European Policy Brief

Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE)
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The mining-tech sector in the European Union – A collaborative competitiveness

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STRADE is an EU-funded research project focusing on the development of dialogue-based, innovative policy recommendations for a European strategy on future raw materials supplies. In a series of policy briefs and reports, the project will offer critical analysis and recommendations on EU raw materials policy.

This policy brief is part of a series of research articles and reports to be produced under STRADE. This brief discusses the leading role that European equipment suppliers and service providers, collectively the mining-tech sector, play in the global mining sector. The brief highlights the collaboration between European mining companies and the technology suppliers as the key to maintain this lead.

1. Introduction

Given the importance of European mining during previous centuries, the mining-tech industry has a long history in Europe. Many of the leading equipment companies were set up in the late 19th and early 20th centuries. Although mining production in Europe has declined, particularly during the past 30 years[1], the mining-tech companies are still important. Their importance, on the global level, is much greater than the European share of global mining would indicate. In particular, in under-ground mining technology, the dominance of European companies is significant[2] [3].

Historically, the mining industry inspired the development of new equipment, supply of consumables such as explosives and ropes for hoists, etc. Finding cost-efficient solutions to technical problems encountered during mining and smelting operations was an important driver of the development of modern chemistry from the late 17th to early and mid-19th centuries. The first mining universities were set up in the early 1800s and technical development was gradually based on more solid scientific grounds and research.

So far technical development within the mining equipment and service providers has been progressing at a speed sufficient to offset declining ore grades, more exacting environmental demands and increasing cost levels. European mining-tech companies have been an important part of this process. The need for research and development (R&D) within the global mining sector is still important, given the challenges it faces: continued increase in demand for virgin minerals, need to mitigate environmental impacts and reduce carbon emissions, addressing wider societal acceptance for the necessity of the mining sector.

A company, whether in mining or in mining-tech, presenting a new solution to the challenges facing the mining industry will become a market leader within this otherwise mature sector. This is an area where European technology and equipment providers have a global advantage.

The European mining-tech sector has evolved within the specific conditions and regulations of Europe. European based mining operations can face higher input costs[4], relative to their peers, therefor technology developments in Europe have been fundamental in securing competitive overall costs.

This policy brief will discuss the vital role of the Mining-Tech sector within the European Union (EU) mining industry. It highlights the point that, while the European mining and exploration sector has shrunk, the growth of European mining-tech companies has led them to become global leaders in developing new technologies.

[1] See STRADE Report on 'EU The Competitiveness of the European Union's Mining Sector' (*forthcoming*)
[2] Pentti Norras, Magnus Ericsson, Evolution of Mining Clusters in Sweden and Finland, World Mines Ministries Forum, Toronto 3rd March 2006.
[3] UNCTAD, World Investment Report 2007, p113, New York and Geneva 2007.
[4] See STRADE Policy Brief (08/2016); 'On the Cost Competitiveness of Mining Operations in the EU'

Efforts to support the mining sector firms, by the EU and Member States are discussed in STRADE Policy Brief 06/2017.

The policy brief examines a wide range of subsectors of the mining-tech industry: equipment, services, consultants, consumables are some. We use the terms mining-tech industry or mining-tech sector to cover all these subsectors.

This research has been compiled as a desktop study drawing on company reports, conference proceedings, international mining press, industry literature, and various EU project publications. Interviews have been conducted with representatives from government, industry and NGOs drawn from the network of Georange[5]. The examples of new and potentially important technologies are far from conclusive and only represent a sample of current development directions.

This brief starts with a profile of the mining-tech sector in Europe, followed by a presentation of the global market size of this sector. This is followed by a discussion of technology areas that are at the leading edge in the mining sector. Finally, the brief concludes with a discussion, and a few conclusions are drawn.

