STRADE

European Policy Brief

Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE)
No. 08 / 2016

The Cost Competitiveness of Mining Operations in the European Union

7th November, 2016
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Funded by the Horizon 2020 Programme of the European Union

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 reviews the cost competitiveness of major mines operating in the 28 EU Member States based on individual cost factors as well as in comparison to other countries producing similar minerals.

1 Introduction

The second pillar in the European Union's Raw Materials Initiative (RMI) focuses on fostering a 'sustainable supply of raw materials within the EU'. The STRADE project examines possible engagements to boost investments into the mining sector in the region. As a first step in this analysis, this policy brief reviews the cost competitiveness of mines that are currently operating in the region. The research team acknowledges that individual Member State (MS) resource endowments, legal and regulatory structures and regional social and environmental policies impact the level of mining investments. These endowments, structures and policies will be examined in more detail in later reports.

This paper focuses on the economic fundamentals of mineral operations and analyses whether, on a cost basis, EU28-based mines are competitive with other global producers. Operating costs of copper, nickel, lead, zinc, gold and iron ore mines, operational in MS in 2015 are examined. The average operating costs of mines within the EU28 are compared to average operating costs of mines within other countries in order to assess their competitiveness. This is achieved through presenting the placement of EU-based mining operations on a global cost curve, followed by an assessment of individual cost components of operating costs. This paper is limited to comparing regional operating costs, as these are the most significant factor in evaluating the economic feasibility of a mining operation and allow for meaningful comparisons across regions. However, it should be noted that there are other factors to consider when evaluating the economic viability of any mining operation, such as by-product revenues discussed in a later STRADE project report, capital expenditure requirements and other costs not directly related to on-site operations.

The paper first provides the methodology and definitions for the cost competitiveness analysis before presenting the findings.

1.1 Mining in the EU28

Total mined production from EU28-based mines is comparatively small in relation to other mining regions of the world (Table 1). EU28-mined production of copper, lead and zinc accounts for 4.6%, 4.3% and 5.1% of global production respectively, a more significant share than for nickel, gold and iron ore (ranging between 0.9% and 1.6%). While total production figures for the EU appear

Table 1: Global and EU28 Mined Production* (2015)**

	Copper (Kt)	Nickel (Kt)	Lead (Kt)	Zinc (Kt)	Gold (Koz)	Iron Ore (Mt)
Global Production	19,002	2,094	4,980	13,425	96,992	2,106
EU 28	875	34	214	691	917	27
% of Global	4.6%	1.6%	4.3%	5.1%	0.9%	1.3%

* Mined production indicates metal contained in products produced at the mine site which are then either sold to customers or sent to third parties for further processing into finished metals

** data includes estimated production

Source: SNL Metals & Mining

small, there are multiple globally significant mines located within MS, for example KGHM's copper operations in Poland and LKAB's iron ore operations in Sweden.

1.2 Mining Costs Methodology

To assess the competitiveness of EU28 mining operations, this paper considers the mining costs for each metal within the region and compares them with other countries. The analysis is based on SNL's Mine Economics dataset, which covers granular cost estimates of almost 600 mines spread across the globe. The dataset is constructed by using a detailed bottom up modelling approach; looking at each individual mining operation's flow sheet, equipment and geographic location, the model calibrates modelled costs to reported cost information.

Costs are presented in US dollars per unit of paid metal produced; paid metal is the amount of metal within the intermediary product produced that the mining company receives revenue for from the end customer after losses of metal during the smelting/refining stage. Representing costs on this basis allows for a fairer comparison of costs per finished product across projects.

Table 2 shows the EU28 metal production covered by SNL Mine Economics cost estimations. The missing production is accounted for by small and privately held companies which do not report enough information to estimate reliable costs for their operations[1].

Table 2: EU 28 production coverage for cost competitive analysis

Coverage	Copper (Kt)	Nickel (Kt)	Lead (Kt)	Zinc (Kt)	Gold (Koz)	Iron Ore (Mt)
Total mines (number)	134	43	N/A	46	119	31
EU28 Mines (number)	7	3	N/A	7	7	2
EU28 production covered (%)	91%	100%	73%	90%	91%	88%

* Total number of iron ore mines is specific to pellet producers.

