Deliverable D5.3

Report on Foresight Logframe

Project:	Mineral Intelligence Capacity Analysis
Acronym:	MICA
Grant Agreement:	689468
Funding Scheme:	Horizon 2020
Webpage:	www.mica-project.eu
Work Package:	Work Package 5
Work Package Leader:	MinPol, Eberhard Falck
Deliverable Title:	Report on Foresight Logframe
Deliverable Number:	D5.3
Deliverable Leader:	LPRC
Involved beneficiaries:	LPRC, MinPol
Dissemination level:	PU Public
Version:	Final
Status:	Submitted
Authors:	Marco Konrat Martins, Balazs Bodo
Reviewed by:	Eberhard Falck, Nynke Keulen
Approved by:	Nynke Keulen

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 689648.

Notice

The contents of this document are the copyright of the MICA consortium and shall not be copied in whole, in part, or otherwise reproduced (whether by photographic, reprographic or any other method), and the contents thereof shall not be divulged to any other person or organisation without prior written permission. Such consent is hereby automatically given to all members who have entered into the MICA Consortium Agreement, dated 19th October 2015, and to the European Commission to use and disseminate this information.

This information and content of this report is the sole responsibility of the MICA consortium members and does not necessarily represent the views expressed by the European Commission or its services. Whilst the information contained in the documents and webpages of the project is believed to be accurate, the author(s) or any other participant in the MICA consortium makes no warranty of any kind with regard to this material.

TABLE OF CONTENTS

PURPOSE

Deliverable 5.3 of the Mineral Intelligence Capacity Analysis (MICA) project describes the Logframe definition of the task 5.2 *Strategic Raw Materials Intelligence Approaches*. The international review of benchmarks and best practices in raw materials past foresight case studies aims to understand how other EU and non-EU countries have used foresight in raw materials. This review seeks to provide a starting point in developing a classification system to investigate foresight methods and their suitability against specific purposes and the possible combinations of methods that can be applied during foresight.

EXECUTIVE SUMMARY

Deliverable 5.3 of the Mineral Intelligence Capacity Analysis project (MICA) documents a concise summary of the implementation (LogFrame) of task 5.2 *Strategic Raw Materials Intelligence Approaches*. Raw Materials Intelligence (RMI) is developed in a complex context of sectoral policies and regulations at national and international level, stakeholder needs and practical data availability constraints. Task 5.2 will provide outputs for WP6 (responsible for the creation of the MICA online platform, EU-RMICP) to support RMI for longer-term policy making by increasing Europe's capacity for timely responses to the future challenges that concern raw materials and by identifying broader aspects of the sector and needs for future research against different timeframes and by formulating ideas for possible future actions and increasing efficiency and effectiveness of the EU activities related to raw materials policy planning.

Deliverable 5.3 *Report on Foresight Logframe* presents a review of benchmarks and best practices – a review of past international foresight case studies concerning raw materials. This allows for a better understanding of how EU and non-EU countries have used foresight in raw materials. In that sense, 32 case studies have been collected internationally and reviewed – here named as 'Pool of Foresight Case Studies'. After screening, 12 of them have been selected for a detailed review, in function of the presence of foresight methods employed, generating a 'Foresight Case Studies Inventory'. A comprehensive review of raw materials foresight frameworks is undertaken to explore how foresight methods can be structured in a foresight exercise.

The final Foresight Case Studies Inventory is approached through initial classifications:

- A quantitative one – addressing measurable aspects (e.g. number of people and institutions involved, etc.);
- A macro-environmental classification – outlining macro-environmental factors clearly targeted by the studies; and
- A review of the methods observed in the study, generating a methods combination matrix and a 'suitability matrix' – methods vs. purposes.

'Scenarios' emerged as a main method observed in these studies. However, it can vary substantially in terms of how it was employed in the study.

This approach provides a starting point in understanding different purposes of foresight in raw materials, suitability of methods for specific purposes, and how these tools can be combined during a foresight exercise. These outputs will be complemented by the forthcoming sub-tasks – Detailed Methodology Assessment, Pilot Workshop and Final Recommendations. Moreover, D5.5 *Raw Materials Foresight Guide* will be the ultimate product of the task 5.2 *Strategic Raw Materials Intelligence Approaches*.

DELIVERABLE REPORT

1 Introduction

This report summarises the first findings of the Task 5.2 of the MICA project.

The objective of Task 5.2 is to develop recommendations for Raw Materials Foresight approaches. The outputs of this task should enable stakeholders to:

- Increase Europe's capacity for a timely response to anticipated scenarios concerning raw materials challenges;
- Identify major trends, uncertainties, key decision points, driving forces, needs for future research against different timeframes;
- Formulate ideas for possible future actions and increasing efficiency and effectiveness of the EU activities related to raw materials policy planning.

In this context, this particular deliverable will support these objectives by:

- A Logframe definition (Subtask 5.2.1), summarising the implementation of the tasks according to the objectives hierarchy;
- A review of past international raw materials foresight studies, to understand how other EU and non-EU countries have used Foresight in Raw Materials (subtask 5.2.3);
- An initial classification according to the various purposes and goals, the suitability of methods to support specific purposes observed in past studies and the combination of tools and steps that can be applied (subtask 5.2.2).

2 Logframe Definition

2.1 Logical Framework Approach

The Logical Framework Approach (LFA) was developed in the 1960s to support the US Agency of International Development in improving its project planning evaluation protocol (EuropeAid, 2004). It addressed three basic concerns: vague planning (no clearly defined objectives), unclear management responsibilities and evaluation process disagreements.

A logical framework is particularly helpful for considering different aspects and different levels of the tasks implementation. The Logical Framework Matrix, or just Logframe, seeks to illustrate the tasks structure in a logical and concise way. It supports, therefore, project planning and management. It is an iterative process aiding systematic and structured analysis of a project or programme idea.

The LFA should be regarded as an 'aid to thinking', allowing information to be analysed and organised in a structured way. It is important to point out the difference between the LFA, which is an analytical process, and the LFM (Logical Framework Matrix) that provides the documented product of the analytical process (EuropeAid, 2004). LFA as a planning aid today is widely used in international institutions such as the United Nations (UN) and the European Commission (EC). The Logframe consists of a Matrix with four columns and four (or more) rows, summarizing the key elements of a projects plan, namely:

- Hierarchy of Objectives;
- Key external factors critical to the project's success (Assumptions); and
- Indicators and Means of Verification

The Logframe is structured under two logics:

- Vertical Logic
  - Identifies what the project intends to do and achieve;
  - Clarifies the causal relationships (means to an end);
  - Specifies important assumptions and risks.
- Horizontal Logic
  - Specifies indicators to measure progress;
  - Identifies the sources / means by which indicators will be verified.

A typical Logframe structure is shown in Table 1.

As a tool in the project management cycle, the LFA can be used during the identification stage, helping to analyse the existing situation; during the formulation stage, by supporting the preparation of the project plan; during the implementation stage, by providing support to operational work planning and monitoring; and during the evaluation stage, by providing a summary record of what was planned, hence presenting the basis for performance and impact assessment.

Table 1 Logframe Structure (adapted) (EuropeAID, 2004).

Project Description	Indicators	Source of Verification	Assumptions
Overall Objective – The project's contribution to policy or programme objectives (impact)	How x is to be measured including Quantity, Quality, and Time?	How will the information be collected, when and by whom?	
Purpose – Direct benefits to the target group(s)		As above	If the Purpose is achieved, what assumptions must hold true to achieve x?
Results – Tangible products or services delivered by the project		As above	If Results are achieved, what assumptions must hold true to deliver the results?
Activities – Tasks that have to be undertaken to deliver the desired results.			If Activities are completed, what assumptions must hold true to deliver the results?