2. Mining technology sector profile

There are currently several thousands of companies within the EU which belong to the mining-tech sector. More than 2 500 companies are listed within the subsector mining suppliers in Europe (excluding the CIS)[6], the bulk of which are listed as located in the EU28. These firms range from large companies with multiple sector operations (from construction equipment to mining), while others are small-scale, often niche market, operators.

Among the major companies are FLSmidth (Denmark), Metso and Outotec (Finland), Michelin (France), Liebherr and Siemens (Germany), Atlas Copco and Sandvik (Sweden) ABB (Switzerland) and Weir (UK). These firms and their subsidiaries engage in production and sales and services (after-sales) catering for the entire global market. For example, Weir operates in more than 70 countries; Sandvik has employees and representation in more than 130 countries. The mining applications of such large companies form only a small part of their total business.

The major companies have mining as one of their divisions, which also deals with other sectors such as the construction sector (road construction for example), tunnelling and other infrastructural projects which include drilling, blasting and rock work. This makes it more difficult to estimate the mining part of the total sales of these companies. The market shares calculated in Table 1 are only indications of the size of these companies.

Other mining-tech sector companies are medium to small size niche companies. Some of these companies are established globally albeit in a smaller market segment such as Dywidag (bolts and other rock securing supplies), Magotteaux (grinding media), BASF (ground control chemicals), Alvenius (piping solutions), Wassara (hydraulic drills) etc.

Yet another group of companies are new start-ups with a base in Europe like Mobilaris (positioning systems) and Oryx (training simulators). There are many others applying new IT technologies to the mining sector. While still others tend to cater to local (within a country or in Europe) markets or sell their services or products to larger Original Equipment Manufacturers (OEMs) or engineering companies who assemble or use the products within their larger product/ project. Tammet (safety netting) is such a company.

Some Europe based companies are no longer controlled by European interests but have been taken over by competitors from other parts of the world. For example, Flygt pumps,

Table 1: Major mining-tech company revenues and market shares, 2016

	Sandvik	Atlas Copco	Weir	Michelin
Group performance				
Revenues (EUR million)	8 469	10 525	2 196	20 907
Share of mining	38%	36%	60%	14%
				Mining segment
Company estimated value of total market (EUR million)	27 518	na	7 500	16 000
Company revenues (EUR million)	3 219	3 825	1 324	2 836
Global market share	12%	na	18%	18%

Source: Company annual reports

[5] GEORANGE is a non-profit organization whose main task is to expand the concept of "development" in the mining and minerals industry.

[6] http://www.infomine.com/suppliers/buyersguide/r8/europe.aspx

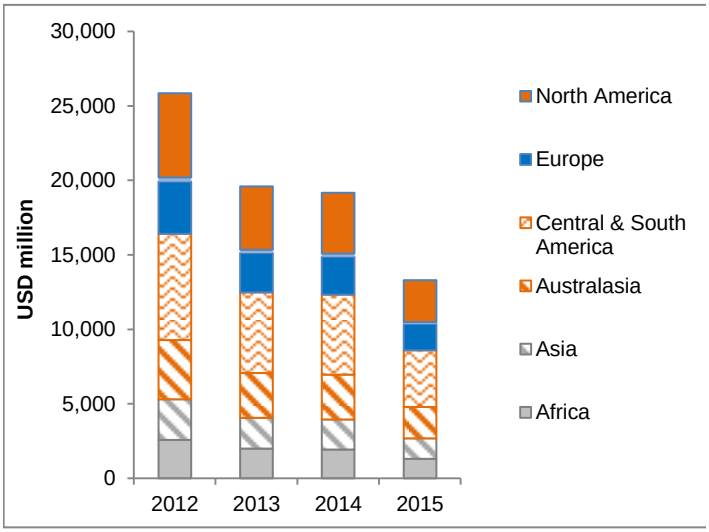
which are part of the US based Xylem (ITT Technologies) and Nitro Nobel, are now mainly part of the Australian based global explosives supplier Orica.

