STRADE

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The Competitiveness of the European Union's Mining Sector

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List of Abbreviations

Abbreviation	Description
$/oz	United States Dollar per ounce
$/t	United States Dollar per tonne
c	United States cent
c/lb	Cents per pound
CD	Canadian Dollar
CEO	Chief Executive Officer
EIA	Environmental Impact Assessment
EU	European Union
Fe	Iron
FMA	Federal Mining Act
IRR	Internal Rate of Return
KGHM	KGHM Polska Miedź S.A.
kwh	Kilowatt-hour
lb	pounds
m	million
oz	ounce
PEA	Preliminary Economic Assessment
TCRC	Treatment Charge and Refining Charges
U.K	United Kingdom
U.S	United States
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar

1. Introduction

An exploration or mining company will have a portfolio of potential investments to choose from at any given time. Projects included within the portfolio will be initially ranked on their economic viability, usually based on the Internal Rate of Return (IRR). The IRR is impacted by a number of factors, including the quality and size of the ore body, the operational costs of extracting the metal, the royalty and taxes, and the costs for shipping the concentrate. Another factor driving the selection/ranking is the risks faced within the operating environment. These would include the state of the mineral regulation/legislation, the ability to receive licenses, security of tenure and mining rights.

The combination of geological potential and the operating environment determine the mineral investment competitiveness of a jurisdiction. How the jurisdiction compares to others will influence the ability of a country to attract international mining investment. A number of perception-based mining attractiveness indices are used by investors, the Fraser Institute's Annual Survey of Mining Companies being the most commonly used. These survey-based rankings often reflect the 'reputation' of a country in terms of their policies and potential investments into their natural resource sector.

In the Fraser Institute's 2016 report, 104 jurisdictions were covered. The 'Investment Attractiveness' index, measuring both policy as well as the mineral potential of a country/region, awarded the top ranking to Saskatchewan (Canada). Finland from within the EU28 was in the top five most attractive jurisdictions (see Table 1). For other EU28 Member States assessed, the results were more disappointing; Sweden ranked the highest at 8/104 and Hungary lowest at 85/104.

Table 1 - Investment attractiveness index (2016)

	Investment Attractiveness Index	Score			Rank (out of 104)
		2014	2016	Change 2014/2016	2016
Top 5 (2016)	Saskatchewan	86.27	89.91	↑	1
	Manitoba	84.14	89.05	↑	2
	Western Australia	84.33	88.88	↑	3
	Nevada	88.38	87.48	↓	4
	Finland	85.70	85.56	→←	5
European Union	Sweden	79.7	84.26	↑	8
	Ireland	80.2	83.13	↑	9
	Northern Ireland	**	72.41	...	32
	Poland	58.03	71.34	↑	34
	Portugal	71.51	70.86	↓	36
	Spain	56.75	70.39	↑	38
	Romania	43.98	56.57	↑	69
	Bulgaria	42.77	51.31	↑	75
	France*	61.78	50.1	↓	79
	Greece*	42.39	48.77	↑	82
	Hungary*	39.59	47.41	↑	85

*** Between 5 and 9 responses*

Source: Fraser Institute Annual Survey of Mining Companies: 2016

Mineral potential is limited by the geological endowment of a country. Apart from ensuring that good geological data is available in the public domain, a country cannot increase its endowment. However, it can work towards increasing the attractiveness of its policy environment. The Fraser Institute's 'Policy Perception Index' ranks jurisdictions on factors such as administration of current regulations, environmental regulations, the legal system and taxation regime, dispute settlements, socioeconomic and community development conditions, amongst a host of other factors. The top five jurisdictions within this category include three Member States (Ireland, Sweden and Finland; Table 2). Portugal, Spain and Poland are ranked in the top thirty, with other Member States ranked much lower.

Table 2 - Policy perception index (2016)

	Policy Perception Index	Score			Rank (out of 104)
		2014	2016	Change	2016
Top 5 (2016)	Ireland	100	100	→←	1
	Saskatchewan	95.67	98.87	↑	2
	Sweden	95.74	98.15	↑	3
	Finland	98.74	97.64	↓	4
	Nevada	91.95	97.64	↑	5
European Union	Northern Ireland	**	92.97	...	10
	Portugal	91.78	90.3	↓	16
	Spain	74.36	85.18	↑	24
	Poland	74.58	84.59	↑	27
	Hungary*	68.97	73.53	↑	45
	Bulgaria	57.44	69.34	↑	56
	France*	79.45	65.25	↓	62
	Romania	48.44	55.71	↑	75
	Greece*	60.97	38.59	↓	91

*** Between 5 and 9 responses*

Source: Fraser Institute Annual Survey of Mining Companies: 2016

The Policy Perception Index ranking for the EU28 jurisdictions is much higher, relative to their Investment Attractiveness Index ranking, and also to the Fraser Institute's Best Practices Mineral Potential Index (BPMPI). The latter helps explain the former, and for example, while Ireland is ranked first for Policy, it is ranked only ninth on investment attractiveness. Poland is ranked 27 on policy, but 34 on investment; Spain is 24 and 38, France is 62 and 79 for police perception and investment attractiveness, respectively. This is due, at least in part, to the relatively low perception of mineral potential in EU countries, with only Finland (12), Sweden (18) and Ireland (30) appearing in the top 30 country ranking.

Previous research has noted that, on the one hand, exploration spending in Member States is low compared with other regions (Ferguson et al, 2016)[1]. On the other hand, the operating costs for mining in the EU are competitive (Webb, 2016)[2]. As the EU looks at increasing mining investment within its Member States, the rankings from the Frasier Institute raise some interesting questions.

The introductory section of this report sets out to answer two principal questions. First, despite the positive policy perceptions, why have the EU Member States been unable to attract more exploration spending, relative

[1] http://stradeproject.eu/fileadmin/user_upload/pdf/PolicyBrief_03-2016_Aug2016_FINAL.pdf

[2] http://stradeproject.eu/fileadmin/user_upload/pdf/PolicyBrief_08-2016_Nov2016_FINAL.pdf

to other jurisdictions? Second, why has the investment attractiveness of the Member States lagged behind policy perception?

To address these questions, the report starts with an assessment of two essential drivers of mining competitiveness: the cost of operations and the mineral legislation and regulation that governs the mining sector in a country. For both these drivers, the EU's performance is benchmarked against other countries. We then present a simple case study that highlights the considerations of mining companies looking at developing projects in the EU. The final chapter then summarises our findings and suggests avenues for continued thinking on EU mining competitiveness.

The purpose of this report is to map the mining cost and regulatory framework performance of the EU Member States, relative to other mining jurisdictions. This report does not attempt to provide recommendations on improving the mining competitiveness of the EU, which will be presented in the final report for the STRADE project in 2018.

2. Operating cost competitiveness

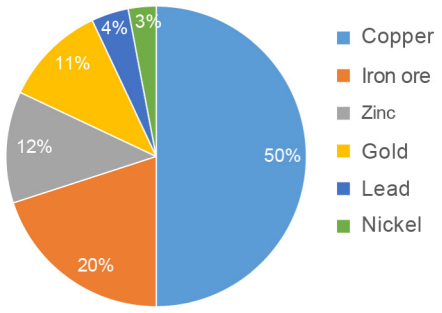
This study examines, in more detail, the EU mine cost competitiveness analysis presented in STRADE Policy Brief 08/2016 (Webb, 2016). EU mines are compared with operations in non-EU countries focusing, on metals that are significant for the EU: copper; nickel; lead[3]; zinc, gold and iron ore (pellets). The cost coverage includes onsite costs (labour, energy, reagents, other), offsite costs (TCRC, shipment, other offsite, royalties) and by-product credits for mines.

Cost competitiveness can be measured on two fronts. The first measure is the individual components, and the second is the placement of countries on the global cost curve reflecting the combined cost components.

The analysis of cost components is based on the following methodology (based on U.S. dollars, in which the price of most commodities is denominated).

Score: Under a cost category**,** for each metal, a calculated value is assigned. This value indicates the US$/lb cost for the production of the metal[4]. A country is awarded a score to reflect is competiveness. The country with the highest costs is awarded a 100, while the country with the lowest score is awarded a zero.

Figure 1 - Revenue split by metal from EU28 mines (2015)



Source: SNL Financial (2016)

Weighted Average Total: To combine the scores from different metals under each cost category, a weighted total average score is constructed. This is weighted by the importance of the metal in EU production. The weight is based on the contribution of the metal to total EU production (Figure 1). So, copper is given the largest weight, as it is responsible for 50% of revenue generated by EU28 mines (2015). A lower weight is given to nickel which was only responsible for 3% in 2015.

By-Product Scoring: Some metals are produced as by-products to the main metal mined. Given that the EU does have a number of co-mined metals, it is important to separate the by-product scoring within this exercise.

[3] Lead coverage for the EU is markedly lower than other commodities considered in this study. This is due to the lack of reliable cost information for the Boleslaw lead mine in Poland, which is estimated to have produced around 60kt of lead in 2015.
[4] Lead and Zinc are usually extracted from the same mines and are therefore combined in our analysis. We have classified these as Zinc operations as this is the more valuable metal.

The highest by-product credits are given the lowest score (as they cost less to produce) and the lowest by-product credits given the highest score. Regions with zero by-product credits are automatically given a score of 100. This is because by-product credits are not a cost but an additional revenue which effectively lowers the net cost of an operation.

Worked Example: A worked example of the ranking system is provided in Figure 2. The individual costs for Labour are recorded for four countries for copper and nickel (columns A and B). Country D has the highest labour costs for copper and is therefore awarded a score of 100 (column C) and Country A has the lowest costs and is awarded a score of zero (column C). For nickel, Country A has the highest cost and Country B has the lowest costs and are therefore awarded 100 and 0 respectively (column D).

The weighted average total score (column E) reflects a score for labour for each country (regardless of metal) and is weighted more heavily for copper than for nickel. This weight reflects the higher revenue generate from copper, relative to nickel (column F)

Figure 2 - Total weighted average score – worked example

	Costs (Labour)		Score			Example Revenue used to calculate total score	
	A	B	C	D	E	F	
	Copper	**Nickel**	**Copper**	**Nickel**	**Weighted Average Total**	**Copper**	**Nickel**
	c/lb	c/lb	Score	Score	Score	$m	$m
Country A	40	110	25	100	37.5	500	100
Country B	50	0	75	0	75.0		
Country C	45	75	50	67	52.8		
Country D	80	70	100	33	88.9		

Source: SNL Financial (2016)

A high score in column E indicates a high labour cost relative to other countries and a low score indicates a low labour cost compared to other countries.

This section now looks at the scores for each of the cost components (Labour, Energy, Reagents and Other, TCRC, and shipment and other offsite, Royalties and production taxes, and By-product credits). The analysis compares the EU28 with other non-EU countries with significant production of these metals. For brevity, the weighted average total scores are presented here, with individual metal costs provided in Annex 1.

2.1. Operating costs benchmark

2.1.1. Labour

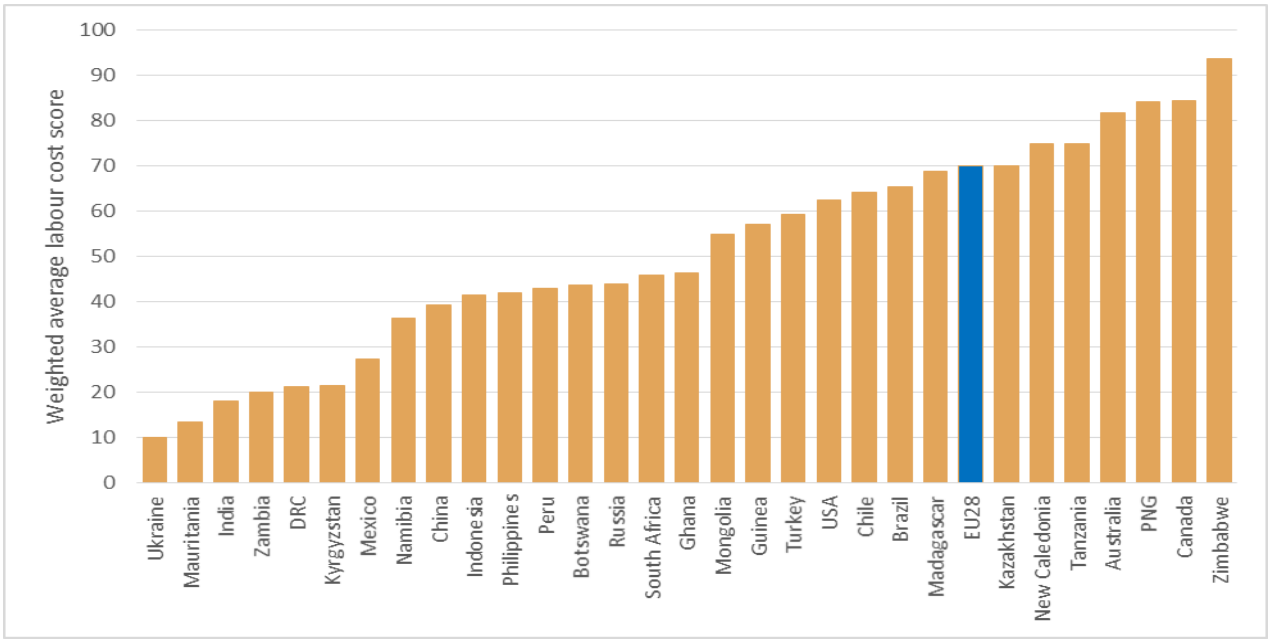
Labour costs in this study represent the total cost of people employed at the mine site in mining and processing the ore to the intermediary product (which is then transported offsite for further processing to finished metal). These figures account for those people directly employed by the mining company itself as well as people employed as third-party contractors. Excluded from these figures are people employed in transporting the mined product offsite and those employed in facilities which undertake further processing of the mined product to finished metal. The labour costs are the costs of all employees on the mine site inclusive of all benefits and bonuses. For each country this is the average per unit of metal from the mines we cover in that country.

