

# Strategic Research and Innovation Agenda

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**Strategic Innovation and Technology Roadmap**



European Technology Platform  
on Sustainable Mineral Resources



# Foreword

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The ETP SMR has come a long way since its creation. It has extended its membership and responded actively to the economic and political changing circumstances.

However, its main objectives and goals remain unchanged. Acknowledging the partial lack of knowledge and the restrictions imposed by the limitations of the locally available mineral deposits in Europe it supports the whole sector in striving for the economic and responsible utilization of Europe's mineral resources in order to support the EU economy in its Agenda 2020 growth objectives.

It supports through research and innovation

- the purposeful and responsible exploration, exploitation and use of mineral primary and secondary raw materials under technically and economically viable conditions;
- resource and energy efficiency under technically and economically viable conditions;
- the highest possible reduction of CO2 emissions within the framework of state-of-the art technology and their economic viability and giving due consideration to their social, economic and ecological impacts;
- the effective protection of life and health of people, in particular of their employees, through prevention of accidents and work related diseases, through the effective protection of their communities, the environment and nature as well as the protection of the mineral deposits, taking into account other land use plans.

The ETP SMR full heartedly supports the European Commission in its efforts in the context of the European Innovation Partnership and with this document would like to outline the contribution research and innovation the ETP SMR members can provide to its agenda. Technological research and education will be a core element of the overall innovation agenda that by 2020 will have extended Europe's raw materials supply, its knowledge and competence and industrial growth and leadership.

**Dr Corina Hebestreit**  
Chair of the ETP SMR High Level Group

# Executive Summary

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The EU faces a number of major societal and economic growth challenges including availability of critical and essential raw materials from primary and secondary sources and availability of jobs, skills and technological competences. At the same time, the need for mineral resources continues to grow because of an increasing global population and a growing middle class as well as growing demand from developing countries and emerging economies (BRICS countries: Brazil, Russia, India, China, South Africa). Addressing these challenges requires that the appropriate technologies, processes and products are in place, along with adequate policies to implement and stimulate the required changes. In November 2008, the EU launched the Raw Materials Initiative (RMI)<sup>1</sup> and in 2011 the Roadmap for a Resource-Efficient Europe<sup>2</sup> to secure reliable and undistorted access to raw materials as being “crucial for the sound functioning of the EU’s economy”.

Raw materials are essential for the functioning of the economy of industrialised regions like the EU. Sectors such as construction, chemicals, automotive, aerospace, electrics/electronics, energy generation and machinery are completely dependent on access to certain raw materials. In this respect, the EU has to secure a reliable and uninterrupted supply of raw materials and achieve a sustainable and efficient management of non-energy raw materials.

The ETP SMR focuses its activities on creating sustainable resource potential, access to, and supply of, essential and critical raw materials (exploration, mining, quarrying, mineral processing, smelting, recycling and metallurgical recovery and refining, including the highly innovative enabling technologies and equipment industry) through research, development and innovation, perfectly in line with the European Innovation Partnership on Raw Materials<sup>3</sup> proposed by EU, based on 3 pillars: fostering sustainable supply within the EU, boosting resource efficiency and recycling as well as international collaboration.

In order to fulfil the sector’s expectations and its overall vision, the ETP SMR builds its research and innovation efforts on 5 critical and interconnected Strategic Ambitions:

## **Strategic Ambition 1 (exploration and inventory of resources)**

By 2020, Europe has a comprehensive overview about available intra-EU geological mineral and metal resource potential (primary resources), and of the mineral and metal resource potential in the “urban mine”, e.g. electronic wastes, and the anthropogenic/ industrial concentrations, e.g. mine/processing wastes and by-products (the first ever European database was created and delivered under PROMINE<sup>4</sup>), to become potential secondary sources. Secondly, we will have developed new, advanced exploration technologies for land and sea-based mineral deposits as well as tools to assess the resource potential in technical infrastructure and products put on the market.

## **Strategic Ambition 2 (mineral extraction from land and sea bed deposits)**

Already today, some of the world’s smartest, and most energy and resource efficient mines and quarries are operating in Europe. By 2020, Europe will maintain and develop further technological leadership aiming at economically viable and environmentally sound mineral extraction operations, including from deeper seated land and sea deposits.

## **Strategic Ambition 3 (mineral processing)**

In-demand critical metals rarely make up even 5% of a deposit or a secondary material. The major difficulty encountered to supply these metals on the market is cost and energy efficient beneficiation / pre-processing and metallurgical processing which enables the recovery of (critical) trace elements in addition to the base metals metallurgical cost. Increasing yields and recoveries of minerals will allow

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<sup>1</sup> Raw Materials Initiative - Meeting our critical needs for growth and jobs in Europe, COM(2008) 669

<sup>2</sup> Roadmap to a Resource Efficient Europe, COM(2011) 571 final

<sup>3</sup> Making raw materials available for Europe’s future well-being. Proposal for a European Innovation Partnership on Raw Materials, COM(2012) 82 final, accompanied by a Commission Staff Working Paper SWD(2012) 27 final

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<sup>4</sup> EC FP7-NMP research project PROMINE, “Nano-particle products from new mineral resources in Europe”, Project reference 228559, May 2009 - April 2013

for up-grading the resources and therefore (1) can decrease the feeds of the metallurgical processes as well as (2) open up more resources to be processed in extractive metallurgy. It could be the key to economic viability of a process.

By 2020, Europe has identified new ore, mineral and concentrates processing technologies that will allow step changes in energy, water and emissions intensity and will allow treating more complex and lower grade (primary and secondary) mineral resources. These technologies will pave the way for expanding European business and future advanced jobs.

### **Strategic Ambition 4 (metallurgy/metals recovery)**

Securing raw materials supply requires tackling the complete value chain and in particular requires a relation between a resource and a process. Projects cannot exist without the resource (see Strategic Ambition 1), nevertheless, numerous projects have failed because of the lack of an economical AND sustainable process to concentrate and extract in-demand metals from resources. On the contrary, mediocre ore bodies are/have been operating mines thanks to an effective and appropriate metallurgical process (e.g. Lodève uranium mine in the South of France). With resources (whether primary or secondary) that are expected to continue to become more complex and lower grade, and environmental requirements that have drastically changed, the associated metallurgical processes will continue to raise more technical challenges.

By 2020, EU shall be able to process complex resources that are discarded by the rest of the world because of metallurgical limitations. Also by 2020, EU metallurgical competences will allow for extraction and processing of EU primary and secondary resources thanks to sustainable multistage processes to valorise smaller ore bodies and difficult end-of-life material streams.

### **Strategic Ambition 5 (recycling)**

Europe has already become the leading continent with regard to recycling of base metals and a number of other raw materials (e.g. construction waste). The

same needs to be achieved for the recycling of critical and essential raw materials, where currently still significant deficits exist, with poor recycling rates for most technology metals, in many cases even being below 1%<sup>5</sup>. In particular, the ambition is therefore to become the leading continent with regard to recycling of both base and critical/technology metals:

- By 2020, the recycling rates of critical and technology metals are at least above 10% in the EU;
- By 2050, the recycling rates of critical and technology metals are at least above 25% and an overall 10% increase in recycling rate is reached for all other metals.

That gives the opportunity to improve the extraction from secondary sources increasing the overall availability of resources for the EU economy.

Construction and demolition waste represents close to a third of all waste produced in Europe. The EU Waste Framework Directive<sup>6</sup> has set an objective whereby 70% of this waste material must be recycled and/or recovered by 2020 in all Member States. Innovative and comprehensive solutions are required to reach this goal.

Collaborative efforts by the various institutions and governments with industry and research institutes in the EU Member States are required to achieve these goals. Industries and raw material supply in the Internal Market are interwoven in a way that only a joint EU effort will have the critical mass to produce the technological leadership and know-how. The ERA-MIN<sup>7</sup> will provide a starting point. Innovations generated will have to foster technology, but also adjust the legal and social framework for innovation and the uptake of the innovative technologies.

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5 Recycling Rates of Metals – A Status Report, UNEP Resource Panel, May 2011, ISBN 978-92-807-3161-3

6 Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance), OJ L 313/3ff

7 ERA-MIN - Network on the Industrial Handling of Raw Materials for European Industries  
ERA-MIN is an ERANET network of European organisations owning and/or managing research programs on raw materials



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# 1. Introduction

## 1.1. History of the ETP SMR

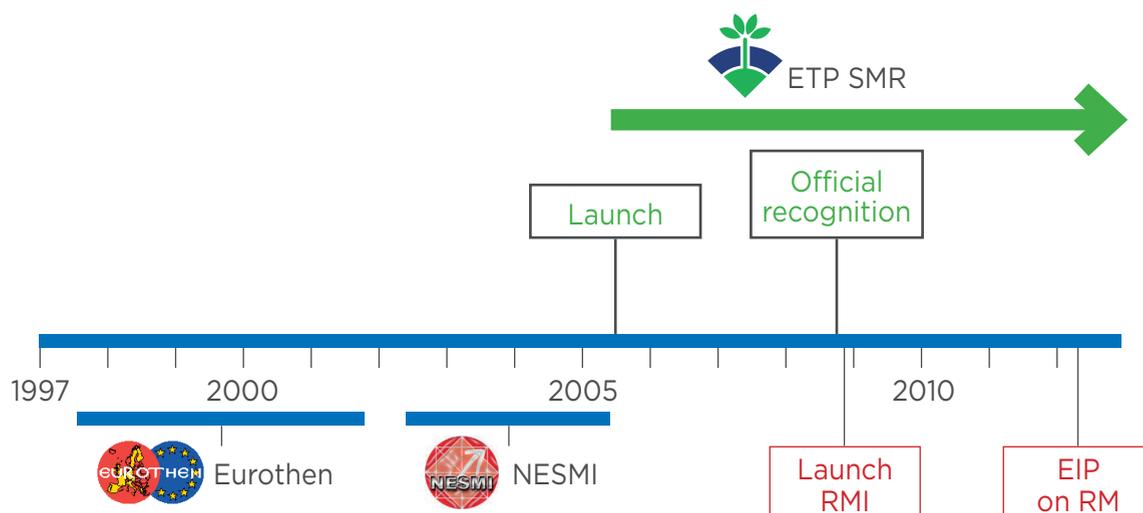


Figure 1: The history of the ETP SMR

Following previous networking programmes and the establishment of a European Minerals Research Council (EMIREC) the minerals industry and related technology and machinery providers decided to make use of a new tool and set up a European Technology Platform on Sustainable Mineral Resources to address the future technological and societal challenges.

The launch of the ETP SMR was in March 2005. It took some time until the European Commission officially recognised the ETP SMR in September 2008. The development of the Platform was positively supported by the changed public view and perception of raw materials in general. This finally resulted in the launch of the EU Raw Materials Initiative (RMI)<sup>8</sup>. The developments in raw materials policy caused several revisions of the Strategic Research and Innovation Agenda, which provides the strategic research efforts the sector needs to undertake in order to fulfil its vision.

The ETP SMR unites many stakeholders from minerals industry and related technology and machinery providers, the research community, regulators,

consumers and civil society around the major technological challenges to the sector, in order to jointly act towards a common vision.

It is going also to contribute to achieving the goals of the Revised Lisbon Strategy and the intentions of the Gothenburg Strategy on Sustainable Development. The identified needs for Pan-European collaborative research aim at a sustainable supply of mineral resources to the downstream European industries, also taking into account the decoupling of economic growth from adverse environmental impacts.

The EU Raw Materials Initiative underlines that: “securing reliable and undistorted access to raw materials is increasingly becoming an important factor for the EU’s competitiveness and, hence, crucial to the success of the Lisbon Partnership for growth and jobs”. The other citation from the Communicate states it very clear: “The critical dependence of the EU on certain raw materials underlines that a shift towards a more resource efficient economy and sustainable development is becoming even more pressing”.