It is difficult to assess the size of the mining-tech industry of Europe as these companies cover several industry sectors and there are no easily available statistical figures to relate to. Suffice to say that the leading companies mentioned above have multi-billion Euro revenues.

3. The market for mining equipment

The size of the global market for the mining-tech sector can be indicated by the investments in the larger mining sector. Investments in the global mining industry have been reduced by roughly 50% since their peak in 2012 and were estimated at USD 13 303 million in 2015 (see Figure 1).

Figure 1: Global Mining Industry Capex excluding China, 2012-2015 (USD million)



Source: SNL Financial (2015)

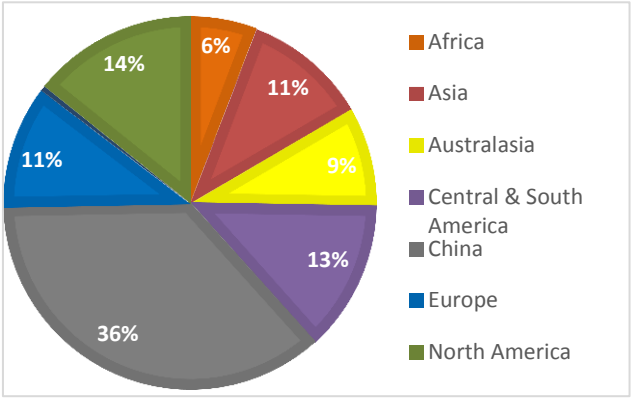
During the mining "super cycle" (2003-2011) the mining industry, including downstream smelters and refineries, grew rapidly. This growth also included the mining-tech industry as sales in all regions increased. For example, Outotec revenues grew 190% in the 2005-2016 period, the mining segment of Atlas Copco saw revenues increase by 354% over the same period.

With the stabilization of prices and the general upturn in the mining industry during 2016 and 2017[7], the mining equipment industry is projecting increased sales and a general improvement of the business climate[8]. For example Weir, between 2015 and 2016, increased their sales by 2%[9] and Siemens by 3%[10].

Regional markets

The market for mining equipment and services is proportional to the physical flows in the mines, or in other words to the production of ore and barren rock[11]. Global ore and rock production in the mid-2010's was some 60 000 million tonnes[12]. With continued economic growth, particularly in the developing world, demand for all minerals is expected to increase. In 2015 only 11% of global ore was produced in Europe, including the CIS. China, mainly because of its large coal production, is the largest market as it produces the most ore (see Figure 2). Thus, the main markets of the EU mining-tech industry have already moved outside Europe.

Figure 2: Ore production including coal, 2015



Source: British Geological Survey, US Geological Survey, Georange

The major mining-tech companies sell their products globally. Theoretically, the European Original Equipment Manufacturers (OEM) market shares by region should mimic the ore production (Figure 2). The Atlas Copco Group, for example, have seen their regional sales shift. The importance of Europe and North America has

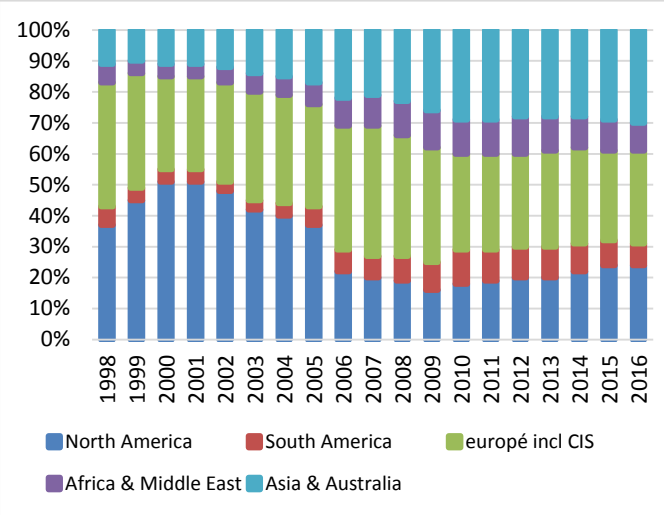
[7] Magnus Ericsson, Anton Löf, Olof Löf, Global Metal Market – Is There a Light at the End of the Tunnel?, World of Mining No.1, 2017
[8] Atlas Copco First-quarter Report, 2017
[9] The Weir Group Annual Report, 2016
[10] Siemens Annual Report, 2016
[11] Barren rock lack the economic potential to become ore i.e. there is not enough metals/minerals to mine it with profit, also known as waste rock.
[12] Minerals4EU Foresight Study- Mining Technology, 2014

