platinum comes from South-Africa.

In addition, some metals used in the latest technologies are often by-products of mining and processing of major metals, such as copper, zinc and aluminium, which means that their availability is largely determined by the availability of the main primary commodity.

In the following sections we have sought to discuss the competitiveness of the NEEI in respect of the following factors which impact on material supply:

1) Knowledge of Mineral Endowment;
2) Access to Land;
3) Environmental Impact of Mining and Quarrying;
4) Logistics; and
5) Security of Supply

5.1.1 Knowledge of Mineral Endowment

A fundamental aspect of competitiveness of the EU28 NEEI is the extent to which there is awareness and knowledge of the natural resources present in the Earth’s crust underlying each member state. Put simply, without such knowledge, the EU28 will be at a disadvantage to those countries and regions that may be more aware of their endowment, regardless of the characteristics and scale of such endowment.

The geology of the Earth is extremely heterogeneous and thus mineral deposits are unequally distributed across borders. The mineral wealth of a country and its geological availability is predetermined by nature, although the actual use of this wealth depends on the attractiveness for economic activity within a political and social framework. Given that only a small part of the Earth’s surface and subsurface have been explored in detail, the potential for discovering new mineral deposits remains considerable and the geological availability is not a fundamental constraint on supply. Consequently geological availability is effectively a ‘non-issue’, as discussed in the first pan-EU criticality study. 235 The main geological challenges relate to where, and how, to efficiently and effectively explore for, and develop, new deposits, rather than to geological scarcity per se.

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In general, the geology of the EU is complex and varied. As a result it has the potential for the occurrence of a wide range of mineral deposit types, including those that host metals and minerals for which demand is rapidly increasing, such as critical raw materials. Even though the NEEI has made tremendous technical progress, particularly over the last 50 years, with new exploration technologies and geological models for mineral deposits, it is still impossible to predict with any certainty the outcome of a planned exploration campaign. There remains a considerable element of unpredictability so that the investment risk is very high. Hence, the link between expenditure in exploration and discoveries is not as robust as envisaged.

Nevertheless, over the past 50 years, the extractive industries sector has succeeded in meeting global demand, and the calculated life time of reserves and resources has continually been extended. However, given the commercially sensitive nature of information regarding reserves, both at the company and country level, there is little reliable information in the public domain on the quantity and distribution of reserves, either within the EU28, or for any of the major competitors. Accordingly this section focuses on exploration, where more data is available.

5.1.1.1 Investment in Exploration Activities

Over the last decade, global exploration expenditure rose 10-fold, reaching an all-time high of approximately €21 billion in 2012 from a level of €2 billion in 2002. The level of exploration spend has been driven by commodity prices, world economic growth and the availability of funds for junior companies. Gold accounted for around 33 per cent of all exploration expenditure in 2013, followed by base metals with 24 per cent of the global total. Data is not available for the critical metals but this is likely to comprise no more than a few per cent of the total, with most of that directed towards the rare earth elements, platinum group metals and lithium.

The geographic distribution of investment in exploration in 2013 is shown in Figure 45. The highest level of expenditure was in China, with 17 per cent of the global investment. By comparison, in 1997, China’s share was 2 per cent. Additionally there was also a notable rise in China’s overall share in 2009.

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Figure 45: Percentage of Total Spend on Exploration (1975-2013)

Source: MinEx Consulting (2014)\textsuperscript{238}

Figures are only available for Western Europe, and Eastern Europe including the Former Soviet Union (FSU).\textsuperscript{239} The combined contribution of these two regions was estimated to be 9 per cent of global expenditure in 2013.

Most Member States of the EU28 have government-funded institutions, chiefly geological survey organisations, which undertake national geological, geophysical and geochemical surveys to provide baseline geoscience data on the geology and possible location of mineral resources.\textsuperscript{240} Most mineral exploration in the EU28 is undertaken by the private sector.

Mining companies normally invest only to prove the existence of adequate reserves for their short-term operational needs, but will also take a longer term perspective when considering major investments in new mines or expanded capacity. Consequently, although reserve data may provide some reassurance about short-term supplies, reserves are, in fact, dynamic economic measures that should not be regarded as reliable indicators of future mineral availability, especially in the medium and long term.

Over the past few decades there has been a shift in exploration away from the mining companies themselves over to the so-called junior companies (as identified in Section 2.1.6).\textsuperscript{241} Figure 46 identifies the types of companies responsible for ‘moderate’, ‘major’ and ‘giant’ discoveries in the western world. The figure shows that junior companies are responsible for between 50 and 60 per cent of all these discoveries.

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{238} Ibid
\item \textsuperscript{239} Information relating to the countries included in the terms ‘Western Europe’ and ‘Eastern Europe’ has not been made available.
\end{itemize}
\end{footnotesize}
Junior companies tend to operate more speculatively than other companies and are very vulnerable to movements in commodity prices. For example, during the 2008/09 financial crisis, exploration expenditure dropped dramatically due to the almost complete stop in funding for these companies. However, the governments in both Canada and Australia support junior exploration companies through generous tax deduction schemes, known as the flow-through share system in Canada and the Mineral Exploration tax Credit in Australia.

Such tax deduction systems reduce the risk of investments in such companies and therefore provide a key incentive for encouraging private sector exploration and thus identifying new resources and for maintaining an adequate pipeline of new mining projects. Equivalent measures are not believed to be in place in the EU28, although it is understood that broadly similar schemes to promote commercial mineral exploration previously existed in Finland, UK and Germany. It would appear, therefore, that the EU28 is at a significant relative

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242 Information relating to the countries included in the terms ‘Western Europe’ and ‘Eastern Europe’ has not been made available.


disadvantage when compared with Australia and Canada in this regard. Given this disparity, there appears an opportunity for the EU28 NEEI to promote the utilisation of modern geoscience techniques so that minerals can be discovered within the EU28.

5.1.1.2 Types of Exploration Activities

It is also important to note that in recent years, new additions to resource and reserve inventories have come from exploration around previously recognised targets and disused mines, while new prospective terranes and deposits have also been identified as a result of the availability of new baseline data and the application of new scientific findings and exploration technologies.

Figure 47 and Figure 48 demonstrate how the depth of cover for base metal deposits has increasingly become deeper over time. Although data for the EU28 is not available, the average depth for the discovery of base metal deposits in Western Europe is 315m, more than double the global average (132m). Thus the challenge within Europe is to develop exploration technologies which can be successfully deployed to find deeper buried deposits as most of the shallow discoveries have already been made. For industrial minerals the average depth of cover for deposits is understood to be far shallower and for aggregates, the vast majority of deposits are understood to be closer to the surface.

Figure 47: Base Metal deposits found in the World (1900-2013)

![Depth of Cover (Metres)](image)

Source: 
MinEx Consulting (2014)

Some metals face additional supply challenges as they are mainly derived as ‘by-products’ from ores of major industrial or ‘carrier’ metals, in which they are present in low concentrations. For example, gallium is derived from bauxite (aluminium ores), indium from zinc ores, and tellurium from copper and lead ores. The economic driver for extracting these materials is driven by the economics of mining the major metal, although by-product metals can generate additional revenue if they can be extracted economically. When that is not the case they are regarded as impurities that drive up production costs.

Figure 49 demonstrates the relationships between various groups of inter-connected metals. In addition to the major industrial metals and their by-products, some metals are produced as ‘coupled products’ or co-products because they occur together in nature and there is no option other than for them to be produced together and separated subsequently. The rare earth elements and platinum-group metals are the most important examples of co-product metal groupings.

Source: MinEx Consulting (2014)248

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248 Ibid
A wide range of supply challenges also faces some industrial minerals, especially those produced for specialised applications. Important examples include barite and limestone of high grade and whiteness that are used in specialised fillers for the paint and paper industry, and fluorspar used for the production of hydrofluoric acid which has to meet certain grade and purity criteria. These value chains depend on reliable sources of material of consistently high quality. For many of these applications, the supply base for such products is highly concentrated, although, given the commercially sensitive nature of the data, we have been unable to obtain actual figures during interviews with chemical mineral suppliers carried out in this study.

### 5.1.1.3 Skills and Expertise in the Minerals Industry

Another factor which can also impact on exploration, mining and mineral processing activities is the availability of trained and experienced geologists and other professional staff to undertake work in these fields. Through workshops held with industry representatives, it is believed that the EU28 is affected by a lack of skilled workers in this respect. The shortage is currently most acute at the middle management level and, as senior managers are retiring, there are few appropriate replacements available to fill these important roles. Consequently the number of people entering the minerals profession in Europe has reduced. Another major problem facing the European minerals industry is that a large proportion of the graduates from European universities do not stay on to work in

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250 Workshop held with trade association representatives from the EU28 NEEI on the 17th September 2014
Europe. Many find employment in EU competitor countries where there is a larger number and greater range of opportunities, and where salaries are commonly higher.

In contrast, research conducted on behalf of the European Union has found that the supply demand situation for the MRMS is in balance in Europe as a whole. However, the research also noted that most geoscience educations are not focused towards mineral exploration and extractive industries.

Considering the private sector view of this issue, the Survey of Mining Companies, conducted by the Fraser Institute, tracks the views of professionals within the mining industry. The results of the survey for 2013 indicated that the availability of labour and skills in Europe varies considerably by country. Six of the ten EU Member States represented in the survey were ranked in the top 20 of the 112 jurisdictions surveyed and only one EU Member State (Romania) was ranked below the median level for this factor in the survey. Most of the major competitor countries considered in this study were also ranked in the top half of the survey results for this factor, although Brazil, South Africa and Indonesia did not score well, and were ranked below the median value.

5.1.1.4 Locations of Discoveries

Major new discoveries have been made on each continent over the last 10 years. However, as shown in Figure 50, the number of discoveries in Europe is fewer than in other regions of the world. The lack of significant discoveries in Europe places the EU28 at a competitive disadvantage because our indigenous resources are not being converted into reserves and extracted for the economic benefit of the EU. Furthermore, as domestic supplies from the EU diminish so our reliance on imports increases.

Figure 50: Significant Discoveries of selected Metals in the World (2004-2013)

Notes:

“Moderate” >100k oz Au, >10kt Ni, >100Kt Cu equiv, 250kt Zn+Pb, >5kt U3O8

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“Major” >1Moz Au, >100kt Ni, >1Mt Cu equiv, 2.5Mt Zn+Pb, >25kt U₃O₈

“Giant” >6Moz Au, >1Mt Ni, >5Mt Cu equiv, 12Mt Zn+Pb, >125kt U₃O₈

Source: MinEx Consulting (2014)²⁵³

5.1.2 Access to Land

Another important factor that affects the supply of many mineral raw materials worldwide, including the EU, relates to the ability to gain access to land that is underlain by potentially economic mineral resources.

Access to land is a key requirement for the extractive industries, but the areas available for extraction in the EU28 are sometimes in direct conflict with other land uses such as urban development, agriculture and nature conservation. This is an important factor which can act to constrain some activity.

Metallic mineralisation is often located in older, harder rocks in upland areas that may be designated for their landscape and ecological importance. The continuing need to develop new mines and quarries in order to replace exhausted deposits means that increasing conflict with other land uses could become a serious threat to supply, particularly where the resources are located in areas of high population density.

As prices for minerals increase over time, more marginal sites (i.e. those with low concentrations of ores, or re-work mining wastes) can become viable sites for mining and quarrying activity. Additionally, alongside higher prices, the costs of extraction may also decrease as improvements in technology are made. This can place pressure on existing uses of land, especially those near sensitive receptors, where mining and quarrying activity was previously ruled uneconomic. Thus for the EU28 and the rest of the world, the availability of land available to mining, is not just based on the geology, but prices of ores, concentrates and technologies.

It is difficult to provide a comprehensive assessment whether the EU28 is at a competitive advantage or disadvantage with regard to conflict with other land uses, as this type of assessment would ideally require all deposits of minerals (which are not known) to be mapped against land use types. Therefore only an indication can be provided of the likelihood that conflict might occur. Table 34 summarises the population density and the percentage of the total population which reside in urban areas. In both indicators the EU28 can be considered middle ranking, thus it is difficult to state whether the EU28 is at a competitive advantage or disadvantage in this regard.


<table>
<thead>
<tr>
<th>Country</th>
<th>Population Density (people per sq. km of land area)</th>
<th>Urban Population (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Union</td>
<td>120</td>
<td>74</td>
</tr>
<tr>
<td>Australia</td>
<td>3</td>
<td>89</td>
</tr>
<tr>
<td>Brazil</td>
<td>24</td>
<td>85</td>
</tr>
<tr>
<td>Canada</td>
<td>4</td>
<td>81</td>
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<tr>
<td>Chile</td>
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<td>89</td>
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<tr>
<td>China</td>
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</tr>
<tr>
<td>India</td>
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<tr>
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<td>64</td>
</tr>
<tr>
<td>United States</td>
<td>35</td>
<td>81</td>
</tr>
</tbody>
</table>

Source: World Bank (2014)\(^\text{254}\)

5.1.2.1 Mineral Policies

A key aspect to managing the land use is a defined minerals policy (as described in Section 4.1.4). As minerals policies are not necessarily reflected in the land use planning procedure, it is a matter of local competence in how competing land use issues are ranked, and whether land that could be used for extraction is designated as appropriate for such use. This may lead to decisions at the local level which are inconsistent with national priorities and with the general need to exploit deposits to ensure continuity of supply.

Minerals policy in many Member States has been a low priority issue and few Member States have specific, clearly defined and published mineral policies. A number of Member States still have minerals legislation which dates back to a time when minerals were considered as important for economic development, and therefore, have a prominent legal

status as reflected by the category of “free minerals\textsuperscript{255}”, i.e. Austria, Germany, Finland, and Sweden.\textsuperscript{256}

One of the key issues is that in most Member States construction minerals are not considered to be of national or high importance. This is despite the fact that the European society is strongly dependent on a sustainable supply of construction minerals, which, as far as the interior of Europe is concerned, should, for environmental and economic reasons, involve short transport distances.\textsuperscript{257}

5.1.3 Environmental Impact of Mining and Quarrying

Mining and quarrying operations inevitably give rise to a range of potential environmental impacts. During mineral exploration and the development of a deposit, the environmental impacts tend to be local in character, and relatively easy to prevent or mitigate. Mining and mineral processing may, however, potentially result in more widespread environmental damage. Such impacts vary considerably according to the type of mining involved and local conditions including:

- The geological and hydrogeological setting;
- The climate and topography;
- The particular mining method deployed;
- The amount and type of processing; and
- The waste management strategy.

The geological setting is perhaps the most important, as it determines the geochemical characteristics of the site, and the type of mining methods to be used. Underground mining, for example, although it can bring with it problems of subsidence, generally has a relatively small footprint at the surface. Strip mining of deposits at or near the ground surface for bedded minerals, like bauxite, nickel laterites and titanium beach sands, is considered to have limited long-term environmental impacts. This form of mining permits almost complete rehabilitation of the ground and its natural vegetation after the mineral has been removed.

Other forms of mining may pose bigger problems. Open-pit mining creates large holes and waste dumps which are unsightly and the exposure of sulphide rocks to surficial weathering can result in acid-mine drainage (AMD, also known as acid rock drainage, ARD) into ground water. AMD is one of the major potential long-term effects of sulphide-bearing mine waste, and can remain present for hundreds or thousands of years. It occurs when the disturbance of rock liberates sulphide and results in the oxidation of sulphide minerals. Precipitation results in acidic runoff which has considerable pollution potential that might affect water

\textsuperscript{255} These are state owned minerals.


quality, animal habitats and plants. The acidic runoff is normally collected and treated before discharge or re-cycling.

There is also a range of additional environmental impacts that may result from mining activity, but which are generally most serious for open pit operations. These include noise, dust and vibration from the drilling, blasting and removal of the ores. Given that metallic ores generally form only a very small proportion of the total volume of material extracted, a relatively large amount of waste (overburden and interburden) is produced during the course of mining. How this material is handled, and the environmental and amenity impact of the waste tips produced, are serious issues that need to be considered at the mine planning stage. Such issues may impact significantly on the economic competitiveness of mining in the EU. For example, where open pit mining is carried out in areas close to human settlement, the nature, scale and timing of the operations may have to be curtailed to minimise local disturbance. In contrast, in many developing countries, such restrictions are less severe, and it is commonplace for mining to be conducted continuously, 24 hours per day, 7 days per week.

Underground mining of metals, as is most common in the EU28, typically has a smaller surface footprint than open-pit operations and some of the environmental impacts are also significantly reduced. For example, noise and dust from underground mining are less than from open pits. The ratio of waste to mineral is much lower in underground mining and, as a result, the problems associated with the storage and/or disposal of the waste are reduced.

The processing of metallic ores generally involves more intensive and complex procedures than required for construction and industrial minerals. It typically involves crushing and milling of the metalliferous ores to a fine particle size. This is followed by a range of procedures aimed at removing the waste rock particles (often referred to as gangue). The techniques used generally exploit the differences in certain physical and chemical properties of the ore and gangue minerals. Magnetic, electromagnetic and density separation methods are widely used, as are sequential leaching and flotation techniques. The widely-employed practice of cyanide leaching gold-bearing ores carries a serious risk of toxicity if its use is not effectively regulated and managed. The metallurgical processing of the concentrates derived from mineral beneficiation, commonly comprising smelting and refining, has the potential to produce air pollution, while the waste products of these operations, such as slags and dross, require careful and effective disposal/storage to minimise their pollution potential.

Other environmental impacts of the mineral beneficiation, concentration, smelting and refining processes include the disposal of effluent and particulate matter which can potentially find its way into rivers and the sea. Infrastructure associated with mining and mineral processing activities may not only be visually intrusive, but may also be hazardous to migrating animals.

The fine-grained waste material which remains after beneficiation is referred to as ‘mine tailings’ or ‘slimes’. Although tailings are of lower volume than waste rock from mining, they are a significant challenge for the industry as they usually need to be stored for long periods in lagoons or tailings dams to allow them to dewater. Unlike most wastes from open pit mining which are used in the progressive restoration of worked-out areas, tailings are generally difficult materials to use in restoration. Tailings dams are commonly relatively
large, visually conspicuous structures that remain in use for many years and they may, therefore, be much less acceptable in densely populated areas than in remote locations.

5.1.3.1 Regulatory Framework

In order to prevent and mitigate the impacts outlined above, before a new facility for the extraction of mineral products can begin operation, it is necessary to obtain a range of legal permissions and to comply with various regulatory requirements (see also Section 4.0). Almost all the European legislation affecting the industry is horizontal and was not developed with the specific requirements of the extractive industry as a key objective. Thus, often a key challenge faced by the NEEI is the fact that the interpretation of such legislation varies between Member States.

The permitting processes tend to involve long and complex planning stages, and large investments of capital. It is recognised, however, that in recent years the European Commission has released guidance aimed at recommending streamlined environmental assessment and strategic planning. This aims to reduce the burden and speed up decision making processes.

Such permissions include the requirement for an Environmental Impact Assessment (EIA) or, more commonly known as Environmental Social Impact Assessment (ESIA) outside of the EU28. EIAs or ESIA, or even State Environmental Reviews (ekspertisa or OVOS in CIS countries), are also increasingly required outside of the EU28 for all investments involving new ‘greenfield’ developments, or a significant expansion or modification of an existing facility, before the proposed development or investment is approved. It should be noted that there are also conditional requirements for funding applications from banks and financial institutions such as the World Bank and the European Bank for Reconstruction and Development. Depending on the activity, some of these requirements can replicate the EIA process, where it is not required under national law. It is difficult to generalise as to whether the regulatory framework is more favourable in the EU28, or otherwise. However, an issue which has been raised during the conduction of this research is the requirement to designate areas of high biodiversity value as sites of Community importance and form the European network of protected areas (Natura 2000).

