Deliverable D5.4

Report on Pilot Foresight Workshop

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Notice

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PURPOSE

This document summarises the WP5 Raw Materials Foresight Methodology Workshop, held in Las Palmas de Gran Canaria, Spain, on the 10th and 11th of May 2017, providing an overview on the workshop's structure, content and highlights. The purpose of the workshop was to inform WP5 Policy-making and provide recommendations in terms of foresight methodologies to the MICA online platform (RMICP) and Deliverable D5.5 *Raw Materials Foresight Guide*.

EXECUTIVE SUMMARY

Deliverable 5.4 documents the Raw Materials Foresight Workshop in the context of Work Package 5 of the MICA Project.

The two-day workshop focused on evaluating foresight methodologies in the raw materials context, producing related recommendations and informing both MICA Deliverable 5.5 *Raw Materials Foresight Guide* and the MICA online platform (RMICP).

The first day encompassed six presentations on foresight and raw materials providing grounds for pertinent discussions over foresight methodologies and evaluation. The presentation titles are listed as:

- Innovation and resource governance: foresight approaches in mineral futures (Prof. Damien Giurco, Institute for Sustainable Futures and Dr Tim Prior, ETH Zurich);
- Future metal mining: Seventeen predictions (Prof. Jan Johansson, Luleå University);
- The use of foresight methods in strategic raw materials intelligence approaches – an international review (Marco K. Martins, LPRC);
- Extract-IT Project: Defining research topics supporting the ICT challenges of mineral extraction under extreme geo-environmental conditions (Balazs Bodo, LPRC);
- Foresight methods and practice: Lessons learned from international foresight exercises (Dr Totti Könnölä, IFI);
- Application of STEEPVL, Structural Analysis and Scenario Building to construction of nanotechnology development scenarios (Prof. Joanna Ejdys and Dr Katarzyna Halicka – Bialystok University).

The second day started with two presentations framing the following discussions. They were entitled:

- Safeguarding mineral deposits for future society's needs – The Project Minatura2020 (Prof. W. Eberhard Falck, MinPol)
- Process and results for future-oriented policy crafting (Dr Aaron Rosa, Fraunhofer-ISI)

The workshop ended with a scenario exploration exercise delving into different futures and its implications for different raw materials stakeholders' needs.

Recommendations were mostly related to:

- Deliverable 5.5 *Raw Materials Foresight Guide*: Relevant topics to be featured in the report and describe how foresight can be integrated to the platform;
- MICA online platform (RMICP): New FactSheets to be produced and possible constraints to be considered;
- Foresight methodologies: Integration to strategy, side benefits of foresight processes and importance of each step in a foresight exercise.

The presence of experts from both raw materials and foresight helped to provide important insights. As concluded, stakeholder's needs shape the methodological foresight approaches - it is crucial for potential foresight users to understand their own context, needs and resources in terms of foresight before undertaking and designing a foresight process.

DELIVERABLE REPORT

1. Introduction

WP5 Task 5.2 *Strategic Raw Materials Intelligence Approaches* complements the operative tools from WP4 focusing on longer-term future (foresight) methods. In that context, the *Raw Materials Foresight Methodology Workshop* (sub-task 5.2.6[1]) aimed at providing a common understanding on the spectrum of foresight methods and tools, and how they can be employed to serve stakeholders' needs. More broadly, it informs both the integration of these outcomes to the MICA online platform (RMICP) and the development of the D5.5 *Raw Materials Foresight Guide*. The workshop built upon the review of past raw materials foresight case studies (D5.3) and the gathering of experts and partners to discuss foresight methodologies.

[1] Originally named "Pilot Workshop" as per Grant Agreement.

2. Foresight Methodology Workshop

The Raw Materials Methodology Foresight Workshop (Sub-task 5.2.6) took place in Las Palmas de Gran Canaria, Spain, on the 10th and 11th of May 2017. It gathered experts from both the raw materials and foresight community as well as MICA WP1, WP2 and WP5 partners. The workshop built on the review of past raw materials foresight case studies collected internationally, providing the basis for discussions during the meeting with a focus on foresight methodologies. The main objectives of the meeting were to:

- Evaluate foresight methodologies framed by the WP5 Minerals Policy Context and stakeholders' needs (WP2);
- Synthesise recommendations in terms of foresight methodology;
- Consider possibilities on how to better translate these outputs to the MICA online platform (RMICP); and
- Inform the deliverable D5.5 *Raw Materials Foresight Guide*.

The first day of the workshop was structured with a focus on presentations of foresight case studies and open discussions about their contents. The case studies encompassed foresight methods and methodology, the future of the raw materials sector and evaluation of foresight processes.

The second day started with two presentations on the safeguard of mineral deposits for future society's needs and future-oriented policy needs from identified stakeholders (WP2), framing the following discussions. These discussions focused initially on establishing a common understanding on how to provide recommendations with respect to foresight methodology in the MICA project context. Then, the focus was re-oriented towards how to better translate this understanding on how to provide recommendations to the MICA online platform (EU-RMICP). The final session was planned with a more exploratory foresight background over the scenarios produced by WP2 from the INTRAW project (Appendix B, page 26), not only synthesising the workshop discussions, but also looking forward into the future of the mineral raw materials sector, how the stakeholders needs evolve into the future and under different scenarios, the MICA online platform and how final recommendations could scope these future aspects.

The following sub-chapter presents an overview of the workshop presentations.

2.1 Workshop Presentations

The MICA Foresight Methodology Workshop started with an overview and status of the MICA Project by the project coordinator Erika Machacek. The workshop encompassed six presentations on forward-looking approaches focused on the raw materials sector and relevant foresight methodologies. It also featured a presentation on the MINATURA2020 project and its aim to safeguard mineral resources for future utilisation, as well as a MICA WP2 presentation. These presentations will be briefly described further in this chapter and are available on the MICA intranet (MICA Public Documents/Home/WP5/Foresight methodologies workshop).