Source: SNL Metals & Mining

The same principle applies to the other countries used in this study; the cost data does not cover all mines, but a significantly high proportion of them to allow for meaningful comparison of EU28 mining operations to mining operations in other countries.

1.3 Measuring cost competitiveness

Cost competitiveness can be measured on two fronts. The first looks at the individual variables included in constructing a cost curve for the country and includes labour, energy, reagents, other onsite, TCRC & shipment (offsite in the case of iron ore) and royalty & production taxes. The second compares the placement of EU28 mines along a global cost curve.

Labour: These cover total employee costs (salaries and benefits) for all employees (direct and contractors) at the mining and processing operation. These costs do not include people employed in transport and further processing once the intermediary product leaves the mine site.

Energy: These relate to the cost of electricity and fuel used in mining and processing ore to produce the intermediary product at the mine site.

Reagents: These represent the cost of chemicals used in the processing of the ore to intermediary products at the mine site. This covers a wide range of chemicals such as cyanide used in gold processing, acid used in copper leaching and various chemicals used in the froth flotation process.

Other Onsite: The other onsite cost category represents any other cost on the mine site not covered in labour, energy or reagents. This can include, but is not limited to, explosives, spare parts, mine camp supplies and other on-site services.

TCRC & Shipment: TCRC & Shipment costs apply for all minerals in this study. For iron ore, since there are no associated treatment costs, this category is referred to as Offsite costs (iron ore). This category covers the cost of transport of the product produced at the mine to either the end customer or to the processing facility (usually smelter/refinery) that will turn the mined product into finished metal (treatment charges or TC) as well as the charge which these facilities will bill the mine for undertaking this service(refining charges or RC). It is important to note here that there are several mining operations within the EU28, such as KGHM and Boliden, which are integrated with smelters and refineries operated by the same company which operates the mine itself. In these cases treatment and refining charges are reflective of the costs of operating these facilities.

[1] Lead coverage for the EU is markedly lower than other commodities covered in this study. This is due to Boleslaw lead mine in Poland which is estimated to have produced around 60kt of lead in 2015 but does not publish sufficient information to reliably estimate costs.

Royalty & Production Taxes: Royalty & Production taxes include state, company and private landowner royalties and taxes related to production on a per unit or net smelter value basis. It excludes corporate income tax.

These cash costs are presented per metal in the following chapter.

2 Placing EU28 on the global cost curve

In the graphs shown below, the horizontal axis represents the cumulative metal production for mines included in the study while the vertical axis shows the total cash cost to produce one unit of metal, meaning the width of the bars indicate the production of the region/country while the height shows the cost. The total cash cost is the total onsite and offsite cash operating cost of the mine. The further to the right a country/region is located on the horizontal axis, the higher its mine costs per unit of metal.

Copper, nickel and zinc costs are shown in c/lb, gold in $/oz (Troy ounce) and iron ore in $/dry metric tonne (DMT), the conventional metrics for representing costs for these commodities within the mining industry. Production of copper, nickel and zinc are shown in thousand tonnes (kt), gold in thousand ounces (Koz) and iron ore in millions of dry metric tonnes (Mdmt), again, the conventional metrics for reporting on these commodities.

The following section provides an overview of EU28 mines across the global cost and production curve and is followed by a more detailed discussion of individual cost factors in the next section.