Figure 3 illustrates the weighted average total labour cost scores for all metals and countries. Individual cost values are provided in Annex 1.

With a total score of 70 the EU28 has relatively high labour costs compared with the other countries in this study. This is somewhat expected given that wage rates are higher in the EU28 than in many countries covered in the study. The EU28 still compares favourably to similarly developed regions such as Canada and Australia which have scores in the 80s. It should be noted that labour costs in the mining industry in many countries are significantly higher than labour costs in general, which explains why the differences between poor and rich countries are not larger.

The score is based on the cost in c/lb or $/oz of metal. This cost is a combination of two factors, the wage rate and the productivity (number of people employed per metal produced). Zimbabwe for instance would score high because, although it has low wage rates, it also has very low productivity rates due to many of its mines being deep, narrow and underground which require labour intensive mining methods. This leads to a high cost in terms of c/lb or $/oz of metal. The majority of mines in DRC and Zambia on the other hand are open pit so they benefit from a combination of low wage rates and higher productivity per unit of metal due to open pits generally being able to utilize bulk mining techniques which are less labour intensive.

Figure 3 - Weighted average total score – labour costs (2015)

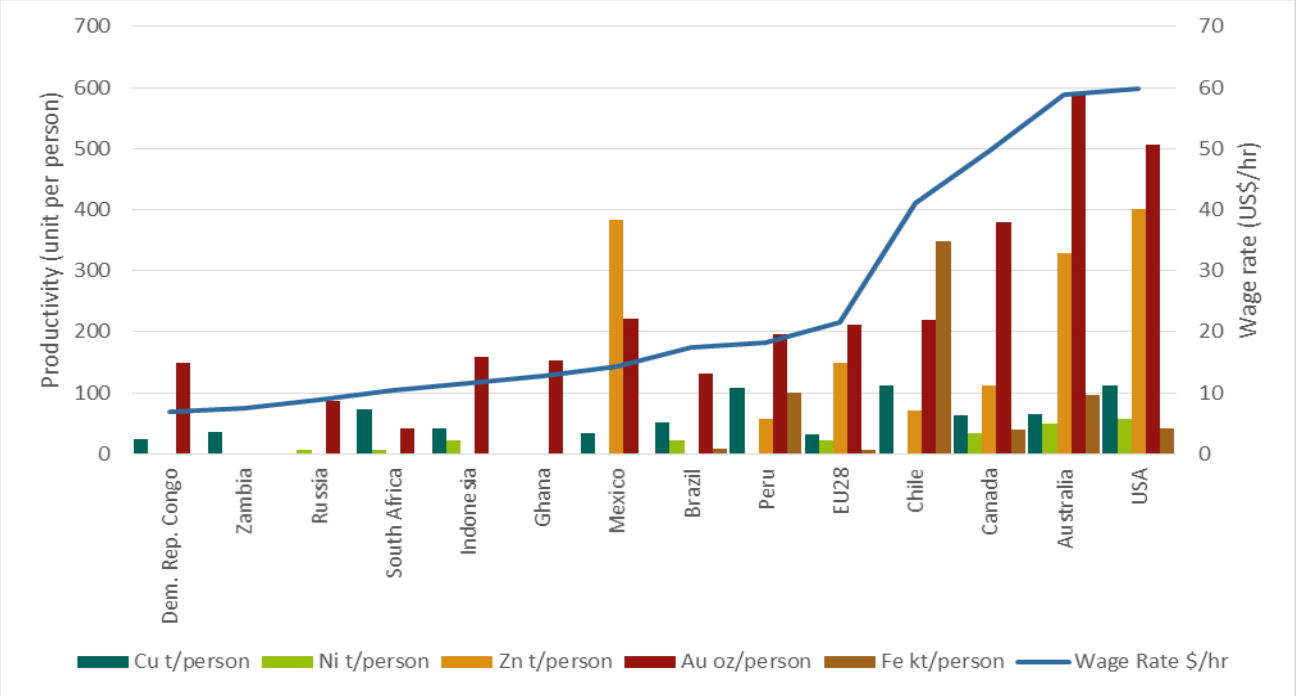


Source: SNL Financial (2016)

Labour costs are a result of the wage rates payed to employees and the number of people employed on site. Changing either of these items will have an influence on the labour cost. The wage rate can be adjusted by the company operating the mine to some extent, however it is mainly dictated by the country within which the mine is operating. For example, the average wage rate of an employee in a mine in Australia will always be far higher than an employee in a mine in Zambia. The wage differential can be linked to a number of reasons: labour laws, minimum wage rates, costs of living, skill levels etc. The number of people employed can be more easily manipulated by the operating entity by changing the methods or working practises at an operation to increase the productivity.

Productivity: The productivity of an operation can be assessed by assessed in several ways, most normally by evaluating the amount of ore or metal produced per person. The former is heavily dependent upon the mining method employed, so for this report we have focused on the amount of metal produced, which provides a good measure of the labour intensity of a mining operation and, combined with the wage rate, shows the drivers behind the labour cost component. Figure 4 shows the average mining wage rate and productivity for the EU28 and selected major mining regions covered in this study. On the left vertical axis is the productivity (per unit of metal per person) while the right vertical axis shows the wage rate. The individual bars represent different metals. The higher the bar, the greater the productivity. The wage rates are depicted as USD/hour.

Figure 4 - Wage rates and productivity (2015)



Source: SNL Financial (2016)

Figure 4 shows that there is some correlation with higher wage rates and high productivity, although this is not always the case (see gold oz/person). This is generally born of necessity; if higher wage rates are to be paid, then productivity must be higher to compensate. This will allow the labour cost component to be kept low and the project to be economically viable.

In a country where wage rates are relatively lower, a lower productivity per employee may be seen as acceptable as it will not have a very large impact on the economic viability of a project. The average wage rate of employees at mines in the EU28 was estimated to be USD21.5/hr in 2015. This is lower than expected; major mines are located in Member States where wages are generally lower (such as Poland and Bulgaria), balancing higher wage rates in the Scandinavian countries.

Productivity within the EU28 is somewhat mixed in comparison to other countries, and varies depending on the metal. Copper and iron ore operations in the EU28, for example, have low productivity compared with their peers. KGHM's copper operations in Poland and LKAB's iron ore mines in Sweden are both the main contributors to their respective metals in the EU28. Both operate underground mines whereas most production globally for both metals comes from large open pit operations. Underground operations are far more resource

and labour intensive than open pit operations and therefore these metals show comparatively low productivity compared to other countries.

The reason these low productivity rates do not destroy competitiveness is partly that the main customers are nearby, and high production costs are therefore to some extent compensated by low transport costs. This is the case in particular for LKAB, which compared with its competitors has a short railway distance to the coast and a short sea voyage to the customers.

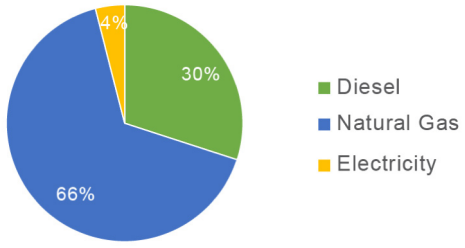
Productivity for gold and zinc in the EU28 compare favourably with many countries but still fall behind some others, including Australia and the U.S., where productivity for these metals are substantially higher. This is likely a result of multiple factors, but key would be the presence of multiple large, high grade gold and zinc mines in both countries compared with the smaller, lower grade mines in the EU28. Economies of scale at these mines allow for greater metal production per employee. These points highlight the importance of the ore grade and deposit type in the economics of any mining project.

In general the labour cost is largely determined by the country wage rate, it is also dependant on the number of people that must be employed to run the operation. While the wage rate cannot be meaningfully impacted by the operating entity, the number of people employed can be optimised by improving of work practises and techniques. This is largely dictated by the type of deposit that is being exploited.

2.1.2. Energy

Energy costs represent the cost of electricity, diesel and natural gas consumed at the mine-site and associated processing facilities per annum. Excluded from these figures are the energy costs used in transporting the mine's product to facilities for further processing to finished metals, and the use of these energy sources at the downstream facilities themselves. The energy cost is the total cost of electricity, fuel and natural gas at the mine site. For each country this is the average per unit of metal from the mines we cover in that country.

Figure 5 - Contribution of energy sources to total energy cost



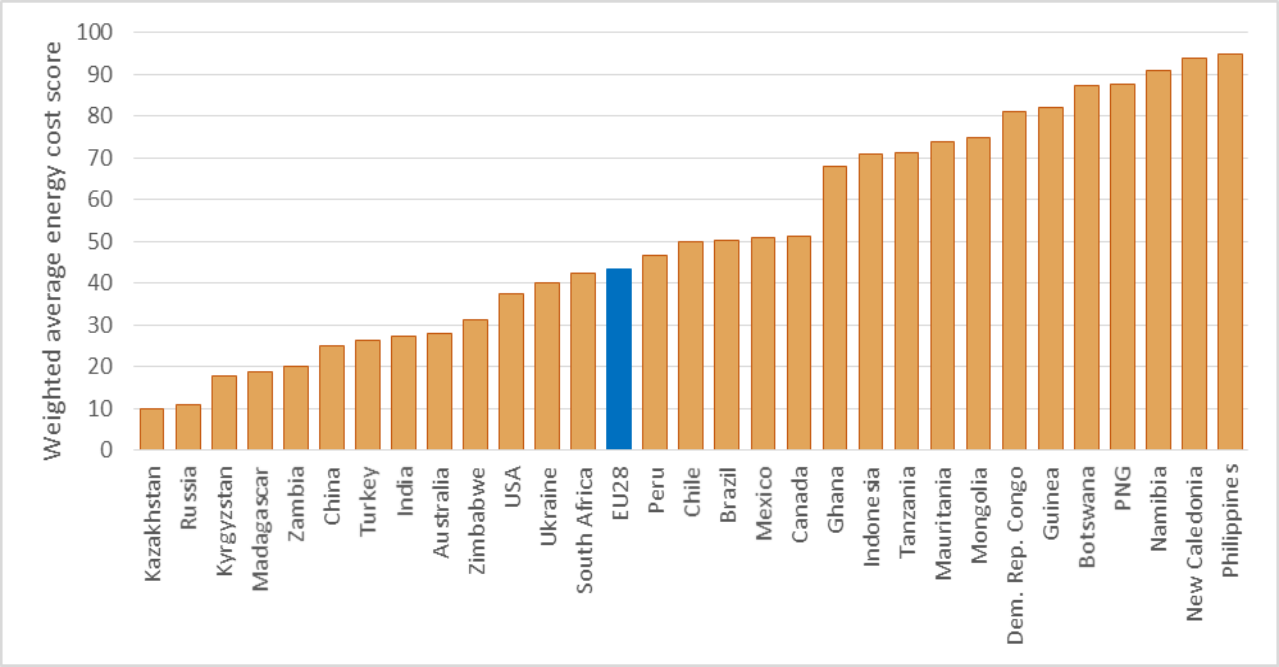
Source: SNL Financial (2016)

As Figure 5 illustrates, electricity is the most significant contributor to energy costs at mine sites and therefore this will be discussed in most depth. Diesel costs will be discussed briefly while natural gas will not be discussed further due to its small impact on total energy costs at mines in this study.