Appendix A (page 24) provides an overview of the final agenda and the participants.

Presentation I: Innovation and resource governance: foresight approaches in Mineral Futures

Prof. Damien Giurco – Institute for Sustainable Futures, University of Technology Sydney
Dr Tim Prior – Center for Security Studies, ETH Zürich

Figure 1 Innovation and resource governance: foresight approaches in Mineral Futures (Presentation).

In the context of the last mining boom in Australia, the Mineral Futures Collaboration Cluster (2009-2013), looked collaboratively into new opportunities, challenges and strategies for resource governance through different research streams – Commodity, Technology and Regional futures. Foresight was used to provide rich insights for a long-term view, placing research in context. The Peak Minerals Forum, a survey with experts over key drivers and megatrends provided inputs for an 'Australian' exploration of the mining and metals scenarios developed by the World Economic Forum (2009). This survey supported the identification of the need for a national mining strategy and a sustainability rating system for mining operations. It led to a second workshop 'Vision 2040', tapping into different foresight methods and tools. Delving into the scenarios to better develop the 'Vision 2040' and related key themes led to considerations on what was needed to get there and how to get there. Ultimately, the 'Vision 2040' sought to help Australia in avoiding risks such as the 'resource curse' or the 'Dutch disease'. The presentation shared also outcomes ('domains of impact') following the finalisation of the project and the launch of the 'Vision 2040' with important developments ranging from industry, government, community and research initiatives that could enrich the discussions over the evaluation of the project and foresight approaches. The 'Wealth from Waste Cluster' was introduced as a follow-on project, focusing on industrial ecology, urban metal stocks and future business models – the 'above-ground mining'.

Related publications
Peak Minerals Forum (www.uts.edu.au/sites/default/files/PriorGiurco2010forumsummary.pdf)
WEF Australian Workshop (http://resourcefutures.net.au/sites/default/files/WEF_Australian_Workshop_Session_Summary.pdf)
World Economic Forum – Mining & Metals Scenarios to 2030 (WEF 2010)
Applying Causal Layered Analysis and Art (Mason et al. 2011a)
Mining, Minerals and Innovation: A vision for Australia's mineral future (Mason et al. 2011b)
Advantage Australia: resource governance and innovation for the Asian Century (Mason et al. 2013)
Wealth from Waste Cluster (http://wealthfromwaste.net/)

Presentation II: Future Metal Mining – Seventeen Predictions
Prof. Jan Johansson – Centre of Advanced Mining and Metallurgy, Luleå University of Technology

Figure 2 Future metal mining: seventeen predictions (Presentation).

The presentation summarised seventeen (ongoing) changes in the metal mining sector that will eventually take place, according to the presenter, due to current challenges faced by the industry. These changes are summarized as:

- International competition will determine the costs of production: assumption that the demand for metals will continue growing;
- New ore discoveries will happen in more remote and deeper levels – also under the sea: though contrary trends should not be overlooked such as improved concentration technologies. The largest open pit mine in Europe (Aitik mine) has a copper grade of 0.2%;
- Full face drilling, cutting and blasting for controlled fragmentation can become the norm: as mining depths increase, stability problems become more critical;

- Cost of emission allowances: as environmental requirements affect energy consumption and management of ore tailings, the cost becomes more critical especially in developed countries (Paris Climate Agreement);
- Waste management: leaving as small footprints as possible, by closing loops and increasing the contribution of combined underground mining and underground processing;
- Mining industry's social responsibility for the welfare of the local communities;
- Increased automation pushed by Health & Safety requirements;
- Attractive workplaces: good and safe environments are a pre-requisite for attracting skilled workers, especially in remote locations;
- Reversing the design process: the mine layout designs should start from the requirement of an automated mine and not just try to fit automation into conventional operations;
- Internet of Things (IoT): seen as one of the pre-requisites for the *zero entry* mine;
- ICT (Information and Communication Technology) and Big Data creating new opportunities (and problems): opportunities to improve the production and organisational aspects, but also potential problems, such as acceptance ('big brother effect');
- Industry 4.0: based on implementation of IoT, 5G and Big Data transforming mines to 'smart' mines;
- Virtual reality: under the extended business and open collaboration concepts, it can help a more integrative approach to production functions, such as planning, mining, maintenance and coordination of external aspects;
- New professional roles: increasing degree of remote control from production centres and collaborative visualisation rooms;
- Knowledge transformation: moving from physical and tacit knowledge and skills to something new (a more 'abstract knowledge');
- Mine of the future workforce: a smaller staff with multi-skilled workers, who can operate in several areas and functions;
- Cooperation with other sectors: space, aviation, military, etc.

The presentation concludes on the need for a new and modern vision for the whole industry and new cooperation based on socio-technical approaches.

Related publications
Future of metal mining: Sixteen predictions (Abrahamsson et al. 2009)

Presentation III: The use of foresight methods in strategic raw materials intelligence – an international review

Marco K. Martins – Researcher, La Palma Research Centre

Figure 3 The Use of Foresight Methods in Strategic Raw Materials Intelligence – an international review (Presentation).

The presentation outlined the work completed up until the D5.3 *Report on Foresight Logframe* and additional upgrades in the 'Raw Materials Foresight Case Studies Inventory' (Martins & Bodo 2017). The presentation provided an overview of foresight studies in the context of raw materials with relevant classifications – sub-areas of addressed methodological approaches, and methods and tools observed – with the specific case of Scenarios Development for the repeated presence across the different studies. Numerous methodological frameworks were described in more detail and some gaps were identified. The work of task 5.2 *Strategic Raw Materials Intelligence Approaches* was also presented against the timeline of activities as well as the work plan of D5.5 *Raw Materials Foresight Guide*.