2.2 Logframe Matrix

As was pointed out in Section 2.1, the Logframe Matrix is no more than the product of the analytical process of LFA. The hierarchy of objectives should contain (vertical logic):

- Overall Objective – as the bottom-line outcome;
- Purpose – determined by asking the question "Why is this goal to be achieved?";
- Results – the deliverables through which the purpose will be achieved; and
- The Activities – main elements of a project, through which the outputs are achieved.

In the horizontal logic the matrix should contain:

- Indicators – they should ideally be objectively verifiable, when possible including quantities, qualities and time/dates;
- Sources of Verification – sources that are reliable and accessible, in a reasonable cost of obtaining;
- Assumptions – External factors that can influence or determine the success of the project, lying outside the control of the project.

Table 2 on the next page presents the Logframe Matrix for the implementation of MICA Task 5.2 *Strategic Raw Materials Intelligence Approaches.*

Table 2 MICA Task 5.2 Logframe Matrix Definition.

	Project Description	Indicators	Source of Verification	Assumptions
Goal (overall objective)	**To develop recommendations for European Raw Materials foresight approaches, complementary to WP4.**			
Purpose (direct benefits to the target group)	**Enable stakeholders to conduct RMI Foresight exercises**	Europe's capacities for a timely response to anticipated scenarios that concern future raw materials challenges;	Official eports, Stakeholders feedback	EU-RMICP will become a relevant tool for the stakeholders' long-term decision making.
		Identification of major trends, uncertainties, key decision points, driving forces, needs for future research against different timeframes;	Official Reports	Scoped aspects are enough to provide a proper picture of the sector.
		Ideas created for possible future actions (bringing a 'preferred future') and increased efficiency and effectiveness of the EU activities related to raw materials policy planning.	Official Reports, Mica EU-RMICP	Experts involved are aware of data and facts.
Results (Outputs)	**Understanding different purposes of RMI Foresight**	7 qualitative & 4 semi-quantitative methods observed in past studies of 27 methods in total scoped from D5.1. 12 different purposes collected.	Raw Materials Foresight Logframe - Deliverable D5.3 - release date: 01.17	Reviewed studies provide a solid representation of possible purposes for a RMI foresight exercise.
	Benchmarks & Best Practices	More than 30 exercise studies reviewed and classified accordingly (inventory), generating a final list with 10 to be reviewed in detail.		All relevant information is documented / available in the case study reports.
	Methodology assessment	A number of methods and purposes are confronted with identified stakeholders needs.	Raw Materials Foresight Guide - Deliverable D5.5 - release date: 07.17	Information collected is able to provide guidance for the methods and implementation.
	Pilot Workshop	Up to 20 experts from Foresight to Raw Materials testing methods supporting MICA objectives.	Pilot Foresight workshop - Deliverable D5.4 - release date: 07.17	Foresight and Raw Materials experts are able to provide a representative view of the tasks objective.
	Recommendations	Number of purposes matched with the respective methods addressing them.	Raw Materials Foresight Guide - Deliverable D5.5 - release date: 07.17	Foresight guide aligned with stakeholders current and anticipated needs.
Activities (inputs)	**Summary of implementation of the task 5.2** **Classification System according to the various purposes and goals** **Matrix with possible purposes of a Raw Materials Foresight** **Definition of most suitable methods according stakeholders needs and implementation steps** **Method analysis through pilot workshop supporting implementation of the EU-RMICP** **Detailed guide conducting raw materials foresight exercises and its evaluation**			

3 Review of Past International Raw Materials Foresight Exercises

Foresight studies have been conducted in several countries / regions over the past decades. An assessment of a selection of these studies was undertaken – targeting the last 15 years – to understand how EU and non-EU countries have used foresight recently in the raw materials sector. The research was done via keyword search aiming at foresight portals, scientific journals, research institutions related to raw materials and / or foresight. This desktop research provided a pool of 32 study cases that were reviewed. Eleven of them were selected for a detailed analysis and classified according to their background and goals, in function of methods employed and to the purpose of each method. The main criteria for this selection were the actual presence of foresight methods in the study.

3.1 Pool of Case Studies

The pool of case studies was conceptualised as an initial review of raw materials past foresight exercises collected internationally via keyword search. Only published documents related to these studies were gathered for review. Table 3 was constructed providing an overview on basic information from the collected studies.

Some of these studies featured in Table 3 (no. 7 and 22) are focusing on the energy sector. The present report focuses on non-energy and non-agricultural raw materials in accordance with the MICA scope. However, as an energy-intensive sector, raw materials and energy demand are broadly interrelated – from primary and secondary production, or even raw materials as source for energy-related technologies. This approach underpins the presence of such studies in this report.

Table 3 Pool of Raw Materials Foresight Case Studies.

	Title	Year	Country / Region	Authors
1	Australia Minerals Futures Collaboration Cluster	2013	Australia	CSIRO/Cluster Partners[1]
2	Advantage AUS - Resource Governance and innovation for the Asian Century	2013	Australia	Mason, L. et al. (2013)
3	Mining & Metals in a Sustainable World 2050	2015	Global	World Economic Forum (2015)
4	Foresight as a tool for sustainable development in natural resources: The case of mineral extraction in Afghanistan.	2014	Pakistan	Sheraz, U. (2014)
5	Resourcing the Future: Using Foresight in Resource Governance	2013	Australia	Prior, T. et al. (2013)
6	Mining & Metals Scenarios to 2030	2010	Global	World Economic Forum (2010a)
7	Vision 2040 - Global scenarios for the oil and gas industry	2014	Global	Deloitte (2014)
8	Alternative scenarios for the American Mining and Minerals industry	2001	United States	Institute for Sustainable Development (2002)
9	Envisioning the Future of Mining	2009	Global	IBM (2009)
10	Foresight Mining and Metallurgy Report	2000	South Africa	Barcza, N. (2000)

[1] This project was reviewed through several publications: Giurco, D. et al. (2009a), Giurco, D. et al. (2009b), Mason, L. et al. (2011a), Mason, L. et al. (2011b), Mason, L. et al. (2013), Prior, T. et al. (2013), World Economic Forum (2010b). Check References for more information.