Whilst it is possible to conduct mining and quarrying operations in some localities that are protected, it is argued that it will be more difficult than otherwise. However, as clarified in relevant EU guidance, the EU Habitats Directive underpinning Natura 2000 provides a framework for sustainable development of activities on the basis of appropriate assessments and justified decisions. In 2012, the Natura 2000 network covered in average

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258 We have not sought to present all of the permissions required in each Member State and comparison countries, as the requirements for permissions vary depending on the nature of the activity, its location, and the potential for impacts on receptors. Thus this section is focused on the regulatory framework as a whole.


261 European Commission (2010) Non-energy mineral extraction and Natura 2000, July 2010, 
approximately 18 per cent of terrestrial Europe. Whilst this in itself may not make the EU28 less competitive, it probably makes the conditions for mining and quarrying operations occurring in these areas more demanding. The operating conditions for mineral extraction or processing activities in designated areas\textsuperscript{262} are likely to be more onerous and subject to a higher level of scrutiny from stakeholder groups than those located elsewhere.

An indicator of the ‘attractiveness’ of the permitting and planning systems within the EU28 and elsewhere can be found in the Survey of Mining Companies, conducted by the Fraser Institute.\textsuperscript{263} Since 1997, the Fraser Institute has conducted an annual survey of mining and exploration companies to assess how mineral endowments and public policy factors such as taxation and regulation affect exploration investment. The institute provides a survey question relating to the perception of uncertainty concerning environmental regulations. Adherence to environmental regulations is often cited as a concern by the mining sector and featured heavily in our interviews with operators in the sector. For the 10 EU28 Member States considered, the survey found that, on average, 7 per cent of mining companies would not pursue investment due to uncertainty over environmental regulations, compared to an average of 4 per cent for the rest of the world. Whilst this gives some indication of issues within the EU28 as a whole, the aggregated results disguise a wide variation in results between countries. For example, over 20 per cent of mining companies would not pursue investment in Romania or Greece because of this issue, whilst for Bulgaria, Ireland, Portugal and Poland, no companies were deterred by this factor. Therefore it appears that a small number of EU28 Member States are perceived to have a particular issue with the way companies perceive that they apply environmental regulations.

This general finding is also support by research conducted on behalf of the European Commission which evaluated the Article 6 of the Habitats Directive.\textsuperscript{264} The research found that Natura 2000 does not, on the whole, act as a general ban on developments. However, the presence of a Natura 2000 site can sometimes act as a deterrent. Because of the time consuming nature of the procedures and the uncertainty of the outcome, some companies will actively avoid proposing projects in or near Natura 2000 sites unless they can be sure of a reasonable chance of success; though it is noted that this is not uniform across the EU28.

Uncertainty in the regulations surrounding mining activity is an important consideration for the developers of new mines. The survey by Fraser Institute also included a question concerning the administration, interpretation, and enforcement of existing regulations. The survey produced a generally favourable response for the EU28 compared to the rest of the world. Only 5 per cent of respondents stated that they would not pursue investment in the EU28 due to this factor, compared to an average of 9 per cent for the rest of the world.

Additionally another factor that should also be considered is the social acceptance of mining. Based on the interviews conducted, it was clear that the economic and social benefits of mining were more likely to be observed in countries outside of the EU28 than

\textsuperscript{262} Beyond their intrinsic biodiversity value, such protected areas also provide significant social and economic benefits. See: \url{http://ec.europa.eu/environment/nature/natura2000/financing/docs/ENV-12-018_LR_Final1.pdf}


inside the EU28. In general, mining and quarrying activities are seen within the EU28 of having low public acceptance.

Despite the lack of quantifiable evidence, it is recognised that the EU28 is one of the leading regions in respect of mitigating environmental impacts from the NEEI and planning for restoration and aftercare. This is supported by the assessment provided in Section 4.1.3. Based on the interviews conducted in this study, there is a common view that a high degree of environmental protection takes place within the EU28, and this subsequently facilitates a more sustainable industry than otherwise. Importantly, this regulation goes some way to increasing the social acceptability of the NEEI, particularly by communities living close to mining activities.

In assessing the competitiveness of the EU28 in respect of environmental impacts, it is understood that no standardised approach to environmental performance reporting exists in Member States or competitor countries on the impacts of environmental regulation on the NEEI. Most of the large mineral producing companies in Europe do, however, report on environmental performance in their Annual Reports, but these cannot be relied upon to provide an assessment of competitiveness. A key issue associated with competitiveness is that many of the environmental impacts associated with the NEEI are externalities and are, therefore, not included in the market prices. This inhibits the ability to identify the impact in a systematic manner.

5.1.4 Logistics

The ability to process and move raw materials to market cheaply and securely is another important factor that influences competitiveness. Mining sites have to be located where the minerals occur in the ground and where they can be extracted economically in an acceptable way, often being in remote locations. This remoteness can create some problems, such as insufficient capacity within the local transport network to handle minerals, and associated high freight costs.

An assessment of the relative logistical infrastructure on a regional basis is difficult to complete and, in any case, the exact location of the mine is key to determining whether its logistics are cheaper and more secure. Thus this aspect of the assessment can only be focussed on more general issues that impact on the NEEI.

Based on the workshops conducted with representatives of the NEEI it is understood that the EU28 is well serviced by a strong transport network which helps the transfer of raw materials throughout the EU28 and beyond. The trans-European transport network (TEN-T) is a network which comprises roads, railway lines, inland waterways, inland and maritime ports and rail-road terminals throughout the 28 Member States and connects all parts of the European continent. The network, shown in Figure 51, acts as a series of conduits across Europe and provides an advantage to the NEEI by enabling the safe and cheap movement of raw materials.

265 Interviews were conducted throughout 2014 with mining operators within the EU28 NEEI


The network is expected to be further developed as €26 billion for the period 2014-2020 has been allocated to invest in a further nine major EU transport corridors. This compares to the allocation of €8 billion for the 2007-2013 period.

It is difficult to form a coherent view of the efficacy of the logistical networks of competitor countries compared to the EU28. However, the Fraser Institute Institute’s 2013 Annual Survey of Mining and Exploration Companies does provide some insight into this. Whilst the issue of transport logistics was not directly tested by the survey, a broader question relating to whether the quality of infrastructure encourages or discourages investment was asked. The results of the survey question are shown in Table 35 and Table 36. These highlight the fact that the selected Member States score well compared to key comparison countries. For example, the 10 EU Member States score best in terms of having the lowest

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number of companies answering in categories 4 and 5 (2%), whilst only the USA scores higher in respect of encouraging investment through the quality of its infrastructure.

**Table 35: Quality of Infrastructure (includes access to roads, power availability, etc.) – Outside the EU**

<table>
<thead>
<tr>
<th>Country</th>
<th>1: Encourages investment</th>
<th>2: Not a deterrent to investment</th>
<th>3: Mild deterrent to investment</th>
<th>4: Strong deterrent to investment</th>
<th>5: Would not pursue investment due to this factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA*</td>
<td>36%</td>
<td>50%</td>
<td>10%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>South Africa</td>
<td>22%</td>
<td>51%</td>
<td>16%</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>Australia</td>
<td>32%</td>
<td>40%</td>
<td>22%</td>
<td>6%</td>
<td>1%</td>
</tr>
<tr>
<td>Mexico</td>
<td>14%</td>
<td>55%</td>
<td>24%</td>
<td>7%</td>
<td>1%</td>
</tr>
<tr>
<td>Chile</td>
<td>19%</td>
<td>46%</td>
<td>29%</td>
<td>5%</td>
<td>1%</td>
</tr>
<tr>
<td>Canada</td>
<td>28%</td>
<td>34%</td>
<td>28%</td>
<td>10%</td>
<td>1%</td>
</tr>
<tr>
<td>China</td>
<td>9%</td>
<td>50%</td>
<td>31%</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>India</td>
<td>5%</td>
<td>33%</td>
<td>38%</td>
<td>19%</td>
<td>5%</td>
</tr>
<tr>
<td>Brazil</td>
<td>7%</td>
<td>30%</td>
<td>53%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Russia</td>
<td>0%</td>
<td>17%</td>
<td>61%</td>
<td>22%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Notes:**

*The USA encompasses the following states only: Alaska, Arizona, California, Colorado, Idaho, Michigan, Minnesota, Montana, Nevada, New Mexico, Utah, Washington and Wyoming.*

*Source: Table A10 – Fraser Institute (2014)*

**Table 36: Quality of Infrastructure (includes access to roads, power availability, etc.) – Inside the EU**

<table>
<thead>
<tr>
<th>Country</th>
<th>1: Encourages investment</th>
<th>2: Not a deterrent to investment</th>
<th>3: Mild deterrent to investment</th>
<th>4: Strong deterrent to investment</th>
<th>5: Would not pursue investment due to this factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>51%</td>
<td>49%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>France</td>
<td>47%</td>
<td>53%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Portugal</td>
<td>38%</td>
<td>58%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Finland</td>
<td>60%</td>
<td>34%</td>
<td>6%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Spain</td>
<td>36%</td>
<td>58%</td>
<td>3%</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Sweden</td>
<td>59%</td>
<td>32%</td>
<td>9%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Poland</td>
<td>27%</td>
<td>53%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
### Greece

<table>
<thead>
<tr>
<th></th>
<th>14%</th>
<th>43%</th>
<th>38%</th>
<th>5%</th>
<th>0%</th>
</tr>
</thead>
</table>
### Bulgaria

<table>
<thead>
<tr>
<th></th>
<th>12%</th>
<th>41%</th>
<th>47%</th>
<th>0%</th>
<th>0%</th>
</tr>
</thead>
</table>
### Romania

<table>
<thead>
<tr>
<th></th>
<th>9%</th>
<th>32%</th>
<th>46%</th>
<th>14%</th>
<th>0%</th>
</tr>
</thead>
</table>
### Average of Selected EU MSs*

<table>
<thead>
<tr>
<th></th>
<th>35% (Range 9% to 60%)</th>
<th>45% (Range 32% to 58%)</th>
<th>17% (Range 0% to 47%)</th>
<th>2% (Range 0% to 14%)</th>
<th>0% (No range)</th>
</tr>
</thead>
</table>

**Notes:**

* EU28 was not considered within the survey. A simple average was taken from selected Member States. These included Bulgaria, Finland, France, Greece, Ireland, Poland, Portugal, Romania, Spain and Sweden.

**Source:** Table A10 – Fraser Institute (2014)

An average of 80 per cent of respondents stated that the infrastructure within selected European Member States either ‘encourages investment’ or is ‘not a deterrent to investment’. Only the USA scored a higher percentage. Whilst it is difficult to conclude definitively that the logistics and infrastructure in the EU28 contribute more to enhancing competitiveness than in most competitor nations, it is clear that EU28 has a well-developed transport infrastructure that supports the activities of the NEEI.

### 5.1.5 Security of Supply

The EU economy requires secure, adequate and sustainable supplies of minerals and metals of which a large proportion are currently derived from overseas sources. Changes in the global geopolitical-economic situation may impact on the supply and demand of the raw materials and minerals. In recent years the demand for many raw materials and minerals has escalated rapidly, mainly driven by economic growth in developing economies and the requirements of new and green technologies. Many emerging economies are pursuing industrial development strategies which involve some form of ‘resource nationalism’, aimed at maximising the benefits from indigenous extraction and processing, and at conserving resources for their own long-term benefit.

In the light of these changes to traditional patterns of supply and demand, the European Member States have become increasingly concerned about the security of supply of the mineral raw materials needed to sustain economic growth and competitiveness. This has led to the conduct of various criticality assessments, at corporate, sectoral, national and international scale, which have been undertaken to assess which materials may be at risk of supply disruption and the economic impacts that would follow from any interruption to supply.

On the basis of such assessments a broad range of measures has been proposed to reduce the likelihood of supply disruption and to mitigate the effects of such events.

Risks to supply are many and varied. They include:

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i. the political-economic stability of the producing countries;

ii. the concentration of production and processing capacity within a few countries
    (‘country concentration’);

iii. the extent to which the potential for substitution by other materials is limited;

iv. the recycling rate;

v. the nature of environmental regulation;

vi. the concentration of production and processing capacity in a few companies
    (‘corporate concentration’);

vii. mining governance;

viii. ore grades;

ix. by-product dynamics;

x. land use competition; and

xi. price volatility.

Factors i – v were included in the pan-EU criticality assessments as contributing factors to
the estimation of a compound indicator for supply risk. The remaining factors (vi – xi) were
examined in the 2013 criticality study but were not included in the assessment for a variety
of reasons of which lack of data was the most significant.273

5.1.5.1 The Political-Economic Stability of Producing Countries

As discussed above, the geological availability of mineral resources on a global scale is not
considered to be a major issue influencing security of supply in the medium and long term,
given adequate and timely investment in the R&I needed to deliver efficient and effective
exploration, mining and mineral processing. What is actually more important is the ability to
access the mineral resources in the ground and to be able to extract them in a sustainable
and economic manner.

Given that mineral resources are distributed heterogeneously across the globe, some
countries are well endowed with large quantities of many commodities while others lack
significant deposits of the materials needed to support their economic growth and
competitiveness. As a result many economies in the West, including the EU28, are reliant,
wholly or in part, on mineral supplies imported from overseas. The political and economic
stability of the main producing countries may therefore impact significantly on the security
of supplies to the user countries.

Numerous factors influence how easy it is to establish and maintain extractive operations
for minerals and metals and thus to meet the demands of the markets worldwide. These
include access to land, land and mineral ownership, security of land tenure, social attitudes,
financial and fiscal conditions, mineral and environmental policies, mineral licensing
systems, infrastructure, labour relations, possibility of natural disasters, etc.

Ernst & Young (EY) publish an annual report on the chief business risks facing the global
mining and metals sector. In the latest survey, capital allocation/access and productivity are
viewed as the biggest risks, given the continuing difficult global economic conditions and
rising costs.274 These are followed by ‘social licence to operate’ and ‘resource nationalism’,

273 Ibid

thus emphasising the growing influence that these factors have on developing and maintaining economic mineral extraction operations.

In many countries the influence of policies affecting the mineral industries has grown steadily over the past five years as governments have sought to increase their share of the benefits derived from the extraction of indigenous resources. Initially taxes and quotas were imposed on exported materials, but, more recently, a wider range of measures has been implemented including mandated beneficiation, increased government participation and limits to foreign ownership. The key risks identified by EY are analysed to a limited extent in terms of their variation by commodity, but their variation between countries is not discussed.

Figure 52 illustrates this trend. It shows the relations between China’s market share of key materials and the number of export restrictions applying to them.

**Figure 52: Concurrent Rise in China’s Market Share of Key Materials and the Number of Export Restrictions Applying to Them**

![Figure 52](image)

**Notes:**

Materials list in ‘Table 2.1’ include, Rare earths, Antimony, Tungsten, Magnesium, Magnesite, Germanium, Graphite, Gallium, Fluorspar, Barites and Vanadium

*Source: RAND Corporation (2013)*

A number of other surveys, most conducted annually, are undertaken to assess how factors such as government policy and mineral endowments influence locational decisions regarding investments in the exploration and mining sectors. These surveys provide some insight into how supply risks are distributed globally. It is pertinent to note that one such survey by Behre Dolbear, which focuses exclusively on ‘political risk’, assuming that geological potential is present, deals only with 25 countries, none of which are in Europe.


The longest established and most comprehensive annual survey is conducted by the Fraser Institute of Canada. This survey attempts to assess how mineral endowments and public policy factors affect exploration investment (as discussed in Section 5.1.1.1). In 2013 more than 4,000 exploration, development and other mining-related companies around the world were surveyed, with 690 responses received. These represented a total exploration expenditure of US$3.4 billion in 2013. (Global exploration expenditure for non-ferrous metals in 2013 was reported to be US$15.2 billion). The results of the survey are presented for 112 jurisdictions, comprising either individual countries or, in some cases, individual provinces or states within a country.

The results of the Fraser Institute surveys are presented as a series of indices derived from the survey responses. In the 2013 survey the Policy Perception Index (PPI) provides a comprehensive high-level overview of the attractiveness of mining policies within individual jurisdictions. The PPI is a composite index derived from the answers to questions related to 15 policy factors that might influence company investment. Many European countries were not included in the survey because of an insufficient number of responses. However, a total of 15 European countries were ranked including 10 EU Member States. Three of the top ten countries ranked by PPI were in the EU28: Sweden (1st), Finland (2nd) and Ireland (5th). Other favourably rated EU28 Member States included France, Portugal, Spain and Bulgaria, all of which were ranked in the top half of the 112 jurisdictions for which results were available. Romania and Greece, on the other hand, were the lowest ranked EU countries, at 86th and 89th respectively, although both of these scored better than Russia which was ranked 91st. In terms of the performance of competitor countries to the EU, most states and provinces in USA, Canada and Australia are ranked in the top half of the PPI index. By contrast, South Africa (64th), Brazil (65th) and China (88th) are ranked in the bottom half of the jurisdictions reported.

Among the various factors that contribute to the PPI in the Fraser Institute survey, it is particularly instructive to examine the ranking of ‘political stability’. This factor is assessed according to its encouragement of, or deterrence to, investment in the minerals sector. Our calculations on the data collected in this survey suggest that, on average, for the ten EU Member States for which results are presented, 68% of respondents found that political stability was either a positive encouragement to investment or did not deter investment. This compares with an average of 55% for the rest of the world. There is, however, considerable variation within the EU and within the rest of the world. In the EU28, Finland, Ireland and Sweden score very highly on political stability, while Greece and Romania perform poorly. In the rest of the world most of the competing jurisdictions in USA, Canada and Australia score very highly and in most cases better than the EU average. In contrast, South Africa, Brazil and Mexico perform less well than the EU average for this factor.

The Fraser Institute survey also presents an assessment of how much ‘room for improvement’ there is within each jurisdiction surveyed. This factor is determined by subtracting the scores for mineral potential under what are regarded as ‘best practice’ framework conditions from the mineral potential scores under ‘current regulations’. The EU states surveyed again compare relatively well with the rest of the world and some of the key

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competitors in this assessment. Ireland, Sweden, Finland and Portugal rank among the top 25 countries in having the least room for improvement, while Spain, France and Poland also report at better than the median value. The results for the competitor countries are mixed: some states or provinces within USA, Canada and Australia appear near the top of the rankings while others do much less well. For example, in Canada, New Brunswick and Alberta are ranked 7th and 8th respectively, while Ontario, British Columbia and the Northwest Territories lie between 73rd and 79th positions. Other competitor countries, such as Brazil (95th), Russia (99th) and China (110th), perform badly according to this particular index. It is clear, however, that production is occurring in all countries, irrespective of this scoring.

5.2 Recycling Industries

The competitiveness of the RI hinges upon a reliable supply of waste materials of the desired quality so as to enable reprocessing industries to function efficiently, and without incurring disposal costs for unwanted materials.

This material supply analysis can be broken down into distinct stages that effectively describe the lifecycle of materials. Although much discussion has taken place regarding the circular economy and new business models, and whilst these may keep materials out of the waste stream for longer than in conventional models, consumption still largely dictates the size and composition of the waste stream. The other important variable is the delay between the point at which materials, products and packaging are consumed, and the time at which products enter the waste stream (in other words, what level of materials are in ‘stocks’ because the materials are still in use, or being hoarded).

At the end-of-life stage, the origin of the material, and the available waste collection infrastructure, tend to be the key factors determining whether the material, or product, will be collected in a manner which allows it to be made available in sufficient quantity and quality for reprocessing. A top down view of the fate of the waste materials can be explored by reviewing the dismantling methods employed to separate complex products and the different waste facilities that are effectively facilitating or competing with recycling activities.

