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List of Abbreviations:

Abb.	Description
EIP	European Innovation Partnership
EEZ	Exclusive Economic Zone
KIC	Knowledge Innovation Community
NGO	Non-Governmental Organization
PPP	Public-Private Partnership
R&D	Research and Development
R&I	Research and Innovation
RM	Raw Materials
RMI	Raw Materials Initiative
TRL	Technology Readiness Level
SDG	Sustainable Development Goals
SIP	Strategic Implementation Plan

1 Executive Summary

This report compiles together a number of policy recommendations aimed at EU-level policy makers, to support policies covering topics relevant to the ¡VAMOS! technology and that can affect its market uptake. The concept of using seafloor mining methods for the extraction of mineral resources in land is a crucial example; it is not currently covered by European policies.

To deliver meaningful policy recommendations a set of steps was taken, including: 1) a review of current European policies on raw materials and innovation, 2) a review of EU projects assessing policy aspects on the raw materials value chain, 3) an analysis of current and future challenges in European policies, 4) a ¡VAMOS! scenarios analysis for the future of raw materials and 5) the project's stakeholders' considerations for the development of the ¡VAMOS! technology.

Above cited methods helped to identify five distinct areas that need to see the creation of new policies (or adaption of current ones) and that will, ultimately, facilitate the viability and market uptake of the innovative ¡VAMOS! technology in the EU. These areas are: 1) minerals policies and regulatory frameworks, 2) innovative mining conditions, 3) new research and innovation areas, 4) innovation and the transition to market and 5) awareness raising. For each of these areas a number of specific policy recommendations were made, with the ¡VAMOS! project development always in focus. Although developed with ¡VAMOS! in mind, these policies can still be applied to support other innovation technologies, acting as transversal recommendations that would benefit the EU landscape at large.

Applying the recommendations presented in this document would allow the proliferation of the ¡VAMOS! technology on the European market, thus fulfilling one of the main aims of the EU's Horizon 2020 programme.

2 Introduction

2.1 The ¡VAMOS! Project

Estimates indicate that the value of unexploited European mineral resources at a depth of 500-1,000 meters is ca €100 billion, however, a number of physical, economic, social, environmental and human constraints have as yet limited their exploitation. ¡VAMOS! will provide a new safe, clean and low visibility mining technique and will prove its economic viability for extracting currently unreachable mineral deposits, thus encouraging investment and helping to put the EU back on a level playing field in terms of access to strategically important minerals. Deriving from successful deep-sea mining techniques, the ¡VAMOS! mining solution aspires to lead to: Re-opening abandoned mines; Extensions of opencut mines which are limited by stripping ratio, hydrological or geotechnical problems; and opening of new mines in the EU. ¡VAMOS! will design and manufacture innovative automated excavation equipment and environmental impact monitoring tools that will be used to perform field tests in four mine sites across Europe with a range of rock hardness and pit morphology. ¡VAMOS! will:

1. Develop a prototype underwater, remotely controlled, mining machine with associated launch and recovery equipment
2. Enhance currently available underwater sensing, spatial awareness, navigational and positioning technology
3. Provide an integrated solution for efficient Real-time Monitoring of Environmental Impact
4. Conduct field trials with the prototype equipment in abandoned and inactive mine sites with a range of rock types and at a range of submerged depths
5. Evaluate the productivity and cost of operation to enable mine-ability and economic reassessment of the EU's mineral resources.
6. Maximize impact and enable the Market Up-Take of the proposed solutions by defining and overcoming the practicalities of the concept, proving the operational feasibility and the economic viability.
7. Contribute to the social acceptance of the new extraction technique via public demonstrations in EU regions.

2.2 Deliverable D6.5 Policy Recommendations report

2.2.1 Objectives

The aim of this deliverable is to suggest policy options at European level to better allocate the ¡VAMOS! technology and other raw materials innovative technologies in the European market. Recommendations also aim at supporting and step-up current European raw materials and innovation policies. Ultimately, this report also aims to contribute to a necessary paradigm change in the European mining landscape.

2.2.2 Approach

To develop policy recommendations a series of current documents related to environmental and minerals policies, regulations and socio-economics at EU-level were screened including directives, programmes, projects assessing European raw materials policy and others. To

support policy recommendations the ¡VAMOS! technology potential was assessed against the backdrop of future scenarios for the world of raw materials (based on the INTRAW project scenarios for the year 2050) together with ¡VAMOS! stakeholder considerations regarding the technology and its impacts, obtained from Work Package 1. With all these background data, policy recommendations for the future of ¡VAMOS! (and other disruptive technologies in the raw materials sector) were made to be considered at EU-level to properly accommodate new innovative ideas in the EU. Ultimately, these should contribute to European policy strategies in place such as the ones evidenced by the Raw Materials Initiative or the Strategic Implementation Plan of the European Innovation Partnership (EIP) on Raw Materials or even lead to new ones.

2.2.3 Input for policy recommendations

The ¡VAMOS! policy recommendations report is built primarily for policy makers at EU level with focus on the raw materials sector. The recommendations made in this document, are based on the input from 1) the current European policy landscape in relevant fields (raw materials and innovation), 2) scenario planning exercises and 3) comments and suggestions made from relevant stakeholders. The recommendations have been validated among the project partners and advisory board members (that also represent different stakeholder groups) through the revision of this report.

3 Current and future EU policy challenges

Raw materials are of extreme importance to the EU's economy due to their use in different industries such as construction, automotive or renewable energy. Their representation on the EU economy account for a combined added value of more than EUR 1,300 billion, where the entire mineral raw materials value chain accounts up to 40% of value to EU's manufacturing sector while giving employment to over 30 million citizens¹.

Despite the EU's needs for raw materials, it is not self-sufficient in the production of most necessary mineral raw materials and, thus, needs to guarantee a supply of raw materials from different sources in order to keep its industry strong. Ensuring access to raw materials from third countries while promoting a level playing field in trade, fostering sustainable supply from European sources and guaranteeing efficient use of raw materials and recycling, constitute the base pillars of the Raw Materials Initiative (RMI), the main policy strategy for raw materials in Europe.

Linked to the above-mentioned challenges (i.e. linked to the pillars of the RMI), some specific ones arise, such as, the use of deep-sea mining as a go-to to diversify the mineral supply and its needs for regulation, the focus on energy efficiency that calls for innovative solutions, the investment gaps towards research and innovation for safer and more productive technologies and processes and, ultimately, the transition to a low carbon economy, among others. Most of these challenges have been addressed in recent European policies such as seen in the EIP on Raw Materials Strategic Implementation Plan or the different Innovation Policies².

Regarding the raw materials value chain, the following specific challenges need to be assessed to facilitate the implementation of the European policies (SIP, RMI et al.):

- Increased demand for mineral raw materials
- Securing the access for raw materials with supply from both primary and secondary sources
- Improve the resource efficiency and recycling capacity
- Better waste management (e.g. mining waste)
- Assessing the mineral potential in Europe and creating a uniform raw materials knowledge base
- Develop a good raw materials international diplomacy based on resource sustainability
- Acquiring social license to operate and raising public awareness on mining
- Ensuring social and environmental standards are met in supply chains
- Facilitating access to data and ensure data security

¹ <http://ec.europa.eu/trade/policy/accessing-markets/goods-and-services/raw-materials/>

² https://ec.europa.eu/growth/industry/innovation/policy_en

- Push for technological transformation and innovation of processes and services
- Adapting to new skills and employment in the raw materials sector
- Creating new policy approaches while involving relevant stakeholders, both horizontally and vertically
- The lack of concreteness of national minerals strategy in some member-states

Some of these challenges have been identified and discussed for a long time among different institutions, leading to part of them being addressed by the European Commission in due time and manner. This is seen, for example, on the funding of some of the Horizon 2020 projects. However, some of the challenges still remain to be tackled and this report may facilitate a push for possible solutions.

Hand-in-hand with the industry and the raw materials sector is innovation. The EU acknowledges the need for innovation as it is seen with the implementation of its innovation agenda based on EU's strategic flagships (i.e. Innovation Union), R&I programmes (e.g. Horizon 2020) or its own Industrial policy³.

Innovation is crucial for the EU's industry competitiveness in global chains, and therefore, one can defend that the link between innovation and the raw materials sector needs to become stronger in order to put and maintain the EU on the forefront of industrial competitiveness. The EU already implements policies to support innovation and to increase investment in R&I and transform the gained knowledge into marketable goods or services, but this is not entirely seen in the raw materials sector.

Innovation and, consequently, innovation policy can be a cornerstone for the raw materials industry as it can help to improve productivity, securing supply chain activities and diversify activities through the raw materials value chain. Raw materials, themselves, have a specific role in leading innovation. Faure-Schuyer et al. (2018) suggest that raw materials can become one of the most relevant items in the EU's knowledge and scientific capability in the future. Therefore, the need for more R&D is identified for fields such as materials science, that needs to be coupled with the evolution of recycling procedures and with development of worker's competences and skills. Challenges in the European innovation scheme that calls for action are (JRC, 2017):

- The need of better innovation performance to boost the EU industrial growth
- Increasing knowledge intensive industrial activities on industrial value chains
- Facilitate the access to financial support for innovation
- The systems in universities and training centres that need to be adapted to new skills on the workforce panorama

³ https://ec.europa.eu/growth/industry/policy_en

- Better administration of research and innovation programmes
- More research efforts made towards humanity and social sciences

The challenges presented by the raw materials and innovation sector in the EU will shape the future of those fields and will have a major impact on the EU as a competitive block in the global scheme. Therefore, they need to be properly looked upon and answered by European policy makers, as solving these – or part of these – challenges would facilitate the EU to achieve a better, economical and social status worldwide.