11	A vision for mining & minerals: applying CLA and art	2011	Australia	Mason, L. et al. (2011a)
12	Global Foresight and Local Strategy Roadmapping for the development of the Rare Earth Industry in Brazil	2014	Brazil	Almeida & Moraes (2014)
13	Minerals 4EU - Developments on the Raw Materials Market	2015	Europe	Wittmer & Sievers (2015)
14	Priorities and innovative technologies of waste management resulting from hard coal mining	2011	Poland	Olszewski, M. (2011)
15	Polinares - Future World Images and Energy and Mineral Markets	2012	Europe	Clingendael (2012)
16	Resources Futures	2012	Global	Chatham House (2012)
17	Breakthrough Technologies: for the security of supply of critical minerals and metals in the EU	2011	Europe	Georghiou, L. (2011)
18	The Future Availability of Natural Resources: A New Paradigm for Global Resource Availability	2014	Global	World Economic Forum (2014)
19	African Futures 2050-2011	2011	Africa	Cilliers, J. et al. (2011)
20	Critical minerals for the EU economy - Foresight to 2030	2008	Europe	BRGM (2008)
21	Finlands Mineral Strategy 2050-2010	2010	Finland	Nurmi, P. et al. (2010)
22	Energy Futures for Canada	2013	Canada	Conference Board of Canada (2013)
23	ICSU Foresight Analysis - International Science	2011	Global	ICSU (2011)
24	Foresight - A global infrastructure perspective	2015	Global	Eberst, M. (2015)
25	Africa Mining Vision	2009	Africa	African Union (2009)
26	The future of global minerals and metals sector: issues and challenges out to 2050	2012	Global	Bloodworth, A. (2012)
27	Mining Futures: Beyond the Headlines	2010	Global	Sheraz, U. (2010)
28	Critical metals for future sustainable technologies and their recycling potential	2009	Global	Buchert, M. et al. (2009)
29	Using the Oxford Scenarios deductive methodology to understand the long-term future of copper mining and guide minerals exploration targeting strategies	2015	Australia	Sykes, J. (2015)
30	ResourcesQ Foresight Study	2014	Australia	Littleboy, A. K. (2014)
31	Japanese S+T Foresight 2035	2004	Japan	Cuhls, K. (2008)
32	Transitions in Theory and Practice: Managing Metals in the Circular Economy	2014	Australia	Jackson, M. et al. (2014)

3.2 Case Studies Inventory

The case studies that employed foresight methods were reviewed in detail and were classified according to their background, goals and methods. This approach involved understanding how the methods were employed and what their role in the study was. Breaking down the framework used in the study provided a picture of how the study was structured, highlighting important aspects of the exercises, which in turn could provide valuable information in understanding the different purposes and goals of foresight studies, how suitable certain methods are in addressing such purposes and possible combinations of methods and tools that could be applied. Table 4 shows the final Foresight Case Studies Inventory and the respective information.

Table 4 Foresight Case Studies Inventory.

Title	Country / Authors	Year	Main Goals	Context / Background	Methods / Tools	Scope
Workshop Future Scenarios - WEF Mining & Metals Scenarios Australia	**Australia/CSIRO + Cluster Partners**	**2010**	30 participants exploring implications of global megatrends under the WEF3 scenarios.	Explore future contexts and consider new strategies at different levels - organization, industry, policy - and propose actions. (Workshop over WEF 2009 Scenarios)	**Scenarios Exploration**	Primary / Secondary Raw Materials
The Vision 2040: Innovation in Mining and Minerals Forum.	**Australia / CSIRO + Cluster Partners**	**2011**	Opportunity for mining stakeholders to explore and analyse plausible future scenarios as input to developing a preferred vision, in line with the 'iterative back-casting' approach.	Vision 2040 is part of Commodity Futures stream in a broader program of research supported by the CSIRO Mineral Futures Collaboration Cluster, bringing together stakeholders to develop key elements of a shared vision for Australia's mining and minerals future	**Backcasting / Futures Wheel / Art Analysis / CLA / Futures Triangle**	Primary / Secondary Raw Materials
Mining & Metals in a Sustainable World 2050	**WEF / BCG**	**2015**	Framework supporting major transitions shaping the industry value chain, adjusting critical questions to a more sustainable world.	Financial Crisis / More sustainable operations / SD Goals Agenda (UN) / Uncertainties	**Scenarios Development**	Primary / Secondary Raw Materials
Foresight as a tool for sustainable development in natural resources: the case of mineral extraction in Afghanistan	**Pakistan / Sheraz, U.**	**2014**	Realize the mineral potential efficiently, equitably and use it as means of effective socio-economic development and prosperity.	Recent mineral wealth discovered / China as an ally / Production in the vicinities of consumption / Resource curse risk	**CLA / Scenario Development**	Primary Raw Materials
Mining & Metals Scenarios to 2030	**WEF / McKinsey**	**2009**	Stimulate dialogue / Provide multidisciplinary perspective insights / context for stakeholders to share their perspectives / Provide tools for decision making and collaborative actions.	Financial Crisis / Ever-increasing Globalization / Environmental & Climate Challenges	**Scenarios Development / Brainstorming**	Primary / Secondary Raw Materials
Vision 2040 - Global Scenarios for the Oil & Gas Industry	**Deloitte**	**2014**	Brazilian Industry to realize its full potential - pitching the technical and logistical challenges of the pre-salt exploration against global economic, social and geopolitical factors influencing Oil & Gas Industry.	Pre-salt exploration /Higher Energy Demand / Increased Costs of oil extraction	**Scenarios Development**	Energy sector

Alternative Scenarios for the North American Mining & Minerals Industry	***US / MMSD Scenarios Work Group IISD***	***2001***	*Assess global mining & minerals in terms of transition to sustainable development / Identify how and if the services provided can be delivered in accordance with sustainable development / Propose key elements for an action plan / Build a platform of analysis and engagement for ongoing cooperation and networking between stakeholders.*	*Disconnection between practices and values of today's society leading to concerns over the Social License to Operate*	***Scenarios Development / Back-casting / Brainstorming***	*Primary / Secondary Raw Materials*
Foresight Mining & Metallurgy Report	***South Africa /NRTF-DACST***	***2000***	*Improve wealth creation and quality of life, To identify key topics and strategies the Mining & Metallurgy sector over the next 10 to 20 years.*	*National Research & Technology Foresight launched program seeking to identify key areas and market opportunities*	***Scenarios Development / Trend Analysis / SWOT / STEEP / Delphi***	*Primary / Secondary Raw Materials*
Global Foresight and Road mapping for the development of the Rare Earths Industry in Brazil	***Brazil / PUC Rio***	***2014***	*To structure a long and Medium term agenda, linked with the development of REE productive application chains.*	*Chinese Monopoly / Chinese Exports Quota Restrictions / Higher Prices / Increasing Demand / Limited Supply*	***Scenario Development / Roadmapping / Brainstorming / (Expert Interviews)***	*Primary Raw Materials*
Priorities & Innovative technologies of waste management resulting from hard coal mining	***Poland / IMBiGS***	***2011***	*To identify leading technologies for management of waste mining of strategic importance, whose development in the next 20 years will be a priority for Poland, and the creation of scenarios for their development through the use of systematic research methods.*	*42 hard coal mines in Poland producing waste / Significant part deposited in the environment*	***Scenario Development / SWOT / Delphi / Experts Panel / Cross-Impact Analysis***	*Primary Raw Materials*
Polinares - Future World Images and Energy and Mineral Markets	***EU / Clingendael***	***2012***	*Identify the main global challenges relating to competition for access to resources, and to propose new approaches to collaborative solutions - Reconnaissance of the future of geopolitical and geo-economic relations and the impact on energy and mineral market policies*	*World on the verge of a transition period, in which the share in international production, trade and finance of emerging markets is growing fast. Larger weight of the emerging economies in world GDP. Geopolitical impact of these countries is increasing, not only as a result of their growing soft power but because of their increasing hard power. OECD countries are meanwhile experiencing a relative decline in terms of economic importance and geopolitical impact.*	***Scenario Development***	*Primary / Secondary & Energy Raw Materials*