Related publications
MICA Deliverable 5.3 "Report on Foresight Logframe" (Martins & Bodo 2017)

Presentation IV: Extract-IT Project: Defining FET research topics supporting the ICT challenges of mineral extraction under extreme geo-environmental conditions
Balazs Bodo – Head Advisor, La Palma Research Centre

Figure 4 Extract-IT: A Mining Technology Foresight Case Study (Presentation).

Extract-IT was a 12-month technology foresight exercise (2012-2013) dedicated to mining and ICT (Information and Communication Technologies) under the FP7 programme (Project No. 318149). It sought to identify emerging and potentially disruptive trends in the use of ICT in future underground mining (2050). The project involved 3 workshops and experts from the mining/geosciences sector as well as ICT experts. A foresight methodology was deployed throughout the workshops including methods and tools such as Mindmapping, Scenarios Exploration and Delphi Survey.

The first workshop focused on exploring three existing scenarios by the experts, where they should select one to define Delphi statements on critical/emerging ICT. As output, the first workshop provided Delphi statements for each of the three scenarios and key ICT requirements. A second workshop consolidated the findings of the previous one and fine-tuned the Delphi statements. Also, a strategy for the implementation of the Delphi survey was developed. The first round of the Delphi survey considered two futures: a fragmented Europe and a prosperous Europe, covering the likely realisation date, required research, technological challenges and future impacts.

The second workshop discussed the findings of the Delphi first round to formulate the round two statements. The second round redefined the statements under three likely technological development pathways. Pre-conditions were also defined in a way that they reflected the expected

emergence of the already identified potentially disruptive ICT trends. The last workshop focused on converting initial concepts drawn from the surveys into draft call topics.

The calls were proposed together with thematic areas for FET (Future and Emerging Technologies) as summarised below:

- Thematic Area I – Evolution Underground:
  - Bio-inspired underground technologies;
  - Microbiology-Energy-ICT Convergence for machine autonomy;
  - Underground machine evolution.
- Thematic Area II – Resilient Artifical Ecosystems:
  - Beyond pervasive adaptation;
  - Machine-repairable machines;
  - Heavy-duty swarm robotics underground.
- Thematic Area III – Broadband through the Rock:
  - Breakthrough data transmission technologies;
  - Self-organised in-mine communication;
  - SwarmCom.
- Thematic Area IV – Cross-cutting calls:
  - Smart Systems Integration;
  - Coordinating communities – Resilient Robotics for Future Mining.

Extract-IT started up a new dialogue between mining and ICT communities providing the 'first step' on the way towards future scientific and industrial leadership in areas that today simply do not exist. This new multi-disciplinary dialogue will open up possibilities for new academic research areas and new potential technology pathways for industry in the future.

Related publications
Extract IT D3.1 *Recommendations for the Future and Emerging Technologies Programme* (Bodo et al. 2013)

Presentation V: Foresight Methods and Practice: Lessons Learned from International Foresight Exercises

Dr Totti Könnölä – CEO, Insight Foresight Institute

Previous relevant case studies experiences were presented covering the foresight process – scope, foresight methodology, outcomes etc., such as:

- Antofagasta (Chile) mining region: focused on capacity building in the context of diversifing economy and developing competences at the regional level;
- VTT Mineral economy innovation programme: towards a circular mineral economy;
- Intelligent Manufacturing Systems 2020: using scenarios and roadmapping.

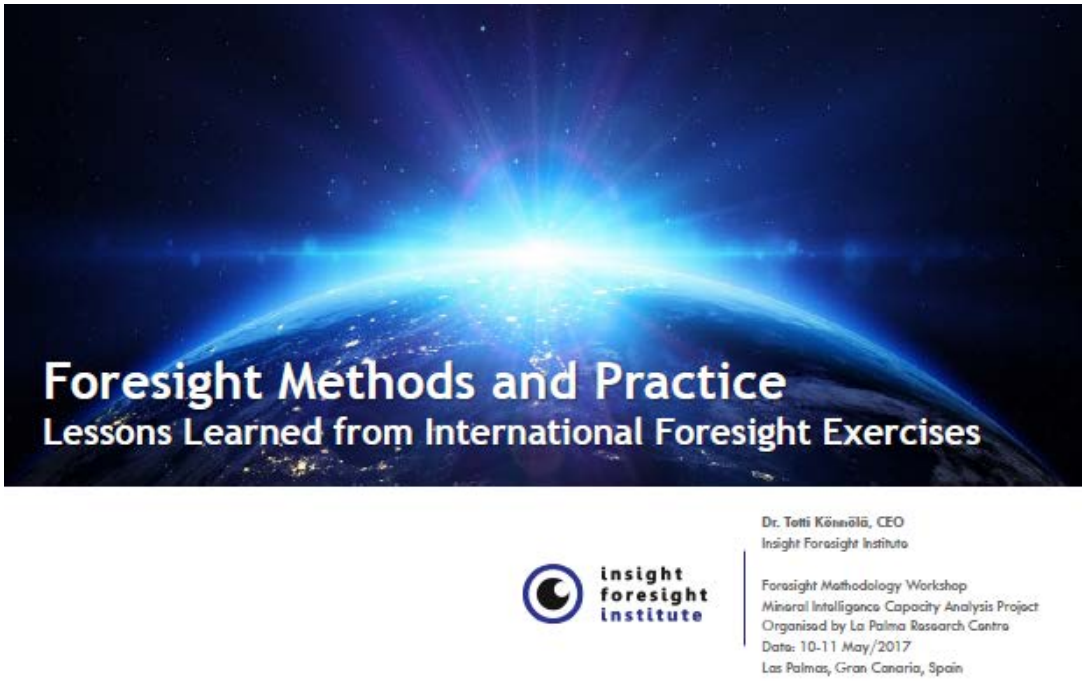

Figure 5 Foresight Methods and Practice (Presentation).