4 State of EU policies and the ¡VAMOS! project

4.1 The present moment

Currently, the EU has a set of policies in place that directly and indirectly affect the ¡VAMOS! potential as a new product/service to the European market: a new mining technique to mine inland deposits in flooded open-pits, but also aimed at other water environments and applications. These policies vary from raw materials strategies to environmental norms to be followed or even innovation fostering. Mechanisms including minerals legislation, deep-sea regulations and health, safety and labour directives are among them.

The fact that mining activities are already covered by EU legislation ruled by many directives and other instruments further supports the uptake of new innovative technologies to the raw materials sector to a great extent. Moreover, the current EU regulations do not show any factors that can hinder the implementation of innovative technologies (¡VAMOS! Deliverable 1.1). However, changes in the EU and/or national regulations respecting mining, innovation and raw materials need to be assessed, constantly screened and adapted to ensure proper deployment of innovative technologies such as the ¡VAMOS! mining technique.

In the EU landscape, environmental policies, minerals policies, regulations and socio-economic factors are of importance to the proliferation and uptake of ¡VAMOS! technology from a research and innovation project developing a prototype into a concrete market product and service, and thus were the ones considered in this chapter. A comprehensive list of different EU policy instruments that currently are applicable and relevant for the future commercial exploitation of the ¡VAMOS! technology can be found on Annex 1 (developed after ¡VAMOS! Deliverable 1.1).

4.2 Adaptation level of ¡VAMOS! to the policy context in the EU

The ¡VAMOS! project is a research and development project funded by the EU under its R&I programme Horizon 2020. ¡VAMOS! is developing and perfecting a prototype machine to mine in-land submerged raw materials based on technologies coming from different sectors. The prototype for this innovative technology was finalized in 2017. Two trials were planned to test the technology in the field: the first took place in September 2017 in Lee Moor, UK, in a kaolinite mine and the second, in Ireland. Both are flooded, former open-pit mines. Flooded mines are, in fact, the main target of the ¡VAMOS! technique and the envisaged application environment. To proceed with the trials with this technology, the ¡VAMOS! team has to prove to interested parties (e.g. government, NGOs, communities, others) that the technology can, in fact, be used in these sites while complying to all necessary EU and national regulations. These include permitting procedures, licensing, stakeholder engagement at local level, environmental compliances and others. An account of the procedures needed in order to test with the ¡VAMOS! technology is given in Deliverable 1.1 and Deliverable 5.1.

Making the shift of the ¡VAMOS! technology from the project environment to the application market will involve following similar guidelines for permitting procedures, engagement and environmental obligations. Therefore, the current adaptation level of ¡VAMOS! to the policy context in the EU is briefly considered below due to its importance from a future European market perspective.

Permitting and Licensing

- Required permissions from mine site owners (e.g. state, private company) must be obtained;
- Mining permits may not be necessary for trials, depending on the country, but one is needed in a commercialization case;
- The EU regulations are to be applied in case the country does not have specific policies developed. Otherwise, European regulations are already considered in national policies beforehand;
- Permits in case of a commercialization mining activity are more rigorous than for trials;
- Leases and environmental licenses are needed;
- The lack of regulations for inland submerged mining of mineral resources, with special focus on the metallic ones, are a given fact.

Environmental assessment

- Environmental impact assessment is needed for both trial and real mining activities;
- Environmental licenses complying with EU and national regulations are needed in order to proceed with activities.

Stakeholder engagement

- Social License to Operate is not mandatory for trials (country by country analysis), but is needed for real mining activities;
- Local authorities and stakeholders usually require a good account of information regarding mining activities, including technical details, in order to support the technology and the mining activity itself;
- Contacts between the project partners/mining companies and stakeholders need to be strengthened.

In general, and considering the trial activities developed by the ¡VAMOS! team during the project, the EU (and national) regulations in place are enough for a mining in-land submerged trial to take place while complying with all necessary legislation. However, it must be noted that in case of future commercialization of the technology as a mining equipment, more rigorous regulations are to be followed and this aspect needs to be considered in the development of the technology. The lack of regulations for inland submerged mining for metallic minerals and stronger stakeholder engagement need to be further assessed before any mining activities with this technology can take place on a commercial scope.

4.3 What is missing?

The instruments used/followed within the EU cover the areas where ¡VAMOS! can have an impact, but only to a certain extent. ¡VAMOS! is bringing an innovative technology approach to the playing field, that brings together aspects from different sectors, many of them quite recent (e.g. deep-sea mining techniques, re-opening of flooded closed mines), and that are not yet covered in EU policies or are only partly covered. An example is that of using seafloor mining methods for extraction of minerals in land, that is not currently considered by EU policies. This calls for specific legislation in this regard, as no EU regulations clearly regulate or discuss inland submerged mining for mineral deposits, which will hinder the uptake of ¡VAMOS! technology from European companies. A similar question needs to be posed to all innovative solutions that might enter the market and, therefore, policies should be constantly reviewed and adapted or created from scratch.

4.4 Conclusions on the state of EU policies

Current EU policies related to the raw materials, technology and innovation sectors allow the proliferation of the ¡VAMOS! technology within EU markets as they are, although some regulations need to be created from scratch or further adapted to the novelties before. Also, ¡VAMOS! is complying with all the necessary regulations in order to use its technology in Europe, which will facilitate its market uptake. However, much can be done to better accommodate it on the European market if some policy aspects are pursued. Mechanisms such as new public funding for further technology improvement or more innovation – for ¡VAMOS! or any other technology - and new regulations for the use of sea mining techniques inland are two of the few recommendations that can make ¡VAMOS! (and other similar technologies) a success in the future.

Furthermore, the technology and market potential of the ¡VAMOS! system as a whole has significant potential and mineral laws and innovation frameworks need to be in place to support transition of this innovative technology to the European market.

New policies should aim to make tenure application and the management processes simple and quick, among other aspects. A report by the MIN-GUIDE project suggests the following gaps need to be overcome, when referring to deep sea mining (Pinheiro et al., 2017): 1) take a precautionary approach and an adaptative management solution, 2) set aside areas from mining zones, 3) determine protected areas by capturing local and regional heterogeneity/diversity and 4) collaborate with the industry to reduce possible environmental impacts, based on scientific knowledge through technological advances. A parallel analysis of these can be made to the ¡VAMOS! application environment as being similar. Policies need to take these new aspects into account.

Innovation on the raw materials sector is safeguarded by different mechanisms including important legislation on environmental, nature protection and health and safety aspects, together with funding mechanisms. In this field, innovation is supported by safety, environmental, social and economic values. For example, the royalty and tax regimes in place seem to be beneficial to develop mining activities in mineral exploration and exploitation and to maintain the competitiveness of mines in Europe, which supports the uptake of ¡VAMOS! technology to the market, without the need to change innovation related policy to a great extent.

5 ¡VAMOS! evolving scenarios

5.1 Introduction to scenarios

One way to gather information for future policy possibilities that might influence the market/technology evolution of the ¡VAMOS! innovative solution is to think about the future and how the different aspects provided by ¡VAMOS! would fit and adapt in that same future (or futures). For this purpose, scenario planning, among other future thinking tools, is useful. In the case of ¡VAMOS!, scenarios were used to “have a look” onto the future. ¡VAMOS! scenario considerations aimed at bringing discussions related to environmental and minerals policies, regulations and socio-economics into the table to help in the elaboration of relevant policy recommendations that might answer to the challenges posed by those futures.

5.1.1 What are scenarios?

Scenarios are visions of possible futures that consider a set of aspects (economics, social, political, environmental, technological, others) and analyse how they would behave in a certain timeframe in the future. Scenarios are not predictions of the future; however, they are generally used to provoke ideas and discussions.

5.1.2 How do scenarios lead to strategic output?

Scenarios are used to provide decision-makers with tools to create opportunities or anticipate hazards on a future vision. They help to take better decisions, have stronger strategies or facilitate understanding and collaborative actions. Data shown by different scenario deliberations on different topics is considered to help define appropriate actions to benefit from opportunities or overcome challenges shown in specific areas.

5.2 ¡VAMOS! under the umbrella of the INTRAW scenarios

The scenarios developed by the INTRAW project were used to build considerations for ¡VAMOS!. In INTRAW three different scenarios for the world of raw materials for the year 2050 were created (Schimpf et al., 2017), considering different political, economic, societal, technological and environmental visions on each scenario. Considering ¡VAMOS!’ own aspects inside these fields and scenarios, the project development was regarded under the most relevant considerations of the INTRAW scenarios (political situations that might affect ¡VAMOS! technology, acceptance of mining, push for sustainability, etc.) to obtain a possible vision of ¡VAMOS! in the future. From there, opportunities and challenges seen in the ¡VAMOS! horizon were considered. Policy recommendations made in this report take some of these future considerations into account.