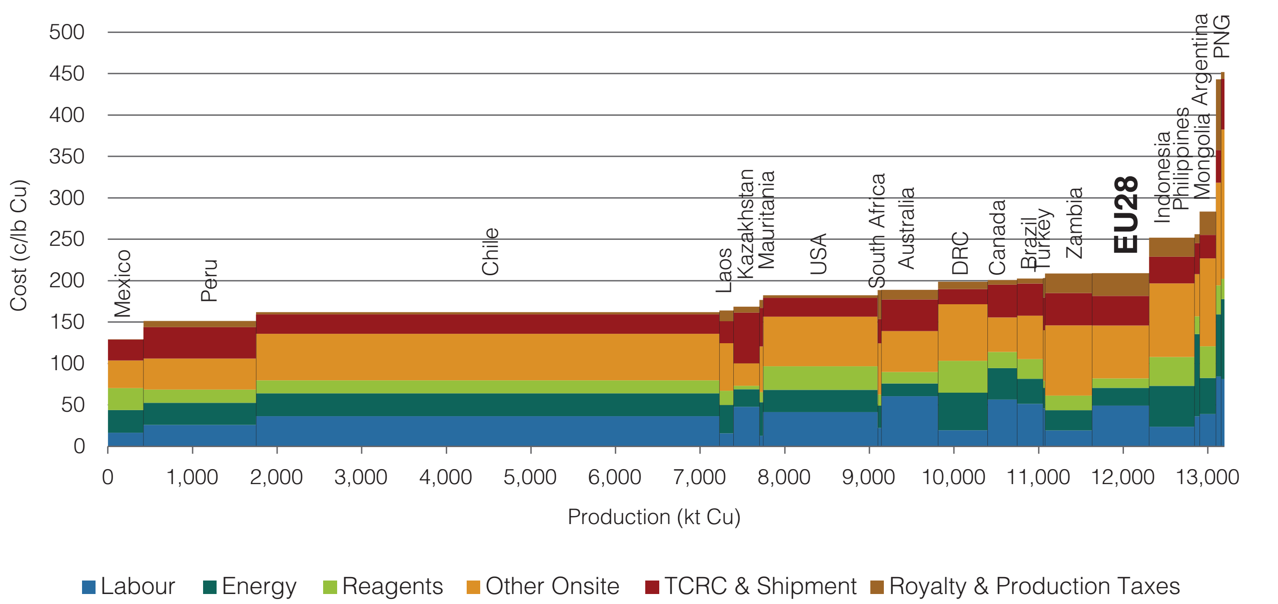
2.1 Copper

The EU produces copper from mines in Bulgaria, Cyprus, Finland, Poland, Portugal, Romania, Spain and Sweden. Of note is KGHM's Polish operations, which accounted for nearly 50% of copper production from the EU28 in 2015 and is one of the biggest copper mining complexes in the world. This complex is also the biggest silver producer in the world, mined as a by-product of copper production.

Figure 1 illustrates the operating costs for copper mines in the EU28 and other regions. In terms of costs per unit, Mexico is the most efficient producer, while Papua New Guinea (PNG) is the highest cost producer. The EU28 are located in the upper quartile of the chart and have costs similar to those of Brazil, Canada and Zambia.

In terms of individual costs, the EU28 indicates higher 'royalty and production taxes' costs in comparison to countries with similar total mine costs (Canada, Brazil and Zambia). EU28 labour costs are similar to those in Canada and Brazil, while its costs associated with 'reagents' are lower.