Figure 6 illustrates the weighted average total labour cost scores for all metals and countries. Individual cost values are provided in Annex 1.

The EU28 scores 43.5 for energy costs, which indicates that mines operating within the Member States are more competitive on energy costs than many of the countries covered. This is mostly a result of the availability of reasonably priced electricity and fuel (primarily diesel) within the region. Energy costs are the result of two factors, the consumption of electricity/fuel and the unit price of electricity/fuel. Price and consumption of electricity for the EU28 and selected major mining countries covered in this study can be seen in Figure 7. The left hand vertical axis shows the electricity consumed per ton of ore processed (indicating productivity). The right hand vertical axis shows the electricity price. Each bar represents a particular metal. The higher the bar, the greater the productivity of energy consumption.

Figure 6 - Weighted average total score – energy costs (2015)



Source: SNL Financial (2016)

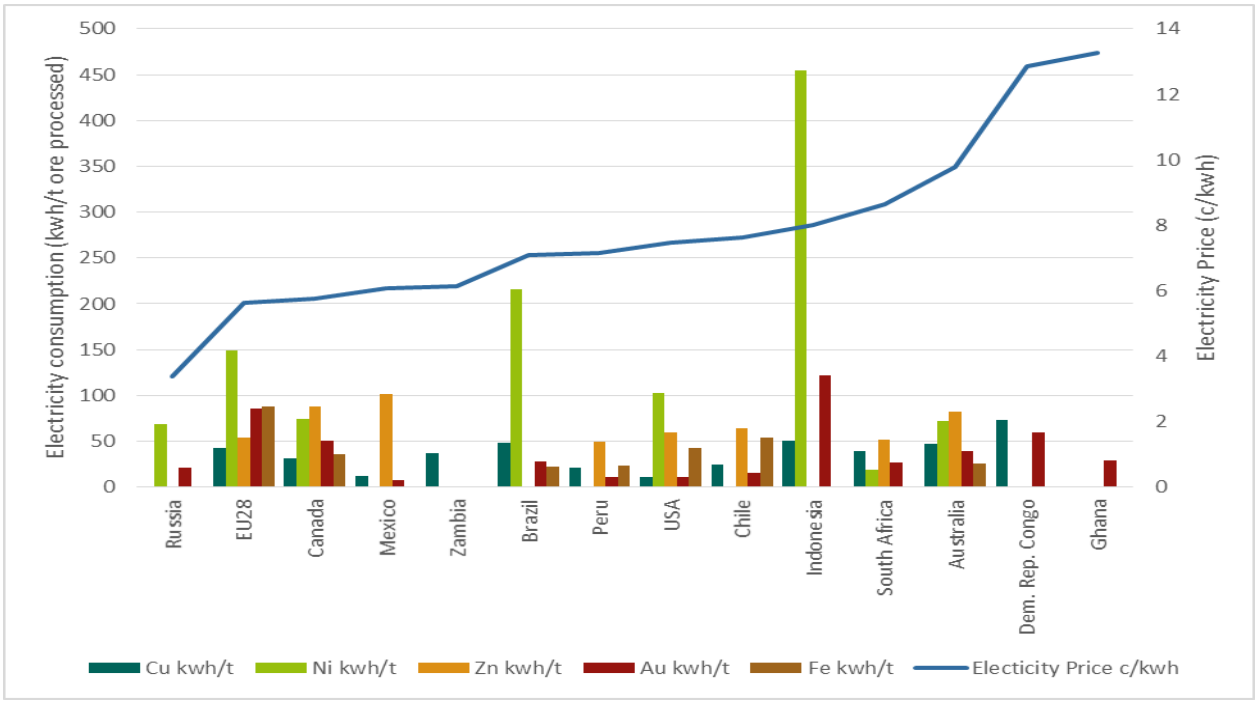
Figure 7 illustrates there is no correlation between price and consumption of electricity at the mine site. The electricity price is controlled by its source. For example, mines in Russia that can access the national grid will have access to electricity generated from power stations that have access to cheap natural gas. This is why the Russian mines in this study paid an estimated average of only 3.4 c/kwh in 2015.

Mines operating in Ghana may have to rely on diesel generators for power as there may not be infrastructure available in the area to access the national grid or they may be too remote from infrastructure that does exist. Diesel generators are the most expensive means of generating electricity and can cost over 25 c/kwh, which is why mines operated in Ghana paid an estimated average of 13.3 c/kwh in 2015.

In general, mines that are remote, or in countries that lack infrastructure to provide cheap, reliable electricity, will pay a higher price for electricity than those that are less remote and/or in countries with good infrastructure and access to reliable electricity. Mines operating within the EU28 are estimated to have paid an average 5.6 c/kwh for their electricity in 2015, which is one of the lowest rates paid for all the countries in this study.

Unlike the electricity price, electricity consumption rates are controlled by the equipment being operated at the mine site. An identical piece of equipment in Russia and in Ghana will consume the same amount of electricity. For this reason electricity consumption is dependent on the type of deposit being exploited and the equipment necessary to mine and process it. Figure 7 shows high electricity consumption rates for nickel in Indonesia, Brazil and, to a lesser extent, the EU28. This is a result of mines in these countries exploiting nickel laterite deposits which are processed in electric arc furnaces at very high temperatures to produce ferronickel. The equipment used in this process requires far more electricity than other processing techniques used in the mining industry, such as conventional crushing, grinding and flotation of ore. In the EU28, this process is used at the Larco nickel operations in Greece and is responsible for the relatively high electricity consumption rates attributed to EU28 nickel mines.

Figure 7 - Electricity prices and consumption (2015)



Source: SNL Financial (2016)

Electricity consumption rates for other metals in the EU28, and non-EU countries, display less variability as most operations are using similar processing techniques and equipment. Low electricity consumption rates for copper and gold may be achieved at mines that employ heap/dump leaching techniques. This process involves leaching of metals from large dumps or heaps by passing sulphuric acid (copper) or cyanide (gold) through the material. Metal is then recovered from the solution through electrolysis, which accounts for the only significant electricity consumption. This process technique generally consumes less electricity than conventional processing as it can circumvent grinding, sometimes crushing, of the ore.

The final factor that will affect the consumption of electricity at a mine site is the age of the equipment. Newer equipment tends to be more efficient than older equipment and consumes less electricity per tonne processed than older equipment. This effect is relatively small, however, when compared with the other factors discussed above.

The other major component of the energy costs, after electricity costs, is the cost of fuel (usually diesel). The cost of fuel obeys the same principles as described for electricity costs, with the cost driven by fuel price paid and the consumption of fuel at the mine site. The price of fuel varies by country, although this variance is far less than with electricity as the price of fuel is mostly tied to the oil price (the greatest variance comes from local fuel taxes). Consumption of fuel, like electricity, is once again wholly dependent on the equipment being used.

The consumption rates of both electricity and fuel at mine sites are relatively fixed based on the deposit type and the type of equipment that is required to extract and process the ore. Both consumption rates can be optimised by investing in new, more efficient, equipment or adjusting techniques used however the effect of these changes on the overall energy cost is limited. The price of both electricity and fuel has a far greater influence on the energy costs of a mining operation as this is more variable.

The influence of individual states on fuel prices is somewhat limited due to the fuel price being closely related to the oil price, although reducing fuel taxes can help reduce the fuel cost component of energy costs. Nevertheless, individual states can greatly influence energy costs overall by making access to cheap and reliable electricity available to mining operations. This is by far the most significant and variable factor involved in the energy costs of mining operations.

2.1.3. Reagents and other costs

Reagent and other costs in this study have been grouped together as these costs have similar characteristics in that they are made up of a wide variety of different components. This makes the drivers behind these costs difficult to analyse in depth on a regional basis as they are so variable in both the type and consumption rates of material and chemicals that are used. For this reason this study will not be able to look at the drivers of these costs in as much depth as other costs.

Reagent costs cover the cost of chemicals used in the processing of ore to produce the intermediary product at the mine site. Chemicals used vary depending on the ore being processed, by what techniques and what metals are being recovered. Typical chemicals used in the mining industry include sulphuric acid and cyanide alongside a wide variety of other chemicals which are used at different stages to separate the metal of interest from gangue material.

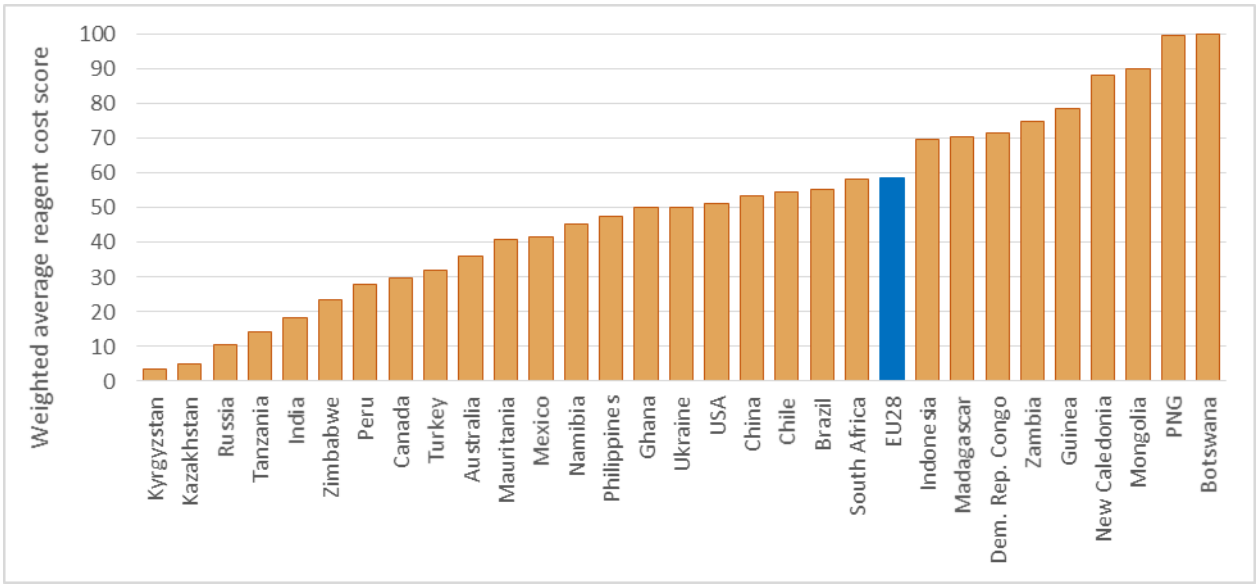
The other cost covers every other onsite costs not covered in labour, energy or reagents. This includes, but is not limited to, explosives used in blasting rock in the mine to allow for extraction, grinding media such as balls or rods used in mills to reduce the size of ore particles and spare parts and materials needed to maintain on-site mining and processing equipment. The massive variety of what can be included in the other cost component makes meaningful analysis difficult.

Figure 8 illustrates the weighted average total reagents cost scores for all metals and countries. Individual cost values are provided in Annex 1.

Figure 8 shows that the EU28, with a score of 58.8, has a higher reagent and other cost than many of the countries covered in this study. Although this score would suggest that mines in the EU28 are not significantly disadvantaged by these costs when compared with mines operated in other countries. As mentioned above, meaningful analysis of these particular costs is difficult as they are dependent on the deposit type, metal being extracted, and processing techniques employed at each mine site alongside a multitude of other factors.

It can be noted, however, that the large copper producing nations of Democratic Republic of Congo and Zambia score higher than the EU28. This is likely to be the result, at least partially, of operating mines being quite remote and the infrastructure, particularly transport links, being generally poor. This results in higher transport costs to get reagents and materials to site, which leads to higher reagent and other costs. This is not generally an issue for mines operated in EU28 countries as they usually have access to good infrastructure. They are also less remote, which may explain the lower reagent and other costs in the region when compared with countries with these more remote mining operations and poor infrastructure.

Figure 8 - Weighted average total score – Reagents costs (2015)



Source: SNL Financial (2016)

Few conclusions can be drawn on the reagent and other costs for EU28 mines but it can be noted that mines in this region do not appear to be significantly inhibited by these costs when compared with mines operated in other countries.