The three scenarios developed by the INTRAW project are entitled Sustainability Alliance, Unlimited Trade and National Walls. The first is characterized by a global focus and effort on increasing sustainability standards for living (Figure 1). Among others, only “green” – environmentally sensitive - mining is seen, coupled with a reduction in the consumption of primary raw materials, avant-guard technologies that are widely applied for exploration and extraction of minerals and where there is a great progress in re-use, recycling and substitution of materials. The Unlimited Trade scenario depicts a world where there is an increased demand for raw materials seen by growing consumption, with increased use of high techs for exploration and extraction of raw materials, translated in a wide application of remote mining (Figure 2). Finally, the National Walls scenario shows a world where countries that abandoned mining have re-started it to gather their own resources, with mining

technology development at a standstill and with techniques similar as of today, but where mining activities are widely accepted by society (Figure 3).

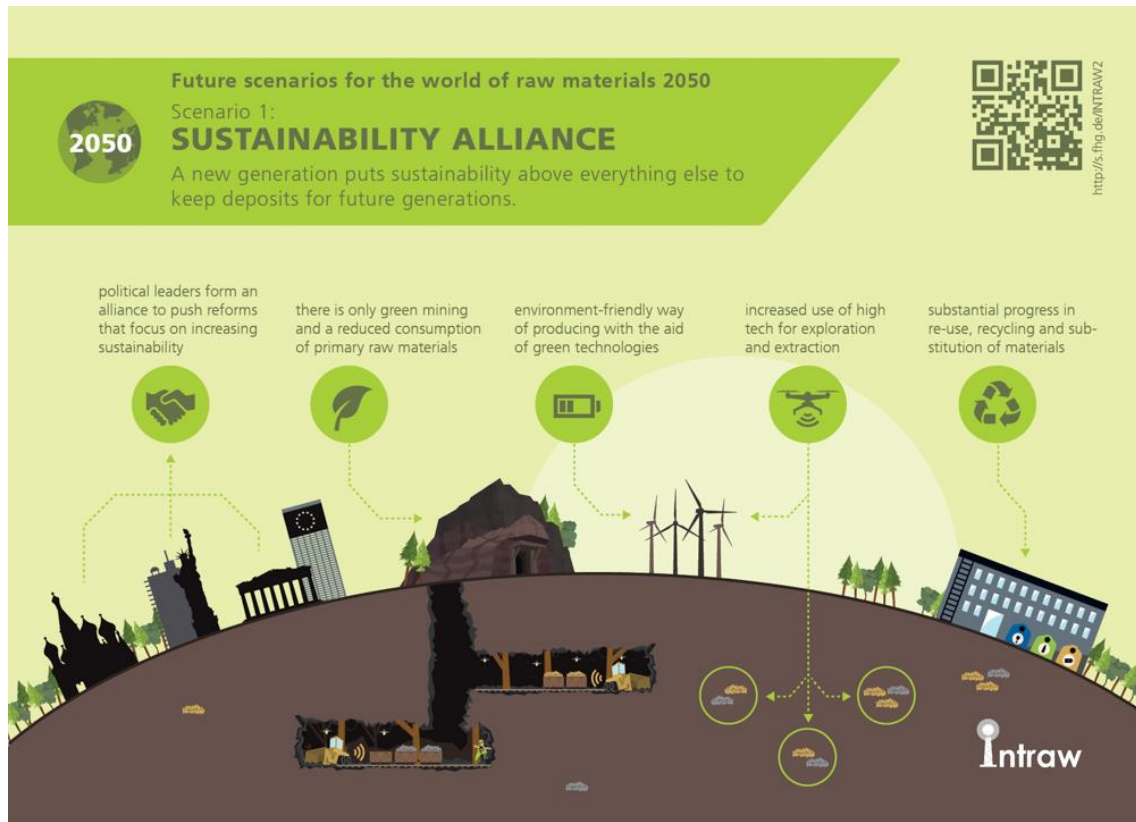


Figure 1: Sustainability Alliance scenario



Figure 2: Unlimited Trade scenario

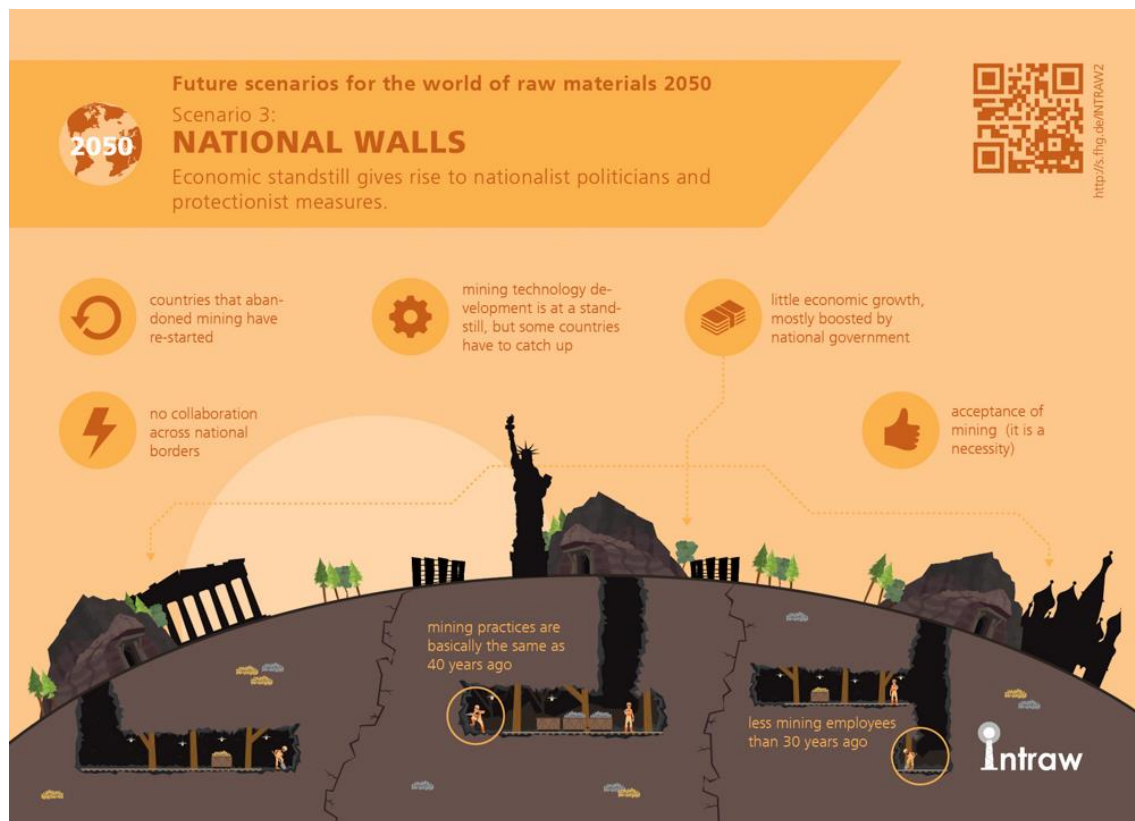


Figure 3: National Walls scenario

The entwining of ¡VAMOS! with the INTRAW scenarios proceeded with two sets of exercises: an internal and an external analysis.

5.2.1 Internal scenarios analysis

INTRAW scenarios were developed taking into consideration different aspects according to the PESTEL categories: political, economic, social, technological, legal and environmental factors. These areas are also of extreme importance to the ¡VAMOS! project as their development both within the EU and globally can strongly influence the further development and market uptake of the technology. To compare the state of these areas in each scenario, the author of this document, studied the aspects related to those categories as they are depicted in the INTRAW scenarios: as statements referring on how the future will look like for each specific item. An example can be indicated here for clarity:

“An entire generation has grown up to be environmentally aware and has developed a sustainable lifestyle.” - respecting to the thematic of Society under the Sustainable Alliance scenario vision, or

“Environmentally-friendly mining and extraction of raw materials, with strict environmental policies in the mine closure period that are followed around the globe have been strongly integrated.” – respecting to the thematic of Environment under the Unlimited Trade scenario vision.

The process continued with gathering the statements that are most relevant and applicable for the ¡VAMOS! case. These are the ones that can have some kind of influence, positive, negative or

even neutral, or create an opportunity or challenge for the future of the technology. The selected statements can be found in Annex 2.

5.2.2 Road-mapping workshop

As part of the work developed in Work Package 6, a scenario workshop for the ¡VAMOS! project was held in January 2018 in Bled, Slovenia, on the event “Use of robotics and automation for mineral prospecting and extraction”. Here the ¡VAMOS! technology and its potential was analysed by the participants, considering the specifics of each different scenario, where they studied how the technology would behave on the different conditions presented by the specific scenarios. During the exercise, participants were asked to make comments and/or suggestions on possible future opportunities and/or challenges that the ¡VAMOS! technology might face in light of the conditions envisaged by the three scenario situations. More on this specific exercise can be found on ¡VAMOS! Deliverable D6.6.