At each stage in the material lifecycle it is important to understand the different factors that are at play: the reasons for losses of material and competing demands by those in control of the material. The scale at which RI operate and over which materials are traded is also key to understanding competitiveness, especially with regards to how policy and legislation can affect the market. All of these aspects are explored in more detail in the sections below and tied together to assess the ability to generate a constant flow of recyclable material.

5.2.1 Consumption of Relevant Materials and Products in the EU

In the following analysis, consumption data are presented for the EU27 using the aggregated figures from the Eurostat dataset. The term non-metallic minerals include industrial and construction minerals which largely account for the properties seen in the data below.

279 Although data for Croatia are available separately there is not sufficient clarity of data and procedure to combine it with the information from other Member States.
Eurostat records various statistical datasets on mineral consumption within the EU, including mineral extraction, imports and exports. From the perspective of waste generation, a key metric is the Domestic Material Consumption (DMC) indicator, which measures the total amount of materials directly used by an economy, and is available for metals and non-metallic minerals in the EU27. DMC is calculated as the aggregated weight of the used domestic extraction of raw materials, plus the direct weight of imports (raw materials and products), minus exports (raw materials and products) measured in tonnes. It should be noted that DMC denotes apparent consumption and not final consumption as it does not include the upstream flows related to imports and exports of raw materials and products originating outside the local economy.

The DMC of metals and DMC of non-metallic minerals in the EU27 are shown in Figure 53 and Figure 54, respectively.

The flow of metals is dominated by imports and exports, and imports far outweigh exports, as shown in Figure 55. This negative balance of trade is reduced in the later years as the domestic extraction used increases. This also happens in the wake of the economic crisis late in 2008, reflected in a dip in DMC figures in 2009.

The DMC of non-metallic minerals in Figure 54 shows that imports and exports are small relative to the domestic extraction used. The balance of the two is also small relative to domestic extraction used (see Figure 56). The data reflects the large quantities of industrial and C&D minerals extracted for local use with little cross-border trade. Around ten times more non-metallic mineral is consumed domestically than metals.

DMC of both groups shows a general decline since 2007, and this is more pronounced in non-metallic minerals (26% reduction) than metals (18% reduction). DMC for metals is closer to levels prior to the economic crisis than is the case for non-metallic minerals.

**Figure 53: Components of Domestic Material Consumption of Metals in the EU27 (million tonnes)**

![Figure 53: Components of Domestic Material Consumption of Metals in the EU27 (million tonnes)](http://ec.europa.eu/eurostat/statistics-explained/index.php/Material_flow_accounts)

Source: Eurostat (2014)
Figure 54: Components of Domestic Material Consumption of Non-Metallic Minerals in the EU27 (million tonnes)

Source: Eurostat (2014)²⁸¹

Figure 55: Domestic Material Consumption of Metals in the EU27 (million tonnes)

Notes: The stacked bars sum to equal the Domestic Material Consumption.

Source: Eurostat (2014)²⁸²

²⁸² Ibid
The data presented shows that there is considerable consumption of metals within the EU. Furthermore, a large portion of that consumption is satisfied through imports from outside the EU, suggesting that there is an opportunity for the RI to increase the share of demand for metals for which it is responsible, provided that it can compete on cost and quality with primary materials.

Consumption of non-metallic minerals is an order of magnitude greater than of metals. The majority of this is industrial and C&D materials extracted for local use and which would be too expensive to transport far. Consequently imports and exports are small and roughly equal in magnitude.

Consumption for non-metallic minerals is large enough that it can be assumed that, as with metals, some of the demand could be met by the RI. It does not necessarily follow that increased recycling will be cost competitive with primary extraction, and in order to be so, then for materials like aggregates, for example, the RI would need to be located in close proximity to potential users so as to minimise transport costs.

It is clear that there is a relatively high level of consumption of primary minerals within the EU which presents opportunities for the RI, both in terms of the material being available at end of life, but also, in respect of meeting some of the demand for these materials.

5.2.2 Stocks in Use

The consumption of minerals in manufacturing effectively means that the mineral is not available for recycling or remanufacture until it is discarded as waste. These ‘stocks in use’ represent the total tonnage of material currently locked away that could potentially be made available for recycling. The composition of the stocks in use, being a mixture of old

Note: Croatia was not included in Figures 53-56 in response to the aggregate format used by Eurostat.

Source: Eurostat (2014)\(^{283}\)

and new products, is altered through two fundamental processes: older products reach end-of-life and are discarded as waste, and new products are fabricated and enter the stocks. Where the lifetimes of products is short, the stocks in use will mostly reflect the nature of recently manufactured products, but where lifetimes are longer, stocks in use will be a mixture of old and new products and will take longer to reflect recent changes in manufacturing.

Figure 57 shows input to the stocks in use from manufacturing production, the stocks in use (composed of new products and old products in use at various stages of their lifespan), and old products that have been discarded as they have reached their end-of-life.

**Figure 57: Stocks in Use and Availability of Manufactured Products for Recycling**

The amount of material that is potentially available for recycling in a given year depends upon what products reach the end-of-life at that point. Social and economic factors such as changes in fashion, technology, and regulation can also have a widespread effect on when products are replaced and disposed of. Whilst some end-of-life products may be temporarily stockpiled, the majority will be subject to some form of treatment and processing without much delay.

The lifetime of products and packaging using metallic minerals varies from very short (for example, an aluminium can) to very long (for example, in respect of steel girders used in construction). Construction minerals are often locked away in structures with long lifetimes, whether it be a building, bridge, road or otherwise, and so lifetimes can range from a decade to over a hundred years. Physical industrial minerals have the greatest spectrum of lifetimes due to the broad range of uses, from graphite in pencils and automotive products, and gypsum in plasterboard and concrete. Chemical uses of industrial minerals generally have no product lifetime at all as they are chemically altered during use and so removed from future recovery.

Globalisation of manufacturing and building practices means that product lifetimes vary very little between countries, though climatic variation might affect building lifetimes, for example. However, consumption is intrinsically tied to wealth and accordingly the size and
composition of the stocks in use can be expected to be largely dictated by GDP and population.

EU27 domestic mineral consumption of metals has plateaued in recent years, and has been falling at an average rate of 5.5% annually for non-metallic minerals. The latter almost certainly reflects the drop in construction activity, which typically occurs during periods of economic crisis.

Future trends of consumption, stocks in use, and hence, the availability of materials for recycling are difficult to forecast, the more so for the longer-life products. There is generally a movement towards light-weighting products, especially packaging, to cut down on material and transport costs. This in itself can affect material choice by manufacturers, as is seen with the rising quantity of aluminium used in vehicles. However, material consumption decisions will also be influenced strongly by cost, which itself is dictated by supply and demand.

Where substitute materials exist for a given application, the market dynamics can become quite complicated as consumption will be intrinsically linked to the relative raw material price changes amongst substitutes. Markets have diversified as technological use has led to the increased use of a wider spectrum of minerals and metals in everyday consumer products. For example, rare earths are used for their specific properties, some of which have substitute materials, and some of which do not. Here technology is driving demand, and so it follows that changes in technology will inevitably affect the demand for particular minerals and metals, depending on the specific properties required.

As with estimates of global and European consumption, stocks in use estimates suffer from issues of accuracy and comparability making meaningful analysis impossible. Our rapid evidence assessment has found that in order to calculate the stocks in use good historic consumption data is a prerequisite and often this is lacking, especially where there is a long history of widespread use. EU stocks in use within products and infrastructure are thought to be considerable for the minerals analysed.

The significance of understanding stocks in use relates in part to understanding the extent to which the RI might contribute, at any given point in time, to overall demand for material. The stocks in use effectively gives rise to a time lag in the rate at which material becomes available for recycling. As such, if demand for a material is growing rapidly, and if that material is locked up in stocks for a lengthy period of time, it follows that even an extremely successful recycling effort would only ever be able to meet a small fraction of demand. On the other hand, if demand is relatively stable, and if the lifetime of the product is short (or if the material is used as packaging), then the potential for the RI to meet a substantial share of demand is limited largely by the success of the RI and upstream activities (notably in respect of collection – see next Section) in accessing the material in sufficient quantities and at the appropriate quality.

### 5.2.3 Collection Methods

Collection of materials for recycling is the first step in the recycling chain. It is this step that determines what proportion of all the mineral material which appears in the waste stream

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can be separated and collected for recycling in the first instance. This is not to say that waste collection wholly dictates subsequent recycling activities, but it does have a significant bearing upon what is possible. The collection methods used will determine the subsequent treatment requirements by the level of homogeneity of the waste collected.

The ideal collection method maintains the waste stream in as homogenous form as could reasonably be expected, taking into account the fact that many products are composed of multiple materials, and the ability of treatment and sorting infrastructure to deal with heterogeneous mixes in a way that guarantees high quality material for reprocessing. This may be tempered, in reality, by the practicality and cost of such procedures (it might, for example, make technical sense to collect all light bulbs of a given type in one scheme, but the costs of doing so may be prohibitive). It is also at this point that material losses first occur due to non-target materials being set out for collection along with the target materials, or practical problems around physically separating the waste into separate material streams.

Waste is collected using the method most applicable and cost effective to the waste stream and waste infrastructure operating within a region. Waste is produced not by material type but by users, and so collection methods must be reviewed in terms of waste producer and waste stream. These are broadly categorised as municipal waste, industrial waste and construction and demolition (C&D) waste.

5.2.3.1 Collection of Municipal and Municipal Type Commercial Waste in the EU

Minerals exist in municipal and municipal type commercial solid waste primarily as steel and aluminium packaging (e.g. cans, tins, trays, and foils). Further minerals are found as components in Waste Electrical and Electronic Items (WEEE) and bulky items such as white goods. Some Member States include in their reporting wastes which others do not. For example, some countries include some C&D wastes in the reported figures. Such wastes commonly contain minerals of interest. The systems for collecting this material vary across the EU28, and this is reflected in widely varying municipal waste recycling rates (though some of this also relates to different approaches to reporting the statistics to Eurostat).

There are generally five main collection routes: door-to-door recycling collection; bring site recycling collection; civic amenity site recycling collection; bulky waste collection; and deposit refund systems. All five collection methods may either collect each material as a separate waste stream (source separated) or commingled with other materials. Some additional segregation of materials for recycling may occur through extraction by residual waste treatment facilities, for example, through mechanical-biological treatment, or through recovery from bottom-ash post-incineration. Furthermore, the role of ‘in-store’ take-back, or take-back in exchange for new purchases, have important roles to play in some countries’ systems for collecting, for example, WEEE and batteries.

The type of system used, and the way it is operated, can have profound implications for the quality of the materials collected for recycling. There is no ‘hard-and-fast’ rule, in this respect, since any scheme can be badly run, but higher quality materials are generally found in deposit refund schemes, take-back schemes, well-staffed civic amenity sites, and well-designed kerbside collection (and sorting) schemes.
Recovery of aluminium and steel from incinerator bottom ash (IBA) makes a significant contribution to the municipal metal packaging recycling rates of some Member States. Previous work Eunomia has undertaken on behalf of metal packaging industry indicates that metal packaging captured or recycling in Northern European countries such as Denmark and Belgium are based on close to a 50/50 split between separate collection and IBA recovery.\textsuperscript{285} For countries which rely more heavily on IBA recovery, collection of metal packing through door-to-door, bring site, and CA site may be given a reduced emphasis.

The above illustrates the complexity involved in recovering mineral fractions from the heterogeneous municipal and commercial waste stream. Compared to the recovery of minerals from industrial and C&D waste, municipal waste management involves greater efforts in the design of collection systems, principally because the quantities of material available from any given participant in a collection service are typically lower than in the case of industrial producers, and C&D waste sites (and larger producers of commercial waste).

### 5.2.3.2 Collection of Municipal and Municipal Type Commercial in Competitor Countries

In Japan, a competitor to the EU28, aluminium beverage cans are collected source separated by the country’s municipalities. Additional collection is made by community groups, commercial retailers and companies as part of corporate social responsibility indicating that Japan has a well engrained recycling culture.\textsuperscript{286} In April 2013 Japan introduced a law mandating the recycling of a wide range of small WEEE such as mobile phones, personal computers and games consoles.\textsuperscript{287} Municipalities are free to determine their own collection systems, meaning that collection could either be door-to-door or from collection points. Services are not charged to the consumer, as revenue is expected to be generated through the sale of valuable recovered minerals such as rare earths and gold.

In the United States, there is no federal law on recycling. Instead, central government has delegated responsibility to individual states. Therefore, a range of door-to-door collection methods exist from state to state with no uniformity on source separation or commingling. Furthermore, states are free to implement additional systems such as deposit refunds.\textsuperscript{288} The USA Environmental Protection Agency is backing the introduction of Pay As You Throw (PAYT) for collection systems.\textsuperscript{289} PAYT has already been introduced with success in a number of states.

### 5.2.3.3 Collection of Industrial Waste in the EU

It is important to distinguish between the possibilities of collecting those industrial minerals put to physical uses and those put to chemical uses. For chemically useful industrial minerals, recovery is not possible for two reasons:

\textsuperscript{285} Report not published.


\textsuperscript{287} Recycling of useful metals / The Japan Times, accessed 2 September 2014, http://www.japantimes.co.jp/opinion/2013/04/27/editorials/recycling-of-useful-metals/#.VAXsIWOjub1

\textsuperscript{288} Time for a national recycling mandate / TheHill, accessed 3 September 2014, http://thehill.com/blogs/congress-blog/energy-environment/189000-time-for-a-national-recycling-mandate

\textsuperscript{289} This is where producers of waste pay for the amount they produce.
By its very nature, a chemical use involves a change in chemical properties which may be neither easy nor desirable to reverse (e.g. fluorspar used as a catalyst in steel production).

For chemical applications such as potash’s use as a fertiliser, in addition to chemical changes, the mineral is spread in such small amounts over a wide area that it becomes dispersed. Recovery of such dispersed material is not practical (other than further down the cycle of use at, for example, sewage treatment facilities).

By contrast, collecting physical industrial minerals can be highly practical, as in addition to not having undergone chemical change, they are often used in large, homogenous quantities. This is usually the lowest cost source of quality materials and is often considered to be ‘low hanging fruit’. It includes waste arising from the fabrication of products, often referred to as new scrap. For example, automobile manufacture will result in off-cuts as metal sheets are fashioned into the required parts. Fabrication off-cuts represent a homogenous, highly pure, and voluminous waste stream which can be collected easily at source with clear economic benefit. This material is usually loaded onto trucks and driven straight to remelters to be turned back into sheets for further fabrication. This collection of ‘new scrap’ takes place on a business to business basis, and therefore, there is relatively little information available regarding its true extent. However, the process is thought to be highly efficient, and there is thought to be little potential for further incentivisation of improvements, not least because of the high value of the material.

5.2.3.4 Collection of Construction and Demolition Waste

Data regarding the recycling of C&D wastes is notoriously poor. The composition of C&D wastes is usually such that the majority of the wastes by weight are relatively low value materials such as soil and inert hardcore materials (bricks, stones, concrete), as well as wood (some of which may have been treated using chemicals which are considered hazardous, or which have the potential to generate problematic emissions when combusted) and gypsum (from plasterboard). Other materials include glass (e.g., from windows), plastics (e.g. from guttering and piping) and metals (e.g. from gas pipes, wiring, and girders). These materials are mostly non-biodegradable when landfilled. Consequently, one issue which plagues the management of C&D wastes is the regulation of the management of these wastes, some of which may be buried illegally, or simply fly-tipped, or used as fill for basic engineering works such as bunding. Ensuring materials are recycled is problematic because of the low value of the bulk of the material, and the fact that disposal options may also be cheap.

Beyond regulations regarding recycling, and incentives such as taxes on landfilling, one of the main issues influencing the extent to which construction and demolition (C&D) waste is collected in a form suitable for recycling is the extent to which materials can be kept separate. Given that C&D waste is generated on sites of varying scale, the space available for separate bins, or skips, can be a limiting factor in this regard. Any construction or demolition site management plan will have to balance space allocated to recycling containers with that allocated to plant and vehicles, work space, and other storage. As such, there will not always be enough free space available to provide separate collection for every

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potentially recoverable material. Therefore, decisions must be taken as to which materials are selected for separate collection, and which are collected mixed in, for example, skips.

Plasterboard waste (made from gypsum) is among the larger components of C&D waste (after concrete, bricks, soil and wood) and sometimes constitutes 10% to 15% of the total C&D waste stream if excavation is excluded. Furthermore, the Landfill Directive bans the landfilling of gypsum at landfills as gypsum reacts with water to form toxic hydrogen sulphide in anaerobic conditions. Construction generates plasterboard offcuts which are, in principle, easy to recover in large, homogenous amounts, facilitating the operation of take back schemes. However, space can still make segregation difficult, so that it remains the case that gypsum may be found in skips with other wastes. This is problematic for two reasons: first, the gypsum may simply crumble under the weight of other materials, and so, become difficult to segregate from other materials. Second, fragments of gypsum may compromise the quality of other materials which can be recovered from C&D waste. At modern sorting facilities for C&D wastes, it is generally possible to separate out construction steel and aluminium from mixed demolition waste, as well as rigid plastic.

5.2.3.5 Collection of Construction and Demolition Waste in Competitor Countries

Plasterboard recovery for gypsum recycling follows similar methods in Canada. Plasterboard is collected in on-site bins which are then hauled to recyclers, or to transfer stations until required amounts are reached. Furthermore, as in Europe, manufactures also take responsibility for recycling plasterboard offcuts into new plasterboard sheets, even collecting from the construction sites.291

In China, it is not currently common practice for building developers and contractors to develop C&D waste management plans, although waste from C&D sources makes up 30–40% of total urban waste.292 C&D waste is not commonly recycled, but is collected as a single stream of residual waste on site which is then driven straight to landfill for disposal. Analysis of the costs of C&D recycling in China293 has shown that there are cost savings to be made by switching from landfill to reuse and recycling as the primary waste management method.

5.2.3.6 The Effect of Collection on the Competitiveness of Recycling Industry in the EU28

Source separation is the key to high recycling rates and high quality recyclate. Collection methods are found to vary by waste stream based on a number of factors elucidated above. The current structure of the market encourages recycling of high value metals but other materials less so. Policy and legislation will play a crucial role in increasing the competitiveness of RI with a knock-on effect on collection methods to facilitate the collection of homogenous waste streams. The policy and legislative framework in the EU is far more robust than in competitor countries, but there is little consistency across Member States resulting in large variations in collection methods as well as recycling performance.

293 Ibid
While the EU is a world leader in recycling, there are still improvements to be made. These will come partly from improvements in the recycling performance of Central and Eastern European countries as they move towards the targets contained in the Waste Framework Directive. By bringing the worst performing nations up to the current standards of the best performing, the competitiveness of the EU as a whole will be increased.

Policy measures such as PAYT, deposit refund and producer responsibility schemes which currently have limited application across the EU could serve to increase competitiveness if implemented with greater uniformity. Such methods have been proven to bolster collection rates in the best performing nations, and have the potential to do so more widely.

Recovery of minerals such as rare earths, precious metals and other minor metals from WEEE is currently limited by the economics of the situation: these minerals occur in small amounts and are difficult to extract, meaning that recovery costs are high with limited return. However, nations such as Japan have begun to mandate the recovery of WEEE and expect the recovery of elements such as gold to help finance collection systems over time. Further investment in WEEE collection and recycling infrastructure could provide an additional source of materials of which the EU currently has no production or reserves.

5.2.4 Fate of Waste Materials

As waste is separated into separate streams through waste management systems its treatment becomes more material focussed than source focussed. However, data reported is often still related to the source intrinsically linking any analysis to the waste producer.