The ETP SMR influenced the development and establishment of raw materials policies but was also influenced by policy developments that affected the sector.

<sup>8</sup> Raw Materials Initiative - Meeting our critical needs for growth and jobs in Europe, COM(2008) 669

In FP6 few research projects were launched which was a success at that time. However, major and important projects were launched under FP7 and will continue to be launched till 2013 and it is hoped that Horizon 2020<sup>9</sup>, the next EC Framework Programme for Research and Technical Development running from 2014 until 2020, as well as the innovation flagship programmes of the EU will provide additional public support for a future sustainable supply of raw materials. The Platform will contribute to strengthening one of the fundamental pillars of the European economy and society.

## 1.2. Mineral raw materials in the EU policy context

In 2008 the EU launched the first Raw Materials Initiative (RMI) – Meeting our critical needs for growth and jobs in Europe<sup>10</sup> (accompanied by a Staff Working Document SEC(2008) 2741<sup>11</sup>). Both the first report in the framework of the RMI (Report on Critical Raw Materials, June 2010<sup>12</sup>) and the second Communication on Raw Materials (February 2011)<sup>13</sup>, adopted by the EU, set out measures to secure and improve access to raw materials for the EU. The strategy reinforces the 3 pillar-based approach to improve access to raw materials for Europe through fair and sustainable supply from international sources; fostering sustainable supply within the EU and boosting resource efficiency and recycling. In parallel, the Commission has developed and implemented a number of more specific measures/policy initiatives which in some way contribute to or support access to raw materials. Just to name a few:

- Various reports on the Competitiveness of related EU industries

<sup>9</sup> see more and up-to-date information about Horizon 2020 under [http://ec.europa.eu/research/horizon2020/index\\_en.cfm](http://ec.europa.eu/research/horizon2020/index_en.cfm)

<sup>10</sup> Raw Materials Initiative – Meeting our critical needs for growth and jobs in Europe, COM(2008) 669

<sup>11</sup> Commission Staff Working Document accompanying COM(2008) 669, SEC(2008) 2741

<sup>12</sup> Critical Raw Materials for the EU - Report of the Ad-hoc Working Group on defining critical raw materials, European Commission June 2010

<sup>13</sup> Tackling the challenges in commodity markets and on raw materials, COM(2011) 25 final

- Analysis of the competitiveness of the EU Non -Energy Extractive Industry<sup>14</sup>
- The Sustainable Consumption and Production Action Plan (2008)<sup>15</sup>
- The EU Report on Critical Raw Materials which identified 14 critical mineral resources based on the supply shortage risk and their impacts on the economy
- The Thematic Strategy on Sustainable Use of Natural Resources<sup>16</sup>
- The Thematic Strategy on the Prevention and Recycling of Waste (2005)<sup>17</sup> and the 2011 Commission report on the Thematic Strategy<sup>18</sup>
- Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries<sup>19</sup>
- Reference Document on Best Available Techniques for the management of tailings and waste-rock in mining activities<sup>20</sup>
- EC guidance on undertaking non-energy extractive activities in accordance with Natura 2000 requirements<sup>21</sup>

<sup>14</sup> Commission Staff Working Document - Analysis of the competitiveness of the EU Non -Energy Extractive Industry, SEC(2007) 771

<sup>15</sup> Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, COM(2008) 397 final

<sup>16</sup> Thematic Strategy on Sustainable Use of Natural Resources, COM(2005) 670

<sup>17</sup> Thematic Strategy on the Prevention and Recycling of Waste, COM(2005) 666

<sup>18</sup> Commission report on the Thematic Strategy on the Prevention and Recycling of Waste COM(2011) 13 final, accompanied by a Commission Staff Working Document

<sup>19</sup> Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries, OJ L 102/15ff

<sup>20</sup> Best Available Techniques reference document for the management of tailings and waste rock in mining activities, BREF 0109, 2009

<sup>21</sup> EC Guidance on undertaking new non-energy extractive activities in accordance with Natura 2000 requirements, European Union 2011, ISBN 978-92-79-18646-2

- The European Innovation Partnership (EIP) on Raw Materials<sup>22</sup> will see that, by 2020, Europe will have made a great step in reducing its import dependency on raw materials.
- The European Parliament Report on Raw Materials Strategy for Europe <sup>23</sup> (issued on 12.9.2011)
- The Resource Efficiency Roadmap<sup>24</sup> issued on 20 September 2011
- The EU report on Minerals Policy, Land-planning and Permitting<sup>25</sup> (June 2010)

In 2010, the European Union issued its “Europe 2020 Strategy – A strategy for smart, sustainable and inclusive growth”<sup>26</sup>. The strategy set headline targets to be reached until 2020. In order to reach these targets, a wide range of national, EU and international actions will be necessary. Seven so-called Flagship Initiatives were put forward to catalyse the progress under each of the three priorities smart, sustainable and inclusive growth. One Flagship Initiative called “Innovation Union”<sup>27</sup> is to improve framework conditions and access to finance for research and innovation so as to ensure that innovative ideas can be turned into products and services that create growth and jobs. A second Flagship Initiative called “Resource efficient Europe”<sup>28</sup> is to help decouple economic growth from the use of resources, support the shift towards a low carbon economy, increase the use of renewable energy sources, modernise our transport sector and promote energy efficiency.

22 Making raw materials available for Europe's future well-being. Proposal for a European Innovation Partnership on Raw Materials, COM(2012) 82 final, accompanied by a Commission Staff Working Paper SWD(2012) 27 final

23 European Parliament resolution of 13 September 2011 on an effective raw materials strategy for Europe, 2011/2056(INI)

24 Roadmap to a Resource Efficient Europe, COM(2011) 571 final

25 Improving Framework Conditions for Extracting Minerals for the EU – Exchanging Best Practice on Land Use Planning, Permitting and Geological Knowledge Sharing, European Commission 2010

26 Europe 2020 Strategy – A strategy for smart, sustainable and inclusive growth, COM(2010) 2020 final

27 Europe 2020 Flagship Initiative “Innovation Union”, COM(2010) 546 final

28 A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy, COM(2011)21

In 2011 the Commission issued its Second Communication on the Raw Materials issue taking stock of the work done so far and outlining future actions. The European Council of Ministers welcomed this second Communication which led in autumn 2012 to the announcement of the European Innovation Partnership on Raw Materials. The European Innovation Partnerships will bring together Member States and other stakeholders (companies, NGOs, researchers etc.) to develop joint strategies, pull together capital and human resources and ensure the implementation and dissemination of innovative solutions within Europe.

### 1.3. Mineral raw materials' contribution to sustainability of the EU

Mineral raw materials are essential for the sustainable functioning of modern societies. Access to and affordability of mineral raw materials are crucial for the sound functioning of the economy. Since the time when the minerals industry sectors joined forces and established the ETP SMR, the sector is committed to sustainable development principles. The sector already achieved a high level of sustainability in its operations but is also committed to solve the challenges ahead of us that are in principle mentioned in the Europe 2020 Strategy.

Global socioeconomic development and its potential impact on the minerals sector in the next few decades are difficult to forecast. The world-wide demand for mineral resources has increased in a way that it has totally transformed the global market in the minerals sector. Governments are having an increasingly important role in mining activities and the resolution of problems relating to sustainable production and consumption of minerals will require closer political cooperation in the future. Production and consumption must move towards improvements in reducing waste and conserving resources, and in promoting sustainable utilisation and recycling of raw materials.

The future mineral supply is a grand challenge for society at large. The minerals industry is committed to contribute to sustainable mineral supply and meeting future challenges by excellent R&D. Improved transparency and simplifications are necessary in the mechanisms and administrative procedures governing EU-funded research.

The growth of industrial economies, like for instance the BRICS countries (Brazil, Russia, India, China, South Africa), has led to a tremendous upward spiral of mineral consumption, in this case accompanied by a shift of emphasis to base metals and industrial minerals for steel manufacturing and building. The demand is becoming so great that even low-grade and deep-seated mineral concentrations can reasonably be considered ore deposits. This means the European mineral industry will probably have to be reshaped in terms of exploration and exploitation practices. The main target is to increase the commodity base and range of European mineral resources.

### 1.3.1. Societal needs

The EU faces a number of major societal challenges as addressed in the Europe 2020 Strategy<sup>29</sup> including climate change, energy supply, availability of critical and essential raw materials from primary and secondary sources and availability of jobs, skills and technological competences. Addressing these challenges requires that the appropriate technologies, processes and products are in place, along with adequate policies to implement and stimulate the required changes.

All mineral resources and metals are essential to our developed high-tech economy as a whole and more specifically to the products and technologies that will allow a transition towards a competitive and sustainable European economy. The situation may be summarised as follows:

- 70% of EU manufacturing depends on minerals and metals
- The rebuilding of Eastern Europe is still not completed
- The electrification of Europe for the increased use of electrical vehicles requires substantial amounts of raw materials
- Alternative energy generation requires new networks and raw materials

<sup>29</sup> Europe 2020 Strategy – A strategy for smart, sustainable and inclusive growth, COM(2010) 2020 final

- An aging population requires different types of infrastructure and products to maintain the same or an even better standard of living

Minerals and metals are vital to downstream sectors such as information technology, renewable and efficient energy production, investment, medical devices, construction, automotive, aerospace, chemicals, machinery and equipment (these sectors provide a total added value of €1,324 billion and employment for some 30 million people<sup>30</sup>). In a more direct sense, the mineral resources sector contributes strongly to European jobs and added value, employing at least 1.2 million people and some €470 billion<sup>31</sup>.

The long-term sustainability of these sectors and in turn the achievement of the EU 2020 objectives of moving towards a competitive and sustainable economy requires that the EU downstream industry will have unrestricted access to raw materials in the required quantity and quality and at competitive cost.

The strategic importance of a sustainable supply of raw materials to the EU – for its industry and society as a whole – has been well recognised in different strategic policy documents such as the Raw Materials Initiative<sup>32</sup> proposed by the European Commission, related Council Conclusions<sup>33</sup> and Report from the EP<sup>34</sup>. The Europe 2020 Strategy highlighted the importance of this issue both within the “Industrial policy”<sup>35</sup> and “Resource efficiency”<sup>36</sup> Flagship initiatives. Moreover, the importance of an

<sup>30</sup> [http://ec.europa.eu/enterprise/policies/raw-materials/critical/index\\_en.htm](http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm)

<sup>31</sup> Data from websites of Eurometaux, Eurofer, IMA-Europe and UEPG

<sup>32</sup> Raw Materials Initiative – Meeting our critical needs for growth and jobs in Europe, COM(2008) 669

<sup>33</sup> Council Conclusions - An integrated approach to a competitive and sustainable industrial policy in the European Union, 2945th COMPETITIVENESS (Internal market, Industry and Research) Council meeting, Brussels, 28 May 2009

<sup>34</sup> European Parliament resolution of 13 September 2011 on an effective raw materials strategy for Europe, 2011/2056(INI)

<sup>35</sup> An Integrated Industrial Policy for the Globalisation Era - Putting Competitiveness and Sustainability at Centre Stage, COM(2010) 614

<sup>36</sup> A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy, COM (2011) 21

efficient use of resources has been highlighted in the associated Roadmap on Resource Efficiency<sup>37</sup>. These documents clearly outlined the new challenges and risks related to supply shortages and of an inefficient use of resources faced by the EU in view of the mounting global competition for raw materials.