5.2.3 Conclusions on scenarios

The results from both scenario analysis suggest that the ¡VAMOS! technology can benefit from different opportunities, but have to be prepared for challenges arising, including different futures, and different cases. This can be pursued by applying new policies or adapting existing ones to the scope of ¡VAMOS!. Distinct scenario visions need particular approaches to the future. However, in some cases one approach can be beneficial for two or more scenarios, and thus, has a higher chance of impact. It should be stressed, again, that scenarios are not forecasts of the future, but rather plausible, probable or possible alternatives and that this type of exercise is managed with subjective interpretations rather than objective reasoning.

The following three tables bring together the most important points for the ¡VAMOS! technology considerations respecting each scenario, arising from both internal and external scenario analysis exercises and discussions. Each item is identified by a statement regarding the ¡VAMOS! mission. The division between opportunity or challenge (or positive or negative impact, respectively) is also made. General recommendations are then linked to these statements, aiming at providing a good basis for the final policy recommendations. Ultimately, the statements here presented can help to identify the gaps, challenges and opportunities in policy to accommodate the ¡VAMOS! technology in the European landscape in the future.

Table 1: Sustainability alliance scenario analysis

Statement	Opportunity /Challenge	General recommendation
Environmentally superior solution to conventional or seabed mining increasing market demand	Opportunity	Transfer from R&I state into market product; Great opportunity for ¡VAMOS! technology, as it can deliver on this market demand: policy shall support such innovative technologies with shorter permitting processes;

		Reduced royalty prices for innovative mining activities.
Global green approach and focus on sustainability facilitates the use of ¡VAMOS! technology for mining of primary raw materials	Opportunity	Foster sustainable mining; Support technologies that contribute to sustainable raw material sourcing: extracting maximum amount of ore from a given deposit is highly desirable, and ¡VAMOS! technology supports this which in turn contributes to sustainability objectives.
Environmental and technological standards for mining operations are raised globally	Opportunity	Foster innovative mining solutions that are in line with more uptight environmental and social conditions; Prioritize innovative mining technologies at new permitting processes.
As society is environmentally aware, and with a sustainable lifestyle, it will understand the need for mining of primary raw materials	Opportunity	Raise awareness of the need of mining towards raw materials stakeholders and general public.
Only high-tech and low impact mining is tolerated	Opportunity	Foster more innovative solutions and deploy more funding towards them; De-prioritize low-tech and high impact mining at permitting processes; Authorize only high standard mining activities.
New technologies allow more accurate exploration; new mines are opened, some in remote areas	Opportunity	Adapt or create new policies to facilitate mining in remote and/or extreme environments.
Sophisticated environmental monitoring, prevention and mitigation technologies are being deployed. Compliance with the strongest environmental standards is now the biggest share of running costs in mining operations.	Opportunity	Adapt current environmental policies and develop better environmental tools to evaluate mining, while supporting sustainable mining; Support low environmental impact mining activities, such as ¡VAMOS!; Prioritize brown field investments over green field.
Risks are still present in mining activities, and impacts need to be better monitored	Challenge	Invest in more R&I towards innovation; Step-up environmental, technical and social assessment measures.

With secondary raw materials dropping in price and becoming more attractive than primary RM, the ¡VAMOS! technology can suffer market uptake. However, primary raw materials are still needed.	Challenge	More innovation to make mining of primary raw materials more economic and environmentally positive.
Efficient processes on the RM value chain are a must. ¡VAMOS! brings together mining and processing stages at one step.	Challenge	More R&I funding towards innovation of raw materials value chain activities with strong focus on mining.

Table 2: Unlimited trade scenario analysis

Statement	Opportunity /Challenge	General recommendation
Cross-fertilization of the technology developed under ¡VAMOS! with other technology domains will benefit both ¡VAMOS! and other industrial sectors and should be facilitated	Opportunity	Make data on R&I and innovation more easily accessible between different industries.
Growing importance of mining of small rich deposits makes ¡VAMOS! solution preferable over others	Opportunity	Adapt or create new policies to facilitate mining of small deposits; Funding on R&I to support innovation extraction technologies; Facilitate the ¡VAMOS! transaction from project to market by fostering Public Private Partnerships.
Total demand for mineral raw materials increases globally, with the inherited need to obtain minerals from different environments	Opportunity	Facilitate the exploitation of minerals in different conditions through funding schemes for R&D and innovation; Facilitate the transition from project R&I to market product.
Extraction of RM continue and new mines are opened; more efficient regulatory frameworks that support governmental bodies, industry, local communities and other stakeholders to resolve conflicts and to reach a consensus on establishing new mines in shorter periods of time	Opportunity	Adapt current regulatory systems through the raw materials value chain; Raise awareness and bring stakeholders to discuss mining.
Secondary RM have an increasing role in provision of RM, however they cannot keep	Opportunity	More R&I funding schemes specific to innovative mining

with demand and primary RM exploitation is still a reality		solutions in order to secure RM supply.
Better public perception, due to the understanding of contribution of mining to sustainable development	Opportunity	Raise awareness among the general public and raw materials stakeholders on how mining contributes to sustainable development (eg. SDG); As the public accepts mining activities, reopening mines with innovative mining technologies becomes easier, giving way to ¡VAMOS! platform.
Advanced mining technology spreads increasingly fast across borders as good practices are shared	Opportunity	Keep track of mining innovations globally and facilitate their use to European mining companies; Facilitate technology spread by networks like FORAM, INTRAW observatory and other raw materials matchmaking platforms.
Cost and productivity limitations can restrain applications for ¡VAMOS! mining method and reduce market uptake	Challenge	Further develop the technology, focusing on cost effective operations; Foster innovative mining solutions by tax/royalty reduction on technologies like ¡VAMOS!, to increase financial feasibility.

Table 3: National walls scenario analysis

Statement	Opportunity /Challenge	General recommendation
National mineral production will have to increase, to open up additional opportunities for ¡VAMOS! More protectionism measures and breached trade agreements arise the need for solutions that can feed a country's necessity for materials	Opportunity	Support the sustainable supply of RM from internal sources; De-risk innovative mining operations with financial instruments (investment insurance); More funding for R&I and innovation solutions in the raw materials value chain to satisfy national RM needs.
Securing access to all required RM for industry is a challenge and requires the use of	Opportunity	More funding for R&I together with focus on

different techniques that can guarantee the access to RM in different environments		innovation for new solutions on the raw materials value chain, specially mining.
With the restart of mining from countries that abandoned it, one of the main targets will be old open-pit mines	Opportunity	Create proper regulation that facilitates re-exploitation of old mines with innovative technology; Foster brown field investment for mining companies with easier permitting processes and financial security options.
High-tech and low-tech mining coexists in raw materials chains. ¡VAMOS! technology need to compete with low-tech/low-cost mining techniques.	Opportunity	Raise environmental, technological and safety standards in mining.
Mining is a somewhat dull industry, made by the slow uptake of new techniques Mining practices are the same as 40 years ago (year 2010)	Challenge	Foster the uptake of new technologies from project prototypes to market products by financial support for PPPs.
Environmental permitting procedures for mining are mostly a formality, any investment that meets basic environmental criteria and generates employment is approved very quickly. Environmental policies are in place but often ignored.	Challenge	Create an EU governmental body to properly evaluate permitting and environmental mining procedures while at the same time raising the current standards

It is shown, through the analysis of the statements, that the ¡VAMOS! technology can become a valuable technology in mining practices in any of the scenarios, even if in some cases it can become kind of a niche innovation (as in Sustainability Alliance to mine primary raw materials). However, some paths – policies – on both raw materials and innovation related fields should be pursued to accommodate the ¡VAMOS! technology to the future of the European market as it would certainly be a useful technology.

In a world dominated by sustainability, where mining is reduced but still needed, the ¡VAMOS! technology can provide primary raw materials in a cleaner, more sustainable way, without the need to open new mines and causing major environmental and social problems. Focus should be on fostering innovation, fostering sustainable mining, having more R&I funding, promote fiscal and social benefits and adapting or making new policies for ¡VAMOS! to succeed in such a world.

With global unlimited trade, ¡VAMOS! can have a great impact on providing primary raw materials as the demand on these will increase substantially – being able to mine on closed mines that still have mineral raw materials at lower costs will become an asset. In this case it is suggested that supporting the supply of raw materials from internal sources should be pursued, together with focus on innovation and funding for more R&D.

In a case of close borders to global (and possibly regional) trade and on which mining techniques and innovative technology see a halt, the ¡VAMOS! mining technique can find its way as it can be used to obtain as much primary raw materials as possible from national sources (usually from closed mining sites). In this last case, the secure of the supply of raw materials mainly from internal sources should be closely supported, together with the adaptation of other regulations (e.g. regulations on reopening mines).

Despite the specific suggestions made, recommendations can fall on other topics such as raising awareness of the importance of mining and raw materials to the European industry near stakeholders and the general public, adapting or creating new policies that allow mining in different conditions (that will be crucial in the near future), investing in more R&I and innovation in the processes representing the raw materials sector, and creating mechanism to help the transition of project's outputs in market products and services. These general suggestions are further developed and detailed in the recommendations chapter, resulting in more concise recommendations.