The presentation focused on four foresight key messages:

- Foresight can be applied to the whole policy cycle: influencing agenda setting, policy definition, impact assessments, policy implementation and evaluation in a closed 'loop';
- Foresight designs should be always customised: the 'design' phase of the foresight process can also be explorative by combining quantitative and qualitative methods, face-to-face and on-line approaches, intuitive and rational, subjective and objective views, creative and evidence-based. Having 'checklists' can be useful for fast-tracking the process, however they will not be always applicable, as foresight approaches are always context-dependant;
- Foresight tools and methods definition are never the 'first step';
- It should seek to engage the 'clients'.

In the context of 'innovation ecosystems', volatility, uncertainty, complexity and ambiguity require collaborative work for innovation capacity and foresight can be a tool to support this process. A modular combination of methods accounts for a more responsive design to the project's needs along the process. Modules can also be utilised in parallel to be integrated in re-evaluating the directions and set-up of the process. This can facilitate the demands of informing policy decisions, as it renders the timing of the foresight exercise outputs more flexible. Evaluation of foresight should be seen as how one connects and relates to the system and how one influences the stakeholders participating in the process. Ultimately, foresight is seen as a tool not only for providing recommendations, but also for capacity building, for connecting and engaging stakeholders, influencing the system under study.

Presentation VI: Application of STEEPVL, Structural Analysis and Scenario Building to construction of nanotechnology development scenarios.

Prof (Associate) Joanna Ejdys – Dean, Faculty of Management, Bialystok University of Technology
Dr Katarzyna Halicka – Vice-dean for Research, Faculty of Management, Bialystok University of Technology

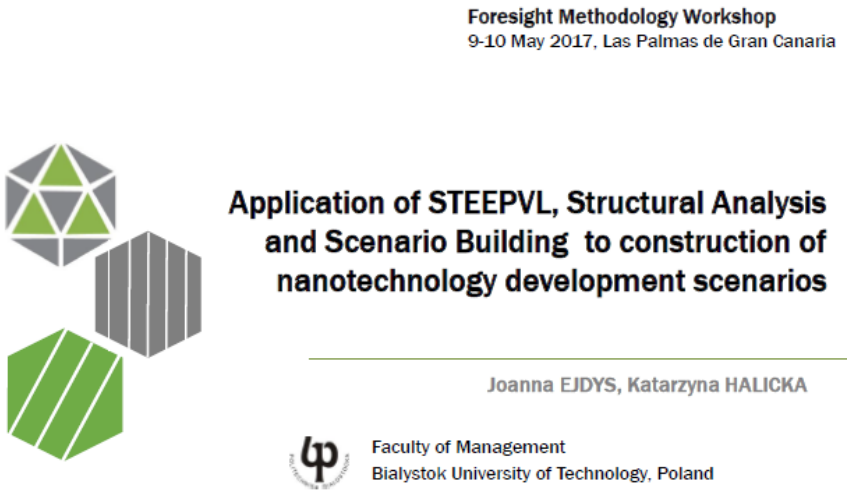

Figure 6 Application of STEEPVL, Structural Analysis and Scenario Building to construction of nanotechnology development scenarios (Presentation).

The presentation focused on the foresight methodology approach applied in the projection of the Podlaskie region's nanotechnology development strategy until 2020. Several methods and tools were used in the process, however STEEPVL (Social, Technological, Economic, Ecological, Political, Values and Legal) Scanning, Structural Analysis and Scenario Building were chosen to be outlined in more detail. The STEEPVL was applied to identify the key factors to develop the potential of nanotechnology at the regional level. This identification was used to construct 2-axis scenarios. As many factors were identified, an additional round was undertaken classifying the factors by their intensity and relevance, thus reducing the number of factors. Additionaly, Factor Analysis was also used to reduce the number of factors. These factors were then ranked according to their uncertainty and significance. This sequential approach narrowed down the number, but it was concluded that another layer of analysis was required to bring the process forward. Structural Analysis supported an additional layer of screening of the factors, by analysing the relationship between the different variables with a view to facilitate the process of identifying the main factors for the Scenario Building step.

Related publications
Application of Enhanced SWOT Analysis in the Future-oriented Public Management of Technology (Nazarko et al. 2017)
Factor Analysis as a Tool Supporting STEEPVL Approach to the Identification of Driving Forces of Technological Innovation (Nazarko et al. 2017)
Structural Analysis as an Instrument for Identification of Critical Drivers of Technology Development (Ejdys et al. 2017)

Presentation VII: Safeguarding Mineral Resources for Future Society's Needs – The Project MINATURA2020

Prof W. Eberhard Falck – MICA WP5 Leader, MinPol

Figure 7 Safeguarding Mineral Resources for Future Society's Needs: The Project MINATURA2020 (Presentation).

The project was developed recognising the importance of a sustainable supply of mineral raw materials for society and that there may be competing uses of land and the subsurface. Such competing uses may include the protection of aquifers for drinking water supply, nature reserves and species habitat protection, agriculture, urban development, protection of cultural heritage and others. In many instances the public is sufficiently sensibilised to these issues at stake. This is less so for the extraction of mineral raw materials. Notwithstanding the importance of mineral raw materials for our society – regardless of which future development trajectories are envisaged, public awareness of the need is low. Owing to inadequate practices in the past that led to devastation of land and significant environmental and societal impacts, the public image of mining is rather negative. For many in Europe it is also a problem of remote locations in the world, as very little mining still takes place within the boundaries of the EU. With a growing world population the competition for resources becomes more fierce on a global scale, so that Europe will need to foster domestic mining.