Using the Oxford Scenarios deductive methodology to understand the long-term future of Copper Mining and Guide minerals Exploration targeting strategies	***Australia / Sykes, J.***	***2015***	*How the methodology can begin defining some parameters for the 'undiscovered accessible reserves' - considering the complex interaction of geological, socio-political, environmental, technological and other factors. To compare each scenario with the 20 main copper projects to determine which deposits are the best proxies to guide exploration targeting.*	*Consensus over the declining copper ore quality, with resource depletion paradigms determining views of long term future. Increasing on general costs can be mitigated with new discoveries. Struggle in scientific and economic techniques to incorporate the multiple external factors affecting the copper mining in the future.*	***Scenario Development / SWOT***	*Primary Raw Materials*
Minerals 4EU - Developments on the Raw Materials Market	***Miinerals4EU / BGR***	***2015***	*Explore how technological change influences the demand for raw materials and to illustrate how this can be taken into account when generating forward-looking raw materials intelligence, including scenarios for future demand. A particular focus is placed on so-called "technology metals"*	*On the influence of technological change and substitution on the demand for the non-energy raw materials*	***Scenario Exploration (Over Polinares')***	*Primary/ Secondary Raw Materials*

The foresight methods were employed in the studies mainly through workshops and stakeholders engagements. Most of these studies were funded by government institutions, non-profit foundations and consulting firms from the private sector. Scientific research publications (academia) employing foresight methods for raw materials were also observed. Table 5 provides quantitative information, such as numbers of people involved in the study and in particular workshops (e.g. scenarios development, etc.).

Table 5 Foresight Case Studies Inventory – quantitative aspects.

		Funding agency	Year / duration	Stakeholders Engagement / Foresight Workshops	No. of institutions (foresight)	At Foresight (Exercises)
1	Workshop Future Scenarios – WEF Mining & Metals Scenarios Australia	Government	2009-2013	Yes	7	31
2	The Vision 2040: Innovation in Mining and Minerals Forum			Yes		30
3	Mining & Metals in a Sustainable World 2050	Non-profit Foundation / Private	2015	Yes	2	37
4	Foresight as a tool for sustainable development in natural resources: the case of minerals extraction in Afghanistan	NA	2014	No	1	1
5	Mining & Metals Scenarios for 203	Non-profit Foundation / Private	2009	Yes	2	38
6	Vision 3024 – Global Scenarios for the Oil & Gas Industry	Private	2014	No	1	8
7	Alternative Scenarios for the North American Mining & Minerals Industry	Government	2001	Yes	5	3?
8	Foresight Mining & Metallurgy Report	Government	2000	Yes	1	
9	Global Foresight and Road mapping for the developing of the Rare Earths Industry in Brazil	Government	2015	No	2	2
10	Priorities & Innovative technologies of waste management resulting from hard coal mining	Government	2011	NA	3	NA
11	Polinares – Future World Images and Energy and Minerals Markets	Government	2012	Yes	NA	NA
12	Using the Oxford Scenarios deductive methodology to understand the long-term future Copper Mining and Guide minerals Explorations targeting strategies	NA	2015	Yes	1	NA
13	Minerals4EU – Developments on the Raw Materials Market	Government	2015	Yes	NA	NA

4 Different Frameworks of a RMI Foresight

The methodological framework used in a Foresight project should be tailored to meet specific objectives of the project and the resources and capabilities that are available (Popper, 2008). In that sense, it should be taken into account the contribution of each method in the context of the study and the ways these individual methods can be combined and synthesised to produce the desired effect. There is no 'ideal' methodological framework providing the best combination of methods. Scoping a dozen of methods can result in a wide range of possible combinations even by choosing a small number of them. The definitive approach should certainly consider the expertise and the accumulated know-how of the practitioners for the selection of the methods supporting a specific purpose.

Understanding the stakeholders' objectives plays also an important role in defining a combination of tools most likely to yield a set of rich outputs. It should be noted that the selection of methods is also subject to other factors, such as budget, availability of expertise, political support, technological and physical infrastructure, and time.

For instance, the Australian "Mineral Futures Collaboration Cluster" (MFCC) case study combined two different workshops with pre-existing studies, generating the framework seen in Figure 1.

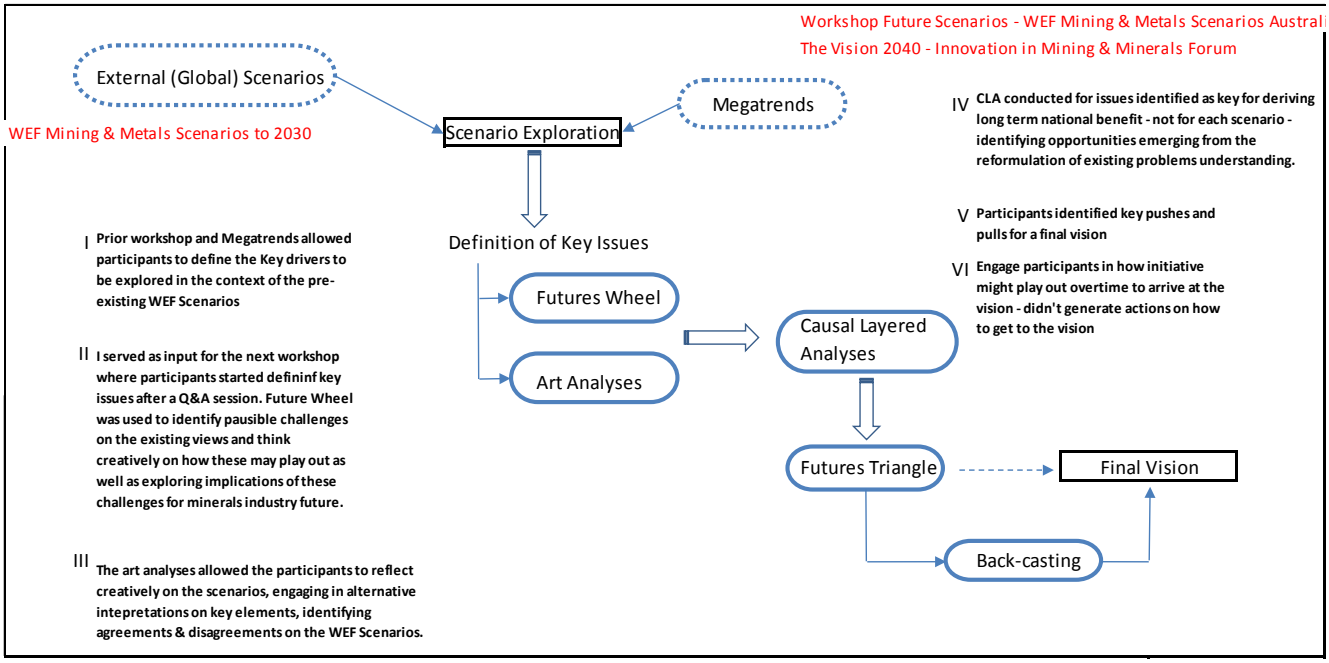

Figure 1 Foresight Methodology Framework Example (adapted) (Mason, L.. et al., 2011a and Prior, T. et al., 2013).

In the publication "How are foresight methods selected", Popper (2008) presented a foresight methods combination matrix (MCM) based on 886 general (i.e. non-raw materials specific) cases capturing the frequency rate of observed combinations from a pre-set foresight methods list (see Figure 2). In Figure 2 'L', 'M', 'H' and 'VH' stands for:

- 'L' is for low combinations (i.e. below 19 per cent);
- 'M' is for moderate combinations (i.e. 20-39 per cent);
- 'H' is for high combinations (i.e. 40-59 per cent);
- 'VH' is for very high combinations (i.e. figures above 60 per cent).