At present, in most cases, mineral resources in Europe are not able to provide self-sufficiency for the European economy. The EU depends heavily on imports of metal concentrates (European extraction covers only 29% of the demand for concentrates necessary to meet the requirements for production in metallurgical plants), while the increased use of recycled scrap (40-60% of input of EU base metal production) is not sufficient to meet growing demand. In addition, the EU faces major problems in accessing its scrap as exports of scrap and end-of-life products containing valuable raw materials has increased dramatically over the last decade (more than 125%) while imports have dropped significantly (-40%).

The EU also relies heavily on imports of metals. 14 critical raw materials for the EU have been identified in 2010, but the challenge of access to raw materials is a dynamic one that calls for an overall approach, not only limited to these critical materials.

Special attention should be given to critical metals for strategic energy as well as other modern technologies. A shortage of these metals could be a potential bottleneck to the deployment of low-carbon energy technologies (nuclear, solar, wind, bioenergy, tide energy) and new applications in XXI Century technologies (IT, embedded systems, sensors, robotics and automation in mining operations).

Increasing European mineral and metals production (exploration, extraction and processing of primary resources), increasing recycling and reuse of secondary resources and finding substitutes where necessary should be key parts of the roadmaps of initiatives dedicated to mineral raw materials.

The ETP SMR will contribute to activities related to the substitution of especially critical minerals with

all competences available in the industry sectors covered. However, the scientific background needed for research work on substitution is not wide-spread in the ETP SMR membership.

It should be of major intention to enhance society's opinion on minerals extraction by providing information and related activities about sustainable development of natural resources, waste management and recycling, implications of knowledge economy, innovation in scientific and technological capabilities, organization of information, education and communication, identifying the factors underpinning the image and the social acceptance of mining, establishing outreach programmes to promote the acceptance of mining, developing education in mineral resources management and generally ensuring a strong mining industry for Europe.

Industry commitment to sustainable development in terms of minimising any possible adverse effects on the community or environment should be given particular attention. The resources sector should be aware that, to maintain its social licence to operate, it must engage constructively with communities and stakeholders. An open and effective social engagement involves transparency and communication on mineral resources economic potential and development perspectives. The accessibility to an interoperable digital data base on European mineral resources will make an efficient tool in achieving high potential exploration areas and new mineral resources.

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<sup>37</sup> Roadmap to a Resource Efficient Europe, COM(2011) 571 final

### 1.3.2. Economy

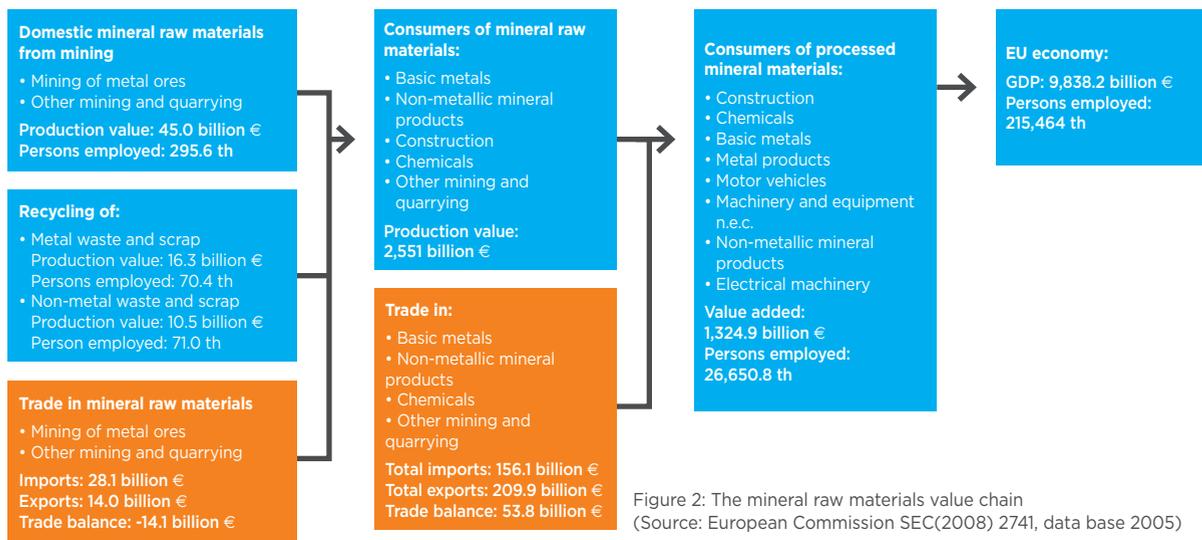


Figure 2: The mineral raw materials value chain (Source: European Commission SEC(2008) 2741, data base 2005)

Figure 2 shows the mineral raw materials value chain. Although the figures given there are from 2005 and thus may have slightly changed until today, the general situation remains: the mineral raw materials are essential for a prosperous European economy but Europe still is a net importer for base metals, metal concentrates and some other minerals.

The mineral raw materials sector has the ability to change this situation in a sustainable way and to significantly contribute to reduce the mentioned import deficit. However, several actions will be necessary to achieve this.

We need to undertake an in-depth assessment of the European mineral resource base. It has been explored with modern, latest technologies and in many cases has been underexploited due to the availability of resources from other parts of the world at more competitive prices. The results from the PROMINE project<sup>38</sup> show that Europe owns significant deposits.

These resources could become operating mines and contribute to reduce import dependency for metals and especially critical mineral raw materials if an economical and sustainable metallurgical process could be developed for these resources. Nevertheless, much more exploration work will be necessary.

The mineral resource productivity of the European economy needs to be increased through not just per tonne of raw material, but also as a value chain in total. The available EU mineral resource base should be put to increased and better use, also because the extraction and utilisation in Europe is of high environmental and social standard in comparison and therefore enhances the sustainability of Europe's development, growth and consumption.

The design of products has not necessarily been driven by resource efficiency considerations. Today both criteria performance and material efficiency should be considered in product design. This also needs to include the aspect of reuse and recyclability throughout the various waste streams and the end-of-life products.

European regions need to build on their potential for economic development and growth to provide

38 EC FP7-NMP research project PROMINE, "Nano-particle products from new mineral resources in Europe", Project reference 228559, May 2009 – April 2013

employment and perspectives for future generations in order not to threaten the social cohesion in Europe. Economic development can be associated with the establishment of mineral raw materials environmentally friendly exploitation and processing operations.

### **1.3.3. Environment**

Natural resources underpin the functioning of the European and global economy and our quality of life. These resources include raw materials such as fuels, minerals and metals but also food, soil, water, air, biomass and ecosystems. The pressures on resources are increasing. If current trends continue, by 2050, the global population is expected to have grown by 30% to around 9 billion and people in developing and emerging economies will legitimately aspire to the welfare and consumption levels of developed countries. As we have seen in recent decades, intensive use of the world's resources puts pressure on our planet and threatens the security of supply. Continuing our current patterns of resource use is not an option.

In response to these changes, increasing resource efficiency will be key to securing growth and jobs for Europe. It will bring major economic opportunities, improve productivity, drive down costs and boost competitiveness. It is necessary to develop new products and services and find new ways to reduce inputs, minimise waste, improve management of resource stocks, change consumption patterns, optimise production processes, management and business methods, improve logistics and promote more quality recycling. This will help stimulate technological innovation, boost employment in the fast developing 'green technology' sector, sustain EU trade, including by opening up new export markets, and benefit consumers through more sustainable products.

Using resources more efficiently will help us achieve many of the EU's objectives. It will be key in making progress to deal with climate change and to achieve our target of reducing EU greenhouse gas emissions by 80 to 95% by 2050. It is needed to protect valuable ecological assets, the services they provide and the quality of life for present and

future generations. It will help us ensure that the agricultural and fisheries sectors are strong and sustainable and reduce food insecurity in developing countries. By reducing reliance on increasingly scarce fuels and materials, boosting resource efficiency can also improve the security of Europe's supply of raw materials and make the EU's economy more resilient to future increases in global energy and commodity prices.

A vision of where Europe should be in 2050 and a long-term policy framework can provide a clear path for businesses and investors. It is important to sharpen the focus on the action that has to be taken in the next ten years to put Europe on the right track and to speed up the transition.

To achieve a resource-efficient Europe, we need to make technological improvements, a significant transition in energy, industrial, agricultural and transport systems, and changes in behaviour as producers and consumers. To give businesses the certainty which they need to invest now, and to ensure that future generations benefit from smart investment, we have to start taking action immediately, on the basis of a regulatory framework that provides long-term stability. Improving resource efficiency also provides an opportunity to keep costs under control by reducing material and energy consumption and thus to boost future competitiveness.

The EU has already shown that progress on resource efficiency is possible. Recycling has started to become a normal practice for businesses and households across the EU. Since 1990, we have reduced greenhouse gas emissions in the EU by more than 10% while our economies have grown by about 40%. We are reducing our reliance on fossil fuels by increasing energy efficiency and developing alternatives. However, we now need to accelerate progress, extend efforts to other areas and reap the benefits that a successful strategy can bring for competitiveness, job creation and prosperity.

### 1.3.4. Corporate Social Responsibility (CSR)

In October 2011 the European Commission published a new policy on corporate social responsibility<sup>39</sup>. It states that to fully meet their social responsibility, enterprises “should have in place a process to integrate social, environmental, ethical and human rights concerns into their business operations and core strategy in close collaboration with their stakeholders”.

The aim is both to enhance positive impacts – for example through the innovation of new products and services that are beneficial to society and enterprises themselves – and to minimise and prevent negative impacts.

Corporate social responsibility concerns actions by companies over and above their legal obligations towards society and the environment. Certain regulatory measures create an environment more conducive to enterprises voluntarily meeting their social responsibility.

A strategic approach to CSR is increasingly important to the competitiveness of enterprises. It can bring benefits in terms of risk management, cost savings, access to capital, customer relationships, human resource management, and innovation capacity<sup>40</sup>.

Because CSR requires engagement with internal and external stakeholders, it enables enterprises to better anticipate and take advantage of fast changing societal expectations and operating conditions. It can therefore drive the development of new markets and create opportunities for growth.

By addressing their social responsibility enterprises can build long-term employee, consumer and citizen trust as a basis for sustainable business models. Higher levels of trust in turn help to create an environment in which enterprises can innovate and grow.

<sup>39</sup> Green Paper - Promoting a European framework for Corporate Social Responsibility, COM(2001) 366 final

<sup>40</sup> European Competitiveness Report 2008, European Communities 2009, ISBN 978-92-79-09773-7, including Communication from the Commission on the European Competitiveness Report 2008, COM(2008) 774 final, and accompanying Commission Staff Working Document SEC(2008) 2853

Through CSR, enterprises can significantly contribute to the European Union’s treaty objectives of sustainable development and a highly competitive social market economy. CSR underpins the objectives of the Europe 2020 strategy for smart, sustainable and inclusive growth, including the 75% employment target. Responsible business conduct is especially important when private sector operators provide public services.

An increasing number of companies of the European minerals sector are promoting their CSR strategies as a response to a variety of social environmental and economic pressures. Social dialogue has become an important part of their strategy. However, it is also a social responsibility to guarantee the accessibility of mineral deposits.

### 1.4. Key to Europe’s future: innovation, knowledge, skills and industrial leadership

Apart from ensuring a predictable legal framework that supports industrial development by acknowledging the need for industry in Europe, by providing internationally competitive framework conditions for long-term industrial investment (key words: energy, taxation and lean administration) the key factors to Europe’s economic recovery will be innovation, knowledge and education. These three key words are usually shown in a triangle, the so-called knowledge triangle.