2.1.4. TCRC, shipment and other offsite costs

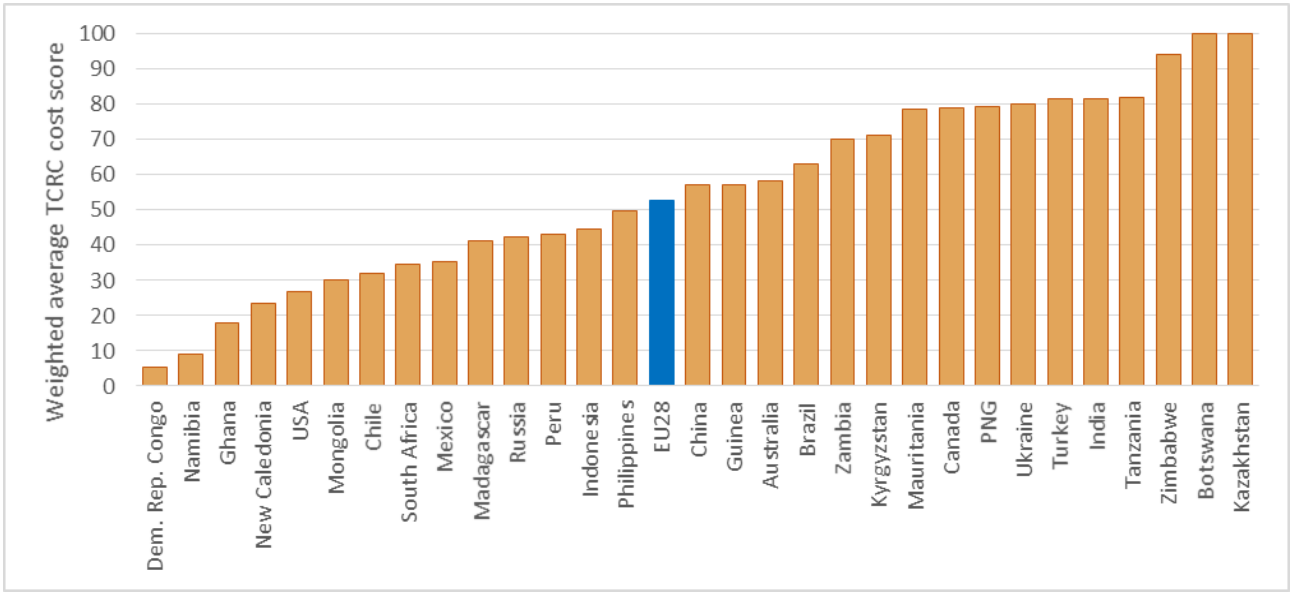
TCRC (Treatment Charge and Refining Charges), shipment and other offsite costs cover the costs incurred by the mine to transport and further process the product produced at the mine site to the final product. In all cases, with the exception of iron ore, for metals covered the final product produced is finished metal. For iron ore this cost covers the transport of iron ore pellets produced at the site, which contain between 64-67% Fe, to customers who will use these pellets in the manufacturing of steel. Figure 9 illustrates the weighted average total offsite cost scores for all metals and countries. Individual cost values are provided in Annex 1.

With a score of 52.7 the EU28 ranks towards the middle of all the countries covered in this study in terms of TCRC, shipment and other offsite costs. This ranking is increased somewhat due to the high TCRC costs attributed to gold as a result of several mines within the EU28 producing a precious metal concentrate which requires significant further processing to produce finished gold, whereas the vast majority of gold mines produce doré, which only incurs a small cost to refine to finished gold. In addition to this, the 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.

This cost can be lowered in countries as a result of the prevalence of processing techniques that do not require further processing to finished products. The most important example of this is the leaching of copper oxide ore using sulphuric acid with copper then being recovered from the leached solution via electrolysis at the mine site. The only TCRC, shipment and other offsite cost incurred at these operations is the cost of transporting the finished copper to customers. This technique is wholly dependent on the type of ore present in the deposit and is used widely in Chile, the DRC and USA alongside other countries and is partly responsible for these

countries scoring low in this section. This type of technique is not widely used in the mines operating in the EU28 simply because of the deposit types that are present.

Figure 9 - Weighted average total score – TCRC/others (2015)



Source: SNL Financial (2016)

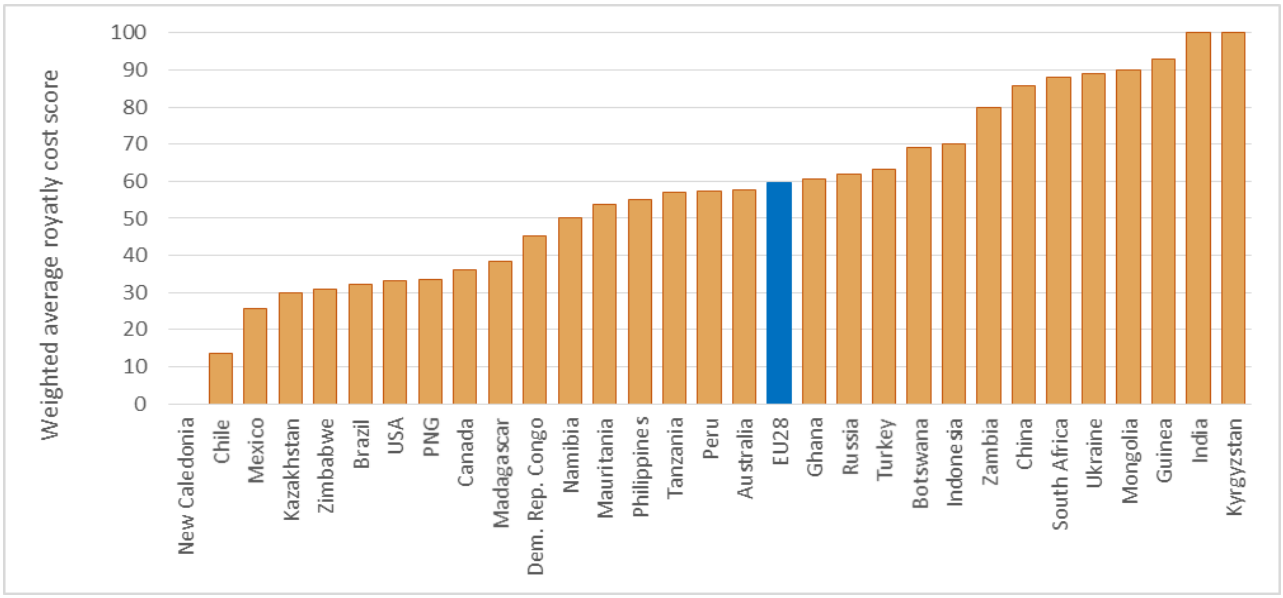
Despite the adverse effect of gold mines and lack of copper leaching operations in the EU28 TCRC, shipment and other offsite costs in the EU28 score lower than many countries, including the similarly well-developed mining powerhouses of Australia and Canada. This is a result of mines operating within the EU28 once again benefiting from having access to good infrastructure as well as ready access to several smelting and refining operations in the region. This effectively reduces the transport cost of getting the mines product to these facilities compared to other countries with poor infrastructure and/or remote mine sites. The importance of geographical distances and infrastructure is underlined by the fact that the three countries with the highest offsite costs are all landlocked.

2.1.5. Royalties and production taxes

This cost covers all royalties and production taxes paid, whether they be at a country level, intra-company or to land owners. They do not cover export taxes. Although this cost can be comprised of any royalty or production tax it is dominated by those that are paid to the government of the country where the mine is operating. For this reason the most significant, and in many cases the only, factor influencing this cost is the royalty/production tax policy of the country within which the mine is operating. Figure 10 illustrates the weighted average total royalty and taxes cost scores for all metals and countries. Individual cost values are provided in Annex 1.

The EU28 scores 59.7 for royalty and production taxes, indicating that many of the other countries in this study have more lenient royalty/production tax structures than those present in the EU28. This is perhaps an unexpectedly high score given that Finland and Sweden, which are major contributors to mining in the EU28, both have zero state royalties on mining operations. The high overall score can mainly be attributed to the mining tax introduced in Poland in 2012 which increased this cost at KGHMs Polish operations. This mine is by far the biggest copper producer in the EU28 and the production tax here has resulted in the overall royalty and production tax cost for copper in Poland being better than only Argentina, South Africa and Mongolia.

Figure 10 - Weighted average total score – Royalties/taxes (2015)



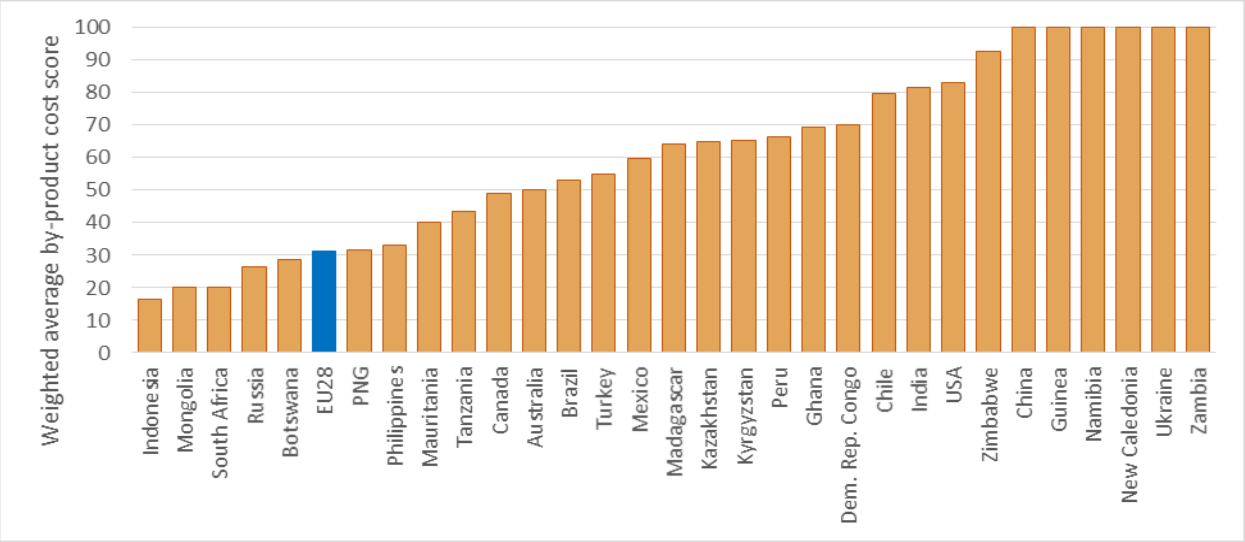
Source: SNL Financial (2016)

2.1.6. By-product credits

By-product credits represent the additional revenues generated from valuable by-products at the mine, additional to the primary metal being produced. These by-products usually, but now always, consist of other metals that are present in the ore being extracted alongside the primary metal. These by-products generate additional revenue to that from the primary metal and effectively lower the total cost of the mining operation. By products are not produced at iron ore mines therefore our analysis in this section is limited to copper, nickel, zinc and gold. Figure 11 illustrates the weighted average total by-product cost scores for all metals and countries. Individual cost values are provided in Annex 1.

As mentioned earlier, the highest by-product credits are given the lowest score (as they contribute most to reducing costs) and the lowest by-product credits are given the highest score. The EU28 scores 31.2 for by-product credits meaning that mines operating in the region generally benefit more from by-product credits than most of the other countries assessed in this study. By-product credits are solely dependent on what metals are present in the deposit being mined and cannot be controlled to a significant degree by operating companies or countries. Higher by-product credits in a region may indicate the deposits are more likely to be polymetallic and have higher concentrations of by-product metals.

Figure 11 - Weighted average total score – By-product costs (2015)



Source: SNL Financial (2016)

By-product credits are heavily influenced by the composition of reserves and resources for each metal.

Copper reserves and resources in the EU28, although relatively small compared with those in other countries, contain substantially more precious metals. This is largely because of the high silver content of the kupferscheifer deposit which is exploited by KGHM's operations in Poland. Although the primary metal produced at KGHM's Polish operations is copper, in 2015 it also produced more silver than any other single operation in the world.

The deposit mined by KGHM in Poland is unique to the region and no deposits like this are currently mined anywhere else in the world. Most global copper production currently comes from porphyry copper deposits which are generally lower grade in copper and far lower in precious metal content than what is available in Poland. Copper reserves and resources in Portugal are also very high in silver content which has contributed, to a lesser extent than Poland, to the EU28 having such high average precious metal content of copper reserves and resources. In terms of size the biggest reserves and resources in the EU28 are currently located in Poland and Sweden.