Recycling rates of minerals are discussed in Section 3.2.1. The only comparable metrics found appear to show that the End of life recycling rates (EOL-RRs) for metals are above 80% in the EU28, Singapore and HK, and that the EU28 lags behind the two comparator countries in ferrous recycling and leads in non-ferrous recycling. However, there is some doubt over the validity of the EU28 recycling data, as explained within that section.

A less material-centric but arguably more revealing approach is to assess the fate of different the waste streams in relation to the mineral content of those waste streams.

5.2.4.1 Municipal Waste

Minerals found in municipal waste are generally metals in packaging, particularly steel and aluminium. The high raw material price, large quantities, purity of material, simplicity of separation and ease of recycling these materials usually results in them being amongst the first materials to be targeted for recycling. Nevertheless, recycling collection relies on correct identification and placement of materials in recycling containers by householders and so a significant fraction can remain in the residual waste. This does not mean however that the material is dispersed and removed from circulation as metals are often recovered from incinerator bottom ash. Indeed, many countries rely on this as the sole means of metal recovery where no other separation processes are in place.

Analysis of the fate of waste materials in municipal waste across the EU28 in Figure 58 naturally shows recycling activity displacing recovery and disposal methods. Many Member States also appear to be replacing disposal to landfill with incineration, most likely

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294 Note that specific metals are not referred to.
295 These include landfill and incineration.
in response to the Landfill Directive. This appears to be most common in Member States where recycling rates are high.

**Figure 58: Treatment of Municipal Waste in the EU28, 2012 Ordered by Recycling (%)**

Source: Eurostat (2014)

5.2.4.2 C&D Waste

A large portion of C&D waste is reused onsite or transported locally for reuse. The waste material is cheap compared to other primary material which carries the cost of extraction and transportation; and reusing the waste material provides the added financial benefit of avoided treatment and disposal costs. Environmentally this has many benefits and is reflected in the waste hierarchy in which reuse sits higher than recycling in the list of preferred waste management options. The material that is sent for recycling or disposal is what is left after the reuse fraction is removed. The weight and volume of C&D waste prevent affordable transportation over large distances and so recycling industries do not tend to compete geographically; instead recycling industries compete with local waste disposal options to provide the lowest cost means of handling the waste. The overall dynamics of C&D waste management are very positive when compared to other waste streams but as these underlying factors arise from the physical qualities of the waste the same can be assumed to be true in other countries.

Construction activities generally produce clean, separate and high quality wastes from offcuts, shavings and broken products. These wastes can be traded with the product manufacturers on a business to business level, rationalising logistics on larger construction projects so that after products are delivered the same trucks then transport the waste materials back to the manufacturer. However, due to a lack of space on a construction site for containers for separate materials the wastes are usually mixed in a single container.

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Soils and other aggregates excavated in the course of construction activities are often reused onsite for landscaping and other purposes. Such use excludes the material from the classification of a waste according to the Waste Framework Directive, and such use of such materials is also common outside of the EU as it saves on transport and disposal costs. When excavated materials are removed from the construction site they technically classify as a waste in the European Waste Framework Directive (2008/98/EC). The cost of transporting such heavy materials implies that they will be used locally and more often than not they are taken to a nearby construction site of the same firm. In less assiduous environments such transfer of waste may be unregulated and unrecorded as the material is not moving between organisations or across political borders, nor is it subject to processing or treatment.

Demolition wastes tend to be particularly difficult to separate into their mineral components; a problem that is further exasperated by the lack of space for containers for separate materials. Even when buildings are dismantled by specialist crews stripping out high value reusable or recyclable products, the structural metal components may be reclaimed but much of the remaining mineral content will be contaminated with paint or bonded to other surfaces. Where legislation controls the disposal of certain mineral wastes there is the opportunity to create a recycling culture but as is seen with gypsum waste in the UK this is often poorly regulated and suffers from a lack of enforcement.

Waste treatment data in Eurostat are not disaggregated by the source of the waste and so it is not possible to determine what portion is derived from the construction and demolition industry. As such, Eurostat data cannot be used in C&D recycling analysis unless combined with other data sets. In the figures below, recycling is used to refer to ‘recycling and other material recovery’ as defined in the Waste Framework Directive. C&D waste recycling data is shown from 18 out of the EU28 countries and Norway; other Member States have not been included in the analysis as insufficient data was available.

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Recycling rates in Figure 60 are calculated using the recycling data above, acquired from national reports and statistics, and Eurostat data, presumably using the NACE code for Construction waste to obtain C&D waste arisings. NACE code ‘F Construction’ includes civil engineering works as well as repair, additions and alterations. 300 Included in this NACE category are the activities ‘Demolition and wrecking of buildings; earth moving’ and ‘Site preparation’. 301 It is not clear whether each county has used the same classification of waste in reporting waste arisings to Eurostat as was used in the national recycling data due to the differences in waste management, monitoring and reporting practices. Nor is it certain that one country’s results are comparable with the rest of the set. The analysis is of limited value therefore in evaluating either recycling rates as absolute figures or in terms of relative performance. The analysis does however provide an insight into the reporting of waste and recycling data by Member States, especially with regard to the 70% recycling target for 2020 and how powerful a driver this target will be on future recycling efforts.

Source: ETC/RWM, 2008 based on national reports and statistics 299
Figure 60: Recycling Rates of Construction and Demolition Waste in 17 of the EU Countries and Norway, circa 2008

![Recycling Rates](image)

Source: Eurostat and ETC/RWM, 2008 based on national reports and statistics

The composition of the recycled C&D waste in Figure 61 shows a great variation across the Member States included in the analysis. However, concrete and bricks are commonly the larger portions of the recyclate, although the category that includes gypsum and metals amongst other materials is significant in Estonia, Hungary and Poland.

Figure 61: Composition of Recycled Construction and Demolition Waste in 17 of the EU Countries and Norway

![Composition](image)

Source: ETC/RWM, 2008 based on national reports and statistics

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303 Ibid
Differences in management of C&D waste in Europe compared to other countries can be linked to the legislative environment which exists there. The Waste Framework Directive effects C&D recycling via three instruments:  

► Waste management must adhere to the waste hierarchy, of which disposal and landfill are the lowest priority measures;
► Member States are encouraged to introduce extended producer responsibility for the waste arising from their manufactured products; and
► A target of 70% ‘recycling’ is set for all C&D waste by 2020.

The most influential instrument is arguably the recycling and recovery target for C&D waste, although such statistics are difficult to audit due to the lack of reliable waste data in this area. C&D waste, as with other waste streams, is also subject to the conditions set out in the Landfill Directive (1999/31/EC). The Landfill Directive determined that all landfills would be categorised as either:

► Landfill for hazardous waste;
► Landfill for non-hazardous waste; and
► Landfill for inert waste.  

The Landfill Directive banned certain wastes from landfill disposal and defined which wastes are permitted at each of the above classes of landfill. Due to the requirements of the Landfill Directive, 1/3 of all landfill sites in Europe ceased operations and the remaining 2/3 had to be upgraded resulting in higher operating costs.

The reduced capacity and increased costs have altered the treatment and disposal market making alternative disposal methods with higher gate fees appear more attractive. Additionally, the Landfill Directive requires that waste must be treated prior to disposal; the simplest of compliant treatments being the sorting of waste. This effectively banned mixed loads of C&D waste from entering landfill and provided a strong incentive for on-site sorting and separation of waste. Member states have implemented various measures to meet the targets set out in the landfill directive including landfill taxes and landfill bans on certain wastes. The Member States with strong C&D recycling industries tend to have landfill taxes that cover a broad range of waste types and have a relatively high level of tax. The converse is also true in that Member States with low C&D recycling rates tend not to have broad taxation on landfill waste.

Land prices and the availability of land for landfilling also play a crucial role in how much material is landfilled and how much is diverted to other routes, especially where the international transport of waste means that waste operators can take advantage of cheaper gate fees or less stringent waste policy in nearby countries.

The largest mineral components of construction waste are concrete, masonry, asphalt, stones, sand and gravel. If recycled, this mineral fraction would displace relatively cheap materials.
virgin material and so there is little economic incentive to do so. Introducing high levies or bans on landfilling construction waste has proven to drive higher recycling rates, leading to an increase in the supply of secondary material which tends to lower prices making them more economically attractive.

5.2.4.3 Industrial Waste

Industrial waste often includes a variety of minerals and is not restricted to those termed industrial minerals. The innate qualities of industrial minerals do not lend themselves to easy separation unlike metals which can be removed from heterogeneous waste using magnets. Consequently, recycling of industrial minerals is focussed where large quantities of a mineral are found isolated from other contaminants.

Some gypsum is recycled from drywall products in the C&D waste stream where environmental legislation makes recycling an economically competitive option. Graphite has a number of industrial applications and is used in the manufacture of electrodes and engine blocks from which new scrap collection and recycling is feasible. Graphite is also used in the manufacture of steel from which recovery is or not economically viable. Old scrap can also be recycled, such as electrodes from electric arc furnace plants and other industrial graphite products. When recycled, graphite is crushed to a powder and used in steel manufacturing, or used in products such as brake linings and thermal insulation.307 308

Most fluorspar is essentially consumed in use and recycling or reuse is not usually feasible. Small amounts of fluorspar can be recovered and recycled from the waste streams in hydrofluoric acid (HF) manufacture. Fluorspar is not generally recovered from manufactured goods (such as flint glass, enamels, and fibreglass insulation) due to the dispersive nature of these applications, and, although some limited recycling is at least theoretically feasible we are not aware of any operations of this kind in the EU.309 310 Acid-grade fluorspar prices declined between 2011 and 2013, although long term trends demonstrate an upwards trend from 2000 onwards; if this growth continues it is speculated that increased recovery of fluorspar may become economically viable in the future.311

In the USA, a few thousand tonnes per year of synthetic fluorspar are recovered, equivalent to a minute fraction of the estimated consumption of fluorspar in the USA, which totalled 605 thousand tonnes in 2013.312 Fluorspar is recovered mainly from uranium enrichment, but also from petroleum alkylation and stainless steel picking. Some HF and other fluorides are also recycled by primary aluminium producers and in the petroleum alkylation process. Considering the abundant supply of potash and dissipative nature of manufactured

307 3 Reasons graphite recycling is better than disposal, accessed 4 September 2014, http://www.semcocarbon.com/semco-carbon-blog/3-reasons-graphite-recycling-is-better-than-disposal
applications, it seems unlikely that potash recycling will become economically viable in the future.

5.2.5 Dismantling Methods

As explained in Section 5.2.3, waste is often collected as mixed materials. The waste must be separated by material and ideally free of contamination before it can be recycled. Various technologies exist to separate materials from mixed waste streams and vary in complexity as dictated by the nature of the waste and the materials sought.

5.2.5.1 Dismantling Complex Products

As products grow in complexity, both in terms of design and the number of materials used in their manufacture, dismantling becomes an increasingly important stage of waste management. In recognition of this fact, some designers are now considering the dismantling and recycling requirements for when products reach the end-of-life stage. Take back schemes link the manufacturer with waste management and promote integration of Life Cycle Analysis into product design. In Europe, the RoHS Directive (2002/95/EC) restricts the use of hazardous substances in electrical and electronic equipment, which had previously posed a serious and expensive barrier to dismantling.

The majority of products in current scrap arisings and stocks in use have not been designed for recycling, and so dismantling methods can by necessity be as numerous as the products themselves, for each product creates its own challenge in material recovery at end-of-life. Indeed, the complexity of the dismantling process and the financial viability of doing so can create a barrier to recycling. There are, for example, significant challenges over recycling the precious metals contained within catalytic converters in End of Life Vehicles (ELV) due to the lack of reprocessing facilities to dismantle them.

5.2.5.2 Material Separation in Mixed Waste Streams

For less product specific waste, it is useful to understand dismantling in terms of the larger waste streams: municipal waste, industrial waste, and C&D waste.

Householders can prove to be effective dismantlers of municipal waste, for example removing metal caps from glass bottles. However, municipal waste is generally composed of packaging products that do not require dismantling such as steel cans, aluminium cans and aluminium foil. Where municipal waste is collected as two-stream or comingled, it is sent to a material recovery facility (MRF) for separation. The steel and aluminium separation methods are thought to produce fairly clean materials streams as they rely on properties of the metal not found in other materials. Other materials sorted by size and weight can have issues with contamination as these properties are less unique to particular materials. Consequently, it is not uncommon for bales of material to be “dressed” before sale, a process of manually removing contaminants from the outside of the bale to improve the appearance of material purity.

Construction waste also tends to be offcuts of broken pieces of simple products such as drywall, tiles, or concrete slabs. Demolition work on the other hand breaks apart structures using large machinery creating a very mixed waste stream. Occasionally demolition involves dismantling or partial dismantling to remove valuable or hazardous materials first but the remainder is still a largely mixed waste stream. Space restrictions for waste containers mean
that mixed waste containers are used and waste is sent to a C&D MRF. The age of the facility and the space available are the key determinants in the variation of MRF technology, and so the number and quality of material types that can be separated. Generally the economics of source segregation on a construction or demolition site do not stack up as it is cheaper to send mixed waste to a C&D MRF. However, it is increasingly common to have source segregation at larger and more organised sites.

5.2.6 Difference in Waste Facilities

Unfortunately recycling capacity in Europe is an area grossly unrepresented in the literature. As part of this study, thorough research was undertaken into online data sources, utilising scholastic as well as broader search portals; however, it does not seem that any relevant studies have been undertaken as yet. One recycling capacity report was identified, but this did not include minerals under the materials focussed upon in this report. It is therefore not possible to quantify in any helpful way the numbers of MRFs, transfer stations, remelters or other reprocessors across Member States or draw comparisons as to the quality of material leaving such facilities. So while it is known that Western and Northern Europe have a greater number and more advanced MRFs than Central and Easter Europe, it is not possible to quantify this with any exactitude over the EU, except to site specific instances pulled from the existing literature.

Although a full comparative analysis of MRFs across the EU is not possible due to a lack of data, it is possible to make some general remarks on potential differences between MRFs, bearing in mind that more advanced technologies are more likely to be found operating in Western and Northern Europe. The main split in MRFs operations is between manual and automated sorting methods, the former being hand sorting by eye and the latter involving a whole range of technologies. As it is common throughout the EU to collect metal packaging commingled with plastics, the major relevant automated methods will be the use of magnets to separate out ferrous metals and electrical eddy currents to separate out non-ferrous metals from plastics. As such, differences in MRFs will come down to the presence or absence of such technologies.

Eurostat data, shown in the Technical Appendix (Section A8.0), gives a high level view of the balance of waste treatment facilities in the EU. Unfortunately, although there is a breakdown of landfill facilities by type, recycling facilities and a range of other treatment types share a single ‘recovery’ classification making further analysis impossible. Intuitively treatment type and capacity will closely match the profile of waste treatment trends seen in Member States, and any variation will be seen in the waste import and export data.

The relative trade balance presented in Section 3.2.3 shows that the EU28 is a net exporter in recylcate of ferrous metals, base metals and critical metals. This would suggest that there is either insufficient capacity to process all of the metal recylcate collected in the EU28 or that the recycling plants for these minerals are not sufficiently competitive with other countries across the full spectrum of recylcate. This may be especially true of ferrous metals which show a large relative trade surplus that has grown significantly in the last decade. Collection rates of these minerals are considered to be higher in the EU28 than many

competitor countries, and subsequently the amount of recyclate circulating is correspondingly large. However, this is not a sudden phenomenon and RI markets have had sufficient time to respond to changes in recyclate supply.

A comparison of aluminium recycling tonnage shown in Figure 62 indicates a strong European RI, and the distribution of aluminium recycling plants compares favourably with the rest of the world, as evidenced in the Technical Appendix. Figure 62 also shows that Europe commands a much larger share of aluminium recycling than it does of primary production. In fact, in 2004 the production of recycled aluminium in the EU (at the time the EU25) had outstripped primary aluminium production by 4.5 million tonnes to 3 million tonnes respectively, but imports were still necessary to meet the demand of 11.4 million tonnes used in the fabrication of goods. 315

Figure 62: Regional Bauxite, Alumina, Primary and Recycled Aluminium Production, 2007

Source: European Aluminium Association (2009) 316

5.2.6.1 Competitiveness

Clearly, for RI to increase in competitiveness then the type of waste facilities currently in place or planned for the future is crucial. Technology is an important factor in the fast developing area of waste treatment, but it is also important to consider the other treatment and disposal options that may be competing for recyclable material within a region. If cheaper disposal methods exist then recycling will struggle without further policy intervention.

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5.3 Summary of Findings

5.3.1 Non-Energy Extractive Industries

For the NEEI, material supply, or availability, is not so much a factor determining the competitiveness of the industry, rather a pre-requisite for its existence. In this respect, it should be noted that research has shown that the extent of investment in exploration within the EU28 as a whole is lower than in some competitor countries. This reduces the likelihood of (or increases the costs of) identifying mineral deposits, and therefore, acts to limit supply from the EU’s extractive industry. Additionally, it should be noted that other countries make use of tax incentives to encourage private sector investment in exploration and in some cases (most notably China), finance and operate the industries with the public sector.

A greater percentage of the land mass in the EU28 is given some form of conservation status than in other countries. Whilst this does not necessarily preclude mining and quarrying activities, it might be suspected that it makes them more challenging to undertake than where the land was not so designated. Evidence from a survey with mining executives has shown, however, that the way in which environmental regulation is applied within EU Member States has a variable impact on investment decisions, and does not, perhaps, hinder investment as much as might be expected.

Considering logistics, the EU28 has favourable transportation routes and this is regarded positively by investing companies relative to other competitors. Good infrastructure in this respect enables the industry to move its products to where they are needed without having to make major investments themselves.

The processing industries’ supply of material is determined by the access they have to primary materials. This is largely determined by the extent to which other countries make their materials freely available to trading partners. The principle concern in this respect must be the restrictions which are applied by some countries to exports of their primary products, especially for those materials whose supply is dominated by a small number of countries. This can have a direct impact on competitiveness by raising the costs of the materials relative to those which prevail in the country restricting exports. In respect of security of supply, therefore, the EU28 processing industries are in a challenging position when the concentration of production is centred on countries with restrictive trade practices (though it should be said, that other countries are also similarly impacted by the concentration in supply). The effect of supply concentration is particularly important for the security of supply of many metals, especially those used for new and green technologies. For some industrial minerals, supply security is less problematic, although it is important to note that 7 of the EU’s designated 20 critical raw materials are industrial minerals. In the first pan-EU criticality assessment only 2 industrial minerals were identified as ‘critical’ for the EU economy.

Figure 63 provides an illustrative overview of the assessment of material supply with respect to NEEI. The figure is based on a qualitative interpretation of the data identified and derived, at least in part, from the consensus of views and evidence obtained in this study.
5.3.2 Recycling Industries

For the RI, collection methods determine how much of the waste material is captured for further processing. The combination of collection, sorting and pre-treatment of the collected materials will have a major bearing on the quality of the material made available to reprocessors. The ideal system for high quality recyclate is separate collection of each material, although this is sometimes economically prohibitive. Ironically, one of the factors that can drive increases in recycling – high costs of residual waste management (as a result of landfill taxes or bans, for example) – is one that also makes it more difficult for the RI to deal with materials which are of low quality (since the material may have to be ‘cleansed’ of contrary materials, which then have to be sent for high cost disposal / treatment). This may have the effect of driving material to overseas markets with lower disposal costs. Some commentators believe this may be happening with, for example, metals collected from incinerator bottom ash.

This raises an important point regarding the link between the supply of secondary materials that have been collected to be recycled, and the EU’s RI – there is no guarantee that materials collected for recycling in the EU will remain within the EU. The materials may be exported to a range of destinations across the world, with the price offered, net of transport, for the material being a key determinant of the chosen location for the material.