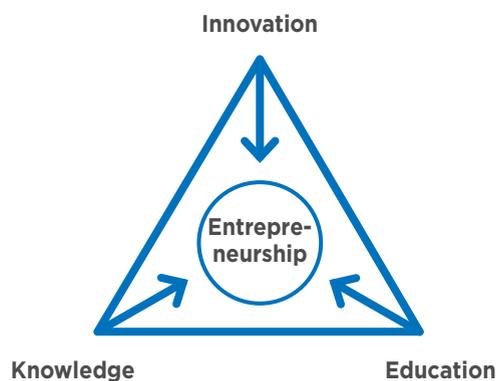


Figure 3: The knowledge triangle

The knowledge triangle is a central theme of

the Lisbon strategy, representing the integration of education, research and innovation working together as key drivers of the knowledge economy in delivering sustainable growth. It is useful as a tool for describing and understanding the dynamics of education, research and innovation working together. It is evident today how education is stimulating research, and that there is a bi-directional relationship between research and innovation; however, paths back from research, and particularly from innovation, into curriculum development and educational practice are much more difficult to trace. In practice, it would seem that the knowledge triangle is largely being implemented in a linear progression or continuum: education leading to research, which in turn fosters innovation.

The different roles and interplay between education, research and innovation - and their respective weights - will vary depending upon national or regional circumstances. So, the knowledge triangle should not be perceived as a rigid structure. However, in all circumstances strengthening linkages between the three elements is crucial in ensuring the full benefits are secured from investment in any of the three. In this way, multiplier and (often unexpected) spinoff effects can be maximised.

The ETP SMR comprises all key players of the knowledge triangle so that targeted innovation activities are possible. The Platform includes universities and research institutes as well as industry and technology providers. Successful research has already been carried out or is currently under way in order to fulfil the overall aim to provide Europe with minerals raw materials in a sustainable way.

However, innovation in the sense of developing and implementing new processes is complex and requires time (10-15 years are accepted figures). Prior to establish a new process plant in Europe, Europe needs:

- Integrated research (from fundamental to applied research) and development in specific areas that converge towards a concrete ambition to be determined
- “Cross the valley of death” (see Figure 4), i.e. develop a final flow sheet thanks to back and forth between laboratory work -to fine tune thermodynamics and kinetics- and pilot scale -to test on a continuous basis a complex flow sheet in real conditions. This back and forth will allow for a complete understanding of each step in the process thanks to an empirical confrontation of all the hypothesis made at lab scale (on the negligible

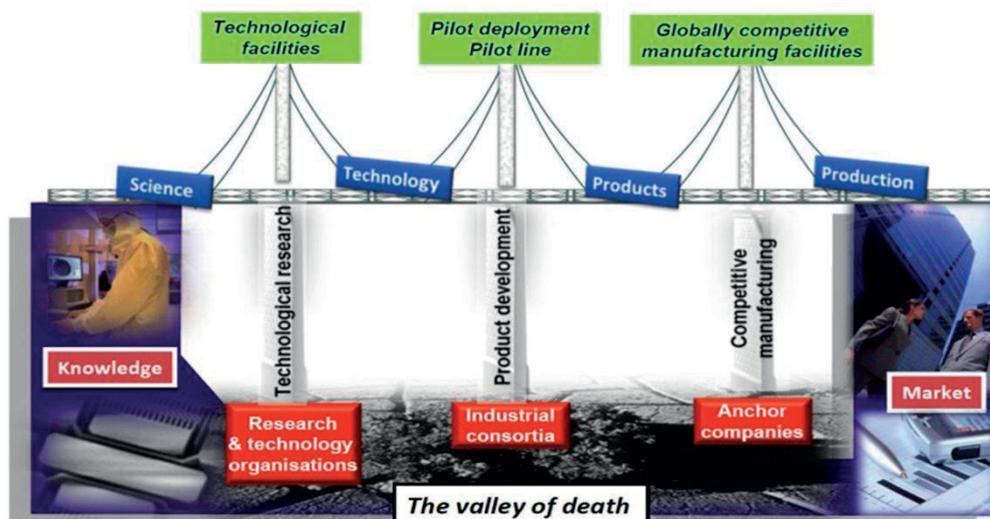


Figure 4: “The valley of death”

effect of many parameters) to reality, where these parameters, and their real consequences on a process flow sheet, might not actually be negligible. "Crossing the valley of death" is (1) a critical step for innovation; (2) critical to develop a new operational metallurgical process that can be industrialized and (3) critical to create jobs and growth.

This stage is capital intensive and the risk is still relatively high. Financial support, for individual companies or to shared facilities that would provide tools and expertise, would push innovation and companies to cross "the valley of death". Failing in this stage would cause disruptions in the value chain.

In 2006, the European Commission submitted the vision for a European Institute of Innovation and Technology (EIT). It was the answer to the fact that Europe could do much better at innovation. The EIT seeks to allow Europe's excellent universities, research centres, businesses and other innovation actors to grow and capitalise on their innovation capacity and capability. In doing so, it will stand out as a world-class innovation-orientated reference model, inspiring and driving change in existing education and research institutions.

The EIT is the first EU initiative to fully integrate all three sides of the knowledge triangle by way of so-called Knowledge and Innovation Communities (KICs). The link between all three sides and the effective transmission and sharing of knowledge, information and skills for joint exploitation is crucial to delivering the jobs and growth opportunities that Europe is seeking, because excellent researchers, students and entrepreneurs working in isolation are much less efficient in delivering the results needed and wanted by the market and consumers.

By connecting European business and research, businesses stand to gain as they will be given fresh opportunities to commercialise the most up-to-date and relevant research findings, with the aim of giving Europe first-mover advantage in the latest technological and non-technological fields as well as in open innovation. In return, research organisations will benefit from additional resources, an enhanced networking capacity, and new research perspectives stressing interdisciplinary approaches in areas with

strong societal and economic importance. By adding higher education into the mix, businesses will be able to take advantage of a workforce with skills tailored to their needs able to drive their market share forwards; and students will benefit from an education that will make them more attractive to future employers and also more apt at contributing to the development of those employers' businesses.

Innovation needs entrepreneurship. One of the EIT's main objectives is therefore to create a favourable framework for promoting a fresh entrepreneurial culture in Europe. Through its business-oriented approach as well as through its educational component, the EIT will help to train a new generation of entrepreneurs, who have the right skills and knowledge to turn ideas into new business opportunities.

The KIC is the independent but operational part of the EIT, which puts the innovation web into practise.

A KIC is a highly integrated, creative and excellence-driven partnership which brings together the fields of education, technology, research, business and entrepreneurship, in order to produce new innovations and new innovation models that inspire others to emulate it. They are to become key drivers of sustainable economic growth and competitiveness across Europe through world-leading innovation. The KICs will be driving effective "translation" between partners in ideas, technology, culture, and business models, and will create new business for existing industry and for new endeavours.

The minerals sector is ready to take part in competition together with other RTD partners dealing with raw materials and apply for a KIC on Raw Materials if such competition will be announced in near future by the EIT. This would support the innovation processes necessary for the minerals sector to fulfil the vision and Strategic Ambitions outlined in this document.

# 2. The Vision

## 2.1. Vision 2020

Minerals related topics returned to the political and research agenda at the European level since the EC launched the Communication about the “Raw Materials Initiative (RMI)<sup>41</sup>” as well as the related WG reports on Best Practices and Criticality<sup>42</sup> with respect to non-energy minerals industry. As a consequence and just to mention a few items, several European Research Program (e.g. FP7) calls for minerals related projects were published, the Europe 2020 Strategy targets on resource efficiency and the European Innovation Partnership (EIP) on Raw Materials<sup>43</sup> has recently been launched. This development creates a historic opportunity to establish the Mineral Intelligence on an EU level that would be built on existing national / member states capacities and other international ones.

The European Technology Platform on Sustainable Mineral Resources will provide a focal point for the industry’s research efforts and strengthen the competitiveness of this sector by a major increase in cost efficiency and resource efficiency. Through integrating all stakeholders across the raw-material value chain a critical mass will be established to implement successful R&D with cross-sectorial application potential. The consumption of raw materials in Europe was always high in the past and can likely to grow due to increased market demand, particularly in the new member states.

The ETP “Sustainable Mineral Resources” will:

- ✿ Reshape a “traditional” industry from a resource-driven to a knowledge-driven industry;
- ✿ Foster new and better jobs, including SMEs and New Member States;
- ✿ Supply and secure the mineral resources needed by the EU economy, while minimising the related environmental footprint (decoupling);
- ✿ Strengthen world leadership and competitiveness in mineral sector technology;
- ✿ Add value for customers and society.

By 2020, the EU will have secured sustainable minerals and metals supply base to ensure competitiveness and growth of the EU industry as a whole. Scientific breakthroughs and sustained innovation efforts will have significantly improved access to, production, use and recycling of resources. By 2050, the EU will have managed on a sustainable basis the entire life-cycle of minerals and metals in the EU.

On the way to make this vision a reality, the following strategic ambitions, which cover all commodities and are based on a value chain approach, can be formulated.

## 2.2. Strategic Ambitions

The ETP SMR defined 5 so-called Strategic Ambitions in order to fulfil its vision. They were formulated along the mineral raw materials value chain and are focussing on technology development and innovation to gain industrial leadership, on resource sustainability and efficiency.

The overarching challenge will be to integrate the Strategic Ambitions and the following detailed objectives into a systemic process view of the whole chain as shown in Figure 5 with all research activities coherently feeding into this while considering interdependencies.

Although the Strategic Ambitions and the related detailed objectives are formulated related to particular fields of technical application, all research and development activities will need to be carried out with the overall process of raw material provision in mind. Only in this way resource efficiency will be achieved.

<sup>41</sup> Raw Materials Initiative – Meeting our critical needs for growth and jobs in Europe, COM(2008) 669

<sup>42</sup> Critical Raw Materials for the EU - Report of the Ad-hoc Working Group on defining critical raw materials, European Commission June 2010

<sup>43</sup> Making raw materials available for Europe’s future well-being. Proposal for a European Innovation Partnership on Raw Materials, COM(2012) 82 final, accompanied by a Commission Staff Working Paper SWD(2012) 27 final

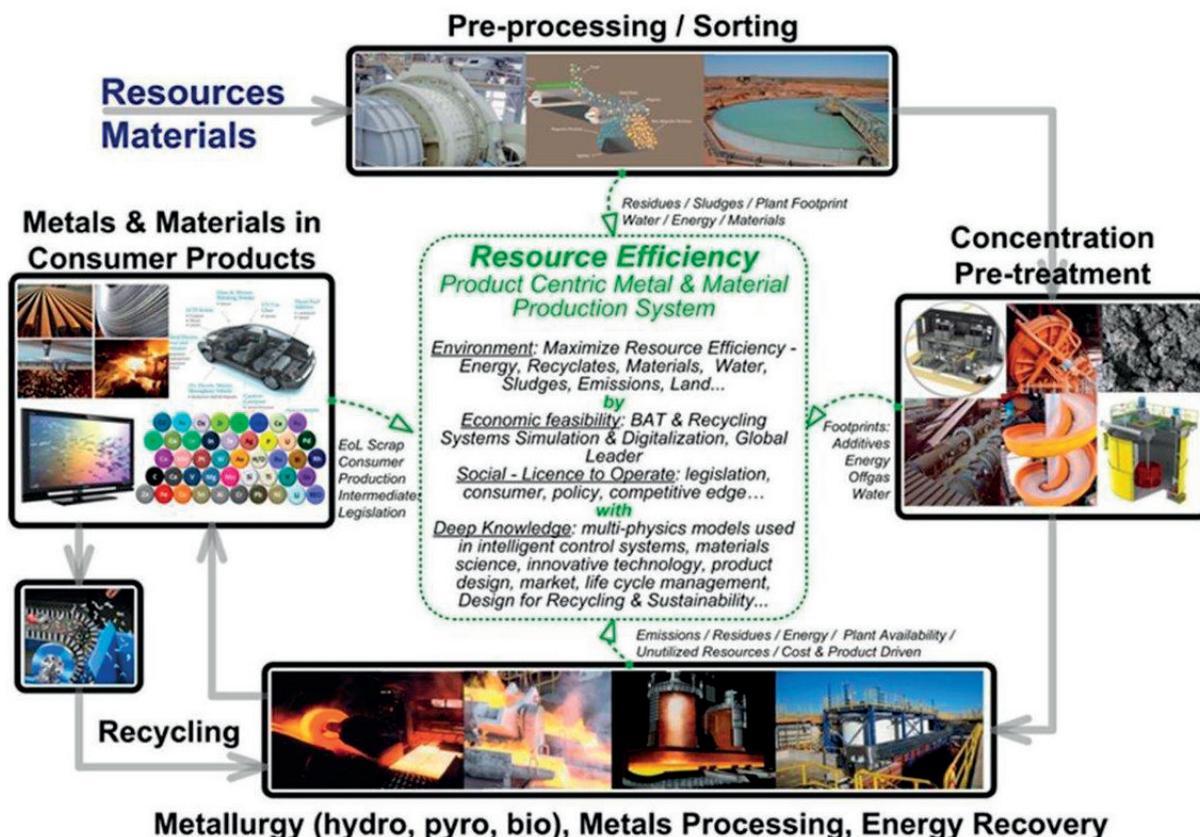


Figure 5: Sequence and interlinkages of process steps to be considered for achieving resource efficiency