The project's overall aim is to develop a strategy for ensuring the access to mineral raw materials within the EU. It proposes a mechanism to balance competing land-uses, avoiding the 'sterilisation' of mineral deposits of public importance (MDoPI). An algorithm is being developed taking into account geological, technical, mining, economic, and societal aspects. The project also seeks to raise awareness among land-use planners and policy makers that mineral resources need to remain accessible for the present and future societies.

Presentation VIII: MICA WP2: Process and Results for Future-oriented Policy Crafting

Dr Aaron Rosa – on behalf of the MICA WP2 Leader, Fraunhofer-ISI

Figure 8 MICA WP2: Process & Results for Future-oriented Policy Crafting (Presentation).

The MICA WP2 identified and mapped stakeholders (D2.1) and stakeholders needs (D2.2) in the context of the raw materials sector and the MICA online platform (RMICP). Surveys, workshops and interviews were undertaken to explore the breadth of stakes, in order to support the co-development of Raw Materials Intelligence and related needs. Future-oriented questions from the identified stakeholders focused on the following areas:

- Strategic issues:
  - Budget pressure;
  - Public attitude;
  - Raw Material Initiative, etc.
- Developments towards the year 2020:
  - Soft/Social Conflicts;
  - Raw Materials abundance;
  - Raw Materials competition etc.

More specifically, future-oriented statements and queries from surveys – from which needs can be derived – were drawn as:

- Planning-related:
  - Loss of manufacturing in Europe – Future skills deficit (Industry)
  - Abandoned mining sites for future land use
- Future projections & Scenarios:

  - Future needs of non traditional industrial minerals
  - Future primary and secondary production in Europe
  - Commodity prices: 10 year forecasts (range, assumptions)
- Educated guesses:
  - Where could we possibly find the next "mega deposit"?
  - The possibility to replace a specific raw material with another material that could meet similar requirements.

Mapping such future-oriented questions is the starting point to think about how to address them with Foresight and Foresight methods and tools. Ultimately, any methodological recommendation will be strongly influenced by the stakholders' motivations.

Related publications
MICA Deliverable 2.1 *Stakeholder Report: identification & analysis* (Erdmann et al. 2016)
MICA Deliverable 2.2 *Stakeholder Needs* (Erdmann et al. 2016)

3. Conclusions

The workshop was successful in generating relevant discussions in relation to the WP5 scope on foresight methodologies, framed by the MICA online platform (RMICP) and the WP2 Stakeholders' Needs. The presence of partners and experts from both the raw materials and foresight community guaranteed the attainment of the described objectives.

The utilization of raw materials scenarios from the INTRAW project (Appendix B, page 26) provided the backdrop for a final thinking exercise on how stakeholders' needs can evolve in the future under alternative assumptions. Moreover, the exercise provided a 'demo' on how Foresight methods can aid exploratory futures thinking, with thought provoking discussions.

The findings from the exercise on how Foresight methods can aid exploratory future thinking are summarized below (Scenarios exercise) and in Table 1 (general discussion highlights):

- As the future cannot be predicted, the future stakeholders' needs also have to be supported by a systematic thinking of the future (Foresight) and how such different needs can evolve. MICA assessments provide a comprehensive starting point for such line of inquiry. The same could be regarded to foresight methodology: Development of new practices and approaches in a more experimental and adaptive manner can also reshape the application of Foresight studies.
- Societal limitations to raw materials access: stability of supply is a critical theme when looking into longer term futures. Under more 'stable' scenarios the possibility of destabilising factors should always be contemplated, e.g. geographical concentration is a highly influential feature for the supply risk of (critical) raw materials;
- On a normative basis, future trajectories would preferably envisage a society which is socially, environmentally, and emotionally responsible, and ideologically comfortable with the futures. Such set of values can influence future society's demand for raw materials.

Table 1 Raw Materials Methodology Workshop – Discussion Highlights.

Context	Description
Raw Materials Foresight Guide (D5.5)	Additional chapter for EU initiatives on raw materials with strong future/forward-looking component.
	Feature information on other EU projects with foresight components.
	Development of a framework for categorising stakeholders' questions in function of multiple foresight classification systems, constraints and other boundary conditions, encompassing the review of raw materials foresight case studies, the MICA platform concept and the foresight methodologies. To enable the platform user to better understand its own query according to the different foresight approaches.
MICA online platform (RMICP)	Identification of new MICA FactSheets to be developed: General Foresight planning overview and summary of raw materials foresight case studies review.
	Translating foresight intelligence into the platform. The platform can provide the elements to consider for arriving at a certain vision/future

	by providing foresight knowledge to the end user. It can act as an educational tool supporting the understanding of the different variables and conditions determining the raw materials futures guiding users to the complexity of their own queries through correspondent Fact- and DocSheets. Keywords recognition and linkages and timeframe relation (temporal domain).
	Related (WP3) Meta-data records encompassing multiple links with the FactSheets and complementary external links.
	MICA platform can provide a more "anonymous" space for stakeholders to explore potential issues that otherwise would be harder for them to explicitly commit to.
	Sampling all the possible (raw materials) stakeholders needs is not only virtually impossible, but would evolve in the future as stakeholders needs also evolve with time. A more 'educational' and open Foresight approach to be embedded in the platform can better respond to this by enabling the user to recognise how foresight and methods and tools available can support its queries in the various contexts. This can be done by including relevant FactSheets, DocSheets and FlowSheets, and appropriate links.
Foresight case studies presentations	Importance of translating a vision (foresight) into reality through strategy. Critical aspect for normative approaches.
	Recognition of the importance of a national conversation about mining and minerals e.g. in Australia – foresight not just about uptake of policy recommendations but also about creating and improving the network of stakeholders, fostering dialogue between different communities.
	Identification of ongoing changes in the sector e.g. metals mining – sets a compelling example of input for a foresight planning (e.g. Delphi Survey) as well as identification of emerging stakeholder's needs.
Foresight methodology recommendations	Foresight to be seen also as an opportunity to understand how different factors (technological, social, economic etc.) interrelate. Drawing these relationships should be an added value of a foresight study.
	Platform to orient stakeholders towards the possible combination of methods (WP4 + WP5).
	Defining foresight tools and methodology framework is never the first step – the process should always be customised.
	The importance of understanding the perspective of the decision-maker i.e. how the decisions are made. This is to be brought into the foresight and system under study.
	As Foresight exercises - and by extent its methodologies - heavily rely on the resources available and the type of stakeholder questions, any methodological approach should account for such boundary conditions. This improves the capacity to design a sound and appropriate foresight methodology framework.