6 Outputs from ¡VAMOS! Stakeholder Engagement

Stakeholder engagement is essential to understand the scope of challenges and opportunities that the ¡VAMOS! technology might face in the future and how interested parties (e.g. future consumers of the technology, governmental bodies, NGOs, local communities) perceive them. These go together with the considerations for future policies that might affect the uptake of the technology by the European market. This chapter builds on the stakeholder engagement developed during Work Package 1 throughout the project to help in consideration of policies recommendations.

A similar exercise to the one reproduced using scenarios (Chapter 5) is reproduced here. This one relates to the different statements collected during the various engagements done in WP1 such as the stakeholder workshops and the innovation agenda (¡VAMOS! Deliverables 1.2 and 1.5, respectively).

Table 4: Stakeholder engagement analysis

Statement	Opportunity /Challenge	General recommendation
Stakeholders accept only high environmental and safety standards for mining operations	Opportunity/Challenge	Maintain or improve environmental and social mining assessment; Support innovative mining solutions, such as ¡VAMOS! in order to comply with the high environmental standards.
Environmental performance of the technology is the most important factor	Opportunity	Raise awareness to stakeholders and public of local communities of the environmental performance of innovative solutions such as ¡VAMOS! technology.
Stakeholders were very interested in the technological approach and feedback on the project aims and methodology	Opportunity	Frameworks to facilitate joint cooperation between technology developers and stakeholders for the transition from project output into market product and service.
Stakeholders acknowledge the fact that mining is a cycling business and that the re-opening of closed mines in Europe will become a reality in the future; Need to surpass legal and social constraints in order to reopen mines	Opportunity	Adapt frameworks and regulations on reopening and mining in old mine sites; Further R&I funding and innovative solutions for mining in closed mine sites.
Stakeholders perceive the ¡VAMOS! technology as highly innovative	Opportunity	Frameworks to facilitate the transition from project output into market product and service; Facilitate market uptake to European mining companies.

Stakeholders see that the technology can have an overall positive impact in the long-term	Opportunity	Raise awareness to stakeholders and public of the positive impacts of innovative mining solutions.
¡VAMOS! represents a new technology that most stakeholders are not aware of this new approach to mining nor of its impacts	Challenge	Raise the stakeholder awareness for new innovations in the raw materials sector.
Stakeholders want the development of some components: Excavation and processing system Robotics equipment Economic and commercial proofs Public relations and promotion strategies Social and environmental factors	Challenge	More funding for R&I to comply with these specific stakeholder needs.
Stakeholders would like to see the further functions: Grade control and mineral sampling Excavation system functions Operational environments Processing functions Environmental monitoring	Challenge	More funding for R&I to comply with these specific stakeholder needs.
Stakeholders identified the following bottlenecks for the technology: Economic and commercial concerns Mine planning and operational concerns Technical concerns Social and environmental concerns	Challenge	More funding for R&I to comply with these specific stakeholder needs.

The ¡VAMOS! stakeholders – mining companies and their customers, policy makers, NGOs, governments – perceive the technology that is being developed as an environmentally sound and sustainable mining technology that can help Europe to secure a supply of raw materials from internal sources, in line with European raw materials policies, and to potentiate its industrial sector. Therefore, in general, ¡VAMOS! stakeholders support current and further development and market uptake of the technology.

However, in order to reach a state where the ¡VAMOS! technology can be considered totally useful, implementation of a series of policies is necessary. This can include raising awareness of new raw materials technologies, specially mining, having more funds for R&I to develop new innovative solutions for the raw materials value chain processes, fostering sustainable mining that is compliant with high standard environmental and social aspects and adapting or creating new legal frameworks that can make the usage of new technologies in new environments regulated at all levels (e.g. reopening of European closed mine sites for exploration/exploitation).

7 Policy recommendations

The ¡VAMOS! consortium, having revised and used information from documents from European projects that actively deal with policies on raw materials and innovation, strongly supports the recommendations made by those same projects and advises that their recommendations should be considered. This is the case for policy-focused EC-funded projects such as MIN-GUIDE, Minatura 2020, INTRAW and STRADE, among others. Pursuing the recommendations suggested by those projects would help to set conditions for the future of the raw materials European landscape and, at the same time, would have a positive impact on the implementation of ¡VAMOS! and other innovative technologies.

The review of challenges in the European raw materials and on innovation sectors, together with the consideration of current European policies and ¡VAMOS! adaptation to future scenarios allowed to get a grasp on the European landscape and to create a number of ¡VAMOS!-specific policy recommendations that can shape the future of the technology.

The following suggestions aim at creating a good European environment to foster innovation and to further shape the policies relevant for the raw materials sector, with special focus on the development and market uptake of the ¡VAMOS! technology. Ultimately, these recommendations will help the EU to fulfil the targets presented by its current policies and addressing identified challenges.

7.1 Policy recommendation 1: Develop a coherent minerals policy and stable regulatory frameworks

7.1.1 Description

With the goal of providing a stable and competitive supply of raw materials from internal sources, the EU needs to develop and put into practice a minerals policy coupled with a stable regulatory framework at EU level, that can be transversal to the objectives of its member-states. These are being currently covered at EU level by different EC working groups (e.g. Ad Hoc Working Group on Exchange of best practices on minerals policy and legal framework, information framework, land-use planning and permitting) and research and innovation funded projects, for example. These are seen for both onshore and offshore situations.

There are factors, among which, the price of mineral commodities, high environmental standards and land and water use competition that led to a near-all halt in mining activities in Europe in the recent decades. However, Europe is a resource-rich region and has the potential to produce more raw materials than it actually does and therefore to sustain itself and decrease its dependency from the import of mineral raw materials from third party countries. Moreover, establishing a sustainable supply of raw materials needs to be considered as a priority from an EU-perspective, overcoming national policies and country borders, in order to secure the future of EU industry. One aspect to keep in mind is that raw materials policies, regulations and priorities are in a constant change in both Europe and worldwide, which requires a regular monitoring of the evolution of legislative frameworks that are applied within European borders. Projects that focus on minerals

and innovation policies are a good way to keep an account of these (e.g. Minatura 2020, Min-Guide, others).

Moreover, the application of new technologies, processes, activities and others, also need to be regulated, whatever field they relate to. These regulations can be adapted from existing ones or created from scratch. From a legislative point, related to inland submerged mining respects, there seem to be regulations in the necessary areas (e.g. dredging, surface and subsurface mining) to support permitting processes for the operation of ¡VAMOS! technology, but only on a case by case scenario. However, and to reach a bigger scope, EU level recommendations and guidelines for inland submerged mining for mineral resources – with special focus on metallic minerals - should be pursued, in order to facilitate efficient permitting procedures for the deployment of this technology. The EU should also constantly revise its legislation and adapt to the new conditions brought by different innovations to the European field.

The following ¡VAMOS!-related recommendations aim at fostering conditions to create a coherent minerals policy at EU-level that can be shared by all member-states and aim at organizing stable regulatory frameworks to accommodate the ¡VAMOS! technology.

7.1.2 Recommendations for a coherent minerals policy and stable regulatory frameworks

- **Develop specific inland submerged mining regulations** that are in-line with the ¡VAMOS! mining technique specificities, in order to create permitting and market conditions for the technology. These are not currently envisaged by EU policies and need to be created as policy and legislative support so that ¡VAMOS! can become part of the market. One of these could be to simplify the permitting procedures using this technology by creating one-stop shops.
- **Consider and acknowledge the EU offshore mineral potential**, as described in the ¡VAMOS! deliverable 5.7 (among other studies) and its relevance for the EU sustainability. Actions towards exploration and exploitation of mineral resources offshore should be held in line with policy recommendations 2, 3 and 4 of this document.
- **Develop a harmonized EIA procedure for deep sea mining/inland submerged mining at EU level**, that could bring together all environmental considerations of deep-sea and inland submerged mining facilitating exploration and exploitation of resources with the ¡VAMOS! technology while following all environmental regulations. It is suggested to amend EU Directives 2011/92/EU (EIA directive), 2014/52/EU (amendment to EIA directive) and 2014/89/EU (Maritime Spatial Planning) (in line with suggestions from the MIN-GUIDE project).
- **Review and update the legislation on the reopening of flooded mines.** The ¡VAMOS! technology has a demonstrated capacity to operate in open-pit flooded mines deriving from past mining areas. In order to support the use of the ¡VAMOS! technique to mine at these sites, a revision and update of the legislation on the reopening of flooded mines should be considered. This should keep in mind other technologies such as the ones developed by the UNEXMIN and STAMS projects.
- **Implement the ¡VAMOS! Zero-State Environmental and Geo-hazard Evaluation criteria into national permitting procedures** for mining operations within the territory

of the European Union, involving it in future regulations. This comprehensive list of criteria (¡VAMOS! Deliverable 1.3) is a way to assess the possible environmental and geo-hazard impacts that might be caused by submerged inland and offshore mining.

- **Develop a concrete study on the macroeconomic impact of the mining sector in Europe**, considering the many factors that dictate macroeconomic volatility. A good overview of these factors and possible consequences is given on ¡VAMOS! Deliverable 6.1.