Gold reserve and resource grades within the EU28 follow along a similar trend as those for copper. Precious metal (gold and silver) reserve and resource grades are higher than most other countries in this study. Base metal grades, which are by-products in these mines, are also higher than average. This grade trend in EU28 is largely a result of reserve and resource grades in Romania and Greece, which make up about three quarters of the total EU28 reserve and resource base. Greece has notably higher base metal by-product grades in its precious metals deposits than in the equivalent deposits in most other countries. Comparable grade trends can also be seen from reserves and resources in Bulgaria and Spain, although from much smaller total reserves and resources.

Nickel reserves and resources in the EU28 are far less impressive in terms of grade than either copper or gold. They are lower grade in terms of nickel and additional base metals compared with other countries looked at in this study, and are comparable to most other countries in terms of precious metal content. All the countries' precious metal grades of nickel reserves and resources looked at in this study are dwarfed when compared

with Russian reserves and resource, mostly held by Norilsk Nickel, which contain significant amounts of palladium and platinum.

Although the grade of EU28 nickel reserves and resources is not particularly notable, the size of total EU28 nickel reserves and resource is far more comparable to those of other countries looked at in this study than those of copper and gold. The biggest contributing country to total EU28 nickel reserves and resources is Finland with less significant, but still sizeable, contributions coming from Sweden and Greece.

Lead/Zinc reserves and resources in the EU28 are relatively average base and precious metal grades when compared with those in other countries in this study. Much like nickel, the total reserve and resources in the EU28 is more comparable to those countries with the largest lead/zinc reserves and resources. The largest contribution to lead/zinc reserves and resources in the EU28 is Spain, closely followed by Poland and Sweden.

The by-product credits that can be achieved at a mining operation is almost solely dependent on the metal contained within the deposit that is being mined and whether this metal can be successfully extracted or not based on the characteristics of the material. The reserve and resource data of deposits within the EU28 shows that they tend to have higher than average primary metal and by-product grades for copper and gold whilst nickel and lead/zinc deposit grades are average when compared with reserves and resources in other countries. Although these factors cannot be controlled, the prevalence of some of these deposit types within the EU28 can be seen as advantageous when comparing to other parts of the world.

2.2. Total weighted average costs

Table 3 depicts the total weighted average scores given to each cost category for mines operating in the EU28 and non-EU countries. A lower score (green) indicates lower category costs, while a higher score (red) indicates a higher category cost. The scoring indicates that no single country or region is competitive across all categories; this is the nature of the mining sector. The combination of each cost category depicts the 'optimal' solution for the costs in each country. Depending on the orebody, reagent and by-product costs will be unique to each country.

Generally, the EU28 cost categories place it in the mid-range of the scores given, ranging from 44 to 60. Labour costs, as expected, are on the higher side. This is balanced on by-product credits, which are towards the lower end of the spectrum.

Table 3 - EU28 & non-EU scores for all cost categories (2015)

	Labour	Energy	Reagents	TCRC	Royalty	By-product
EU28	**70**	**44**	**59**	**53**	**60**	**31**
South America						
Argentina	98	76	86	69	91	17
Brazil	65	50	55	63	32	53
Chile	64	50	55	32	14	80
Peru	43	47	28	43	57	67
Venezuela	20	60	100	70	22	100
Asia Pacific						
Australia	82	28	36	58	58	50
China	39	25	54	57	86	100
India	18	27	18	82	100	82
Indonesia	42	71	70	45	70	17
Mongolia	55	75	90	30	90	20
PNG	84	88	100	80	34	32
Philippines	42	95	48	50	55	33
Turkey	59	26	32	82	63	55
Africa						
Botswana	44	88	100	100	69	29
Burkina Faso	11	100	25	32	43	100
Dem. Rep. Congo	21	81	72	5	45	70
Ghana	46	68	50	18	61	70
Guinea	57	82	79	57	93	100
Namibia	36	91	45	9	50	100
South Africa	46	42	58	35	88	20
Tanzania	75	71	14	82	57	44
Zambia	20	20	75	70	80	100
Zimbabwe	94	31	24	94	31	93
North & Central America						
Canada	85	51	30	79	36	49
USA	62	37	51	27	33	83
Mexico	27	51	42	36	26	60
Central Asia						
Kazakhstan	70	10	5	100	30	65
Kyrgyzstan	21	18	4	71	100	65
Russia	44	11	10	43	62	27
Ukraine	10	40	50	80	89	100

Source: SNL Financial (2016)

Labour scores highest, at 70.0, indicating that labour costs at EU28 mines are higher than most mines operated elsewhere in the world. This is mainly a result of the relatively high wage rates payed to employees at EU28 mines compared with many other countries and the mining techniques used to extract ore at mines in the EU28, which is dictated by the characteristics of the orebodies being exploited. This cost cannot be easily reduced as both wage rates and orebody characteristics are generally fixed based on the economic situation of the country of operation and type of orebodies that are present in the region. However one way to lower this cost is to improve productivity per employee at mine sites. The current trend towards automated equipment in mining operations would be one area that could be investigated to potentially reduce the labour cost component of mining operations within the EU28.

Energy also scored relatively low, at 43.5, as a result of mines in the EU28 having access to reliable, cheap electricity as a result of the good infrastructure in the region allowing most mines to link to national grids. The other factor effecting energy costs is consumption rates of both electricity and fuel. However, these are effectively fixed based on the type of equipment being used and therefore cannot be manipulated to lower energy costs notably. Future increase in energy prices, associated with carbon emissions permit, have not been factored into this study.

Reagent and other and TCRC, Shipment and Other Offsite costs score similarly at 58.8 and 52.7 respectively for similar reasons. Both costs benefit from mines in the EU28 having access to good infrastructure, particularly transport links, which allow for cheaper transport costs of materials and chemicals into the mine sites and the mines products out of the mine sites.

The TCRC, Shipment and Other Offsite cost component score is adversely affected by other countries using processing techniques which substantially lower this cost component and also several gold mining operations in the EU28 using processing techniques which substantially raise this cost component compared to mines operated in other countries. Although the gold mines operating in the EU28 may be able to optimize their processing to reduce this cost, most of the time processing techniques are dependent on the type of ore present therefore changes in this respect are likely not possible to any significant degree to reduce this cost.

Royalties and Production Taxes scored 59.7 meaning that most countries in the study are more competitive in terms of this cost. However, this is heavily influenced by the current mining tax that is in place in Poland and reducing this would have a substantial impact on lowering this overall cost for mines operated in the EU28. It should be noted that other countries in the EU28 appear to have low royalty and production taxes for mining, of particular note is Finland and Sweden where these are currently zero.

By-product Credits are most favourable for mines operated in the EU28. As described earlier, this is as a result of the prevalence of copper and gold mines operating within the EU28 exploiting deposits that contain higher concentrations of by-product metals than elsewhere in the world. This cost component is solely down to what deposits are in the EU28 countries and cannot be adjusted or improved upon by human influence.

In conclusion, none of the various cost elements constitutes a major problem for the competitiveness of the EU mining industry. Most important, there are no obvious policy measures that could easily be taken to improve cost competitiveness.

2.3. Operating margin

The difference between the operating cost of a mining operation and the price received for the mined product is the operating margin. This margin plays a fundamental role in deciding whether a particular mine is economically viable or not. Mines that produce their metal at a higher cost than they can receive for their product are operating at loss and are therefore liable to closure. Exceptions to this may be where a mine is in

the ramp-up phase, where high costs and low production leads to high costs per unit of metal. Once full production is reached, the cost per unit of metal drops to a more sustainable level simply because of higher metal production.

There are also instances where the operation's circumstances are expected to improve, for example by the extraction of higher grade ore in the near future. Another exception may be where a mine is kept operational in the anticipation of metal prices increasing in the future with the operator not wanting to incur the closure/re-start costs of an operation in favour of keeping the mine operational and awaiting higher metal prices, or where the operator is content with getting some contribution towards covering capital costs.

To illustrate the operating margins for EU mines, we constructed a global cost curve and plotted it against the metal price for that year. Analysis for copper and zinc is provided here, given these are the major minerals mined in the Member States. Iron ore has been excluded from this analysis as the price received for the iron products from each mine varies depending on its specifications and on transport costs to clients. The analysis is limited to operating costs and margins; any additions to operating costs, capital expenditure on the mine, corporate overheads and corporation are not included here, although they affect the profits of any mining operation.

Figure 12 shows the global operating cost curves (inclusive of by-product credits) for primary copper, zinc, gold and nickel, in 2015. The area under the curve represents production from various countries, with the EU28 production level marked separately. For copper and zinc the EU28 production is towards the lower levels of the global operating cost curve, while for nickel and gold, the EU production tends to be towards the higher end of the cost curve. The horizontal line depicts the average price for the metal in that year. Therefore, the gap between the global cost curve and the price is the operating margin. The larger the gap, the higher the operating margin.

The EU28 are well placed on the copper, gold and zinc curves, with healthy operating margins. For nickel, EU28 operating margins are very small. Russia is a major nickel producer and has much lower costs for production. The left hand side of the figure is dominated by Russia, where nickel (with by-product credits) is often produced in multi-metallic mines, therefore lowering the costs of extraction for one particular metal.

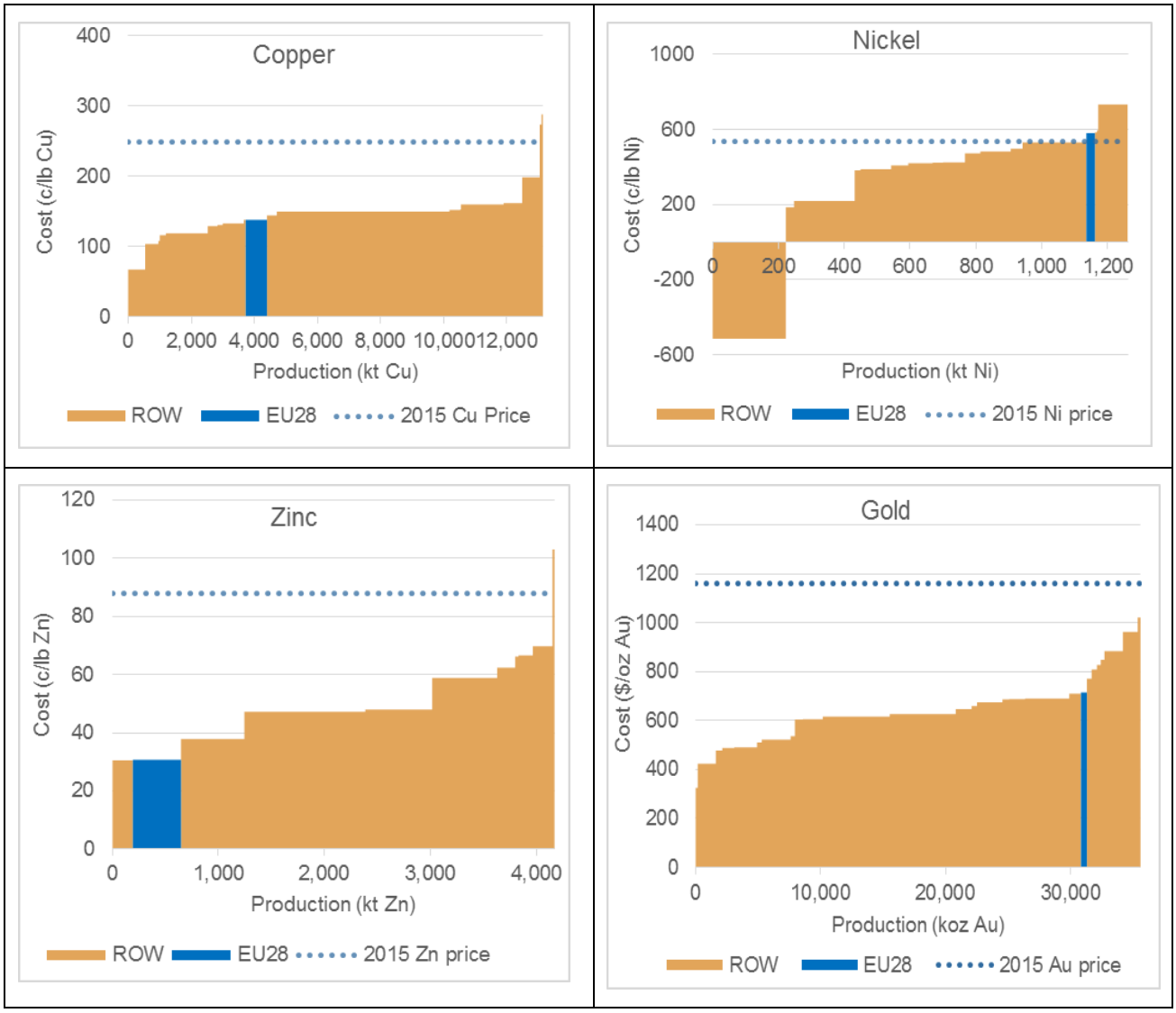
Based on the findings of this section, the EU28 can take several steps to encourage and promote mining investment in the region. Continued investment in reliable and low-cost electricity sources will help to maintain and possibly improve the competitive advantage in energy costs currently enjoyed by mines operating within the EU28 compared to those operating in areas that lack this infrastructure.