Ranking by frequency of use	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Methods Combination Matrix (MCM)	**Literature Review**	**Expert Panels**	**Scenarios**	*Trend extrapolation/Megatrends*	**Futures Workshops**	**Brainstorming**	Other methods	**Interviews**	Delphi	Key Technologies	**Questionnaires/Surveys**	**Environmental Scanning**	**Essays**	**SWOT Analysis**	Technology Roadmapping	*Modelling and simulation*	**Backcasting**	Stakeholder Mapping	Cross-impact/Structural Analysis	*Bibliometrics*	**Morphological Analysis**	**Citizens Panels**	**Relevance Trees**	Multi-criteria Analysis	**Gaming**
1 **Literature Review**	477	H	H	H	M	M	M	M		M															
2 **Expert Panels**	VH	440	M	M	M	M		M	M	M															
3 **Scenarios**	H	H	372	H	M	M	M																		
4 *Trend Extrapolation/Megatrends*	VH	VH	VH	223	M	M	M	M		M	M	M	M			M									
5 **Futures Workshops**	VH	VH	H	M	216	M	M			M															
6 **Brainstorming**	VH	VH	H	M	H	169	H	M	M	M	M	M		M											
7 Other methods	VH	H	H	M	H	H	157	M	M	M	M	M		M											
8 **Interviews**	VH	VH	H	H	M	M	M	154			H	M		M											
9 Delphi	VH	VH	M	M	M	H	M		137	M	M	M													
10 Key Technologies	VH	VH	M	H	M	M	M	M	M	133		M		M	M										
11 **Questionnaires/Surveys**	H	VH	H	H	M	M	M	H	M		133	M		M											
12 **Environmental Scanning**	VH	VH	H	H	M	H	VH	M	M	M	M	124	M	M				M							
13 **Essays**	H	H	H	H	M	M	M	M				M	109												
14 **SWOT Analysis**	VH	H	H	M	H	H	VH	M	M	M	M	M		101				M	M						
15 Technology Roadmapping	VH	VH	M	M	H					H					72										
16 *Modelling and simulation*	H	M	VH	VH												67									
17 **Backcasting**	H	H	H	H	M	M		M				M				M	47								
18 Stakeholder Mapping	VH	VH	H	VH	H	VH	VH	H		M	M	VH	M	H				46	M	M	M		M		
19 Cross-impact/Structural Analysis	VH	VH	VH	VH	M	VH	VH	VH	M		VH	VH	M	VH				M	36		M				
20 *Bibliometrics*	VH	H	M	VH	M	H	VH	VH		VH	H	VH	H	H				H		22	M		M		
21 **Morphological Analysis**	VH	VH	VH	H	H	VH	VH	VH	M	M	H	H	VH	M			M	H	H	M	21		H		
22 **Citizens Panels**	H	VH	H	M	VH	H	VH	H	M		M	H	M	H				M	M			19			
23 **Relevance Trees**	VH	VH	VH	VH	VH	VH	VH	VH	M	M	H	VH	VH	VH				VH	M	M	H		17		
24 Multi-criteria Analysis	VH	M		VH	M	M	M	M		M	M	M	M			H								11	
25 **Gaming**	VH	VH	VH	VH	VH	VH			M			H				H	M	VH	M						6

Key: Low (blank); moderate (M); high (H); very high (VH); **bold** = qualitative; *italic* = quantitative; normal = semi-quantitative

Note: 886 cases

Sources: EFMN and SELF-RULE (2008)

Figure 2 Methods Combination Matrix (MCM) (Popper et al., 2008).

A similar, simplified, approach was adapted for the inventory case studies. The methods in the inventory are presented in a matrix, where the observed combinations are pointed out; see Table 6. This was complemented by a theoretical assessment of other possible combinations. Given the small population of case studies analysed, they were not assessed in quantitative terms. In Table 6 a double X refers to actual combinations and while a single X refers to theoretical combinations.

Table 6 Inventory methods combinations matrix (adapted).

	Scenario Development	Scenario Exploration	Futures Wheel	Art Analyses	Causal Layered Analysis	Futures Triangle	Back-casting	Brainstorming	Experts Interview	SWOT	STEEP	Delphi Surveys	Cross Impact Analysis
Scenario Development	-		X		X	X	X	XX	XX	XX	XX	X	X
Scenario Exploration		-	XX	XX				X					
Futures Wheel			-	X	XX			X					
Art Analyses[2]				-	XX		X						
Causal Layered Analysis					-	X X	X				X		
Futures Triangle						-	XX	X					
Back-casting							-	X					
Brainstorming								-	X	X		X	X
Experts Interview									-				
SWOT										-	XX	X	X
STEEP											-		
Delphi Surveys												-	XX
Cross Impact Analysis													-

[2] For reference please see Mason et al. (2011a) and Lederwasch, A. (2012)

5 Case Study Classifications

As the final inventory of case studies was defined, further classifications were done in order to assess critical information, such as how the methods were employed, what they provided, and to enable relevant interpretations of observed results from these studies.

An assessment of the macro-environmental factors was undertaken as well, according to the targeted purposes of the study. This analysis was based on the overall objectives of the studies and on how they could be framed in terms of macro-environmental factors, namely: Social, Economic, Technology, Environmental, Global, Sustainability[3] and Policy aspects. It should be noted that Sustainability can be treated as a cross-cutting aspect. In this regard, this assessment is an output of a subjective evaluation of the studies. Table 7 provides a comprehensive picture of the assessment. In Table 7 a double X refers to the respective macro-environmental factor as a clear and strong element in the study, while a single X indicates that the factor is also clearly addressed in the study, but not as a main component. A blank cell means that there was no clear evidence in the study for the correspondent factor being targeted. This approach was selected so one could differentiate, by weight, the relevance that certain elements had in the study in comparison with others that were also observed.

Table 7 Foresight Case Studies Inventory – Macro Environmental Classification.

		Social	Technology	Economic	Environmental	Global	Sustainability	Policy
1 2	Workshop Future Scenarios - WEF Mining & Metals Scenarios Australia The Vision 2040: Innovation in Mining and Minerals Forum	XX	X	X	XX		X	
3	Mining & Metals in a Sustainable World 2050					XX	XX	
4	Foresight as a tool for sustainable development in natural resources: the case of mineral extraction in Afghanistan	X		XX			X	X
5	Mining & Metals Scenarios to 2030					XX		
6	Vision 2040 - Global Scenarios for the Oil & Gas Industry			X		X		
7	Alternative Scenarios for the North American Mining & Minerals Industry	X		X	X		XX	X
8	Foresight Mining & Metallurgy Report	XX	X	XX				X
9	Global Foresight and Road mapping for the development of the Rare Earths Industry in Brazil		XX	X				X
10	Priorities & Innovative technologies of waste management resulting from hard coal mining		XX		X			
11	Polinares - Future World Images and Energy and Mineral Markets					X		X
12	Using the Oxford Scenarios deductive methodology to understand the long-term future of Copper Mining and Guide minerals Exploration targeting strategies			XX				
13	Minerals 4EU - Developments on the Raw Materials Market					X		

[3] There is no universally agreed definition of Sustainability, however considering the background of these studies the term Sustainable Development could also be used, as it being a holistic approach leading to a sustainable point.

A 'Global' factor was also defined, scoping the studies featuring global approaches (e.g. scenarios), supporting a broader usage of the outputs.

With this assessment a radar chart was built; see Figure 3, in order to provide a more illustrative view on the analysed inventory, regarding its macro-environmental classification.