Some materials, such as aggregates, are costly to transport relative to their value. For these materials, the RI requires secondary material to be made available in close proximity to end users. For these materials, it is difficult for other countries to compete with industry located within the EU.
In many cases collection methods do not exist to support complex waste streams as the infrastructure for further treatment and separation is missing. It is here that the policy and legislative framework in the EU, particularly around WEEE and hazardous waste, can have a pronounced effect on securing wastes for recycling. However, as noted above, this does not guarantee that the material will remain within the EU.

It is important to note that the major competing countries all have recycling systems in place, though these vary in their effectiveness. Equally, most countries aspire to improving their recycling, although in some of these, the implementation leaves much to be desired.

Importantly, collecting material for recycling does not guarantee that it remains within the EU. In principle, and especially for metals, the market for secondary materials is increasingly integrated globally so that materials are traded between nations. This relies upon the market for the materials being characterised by standards that allow the materials to be traded with confidence by all parties.

Other things being equal, the competitiveness of the RI in the EU will be enhanced where significant quantities of high quality material are made available to the industry. However, all nations are free, in principle, to compete for the same material. If the costs of transport to competitors are low (as they can be if the counterfactual is empty containers returning to competing countries), then there is no specific advantage that the EU gains from a greater availability of the material to be used by processors.

It is important to consider that some parts of the RI are closely linked to the NEEI. For example, the processing of some steel scrap takes place in furnaces which also deal with primary ores. At basic oxygen furnaces, at the margin, secondary material substitutes for primary materials. As such, the availability of secondary materials can have implications for the ‘materials supply industry’ in the EU, this being understood to be composed of production from both primary and secondary materials. For example, at times of high prices of primary commodities, the availability of secondary materials can help to reduce costs of production at such facilities by reducing input prices.

Figure 64 provides an illustrative overview of the assessment of material supply with respect to the RI. The figure is based on a qualitative interpretation of the data identified and derived, at least in part, from the consensus of views and evidence obtained in this study.
Figure 64: Raw Material Supply Competitiveness - RI

Notes:
1) The figure is based on a subjective assessment of the competitiveness based on the author’s views.
2) Lines nearer to the centre of the shape denote lower levels of competiveness. Lines towards the outside of the shape denote higher levels of competiveness.
3) RoW (Rest of the World) is based on the analysis of the representative countries presented in this research.
6.0 Research and Innovation Assessment

This section focuses on Research and Innovation (R&I) as opposed to Research and Development (R&D). Although two very similar terms, the main distinction between the two appears to be that R&D can lead to innovation, whereas in R&I, innovation is implicit. In this way, research and development requires investment that may, or may not, lead to an innovation. Therefore in the context of funding, the term research and development is often employed. Conversely, research and innovation relates specifically to the innovation stage. Thus discussion around the subject may be more focused upon the dissemination of a new technology that has already been through the development process. However, the two terms are often used interchangeably and, considering the similarity in meaning, this is not considered a distinct problem.317

6.1 Non-Energy Extractive Industries

6.1.1 How the R&I Process Works

Research and Innovation (R&I) is critical in improving productivity, guaranteeing minerals and raw materials supply and thereby maintaining competitiveness of the non-energy extractive industries of the EU NEEI. Innovation can help to lower the demand for energy and labour, both key components in the NEEI. Many thousands of R&I projects are currently being undertaken, however many are limited to individual companies, countries or disciplines within the mining and raw materials sector.

6.1.2 What Drives Innovation

According to the industry interviews undertaken during this study, there are two primary drivers for research and innovation in the mining and quarrying sectors that apply to both developed and developing nations, albeit to differing degrees.

The first is environmental concerns, particularly in more developed economies. Technologies such as integrated waste management facilities have been developed in response to environmental concerns and the footprints of large scale mining operations are being monitored and calculated. The stability and security of tailings are also being closely observed. Similarly, paste and thickened tailings are being used to reduce the risk of containment failures and to reduce the scale of tailings storage facilities (TSF’s).

The second major driver is energy requirements. More developed economies are under increasing pressure to improve the efficiency of their operations, use less energy and produce less adverse environmental impacts through the use of renewable energy sources (e.g. wind, solar PVs, etc.). Developing economies are also coming under pressure but the primary driver in that case is the availability of sufficient power generation to meet demands of large scale mining operations, rather than the source. Glencore Xstrara Plc’s Katanga mining project in the Democratic Republic of Congo (DRC) lost 67 days of output in 2012 due to recurrent power disruptions. For this reason, mines are keen to become less dependent on national power infrastructure (i.e. the grid) and to develop ways of generating (renewable) power on-site to meet periods of high demand.


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6.1.3 Types of R&I Projects

Research projects are being undertaken worldwide by both academia and industry, as well as through intra-industry collaborations, addressing mining methods, metallurgy and recycling for most, if not all of the minerals and raw materials covered in this study. It has not been possible to find specific information for many of the projects undertaken by industry due to their commercial nature.

Projects can be assigned a commercial status using the ‘Technology Readiness Level’ (TRL). This tool allows pre-commercial technologies to be assessed on a scale between 1 and 9 (1 being the most commercial immature technology and 9 being the most commercially mature). Where identifying the specific TRL of a technology was not possible, the general group it falls within was discussed as follows:

- TRL 1-2: Basic Research
- TRL 3-5: Applied Research and Development
- TRL 6-7: Demonstration
- TRL 8-9: Pre-commercial Deployment

A large number of new technologies or processes close to market readiness would suggest a competitive advantage from R&I activities. In general R&I projects seem to focus on processes or steps in the production chain rather than simply on specific minerals or raw materials. R&I projects for specific minerals and raw materials tend to be more localised and dictated by the type of mineralisation within the geological strata. Examples of the key R&I initiatives undertaken by the public sector and academia in the EU28 for the minerals and raw materials considered in this study are summarised in Technical Appendix (A7.0).

6.1.4 Types of R&I Expenditure

Different types of R&I expenditure exist for the mining and quarrying industry e.g. private sector, public sector, abroad, ‘other’, etc. It is useful to compare how the R&I expenditure varies between the EU28 and the comparator countries over time and how this expenditure is being allocated between various activities. Particularly in the context of the EU28 it would be useful to determine how changes to R&I expenditure over time might affect the EU’s ability to remain competitiveness with regards to its NEEI.

Data relating to R&I expenditure into the mining and quarrying industries from a variety of funding sources across countries has been taken from the Organisation for Economic Co-operation and Development (OECD). This dataset presents annual data on R&D expenditures made by business enterprises in the mining and quarrying sectors and financed by all possible sources of funds, such as businesses, government, abroad, ‘other’. All sums and totals presented are in current prices and utilise Purchasing Power Parity (PPP), which corrects for currency exchange rates and makes all currencies directly comparable to the USA Dollar (US$). The EU Member States used in this analysis are:

- Germany;

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318 A tool which allows pre-commercial technologies to be assessed on a scale between 1-9, with 1 being the most commercially immature technology and 9 being the most technologically mature.

► France;
► United Kingdom;
► Spain;
► Italy;
► Poland; and
► Finland.

In order to assess how the EU28 are performing relative to comparator countries, the following comparator countries have been selected due to the availability of funding data in R&I, but also based on their prominence in the global mining industry;
► Canada;
► Norway;
► Mexico;
► Japan;
► USA;
► Australia; and
► China.

Figure 65 shows the gross domestic expenditure on R&D (GERD) as a proportion of GDP for selected EU Member States and comparator countries, distinguishing between public, private and ‘other’320 sources of funding. The data indicates that the percentage of GDP allocated to R&D across various funding sources differs between countries, with Japan and the USA allocating the highest proportion of GDP to R&D (3.36% and 2.91% respectively). The highest percentage of GDP to R&D within the EU28 is in Germany (2.82%), followed by France (2.25%), with the lowest percentage from the observed countries being in Italy (1.26%). Once again private sector funding in R&D seems to be the biggest contributor to national research budgets, followed by contributions from the public sector (i.e. government). It is interesting to note that despite the growing budget for China to invest in R&D, it still lacks behind historic powerhouses such as the USA, which could reflect on its competitiveness for the NEEI as compared to the USA.

320 ‘Other’ funding sources include Higher education; Private non-profit; Abroad; and Unspecified source of funds.
6.1.4.1 Expenditure by Industry

Based on the most current data provided by the OECD, UK businesses invest significantly more than other businesses in other EU28 Member States in R&D for the mining and quarrying sectors. This investment however is still considerably lower than the comparator countries. The R&D investment made by businesses in all seven of the selected EU Member States for the mining and quarrying sectors amounted to ~US$530 million (using most recent data available for each country) but still falls short of the individual contributions made by some of the comparator countries as presented in Figure 66. Businesses in China for example invested US$6.62 billion in 2012, followed by the USA with US$2.73 billion in 2011 and Australia with US$2.72 billion in 2011 (using current prices in million PPP US dollars). It should be noted that in some countries, such as China, some of the businesses are likely to be state owned enterprises and therefore some of this expenditure could be reclassified as public sector investment. There is also significant doubt surrounding the quality of the OECD figures for other countries, as over time the level of investment in a number of Member States appear to change dramatically.

Source: Scienceogram (2013)\(^{321}\)

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6.1.4.2 Expenditure by Governments

The importance of investing in R&D can also be seen in the public sector where Europe’s 2020\textsuperscript{324} strategy identifies funding in R&D as a key component of the strategy for economic growth. Government R&D budgets dictated by public policy provide an indication of the relative importance of various socio-economic objectives such as the NEEI to the country’s economy and can stimulate and orientate innovation efforts from the private sector to address these.\textsuperscript{325} One of the five targets for the EU in 2020 is for 3\% of EU’s GDP to be invested in R&D, in order to capitalise on Europe’s scientific expertise and create marketable products and services. Another aim is to strengthen the EU’s knowledge base and relationship between research, innovation and education, in order to stimulate a further expansion of the digital economy. The main mechanism for public sector funding is

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Horizon 2020, running from 2014 to 2020, which will be investing nearly €80,000 million in research and innovation, with a focus of turning scientific breakthroughs into innovative goods and services that have the potential to provide business opportunities, create new jobs and change people’s lives for the better.

Data for government budget appropriations or outlays for R&D (GBAORD) for the exploration and exploitation of the Earth over time, indicates that the USA is leading the way in the size of government budgets allocated for R&D for the NEEI, with other comparator countries such as Japan and Australia also exhibiting an upward trend in budgets. Germany has historically had the highest government budget for R&D for the EU28 followed by the UK.

6.1.4.1 European Innovation Partnership (EIP) on Raw Materials

European Innovation Partnerships (EIPs) are initiatives launched under the Innovation Union that focus on the societal benefits of research and innovation and the acceleration of the market take up of innovations which address key challenges for Europe. The EIP on raw materials focuses on non-energy non-agricultural raw materials, including metals, industrial minerals and construction minerals. Its main aim is to help raise industry’s contribution to the EU GDP to around 20% by 2020. It will also play a role in meeting the objectives set by the Innovation Union itself and those set by Resource Efficient Europe (the flagship initiative for a resource-efficient Europe under the Europe 2020 strategy). The EIP states that this will be done by ensuring the sustainable supply of raw materials to the European economy whilst increasing benefits for society as a whole.

The EIP’s Strategic Implementation Plan lists a number of concrete targets that are to be achieved by 2020. These include, amongst other things, up to ten innovation pilot actions on exploration, mining, processing, and recycling for innovative production of raw materials. A call for commitments was held in 2013 for projects relevant to the targets. Further calls for commitments are scheduled for 2015, 2017 and 2019, making it difficult to assess the impact that this partnership will have in the short and medium term future. However, the planned collaboration of Member States, companies, researchers and NGOs to ensure the development and implementation of innovative solutions along the entire value chain of raw materials should produce tangible steps towards increasing the competitiveness of the NEEI and RI.

6.2 Recycling Industries

6.2.1 What Drives Innovation

Many EU policies exist to support this shift to recycling. For example, there’s the EC’s Action Plan on Sustainable Production and Consumption and Sustainable Industry (European Commission, 2008a), the 2008 communication from the EC on the Raw Material Initiative
(European Commission, 2008b), the European Council’s communication of the need to focus on ‘steering the market towards recycling and waste reduction and recycling certificates’ in 2010 and the role of recycling in the many waste management and resource efficiency policies in Member States (EEA, 2011).

Other than these policies there are also many drivers behind this shift, all of which are more prominent in the EU28 as opposed to the comparator countries. These are summarised in Table 37.

**Table 37: Drivers for Research and Innovation in the EU28**

<table>
<thead>
<tr>
<th>Driver</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher energy and labour costs than some competitors</td>
<td>The EU28 is a higher cost environment, partly due to higher energy and labour costs than some competitors. Cost pressures have inevitable led the EU’s RI to invest in research and innovation in order to become the most technologically advanced, most capital intensive and most resource efficient sector globally with regards to its recycling industries in order to be able to be competitive. Other than alleviating some of these cost pressures and ensuring compliance with regulation, investing in recycling has meant investing in higher value added production.</td>
</tr>
<tr>
<td>Waste hierarchy</td>
<td>The waste hierarchy promotes the recycling of wastes ahead of disposal and recovery activities and acts as a key driver to invest in recycling activities.</td>
</tr>
<tr>
<td>Alternative source of supply</td>
<td>Reducing imports of primary sources of minerals through supplementing demand with recycled materials thus contributing to the EU supply chain. This is crucial given the scarcity of primary raw materials supply in the EU28 and the high global prices for primary raw materials</td>
</tr>
<tr>
<td>Creating employment</td>
<td>Generating local jobs at various skill levels, including higher income levels (e.g. collection, materials handling, processing to manufacturing products, etc.) compared to other forms of waste management, as these services are dispersed all over the EU Territory. For example between 2000 and 2007 EU employment related to recycled materials had an annual growth rate of ~11%, the second largest increase of all eco-industry sub-sectors (to include: water supply, wastewater treatment, waste management, renewable energy, air pollution, biodiversity, soil and groundwater, noise and vibration and others).</td>
</tr>
</tbody>
</table>

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| Generation of new sources of income | The potential to develop new technology (e.g. BATs on recycling) and services (e.g. knowledge, systems, management approaches) for the recycling industries that can be patented, licensed and exported. Therefore investing in research and innovation for the recycling industries can lead to the generation of rent as well as global market opportunities for innovative solution providers, and an increase in EU competitiveness. |

Despite the many drivers for investing in R&I for the recycling industries however, many barriers to investment also exist. The many EU Directives and other relevant legislation vary in their interpretation and implementation between Member States, creating a confusing and uneven operating environment, potentially discouraging investment. Recycling is still quite expensive for certain types of raw materials, which limits investments in their innovation.

Lack of good quality data on mineral and raw material waste statistics makes it hard to construct a solid business cases for potential investors, as does the increase in illegal waste dumping, which threatens the EU's supply of recyclates. This hinders investment in innovation in terms of the recycling industries to the benefit of metal producing countries such as China, Russia and India. Additionally complex product design can disadvantage recycling, wherever it is takes place.

Although it is important to address all of these barriers and ensure that recycling meets its full potential in the EU in terms of providing material inputs to the economy, it is worth noting that even if all mineral and raw material waste were recycled then it could only meet the demands of a substantial part but not all of EU material consumption, and that’s assuming that the quality of the recyclables fully matches the quality demands of the raw materials’ recycling industries.

Recycling already covers in weight, 10% of the EU consumption of aluminium, 28% of ‘other metals’ (the relevant ones to this research are silver, gold, platinum, zinc, tin, cobalt, indium and niobium), 9% of copper and 4% of WEEE. In the case of aluminium, the potential contribution from recycling to consumption could increase to ~15%, for ‘other metals’ it could increase to ~50%, for copper it could increase to ~12%, and for WEEE it could increase to ~8%.

What this indicates is that there is considerable room for improvement with recycling being able to cover a larger percentage of total EU consumption, but also that recycling alone cannot meet total EU demand for any of these raw materials. In fact it could not cover more than half of the consumption even if 100% of the related waste materials were being recycled. This is partly due to the EU economy accumulating goods, which act as a long-term storage for materials that will not become available for recycling for many years. In addition there are technical limits for recycling, which vary depending on the mineral and material, and the quality of the scrap often does not match demand, so some raw materials may need to be down-cycled as opposed to recycled. With aluminium and copper that is particularly prominent because of high levels of demand which are much greater than waste generation

331 EuroMetaux (2005) Recycling - an integral part of the non-ferrous metals industry
and recycling. Aluminium for example is increasingly used in construction, meaning increased stockpiling.  

### 6.2.2 The Role of R&I for the Recycling Industries

It is widely acknowledged that there is considerable potential to improve productivity through research and innovation within the EU, and that this is necessary for it to compete with lower-cost economies. The Lisbon Strategy and, more recently, Europe 2020 frame the importance of innovation as an important component of economic growth and as a way to remain competitive. In line with this, WRAP estimated that the commitment to the circular economy, and therefore better stewardship of resources, could increase the amount of material recycled in the EU by 31%.  

Other than enhancing resource use, recycling is also less environmentally impactful compared to extraction, and can generate jobs and business opportunities. Recycling can also ensure a supply of particularly critical resources and the continuous production of emerging technologies (e.g. solar panels, wind turbines), thereby encouraging further investment in innovation and creating markets for new products and services. It will also ensure that the EU is not limited in any future economic and technological development which could be crucial in maintaining the competitiveness of the sector because of lack of inputs to its production. Alongside the EU28, Japan and the USA also have limited raw materials reserves compared to existing consumption, and it is as crucial to them that the scarcity of rare metals does not limit future economic and technological development.  

Investing in recycling innovation can have significant economic importance for the EU economy. According to the European Environment Agency report on the economic importance of recycling to Europe, seven core group of materials dominate the EU recycling sector and from these seven, three sub-groups are relevant to this research: (i) base metals, specifically copper, aluminium, nickel and zinc; (ii) precious metals, specifically silver, gold and platinum; and (iii) other (high-tech) metals - the relevant ones from the list provided are lead, cobalt, niobium and indium. Total turnover of the EU recycling sector as it relates to these three groups of recycling materials (i.e. base metals; precious metals; and ‘other metals’), has been equal to ~15 billion Euro in 2009 (based on current prices).  

According to the Raw Materials study on innovative technologies and possible pilot plants, Europe has already become the leading continent with regard to the production of recyclates of some base metals (specifically copper, aluminium and nickel waste) and a number of other raw materials (i.e. precious metals waste such as silver, gold and platinum and ‘other metals’ waste such as cobalt, indium, niobium, zinc, etc.).  

For that to happen, innovation along the entire reuse and recycling chain (i.e. logistics, pre-processing, material recovery) is required over all possible sources (i.e. production waste streams, end-of-life products, industrial side streams like slags, dusts, effluents, etc., tailings

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333 Ibid  
and landfills), as well as in the field of monitoring and flows of end-of-life materials. New recycling technologies will not only enable higher recovery rates but also further lower associated costs with using secondary as opposed to primary raw materials.

6.2.3 Types of R&I projects

6.2.3.1 Framework Programmes

Europe 2020, agreed in March 2010, is the EU’s growth strategy for the coming decade. Aimed at fostering a “smart, sustainable and inclusive economy”, one of its central objectives is focused specifically on innovation. In support of the strategy, the Innovation Union initiative was founded in November of the same year to improve access to finance. Implementing the Innovation Union is Horizon 2020, as outlined in Section 6.1.4.2. Horizon 2020 will specifically allocate funds towards the sustainable exploration, extraction processing and recycling of raw materials. There were a total of 14 projects stemming from the previous framework programme (‘FP7’) which ran from 2007 to 2013. Six of these are focused on innovation in the recycling industry. The projects, which include the recycling of discarded automobile tyres and recovering key elements from batteries, involve the collaboration of more than 140 partners from research organisations and private companies. A summary of the projects is included in the Technical Appendix (Section A7.0)

A large number of new technologies or processes close to market readiness would suggest a competitive advantage from R&I activities. The results of our research however might be slightly skewed as more evidence was expected to be available for the most developed technologies, as these have been typically in existence longer than the less mature technologies.