Figure 1: Costs and production from primary copper mines in 2015



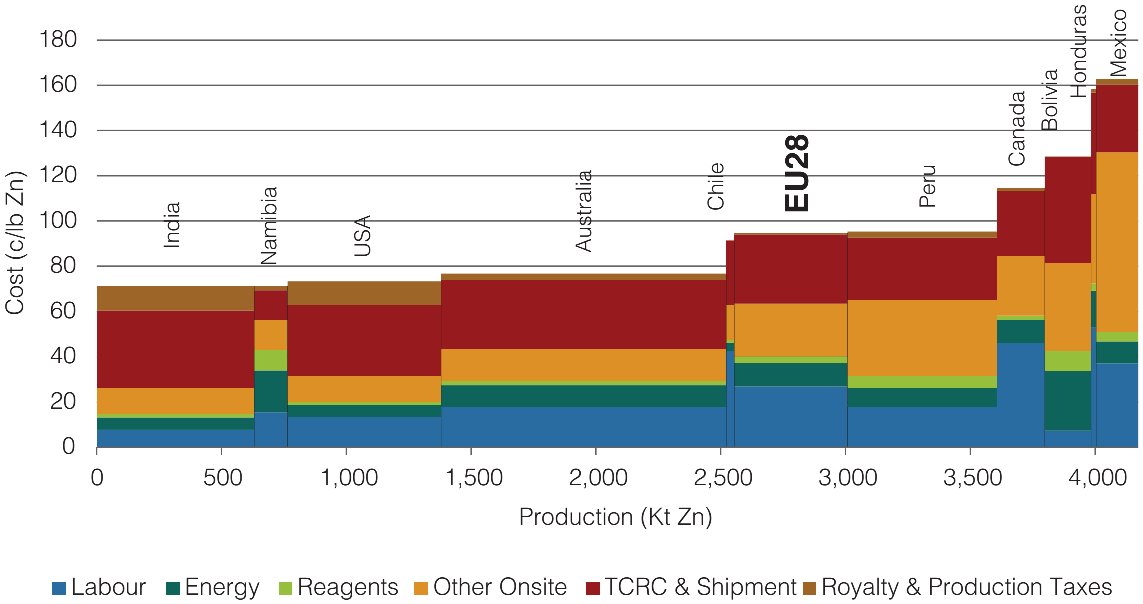
Source: SNL Metals & Mining

2.2 Lead & Zinc

Lead and zinc are usually extracted from the same mineral deposit and are therefore considered together. Within the EU28, mined production in 2015 came from Bulgaria, Finland, Greece, Ireland, Poland, Portugal, Spain and Sweden. Sweden and Ireland are the largest contributors, accounting for approximately 50% of lead and 70% of zinc EU28 production in 2015. Figure 2 illustrates the costs associated with lead and zinc production.

The EU28, located towards the right side of the horizontal axis, have higher per-unit mine costs than Australia and Chile, similar costs to Peru and lower costs than Canada. In terms of individual cost components, the EU28 exhibit higher labour costs than Australia, Chile and Peru, and higher 'other onsite' costs than Australia and Chile, although these are lower than Peru. Royalty and production taxes are not reported as significant for zinc and lead production within the EU28.

Figure 2: Costs and production from primary zinc mines in 2015



Source: SNL Metals & Mining

2.3 Nickel

The 2015 nickel production in the EU28 was limited to Finland, Greece and Spain and will be lower in 2016 with the closure of Spain's only nickel mine, Aguablanca, in early 2016.

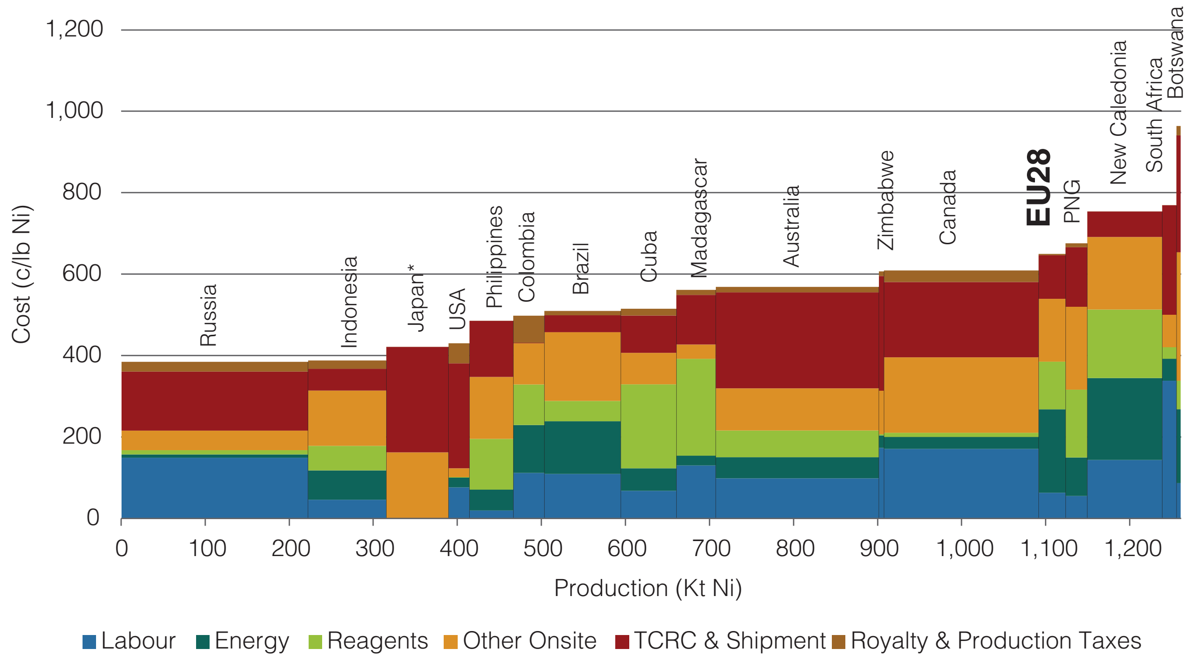
As with other metals, EU28 mines are placed towards the right end of the horizontal axis (Figure 3). The region is slightly more expensive than Canada (which is a major nickel producer) but less than New Caledonia (another major nickel producer). In terms of cost components, energy costs are relatively high for the EU28 mines, while labour costs are lower.