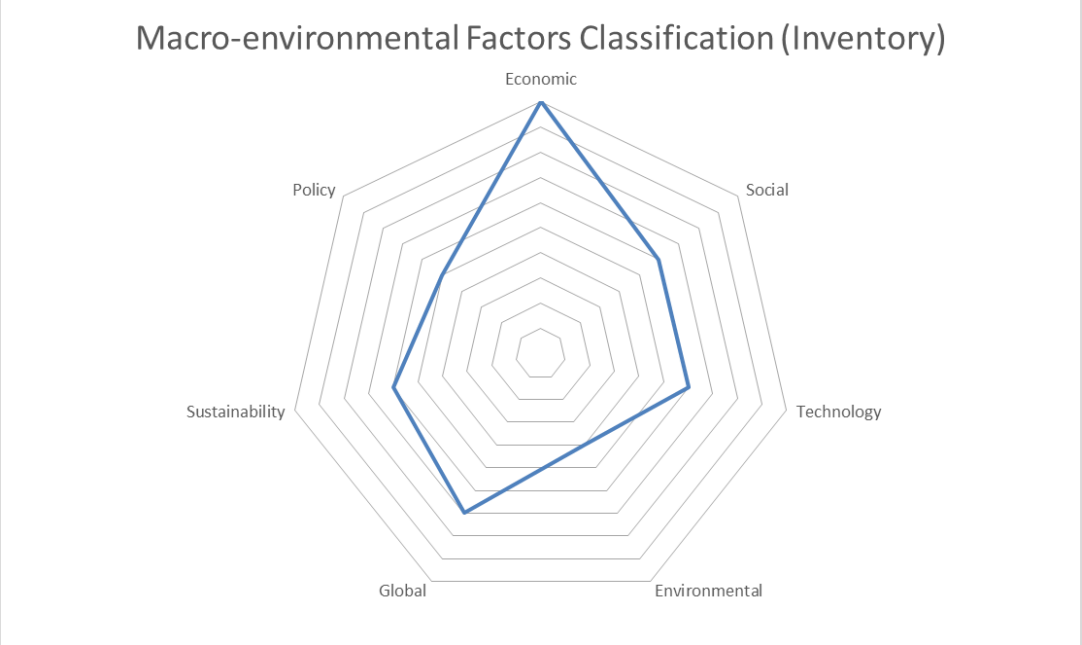

Figure 3 Macro-environmental target factors (radar chart).

The strongest factors addressed in the case studies presented in the inventory fall into the Economic domain, followed by Global, Social and Technology aspects. This result provides a reasonable indication on what are the common domains targeted by the Foresight studies in the Raw Materials sector. Based on the review the following preliminary conclusions can be drawn at this point:

- The future prospect of operating in more challenging environments, where technology development and social acceptance are key for the sector, underlines the weight these aspects had in the chart;
- Global aspects are also strongly present. This might be related to the fact that raw materials are globally interconnected by trade, whereas there is not necessarily a convergence between raw materials geographical availability and its consumption. Assessing Global future perspectives can be thoroughly important in that sense.

5.1 Methods in Focus

A total of 12 foresight methods were identified as being employed in the studies. They mostly fall under the qualitative domain of foresight methods (7), while the rest are semi-quantitative methods. By far the most represented method was 'Scenarios', which was present in all studies. However, its role can have substantial variations in terms of how it was used and deployed in the study (Figure 4).

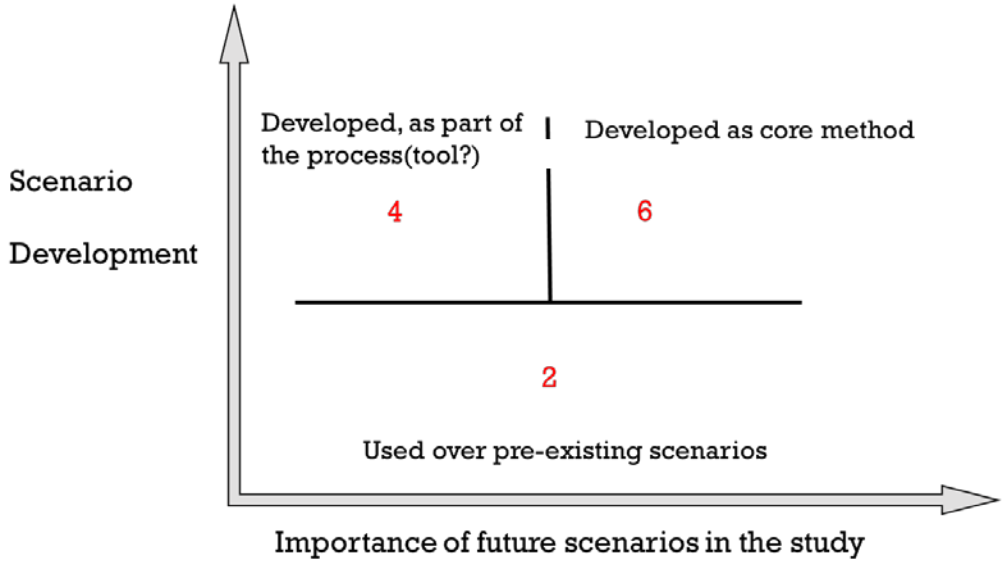

Figure 4 Observed Scenarios role (as per inventory).

The Scenario Development axis represents the actual construction of scenarios within the study as opposed to using it over pre-existing ones. The Importance of future scenarios axis captures the weight the method had in the study.

Therefore, for the purposes of the report the distinction was made between 'Scenarios Development' and 'Scenarios Exploration'. The methods used in each study were also assessed according to their purpose, or in other words, what they aimed to deliver.

Table 8 provides a snapshot of each method in each study with the short description on their purposes.

Table 8 Foresight Case Studies Inventory – Methods purposes overview.

5	**Futures Wheel**	**Art Analysis**	**Causal Layered Analysis**	**Futures Triangle**	**Backcasting**
The Vision 2040: Innovation In Mining and Minerals Forum	Exploration of remaining key issues from previous workshop discussions	Generated in-depth and creative discussions on key issues – potential challenges and opportunities presented by the key elements	Development of alternative views that might make future discussions more effective	Identification of key governance, environmental, social, economic and political pushes and pulls, beginning to create a picture of how to achieve the vision	Limited exploration of the future achieved, but with influence on sequential events. Linked events were identified that could lead to a future vision. Didn't generate actions on how to get it.
4	**Scenario Development**	**SWOT**	**STEEP**	**DELPHI**	
Foresight Mining & metallurgy Report	Captured the possibilities of the future of the sector. Backdrop for a more expansive analysis of future market opportunities and threats would be achieved.	Ordinary assessment over each scenario	Drivers and constraints for the sector – contributing for a picture for the sector (combined with SWOT)	Supporting the definition of the mail goals, key issues to the foresight study. Outputs addressed the Foresight Mining & Metallurgy Mission Statement. Themes defined to be evaluated by the sector working group	
4	**Scenario Development**	**SWOT**	**DELPHI**	**Cross Impact Analysis**	
Priorities & Innovative technologies of waste management resulting from hard coal mining	Development of technology scenarios – optimistic, moderate and pessimistic. Directions of scientific research to guarantee the development of technology in the scenario.	Assessment of institutional and technological levels	Identify urgent need to develop a comprehensive program waste from coal mining and to create conditions legal and institutional enabling the technological development of the mining industry and processing and financial instruments to support technology initiatives in the field waste from coal mining.	Associated with delphi. Allowed to isolate the key factors in within the thematic groups of technology waste from coal mining and factors matrix. Pooled analysis of the results lead to the conclusion.	