### Strategic Ambition 1 (exploration and inventory of resources)

By 2020, Europe has a comprehensive overview about available intra-EU geological mineral and metal resource potential (primary resources) and of the mineral and metal resource potential in the “urban mine” (secondary sources). Secondly, we will have developed new, advanced exploration technologies for land and sea-based exploration as well as tools to assess the resource potential in technical infrastructure and products put on the market. This will make possible to develop an EU vision of the world on minerals (EU minerals intelligence). Enhancement of the accessibility to the existing data / knowledge base on European mineral resources, development of digital data / information interoperability and genuine engagement with

stakeholders and communities is essential for promoting and achieving sustainable development.

### Strategic Ambition 2 (mineral extraction from land and sea bed deposits)

Already today, some of the world’s smartest, and most energy and resource efficient mines and quarries are operating in Europe. By 2020, Europe will maintain and develop further technological leadership aiming at economically viable and environmentally sound mineral extraction operations, including from greater depth of land and sea deposits.

Through 3D/4D modelling applications and interpretations, ore exploration can extend to deeply seated locations. There is also a need for increasing

effort and new implementing rules (e.g. low impact exploration) and methods of exploration to secure commodity supply from European mineral sources. This research will contribute to understanding mineralising processes in different environments, including current deep sea, and using this understanding to find and develop new mineral deposits or deposit types. It also involves the characterisation of ores, rocks, primary and secondary deposits etc. for significant elements and minerals, whose importance has increased and/or which represent cases where the occurrence is poorly understood or constrained.

Development of metallogenetic research and models at regional and deposit scales, with special attention to rare strategic critical minerals for which the EU is highly dependent on, in support of more efficient exploration and mining should be emphasized.

Existing infrastructure frameworks such as GMES need to be further expanded beyond monitoring systems and used in mineral resources exploration and management.

### **Strategic Ambition 3 (mineral processing)**

A/ By 2020 Europe has identified new ore, mineral and concentrates processing technologies that will allow step changes in energy, water and emissions intensity and will allow treating more complex and lower grade (primary and secondary) mineral resources. These technologies, including energy efficient crushing and grinding technology, will pave the way for expanding European business and future advanced jobs.

Innovation in mineral processing will serve recycling by partially compensating for imperfect sorting at the source. Technology needs to be developed to liberalise and disintegrate complex products (cars, electronics, etc.) without dissipating critical metals and trace elements into wrong fractions. While some of these technologies can be adapted from processing of primary materials specific challenges exist for secondaries which require own independent innovation approaches.

In-demand critical metals rarely make up even 5% of a deposit or a secondary material and the major difficulty encountered to supply these metals on the market is cost and energy efficient beneficiation / pre-processing and metallurgical processing which enables the recovery of (critical) trace elements in addition to the base metals metallurgical cost. Increasing yields and recoveries of minerals will allow for up-grading the resources and therefore (1) can decrease the feeds of the metallurgical processes as well as (2) open up more resources to be processed in extractive metallurgy. It could be the key to economic viability of a process.

B/ Europe should stepwise leave the aggregate production based on sand and gravel and go over to crushed rock aggregates in order to save groundwater resources.

### **Strategic Ambition 4 (metallurgy/metals recovery)**

To help secure raw materials supply in Europe, create jobs and support growth, creation of new metallurgical plants and processes will require a resource and its appropriate associated extractive metallurgical process, supported by advanced technologies.

Currently, many resources in the world (whether primary or secondary) are underexploited due to their increasing complexity and low grade which poses significant technical challenges to the associated metallurgical processes. Finding ways at lab scale to extract and concentrate metals is one thing; doing it in an economical **AND** sustainable way is the challenge on which Europe shall take first mover advantage.

To meet tomorrow's challenges, new metallurgical processes shall:

- give economic and environmental viability to new or today unexploited ore bodies and secondary materials
- converge towards the optimal trade-off between energy efficiency, greenhouse gas emission (including CO<sub>2</sub>) and optimization of a resource,

whether in one process or thanks to a network of processes in the area (region, country, EU)

- be robust and versatile to tackle lower grade, more complex and variable (changes in time) resources, most probably thanks to a sophisticated multistage mineral processing / hydrometallurgy / pyrometallurgy flow sheet.

For extractive metallurgy, these objectives can be achieved by focusing on three aspects:

- Support the **development of new processes** (whether hydro-, pyro-, bio-, or electrometallurgical and electrochemical processes) which are compatible with a decarbonated economy and which allow both to minimize wasting resources and to tackle challenges of future resources as well as **optimize integration of hydro and pyro processes**. The up-scaling of such new extractive metallurgical processes will require many iterations between lab work and pilot scale, supported by simulation and modelling.
- Support efforts to **improve the energy efficiency and limit the environmental impact of existing processes** (including capturing of greenhouse gases and recuperation of energy in slags and off-gases of pyrometallurgical processes, optimizing energy use in electrometallurgical or electrochemical processes, regeneration of electrolytes etc.). Additionally, improve recovery of trace elements (range and yields) from thermodynamically difficult material mixes.
- Enhance **flowsheet integration** to minimize waste of resources and energy consumption on a system wide scale. This can be achieved by supporting the use of by-products rich in valuable metals that are not inherent to the system as feed material in other plants/processes. Eventually, the aim is to arrive to a resource fully depleted in valuable metals that can be used to replace natural resources in building industry

Specific challenges in metallurgy for recycling are

1. the non-conventional association of metals occurring in secondary resources which have therefore been less characterized<sup>44</sup>,
2. the lack of visibility with respect to the volumes and nature of the resources and (3) the changes of feed material properties over time, requiring flexible process set-ups able to cope with a large variety of different feed streams. The combination of these two facts often kills at the source the potential, capital and time intensive R&D&I work, necessary to implement the complex and multistage hydro/pyro-metallurgical processes.

#### **Strategic Ambition 5 (recycling)**

Europe has already become the leading continent with regard to recycling of some base metals and a number of other raw materials. The same needs to be achieved for the recycling of critical and essential raw materials, where currently still significant deficits exist<sup>45</sup>. In particular, the ambition is therefore to become the leading continent with regard to recycling of both base and critical/technology metals:

- By 2020, the recycling rates of critical and technology metals are at least above 10% in the EU;
- By 2050, the recycling rates of critical and technology metals are at least above 25% and an overall 10% increase in recycling rate is reached for all other metals.

That gives the opportunity to improve the extraction from secondary sources increasing the overall availability of resources for the EU economy.

Construction and demolition waste represents close to a third of all waste produced in Europe.

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<sup>44</sup> F.-W. Wellmer, M. Dalheimer: The feedback control cycle as regulator of past and future mineral supply. *Mineralium Deposita*, Volume 47, Issue 7 (2012), pp 713-729

<sup>45</sup> Recycling Rates of Metals – A Status Report, UNEP Resource Panel, May 2011, ISBN 978-92-807-3161-3

The EU Waste Framework Directive<sup>46</sup> has set an objective whereby 70% of this waste material must be recycled and/or recovered by 2020 in all Member States. Innovative and comprehensive solutions are required to reach this goal.

Collaborative efforts by the various institutions and governments in the EU Member States are required to achieve these goals since the interdependencies of industries and raw material supply in the Internal Market are such that only a joint EU effort will have the critical mass to produce the technological leadership and know-how. ERA-MIN will provide a starting point. Such innovation will have to foster technology, but also adjust the legal and social framework for innovation and the uptake of the innovative technologies.

The incorporation of mineral resources topics to be addressed as thematic priorities called under the Horizon 2020 and other EU R&D programs and funding schemes should make a challenging target.

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<sup>46</sup> Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance), OJ L 313/3ff

# 3. Detailed objectives / gaps to be overcome / innovation needs

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Innovation is the key to fulfil the strategic ambitions described above. However, innovation is a long-lasting process and successful implementation is not guaranteed in any case. Nevertheless, the members of the ETP SMR went through an in-depth assessment of their professional processes and future needs in light of the upcoming societal challenges in order to identify gaps and derive detailed objectives for the future work and principle innovation needs. The main points as seen by the ETP SMR are:

- To enlarge our knowledge base on the availability of primary and secondary raw materials. Primary raw materials comprise both land and seabed deposits, while secondary address the material composition of relevant (consumer) products, their stocks and flows through manufacturing, use and end-of-life. This will lead to a more comprehensive and updated information on the available EU mineral resources and would for the first time also systematically show the potential we have from secondary.
- To promote networking and co-operation between Member States National geological surveys and industrial as well as science clusters allowing pan-EU assessments and practices to prevent any research capacity fragmentation, including mineral resources education and training. This will be very supportive for the EU initiatives in the field of minerals and will create a strong European added value.
- To develop an INSPIRE<sup>47</sup> compliant network structure delivering mineral data and knowledge, including mineral statistics information.
- To develop new, deep penetrating geophysical technologies and sustainable technologies aimed at exploration, deep land and seabed extraction.
- To apply new metallogenetic interpretations and economic geology modelling focusing on major European mineral belts.
- To apply new metallogenetic interpretations and economic geology modelling on critical raw materials (e.g. Rare Earth Elements) potential areas in the EU.
- To increase our understanding of the functionality of metals and minerals in downstream industrial processes and products, thereby facilitating design-for-recycling and a stepwise improvement of recycling (and substitution) potential.
- To enhance significantly the production efficiency and metal recovery when processing metal ores (Metal Factory of the Future) as well as to promote both sustainable and economical beneficiation and extractive metallurgy processes.
- To develop and implement new extractive processes that allows to competitively exploit new or most probably already known ore deposit, especially in the field of critic/strategic metals.
- To optimally exploit the EU secondary resources as a step towards a circular economy. For this purpose innovation along the entire reuse and recycling chain (logistics, pre-processing, material recovery) is required over all possible sources (production waste streams, end-of-life products, industrial side streams (slags, dusts, effluents, etc.), historic tailings and landfills).
- To develop innovative awareness campaigns, business models (e.g. leasing or deposit systems) and infrastructures to boost the collection of end-of-life (EoL) consumer products and then ensure high quality treatment and recycling.
- To enhance the monitoring and transparency in flows of end-of-life materials by development of smart tracking and tracing technology, right from the moment of collection throughout the entire EoL chain (e.g. tagging with RFIDs).
- To develop innovative pilot plants which enhance the introduction of the innovation pathways addressed above along the whole value chain from exploration, extraction, mineral processing, metallurgy and refinement to recycling.