7.2 Policy recommendation 2: Foster and support innovative mining in new frontiers

7.2.1 Description

Ensuring a secure supply of raw materials has been a European priority since the launch of the Raw Materials Initiative in 2008. In this and other EU policy-related documents it is suggested that Europe should pursue to guarantee this supply from 1) internal sources, 2) sustainable sources and 3) recycling. However, in a world that is seeing a raise in protectionism it is suggested that the EU should focus on supplying itself from internal sources primarily, whenever possible – or feasible. For this to happen, the raw materials value chain, and in particular, mining, needs to embrace new environments to mine for resources including deeper in the earth, in the ocean or even in the outer space. However, new techniques and processes along the value chain are/will be needed to mine smaller deposits, deposits from flooded mines, on the seafloor, deeper in the Earth.

Concerning seafloor exploration/exploitation, international waters need to be excluded as policies and rules are governed by United Nations bodies to a large degree. The EU can influence, but not control these. EU land accounts up to 3.5% of total Earth land, whereas EU waters account for 22.5% of total territorial EEZ waters. These figures show the relevance of water exploration activities – on which ¡VAMOS! might have a part to play – to the future of the EU in terms of economy. With its combined maritime history and skills, the EU needs to ensure that it leads the charge to offshore exploration, while pursuing social and environmental benefits at the same time.

New technologies need to be developed in order to recover resources in an environmental, social and economic way, while being supported by bigger and more automated machines, remotely controlled equipment and with increased use of robotics applications. A step forward in allowing mining in new environments is shown by projects such as ¡VAMOS! and UNEXMIN, focused on reopening inactive and flooded mine sites, many of which still contain valuable raw materials resources to be exploited.

The following recommendations aim to support mining in new conditions and non-standard environments and will definitely have a positive impact on the innovative ¡VAMOS! mining technique.

7.2.2 Recommendations for supporting mining in novel conditions and environments

- **Bring the issue of underwater mining (in the ocean/in extreme environments/inland submerged) to the top of the EU political agenda**, as the best way to ensure that the

importance of mining, especially in new environments, is taken into account and that regulations can be developed specifically for that.

- **Create a Best available techniques reference document (BREFs)** explicitly for submerged in-land mining based on the environmental, social and economic performance of innovative technologies, where the main starting point can be the ¡VAMOS! technology while using the data provided from the project's reports.

7.3 Policy recommendation 3: Extend the Research and Innovation scope and funding in the raw materials sector in support for cleaner, more efficient technologies and processes

7.3.1 Description

EU's efforts on Research and Innovation for the raw materials sector have been strong, as it is seen by the Horizon 2020 programme that has been funding projects that develop innovative solutions for mining, processing and recycling. ¡VAMOS! is one of those beneficiaries, together with projects like UNEXMIN, SOLSA or Real-Time Mining, that are actively contributing to innovative processes to further develop and strengthen the European raw materials value chain.

More innovative solutions and thus financial, technical and structural support is needed to step-up the EU's raw materials sector and, ultimately, its industry. Furthermore, it needs to be acknowledged that policy support at EU level should be developed in line with important research topics in the field of raw materials for the future. This also requires constant tracking of trends and innovations at international level.

Extending funding for research and innovation activities, especially related to developing the ¡VAMOS! technology, is the scope of D6.6 – Research Roadmap, where this topic is further analysed. Therefore, it is suggested that this deliverable is consulted for more details regarding new research and innovation scope and funding possibilities in regarding the ¡VAMOS! technology.

7.3.2 Recommendations for extending the R&I scope and funding in the raw materials sector in support for cleaner, more efficient technologies and processes

- **Raw materials topics, especially on cleaner, more efficient technologies and processes need to be included and considered** in future European R&I funding programmes (i.e. Horizon Europe and others following), supporting further development of technologies such as the ¡VAMOS! one.
- **Foster more involvement of larger mining and mine-technology companies** in European R&I projects to bring technologies uptake to a further level. Facilitating Public-Private-Partnerships in order to support technology uptake, such as ¡VAMOS!, from developers to end-users.
- **Promote conditions to bring together different sectors and companies to jointly develop the raw materials and mining sectors.** Innovation, as it seen by the technology created within ¡VAMOS!, can arise when two or more fields are merged together (deep

sea mining, robotics, etc). The involvement of a wider range of companies and institutions both private and public from more fields of expertise would benefit the innovation on the raw materials sector.

- **Move towards a research strategy focused on robotics/automation/other innovative solutions** to support safer, cleaner and more productive operations for the raw materials sector, especially in the extraction phase, such as seen in the ¡VAMOS! mining technique.

7.4 Policy recommendation 4: Strengthen innovation in raw materials and support uptake from R&I into the market

7.4.1 Description

Innovation is essential to further develop the raw materials sector and thus the European industries and is claimed to be an essential part of EU's development. However, the mining industry is considered as somehow conservative to the uptake of new instruments, and just recently have started to apply innovative solutions such as automation and teleoperation of machinery in its activities worldwide in a wider scale, despite autonomy been present already for more than 30 years. Innovation can contribute, among other things, to more productivity, more safety and less environmental impact.

In the raw materials sector, the innovation concepts of technology push (occurs when research and innovation in new technology drives the development of new products) and market pull (occurs when a problem needs to be solved with a new product) need to be considered at all times, as their analysis is needed for further and adequate technology development and, consequently, innovation. The ¡VAMOS! project, for example, arises from a coupling model where both the technology push (technologies from different sectors available) and market pull (EU's need for innovative mining solutions to answer to the challenges of raw materials supply) conditions are seen.

It is thus advised that the EU creates or opens conditions for an environment that allows for innovation to grow and presses for raw materials companies along the value chain to consume the innovative solutions being developed. This would involve supporting, financially for example, the technologies that arise from R&I projects into products or services to the market.

7.4.2 Recommendations for strengthening innovation in raw materials and support uptake from R&I into the market

- **Enable easy successive funding to bring raw materials projects research results into market solutions**, supporting them over a longer period of time and improving their Technology Readiness Level (TRL). One already existing scheme are the KICs. Solutions that can help projects to be better prepared for the market conditions should be pursued and would be useful to upgrade the ¡VAMOS! technology to another level in order to facilitate its market uptake.
- **Support the uptake of innovation in the mining sector** with financial schemes (e.g. Tax breaks, royalty reduction or other economic benefits) to support mining companies who acquire and use the ¡VAMOS! and other EU-produced mining technologies.

- **Support low-risk mining activities** (environmental, technical, economic), so ¡VAMOS! and other technologies can have a proper market uptake by European companies. One way to improve these is to have better geological knowledge and publicly available data that can be consulted by all stakeholders. This same goal is pursued by other EU projects with great emphasis, such as One Geology Europe, Minventory and Minerals4EU.
- **Urge and recommend the need for future raw materials projects to have Open Days** to showcase their technology to stakeholders. The ¡VAMOS! project included these during its activities and the benefits can be seen, for example, with a social acceptance boost towards mining activities, while bringing together stakeholders with the project and the EU's work.
- **Use ¡VAMOS! as a flagship of the EU potential on research and innovation actions** regarding automated mining, mining of small deposits and alternative mining to attract more innovative projects and stakeholders, including investors, technology producers and end-users.
- **Build an EU-forum**, that brings together and combines the latest scientific developments from raw materials related EU-projects, fostering technology transfer and supporting continuous development on the raw materials value chain. This forum should bring together technology developers, policy makers and end-users. It could be coupled with the EU Industry Days.

7.5 Policy recommendation 5: Raise awareness on new raw materials related technologies and their potential for society, the economy and the environment

7.5.1 Description

Raw materials are essential for EU's industry and for its citizens' current lifestyle. However, most citizens and some of the most important raw materials value chain stakeholders get from near-zero information on raw materials to wrong information, that badly affects their judgement, having negative impacts on acceptance of mining, for example. It is thus necessary to make a paradigm change in communication with the general public and raw materials stakeholders to make them aware of the needs of raw materials and how positively the sector impacts the region and their lives.

Also, the raw materials sector through its activities can help the EU to achieve the Sustainable Development Goals (SDG) as proposed by the United Nations, but only if proper frameworks for political, social, environmental and economic aspects are put in place (see the other recommendations, mainly Policy recommendation 1). Good governance tied with competent and transparent administrations are also needed to achieve these goals. Again, the potential of mining to contribute to these goals is not entirely acknowledged by the public, hindering its acceptance and putting into danger the uptake of raw materials innovative solutions.

¡VAMOS! is moving forward in the way of social acceptance in mining and can be even seen as a potential game changer in this aspect due to (¡VAMOS! Deliverable 1.1): 1) the mining activities being developed in submerged open pits without influencing the water table, 2) scarce noise and

dust pollution and 3) more safety for workers as they are further away from dangers such as rock falls and blasting.

The following actions should be pursued in order to raise awareness to new raw materials related technologies and their potential benefits for European society, economy and environment.