Labour costs for nickel in the EU are also lower than labour costs for other minerals produced in the same region because the largest share of EU28 nickel production comes from the Larco nickel operations in Greece. These operations exploit nickel laterite deposits, which are very easy to extract and therefore require relatively few people compared to other nickel deposits with the majority of the costs of the operations coming from energy and chemical usage at the processing stage.

However, Larco also accounts for the high energy costs for EU28 production of nickel. The processing of the laterite ore mined at these operations is energy intensive; large amounts of electricity are consumed in the processing stage leading to high energy costs. Energy costs are a result of both the high consumption and price of electricity and fuel at an operation.

Again, royalty and production taxes are not reported as significant for nickel production within the EU28.

Figure 3: Costs and production from primary nickel mines in 2015*



* Japan costs relate to nickel smelters that purchase raw ore from nickel mines, with 'other onsite' as the cost of purchasing nickel ore and 'TCRC & Shipment' being the cost of smelting ore to finished product.

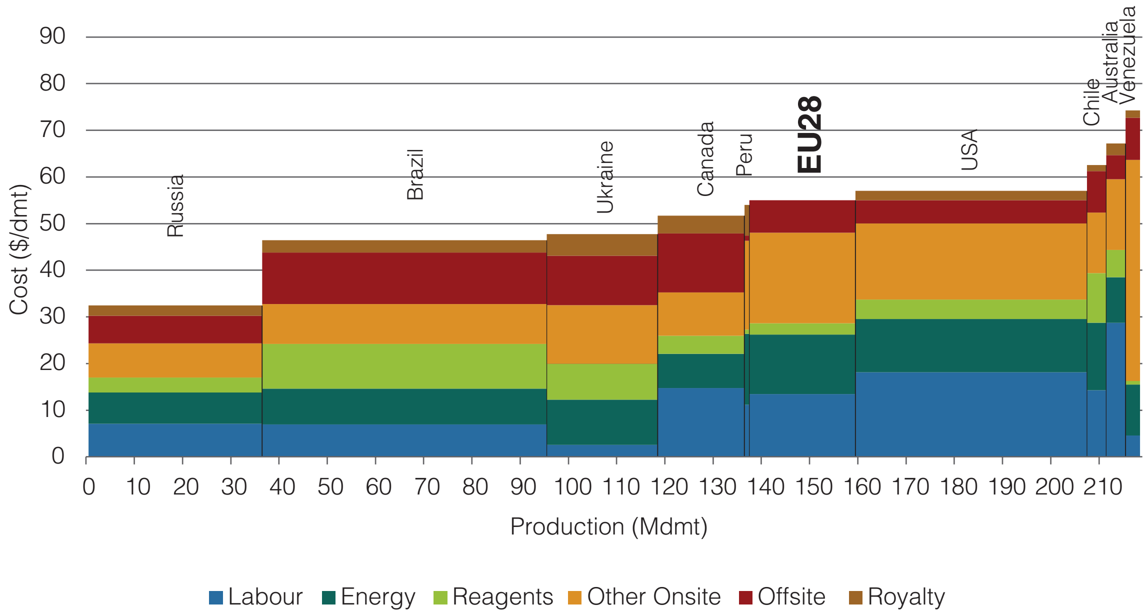
Source: SNL Metals & Mining

2.4 Iron ore

Iron ore production in 2015 was limited to three countries within the EU28: Austria, Germany and Sweden. By far the most significant contribution comes from Sweden's LKAB operations, Kiruna and Malmberget, accounting for almost 90% of total EU28 iron ore production.