FP7 focussed on more than just research and development for specific projects, but also at nurturing the environment for innovation. In this way it has contributed significantly to the development of new technologies in the recycling industry. However, it is difficult to quantify their contribution as there is no insight into the uptake of these technologies in mainstream production.

6.2.3.2 Patents

The number of patents filed can be a good proxy for innovation. Eurostat publishes international data on patent applications over 1996 – 2007 (the most recent data available), which allows for some comparison with countries outside of the EU. A report by ECORYS for the European Commission noted that the EU filed the largest amount of patent applications

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for the basic metals sector over this period (12,335). The USA filed the second largest number of patents (5,371), and Japan third (4,636). According to the report, China averaged just over eight patents a year over this period. 343 Evidence on patents related to the industrial and construction minerals sub-sector were not presented (only the metal sub-sector was presented). Nonetheless, they suggest that the EU has played a key role in the development and application of innovative technologies in at least the basic metals sector, and should continue to invest in R&I to maintain that position and thereby its competitiveness.

In 2013, the World Intellectual Property Organisation released research on the patent landscape for e-waste recycling technologies. 344 The report found that the vast majority of patent activity in e-waste is Asian in nature, followed by activity from Europe. The United States makes up a relatively small proportion of activity, indicating a potential disinterest by USA entities in e-waste technology. The report commented on the emergence of Chinese domestic patent activity overall within the e-waste industry. Patent application rates have increased seven-fold in just 6 years, and is largely driven by academic institutions. This perhaps indicates the existence of incentive schemes for academic patent filing, a point bolstered by the fact that very few Chinese domestic patent applications are also filed in other jurisdictions – a common occurrence for patent rights from other territories. Therefore, it is difficult as yet to assert what the wider implication of this explosion of intellectual property (IP) activity in China will ultimately be. The huge growth also means that the majority of these patents are still applications, as applications tend to remain pending for a period of four years or more, and other metrics of patent quality such as citation rates and patent sales are also somewhat tied to age.

### 6.2.3.3 Case-studies of Comparator Countries

**Australia**

In Australia the raw materials industry is a major contributor to national income, investment, jobs, exports and government revenues. Although the vast majority of these benefits are associated with extraction and processing, there is also evidence of a strong focus on fostering new technologies and research and development in the recycling industry. This serves to demonstrate Australia’s long-term commitment to fostering innovation and, in doing so, sustaining competitiveness.

In the state of Victoria, seven new recycling projects have been given AUD 2.4 million funding in part of a drive to increase investment in recycling. It is hoped that the successful projects have the potential to generate more than AUD 11 million in private investment. However, the focus in these areas for now is on glass, timber, cardboard and general recyclables materials rather than minerals. 345

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The New South Wales government has set aside a Recycling Innovation Fund, specifically targeting the renovation of infrastructure, research and development and increasing recovery of residual waste from recyclers. It is hoped that the AUD 15 million fund will, over 5 years, support industry, councils, not-for-profit organisations and charities to develop projects that provide innovative solutions. The grants will be split into three key program areas:

- Priority Waste Infrastructure program;
- Recycled Markets program; and
- Metal Shredders program.

A list of projects that have received funding has not been released at the time of writing.

South Australia (SA), working with various organisations, such as the Zero Waste SA centre for Sustainable Design and Behaviour, the National Centre for Contamination and Remediation of the Environment and ARRB Group Ltd, has exhibited similar efforts to boost innovation in the sector.

Chile

Fewer examples of research and innovation in the recycling industry are evident in Chile. This is mainly because many firms innovate through the adaptation of imported technologies. In this way it was not possible to identify relevant research and innovation projects in the country.

With regards to WEEE, the Regional Platform on Electronic Waste for Latin America and the Caribbean (RELAC Platform), a civil society initiative, has been working to systematise information, research and studies in this area since 2004. It has also created a public-private working group to promote the implementation of an e-waste management system in Chile.

In recent years Chile’s WEEE market has been hampered by a lack of regulation, with black market operators undermining more environmentally conscious operators. It is hoped that new legislation, passed in 2014, will have an altogether positive impact on the sector and encourage private investment in research and innovation and, ultimately, increasing the recovery of valuable materials.
6.2.4 Types of R&I Expenditure

The allocation of resources to R&I can lead to the development of new products and to innovations that make industrial and manufacturing processes cheaper, subsequently increasing recovery rates and decreasing operating cost structures. Where data is available for a particular R&I program, outcomes can be assessed by examining:

1. Whether the scheme has led to new products and processes;
2. How well these products and processes perform; and
3. How the benefits of these new products and processes compare to the costs of the R&I program.

However there is little or no documented evidence available on the outcomes of a particular scheme, in terms of new products or processes that are the direct results of investments in R&I for the RI. Therefore an assessment of the extent of funding provided to R&I programs by industry and other sources (e.g. academia) and what the split of resources between R&I activities is in the EU28 and the comparator countries, could be a better indicator of the relative impact of R&I on competitiveness.

Eurostat provides information on the amount of spending on R&I across all industries (it was not possible to identify R&I funding allocation just for the recycling industries of the raw materials sector). The remaining share is financed by government, higher education and the private non-profit sector. EU’s percentage spend on R&I by industry has remained relatively static since 2000 – accounting for approximately 55% of all R&I. In contrast, China’s R&I industry sector has increased spend over recent years, rising from 60% of the total in 2000 to 74% in 2011. This increase reflects activities by private domestic and multinational companies as well as the conversion of government-owned enterprises to the private sector. Japan’s industry expenditure has remained constant around 75% since 2000, whilst USA’s industry expenditure has declined from 70% to 60% between 2000 and 2011. This provides an indication of European-wide spending on R&I and shows that businesses lag significantly behind Japan, China and the USA.

Not many metrics exist for capturing R&I. However in the case of R&D, ‘Research and development intensity’ defined as R&D spending as a percent of GDP, is a measure of the relative importance of R&D within a nation’s economy and provides a basis for international comparisons of R&D performance. This measure takes into account industry, academic and government spending. Table 38 presents the R&D intensity for the EU and comparator countries. From this it can be seen that the EU, although it has a larger R&D intensity than many of the comparator countries, falls well behind the researching powers USA and Japan.

The R&D intensity of the USA reached a historical high of 2.85 in 2009. Most of the growth can be attributed to increases in non-federal R&D spending, primarily that financed by industry. This increase in the non-federal proportion of R&D intensity reflects the growing role of industry R&D and, more broadly, the growing prominence of R&D-derived products.

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and services in the national and global economies.\(^{354}\) Indeed, in the context of innovation, many standard indicators reveal that the EU suffers significant disadvantages compared to the USA. For example, previous research has found that innovation capacity, scientific publications and citations, patenting, R&D investments are all higher in the USA\(^{355}\). By contrast, Japan’s high ratio reflects in part the confluence of declining GDP and largely flat R&D spending.

### Table 38: R&D Intensity of the EU and Comparator Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Year of Data</th>
<th>Gross Expenditure on Research and Development (GERD) (€ millions)</th>
<th>R&amp;D intensity (GERD/GDP) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU28</td>
<td>2011</td>
<td>230,213</td>
<td>1.94</td>
</tr>
<tr>
<td>Australia</td>
<td>2010</td>
<td>15,522</td>
<td>2.20</td>
</tr>
<tr>
<td>Brazil</td>
<td>2010</td>
<td>19,115</td>
<td>1.16</td>
</tr>
<tr>
<td>Canada</td>
<td>2011</td>
<td>17,449</td>
<td>1.74</td>
</tr>
<tr>
<td>Chile</td>
<td>2010</td>
<td>1,004</td>
<td>0.42</td>
</tr>
<tr>
<td>China</td>
<td>2011</td>
<td>149,549</td>
<td>1.84</td>
</tr>
<tr>
<td>India</td>
<td>2007</td>
<td>17,735</td>
<td>0.76</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2009</td>
<td>575</td>
<td>0.08</td>
</tr>
<tr>
<td>Japan</td>
<td>2011</td>
<td>105,271</td>
<td>3.39</td>
</tr>
<tr>
<td>Mexico</td>
<td>2011</td>
<td>5,898</td>
<td>0.43</td>
</tr>
<tr>
<td>Russia</td>
<td>2011</td>
<td>25,176</td>
<td>1.09</td>
</tr>
<tr>
<td>South Africa</td>
<td>2009</td>
<td>3,166</td>
<td>0.87</td>
</tr>
<tr>
<td>USA</td>
<td>2011</td>
<td>308,292</td>
<td>2.85</td>
</tr>
</tbody>
</table>

**Notes:**

All currencies have been converted from USA Dollars ($) to Euro (€) using respective Eurostat exchange rates.

**Source:** National Science Foundation (2014)\(^{356}\)

#### 6.2.4.1 Split of Allocated Resources within R&I Activities

Any spend on R&I will be split among a number of different activities. Some of these will potentially lead directly to improved productivity (for example new technologies, processes etc.) whilst others may improve knowledge but not deliver any tangible benefits for the industry. An analysis of the projects identified in Section 6.2.3 suggests that there is a

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\(^{354}\) Ibid.


greater focus on R&I in relation to metals and the development of new technologies in the EU.

6.2.4.2 Balance between R&I Activity by Industry and Academic Organisations

EU28

Owing to a lack of available data, it is not possible to satisfactorily quantify the balance of R&I activity in the recycling industries between academia and industry within the EU28. Therefore, this section provides information on general trends within the recycling R&I landscape, citing specific examples by way of illustration.

Research and development of new waste collection technology, such as collection vehicles, is largely waste industry led—although in some cases the development process may be catalysed through governmental strategy and projects.\(^{357}\) In terms of material recovery technologies, however, R&I activity is conducted by both industry and academia, often in conjunction with one another. The large number of academic institutions in the EU28 provides a fertile environment for the development of new and innovative technologies.

Funded by the EU, industry has been working in conjunction with academia on a pair of projects aimed at improving the recovery of hydrometallurgical components such as indium, cobalt, zinc, and copper from waste electrical and electronic items (WEEE).\(^{358}\) The HydroWEEE project and HydroWEEE-DEMO focus on serving the recycling needs of small and medium sized enterprises (SMEs). The Hydro-WEEE-DEMO developed a mobile recycling plant, capable of being accessed by several SMEs at any point. Dominance in WEEE recycling has been drifting towards large, multinational companies, and this project seeks to re-localise capabilities in this area. These projects aid European competitiveness by increasing resource efficiency and empowering regionalised businesses.\(^{359}\)

Academia may also self-fund research into material recovery technology, such as the University of Leuven (Belgium) funded ‘RARE³ Research Platform for the Advanced Recycling and Reuse of Rare Earths’.\(^ {360}\) This project is seeing a team of chemists, chemical engineers, metallurgists, material scientists, economists, and life cycle analysis experts collaborate in developing innovative recycling processes based on non-aqueous technologies for the recovery of rare earths from permanent magnets and lamp phosphorus.

Research aimed at improving health and safety levels in the shipbreaking industry—a major source of scrap metals—has been conducted through an academic route by scientists from Dalarna University, Sweden.\(^ {361}\) This focussed on developing techniques to measure

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\(^{357}\) See, for example: WRAP (2011) Collection Vehicle Research and Development, October 2011


\(^{359}\) CONVERIS Research database; accessed 9 September 2014, http://www.healthcompetence.eu/converis/publicweb/project/5051;jsessionid=c50544308dc9309dda5d80c68198?show=Person


\(^{361}\) Making shipbreaking a safer craft - Information Centre - Research & Innovation - European Commission, accessed 9 September 2014,
exposure levels, such as for toxic fumes, faced by workers. The data gathered as a result of the innovation in measurement will subsequently be used to develop international standards for ship dismantling. This academic research conducted through EU funding as part of the Dismantling of Vessels with Enhanced Safety and Technology (DIVEST) project.

Industry also conducts its own research as part of business strategy. For example, waste service provider Veolia runs Veolia Environment Research & Innovation (VERI), which consists of 450 scientists and engineers working on new solutions in the area of waste, in addition to other areas of Veolia’s services portfolio.\(^{362}\)

The mineral processing industry also conducts R&I for recycled material. Belgian chemical group Solvay ran a 2007–2009 research and development project focussed on recovery of rare earths from low energy light bulbs.\(^{363}\)

**Comparator Countries**

**Japan**

Japan is leading the vanguard in rare earth recycling, and has seen a $1.5 million dollar Hitachi research project, part funded by government. This industry research project, which lasted a year, has resulted in the development of automated machinery capable of stripping compressors and removing the drives inside in a form suitable for further rare earth recovery. Mitsubishi has also begun research into the economics of extracting neodymium and dysprosium from washing machines and air conditioners.

**USA**

In the USA, the Department of Energy (DOE) has formed a collaborative partnership with industry researching advanced techniques for the recovery aluminium alloys from end-of-life-vehicle (ELV) for specific secondary manufacturing needs.\(^{364}\)

### 6.2.4.3 Global concentration of R&I

In many cases the concentration of R&I activities is based on historical factors, such as where the industry first emerged, and it has not subsequently transferred. However, it is to be expected that the areas where R&I is concentrated will most immediately benefit from the results of these activities, and therefore concentration of R&I will indicate which regions may benefit more quickly from R&I, and therefore have a competitive advantage.

A number of different measures, such as expenditure and employment, could be used to examine the global distribution of R&I for the RI. While there is no R&I information published specifically for the RI, it is useful, however, to look at high-level trends in R&I expenditure across all industries.

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\(^{362}\) Research and innovation for sustainable success - Veolia Environmental Services UK, accessed 9 September 2014, [http://www.annualreview2010.veoliaenvironmentalservices.co.uk/planet/anticipate-innovate](http://www.annualreview2010.veoliaenvironmentalservices.co.uk/planet/anticipate-innovate)


Worldwide R&D expenditures have shown rapid growth in recent years, increasing from an estimated $1,051 billion (current PPP US dollars) in 2006 to $1,435 billion in 2011. R&D activities are predominantly concentrated in three geographic areas: North America, the region covering East/Southeast and South Asia, and Europe. These regions accounted for 32%, 34% and 24% of global R&D expenditure respectively in 2011. This geographical distribution is evident in Figure 67, which presents historic trends in total R&D expenditure for the EU28 and a selection of comparison countries.

366 International comparisons involve currency conversions; the data presented here follows the international convention to convert foreign currencies into USA dollars via purchasing power parity (PPP) exchange rates.
Figure 67 indicates that a large concentration of R&I activities take place in Europe, exceeded only by the USA in magnitude. Between 2000 and 2012, total R&D expenditure in Europe grew at an average annual rate of 5.3% per year, slightly higher than the USA, at 4.5%. However, such rates are low compared to China. With an exceptionally high average growth rate of 20.1% in real terms, it is likely that China will have a greater concentration of R&I activities than Europe in the near future.

Employment trends tell a similar story. Figure 68 presents employment trends in R&D for the EU28 and comparator countries (no data was available for the USA). These demonstrate that China already has a significantly higher number of full time employees in R&D sectors compared to the EU28.

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367 2012 data was available for all EU28 countries with the exception of France, for which a forecasted value, calculated using the average growth rate between 2000 and 2011, was used.
6.2.4.4 Trends in R&I Over Time

Forecasts for R&D expenditure over the last three years are provided in Table 39. Future forecasts predict a continuation of these trends, and a gradual shift in R&I concentration from west to east. This growth is mainly driven by China, however, other countries, such as South Korea and Russia, also show strong leadership in R&D investment.  

Table 39: Forecasts for Gross Domestic Expenditure on R&D

<table>
<thead>
<tr>
<th></th>
<th>Gross Domestic Expenditure on R&amp;D (billion current PPP $)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2012</td>
</tr>
<tr>
<td>United States</td>
<td>447</td>
</tr>
<tr>
<td>China</td>
<td>232</td>
</tr>
<tr>
<td>Japan</td>
<td>160</td>
</tr>
<tr>
<td>India</td>
<td>41</td>
</tr>
<tr>
<td>Europe</td>
<td>350</td>
</tr>
</tbody>
</table>

Source: Battelle and R&D Magazine (2013)  


The EU was the only world region that had negative growth in 2013, and real GDP growth is projected to advance at moderate rates of 1.6% and 2.0% in 2014 and 2015 respectively in the EU area. These economic conditions are reflected in R&D expenditures, which are predicted to have stayed relatively flat between 2012 and 2014 (Table 39). Substantial budgets are, however, also being allocated to future research programs in the EU as indicated by Horizon 2020 (outlined in Section 6.1.4.2).

China has a high political ambition to continue investment in R&D in the future, following the trend indicated in Table 39. China is already an established location for cost-effective manufacturing, which has heavily contributed to its rapid economic growth in recent years. To ensure consolidation of this growth in coming years, China intends to evolve to an innovation based economy by 2020, requiring significant increased investment in R&D. A reputable long-term forecast has predicted that China’s investment in R&D is expected to surpass that of the USA by about 2022, when both countries are likely to reach about $600 billion in R&D.

The modest growth demonstrated by the USA in R&D expenditure is expected to continue through 2020. The USA has always demonstrated a strong commitment to R&D, with total spending ranging from between 2.5% and 2.8% of GDP over the last 15 years. Expert opinion is that this reliable trend is set to continue, despite continuing economic and governance challenges. Bipartisan support for publicly funded R&D continues in the USA, and there is a general acknowledgement in political circles that R&D investment has both short- and long-term return to the economy.

Investment in R&I is inextricably linked to the ability of EU28 to remain competitive with regards to the recycling industries against the comparator countries, particularly China. The EU should in the very least aim to maintain the current level of resources it is investing in R&I and consider how to provide the necessary incentives for industry and academia to increase the amount of resources they are investing in the recycling industries.

6.3 Summary of Findings

As highlighted in policy and legislation (Section 4.0) and raw material supply (Section 5.0) assessments, the EU28 NEEI and RI are faced with a number of significant challenges in respect of competitiveness. By undertaking R&I activity, operators in both sectors may be able to overcome some of these key challenges.

6.3.1 Non-Energy Extractive Industries

For the EU investing in R&I has been made a priority in the regulatory and policy framework with the Lisbon Strategy and Europe 2020. The framework recognises that innovation is an important component of economic growth.

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In a high cost environment such as that of the EU28, whether that’s due to higher energy and labour costs or stricter environmental regulations, R&I can lead to higher productivity. Although it has been difficult to determine exactly what the projects, technologies and products receiving funding for the NEEI (especially considering private expenditure), or what patents are in the pipeline, which can be a good proxy for innovation, the anecdotal evidence we have found and rated using the standardised Technology Readiness Level (TRL) indicate a focus on technologies or projects close to or at market readiness (i.e. TRL of 8-9), which would suggest a competitive advantage for the EU28 from R&I activities. Examined at sub-sector level, many of the projects appear to be focused on the metals sub-sector.

Precise estimates of the expenditure on NEEI R&I activity has not been made available; however, when comparing the total expenditure on NEEI by businesses, the EU28 appears to be at a slight disadvantage when compared to some comparison countries.

The public sector is also a key participant in driving innovation. Europe’s 2020 strategy identifies funding in R&D as a key component of the strategy for economic growth. However, the EU28 is not alone in driving innovation, and public expenditure in other competitor countries is showing an upward trend.

During this assessment, it has not been possible to assess the success of historic R&I activity within the EU28. Increasingly, publicly awarded funding is required to be evaluated and therefore improvements might be expected to be observed in the value for money delivered by certain types of research.