7.5.2 Recommendations for raising awareness on new raw materials related technologies and their potential for society, the economy and the environment

- **Make ¡VAMOS! and other innovative mining solutions knowledge reach more stakeholders.** Common efforts between European and member-states governments and institutions should be pursued to facilitate this. An effort should be made to continue promoting innovative mining solutions, such as ¡VAMOS!, after the project lifetime, focusing on environmental and economic positive performances of the technology.
- **Start a European Union Innovation days – linked to the EU Industry Days - to showcase the ¡VAMOS! technology** and other innovative techniques, especially in the raw materials sector, but that can be applied to other innovation fields. This event would have a special focus on the latest scientific developments targeted to future industrial applications, thus raising market awareness and uptake.
- **Showcase the ¡VAMOS! technology and its new mining approach in National, European and International events** related to raw materials and innovation in the sector in EU and national communications.
- **Raise public awareness on the reopening of flooded mines to unblock social constraints**, thus facilitating the use of the ¡VAMOS! technology in the European market. This should be pursued hand-in-hand with changing the legislation on the reopening of closed mine sites (Policy recommendation 1).
- **Maintain continuous communications with national and EU regulatory bodies** in order to ensure that a regulatory framework is in place and to facilitate the implementation of the ¡VAMOS! technology at an EU and national level.
- **Consider the possibility of advertising the mining industry and its benefits** during television and radio broadcast. This same action is done in other countries, such as Australia, with great success. ¡VAMOS! and other innovative and positive technologies could be featured during advertisements.

8 Conclusion

The ¡VAMOS! Project is bringing to the European field an innovative technology that may change the landscape of the raw materials and innovation sectors. As a novel technology, the ¡VAMOS! mining technique needs proper policies that can accommodate the technology in the European market. Such policies either do not exist nowadays and need to be created from scratch or exist, but need to be adapted to a world in constant change.

To support ¡VAMOS! and possibly other technological innovations on the field of raw materials, a set of policy recommendations are made in five general topics, followed by specific recommendations for each of those general topics, that take into account not only the ¡VAMOS! scope but also englobe a more general aspect. These recommendations are build on stakeholders' involvement and current and future state of play analysis, guaranteeing a best approach, and are aimed at European policy makers.

Recommendations are inline with 1) developing a coherent minerals policy and stable regulatory frameworks for the raw materials and innovation sectors, 2) fostering and supporting innovative mining in new frontiers, 3) extending the Research and Innovation scope and funding in the raw materials sector in support for cleaner, more efficient technologies and processes, 4) strengthening innovation in raw materials and support uptake from R&I into the market and 5) raising awareness on new raw materials related technologies and their potential for society, the economy and the environment.

It is suggested that the recommendations made in this report are followed, partly or in their whole, so as to foster a proper European environment for the market uptake of the ¡VAMOS! technology. Together with these, recommendations from EC-funded projects that specifically or partially focus on policy on the raw materials and innovation sectors should also be considered, as together they can contribute for a better European raw materials, innovation and thus industrial landscape.

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¡VAMOS! Deliverable D1.1 (2015): Policy and regulatory background

¡VAMOS! Deliverable D1.2 (2017) Innovation Agenda

¡VAMOS! Deliverable D1.3 (2015): Zero-state environmental and geo-hazard evaluation criteria

¡VAMOS! Deliverable D1.5 (2016) Stakeholder Workshop Reports

¡VAMOS! Deliverable D5.1 (2018): Field Test Planning

¡VAMOS! Deliverable D6.6 (2018): Future Research Roadmap

(¡VAMOS! Deliverable are available for public download from <http://vamos-project.eu/downloads/>)

10 Annex 1

EU policy instruments in place

Minerals policies

- Raw Materials Initiative (RMI)
- European Innovation Partnership on Raw Materials (EIP on Raw Materials) and their Strategic Implementation Plan (SIP)
- European Institute on Innovation and Technology on Raw Materials (EIT Raw Materials)
- Critical Raw Materials identification
- Knowledge and Innovation Community raw materials (KIC Raw Materials)
- European Union Raw Materials Knowledge Base (EURMKB)
- Various National Minerals Policies (not all member states have them)
- Report on National Minerals Policy Indicators, DG Enterprise and Industry

Related policies

- Europe 2020 strategy (2010-2020) and respective flagships (mainly Innovative Union, Resource Efficient Europe and An Industrial Policy for the Globalisation Era)
- Framework programmes for research and technological development (e.g. FP7, HORIZON 2020 and HORIZON EUROPE)
- European Commission's Investment Plan for Europe (Juncker Plan/initiative)
- EU action plan for the Circular Economy
- Raw Materials Information System
- Raw Materials Scoreboard
- Mediterranean Action Plan (MAP)
- Infrastructure for Spatial Information in the European Community (INSPIRE) (Directive 2007/2/EC)
- Decision No 1600/2002/EC Sixth Community Environment Action Programme (6th EAP) (2002- 2010)
- European minerals day

Deep-sea legislation/regulation

- United Nations Convention on "the Law of the Sea" ('UNCLOS')
- International Seabed Authority (ISA) and the Agreement relating to deep seabed mining
- Convention on Biological Diversity (adopted by the United Nations in 1992)
- OSPAR Convention (The Convention for the Protection of the marine Environment of the North-East Atlantic)
- Barcelona Convention (77/585/EEC)
- Noumea Convention (1986)
- Strategic Environmental Assessment Directive (the SEA Directive) (2001/42/EC)
- Marine Strategy Framework Directive (Directive 2008/56/EC)

Environmental policies/legislation

- Environmental Information Directive (Directive 2003/4/EC)
- Waste Framework Directive (2008/98/EC)

- Maritime Spatial Planning Directive (2014/89/EU)
- Marine Strategy Framework Directive
- Birds Directive (Directive 2009/147/EC)
- Habitats Directive (Council Directive 92/43/EEC)

Other relevant Directives, Regulations and Mechanisms

Mining activities and waste from mining industries

- Directive on the management of Waste from the Extractive Industry (2006/21/EC)
- Commission on the Safe operation of mining activities (COM(2000) 664)
- Mining Waste Directive (2006/21/EC)

Machinery, CE-label

- Directive 2006/42/EC on machinery, amending Directive 95/16/EC

Environmental Impact Assessment and Water

- Directive 2014/52/EU on the assessment of the effects of certain public and private projects on the environment, amending Directive 2011/92/EU
- Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration
- Directive 2000/60/EC establishing a framework for Community action in the field of water policy
- Environmental Impact Assessment Directive (2011/92/EU)
- The Strategic Environmental Assessment Directive (2001/42/EC)
- Water Framework Directive (2000/60/EC)
- Directive on Emissions from Non-Road Mobile Machinery (Directive 97/68/EC as amended)
- IPPC Directive (2008/1/EC) and IED (2010/75/EC)
- The Outdoor Machinery Noise Directive 2000/14/EC
- Air Quality Directive (2008/50/EC)
- Environmental Liability Directive (2004/35/EC)
- Noise Directive (2002/49/EC)
- Directive on industrial emissions (integrated pollution prevention and control)
- Directive relating to the assessment and management of environmental noise

Health and Safety

- Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work
- Directive 89/654/EEC on minimum safety and health requirements for the workplace
- Directive 2001/45/EC on minimum safety and health requirements for the use of work equipment by workers at work, amending Directive 89/655/EEC
- Directive 89/656/EEC on minimum health and safety requirements for the use by workers of personal protective equipment at the workplace

- Directive 90/269/EEC on minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers
- Directive 90/270 on minimum safety and health requirements for work with display screen equipment
- COM(2004)0062 final - Communication on the practical implementation of the provisions of the Health and Safety at Work Directives 89/391, 89/654, 89/655, 89/656, 90/269 and 90/270
- Directive 1999/38/EC on the protection of workers from the risks related to exposure to carcinogens at work and extending it to mutagens, amending Directive 90/394/EEC and Directive 97/42/EC
- Directive 90/679/CEE on protection of workers from risks related to exposure to biological agents at work
- Seveso II Directive (96/82/EC)
- Directive 91/383/EEC on improvements in the safety and health at work of workers with a fixed-duration employment relationship or a temporary employment relationship
- Directive 92/104/EEC on minimum requirements for improving the safety and health protection of workers in surface and underground mineral-extracting industries
- Directive 92/85/CEE on improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding
- Directive 94/33/EC on the Protection of Young People at Work
- Directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work
- Directive 2000/54/EC on the protection of workers from risks related to exposure to biological agents at work
- Directive 2013/35/EU on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)
- Council Directive concerning minimum requirements for improving the safety and health protection of workers in the extractive industries
- Council Directive on the minimum requirements for improving the safety and health protection of workers in surface and underground mineral extracting industries
- Directive on the control of major accident hazards involving dangerous substances