The EU28, on the right side of the horizontal axis, faces higher operating costs than Canada but lower than that of the USA. In terms of individual cost components, 'energy' and 'other onsite' costs are higher in the EU28 than in Canada or the USA.

Figure 4: Costs and production from iron ore pellet producing mines 2015



Source: SNL Metals & Mining

2.5 Gold

In 2015, the mined gold production in the EU28 came from operations in Bulgaria, Finland, Greece, Poland, Portugal, Romania, Spain and Sweden, with over 80% coming from mines in Bulgaria, Finland and Sweden.

Figure 5 illustrates the relative position of the EU28 gold producers on the global cost curve. The region is located on the extreme right of the horizontal axis, indicating its relatively high operating costs compared to all other countries reviewed.

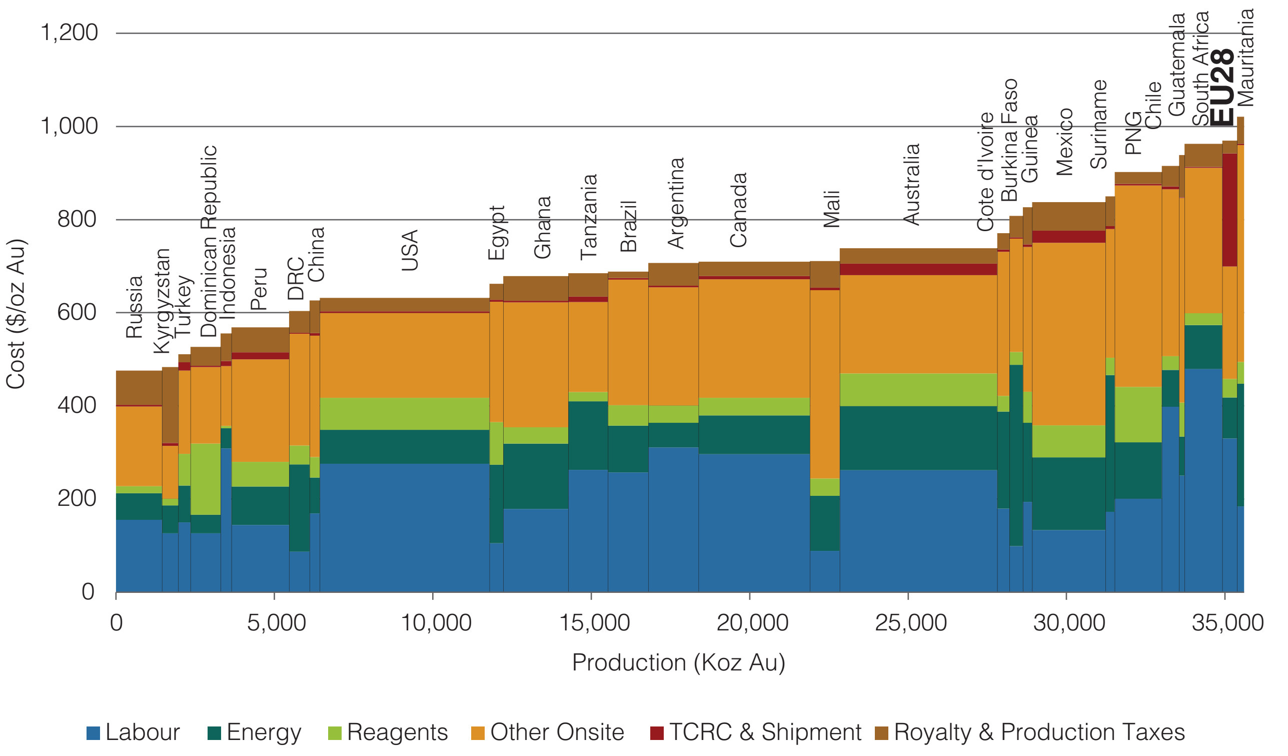
TCRC & Shipment costs for gold mines within the EU28 are higher than all the other countries in this study as a result of a number of gold mines in the region producing a concentrate that requires smelting and refining rather than dore.