There may also be two other important considerations when considering the value of the research undertaken in the EU28. Firstly, the nature of the R&I activity is often focussed at reducing high cost activities. For the NEEI in the EU28, these are typically aimed at lowering energy and labour consumption. Whilst significant gains may be made, it is unclear how the net impact of these activities compares to the costs of activity within the NEEI outside of the EU28 not utilising such R&I knowledge.

The second consideration is the question of whether knowledge gained through R&I activity is likely to remain within the nation state(s) it was undertaken. For some (note not all) activity, the actors involved in R&I are global enterprises. Thus there is a risk of ‘leakage’ of knowledge beyond the place where the R&I is funded. Whilst this aspect could work to the EU28’s advantage, it does represent a risk that the benefits of EU28 funded R&I may also benefit competitor countries.

Figure 69 provides an illustrative assessment of competitiveness with respect for research and innovation for the NEEI. The figure is based on a qualitative interpretation of the data identified and derived, at least in part, from the consensus of views and evidence obtained in this study.

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6.3.2 Recycling Industries

Like the NEEI, the EU28 RI has a number of drivers in the market which encourage investment in R&I. These drivers include energy and labour costs, the waste hierarchy and the need for alternative sources of supply. The drivers, however, are not necessarily unique to the EU28, and to some extent these drivers also are apparent in other competitor countries, thus motivating the mobilisation of R&I activity.

The assessment has highlighted that the EU28 has a number of venues, whereby R&I activity can be hosted and demonstrated. The EU28 is not unique in this regard; however, combined with the drivers in the market, the EU28 is highly competitive when compared to comparison countries.

With respect of spending on R&I activity within the RI, reliable and comparable data has been unable to be identified, though it is clear that the EU28 is investing large sums of money in to the RI.

Figure 70 provides an illustrative assessment of competitiveness with respect for research and innovation for the RI. The figure is based on a qualitative interpretation of the data identified and derived, at least in part, from the consensus of views and evidence obtained in this study.
Figure 70: Research and Innovation Competitiveness - RI

Notes:
1) The figure is based on a subjective assessment of the competitiveness based on the author's views.
2) Lines nearer to the centre of the shape denote lower levels of competiveness. Lines towards the outside of the shape denote higher levels of competiveness.
3) RoW (Rest of the World) is based on the analysis of the representative countries presented in this research.
7.0 SWOT Analysis

To summarise the findings in the main body of this report we have chosen to employ a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. This focuses on the internal and external environments, examining the strengths and weaknesses in the internal environment and opportunities and threats in the external environment of the EU MRMS.

The tables below summarise the strengths, weaknesses, opportunities and threats (or characteristics) for the EU28 NEEI and RI, with each row representing a specific characteristic of the sector based on the assessment provided in Sections 4.0 to 6.0). The tables aim to show what area of analysis the characteristic relates to (for example, policy and legislation), give a brief explanation of its nature and outline which mineral sub-sectors it is relevant to.

For the majority of characteristics identified, all mineral sub-sectors have been checked in the right-hand columns. This is because, for the most part, they are sector-wide impacts and, although they may have a more acute effect on one sector, they have a significant impact on all.

7.1 Non-Energy Extractive Industries

This section outlines the main characteristics of the EU NEEI and, in doing so, identifies areas of competitive advantage or where there is the potential to improve competitiveness. The discussion below summarises the findings for each area of analysis (policy and legislation, material supply and R&I), with more detail presented in the accompanying tables.

Within the EU28 there are a number of strengths which bear favourably on the industry’s competitiveness. Policy and legislation within the EU28 generally provides a stable framework for investment, not least in comparison with some competitor countries. The relatively strong emphasis on social and environmental protection can also contribute to ensuring that the EU develops a sector that is sustainable in the long term. Additionally there is an increasingly strong appreciation, and political will, throughout the EU28 to seek to ensure a secure of supply of materials for industry, an aspect which should improve the outlook for the EU28 NEEI.

In respect of material supply, the EU28 has excellent transport networks and infrastructure which facilitate the movement of goods from places of extraction to locations where they are used. There is also strong support for R&I activity within the EU28 – especially from public funds. This combined with a wide range of diverse academic facilities provide a fertile environment for new innovative technologies to be developed within the EU28.

In the course of the assessment a number of weaknesses have also been identified. In relation to policy and legislation, although the stability of the investment climate is regarded as a positive factor, the legislative background is also highly complex and often unevenly implemented and regulated within the EU28 which can discourage investment. Additionally, whilst there is political will to ensure security of supply, political opposition, as well as public opposition, especially locally, can work to hinder the development of the extractive industries.
Whilst comprehensive data is lacking, it is understood that some of the operators in the EU28 also experiences higher costs, specifically in regards to labour, when compared to competitor countries.

In respect of raw material supply, a key deficiency within the EU28 is a lack of knowledge of mineral endowment. This places the metals and industrial minerals sub-groups within the EU28 at a fundamental disadvantage to other comparison countries. Additionally, we have identified a number of countries which promote private sector investment in exploration. Such measures are rarely found in the EU28. In addition, it is notable that the mining depth for some metallic commodities in the EU28 is deeper than in many competitor countries and thus is likely to result in higher costs within the EU28.

Although R&D activity in Europe receives strong public sector support and funding, current levels of private funding are higher in the comparator countries. ‘Leakage’ of R&I knowledge outside the EU28 is also a risk.

7.1.1 **Strengths- NEEI**

Table 40 summarises the key strengths identified in the assessment. These strengths are summarised from the research provided in Sections 4.0 to 6.0.
### Table 40: Strengths for the EU28 NEEI

<table>
<thead>
<tr>
<th>ID</th>
<th>Strength</th>
<th>Area(s) of Assessment</th>
<th>Description</th>
<th>Relevant Sub-Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEEI-S1</td>
<td>Robust and stable legislation</td>
<td>Policy and Legislation - Section</td>
<td>A strong policy landscape provides a stable business environment and can add benefit through sustainable development, higher value products and increased investment.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-S2</td>
<td>Political will to ensure security of supply</td>
<td>Policy and Legislation - Section 4.1.4.1 and Raw Material Supply – Section 5.1.5</td>
<td>Europe relies heavily on the import of raw materials and minerals and the EU is taking measures to counter this in order to increase domestic growth. The Raw Materials Initiative, amongst other policies, act as a solid regulatory framework behind the sector.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-S3</td>
<td>Proven closure planning and aftercare track record</td>
<td>Policy and Legislation - Section 4.1.5.1</td>
<td>The EU places a strong emphasis on monitoring all risks associated with mining and quarrying activities. Compliance with the Mining Waste Directive (Directive 2006/21/EC) requires operators of mine sites to develop detailed proposals for site closure which maintain a sustainable industry.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-S4</td>
<td>Strong support for R&amp;I activity</td>
<td>Research and Innovation - Section 6.1.4.1</td>
<td>Investment in R&amp;I has been made a priority in the regulatory and policy framework with the Lisbon Strategy and Europe 2020 with the recognition that innovation is an important component of economic growth. R&amp;I in the EU28 more often focused on the extraction of minerals rather than processing.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-S5</td>
<td>High degree of social and environmental protection and awareness</td>
<td>Policy and Legislation – Section 4.2.4 and 4.2.3</td>
<td>The EU is a world leader in the development of policy designed to minimise the negative social and environmental impacts of industrial activity. These benefit the industry by maintaining a socially responsible industry.</td>
<td>All</td>
</tr>
<tr>
<td>ID</td>
<td>Strength</td>
<td>Area(s) of Assessment</td>
<td>Description</td>
<td>Relevant Sub-Sector</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------------------------------</td>
<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>NEEI-S6</td>
<td>Proximity to major markets and transportation routes</td>
<td>Raw Material Supply – Section 5.1.4</td>
<td>The densely populated nature of the EU28 facilitates the transport of materials between Member States. The EU is also well connected to the major shipping routes to the rest of the world.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-S6</td>
<td>Wide range of diverse academic facilities available</td>
<td>Research and Innovation – Section 6.2.4.2</td>
<td>The large number of academic institutions in the EU28 provides a fertile environment for the development of new and innovative technologies. It was not possible to quantify the contribution of academia to R&amp;I activity in this study, but it is generally recognised as being substantial, especially through partnership with industry.</td>
<td>All</td>
</tr>
</tbody>
</table>
### 7.1.2 Weaknesses – NEEI

Table 41 summarises the key weaknesses identified in the assessment. These weaknesses are summarised from the research provided in Sections 4.0 to 6.0.

**Table 41: Weaknesses for the EU28 NEEI**

<table>
<thead>
<tr>
<th>ID</th>
<th>Weakness</th>
<th>Area(s) of Assessment</th>
<th>Explanation</th>
<th>Relevant Sub-Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEEI – W1</td>
<td>Complex legislative framework with the perception of inconsistent implementation across Member States</td>
<td>Policy and Legislation – Section 4.3.1 and Raw Material Supply - Section 5.1.3.1</td>
<td>EU28 policy and legislation, although developed over a long period of time, is in some cases complex and unevenly implemented and regulated by Member States. This can, in some circumstances, deter investment in the EU28.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI – W2</td>
<td>Higher labour and energy costs within some of the EU28 compared to some competitor countries</td>
<td>Policy and Legislation – Section 4.1.2 and 4.1.5.3</td>
<td>Both labour and energy costs in some parts of the EU28 are higher than some competitor countries. Although it can be argued that high labour costs are offset by higher productivity and value added, they can pose a problem when competing with emerging economies such as India and China. With regards to higher energy costs, this has an impact on the sector – especially metal processors – due to its high energy intensity. However, this can be offset (to some extent) through high levels of energy efficiency which has been observed in some of the evidence identified in this research.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI – W3</td>
<td>Political opposition to exploration, mining and quarrying activities</td>
<td>Policy and Legislation – Section 4.1.4.2</td>
<td>Growing public awareness and increasing role of NGOs facilitated by developments in information and communication technologies has compounded the conflict between miners and the communities in which they operate.</td>
<td>All</td>
</tr>
<tr>
<td>ID</td>
<td>Weakness</td>
<td>Area(s) of Assessment</td>
<td>Explanation</td>
<td>Relevant Sub-Sector</td>
</tr>
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</tr>
<tr>
<td>NEEI – W4</td>
<td>Alternative pressures on land results in high cost of land and therefore high set-up costs</td>
<td>Raw Material Supply - Section 5.1.2</td>
<td>Access to land is a key requirement for the extractive industries, but the areas available for extraction in the EU are being steadily consumed by other land uses such as urban development, agriculture and nature conservation.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI – W5</td>
<td>Poor knowledge of mineral endowment</td>
<td>Raw Material Supply - Section 5.1.1</td>
<td>The EU’s large size, geological complexity, regulatory regime and political opposition have led to inadequate systematic exploration using modern exploration techniques and thus poor knowledge of its mineral endowment in recent years.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI – W6</td>
<td>Businesses find it difficult to access funds for mineral exploration in the EU</td>
<td>Raw Material Supply - Section 5.1.1</td>
<td>Governments in some competitor countries provide generous financial incentives to promote domestic mineral exploration.</td>
<td>Metals and industrial minerals</td>
</tr>
<tr>
<td>NEEI – W7</td>
<td>Depth of cover for metal mines are deeper in the EU28 than many other competitor countries.</td>
<td>Raw Material Supply - Section 5.1.1.2</td>
<td>Deeper mining operations are typically more expensive than surface mining operations. Thus the EU28 are likely to have higher cost operations than key competitors.</td>
<td>Metals</td>
</tr>
<tr>
<td>NEEI – W8</td>
<td>Current levels of private funding for R&amp;I is higher in other competitive countries</td>
<td>Research and Innovation – Section 6.1.4.1</td>
<td>China, USA and Japan are all ahead with regards to mining industry spend on R&amp;I, with an apparent lack of motivation to undertake R&amp;I activity in the EU28.</td>
<td>All</td>
</tr>
</tbody>
</table>
### 7.1.3 Opportunities – NEEI

Looking forward, there are a number of opportunities that have been identified in the assessment which point to the EU28 having a sustainable NEEI. These are summarised in Table 42.

**Table 42: Opportunities for the EU28 NEEI**

<table>
<thead>
<tr>
<th>ID</th>
<th>Opportunity</th>
<th>Area(s) of Assessment</th>
<th>Explanation</th>
<th>Relevant Sub-Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEEI-O1</td>
<td>Large demand for minerals and raw materials within the EU28 expected in the future</td>
<td>Economic and Market Assessment - Section 3.1.4</td>
<td>The EU28 is a net importer of raw materials; this therefore offers an opportunity to service the market within the EU28.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-O2</td>
<td>Strong social and environmental protection</td>
<td>Policy and Legislation – Section 4.2.4 and 4.2.3</td>
<td>Through the sustainable use of natural resources, sustained investment from increasingly discerning investors can be achieved.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-O3</td>
<td>Security supply concerns from competitor countries</td>
<td>Policy and Legislation – Section 4.2.1</td>
<td>Trade restrictions on exports imposed in some comparator countries (e.g. China, Indonesia) mean that other nations have to look elsewhere to meet domestic mineral demands – this could include the EU28 NEEI.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-O4</td>
<td>Simplification of ‘old’ legislation</td>
<td>Policy and Legislation – Section 4.3.1</td>
<td>The simplification of complex and sometimes unevenly implemented and regulated legislation could increase efficiencies in achieving legislative approval and reduce the uneven operating environment impacting exploration, mining and quarrying activities.</td>
<td>All</td>
</tr>
<tr>
<td>ID</td>
<td>Opportunity</td>
<td>Area(s) of Assessment</td>
<td>Explanation</td>
<td>Relevant Sub-Sector</td>
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</tr>
<tr>
<td>NEEI-O5</td>
<td>Re-evaluation of geological mapping using more advanced techniques</td>
<td>Raw Material Supply - Section 5.1.1</td>
<td>Modern geoscientific techniques can be used to improve the understanding of the geology of the EU and thus to identify target areas prospective for new resources that in the past were not considered to have economic potential.</td>
<td>Metals and industrial minerals</td>
</tr>
<tr>
<td>NEEI-O6</td>
<td>Diverse geology</td>
<td>Raw Material Supply - Section 5.1.1</td>
<td>The geology of the EU is complex and varied. As a result it has the potential for the occurrence of a wide range of mineral deposit types, including those that host metals and minerals for which demand is rapidly increasing, such as critical raw materials.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-O7</td>
<td>New land based areas to be quarried and mined (including deep mining)</td>
<td>Raw Material Supply - Section 5.1.2</td>
<td>Due to increases in price of minerals and raw materials and lower costs of technologies, marginal deposits will be able to be mined economically.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-O8</td>
<td>R&amp;I activity within the NEEI</td>
<td>Research and Innovation – Section 6.3.1</td>
<td>Higher costs, with regards to labour and energy, can stimulate R&amp;I activity, ensuring that the EU28 utilise modern and efficient extraction and processing techniques.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-O9</td>
<td>Development of new cost effective processing technologies</td>
<td>Research and Innovation – Section 6.1.3</td>
<td>R&amp;I is critical in improving productivity, guaranteeing minerals and raw materials supply and thereby maintaining competitiveness of the EU28 NEEI.</td>
<td>All</td>
</tr>
</tbody>
</table>
7.1.4 **Threats – NEEI**

Alongside the opportunities to the NEEI, there are also a number of threats, which could damage growth in the EU28 NEEI. Based on the research completed in Sections 4.0 to 6.0, these are summarised in Table 43.

**Table 43: Threats for the EU28 NEEI**

<table>
<thead>
<tr>
<th>ID</th>
<th>Threat</th>
<th>Area(s) of Assessment</th>
<th>Explanation</th>
<th>Relevant Sub-Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEEI-T1</td>
<td>Free and fair trade policy not adopted by all competitor countries</td>
<td>Policy and Legislation – Section 4.1.1</td>
<td>EU customs duties allow free exports of recycled metals and raw materials leading to diminished supply whereas some comparator countries have policies in place to keep raw materials within their borders.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-T2</td>
<td>Competitor countries offering more incentives for mining and quarrying</td>
<td>Policy and Legislation – Section 4.1.1.3</td>
<td>The comparator countries examined provide a wide-ranging set of financial incentives (namely tax allowances and reliefs) that reduce the cost structure of domestic operations. Whilst</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-T3</td>
<td>Increased stability of some competitor countries</td>
<td>Policy and Legislation – Section 4.3.1 and Raw Material Supply – Section 5.1.5.1</td>
<td>The EU28 has historically represented a politically stable economic union and this has encouraged investment in its minerals sector. The increasing stability of some comparator countries means that this is becoming less unique and therefore lower risk capital investment may be directed away from the EU28.</td>
<td>All</td>
</tr>
<tr>
<td>ID</td>
<td>Threat</td>
<td>Area(s) of Assessment</td>
<td>Explanation</td>
<td>Relevant Sub-Sector</td>
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</tr>
<tr>
<td>NEEI-T4</td>
<td>Increased regulation of the sector from Member States due to low public acceptance</td>
<td>Policy and Legislation – Section 4.1.5.1</td>
<td>This can impose additional cost burdens on mining operators through administrative tasks. A good example of this is the Mining Waste Directive (2006/21/EC), a response to two high profile environmental accidents within the mining sector in the EU28, which requires operators to draw up, amongst other things, plans regarding on-site accidents and emergency situations.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-T5</td>
<td>Continued poor social acceptance of quarrying and mining activity within the EU28</td>
<td>Raw Material Supply - Section 5.1.2</td>
<td>The environmental and social impacts associated with mining operations are often not widely accepted by the public. Investors are wary of this and strong community opposition can discourage investment.</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-T6</td>
<td>Increased substitution of raw materials</td>
<td>Raw Material Supply – Section 5.1.5</td>
<td>Although at present very few minerals are easily substitutable, increasing demand, R&amp;I and increased scarcity of certain materials may mean that this is likely to be more prevalent in the future.</td>
<td>Metals</td>
</tr>
<tr>
<td>NEEI-T7</td>
<td>Relatively high expenditure of R&amp;I undertaken in competitor countries compared to the EU 28</td>
<td>Raw Material Supply – Section 6.1.4</td>
<td>China, USA and Japan are all ahead with regards to NEEI spend on R&amp;I. These countries could therefore acquire new technologies in advance of the EU28</td>
<td>All</td>
</tr>
<tr>
<td>NEEI-T8</td>
<td>‘Leakage’ of R&amp;I funding from the EU28 to competitor countries</td>
<td>Raw Material Supply – Section 6.3.1</td>
<td>The nature of the mining industry means that it is dominated by a small number of global companies. Technologies that are not patented would leak very quickly as a result.</td>
<td>All</td>
</tr>
</tbody>
</table>
7.2 Recycling Industries

This section outlines the main characteristics of the EU RI and, in doing so, identifies areas of competitive advantage or where there is the potential to improve competitiveness. The discussion below summarises the findings for each area of analysis (policy and legislation, material supply and R&I), with more detail presented in the accompanying tables.

The legislative framework of the EU shows a strong support for the industry and environmental protection in general, for example through the legislation on waste. Further support would be given if the legislative proposal included in the Circular Economy Package would be adopted. Alongside this, the EU28 has a skilled labour force and mature recycling market. Increasingly high capture rates of recyclable material in the EU28 are starting to provide consistent material supply to reprocessors and the Union’s proximity to global market and transport routes provide good trade links to neighbouring states. The future of the sector is strengthened by increased political support for recycling across Member States and increased demand for secondary materials as a substitute for primary materials.

In respect of material supply, the EU28 has excellent transport networks which facilitate competitive movement of goods. The EU28 places a strong emphasis on innovation. Accordingly, there is strong public sector investment in R&I activities with well-established programs in place such as Europe 2020 which position innovation as an important component of economic growth and key to competitiveness.