declined as a share of total sales, while business with Asia & Australia, South America and Africa & Middle East has increased (see Figure 3).

A few conclusions can be drawn from these overviews of the global mining-tech sector:

- The EU market is small but when including Russia and other East European countries the European market is not negligible.
- Central and South America are dominating investments in recent years while the region's share of total volumes of ore produced is smaller. This is due to the fact that Chinese ore production is less capital intensive and often Chinese mines are considerably smaller and less productive than in other parts of the world.
- The gradual modernization and increased productivity of Chinese production will become an important part of the global mining-tech market in the near future. Whether this is also a suitable market for the European mining-tech companies is another issue. For the time being the Latin American continent will remain a motor of global mine production and hence mining-tech markets.
- Africa remains a relatively under-explored and under-exploited region with interesting geological potential and hence a region which should be of prime long-term interest to European mining-tech companies.

Figure 3: Atlas Copco Group sales by region, 1998-2016



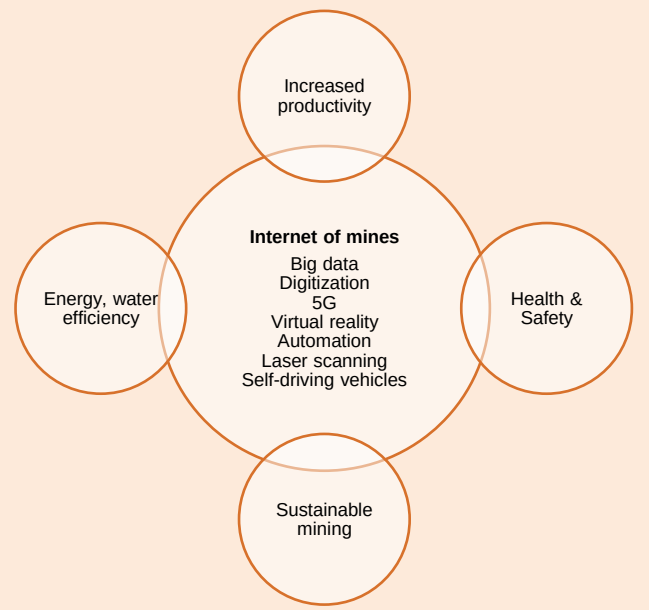
Source: Atlas Copco annual reports 1998-2016

4. Technology areas

The policy brief now turns to the emerging trends in the technology development within the mining sector. The trends can be divided into four main categories of factors influencing and driving mining technology development:[13]

- Increased productivity, and cutting production costs
- Energy/water efficiency, reducing energy and water usage
- Sustainable mining, limit environmental impact and reduce footprint both ecologically and socially while taking greater socioeconomic development responsibilities
- Health & safety, reduce accidents and improve the health and safety situation for miners and neighbours including a more gender neutral work atmosphere.

Figure 4: Schematic overview of trends and drivers



The overriding trend, linking all these factors together can be described as the 'Internet of Mines'. Through digitalization, companies are trying to: remote operate machines, connect machines with other machines, make machines self-diagnosing, monitor employees in the mines etc. These efforts increase the effectivity in the mine and/or the processing plant, logistics, as well as increase safety measures and make the processes more sustainable. Figure 4 shows the interconnections between the emerging mining challenges and the role the Internet of Mines plays.