Member states can be encouraged to ensure that royalties and production taxes are competitive when compared to those implemented in other countries and that they do not excessively impact the costs of mining operations. Encouraging investment in new mining technology such as automation of mining equipment could help EU based companies and mining operations gain a competitive edge and make certain operations more attractive to investors. This can help drive both mining equipment manufacturers in the region as well as potentially leading to lowered labour costs as a result of mines operating in the EU28 adopting the new equipment developed in the region.

To promote mining investment, the EU28 should promote that mines operating in this region have access to excellent infrastructure. Particularly they have access to good transport links (road, rail and sea), cheap and reliable electricity, and multiple smelter/refineries within the region and population centres to recruit workers. Most, although not all, Member States also have favourable royalty and production tax systems in place. Finally, although smaller in total size of reserves and resources than many countries, average reserve and

resource grades for copper and gold deposits are higher in both primary and by-product metals than in many other regions of the world.

Figure 12 - Global operating cost curve, production and price (2015)



Source: SNL Financial (2016)

3. Regulatory framework competitiveness

To assess the regulatory framework, the research team utilised the scoring for mining jurisdictions provided by MineHutte, a legal research group that assess different mining jurisdictions based on their regulations and technical reports submitted by companies. The MineHutte framework allows for an assessment based on the same indicators and views regulations from the point of view of an exploration/mining company rather than governance. Therefore, the scores provided reflect how investors are likely to assess a jurisdiction. The framework is presented in Table 4.

Table 4 - MineHutte regulatory assessment framework

Category	Glossary	Examples of Excellence	Maximum Score
Open Access	Measures the ease of acquiring exploration rights and the 'openness' of the system to foreign, junior and other participants.	Freely open to first applicant.	10
Exploration Exclusivity	Measures the extent to which the exploration rights are exclusive to the holder, including undiscovered minerals.	Exclusive rights giving holder right to all minerals.	10
Exploration Duration	Measures the ability of a holder to retain exploration rights through a minimum exploration period.	Absolute right to keep exploration rights by performing work.	10
Right to Mine	Measures the ability of the explorationist to acquire mining rights (as well as environmental permits).	Explorationist awarded mining rights when discovery of resources; EIA process subject to clear timelines, objective tests and court appeals.	15
Tenure Certainty	Measures the ability to fully extract resources from a mine and the right of access.	All surface rights included in 25 year mining lease that is renewable on application.	15
Economic Certainty	Measures the discretion of government to interfere with economics operationally and on an exit strategy.	Fixed royalty rates; general corporation tax; no consent on sale; stabilization guarantees.	15
Regulatory Certainty	Measures the stability of the regulatory framework.	Regular changes to the mining legislation to constantly modernise its administration.	10
Other Factors	Measures all other aspects of the regulatory framework both positive and negative.	No obligation to operate any differently than a general corporate participant within the country; well-drafted legislation and regulations.	15
MineHutte Score	Measures the risk that an investor or operator will lose the economic benefits of a mineral discovery, based purely on the mining regulation		100

Source: MineHutte (2016)

3.1. Regulatory assessment benchmark

In this section, 13 Member States were evaluated as they account for the majority of the mineral production for the EU. Of these countries, the highest-scored jurisdiction was Sweden and the lowest score was awarded to Poland. Most Canadian jurisdictions scored higher than 80, with Australian jurisdictions scored somewhat lower (Figure 13).

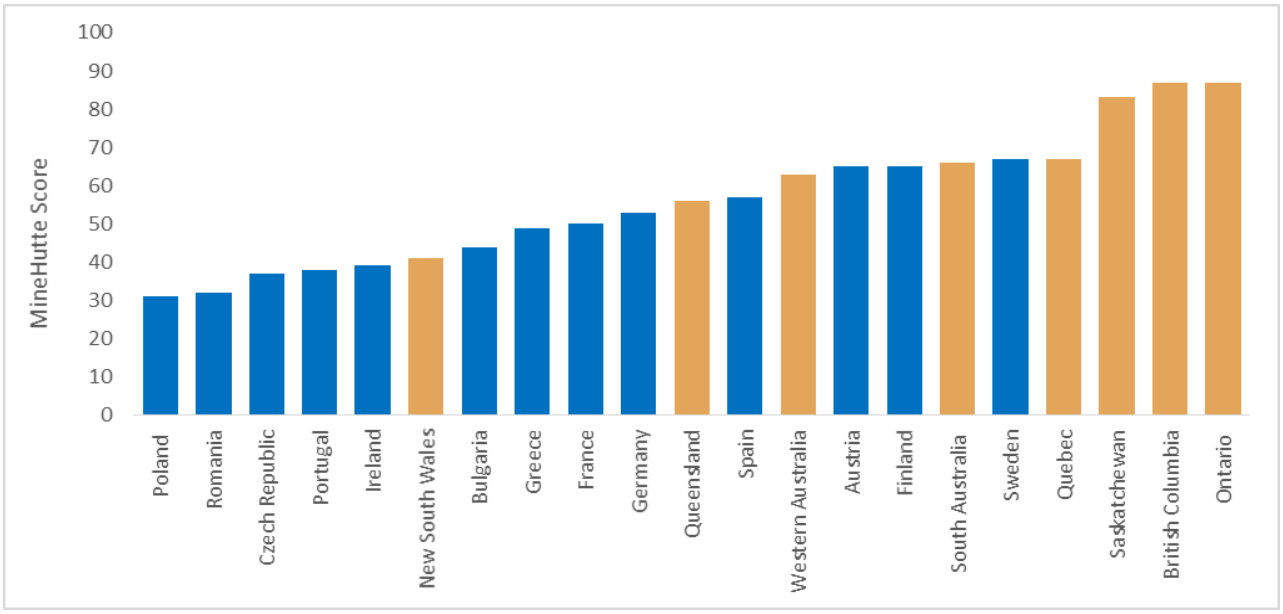
As mentioned earlier, investors tend to examine a country's attractiveness in relation to another country. This section, therefore, looks at the performance of the EU13 countries relative to Australian and Canadian jurisdictions, which would be expected to have comparable regulatory systems and practices, given similarities in political institutions and education level.

Figure 14 compares the EU13 Member States with these regions, and provides a relative assessment of their scores in specific sub-categories. Green indicates a Member State is the top one third of countries covered and therefore considered attractive from an investor's point of view when it comes to mining regulations. Yellow indicates they are in the middle, while red represents placement in the bottom third of the assessment.

Countries in the red category are likely to be considered unattractive relative to other countries in that particular assessment category.

Overall, the EU countries tend to have more reds than greens, when compared with non-EU jurisdictions. This appears to be in contrast to the Fraser Institute Policy Perception Rankings (presented in Table 2). One of the major reasons for the discrepancy is that the first is based on perception, while the second is based on a review of the regulatory and legislative documents. The discrepancy may also reflect a largely positive view of how regulations are applied in practice in the EU.

Figure 13 - Mining regulatory framework scores (2016)



Source: MineHutte (2016)

Figure 14 - Mining regulations assessment comparison

	MH Score	Open Access	Exploration Exclusivity	Exploration Duration	Right to Mine	Tenure Certainty	Economic Certainty	Regulatory Certainty	Other Factors
Austria	🟡	🔴	🟢	🟢	🟡	🟢	🟡	🔴	🟡
Bulgaria	🔴	🔴	🟡	🔴	🟡	🟡	🔴	🟢	🟡
Czech Republic	🔴	🔴	🔴	🟡	🟡	🟡	🟡	🔴	🟡
Finland	🟡	🔴	🟢	🔴	🟡	🟡	🟡	🟢	🟡
France	🟡	🔴	🟡	🟡	🟡	🟡	🔴	🟢	🟡
Germany	🟡	🔴	🔴	🟡	🟡	🟢	🔴	🟢	🟡
Greece	🔴	🟡	🟢	🔴	🟡	🟡	🔴	🟢	🔴
Ireland	🔴	🔴	🔴	🔴	🟡	🟡	🔴	🔴	🟡
Poland	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🟢	🔴
Portugal	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🟢	🟡
Romania	🔴	🔴	🟢	🔴	🔴	🔴	🔴	🔴	🔴
Spain	🟡	🟡	🔴	🔴	🟡	🟢	🔴	🟢	🟡
Sweden	🟡	🟡	🟡	🟡	🟡	🟢	🟡	🟢	🟡
British Columbia	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡
Ontario	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟡
Saskatchewan	🟢	🟢	🟢	🟢	🟢	🟡	🟡	🟢	🟡
Quebec	🟡	🟢	🟢	🟢	🟡	🟡	🟡	🟢	🔴
South Australia	🟡	🔴	🟢	🔴	🟡	🟡	🟡	🟢	🟢
Western Australia	🟡	🔴	🟡	🟡	🟡	🟡	🟡	🟢	🟡
Queensland	🟡	🔴	🔴	🔴	🟡	🟢	🟡	🟢	🟡
New South Wales	🔴	🟡	🔴	🔴	🔴	🟡	🔴	🟢	🟡

Source: SNL calculations based on MineHutte data (2016)

Austria

Austria is a one of the better-scored jurisdictions amongst the EU13 countries. The mining code for the country was promulgated in 1999 and the Environmental Impact Assessment (EIA) act dates from 2000. The legislation is considered supportive of exploration and development activities. The country is considered to offer stable regulations on the tenure and economic certainty. If mining activity is to be conducted on privately held land, the permission of the land owner is required. The provisions around the right to mine could be improved, as a subjective criteria is used for the granting of a mining license. There are no royalty rates on production, but an annual fee per license is required.

Bulgaria

Bulgaria's mining code was promulgated in 1999, with significant amendments made in 2010. Mining is largely conducted under a 'concession agreement', allowing the state to negotiate a number of different aspects individually with an investor. These include financial terms as well as terms for terminating the contract. By law, the concession agreement must also address the training and creation of jobs by the investor.

Bulgaria is scored poorly on open access and exploration duration. Prospecting and exploration permits are granted to entities that are nationals of the country, with international investors required to be registered as traders. It has mid-tier scoring for exploration exclusivity, the right to mine, tenure and economic certainty. The country does score extremely well on regulatory certainty.

Czech Republic

The Czech Republic is one of the lowest/worst scoring countries in the EU13. Open access, exploratory exclusivity, regulatory certainty, exploration duration were all poor scoring categories. The country's performance in exploration duration, the right to mine, tenure and economic certainty were scored in the medium range. The state has the right to reject exploration/mining applications if it considers the activities against its policies on raw materials or the environment and/or its international commitments. The state can also decline an application if it considers this against the country's defence, or believes public interest outweighs the exploration/mining activity. The state retains the option of pursuing a 'special mining claim' over licenses, which increases the risk of the state being able to intervene in any project, if it chooses. The right to mine, awarded to an investor, needs the approval from the Ministry of the Environment as well as consultations from the Ministry of Trade and Industry.

MineHutte's analysis suggests that the regulatory regime in the Czech Republic would certainly benefit from the consolidation of the various pieces of legislation into a single code. It has been described as workable but not without considerable burdens being borne by the investor/miner.

Finland

Finland was one of the best scoring countries in the EU13. The legislation recognises the "first-come, first-served" principle and minor prospecting activity does not require an exploration permit. The land owner, in case of privately held land, can refuse the rights to his property. The state can refuse a license application if it considers the applicant to not meet its financial and technical competency standards/ third parties, by law, are allowed to raise objections against the granting of permits and licenses. There are no mining royalties in Finland, although an annual compensation fee must be paid to land owners of privately held land.

The legislation lays down specific requirements for consultations, where indigenous people may be affected. These consultations are part of the permit application. Where there is a conflict over the rights between the investor and the indigenous people, preference is given to the latter.

MineHutte's analysis suggests that the Finnish legislation is generally straightforward, comprehensive, well drafted and largely tends to support exploration and development activities. Specific requirement for restoration after mining activity has come to an end is also include within legislation.