Foresight methodology recommendations	'Modular' foresight approaches (i.e. creating checkpoints or milestones to assess the development of the exercise according to the objectives and possible change of such initial objectives) can improve the utilization of the methods and tools. These approaches can also facilitate the process of refining the methodological framework in a more timely manner, responding to the process developments.

Raw materials have been increasingly addressed by foresight exercises with different foresight methods and tools, and different approaches being used. However, there is no formal systematic foresight programme for raw materials at the EU level. The actual need for such approach could be more discussed on future related initiatives concercing raw materials and future challenges at the EU level.

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Appendix A – Workshop Agenda and Overview

MICA WP5 Raw Materials Foresight Methodology Workshop – Agenda

09/05/2017 – Arrivals		
10/05/2017 – Foresight Methodology Workshop – Day 1, Morning Session.		
09:00	Welcome – Introduction to the Workshop	Balazs Bodo (LPRC)
09:20	MICA Project – Overview & Status	Erika Machacek (GEUS)
10:00	Mineral Futures Collaboration Cluster	Damien Giurco (ISF-Sydney) [2] & Tim Prior (ETH Zürich)[3]
11:00	Coffee Break	
11:30	Future of Metal Mining: Seventeen Predictions	Jan Johansson (Lulea University)
12:15	Raw Materials Foresight Case Studies – An international review	Marco K. Martins (LPRC)
13:00	Lunch	
10/05/2017 – Foresight Methodology Workshop – Day 1, Afternoon Session.		
14:30	Extract-IT Project: Foresight methodology	Balazs Bodo (LPRC)
15:15	Foresight Methods and Practice: International Examples	Totti Könnöllä (IFI)
15:45	Application of STEEPVL to identification of Technology Development	Katarzyna Halicka, (Bialystok University)
	Application of Structural Analysis and Scenario Building to construction of nanotechnology development scenarios	Joanna Ejdys (Bialystok University)
16:30	Coffee Break	
17:00	Round of (structured) discussions over the methodologies and the content of presented studies.	All
18:00	End of Day 1	
19:30	Common Dinner	All
11/05/2017 – Foresight Methodology Workshop – Day 2, Morning Session.		
09:00	Safeguarding Mineral Resources for Future Society's Needs	Eberhard Falck (MinPol)
09:45	MICA WP2: Process & Results for Future-oriented Policy Crafting	Aaron Rosa (Fraunhofer-ISI)
10:30	Coffee Break	
11:00	Establishing methodology and general raw materials foresight recommendations.	All
13:00	Lunch / End of the meeting.	
	Start of Departures	

[2] Joined via video conference (Institute for Sustainable Futures, Australia)
[3] Joined via video conference (ETH Zürich, Switzerland)

List of participants in the MICA WP5 Raw Materials Foresight Methodology Workshop, 10th & 11th of May, Las Palmas de Gran Canaria, Spain.

Participant	Organisation	Role
Ariadna Ortega	LPRC	Workshop Leader
Aaron Rosa	Fraunhofer-ISI	Partner
Balazs Bodo	LPRC	Workshop Leader
Eberhard Falck	MinPol	WP5 Leader
Erika Machacek	GEUS	Project Coordinator
Evi Petavratzi	BGS-NERC	WP3 Leader
Jan Johansson	Lulea University	External Expert
Joanna Ejdys	Bialystok University	External Expert
Katarzyna Halicka	Bialystok University	External Expert
Marco Konrat Martins	LPRC	Workshop Leader
Totti Könnölä	Insight Foresight Institute	External Expert

Appendix B – INTRAW Project & Scenarios

The INTRAW Project (www.intraw.eu) is an ongoing project (02/2015-01/2018) aiming at developing new cooperation opportunities in raw materials between the EU and other reference countries, i.e. Australia, Canada, Japan, South Africa and the United States, addressing specific fields:

- Research & Innovation;
- Education & Outreach;
- Industry & Trade; and
- Recycling & Substitution.

For these different fields, action plans were developed as recommendations for implementation by the EC and the 'International Observatory for Raw Materials', a non-profit entity to be launched during the 'Raw Materials Week 2017' in November 2017, in Brussels.

As part of the INTRAW project, a scenario-building exercise was undertaken producing three different scenarios for the global long-term future (2050) of the raw materials sector. The scenarios outlook is briefly described:

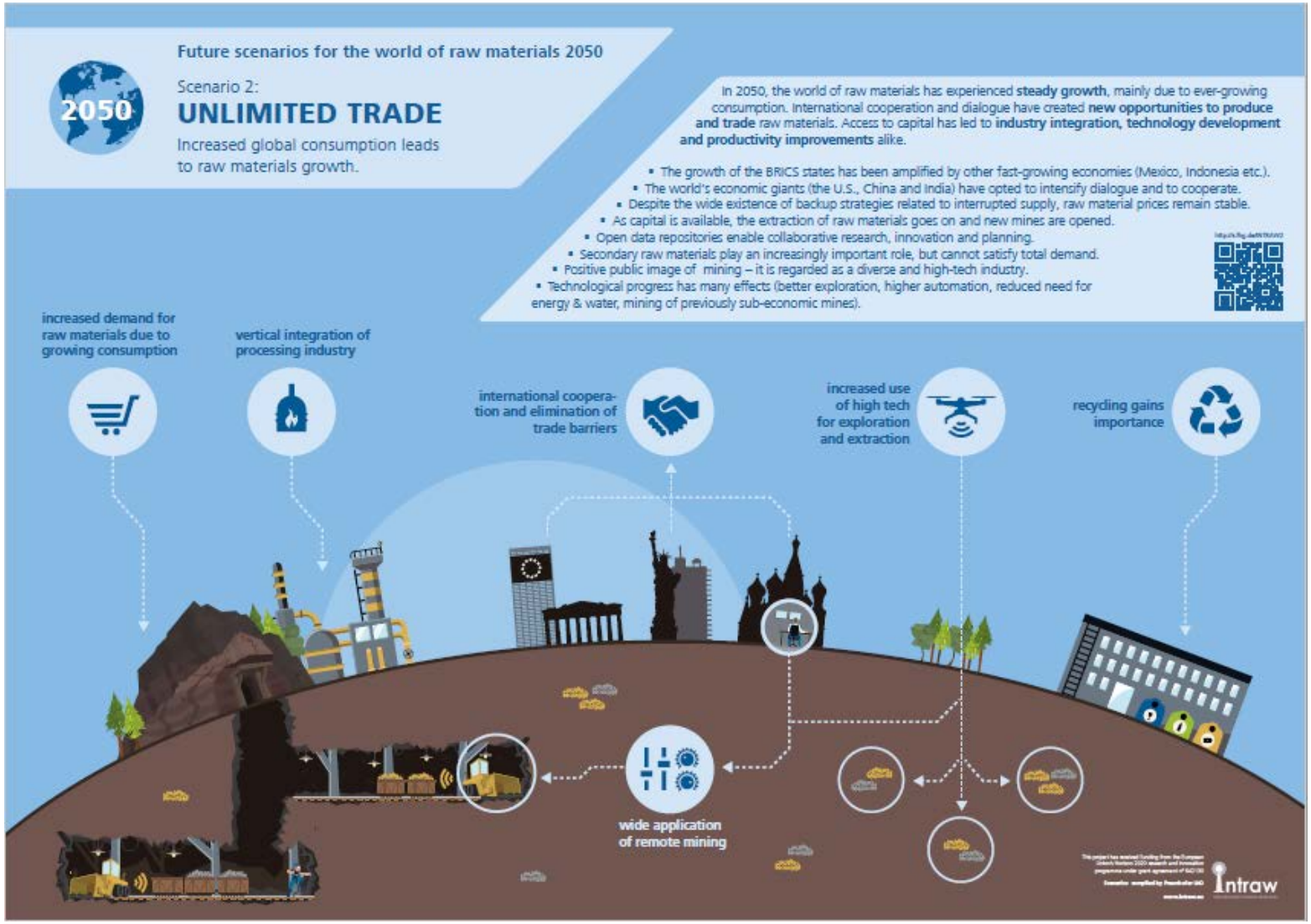
- ***Sustainability Alliance***: sustainable approaches dictate the norms in the sector – circular economy, reforms focusing in increasing sustainability become reality;
- ***Unlimited Trade***: the increase in global consumption of raw materials is confirmed and addressed with increasing cooperation and dialogue for producing and trading raw materials. Access to capital lead to industry integration, technology development and productivity improvement;
- ***National Walls***: protectionist measures on a national level become more frequent, impacting the raw materials sector with diminishing progress in mining practices, lower private investments and cooperation for raw materials open supply.

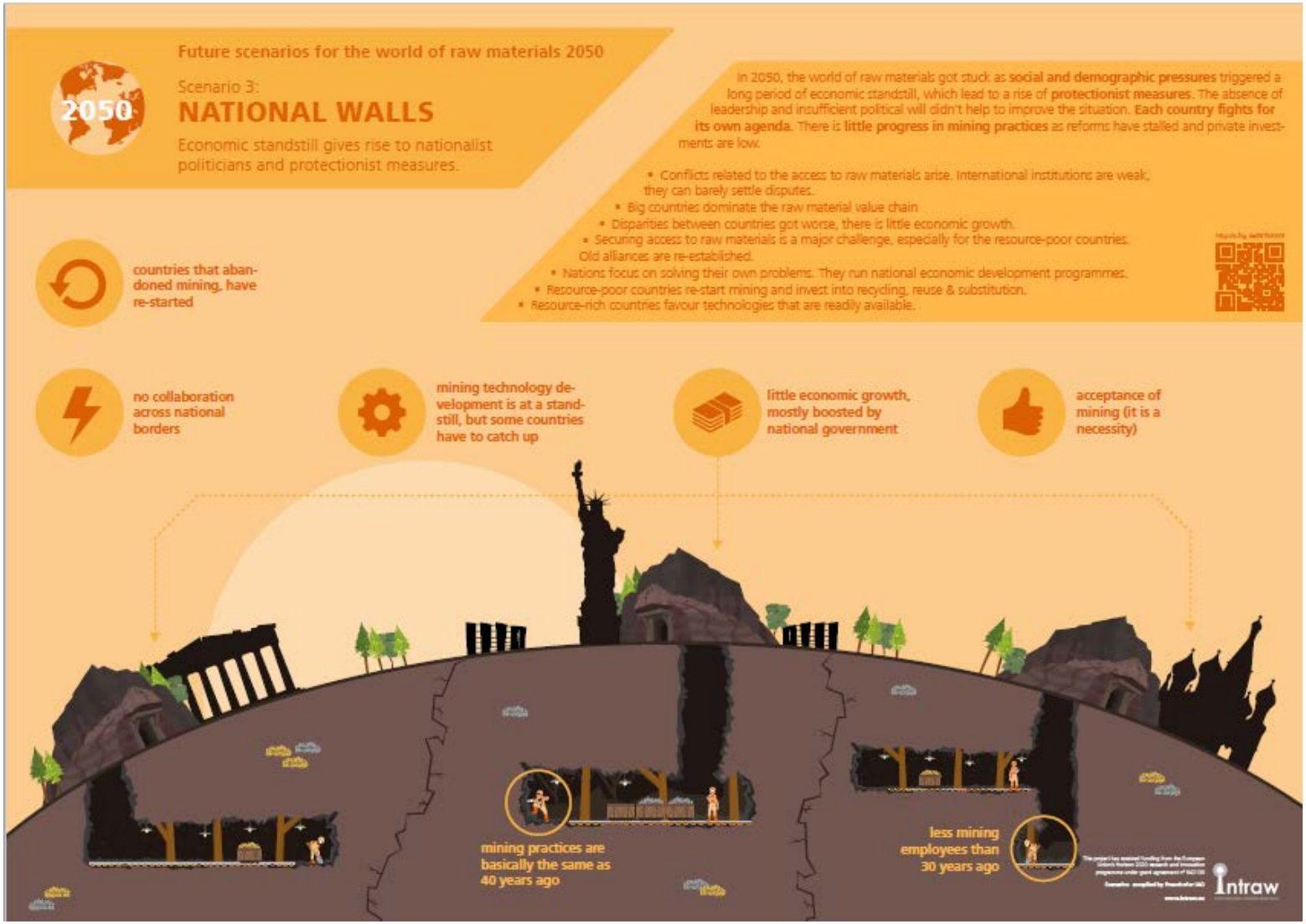
The scenario building process was undertaken through a workshop following a Cross-Impact Analysis[4] for identifying and clustering factors to generate the scenarios framework.