[13] Minerals4EU Foresight Study- Mining Technology, 2014

Digital technologies increasingly find application not only in mine operations but also other areas such as logistics, exploration and acquisitions[14]. The new digital technologies most widely applied include: Robotics, drones, remote operation centres, artificial intelligence and cybersecurity.

We present some of the emerging technology advancements in the sector.

Sensors and laser scanners

The development of cheap sensors and laser scanners has been one of the most important devices developed within the Internet of Mines, with far reaching applications. These devices can typically read the percentage of metals in ores and products, the size of grains etc, in real time, thus enabling the operators to manage the processes much more efficiently. This adds to the cost efficiency of mining operations.

Stemming from sensor technology, Mobilaris has developed a real-time positioning system for employees and equipment in mines. The system is in operation in several mines and allows the mine operator to avoid bottlenecks in underground traffic, increase effectiveness as downtime from searching for tools or people can be minimized. This also contributes to health and safety, as in case of an emergency evacuation of the mine, the location of employees in danger is known. This allows rescue teams to save valuable time and reach miners quickly.

For scanning systems to work efficiently, the mapping of the mine needs to be very detailed. Volvo trucks, for example, have been equipped with laser scanners in some of Boliden's (Sweden) underground mines. With the advancement in digitization technology, they can scan the mine as they drive through the complex. With the 3D models created a new level of control can be gained, which contributes to cost efficient production. The continuous scanning of the mines can also detect movements in the rock, which are monitored and increase the safety of the personnel underground. Another example of technology is the use of drones, which have been deployed successfully in both open-pit and underground mines.

Sensors are also key to a successful development of self-driving vehicles and the automation of processes. In September 2016, Volvo undertook the first tests of its fully autonomous truck in Boliden's Kristineberg underground mine. This was developed as 'concept' truck and is still under research and development. However, Boliden is already using this for commercial operations. The truck is designed to drive down to the loading area (where the ore is extracted) and transport its load up to the crushing machine. The goal is to enable the self-driving truck to leave the mine and drive to crushing sites above ground. Ultimately, the truck should be able drive on public roads and become part of the logistical fleet of the company.

A bottle neck in the development of the Internet of Mines has been the ability to transfer and use large amounts of data i.e. Big Data. In fact many of the new products developed by the European mining-tech industry is dependent on fast and reliant transfer of data without which it won't function. Hence many projects currently aim to increase the effectiveness of data transfer, storage and usage with Wi-Fi and 5G in mines. The industry collaboration program PIMM (Pilot for Industrial Mobile communication in Mining) is a good example. Ericsson, ABB, SISC Swedish ICT, Volvo CE and Boliden, with partial sponsorship from VINNOVA (the Swedish innovation authority), participate. The aim is to install 5G technique in the Boliden mine Kankberg.

Increasing energy efficiency

ABB has developed a technique of ventilating only necessary areas in an underground mine (where employees are present). The result is a 50% reduction in energy consumption for ventilation. The technology has also made possible the remote operation of many processes, which has resulted in decreased work related injuries, as the physical presence of employees in the mine is reduced. This has led to increased efficiency as expert teams do not need to go to the site but can manage several operations from a central location.

Energy efficiency gains have also been made in the refining of processes such as increased usage of continuous mining and electrification of vehicles. There are basically two types of electrical vehicles, those that use a battery and those who are connected directly into the power grid. All major suppliers of trucks for the mining industry offer both types of vehicles.