France

France is in the lower part of the middle tier of the EU13 countries assessed. The Mining code was last amended in 2011 and a draft code was issued for public comments in 2015. The code requires the company to conduct mining in an economically prudent manner, subject to environmental and other concerns. While this may appear to be a positive, it does leave open the possibility for the state to intervene in mining operations, if it chooses to do so. The French regulation is considered highly unsatisfactory in the open access category and the right to mine is not provided by the mining act. The principle of "first-come, first-served" is not included in the Mining Code. Royalty rates are payable and are fixed when the mining concession is awarded.

MineHutte expected France to produce well-drafted laws and regulations and the Code Minier and its accompanying regulations is no exception; it is very comprehensive in covering innumerable chapters of discrete content, but clear and concise in presentation.

Germany

Germany scores 53 out of 100, and so is in the middle of the EU13 countries assessed. The Federal Mining Act dates to 1988, but has been amended and updated on a regular basis. The latest amendments were in 2012. The legislation is dense and detailed, addressing multiple aspects within one single code. The regulatory framework tends to score very low on open access and exploration exclusivity and on economic certainty categories.

The principle of "first-come, first-served" is not contained within the German legislation in relation to exploration rights. Instead, according to the Federal Mining Act (FMA), providing none of the grounds for refusal are met, the work program which is deemed to offer the best plan for efficient and meaningful exploration shall be given priority. Royalties are applied to mineral production, based on the market value of the mineral. Where market values are not available, the authorities can set the royalty rate license holders are required to pay.

Greece

Greece performs well in the exploration exclusivity category and regulatory certainty. Compared with other countries in EU13, it also does well in open access. The mining code was created in 1973, with mining amendments made as recently as 2012. The mining regulations are from 2011. Greece follows the "first-come, first-served" principle in grant exploration licenses. There are restrictions on applications from non-Greek or non-EU nationals (does not apply to legal persons), for exploration license applications. Royalty is applicable on production and is set by the legislation (amended in 2012). The government also has the legal right to place a 'compulsory sales obligation' on a mining company, requiring a certain amount of its production to be to be sold to the Greek metallurgy industry.

MineHutte's assessment of the Greek Mining Code suggests it is fairly advanced for a piece of legislation that was written in the early 1970s. There are extensive appeal rights for the license and mining concession holders. However, there are restrictions on foreign (non-EU) parties on certain matters (such as transfer of licenses/concessions). MineHutte also treats with some caution the ability of the Minister to impose conditions on concession and licence holders on public interest grounds, particularly where failure to meet such terms can result in the loss of rights.

Ireland

Ireland scores only 39 out of 100, which is surprising given its high award in the Fraser Institute's Annual Mining Survey. The low score largely relates to inadequate regulations addressing exploration exclusivity, exploration duration and regulatory certainty. The mining code is dated 1999, with a new draft likely to be brought into force in 2017. The "first-come, first-served" principle is followed (through guidance notes rather than legislation). Application fees for licenses (State Mining Facility) are clearly stated in the legislation, but royalty payments are negotiated on a case by case basis.

In its assessment of Ireland, MineHutte considers the country to be (apart from a few exceptions) encouraging and supportive of the mining sector. The one area of concern is the numerous instances where government discretion is allowed, which will hopefully be reduced in the 2017 mining code.

Poland

Poland's mining code is dated 2011, with considerable amendments made in 2014 and 2015. The low scores are attributable to the legislation largely lacking adequate security for companies on almost all categories, from open access to exploration exclusivity and duration and tenure certainty. Only regulatory certainty scores well,

given that the current mining code was enacted in 2011 and is hence considered up to date. The mining legislation includes numerous provisions on environmental protection (such provisions are normally covered under the environmental protection act). The EIA, although, is governed by the EIA Act.

The legislation is considered, in some cases, to be extreme in regulating unimportant issues such as establishing minimum tonnes that must be extracted from a concession. There are broad discretionary grounds for cancelling a concession.

Portugal

Portugal is at the lower end of the ranking for the EU13 countries assessed. The current law dates from 2015. From open access to exploration exclusivity and duration, right to mine, tenure and economic certainty, the country is assessed at the lower end. The "first-come, first-served" principle is not explicitly stated in the law and exploration rights can be awarded through an application or tendering. There is a fair level of government discretion in regulating the mining sector as well as government approval required. For instance, the decision to suspend operations needs to be approved by the state. In MineHutte's assessment, apart from certain negative points, the legislation is concise and appears to be well-drafted.

Romania

Romania is scored as one of the least attractive countries in terms of mining legislation and regulations. The mining law dates from 2003, with minor subsequent amendments. Apart from exploration exclusivity, it has been assessed to be on the lower end of all the other categories under the framework. Royalty and tax rates are prescribed under the legislation. MineHutte, in its assessment, finds the Romanian law to be short and concise, with many aspects provided under other orders and decisions. The environmental regulations are also found in a different number of government orders, laws and regulations.

Spain

Spain scores well in the tenure certainty, regulatory certainty, as well as under open access. The last substantial amendment to the mining code was in 2009. Royalty and taxes are set in regulations. The 2009 amendments removed any discrimination against non-nationals and the "first-come, first-served" principle is applied by the law.

Sweden

Sweden is one of the leading scorers of the EU13. The mining code dates to 1992, with amendments made as recently as 2014. For all categories included in this framework, apart from right to mine and economic certainty which get medium scores, all others are scored highly. The assessments for regulations offer an overview of the current state of the major mineral producing countries in the EU. Since each mining project tends to be distinct, this report now presents the case of Strongbow Exploration Inc., a Canadian company, which acquired a brownfield tin project in Cornwall (United Kingdom) in 2016.

3.2. Policy and investment attractiveness

Most exploration for new mineral deposits is carried out by ‘Junior’ companies. These companies look for new deposits, not with the intention to mine, but to instead sell their discoveries to major companies that have the technical and financial resources to develop them. There are thousands of Junior companies active in exploration, most of them very small and exploring only within a small area in one country. They have traditionally raised funds on the stock exchanges of Australia, Canada or London. Many such companies fail

to find economically-viable projects but these companies need to be encouraged to identify deposits that can be developed.

The Juniors are active in virtually all countries that allow foreigners to own, and trade, mineral titles. A simple process for the transfer of these mining titles is necessary for the system to work efficiently. The exploration companies tend to concentrate in countries that are considered to have favourable geology, and that have mining regimes that are attractive to foreign investors (since it would make little sense to explore in countries where the geology is unfavourable or where a find is unlikely to interest any buyers). Accordingly, of two countries with similar geology, the one with the more attractive investment regime will receive more exploration interest. In order to understand the magnitude of the effort involved, it should be noted that the likelihood of any particular mineral occurrence that has been investigated actually becoming a mine is very low. The probability of a greenfield exploration project resulting in an actual mine has been estimated at between 1 in 1,000 and 1 in 3,333[5].

Once an interesting deposit has been sold to a larger mining company, the new owners will make their own evaluation of its commercial viability. If the project appears to meet the company's requirements, a full feasibility study will be carried out. At any time, most large mining companies have a portfolio of prospects to be developed.

The objective of building a portfolio of mining assets is to ensure that the company can maintain a stable, or growing, production and profit, and that it is always able to select from a range of project types and locations. The assets in the portfolio have usually been selected on the basis of the company's technical experience and financial resources. For instance, one company may focus on large iron ore deposits costing billions of dollars to develop, while another may emphasize medium-sized base metal deposits that are cheaper to develop but more challenging from the metallurgical aspect.

A company will choose which deposit in its portfolio to develop based on whether the internal rate of return (IRR) of the project meets the company's minimum threshold and the risks associated with the project. Changes in legislation that lower the IRR will thus result in projects in the country concerned being moved lower in the list of projects to be developed and at least delayed, possibly cancelled, while changes that raise the IRR will move the projects concerned higher up on the list.

Accordingly, it is reasonable to expect that the likelihood of any particular deposit being exploited is strongly dependent on the tax regime and other elements of the investment environment. Changes in this environment will thus result in increased investment interest and eventually, usually after several years, in an operating mine. There are abundant examples of changes in the investment regime leading to new mines, as for instance in Tanzania, where efforts to attract mining investment through changes in financial legislation and a new mining law in 1997/1998 resulted in the opening of six new gold mines during a ten year period[6], or in Sweden, where a new mineral law in 1992 led to a dramatic increase in the number of applications for exploration[7] permits and, a few years later, in a reversal of a declining trend in mining employment.

3.3. Case study - Strongbow Exploration Inc.

Strongbow Exploration Inc., a Canadian exploration company, has since mid-2016 been developing the South Crofty tin project in Cornwall, U.K. Cornwall has a long history of mining, dating back to between 1000 and

[5] Kreutzer and Etheridge (2010)
[6] FDI in Tanzania increased from USD10 million per year in the early 1990s to more than USD500 million in the early 2000s, with about two thirds of this going into mining (ICMM, 2009).
[7] Crucial changes in the new law included an end to a ban on foreign ownership of mining titles and the abolition of a right for the government to acquire half of any new mine.

2000 B.C. The mining area in the region was selected as a UNESCO World Heritage Site in 2006 (Cornish Mining, 2017).

Celeste Mining Corp. (Canada), and more recently the U.K-based Cornish Minerals Ltd, have previously attempted to develop the project. However, due to poor market conditions, these attempts were unable to bring the mine into production and the project was put into administration in 2013. Between 2001 and 2013, over GBP 30 million (USD37 million) has been invested in the project. Strongbow's acquired Western United Mines Ltd. and Cornish Minerals, which held the rights to the project area in 2016. Given that restarting the mine required intensive capital commitments, the acquisition cost to the company was comparatively low – CD200,000 (USD148,000).

In February 2017, Strongbow released a successful Preliminary Economic Assessment (PEA) demonstrating the project is economically and technically viable. The company is currently working to secure environmental permits and conduct necessary pre-production activities, including dewatering the mine.

Richard Williams, CEO of Strongbow Exploration, explained that with recent improvements in the tin price, the company had been looking for brownfield tin assets that could be quickly developed into production. Locating a suitable asset in a "safe jurisdiction" was a plus. The company was attracted to this particular project by the work that had already been undertaken by the previous owners. The project had already secured a mining permit, valid until 2071, as well as planning permission to construct a processing plant on site.

With previous work experience in North America, the company was initially hesitant to work in the U.K. As a junior mining company, Strongbow would consider developing a greenfield project in the U.K as high risk. In particular, the private mineral ownership system operated in the UK could act as a considerable barrier to entry for a junior company. Under the private mineral ownership system, mineral rights are privately held by the land-owner, rather than being held by the state, as is common in most mining jurisdictions globally. As a result, the time and resources required to secure permission from every relevant private entity would make a project unattractive. Had a mining permit not already been secured for the project, Strongbow would perhaps have not given this project a high priority in its investment portfolio.

Mr Williams' noted that his team were encouraged by the success Wolf Minerals and Sirius Minerals have had in developing projects in the country. In particular, the public and local government support that Wolf Minerals received in the development of the Drakelands mine (a world class tungsten mine also located in the south west of England) reassured Strongbow Exploration of the viability of developing a similar project. Drakelands, has recently completed construction and entered into production.

The case of Strongbow raises some interesting issues around the mining attractiveness of Member States. First, geology is important. The selected project is located in a well-explored area and the resources and reserves are well identified. Second, the experience of others is an important indicator of success. The positive government support received by Wolf Minerals was an important consideration for Strongbow in its investment decision. Third, the support from the local community is essential. In this case, both the local community and the local council were supportive of the mining company's planned investment, de-risking the ability to gain a social license to operate.

A fourth factor was the support from the environmental agency. The project's success is heavily reliant on the ability to de-water the old mine, which can have significant environmental impacts. The willingness of the environmental agency to work with the company to address mitigation measures, rather than act as a regulator only, reassured the investors of the feasibility of the project. A partnership rather than an adversarial approach in this matter was helpful in ensuring the investment went ahead.

Finally, support from the U.K government's Department of Trade and Industry in making business introductions and locating sources for funding was a positive factor in the company's decision to invest in the country.

4. Conclusion

In the introduction, this report set out two main questions. First, despite the positive policy perceptions, why have the EU Member States been unable to attract more exploration spending, relative to other jurisdictions? Second, why has the investment attractiveness of the Member States lagged behind policy perception?

The difference between the EU's institutional and overall level of attractiveness must logically flow from the fact that its geology is not thought to be so good. It is hard to generalise about comparative geological prospectivity, but economies of scale are an important factor in low-cost mining. Unfortunately, the EU does not appear, for whatever reasons, to have large low-cost resources, such as those found in Western Australia (for iron ore), in the Andean Cordillera (for copper) or in North Africa (for phosphates). This lack of scale may also be a factor in the EU's relatively low ranking for labour productivity.