For each scenario, a graphic illustration was developed to improve visualisation of these different futures:

[4] Foresight method, see D5.1 (page 159)


Future scenarios for the world of raw materials 2050
2050
Scenario 1:
SUSTAINABILITY ALLIANCE
A new generation puts sustainability above everything else to keep deposits for future generations.
In 2050, the circular economy has become the norm in the big advanced economies. A new generation of political leaders has pushed forward a series of reforms that focus on increasing sustainability, not only in the raw materials industry. Almost every product is produced in an environmentally-friendly way with the aid of green technologies.
▪ Severe environmental problems have reached a tipping point. Governments agree to place sustainability above growth and profit.
▪ Concerted actions incentivize the shift towards more sustainable approaches (not only in the raw materials industry but also in agriculture, energy, logistics etc.)
▪ Recycling and substitution technologies have reached a new level of maturity. Prices for secondary (recycled) material fell over time.
▪ Only high-tech, low-impact mining is tolerated. Consumers reward resource-efficiency, waste reduction and durable products.
▪ Sophisticated environmental monitoring, prevention and mitigation technologies are being deployed.
political leaders form an alliance to push reforms that focus on increasing sustainability
there is only green mining and a reduced consumption of primary raw materials
environment-friendly way of producing with the aid of green technologies
increased use of high tech for exploration and extraction
substantial progress in re-use, recycling and substitution of materials
Intraw


Future scenarios for the world of raw materials 2050
2050
Scenario 2:
UNLIMITED TRADE
Increased global consumption leads to raw materials growth.
In 2050, the world of raw materials has experienced steady growth, mainly due to ever-growing consumption. International cooperation and dialogue have created new opportunities to produce and trade raw materials. Access to capital has led to industry integration, technology development and productivity improvements alike.
▪ The growth of the BRICS states has been amplified by other fast-growing economies (Mexico, Indonesia etc.).
▪ The world's economic giants (the U.S., China and India) have opted to intensify dialogue and to cooperate.
▪ Despite the wide existence of backup strategies related to interrupted supply, raw material prices remain stable.
▪ As capital is available, the extraction of raw materials goes on and new mines are opened.
▪ Open data repositories enable collaborative research, innovation and planning.
▪ Secondary raw materials play an increasingly important role, but cannot satisfy total demand.
▪ Positive public image of mining – it is regarded as a diverse and high-tech industry.
▪ Technological progress has many effects (better exploration, higher automation, reduced need for energy & water, mining of previously sub-economic mines).
increased demand for raw materials due to growing consumption
vertical integration of processing industry
international cooperation and elimination of trade barriers
increased use of high tech for exploration and extraction
recycling gains importance
wide application of remote mining
Intraw


Future scenarios for the world of raw materials 2050
2050
Scenario 3:
NATIONAL WALLS
Economic standstill gives rise to nationalist politicians and protectionist measures.
In 2050, the world of raw materials got stuck as social and demographic pressures triggered a long period of economic standstill, which lead to a rise of protectionist measures. The absence of leadership and insufficient political will didn't help to improve the situation. Each country fights for its own agenda. There is little progress in mining practices as reforms have stalled and private investments are low.
• Conflicts related to the access to raw materials arise. International institutions are weak, they can barely settle disputes.
• Big countries dominate the raw material value chain
• Disparities between countries got worse, there is little economic growth.
• Securing access to raw materials is a major challenge, especially for the resource-poor countries. Old alliances are re-established.
• Nations focus on solving their own problems. They run national economic development programmes.
• Resource-poor countries re-start mining and invest into recycling, reuse & substitution.
• Resource-rich countries favour technologies that are readily available.
countries that abandoned mining, have re-started
no collaboration across national borders
mining technology development is at a standstill, but some countries have to catch up
little economic growth, mostly boosted by national government
acceptance of mining (it is a necessity)
mining practices are basically the same as 40 years ago
less mining employees than 30 years ago
Intraw