3	Scenario Development	Brainstorming	Expert Interview
Alternative Scenarios for the North American Mining & Minerals Industry	Identify & discuss issues, challenges and areas of consensus and disagreement, prescription for adjusting policy, practices, behavior and Infrastructure of the sector.	Post-scenarios identification of the major issues facing North M&M industry.	Understand "lesson from the past" and what "went right", how they should be acknowledged for the future, challenges and barriers identification, reflections on the "dark spot" of the future, reflection on key future issues.
2	**Casual Layered Analysis**	**Futures Triangle**	
Foresight as a tool for sustainable development in natural resources: the case of mineral extraction in Afghanistan	Inform & aid best case and worst case scenarios, and the policy recommendations.	Understand the current trends and pictures the desired futures.	
2	**Scenario Development**	**Brainstorming**	
Metals Scenarios to 2030	Platform for discussion of strategic options – tailoring scenarios for partners specific context & better prepare towards a more sustainable future.	Identified drivers for the sector for the next 20 years under different domains.	
2	**Scenario Development**	**SWOT**	
Using the Oxford Scenarios deductive methodology to understand the long-term future of Copper Mining and Guide minerals Exploration targeting strategies	Understanding of which assets and practices are good proxies for mineral explorers to use in strategic exploration targeting.	Convert the scenarios into strategies, strategic approaches for each scenario are derived from what the strengths the client must possess to capture the opportunities and avoid the threats.	

I	Scenario Exploration
Workshop Future Scenarios – WEF Mining & Metals Scenarios Australia	Help to consider strategies at different level to prepare for different challenges & opportunities – exploration under 3 megatrends – an Australian perspective. Inputs for a following workshop to explore the narrative and understand the root causes.
Minerals4EU – Developments on the Raw Materials Market	Compile possibilities with high-level scenario analyses (qualitative), implications for making quantitative estimates on raw material demand.
I	**Scenario Development**
Mining & Metals in a Sustainable World 205	Identification of potential actors and actions for the stakeholders by coming up with roadmaps for action.
Vision 2040 – Global Scenarios for the Oil & Gas Industry	Development global scenarios to understand how they would influence the domestic industry.
Global Foresight and Roadmapping for the development of the Rare Earths Industry in Brazil	Supported the assessment of the national capabilities for the development of upstream stages of R EE supply chain, and also for downstream activities.
Polinares – Future World Images and Energy and Mineral Market	Provide the context from where certain challenges, opportunities and risks in the future can be derived for further assessment. Main global challenges to access oil, gas and minerals.

5.2 Suitability – Foresight Methods vs. Different Purposes

The analysis of the purposes listed allows identifying which methods are suitable to support specific purposes. This assessment can involve not only the observed past case studies as well as a theoretical approach on how different frameworks could also provide reasonable results, based on the understanding of what each method – and possible combinations – can offer. Table 9 provides an overview of a method-to-purpose approach.

5.3 Suitability – Foresight Methods vs. Different Purposes

The analysis of the purposes listed allows identifying which methods are suitable to support specific purposes. This assessment can involve not only the observed past case studies as well as a theoretical approach on how different frameworks could also provide reasonable results, based on the understanding of what each method – and possible combinations – can offer. Table 9 provides an overview of a method-to-purpose approach. In Table 9 a single X refers to theoretical combinations, whilst double X refers to observed ones.

Table 9 Foresight Methods vs. Different Purposes.

	Scenario Development	Scenario Exploration	Futures Wheel	Art Analyses	Causal Layered Analysis	Futures Triangle	Back-casting	Brainstorming	Experts Interview	SWOT	STEEP	Delphi surveys	Cross Impact Analysis
Consider future strategies at different levels and narratives	X	XX					X						
Exploration/Creative thinking of pre-defined issues			XX	XX									
Development of alternative views					XX								
Structured identification of barriers and drivers						XX							
Identification of possible actions to achieve a certain future vision							XX						
Identification of drivers / constraints for the future of the sector			X			X		XX			X		
How different futures can influence the sector	XX	X								X			
Strategic assessment / classification of outcomes									XX			X	
Definition of main goals/key issues to the study			X									XX	XX
Assessment of capabilities in different levels in a given sector/region	XX									X			
Means of assessing the current readiness for future challenges	XX								X			X	
Convert narratives into strategies										XX			

6 Conclusions

Deliverable D5.3 summarises the implementation of Task 5.2 (Strategic Raw Materials Intelligence Approaches) through a Logframe Matrix. In addition, a comprehensive review of past raw materials foresight study cases collected internationally provides an initial understanding on the suitability of various foresight methods in relation to specific purposes. The review informs about possible tools and steps that can be combined in a raw materials foresight study. In foresight studies with longer time-frames, qualitative methods were consistently observed. The reviewed raw materials foresight case studies also repeatedly presented Scenarios. Substantial variations were observed in terms of use and deployment of the method: pre-defined global scenarios can be used to explore futures thinking over a given theme, whereas the development of specific scenarios can be the main element of the study. Other methods such as SWOT, STEEP (Social, Technological, Economical, Environmental and Political) scanning and Brainstorming can be observed in synergetic implementation with the Scenarios, helping to provide either input for its development or post-processing its outputs towards overall objectives.

The volatility of the mineral raw materials sector naturally calls for more explorative and creativity-based methods. Such methods can address the necessity of understanding how different factors may play out in the future, where critical uncertainties can dictate a range of possible futures. Therefore, having a solid backdrop for alternative paths is extremely useful for policy and decision-makers to propose actions and respond in a timely manner to the future challenges of the sector.

These outcomes support the development of a matrix gathering the particular knowledge on possible foresight purposes and methods suitability, providing guidance for the deployment of the methods and for the implementation of foresight exercises in the raw materials sector. This will be complemented by the knowledge on the stakeholders' objectives and needs provided by WP2 generating a foresight guide and recommendations as a final product of MICA Task 5.2 (Deliverable 5.5).

7 References

African Union (2009). African Mining Vision. 55p. www.africaminingvision.org/amv_resources/AMV/Africa_Mining_Vision_English.pdf (accessed 23.01.2017)

Almeida, M.F.L., Moraes, C.A.C. (2014). Global Foresight and Local Strategic Roadmapping for the Development of a Rare Earth Industry in Brazil. 5th International Conference on Future-Oriented Technology Analysis (FTA). 10 p., Brussels.

Barcza, N. A. (2000). Foresight Mining and Metallurgy Report. DACST Mining & Metallurgy Sector Working Group. 72p. South Africa.

Bloodworth, A., Gunn, G. (2012). The Future of the Global Minerals and Metals Sector: Issues and challenges out to 2050. Geosciences: BRGM's journal for a sustainable Earth, 15. 90-97.

BRGM (2008). Critical Minerals for the EU Economy: Foresight to 2030. Farhorizon. 8p. www2.warwick.ac.uk/fac/soc/pais/research/researchcentres/csgr/green/foresight/economy/2013_ec_critical_minerals_for_the_eu_economy_-_foresight_to_2030.pdf (accessed 23.01.2017)

Buchert, M., Schüler, D., Bleher, D. (2009). Critical Metals for Future Sustainable Technologies and their Recycling Potential. Sustainable Innovation and Technology Transfer Industrial Sector Studies. Öko-Institut. 112p.