The electric loader and hauler do present certain advantages to the mining industry, especially when it comes to underground mines where, for example, exhaust fumes can be lowered dramatically. Atlas Copco and Sandvik have been at the forefront in developing these technologies. In Canada, for example, legal obligations have required some mines to rely entirely on electric vehicles, provided to a large extent by Atlas Copco. Siemens has worked on Rail Electrification, where trucks and trolleys can connect to power cables in the air, much like trains do. There are several mines that uses this technique at present in Africa, North America and Asia. Lately Siemens has, together with Scania and trafikverket in Sweden, built an electrified

[14] Digital in Mining: Progress and Opportunity, 2017

road for field trials. The trials commenced in mid-2016 and is planned to go on for 2 years before a final evaluation. Similar trials are happening in the USA in cooperation with Volvo and in Germany.

Virtual reality

Another interesting new technology is virtual reality which has become a tool widely used in training of machine operators. An example of this is Oryx Simulations, a Swedish company and world leader in simulator systems for heavy-vehicle applications. The company design, develop and produce simulations for companies within but not limited to the mining industry. With the help of advanced simulators, operators can learn to handle machines in a more productive, environmentally-friendly and safe manner. Another company that uses the virtual reality within the mining industry is the Swedish company Innan AB that provides fire safety education.

Mobile labs

A trend that should have a positive impact on the mining industry is mobile labs. These container labs will enable companies to be much more efficient in the field. For example, exploration teams on the ground can modify drill plans much more efficiently with the feed-back from the lab at site rather than having to wait for core samples to be sent to labs and data to be sent back. Minalyzer CS has for example, constructed a geolytical core scanner that, through various techniques, can scan a drill core and analyse it onsite without having to use a laboratory.

5. Operations and technology collaboration

Many of these examples of new techniques or approaches to current operation challenges are made possible by collaborations between a mining company and one or more mining-tech companies. It is true that the long mining history in Europe has created a demand for effective equipment and supplies and a scientific base capacity (at mining universities and colleges). These institutions developed in response to problems encountered in the mines, making the long-term growth of the European mining-tech sector possible. All interview respondents for this policy brief agreed that the dialogue and cooperation between the few remaining mines and the mining-tech sector is the main factor behind the sector's continuing global successes.

Without the existence of a small, but highly competitive, European mining sector, the mining-tech companies would not be able to retain their leading position. It is a mutually beneficial, virtuous circle: without the technical solutions which mining-tech companies provide, most mines would not be competitive. Without these demanding and knowledgeable 'domestic' customers the mining-tech companies would not be able to fully understand the miner's pressing problems. Certainly, many of the mining-tech companies are global companies but having a European mining industry base is still important; it is valuable and necessary to maintain their long-term competitiveness. To support the mining-tech sector it is necessary to maintain a thriving mining industry in Europe. Otherwise the European mining-tech industry runs the real risk of gradually losing its leading position. The mining-tech industry may be forced to move to other regions where it can be close to its customers.

Further of note from the interviews is, that indirectly, society's increasing demand for less environmentally damaging mines, as well as the trade unions' efforts for safer working environments have in the long term contributed to the successes of the mining-tech sector and the survival of the European mines. These increasing demands have forced both these sectors to take necessary steps, ahead of most of their global competitors, and in the long run given a competitive advantage. These have included more efficient extraction processes, effective monitoring of onsite operations and personnel, as well investing in energy efficient machines and processes.

Research and development is certainly a corner stone of the cooperation that exists between mining companies and the mining-tech firms. The cooperation seems to work best when the three parties, the mining companies, the equipment manufacturers and government authorities share values and believe in the virtues of metals and mining to the good of the entire society. The potential success of this cooperation is further dependent on the participants sharing their knowledge and willingness to draw on their respective experience to make sure that the end result is optimal in relation to given circumstances and limits[15]. This should not be confused with giving away research, but within a specific development project all participants within the project benefit from an openness between the companies involved. Hence, companies that are competitors will rarely be found within the same project, as they will endeavour to safeguard their trade secrets. As the examples in the previous section illustrated, in most cases one mining company will work with a mining-tech company to develop technology to suit its needs. Once the solution becomes viable and

[15] EU and member state support for the mining sector is discussed in STRADE Policy Brief 06/2017

tested, it is likely to be picked up by other mining companies, and mining-tech competitors may build similar products for sale.