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<sup>47</sup> INSPIRE: Infrastructure for Spatial Information in the European Community Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), OJ L 108/1ff

- To improve efficiency in material use and in prevention, re-use and recycling of valuable raw materials from waste streams, with a specific focus on materials having a potentially negative impact on the environment.
- To contribute to zero-waste principle by further reducing environmental footprints and assessing the waste and/or by-products parameters in order to maximise their re-use.
- To build an innovative knowledge base of EU resources, including exploration of primary and secondary raw materials (on land and in the marine environment) and estimations of the resource availability including urban mines (landfills and mining waste).
- To make sure the minerals resources sector supports local communities, creates employment, provides facilities and enhances services, including health, education and welfare, through its contribution to regional and national economies.
- To promote sustainable management related to the implementation of Environmental and Minerals Policies in Member States, particularly in the field of land use and in mining waste, as well as public procurement, by stimulating and promoting the use of recycled materials, are some of the most characteristic socio-economic challenges.
- To increase cooperation between surveys and institutions across Europe facilitating joint research. Most national geological surveys are strong players in the European geological research network.
- To develop and maintain Pan-European databases and statistics of many types to ensure public and policy-makers access as well as the facilitation of European research into mineral resources.
- To enhance an EU geopolitical role in ensuring access for European companies to raw materials in the world while respecting as far as possible the European environmental standards.
- To identify opportunities and developing new ideas for innovative raw materials and products with market potential

The mentioned topics can be further detailed and grouped related to the 5 aforementioned Strategic Ambitions.

### **3.1. Strategic Ambition 1 (Exploration and inventory of resources)**

The focus should include the following topics:

- Establish an INSPIRE compliant European Minerals Intelligence Network
- Predictive mining districts using large geo-scientific mineral databases
- Modelling of long-term availability of mineral resources
- Ore deposits building, geological processes (metallogeny, economic geology, especially for rare metals).
- Development of sensors and techniques to locate deep-seated hidden deposits (geophysics, geochemistry, remote sensing).
- Acquisition, conservation of data on EU deep subsurface, focused on prospective areas, development of 3D/4D geo-scientific data and knowledge infrastructure (priority 1: 0 - 1000 m, priority 2: 1000 to 3000).
- Deep sea ore geology mapping
- Development of schematic and then semantic multilingual interoperability of public geo-scientific digital data (beyond the INSPIRE Directive) and high resolution scales
- Define the mineral endowment of EU territory - document the location of the known and potential EU mineral occurrences, quantify their economic value as reserves (proven) or resources (inferred)
- Mapping and feasibility evaluation of secondary resources (mapping the occurrence of metals per application and life cycle analysis for each application in order to localize and anticipate the availability of the secondary resources)

- Industrial and mining waste
- End of life consumer products
- Historical landfills
- Scrap from e.g. buildings or non-consumer products

### **3.2. Strategic Ambition 2 (mineral extraction from land and sea bed deposits)**

The focus should include the following topics:

- Mining rock mechanics for deep deposits
- Recovery and use of geothermal energy from deep mines
- Sustainable management of water, reduced water consumption
- Energy efficient transportation in the mine/quarry
- Novel process control through intelligent use of IT, sensors in extraction and mine processing; automation of and making equipment autonomous
- Marine mining
- Improving health and safety
- Mining small deposits
- Energy efficient mining and quarrying
- Further improving mechanical extraction systems (e.g. selective mining, improved extraction rates, etc.)
- Innovative transport/materials handling systems
- Improved waste/tailings handling (regarding land use, efficient utilisation of deposits)
- Improved mining methods for deep mining

### **3.3. Strategic Ambition 3 (mineral processing)**

The focus should include the following topics:

- Micro-scale mineral processing;
- Nano-scale mineral processing;
- Sustainable management of water and effluents;
- Mineral processing technologies: energy efficiency plus higher yield recovery, waste reduction;
- Efficient exploitation and processing technologies for smaller ore bodies;
- Cleaner products;
- Integrating sustainable extraction and processing in-situ (including mineral processing operations underground);
- New technological processes for treatment and extraction of poly-metallic ores and materials;
- Backfilling techniques to increase use of waste, increase efficiency and addressing stability, and subsidence;
- Innovative methods for gaining value from waste;
- New separation technologies, especially in dry conditions (currently limited performances while it could significantly reduce water consumption);
- Crushing and grinding technologies innovation are critical because it is most energy intensive part of mineral processing;
- Innovative energy-efficient screening, classification and de-watering technology;
- Innovation in mineral processing technologies at micro-scale (1-30Qm), where a majority of the uncontrolled unrecoverable losses lie today and will expand tomorrow since primary ore bodies particles size will tend to shift towards smaller particles size (due to weathering and increase interlocking of ores);

- Sensor technologies have a great potential for both primary and secondary resources. Energy consumption is relatively low and challenges lie in optimizing the efficiency to throughput ratio.

### 3.4. Strategic Ambition 4 (metallurgy/metals recovery)

The focus should include the following topics:

- Hydrometallurgical processes for low-grade and non-conventional ore deposits (e.g. complex polymetallic ores, etc.). As the scope in the field is ample, prioritisation shall be guided by the deposits having the most promising potential;
- Biometallurgical processes (extraction and concentration of metals);
- Treatment of complex ores and secondary material streams;
- Cleaner products;
- Recovery of diversity of metals;
- Metallurgy
  - Environmental: decrease of metals in effluents;
  - Precipitation of iron for hydrometallurgy;
  - Simulation: methods, skills, databases, mainly lacking in hydrometallurgy;
- Define for each potential minor element (As, Hg, Se, Tl, Cd, ...) and association of minor elements, some standard/reference of purification and stabilisation to meet environmental requirements;
- Develop new separation technologies (hydrometallurgy and why not pyrometallurgy or combination of both);
- Thermodynamics of complex metal mixes;
- Optimise metal yields and energy efficiency of metallurgical processes;
- Purification (in hydrometallurgy as well as pyrometallurgy);
- Recovery of energy from slags;
- Recovery of valuable substances from (sewage) slags such as Phosphorus;
- High energy/intensity processes (plasma technology, electro-beam, etc.);
- Dust confinement and analysis techniques.

### 3.5. Strategic Ambition 5 (Recycling)

The focus should include the following topics:

- To optimally exploit the EU secondary resources as a step towards a circular economy by innovating along the entire reuse and recycling chain;
- Recycling/metals recovery/non-metallic valuable substances from landfills, flue dust, effluents, ashes, tailings, (sewage) slags, production waste;
- Enhanced recycling of critical, technology and toxic metals in general, including gallium, indium germanium, rare earths, tantalum, arsenic, tungsten, vanadium;
- Technical means for tracking and tracing of materials flows for recycling(e.g. tagging of relevant products/components such as mobile phones, circuit boards, batteries with RFID chips or other tags);
- Pre-shredder technology to remove magnets, PCBs, batteries;
- Efficient sorting, pre-treatment and metallurgy of complex multi-metallic and material wastes including functional surfaces (LCDs, photovoltaic, etc.) and the interface optimisation (addressing interdependencies of the steps by using a systems approach);
- Mechanical and chemical processing of complex products without dissipation of technology metals;
- Recommendations on technical design for disassembly/recycling/detection;

- To develop suitable methods and technology to enable for optimal recycling of construction and demolition waste (e.g. aggregates, concrete, asphalt etc.).

Different non-technological routes can support further access to raw materials including through recycling. The fourth working group identified under the European Innovation Partnership on Raw Materials aims to improve the regulatory framework conditions notably by promoting excellence and prevention, preparation for re-use and recycling through public (e.g. procurement) and private initiatives.

Possible measures to be explored/developed include:

- Support better collection of scrap and end-of-life products;
- Standards and certification scheme to ensure best practices and level playing field conditions for quality treatment and recycling;
- Explore new economic business models;
- Better knowledge of material flows and value chains interactions;
- Explore the effectiveness of product policies to support recycling e.g. GPP;
- Halt dubious or illegal shipments of waste outside the EU;
- Design for recycling.

### 3.6. How to handle innovation

Innovation is the key to fulfil the Strategic Ambitions of the ETP SMR. Innovation is also the key to solving the grand challenges Europe is facing in the upcoming decades. And innovation is giving reality to novelty, meaning going from a new idea, a new concept, new knowledge (quite often initiated by research work) to offering on the market a new product, a new services, a new process, a new organisation, new ways of doing things. Innovation produces solutions and put them on the market in an economic reality. It requires addressing all the

aspects of the real world affected by the novelty. For companies, innovations have, by definition, a socio-economic reality, increasing its power to act on the outside world. Innovation is essential for a company not to die. But the cost to innovate is high. That is why innovating must take into account risk management and often appears in extreme conditions, when technical and economic opportunities arise or at critical stages for a company.

Innovation as the process to gain (industrial) leadership is a long-lasting one. It is a royal access to take the leadership. It is commonly agreed that an innovation process from the first idea to successful implementation and commercialisation may last 10 to 15 years or even longer (for a completely new process). We already outlined in chapter 1.4 how the key drivers for getting to leadership – education, research and innovation – should work together in an integrated way in order to generate a successful process.

Especially overcoming the ‘Valley of death’ in this process needs to receive special attention. This is usually the case when a technology goes from lab-scale to pilot-scale accompanied with high investment and risks. Establishing the right framework for supporting pilot plants as a means to foster innovation along the entire value chain would be desirable.

In a laboratory, process works in an idealistic reality. When it goes out of the laboratory pilot scale, the process is confronted to another reality, in a matter of quantities, residues, environmental constraints, etc. At this moment, many things that had not been imagined appear and have to be solved.

That is why, it is necessary to try the process at a pilot-scale before the step of the demonstration plant. This pilot-scale allows the testing and the development under real conditions and on a continuous basis of a process designed under laboratory conditions and to ensure their viable development. There have to be a back and forth exchanges between the lab and the pilot to optimise and secure the process.

Pilot-scale development of processes is a critical step between the lab and the plant: numerous projects have failed due to a lack of piloting experience.

The minerals sector has significant direct and indirect impacts on EU's economy, employment and society as a whole. The minerals sector is already well-placed to serve as a platform for a sustainable and diverse also export-oriented industry based on refinement and value-enhancement of mineral products and related technologies and services. However, this is only possible by providing an optimal legislative regime and business environment for the sector. Our vision is therefore based on promoting knowledge and skills enhancement coupled with innovation research and development, as a basis for sustained and sustainable growth in the sector.

To innovate is, by essence, an entrepreneurial act in opposition to business as usual proceeding from the logic of capital risk and venture. Innovation has proved to be highly profitable, high value added and to support jobs creation.

Contrary to what it is often believed, it is not the lack of ideas, of new knowledge, of research work, neither in the pragmatism of them. Challenges lie in mastering the process of going from an idea to a concrete implementation of the innovation. More precisely, in the selection of the right ideas, the strategic choices made and overall the determination to proceed until the full potential is achieved, addressing all aspects of the real world. Innovation requires a clear, precise, and concrete strategy along with an implementation framework, which requires initial decision making and risk taking with respect to the chosen vision. The biggest difficulty of innovation is to lead the process of innovation to the end and not to stop at the first obstacle.

After that, the innovation process entails flexibility and freedom for ideas maturation to industrialisation and a series of transversal skills and knowledge, as tools to alleviate uncertainties and unknowns.

### **3.6.1. Skills and knowledge**

Training, capacity building and education is an essential part to foster innovations in the raw

materials sector. The value chain of exploration-mining-processing-refining-recycling offers ample opportunities for jobs, many of them advanced and highly sophisticated. Besides innovations in technology, we also need social innovations to develop skills and transfer knowledge and understanding within and beyond current practice.