At the same time there are a number of weaknesses associated with the EU28 RI. Unfavourable trade policies of certain non-EU countries and apparent higher labour and energy costs in some parts of the EU28 (though reliable data on energy efficiency has not been identified) impact on the competitiveness of the EU28 RI. Additionally some competitor countries have been able to provide a demand-side stimulus for their RI, by lowering relative costs of products made with recycled content; a comparable initiative is not present in the EU28.

Although capture rates are increasing, there is a still a considerable variation between Member States. Furthermore, some metallic waste streams produce low quality recyclate which impose additional costs on the EU28 RI.

7.2.1 Strengths – RI

Table 44 summarises the key strengths identified in the assessment. These strengths are summarised from the research provided in Sections 4.0 to 6.0.
<table>
<thead>
<tr>
<th>ID</th>
<th>Strength</th>
<th>Area(s) of Assessment</th>
<th>Explanation</th>
<th>Relevant Sub-Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI-S1</td>
<td>Legislation which supports high recycling rates</td>
<td>Policy and Legislation – Section 4.2</td>
<td>The EU28 has developed a series of robust legislation that has required Member States to increase the amount of material recycled.</td>
<td>All</td>
</tr>
<tr>
<td>RI-S2</td>
<td>Expertise, skills and increasingly high employment in the RI</td>
<td>Research and Innovation – Section 6.2.1</td>
<td>More jobs at higher income levels are created by recycling than compared to landflling or incinerating waste. Overall employment related to the recycling of materials in European countries increased by 45% between 2000 and 2007.</td>
<td>All</td>
</tr>
<tr>
<td>RI-S3</td>
<td>Political will to ensure security of supply and clear direction for policy</td>
<td>Raw Material Supply – Section 5.2.4</td>
<td>Europe relies on the importation of raw materials and minerals and the EU is taking measures to counter through the development of the RI.</td>
<td>All</td>
</tr>
<tr>
<td>RI-S4</td>
<td>Well-developed transportation infrastructure and proximity to global markets</td>
<td>Raw Material Supply – Section 5.1.4</td>
<td>The densely populated nature of the EU28 and the associated well-developed transport network facilitates the transport of materials between Member States. The EU is also well connected to the major shipping routes to the rest of the world.</td>
<td>All</td>
</tr>
<tr>
<td>RI-S5</td>
<td>Mature recycling market, with strong capture rates of recyclate</td>
<td>Research and Innovation – Section 6.2.1</td>
<td>Recycling targets are mandated by legislative drivers within most EU28 Member States resulting in high captures of recyclate.</td>
<td>All</td>
</tr>
<tr>
<td>RI-S6</td>
<td>Technologically advanced RI</td>
<td>Research and Innovation – Section 6.2.1</td>
<td>The EU28 is known to be the most technologically advanced, most capital intensive and most resource efficient in the sector.</td>
<td>All</td>
</tr>
<tr>
<td>ID</td>
<td>Strength</td>
<td>Area(s) of Assessment</td>
<td>Explanation</td>
<td>Relevant Sub-Sector</td>
</tr>
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</tr>
<tr>
<td>RI-S7</td>
<td>Well established and well-resourced initiatives and programs</td>
<td>Research and Innovation – Section 6.2.3.1</td>
<td>Significant investment has taken place in the EU28 over a long time period from industry and government (e.g. through the Horizon 2020 programme) as well as engaging product designers to consider the recyclability of their products.</td>
<td>All</td>
</tr>
</tbody>
</table>
### 7.2.2 Weaknesses – RI

Table 45 summarises the key weaknesses identified for the EU28 RI.

**Table 45: Weaknesses for the EU28 RI**

<table>
<thead>
<tr>
<th>ID</th>
<th>Weakness</th>
<th>Area(s) of Assessment</th>
<th>Explanation</th>
<th>Relevant Sub-Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI-W1</td>
<td>Structure of customs duties negatively impacting EU operations</td>
<td>Policy and Legislation – Section 4.2.1.2</td>
<td>EU customs duties allow free exports of recycled metals and raw materials leading to diminished supply whereas comparator countries have policies in place to keep recycled metals and raw materials within their borders.</td>
<td>All</td>
</tr>
<tr>
<td>RI-W2</td>
<td>Some higher labour and energy costs within the EU28 compared to a number of competitor countries</td>
<td>Policy and Legislation – Section 4.1.2</td>
<td>Both labour and energy costs in some parts of the EU28 are higher than some competitor countries. Although it can be argued that high labour costs are offset by higher productivity and value added, they can pose a problem when competing with emerging economies such as India and China. With regards to energy costs, there is poor information on energy efficiency and therefore it is not possible to comment on the whether there is a significant impact on the metals recycling sector (for example, smelting operations) due to its high energy intensity.</td>
<td>All</td>
</tr>
<tr>
<td>RI-W3</td>
<td>Lack of demand side stimuli for recycled products</td>
<td>Policy and Legislation – Section 4.2.1.1</td>
<td>With many of the main producers of minerals outside of the EU28 it is difficult to impose policies that affect all producers and increase demand for secondary materials.</td>
<td>All</td>
</tr>
<tr>
<td>RI-W4</td>
<td>Poor quality recyclate captured from some waste streams</td>
<td>Raw Material Supply – Section 5.2.5.2</td>
<td>This relates to the long-standing issue of contamination of recyclate, whereby it is often not deemed economically viable to separate key materials and therefore the overall quality is reduced.</td>
<td>Metals</td>
</tr>
<tr>
<td>ID</td>
<td>Weakness</td>
<td>Area(s) of Assessment</td>
<td>Explanation</td>
<td>Relevant Sub-Sector</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>RI-W5</td>
<td>Inconsistent capture of recyclate across Member States in the EU28</td>
<td>Raw Material Supply – Section 5.2.4</td>
<td>Although all Member States have EU-mandated targets in place, they are not all on course to achieve these, with recycling higher on the agenda in some countries than in others.</td>
<td>All</td>
</tr>
<tr>
<td>RI-W6</td>
<td>Legislation is being unevenly interpreted and implemented in different Member States</td>
<td>Research and Innovation - Section 6.2.1</td>
<td>EU28 policy and legislation, although developed over a long period of time, is in some cases the legislation is complex and unevenly implemented. This creates a confusing investment environment and an uneven operating environment.</td>
<td>All</td>
</tr>
<tr>
<td>RI-W7</td>
<td>Lack of quality data provided for the RI</td>
<td>Raw Material Supply – Section 5.2.2 and 5.2.6</td>
<td>As the RI is a relatively new industry, key data relating to the performance and potential performance of the industry is deficient. This could not give confidence to investors.</td>
<td>All</td>
</tr>
</tbody>
</table>
7.2.3 **Opportunities – RI**

Looking forward, there are a number of opportunities that have been identified in the assessment which point to the EU28 having a sustainable RI. These are summarised in Table 46.

**Table 46: Opportunities for the EU28 RI**

<table>
<thead>
<tr>
<th>ID</th>
<th>Opportunity</th>
<th>Area(s) of Assessment</th>
<th>Explanation</th>
<th>Relevant Sub-Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI-O1</td>
<td>Greater demand for recycled materials</td>
<td>Policy and Legislation – Section 4.2.1.1</td>
<td>Resource constraints on primary materials could lead to increased demand for recyclate with the substitution of raw materials in products.</td>
<td>All</td>
</tr>
<tr>
<td>RI-O2</td>
<td>Simplification of ‘old’ legislation</td>
<td>Policy and Legislation – Section 4.3.2</td>
<td>The simplification of overly complex and sometimes unevenly implemented and regulated legislation could increase efficiencies in achieving legislative approval and reduce the uneven operating environment for the EU28 RI.</td>
<td>All</td>
</tr>
<tr>
<td>RI-O3</td>
<td>Capture of high valued materials</td>
<td>Raw Material Supply – Section 5.2.4</td>
<td>With reported recycling rates for many materials still relatively low, there is plenty more scope for increasing their capture, especially high value items. This in turn will offer potential for economies of scale and increasing returns on investment.</td>
<td>All</td>
</tr>
<tr>
<td>RI-O4</td>
<td>Leadership in the development of products suitable for the circular economy</td>
<td>Research and Innovation - Section 6.2.1</td>
<td>Creates the potential for first-mover advantage in recycling technologies (for export) where pioneering legislation is introduced. This advantage could be used to develop technologies which justify the import of secondary materials from other countries.</td>
<td>All</td>
</tr>
<tr>
<td>RI-O5</td>
<td>Improving the monitoring all possible sources of materials</td>
<td>Research and Innovation - Section 6.2.1</td>
<td>The EU can improve the monitoring of material production, waste streams, flows of end-of-life products, industrial side streams, tailings, landfill etc so to ensure that all possible sources of materials are known.</td>
<td>All</td>
</tr>
<tr>
<td>ID</td>
<td>Opportunity</td>
<td>Area(s) of Assessment</td>
<td>Explanation</td>
<td>Relevant Sub-Sector</td>
</tr>
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<td>---------------------</td>
</tr>
<tr>
<td>RI-O6</td>
<td>Cross-sectoral approaches in R&amp;I investment.</td>
<td>Research and Innovation - Section 6.2.1</td>
<td>The EU28 can encourage the concept of cross-sectoral approaches in R&amp;I investment, employing the concept of the circular economy, keeping product design in mind to increase ease of reprocessing products.</td>
<td>Metals</td>
</tr>
<tr>
<td>RI-O7</td>
<td>Invest in improving existing recycling processes</td>
<td>Research and Innovation - Section 6.2.1</td>
<td>The EU28 can invest in improving existing recycling processes and their efficiencies across the reuse and recycling chain - i.e. logistics, pre-processing, material recovery, to cover a larger percentage of total EU consumption of materials.</td>
<td>All</td>
</tr>
</tbody>
</table>
7.2.4 Threats – RI

Alike the NEEI, alongside the opportunities to the RI, there are also a number of threats, which could damage growth in the EU28 RI. Based on the research completed in Sections 4.0 to 6.0, these are summarised in Table 47.

Table 47: Threats for the EU28 RI

<table>
<thead>
<tr>
<th>ID</th>
<th>Threat</th>
<th>Area(s) of Assessment</th>
<th>Explanation</th>
<th>Relevant Sub-Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI-T1</td>
<td>Free and fair trade policy not adopted by all competitor countries</td>
<td>Policy and Legislation – Section 4.2.1.2</td>
<td>EU customs duties allow free exports of recycled metals and raw materials leading to diminished supply whereas comparator countries have policies in place to keep recycled metals and raw materials within their borders.</td>
<td>All</td>
</tr>
<tr>
<td>RI-T2</td>
<td>Competitor countries offering better incentives for operation</td>
<td>Policy and Legislation – Section 4.2.1.1</td>
<td>The comparator countries examined provide a wide-ranging set of financial incentives (e.g. tax allowances, credits and accelerated depreciation for R&amp;D capital assets) that reduce the cost structure of domestic operations.</td>
<td>All</td>
</tr>
<tr>
<td>RI-T3</td>
<td>Lack of adequate enforcement of export of some materials</td>
<td>Policy and Legislation – Section 4.2.1.3</td>
<td>The prevalence of illegal activity within the EU should not be understated. Notably, the illegal export through the inadequate enforcement of EU regulation.</td>
<td>Metals</td>
</tr>
<tr>
<td>RI-T4</td>
<td>Quality of materials collected and sorted for recycling could fall as targets increase</td>
<td>Policy and Legislation – Section 4.2.3.1</td>
<td>Higher targets could create a perverse incentive to decrease the quality of recyclate in order to meet them, with lower quality input affecting the quality of secondary materials on the market.</td>
<td>Metals</td>
</tr>
<tr>
<td>ID</td>
<td>Threat</td>
<td>Area(s) of Assessment</td>
<td>Explanation</td>
<td>Relevant Sub-Sector</td>
</tr>
<tr>
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<tr>
<td>RI-T5</td>
<td>Increasingly complex product design</td>
<td>Research and Innovation - Section 6.2.1</td>
<td>The increasing complexity of products is increasing the complexity of the dismantling process, thus reducing the financial viability of doing so. It has been argued that the 'metal-centric' approach to recycling is becoming increasingly obsolete. Instead there needs to be a shift to 'product-centric' approach.</td>
<td>Metals</td>
</tr>
<tr>
<td>RI-T6</td>
<td>Lack of long term certainty of product design</td>
<td>Research and Innovation - Section 6.2.1</td>
<td>The recycling industry, naturally reactive rather than proactive, deters investment in reprocessing technologies as product design is constantly changing.</td>
<td>Metals</td>
</tr>
<tr>
<td>RI-T7</td>
<td>Concentration of investment in R&amp;I</td>
<td>Research and Innovation – Section 6.2.3.3</td>
<td>The EU28 risks losing the concentration of investment in R&amp;I activity within the RI. This is a result of other countries increasing allocated resources to R&amp;I for the recycling industries in their regions (both in terms of financial and highly educated labour) in order to evolve into innovation based economies.</td>
<td>All</td>
</tr>
</tbody>
</table>
8.0 Suggested Initiatives

In the following sections a series of suggested initiatives are recommended for consideration by policy makers. These are aimed at improving the competitiveness of the EU28 MRMS and focussing on taking advantage of the strengths and opportunities and addressing the weaknesses and threats summarised in Section 7.0. The suggested initiatives are broken down by the NEEI and RI.

8.1 Non-Energy Extractive Industries

By way of helping to improve the competitiveness of the EU28 NEEI, the following four initiatives are suggested:

Suggested Initiative 1: Improve knowledge of mineral endowment

Finding: There has been a lack of investment in basic geological survey work (see NEEI-W5, NEEI-W6 and NEEI-O7 in Section 7.1). This means that the fundamental knowledge base is much weaker than it could be. This increases the risk of undertaking exploration activity, which, in turn, holds back the development of the EU’s indigenous resources.

Suggested Initiative: Although the measure might not enhance competitiveness per se, there is a suggestion that in order to develop to a greater extent than currently, more basic research is required to improve our understanding of Europe’s bedrock geology and thus to conduct more efficient and effective exploration. As identified in the research, other competitors have been able to incentivise exploration by the private sector via the use of tax breaks and other fiscal instruments. The EU should seek to improve the knowledge of mineral endowment using modern techniques and seek to incentivise relevant research.

Suggested Initiative 2: Address costs of energy

Finding: Energy costs in some parts of the EU28 appear to be higher than those in some competing nations (see NEEI-W2 in Section 7.1). However, the use of energy must also be considered and there appears to be a lack of evidence which enables a full comparison of overall costs within the NEEI.

Suggested Initiative: Building on the efforts already made at an EU level at reducing the costs of energy, consideration should also be given to the amount energy used by processes. Operators within the EU28 could be incentivised to benchmark their energy consumption and engage in knowledge sharing activities that may help reduce energy consumption further.

Suggested Initiative 3: Focus R&I on more efficient extraction methods

Finding: For the metals sub-sector, the EU28 appears to have deeper deposits than other competing countries (see NEEI-W7 in Section 7.1). This hinders competitiveness as more

\[375\] Note that it has not been possible to address all of the weaknesses and threats.
energy is required to extract minerals from deeper depths, when compared to the deposits at the sub-surface.

**Suggested Initiative:** The EU28 should look to focus and increase funding for R&I activity on helping to reduce the costs associated with the types of deposits found in the EU28. This includes deep deposits and recovering the value of materials contained in tailings from existing mining activity. This should be incorporated in research calls and effort should be made to promote the sharing of best practice across organisations within the EU28.

**Suggested Initiative 4: Simplify the regulatory framework**

**Finding:** Although the policy within the EU28 is stable and mature when compared to many of the competitor countries, the regulatory framework is regarded being time consuming, complex with quite unpredictable outcomes by industry (see NEEI-W1 and NEEI-T4 in Section 7.1). This may deter investment in the EU28 as the length of time from the commencement of permitting to starting extractive operations can be very long.

**Suggested Initiative:** Member States should be encouraged to review the legislation impacting on mining and quarrying activities and seek to simplify requirements by following better regulation principles. The EU could facilitate this process through the several instruments, starting from sharing of best practice. Additionally the EU can also ensure that Member States’ performances are calculating and monitoring the impact of legislation in line with best practice.

### 8.2 Recycling Industries

By way of helping to improve the competitiveness of the EU28 RI, the following four initiatives are suggested:

**Suggested Initiative 5: Provide demand-side stimuli for the RI**

**Finding:** There is a lack of demand-side stimuli for recycled materials from within the EU28 (see RI – W3 in Section 7.2). Unlike competitor countries, products made from virgin and recycled products are treated equally within the EU28.

**Suggested Initiative:** In order to increase demand for recycled materials, the EU and its Member States should consider fiscal and other measures to incentivise the consumption of goods made from recycled materials.

**Suggested Initiative 6: Address concerns associated with quality of recyclate**

**Finding:** For some heterogeneous waste streams from the EU28, poor quality recyclate is captured (see RI – W4 in Section 7.2). This impacts competitiveness as it means that the RI has to pay to remove contaminants.

**Suggested Initiative:** There is clear need for policies within the EU28 that standardise what the minimum level of quality of secondary material needs to be before it is traded in the internal market or in global markets. It is critical for the EU28’s RI that there is
increased transparency globally regarding the quality of secondary material being traded and that standards are introduced to ensure consistency.

**Suggested Initiative 7: Place stronger focus on the enforcement of existing legislation and increase its level of ambition**

**Finding:** There appears to be inconsistent application of waste legislation within the EU28 (see RI – W5 and RI – W6 in Section 7.2). This means that valuable feedstock for the EU28 RI is being discarded and not captured for recycling. As demonstrated in some EU Member States, current EU recycling targets do not represent the optimum level from an economic, social and environmental viewpoint.

**Suggested Initiative:** Regulation and policy in the RI is only as strong as the enforcement measures used within each Member State. Where enforcement is inadequate, the RI is undermined and thus the competitiveness is damaged. Member States should be required to ensure that adequate enforcement of existing legislation is undertaken, with a focus on ensuring that a suitable funding regime for enforcement activities is in place. Collaboration between Member States should also be encouraged through the sharing of intelligence on illegal activities and the sharing of best practice techniques in enforcement measures. In addition, current recycling targets should be updated to reflect progress made in the best performing Member States in recent years, while taking into account specific national circumstances.

**Suggested Initiative 8: Establish better accounting of the RI within the EU28**

**Finding:** Economic and market data relating to the RI is poor and the sector is not very well understood (see RI – W7 in Section 7.2). Poor data availability undermines the ability to undertake a comprehensive assessment of the EU28 RI. The same problem could be faced by potential investors and therefore might limit the flow of capital to the EU28 RI.

**Suggested Initiative:** To improve the knowledge and awareness of the EU28 RI, the EU should consider collecting information and data on a regular basis that allows the sector to be better understood. For example, flows of waste intended to be recycled should be linked to locations where it is recycled so that the economic contribution of the EU28 RI can be best understood.

**8.3 Future Assessments**

During the completion of this report, we have identified number data gaps that have hindered the assessment. By way of improving future studies we have suggest one final suggested initiative.

**Suggested Initiative 9: Improve quality of the data to allow future assessments**

**Finding:** As described throughout this report, there are a number of data gaps that make it difficult to analyse trends and identify key findings associated with the performance of the EU28 NEEI and RI.
Suggested Initiative: Given the importance of high quality and up-to-date information, it would seem appropriate that if a similar study is to be conducted in the future, primary research should be devised with operators within the EU28 NEEI and RI. Specifically quantitative (e.g. survey) research would seem suitable as method to ensure statistical significant and ensure that the themes and findings included in this research can be robustly examined. This also has the additional advantage of being repeated over time (longitudinal survey).
Bibliography


European Commission (2011) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Roadmap to a Resource Efficient Europe.