Dore is a product comprising gold and silver almost entirely and is the most common product of gold mining operations. Refining dore to finished gold and silver incurs only a small refining charge and, because of its low bulk, transport costs are negligible. For these reasons most non-EU countries have very low TCRC & Shipment costs.

Instead of dore, several EU28 mines produce a concentrate. This concentrate typically has gold grades of hundreds of grams per tonne and requires both smelting and refining to produce finished metal. The additional smelting required compared to dore incurs a significant additional cost.

Greater transport costs are also incurred within the EU28 due to gold concentrate's greater bulk compared to dore. This discrepancy in mass is due to gold concentrate's comparatively low gold content. In addition, Chelopech gold mine in Bulgaria, which accounted for approximately one-third of the EU28's gold production from primary gold mines in 2015, produces a concentrate with high arsenic content that incurs significant additional costs at the smelting stage. As a result, gold mines within the EU28 have high combined TCRC & Shipment costs.

Figure 5 Costs and production from primary gold mines 2015



Source: SNL Metals & Mining

3 Individual cost components

3.1 Labour

Labour costs from the EU28 mining operations are above the average cost in all cases except for nickel (Figure 3). Despite being above average, the EU28 labour costs are comparable to, and often lower than, developed nations such as Australia, Canada, Chile and USA. It is important to note that high salaries do not necessarily equate to high labour costs.

A good example can be seen in iron ore (Figure 4), where the EU28, comprising LKAB's Swedish mines Kiruna and Malmberget, has a lower labour cost than Australia, USA, Canada and Chile. This is despite these mines being two of the only underground iron ore mines in the world, which are generally more labour intensive than open pit mines, and Sweden having relatively high wages. The reasonable labour costs here are a result of the mine's efficient operation, which has been driven by LKAB over a number of years.

The converse of this can be seen in gold (Figure 5), where South Africa has the highest labour cost despite having relatively low wage rates. This is a result of many South African mines exploiting deep, difficult ore bodies using outdated techniques and equipment, which leads to low productivity rates.

3.2 Energy costs

In all commodities covered, the energy cost within the EU28 was generally close to the global average and sometimes below, apart from nickel which is higher (Figure 3). In general, consumption of both electricity and fuel is dictated by the equipment in use at each mine site rather than its geographical location. Mines operating within the EU28 generally benefit from having access to good infrastructure and therefore are usually able to source their electricity from national grids where electricity prices are reasonable.

The countries with the lowest energy costs tend to be those with access to cheap electricity such as Russia, which has access to electricity generated using cheap natural gas, whilst the countries with the highest energy costs are those with poor infrastructure or remote mine sites where diesel generators are commonly used as a source of electricity.

3.3 Reagent costs

Reagent costs heavily depend on the type of ore being processed and the processing technique, as these factors dictate what chemicals are needed and how much is required. The price of chemicals does vary by region, but as this cost covers such a variety of products, no clear regional patterns can be distinguished. The reagent cost of mines operating within the EU28 will benefit from the good infrastructure in the region, as this will help reduce transport costs of any chemicals required whilst this same factor has an adverse effect on reagent costs in the countries with poor infrastructure or remote sites.

3.4 Other onsite costs

As these costs comprise a variety of components, it is difficult to draw any conclusions from regional figures. It should be noted that the EU28 mines covered in this study have approximately the same average onsite costs as other countries. There appears to be no benefit or detriment of these costs for mines operating within MS.