It is essential that training and education includes a strong interdisciplinary approach to address the complex interdependencies in the mineral resources field and to facilitate a true value chain approach. It further requires collaborative work between research institutions in the EU 27 Member States.

Stronger ties between industry and universities should be developed as well as increased mobility in between sectors to nurture innovations.

Well-funded academic institutions that foster research and education of future researchers will be required to further develop and maintain technological leadership.

A secure access to raw materials also requires capable human resources. We need to raise awareness among young people for the significance of the sector as a corner stone in the sustainable development of Europe and to attract more students to engage in related fields.

### **3.6.2. Core/base research**

Europe owns several of the best universities in the minerals field as well as world-leading technology providers. Further, highly respected research institute complete Europe's potential to generate new knowledge and technology. Given the appropriate framework, Europe's knowledge base will be able and capable to generate the necessary ideas for meeting our innovation needs and Strategic Ambitions.

We believe that research efforts should provide high quality technology solutions for the needs of the raw materials industry. Also fundamental research should be refreshed and constantly updated through intensive communication between faculty and industry. Fundamental research that converges towards the chosen goal should be financially

supported. The research should focus on the key strategic areas identified in order to secure EU raw materials supply.

More than that research is also being regarded as a private engagement especially in research driven SME and clusters. ETP SMR's intention is to link the beneficiaries of the European raw material market, like the consulting industry, with the demand carriers from production industry in order to better define market-oriented R&D for quick commercialisation. Private R&D will allow exploring and developing new market driven business fields thus building up new European private enterprises and to strengthen the private R&D sector. Core and base research output will qualify European enterprises, here especially SME, in global markets.

Research will qualify SME for engagements in small scale mining to foster private engagement of even small enterprises in the raw material value chain.

Core/base research needs strategic partnerships with international entrepreneurs such as clusters and private corporations also in countries associated with the European funding programs. This strategy to get more involved in global market developments will be matched with the bilateral national raw material partnerships of the member states world-wide.

Core/base research must stimulate cross-border cooperation respective the geological setting of the deposits. EU data bases will have a focus on stakeholders of common geological provinces, as R&D programs will better consider networks across similar geological provinces.

### **3.6.3. Faculty**

The minerals sector is facing a shortage of experts. The average age of specialists is high throughout the sector, but due to recent expansion and investments, demand for them is growing continuously. Training has also been poorly coordinated across the sector, while training programmes in the sector have been reduced and teachers have retired. In addition, the minerals sector does not appeal to young people, which is principally due to the characteristic cyclic nature of investment in exploration and mining and

the general image of the sector. The mining industry also demands a skilled professional workforce trained in modern mining techniques, which in turn requires appropriate, comprehensive training programmes in universities of applied sciences, technical colleges and trade schools. There is no quick remedy in sight for the labour problem due to the low training volumes in the sector, and this is made worse by tighter global competition.

The concept of sustainability with respect to the use of natural resources must become an accepted and integral part of the educational system, in order to promote a wider understanding of the importance of raw materials and their geological context, alongside other teaching in the natural sciences. This is important not only to the general educational curriculum but also to economics and commercial studies in particular. Minerals sector training programmes must be further promoted over the medium and long term, with efforts to strengthen international connections. These objectives are aligned with those of the "young people on the move" flagship projects of the Europe 2020 plan, which aims to improve education system results and facilitate young people's access to the job market. We should accordingly actively promote the inclusion of minerals sector education objectives within the EU's training programmes.

Although there are today some good links between academia and industry, a general objective must be to establish even stronger connections between industry and education. The curricula need to be adapted to the needs of the industry given the current shortages in skilled and well-trained workforce. But regarding the innovation needs outline earlier, there will also be a growing need for product-oriented research workforce able to scientifically work on particular items.

### **3.6.4. Sponsors/funds**

Funds like the German exploration funding program already contribute to secure European raw material supply and open the door even for extra European engagement of private enterprises. Substantial progress can be achieved from cross-sectorial themes addressed by many EU 2014-2020 funding programs.

These programs will comprise a broad variety of financial support in structural funds and action programs. Funds like Interreg V-A, B, C; ELER, EFRE as well as action programs like LIFE will contribute with complementary tasks to Horizon 2020 raw material R&D funds. Raw material policies thus become more aware across the European society and the stakeholders of many different industrial and administrative sectors.

### 3.6.5. Horizontal approach

To become really successfully implemented, technical innovation has always to be embedded in a broader context of innovation approaches and has to involve other stakeholders and disciplines.

- This is specifically true for innovation in recycling because here the whole product lifecycle and various interactors need to be considered. Various innovation interlinks exist:
  - Innovations in product design including design for disassembly, design for recycling, design for tracking & tracing. Since product development, design and product recyclability respectively recycling technology are closely interlinked, early communication between developers at both ends and an interactive innovation process are crucial.
  - Innovations in material sciences and substitution impact both demand patterns for primary and secondary production as well as product recyclability.
  - Innovative technologies and models for tracking and tracing product and material flows and for predicting product life times in order to build up an inventory of the potential urban mine and create transparency about real flows.
  - Innovation in sales strategies, economic incentives and business models to close the loop and incentivise the collection of end-of-life (EoL) products.
  - Innovation in consumer/user focussed approaches to raise awareness and trigger handling in of EoL products.
  - Innovation in mechanisms/tools to support quality recycling and ensure better enforcement of existing legislation.

- This is not possible without a cross-disciplinary cooperation involving researchers/innovators from technical disciplines (including information technology), economists and social sciences.
- Innovation at interfaces along the product/material lifecycle and the feedback loop between process innovations and the broader system will be crucial.
- Given the need to have an integrated and interdisciplinary approach, it is key that different EU policies and initiatives reflect this and thus that they are aligned and consistent.

### 3.6.6. Standardisation

An important part of innovation is standardisation, especially European standards but also globally. Standardisation is a voluntary cooperation among industry, consumers, public authorities and other interested parties for the development of technical specifications based on consensus. Standardisation complements market-based competition, typically in order to achieve objectives such as the interoperability of complementary products/services, and to agree on test methods and on requirements for safety, health, organisational and environmental performance. Standardisation also has a dimension of public interest, in particular whenever issues of safety, health, security and of the environment are at stake.

Dynamic standardisation is an important enabler of innovation. This occurs in different ways<sup>48</sup>:

- Standards that express the state of the art give innovators a level playing field facilitating interoperability and competition between new and already existing products, services and processes. Standards provide customers with trust in the safety and performance of new products and allow differentiation of products through reference to standardised methods;
- The development of new standards is also necessary to accompany the emergence of new markets and the introduction of complex systems;

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48 Towards an increased contribution from standardisation to innovation in Europe, COM (2008)133 final

- The use of standards contributes to diffusing knowledge and facilitating the application of technology; this may then trigger innovation, in particular non-technological innovation in the service sector.

Most of the benefits of standards for innovation only materialise when standards are effectively implemented and market-relevant. The actual use of standards remains voluntary, depending on the perception of different market players of their interests and their capacity to use them. Standards may fail to achieve relevance because of the inappropriate timing of their development or their lack of visibility, or due to the existence of competing standards which introduce uncertainty.

# Annexes

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## Annex I: The European Minerals Industry

The Communicate {COM(2008) 699} highlights that: “the EU is self-sufficient in construction minerals, in particular aggregates, and is a major world producer of gypsum and natural stone. The availability of aggregates from regional and local sources is essential for economic development, in view of logistical constraints and transport costs. The EU is also the world’s largest or second largest producer of certain industrial minerals, though it remains a net importer of most of them. However, the EU is highly dependent on imports of metallic minerals, as its domestic production is limited to about 8% of world production”.

In order to fulfil the vision of the Platform ‘to supply and secure the mineral resources for Europe’, we cannot only look at production of mineral raw materials from primary land and sea bed deposits. Secondary resources will become more and more important as source for mineral raw materials. Therefore, the recycling sector forms an integral part of the mineral resources strategy and thus also of the ETP SMR. Finally, from the resources side, ETP SMR has integrated also the energy extractive industry.

ETP SMR is covering the entire range of mineral resources production in Europe. However, the production and tailored provision of mineral raw materials needs more than exploitation and/or recycling. Technology and knowledge is the key to success. Therefore, ETP SMR has also integrated many of Europe’s very strong equipment and technology providers. Those organisations are usually part of every development process and necessary to be successful.

The highly scientific background as well as all necessary education and training activities are covered by universities highly reputable in the minerals sector. The universities provide basic research to obtain the knowledge for technical development as well as education and training to provide the skilled workforce to carry out all tasks along the value chain.

Consequently, the ETP SMR is covering the following groups of mineral resources as well as horizontal activities:

- Metallic minerals
- Industrial minerals
- Recycled metals and minerals
- Aggregates
- Provision of equipment and technology
- Basic research, education and training

About 250 EU companies are engaged in metals extraction, including three major multinationals ranking in the top five largest mining corporations in the world. The capitalisation amounts to more than 96 billion € with about 415000 people directly employed. However, while the EU consumes about 25% to 30% of the world’s metal production, EU metal extraction accounts for a mere 8% of world production. A better balance between production and consumption on one hand and security of supplies considerations on the other will, due to the demand within the EU, call for an increase in extraction within the EU.

Metals are traded on the international market which means that European producers are in direct competition with many lower cost producers. In order to maintain European EHS standards and remain competitive, European producers have to continuously cut costs through modernisation and innovation. If the mining, metals and minerals sector were not to remain in Europe the research competences as well as downstream industry will relocate, too, leaving Europe totally deprived of further possibilities of action. Economic, social and – at the end – environmental consequences would be dramatic. At the same time the European metals industry has been one of the major technology providers in smelting technology around the world, aluminium and copper are just two examples. This technology know-how needs to be continuously developed further to maintain this European asset that provides considerable exports. The European industrial minerals sector is present in all of the EU Member States. and includes the world’s

leading international production companies. It offers direct employment to some 100,000 people. With some 810 mines and quarries and 830 plants, Europe is a major producer of some industrial minerals, for example, feldspar, gypsum, magnesite, bentonite and kaolin, for which over a quarter of global production was recorded within the EU 27 and candidate countries. Another important field is fertilizer production from potash.

The industrial minerals sector produces an annual volume of some 145 million tonnes, contributing a value of around 13 billion € to Europe's GDP. If downstream industries such as glass, foundries, ceramics, paper, paint, plastic, etc. are included, these figures are several orders of magnitude greater. In contrast to aggregates, the geological distribution of specific industrial minerals is more localised. This means there is much international trade in these minerals. Despite significant production of some minerals, the available data suggests that the EU is a net importer of all industrial minerals, even those for which the EU is a major global producer.

The importance of aggregates or construction minerals has increased significantly over the years. The European Aggregates Industry is the main supplier of materials to all types of infrastructure works within the European Union. Construction of roads, railways, airfields, buildings, sewage systems and other civil engineering works depend on large amounts of locally and regionally extracted and processed aggregates. More than 3 billion tonnes of sand, gravel and crushed stone (with a value of more than 35 billion €) are produced annually to meet the demands of the European building and construction industries.

The minerals sector would not be able to supply the different commodities successfully without the support of the European equipment and technology providers and the research, education and training sectors. The European equipment and technology providers provide the necessary machinery and processes for minerals exploitation and provision. This sector is world leader on that market and provides equipment and processes all over the world. The research, education and training sector takes care of well-educated people for the minerals sector in order to overcome the shortage of staff due to retirement of

many employees. Universities and research institutions provide the scientific excellence for research and innovation activities.

## 1. Metallic Minerals

Metal mining include a wide range of ores which - following processing - provide metals. A variety of metal ores are extracted within the EU.