Chatham House. (2012). Resources Futures. ISBN 978 1 86203 277 4. 212p. London.

Cilliers, J., Hughes, B., Moyer, J. (2011). African Futures 2050. Institute for Security Studies. 66p. ISBN 978-1-920422-22-6. Pretoria.

Clingendael International Energy Program (2012). Part II: Future World Images and Energy and Mineral Markets. Polinares working paper n.44. Polinares project. 41p.

Conference Board of Canada (2013). Energy Futures for Canada. Strategic Foresight Initiative, publication 13-288. 12p.

Cuhls, K. (2008). Japanese S+T Foresight 2035: The Eight National Japanese Science and Technology Foresight. The European foresight monitoring network. Pt. 1: Collection of EFMN briefs. Pg. 139-142. ISBN: 978-92-79-07448-6.

Deloitte (2014). Vision 2040: Global Scenarios for the oil and gas industry. www2.deloitte.com/content/dam/Deloitte/ru/Documents/energy-resources/ru_er_vision2040_eng.pdf (accessed 22.12.16)

EuropeAid (EC) (2004). Project Cycle Management Guidelines (Volume I). Part 2: The Logical Framework Approach. https://ec.europa.eu/europeaid/sites/devco/files/methodology-aid-delivery-methods-project-cycle-management-200403_en_2.pdf (accessed 22.12.16)
Eberst, M. (2015). Foresight: a global infrastructure perspective. KPMG, 38th Edition. 2p.

Georghiou L, Varet J, Larédo P (2011). Breakthrough technologies: For the security of supply of critical minerals and metals in the EU. 19p. Brussels.

Giurco, D., Evans, G., Cooper, C., Mason, L., Franks, D. (2009a). Mineral Futures Discussion Paper: Sustainability Issues, Challenges and Opportunities. Institute for Sustainable Futures (University of Technology, Sydney) and Centre for Social Responsibility in Mining. 71p.

Giurco, D., Prior, T., Mudd, G., Mason, L., Behrisch, J. (2009b). Peak minerals in Australia: a review of changing impacts and benefits. Insitute for Sustainable Futures (University of Technology, Sydney) and Department of Civil Engineering (Monash University). 110p.

IBM (2009). Envisioning the Future of Mining. 24p. www-935.ibm.com/services/multimedia/wp_envisioning_mining.pdf (accessed 23.01.17)

ICSU (2011). ICSU Foresight Analysis Report 1: International Science in 2031 – exploratory scenarios. International Council for Science, Paris. ISBN: 978-0-930357-88-7.

Institute for Sustainable Development (2002). Learning from the Future: Alternative Scenarios for the North American Mining and Minerals Industry. ISBN: 1-895536-50-2. 27p. www.iisd.org/library/learning-future-alternative-scenarios-north-american-mining-and-minerals-industry (accessed 22.12.16)

Jackson, M., Lederwasch, A., Giurco, D. (2014). Transitions in Theory and Practice: Managing Metals in the Circular Economy. Institute for Sustainable Futures (University of Technology, Sydney). Resources 2014, 3, 516-543. 28p.

Lederwasch, A. (2012). Scenario Art: A New Futures Method that Uses Art to Support Decision-Making for Sustainable Development. Journal of Future Studies, 2012, **17**(1): 25-40.

Littleboy, A. K., Boughen, N., Brereton, D., Hajkowicz, S., Militon, A., Schleger, A. (2014).

ResourcesQ Foresight Study: Unearthing future resource sector trends and implications for Queensland. Commonwealth Scientific and Industrial Research Organisation (CSIRO). 35p. Brisbane.

Mason, L., Daly, J., Prior, T., Giurco, D., Lederwasch, A. (2011a). A Vision for Mining and Minerals: Applying Causal Layered Analysis and Art. Journal of Future Studies, **15**(4): 203-224. http://jfsdigital.org/articles-and-essays/2011-2/vol-15-no-4-june/report/a-vision-for-mining-and-minerals-applying-causal-layered-analysis-and-art/ (accessed 22.12.16)

Mason, L., Lederwasch, A., Daly, J., Prior, T., Buckley, A., Hoath, A., Giurco, D. (2011b). Vision 2040: Mining, minerals and innovation – A vision for Australia's mineral future, Institute for Sustainable Futures (University of Technology, Sydney). 28p. Perth.
Mason, L., Mikhailovic, N., Mudd, G., Sharpe, S., Giurco, D. (2013). Advantage Australia: resource governance and innovation for the Asian century, prepared for CSIRO Minerals Down Under Flagship by the Institute for Sustainable Futures (University of Technology, Sydney) and Monash University, Melbourne. 94p. Sydney. ISBN 978-1-922173-50-8 (print); 978-1-922173-49-2 (online).

Nurmi, P. A., Lahtinen, R., Vuori, S. (2010). Finland's Mineral Strategy. Geological Survey of Finland. 20p. ISBN 978-952-217-134-4.

Olszewski, M. (2011). Foresight Project on "Priorities and innovative technologies of waste management resulting from hard coal mining.". Institute of Mechanised Construction and Rock Mining. Presentation, 19 September, 2011. Cluj, Romania. www.csnmeridian.ro/files/docs/mr_olszewski.pdf (accessed 25.01.2017).

Popper, R. (2008). How are foresight methods selected? hwww.researchgate.net/publication/228678576_How_are_foresight_methods_selected_Foresight_106_62-89 (accessed 22.12.16)

Popper, R., Georghiou, L., Harper, J. C., Keenan, M., Miles, I. (2008). The Handbook of Technology Foresight: Concepts and Practice. ISBN 978 1 84542 586 9. Cheltenham.

Prior, T., Daly, J., Mason, L., Giurco, D. (2013). Resourcing the future: Using foresight in resource governance. Geoforum, **44**: 316-328.

Sheraz, U. (2010). Mining Futures: Beyond the Headlines. Journal of Future Studies, 15(2): 17-32.

Sheraz, U. (2014). Foresight as a tool for sustainable development in natural resources: The case of mineral extraction in Afghanistan. Resources Policy J., **39**: 92-100.

Sykes, John P. (2015). Using the Oxford Scenarios deductive methodology to understand the long-term future of copper mining and guide minerals exploration targeting strategies. 20 p. www.researchgate.net/publication/299583980_Using_the_Oxford_Scenarios_deductive_methodology_to_understand_the_long-term_future_of_copper_mining_and_guide_minerals_exploration_targeting_strategies (accessed 222.12.16)

Wittmer, D., Sievers, H. (2015). Developments on the raw materials markets: Thematic Report V. Minerals4EU Project (BGR). Pg.97-101.

World Economic Forum (2010a). Mining & Metals Scenarios to 2030. 38p. Geneva. www3.weforum.org/docs/WEF_Scenario_MM2030_2010.pdf (accessed 22.12.16)

World Economic Forum (2010b). Mining & Metals Scenarios: Australian Workshop Session Summary. 6p. Melbourne. http://resourcefutures.net.au/sites/default/files/WEF_Australian_Workshop_Session_Summary.pdf (accessed 25.01.2017)

World Economic Forum (2014). The Future Availability of Natural Resources: A New Paradigm for Global Resource Availability. 47 p., Geneva.

World Economic Forum (2015). Mining & Metals in a Sustainable World 2050. 43p. Geneva. www3.weforum.org/docs/WEF_MM_Sustainable_World_2050_report_2015.pdf (accessed 22.12.16)