3.5 TCRC & shipment and offsite costs

These offsite costs for mines operating in the MS are close to the average cost for other countries covered for all commodities, with the exception of gold (Figure 5). Treatment and refining charges tend to be relatively consistent across the commodities, with facilities that undertake these processes charging the same price irrespective of the product's origin. The presence of several integrated operations, were the mine is integrated with a smelter/refinery operated by the same company that operates the mine, within the EU28 appears to have had minimal impact, either positively or negatively, on these costs. The main variable is the cost of transporting the mine product to the treatment facility, with the mines in the EU28 benefiting from close proximity to multiple smelting/refining facilities. EU28 mines also benefit from access to good infrastructure, in particular, roads, rail and ports. For this reason, countries with poor infrastructure or remote mine sites tend to have higher TCRC & Shipment and offsite costs, as transporting their products to the end customer or smelting/refining facilities is more expensive.

3.6 Royalty & production taxes

Costs from royalty & production taxes are below average for all commodities, with the exception of copper, due to state royalty systems that are favourable to mining in most of the EU28 Member States. In particular, Finland and Sweden have no royalties on commodities covered in this study, which leads to zero royalty and production tax costs for iron ore (Figure 4) as both operations covered here are in Sweden.

The relatively high royalty cost in copper (Figure 1) is a result of the mining tax introduced in Poland in 2012, which impacts the biggest copper producer in the EU28, KGHM's Polish operations. Although this cost can be influenced by fees paid to private landowners or other companies, by far the biggest contributor to this cost is mining royalties and tax policies of individual countries.

3.7 By-product credits

This policy brief has not examined the revenues from by-products for the operating mines, which will be considered in an upcoming report for the STRADE project. It is important to note that there is an effective reduction in total costs as a result of additional revenue generated from valuable by-products produced alongside the primary metal being extracted.

These by-products can have an important impact on an operation's economics, sometimes resulting in a mine that would not be economically feasible from only its primary commodity but that earns sufficient revenue from by-products to maintain operations. By-product credits wholly depend on the commodities present in the ore deposit being exploited and therefore are not influenced by the region or country of operations.

Within the EU28, by-product credits are around average for nickel but above average for copper, zinc and gold, indicating that many of the mines in the region exploit polymetallic ore bodies and produce a significant quantity of valuable by-products. The impact of such ore bodies on mining competitiveness will be discussed in more detail in a later STRADE report.

4 Conclusions

In considering unit costs for operating mines, figures indicate that the EU28's mining operations are, and can continue to be, competitive compared to mines in other countries around the world. While for all minerals considered here the EU28's mines have been shown to be higher cost than operations in many other regions, occupying the right hand side of figures 1-5, they still exhibit competitive cost structures. Although other factors such as by-product revenues and capital expenditure requirements must be considered when assessing the economic viability of any mining project, the EU28's competitive operating costs compared with other regions of the world do not appear to inhibit its mining operations. These other factors will be discussed in more details in an upcoming report for the STRADE project.

The only consistently less competitive component of operating costs at mines within the EU28 is the labour cost. This is a result of high wage rates in the EU28 Member States compared to less developed countries. Labour costs are somewhat mitigated by operations in less developed countries often being more labour intensive and less productive per person than mines operated in more developed countries, such as those within the EU28. Labour costs within the EU28 do compare, often favourably, with those in other developed countries such as Australia, Canada, Chile and USA and should therefore not be seen as inhibitive to having globally competitive mines.

With the exception of copper in Poland, royalty and tax costs within the EU28 are generally more competitive than other countries. Royalty and tax regimes currently in place in the region seem to be beneficial for mining and help in maintaining the competitiveness of mines operating within the region.

Other cost elements in EU28 mines are also generally similar to the average costs from other regions of the world, with mines operating within the EU28 benefiting from being close and having access to good infrastructure.

Lastly, by-product credits within the EU28 are generally above the global average. These credits help bring the effective total cost down due to the additional revenue generated from these by-products. The extra revenue is a result of the nature of the deposit being currently exploited, and as such is a geological factor intrinsic to the EU28.

Translating the EU28's competitive advantages for mining operations into a strategy to promote mining investments into the region will be considered in more detail in future reports and policy briefs from the STRADE project.

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)

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Funding Scheme This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 689364

Funded by the Horizon 2020 Programme of the European Union

Duration 1.12.2015 – 30.11.2018

Budget EU funding: €1 977 508.75

Website www.STRADEproject.eu