The EU is a major producer of some metals such as iron, copper, zinc, gold, mercury, silver, lead and chromium, but is nevertheless dependent on imports of many of these metals and entirely dependent on the import of many others like antimony, cobalt or molybdenum. Imports are in the form of concentrates for metal refinery within Europe, or as metal half-products.

Non-ferrous metals contribute to the European - and global - creation of wealth and jobs: they represent 2% of EU GDP and create 450,000 direct jobs and over 1 million indirect jobs in Europe. Primary and secondary raw materials are complementary, as secondary raw materials cannot on their own meet the growing needs of a sustainable economy.

The non-ferrous metals industry contributes to resource efficiency by enhancing the in-use phase of products and also thanks to high recycling rates ranging between 30% and 95%, depending on the metals and their use.

The European metals sector is a fundamental, strategic pillar of the downstream fabricating, service and consumer industry in Europe. Metals have become such an integral part of our everyday life that many of us no longer recognise them. Metals and their compounds play a major role in the pharmaceutical industry as they do in nutrition, housing, transport, communication and in the household.

## 2. Industrial Minerals

The industrial minerals sector provides a wide range of minerals which can be loosely classified as 'physical' minerals (e.g. calcium carbonates, borates, diatomite, kaolin, plastic clays, bentonite, feldspar, silica, and talc) or 'chemical' minerals (e.g. salt, potash, sulphur). The sector also produces important raw materials for the chemicals and fertilizer manufacturing industries, as well as for ceramics, glass, paper, paints, plastics, iron & steel and construction.

Fertilizers are essential in order to feed the continuously growing world population. According to FAO estimations in 2008, world's food production should be increased 40% by 2030 and 70% by 2050, compared to 2007 figures, in order to keep the pace of population growth. Given the scarce additional land resources available, the use of fertilizers will play a key role in order to increase food production. Biofuels also play a very important role on fertilizer demand.

Therefore, potash consumption and food requirements patterns are strongly connected: China, India, Brazil, South East Asia and other fast developing countries are huge demanders of food and therefore of fertilizers. These are the areas of the world where increases of consumption should be expected in the years to come. On the other hand, in western economies, including European ones, the trend should be of stable consumption. Mineral fertilizers are made from naturally occurring raw materials which have been transformed into more plant-available form. Nitrogen (N) is essential as an important component of proteins, phosphorous (P) is key to energy transfer and potassium (K) has an important role in plant metabolism, for photosynthesis, activation of enzymes, etc. In the EU-27 countries over the last three growing seasons, on average fertilizers containing 10,5 million tonnes of nitrogen (N), 2,4 million tonnes of phosphate (P<sub>2</sub>O<sub>5</sub>) and 2,7 million tonnes of potash (K<sub>2</sub>O) have been applied each season.

Total potash production in Europe amounts about 4,3 million tonnes K<sub>2</sub>O/year, which represents

about 15% from world production figure. In Europe, potash is produced, apart from Spain, also in the UK and Germany. Canada (30%), Russia (20%) and Belorussia (15%) are main production centres in the world. 95% of the world potash reserves and production are concentrated in 8 countries only.

Product is mostly traded in bulk carriers. Shipment size depends on logistics capabilities of each destination.

Potash is mainly used for fertilizer production (over 95%). In such cases, it can be used directly into the fields or transformed as raw material on the production of complex fertilizers together with other nutrients. Other applications include the production of caustic potash on electrolysis units.

## 3. Recycled Metals and Minerals

Recycling plays a major role in the attempt to create a resource-efficient industrial sector in Europe and reduce the dependency on imports. All recycling-processes have to be resource and energy efficient in order to be competitive with the generation of fresh, new material. Nonetheless, all recycling processes require the use of thermal and/or electrical energy. Hence, in order to reduce the dependency on foreign imports, EU has to support science and industry in developing novel technologies and - most importantly - provide the necessary framework for operating such devices in EU:

Recycling of metals such as Steel, Aluminium, Zinc or Lead are state-of-the-art technologies and currently in widespread use within the EU.

Recycling of other substances such as Phosphor or Rare-Earth elements, however, is not performed in the EU on a large scale. Despite minor quantities, such substances are crucial enablers for technological development and hence crucial for the competitiveness of the EU.

The non-ferrous metals industry contributes to resource efficiency by enhancing the in-use phase of products and also thanks to high recycling rates

ranging between 30% and 95%, depending on the metals and their use.

Construction and demolition waste (CDW) represents close to a third of all waste produced in Europe. It comprises aggregates but also concrete, asphalt, etc. The current recycling rates differ in each European Member State reaching from about 10% up to 90%. The EU Waste Framework Directive<sup>49</sup> has set an objective whereby 70% of this waste material must be recycled and/or recovered by 2020 in all Member States.

#### 4. Aggregates

The European aggregate production and consumption is about 3,000 million tonnes - the largest macroregional market in the world. The European Aggregates Industry is the main supplier of materials to all types of infrastructure works within the European Union including aggregates for concrete and asphalt pavements. Construction of roads, railways, airfields, buildings, sewage systems and other civil engineering works depend on large amounts of locally and regionally extracted and processed aggregates. There are currently about 25,000 production sites all over Europe with about 250,000 employees in total. Most of aggregate producers in Europe are small and medium sized companies, SME.

Aggregates can be produced from natural sources, basically from quarries and gravel pits and in some countries from sea dredge as well as from "Secondary Raw Materials", such as demolition waste, recycled concrete and material recovered during road repairs. Recycled materials may replace aggregates from natural sources in as much as 5% of the total amount of aggregates needed in the construction sector.

The particular problem with construction minerals is that they are required in large quantities in the economically more active regions and close to growth centres. Most of the aggregates are

produced locally with the exception of a few mega-quarries next to the sea which can deliver development centres reachable by bulk carriers. The relatively low value of construction minerals places constraints on the distance over which they are transported. Short transport distances are the most effective means of keeping the cost of transport and the environmental impact of mineral supply low. This particularity may create a conflict with other land uses.

#### 5. Provision of equipment and technology

New processing technologies for extraction, processing and recycling will built on the existing excellence of European technology provides and will continue to provide a substantial contribution to the future leadership of European technology and will guarantee growth and exports in this industrial sector.

European equipment and technology providers dominate the market especially in mining industry as well as in minerals and metals processing. European companies such as Sandvik, Atlas Copco, Metso, FLSmidth, Outotec and Tecnicas Reunidas are the global leaders in mining, minerals and metals processing technology, and have developed over decades many breakthrough technologies.

#### 6. Basic research, education and training

Sustainable supply of raw materials for the population is an important task today and for the future. Specialists will be required to develop efficient mining excavation and processing methods as well as intelligent recycling systems to ensure sustainable handling of the world's resources. Graduates from the field of raw materials and disposal engineering make an important contribution to ensure that the raw materials demands of future generations are also covered.

Quite some high-class universities and research organisations active in the fields of mineral engineering, geology and mineral processing are located in Europe. In order to overcome the pressing shortage of well-educated students

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<sup>49</sup> Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance), OJ L 313/3ff

needed in the minerals industry to replace retiring staff, several universities and companies founded the Federation of European Mineral Programs (FEMP). FEMP is a legal organisation in which 25 leading multinational companies participate together with seven leading European Universities. These offer the joint European Mining, Minerals and Environmental Program (EMMEP) which is an integrated program with three specialisations. The Federation is the co-ordinating body for matters regarding education and research covering all aspects of Mineral Engineering in a large part of Europe. The three specialisations are Mining Engineering (European Mining Course (EMC), Mineral Engineering (European Mineral Engineering Course (EMEC) and Geotechnical and Environmental Engineering (European Geotechnical and Environmental Course (EGEC).

But not only the highly renowned field of education and training characterises the scientific excellence in Europe. Many research institutes and organisation, many of which are specialised on particular fields of the raw materials value chain, contribute to the European knowledge base in raw material supply. Institutes are covering base as well as applied research so that Europe has the advantage of owning knowledge and scientific excellence to a great extent.

## Annex II: The ETP SMR on the mineral raw materials value chain

The raw materials value chain is illustrated in the Figure 6 below. It describes the life-cycle of mineral raw materials. It is generally valid for a broad range of raw materials, including industrial minerals, ferrous and nonferrous metals.

As Figure 6 shows, the metals life cycle starts with exploration and mining to provide first hand access and bring materials from the geosphere into the technosphere. From then on the basic concept is simple: extract metals at high rates from the ores, use them as efficiently as possible in the manufacturing process of products, avoid dissipation during the use and EoL phase and minimise losses of metals into residues during all phases of the life cycle. By doing so metals can be reused to a high percentage for a second, third etc. life cycle. This implicitly means that both

scrap occurring during production and end-of-life products are new sources of raw materials that need to be recycled with high efficiencies. It is desirable to reduce unrecycled residues that derive from all stages of the lifecycle. This demands intelligent product design as well as smart processes over the value chain. Historic wastes create additional future resources beyond natural (geological) resources. Moreover, substitution efforts in product manufacturing may help mitigate raw materials access constraints, but it could lead to new challenges for recyclability or for sourcing the substitutes. Promoting more reuse of products and materials is also important, providing it leads into final recycling at the end of the extended lifetime.

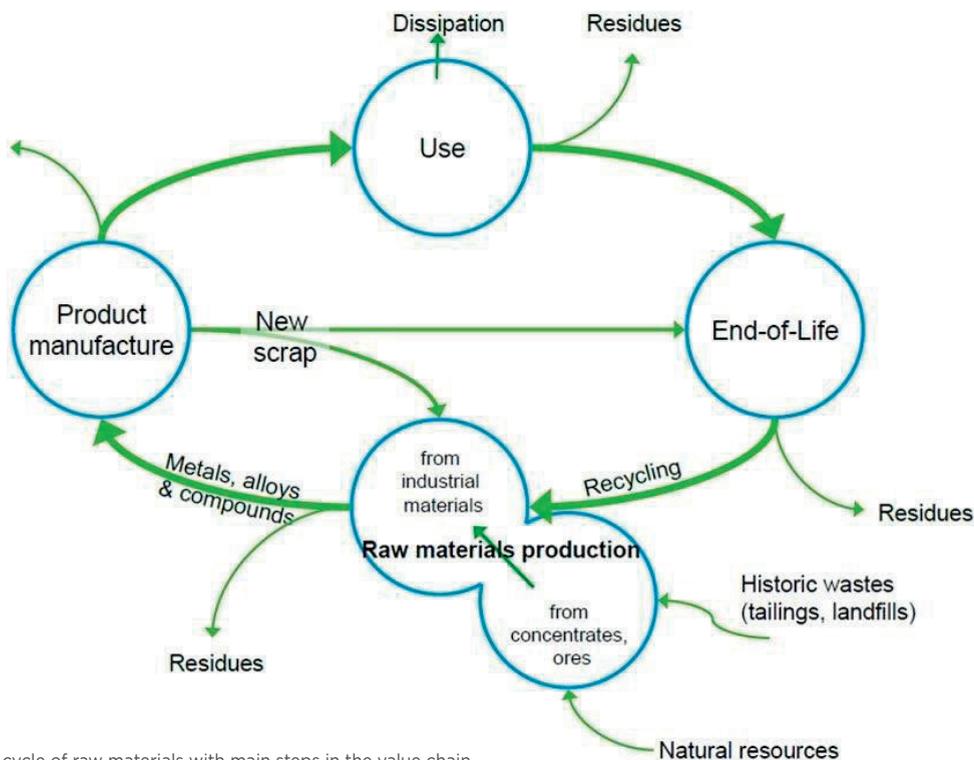


Figure 6: Life cycle of raw materials with main steps in the value chain





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