Socio-economics

- European Transparency Directive Amending Directive (Directive 2013/50/EU)
- Extractive Industries Transparency Initiative
- EU Strategy for Corporate Social Responsibility
- EU Trade and Investment Strategy “Trade for all”
- European Partnership for Responsible Minerals (EPRM)
- European Bank for Reconstruction and Development (EBRD) Environmental and Social Guidelines for mining, extractive industries and mineral processing
- OECD Due Dilligence Guidance documents
- OECD Base Erosion and Profit Shifting (BEPS)
- Sustainable Development Goals (mainly SDG 1 “No poverty”, SDG 7 “Affordable and Clean Energy”, SDG 8 “Decent work and economic growth”, SDG 9 “Industry, innovation and infrastructure” and SDG 17 “Partnerships for the goals”)
- ¡VAMOS! can contribute to the social acceptance of mining due to its innovative scope: 1 - mining can be done in a submerged open pit without influencing the water table; 2 - blasting noise, fumes and ground vibration or dust nuisance are no longer a constant factor accompanying mining activities; 3 - workers are no longer exposed to the danger from rock blasts, roof collapses and other dangerous events)

- ¡VAMOS! mining activities can contribute to development of local economic landscapes with job creation, public revenues, technology ad knowledge transfer and development of infrastructures

EU projects involving raw materials policies

- STRADE – Strategic Dialogue on Sustainable Raw Materials for Europe (689364)
- MIN-GUIDE – Minerals Policy Guidance for Europe (689527)
- MICA – Mineral Intelligence Capacity Analysis (689648)
- INTRAW – International Cooperation on Raw Materials (642130)
- FORAM – Towards a World Forum on Raw Materials (730127)
- MINATURA 2020 – Developing a concept for a European minerals deposit framework (642139)
- EuroGeoSource – EU Information and Policy Support System for Sustainable Supply of Europe with Energy and Mineral Resources (250532)
- ProSUM – Prospecting Raw Materials in the Urban Mine and Mining Waste (641999)
- VERAM – Vision and Roadmap for European Raw Materials (690388)
- MINLEX – Legal framework for mineral extraction and permitting procedures for exploration and exploitation in the EU
- Blue Nodules - Breakthrough Solutions for the Sustainable Harvesting and Processing of Deep Sea Polymetallic Nodules
- MINLAND – Mineral Resources in Sustainable Land-Use Planning (776679)
- Minventory – EU raw materials statistics on resources and reserves
- Minerals4EU – Minerals Intelligence Network for Europe
- One Geology Europe – Providing geoscience data globally
- Article 173 of the Treaty on the Functioning of the European Union (TFEU)
- Articles 179 to 190 of the TFEU on EU policy on research and technological development (RTD)
- Innovation Union (Flagship)
- The Action Plan for Design-Driven Innovation
- European Design Innovation Initiative
- Social innovation
- Design for innovation
- Demand-side innovation policies
- Public sector innovation
- Workplace innovation
- Innovation Union scoreboard
- Innobarometer
- Innovation Council
- InnovFin – EU Finance for Innovators
- Competitiveness of Enterprises and SMEs (COSME)
- EU Industry days

11 Annex 2

Sustainability Alliance	Political	<ul style="list-style-type: none"> _ Given the emergence of severe environmental problems, the biggest economies have come to a tipping point. A political consensus was reached that a new, distinctly “green” approach was needed. _ Virtually all governments agree to place sustainability above growth and profit. _ Concerted actions by governments and the industry incentivized the shift towards more sustainable approaches to provide and use raw materials
	Economic	<ul style="list-style-type: none"> _ Such change in the raw materials sector was only possible because prices for secondary (recycled) material fell over time. They became more attractive relative to primary extracted material. _ Advanced western economies help to raise the mining standards in developing countries. Efficient and environmentally-friendly trade is the overall goal, including higher levels of transparency, equal access and fair trade. _ Strong independent institutions reduce the risk of raw material black markets. _ The shift towards green technologies generated its own economic growth, as spendings in research and innovation increased to develop green technologies, to fight environmental degradation, climate change etc. _ Mining companies want to benefit from the boom in secondary raw materials _ Green technologies, in turn, require raw materials. Often these raw materials are regarded as critical.
	Society	<ul style="list-style-type: none"> _ An entire generation has grown up to be environmentally aware and has developed a sustainable lifestyle. _ The overall public perception of mining tends to be negative, based on historical disasters. Despite this situation, society understands the need for minerals and mining, and accepts the need for the production of primary minerals. _ Manufactured products now have to carry a label that specifies the origin of the (raw) materials used. Consumers prefer locally-produced products.
	Technology	<ul style="list-style-type: none"> _ Only high-tech and low impact mining is tolerated. Mining at new frontiers is a sensitive issue, tolerated by the public, but under continuous scrutiny by decision makers and environmental organisations. _ New technologies allow for more accurate exploration and new mines are opened, some in rather remote (uninhabited) and/or deep (depth at > 5000 m below surface) locations. _ Efficient processes along the whole raw materials value chain can be observed (e.g. less waste, less energy consumption). _ A bigger portion of innovation efforts is focused around resource efficiency, extended product lifetimes and waste reduction.
	Environment	<ul style="list-style-type: none"> _ Sophisticated environmental monitoring, prevention and mitigation technologies are being deployed. Compliance with the strongest environmental standards is now the biggest share of running costs in mining operations. Mine remediation is given priority. _ Mining in extreme environments have become standard practice, but also a subject to continuous discussion and debate.

Unlimited Trade	Political	<ul style="list-style-type: none"> _ Stakeholders in the raw materials business have learned from the ups and downs in the raw materials industry, which has experienced a number of shocks in the 2000 and 2010s. _ The growth of the BRICS states has been amplified by other fast-growing economies (Mexico, Indonesia etc.), which entered the material-intensive development phase. While economic growth is not steady, the total demand for raw materials increases as the world population grows. _ They foster constructive relationships with countries that possess critical raw materials. Long-term trade agreements secure access to raw materials. Measures have been taken to regulate speculation with raw materials and to increase transparency.
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	Economic	<ul style="list-style-type: none"> _ Advanced economies are able to keep growth rates at 2% due to high levels of consumption. It is a win-win situation for both governments and the mining businesses, as total employment in mining has gone up, too. _ As capital is available, the extraction of raw materials goes on and new mines are opened. Virtually all countries have introduced more efficient regulatory frameworks that support governmental bodies, industry, local communities and other stakeholders to resolve conflicts and to reach a consensus on establishing new mines in shorter periods of time. _ Most countries have established stable tax regimes as part of the agreements between governments and the mining industry. _ Secondary raw materials play an increasingly important role in the provision of raw materials. However, the rate of recycling cannot keep up with the total demand. It has reached a plateau.
	Society	<ul style="list-style-type: none"> _ The mining industry and governments have invested heavily into shaping the public perception of mining. _ People now have a much more positive picture than some decades ago, mainly due to a better understanding of the contribution of mining to sustainable development. _ The absence of significant mining accidents and the implementation of higher environmental standards (e.g. reduction of energy consumption, less pollution) has contributed to increased acceptance. _ Student interest in mining increases. Mining is regarded as a diverse and high-tech industry, requiring advanced skills in geology, engineering and business.
	Technology	<ul style="list-style-type: none"> _ To achieve economies of scope, we observe a growing trend towards horizontal and vertical integration. The big mining companies have absorbed a range of suppliers (and their technologies) to enable what was once called “Mine of the Future”. Most mines are now partly automated to reduce costs. _ Sites that were previously considered sub-economic are now found feasible due to advanced technology. Better technology has led to a dramatic reduction of the (relative) need for energy & water. Technology now allows to mine in remote and off-shore locations at reasonable costs. _ Advanced mining technology spreads increasingly fast across borders as good practices are shared.
	Environment	<ul style="list-style-type: none"> _ Environmentally-friendly mining and extraction of raw materials, with strict environmental policies in the mine closure period that are followed around the globe have been strongly integrated. _ Effective recycling processes have substantially lowered the impact of the wider mining sector on the environment.

National Walls	Political	<ul style="list-style-type: none"> _ Disparities between countries got worse. There is a widespread tendency towards protectionism and trade agreement are breached. _ We repeatedly observe conflicts related to the access to raw materials. International institutions are weak, they barely manage to settle disputes. A wave of „neo-colonialism“ can be observed.
	Economic	<ul style="list-style-type: none"> _ Global trade has stagnated during the 2030ies and 2040ies and there is a general sense of global insecurity. _ For most countries, securing access to all required resources is a challenge. _ As demand for commodities stagnates, governments run national economic development programmes to boost their domestic economies.
	Society	<ul style="list-style-type: none"> _ In protectionist, resource-rich countries, mining has become an important job motor. Even countries that almost abandoned mining, have re-started. However, globally speaking, we’ll see less mining employees than 30 years ago, due to stagnating demand. _ Mining has turned into a somewhat dull industry. Mining companies fall from the top 20 most attractive employers list.
	Technology	<ul style="list-style-type: none"> _ Mining has always been a conservative industry, but with a few exceptions mining practices are basically the same as 40 years ago. Technologies that are readily available are favoured.

		<ul style="list-style-type: none"> _ High-tech mining and low-tech mining co-exists as countries /blocks of countries pursue their own agendas with regards to the domestic production of raw materials. _ Technologies for recycling, reuse & substitution are developed – especially by resource-poor countries, but at a slow pace. Domestic R&D gets a boost.
	Environment	<ul style="list-style-type: none"> _ Environmental permitting procedures for mining are mostly a formality, any investment that meets basic environmental criteria and generates employment is approved very quickly. _ Environmental policies are in place but often ignored.