The cluster can be greatly supported by cross-sectorial approaches. For example: the mining sector can learn from the interactive entertainment industry (video/computer game industry). The latest virtual reality technologies, video/computer games and the visualisation technologies can improve profitability, environmental performance and reduce health and safety risks in mining.

A recent workshop in Skellefteå (northern Sweden) revealed that the distance between the two industries is not as wide as one might think. A mutually productive cross fertilization of ideas and solutions can be considered. In fact, the Swedish Geological Survey (SGU) already uses the interactive industry: through the computer game 'Minecraft'[16], SGU built a version that teaches players (including children) about geology. This aids SGU to reach one of its stated goals, to teach society about geology.

One emerging threat to European mining, highlighted by an interview, is the increasing importance of proprietary technologies in mining. The largest global mining companies are developing their own technologies and increasing their internal R&D expenditures. If Anglo American, BHP Billiton, Rio Tinto and other global transnational mining companies develop their own technologies, this will challenge the traditional relationship between mining companies and equipment/service providers. One indication of this trend is the increase in cases where major mining companies requesting exclusive joint cooperation agreements with leading suppliers. The agreements tend to limit the access for other mining companies to techniques developed under the joint agreements.

6. Conclusion

The European mining-tech sector has been able to become a leading global industry because of the interaction between the mines and the mining-tech sector. To continue as a vital industry in the forefront, the European mining-tech sector needs to continue its R&D efforts.

The present push for and strong support of joint industry/ academia R&D activities by the European Commission is also important to maintain the leadership of the European mining-tech sector. This is discussed in more detail in STRADE Policy Brief 06/2017. It is less well understood that the existence of a European mining industry is fundamental not only to the future metal and mineral supply security of Europe but also to the continuing success of the mining-tech industry.

The mining cluster, including mines, mining-tech companies, local society and academia, can thrive best when considered as an integrated whole – without any one of the nodes in the cluster getting weaker. There is a need to present the cluster internationally and present a unified front to the rest of the world. Other leading mining-tech nations, such as Australia, Canada and emerging China, are already actively promoting their mining-tech clusters at conferences and industry fairs around the world.

The European mining-tech sector can play an important role globally in the environment and health & safety areas. Technologies developed in Europe in response to stricter regulations locally can be exported and used as regulations become tighter globally, giving the European mining-tech companies a competitive advantage.

While there are many national industry associations, there are only limited links and co-operation across borders between different countries. This is an area where the EU could play an active role and promote international co-operation between the major mining-tech exporters in various European countries.

[16] BetterGeo – Minecraft with more geology, http://www.sgu.se/en/geology-of-sweden/bettergeo-minecraft-with-more-geology/

Project Background

The Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE) addresses the long-term security and sustainability of the European raw material supply from European and non-European countries.

Using a dialogue-based approach in a seven-member consortium, the project brings together governments, industry and civil society to deliver policy recommendations for an innovative European strategy on future EU mineral raw-material supplies.

The project holds environmental and social sustainability as its foundation in its approach to augmenting the security of the European Union mineral raw-material supply and enhancing competitiveness of the EU mining industry.

Over a three year period (2016-2018), STRADE shall bring together research, practical experience, legislation, best practice technologies and know-how in the following areas:

1. A European cooperation strategy with resource-rich countries
2. Internationally sustainable raw-material production & supply
3. Strengthening the European raw-materials sector

Project Identity

Project Name	Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE)
Coordinator	Oeko-Institut; Doris Schueler, Project Coordinator, d.schueler@oeko.de
Consortium	OEKO-INSTITUT E.V. – INSTITUT FUER ANGEWANDTE OEKOLOGIE Merzhauser Strasse 173, Freiburg 79100, Germany
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