Nevertheless, the real damage to the performance of the EU countries in attracting exploration and mining investment seems to centre on the difference between the perception of policy and mining industry's perception of its implementation, as addressed in 4.1.

4.1. Perception of policy and of its practical implementation

Policy perceptions are often based on the public images created, whether through a concentrated effort by states to promote their mining sectors, or by the sharing of experiences of operating companies. It is not a surprise that most EU jurisdictions score well in this category; the region is politically and economically stable, where space for private enterprise and regulations are generally considered to balance the concerns of companies and communities.

The disappointing performance in terms of translating these perceptions into increasing exploration budgets and mining investments, however, suggests there is a gap between perception and practical implementation. The analysis in section two on operating costs argues that Member States are not unduly hindered by the cost of wages, electricity, royalty and taxation and other mine-site costs. In fact, for copper, gold and zinc/ lead they are relatively competitive on the global benchmark. However, in the case of mineral regulations, most Member States are rated poorly relative to their competitors.

Within the regulations, one of the fundamental determinants of investment activity is the security of tenure and securing the right to mine. The more complicated the process in securing these rights, the less interest from potential exploration and mining companies. There are a number of Member States where the right to minerals is held by private individuals, rather than the state. This impacts the ability of exploration or mining companies to gain access to land, often involving the risk of such negotiations failing.

In terms of licenses, very few Member States clearly state the principle of "first-come, first-served". This is generally accepted, internationally, as best practice when it comes to the granting of exploration and mining licenses. It can be argued, however, that, properly implemented, a focus on the best work programme is preferable. This will be discussed in subsequent STRADE reports.

As the Strongbow Exploration case indicated, the presence of an existing mining license was one of the strongest drivers of their decision to invest in the UK. In other cases, the ability to transfer licenses, without government approval (instead of government oversight) is considered a hindrance by investors.

While this report has not attempted a full comparative analysis of mineral legislation in EU Member States, the score card in Figure 14 indicates that the comparative performance of the EU13 countries is weak on a number of regulatory fronts, at least from an investor's point of view.

It is clear that several EU countries fail to observe two of the most fundamental principles of good mineral governance. First, too many EU countries do not observe the "first-come, first-served" rule. Second, they do not ensure the right to exploit a new deposit provided other regulatory conditions are met. It is likely that these countries fail to apply these basic principles because the allocation of mining rights is seen as an opportunity to practice discretionary industrial policy by specifying particular operators or conditions.

This belief, which is often based on the erroneous assumption that mining investors are captive, is mistaken since there are very seldom any alternative operators. It introduces uncertainty, which deters investors by making it difficult for exploration companies to raise finance and commit to investments. Moreover, any conditions, particularly as concerns the environment, should be covered by clear legislation that allows investors to anticipate expenditure as far as possible, and not be subject to negotiation at the time of the award of the mining title.

Moving regulations toward stronger protection of the right to mine is potentially the most important measure available to strengthen the EU's competitiveness in mining. It would also remove the most important cause of conflicts and bad compromises between mining and other interests.

The gap between perception and implementation is difficult to bridge in the EU. Member States retain sovereignty over their mineral resources, and an EU-wide directive on this issue would be difficult to pursue in the short to medium term. Nor would this research team recommend such a step as the rights over mineral resources should remain the domain of individual governments. However, this does not preclude the idea of mutual agreements between the EU and its Member States to promote specific mining projects. Nor should it preclude a gradual harmonization of regulatory systems, which would attract exploration interest, as shown by, for instance, the harmonization of regulations among West African countries. This concept will be addressed in later deliverables under the larger STRADE research project.

4.2. How do you increase competitiveness?

The STRADE project, over the 2016-2018 period, is exploring ways to support the raw material needs of the EU, based on a strategic dialogue. There are a number of parties to this dialogue, the European Commission, the Member States, non-EU resource rich partner countries in Africa and Latin America. Within these countries are mineral exploration and mining companies, government officials, as well as other stakeholders such as development actors and civil society.

This report is the start of designing an agenda for a dialogue that can lead to increased mining investments in the EU. Its purpose was to present an evidence based assessment of the state of the EU mining sector. By examining two essential drivers of investment, the cost of production and the regulatory environment, we have a starting point. Future workshops under STRADE will start from the evidence generated in this report, and through a dialogue, formulate recommendations for the EU to increase mining competitiveness in its Member States.

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Annex 1: Cost breakdown by category and country

Labour costs per country (2015)

Country	Copper c/lb	Nickel c/lb	Lead/Zinc c/lb	Gold $/oz	Iron Ore $/t	SCORE
Argentina	84.1	-	-	310.8	-	98.2
Australia	60.4	98.2	17.8	261.9	28.7	81.9
Bolivia	-	-	7.3	-	-	9.1
Botswana	-	86.5	-	-	-	43.8
Brazil	51.2	108.9	-	257.3	6.9	65.4
Burkina Faso	-	-	-	99.1	-	10.7
Canada	56.4	170.4	46.0	296.6	14.7	84.6
Chile	36.3	-	42.4	398.0	14.3	64.1
China	-	-	-	169.1	-	39.3
Colombia	-	111.5	-	-	-	62.5
DRC	19.3	-	-	87.1	-	21.3
Dominican Republic	-	-	-	126.2	-	17.9
EU28	**49.1**	**62.8**	**26.8**	**329.9**	**13.4**	**70.0**
Ghana	-	-	-	178.6	-	46.4
Guatemala	-	-	-	250.4	-	64.3
Guinea	-	-	-	194.1	-	57.1
India	-	-	7.7	-	-	18.2
Indonesia	23.6	45.6	-	308.9	-	41.6
Kazakhstan	47.7	-	-	-	-	70.0
Kyrgyzstan	-	-	-	126.7	-	21.4
Madagascar	-	129.8	-	-	-	68.8
Mali	-	-	-	88.6	-	7.1
Mauritania	12.7	-	-	184.4	-	13.4
Mexico	16.4	-	37.0	133.1	-	27.4
Mongolia	38.9	-	-	-	-	55.0
Namibia	-	-	15.4	-	-	36.4
PNG	81.1	54.8	-	200.8	-	84.3
Peru	25.8	-	17.8	144.6	11.1	43.1
Philippines	36.2	19.2	-	-	-	41.9
Russia	-	148.9	-	155.3	7.1	43.9
South Africa	22.1	338.0	-	479.5	-	46.0
Tanzania	-	-	-	262.9	-	75.0
Turkey	45.8	-	-	149.8	-	59.3
Ukraine	-	-	-	-	2.5	10.0
USA	41.2	75.9	13.3	275.9	18.1	62.4
Zambia	19.1	-	-	-	-	20.0
Zimbabwe	-	172.8	-	-	-	93.8

Source: SNL Financial (2016)

Energy costs per country (2015)

Country	Copper c/lb	Nickel c/lb	Lead/Zinc c/lb	Gold $/oz	Iron Ore $/t	SCORE
Argentina	75.1	-	-	53.2	-	76.3
Australia	15.4	51.8	9.5	137.4	9.8	27.9
Bolivia	-	-	26.3	-	-	100.0
Botswana	-	181.4	-	-	-	87.5
Brazil	30.3	129.5	-	100.4	7.7	50.2
Burkina Faso	-	-	-	389.4	-	100.0
Canada	38.0	29.4	10.2	83.2	7.3	51.2
Chile	27.6	-	3.8	79.2	14.5	50.0
China	-	-	-	77.3	-	25.0
Colombia	-	117.7	-	-	-	75.0
DRC	45.4	-	-	187.4	-	81.0
Dominican Republic	-	-	-	40.1	-	3.6
Egypt	-	-	-	168.6	-	78.6
EU28	**21.4**	**205.0**	**10.3**	**88.3**	**12.8**	**43.5**
Ghana	-	-	-	140.3	-	67.9
Guatemala	-	-	-	83.6	-	42.9
Guinea	-	-	-	169.7	-	82.1
India	-	-	5.4	-	-	27.3
Indonesia	49.3	72.1	-	43.2	-	71.0
Kazakhstan	21.1	-	-	-	-	10.0
Kyrgyzstan	-	-	-	59.5	-	17.9
Madagascar	-	24.0	-	-	-	18.8
Mali	-	-	-	118.4	-	57.1
Mauritania	40.4	-	-	263.1	-	73.9
Mexico	27.3	-	9.7	156.7	-	51.0
Mongolia	43.5	-	-	-	-	75.0
Namibia	-	-	18.5	-	-	90.9
PNG	96.6	94.5	-	121.3	-	87.7
Peru	26.7	-	8.4	82.7	15.2	46.5
Philippines	99.3	51.2	-	-	-	95.0
Russia	-	8.1	-	57.0	6.7	10.8
South Africa	26.9	54.0	-	93.8	-	42.3
Suriname	-	-	-	293.2	-	96.4
Tanzania	-	-	-	146.7	-	71.4
Turkey	24.8	-	-	79.2	-	26.2
Ukraine	-	-	-	-	9.7	40.0
USA	26.9	24.0	5.4	72.7	11.4	37.3
Zambia	24.4	-	-	-	-	20.0
Zimbabwe	-	30.8	-	-	-	31.3

Source: SNL Financial (2016)

Reagent & other costs per country (2015)

Country	Copper c/lb	Nickel c/lb	Lead/Zinc c/lb	Gold $/oz	Iron Ore $/t	SCORE
Argentina	159.0	-	-	290.4	-	86.02
Australia	63.3	169.2	15.9	281.2	21.0	36.05
Bolivia	-	-	47.7	-	-	90.91
Botswana	-	385.7	-	-	-	100.00
Brazil	76.2	218.8	-	313.6	18.1	55.41
Burkina Faso	-	-	-	270.5	-	25.00
Canada	61.2	195.7	28.3	291.8	13.2	29.97
Chile	71.9	-	16.7	387.7	23.6	54.71
China	-	-	-	304.1	-	53.57
Colombia	-	200.8	-	-	-	52.94
DRC	106.8	-	-	280.7	-	71.76
Dominican Republic	-	-	-	317.0	-	64.29
Egypt	-	-	-	349.8	-	75.00
EU28	**75.3**	**271.4**	**26.3**	**281.3**	**21.8**	**58.80**
Ghana	-	-	-	303.6	-	50.00
Guatemala	-	-	-	512.7	-	96.43
Guinea	-	-	-	377.3	-	78.57
India	-	-	13.1	-	-	18.18
Indonesia	123.7	196.1	-	133.4	-	69.93
Kazakhstan	31.4	-	-	-	-	5.00
Kyrgyzstan	-	-	-	128.1	-	3.57
Madagascar	-	273.1	-	-	-	70.59
Mali	-	-	-	441.5	-	85.71
Mauritania	67.4	-	-	512.3	-	40.82
Mexico	59.9	-	83.6	460.7	-	41.56
Mongolia	144.4	-	-	-	-	90.00
Namibia	-	-	22.4	-	-	45.45
PNG	204.8	370.3	-	551.4	-	99.60
Peru	53.5	-	38.8	272.8	20.0	27.83
Philippines	72.3	276.9	-	-	-	47.54
Russia	-	58.5	-	186.5	10.5	10.43
South Africa	75.3	108.1	-	337.6	-	58.40
Tanzania	-	-	-	213.6	-	14.29
Turkey	69.5	-	-	246.9	-	32.05
Ukraine	-	-	-	-	20.3	50.00
USA	88.4	23.0	12.8	251.3	20.5	51.30
Zambia	102.5	-	-	-	-	75.00
Zimbabwe	-	109.8	-	-	-	23.53

Source: SNL Financial (2016)

TCRC, shipment and other offsite costs per country (2015)

Country	Copper c/lb	Nickel c/lb	Lead/Zinc c/lb	Gold $/oz	Iron Ore $/t	Score
Argentina	39.4	-	-	3.4	-	68.8
Australia	38.2	235.8	30.6	25.1	5.2	58.3
Bolivia	-	-	47.1	-	-	100.0
Botswana	-	287.2	-	-	-	100.0
Brazil	38.8	41.6	-	3.0	11.0	63.3
Burkina Faso	-	-	-	3.0	-	32.1
Canada	39.6	184.9	28.7	7.2	12.6	79.1
Chile	23.5	-	28.6	6.1	8.9	32.2
China	-	-	-	6.0	-	57.1
Colombia	-	1.2	-	-	-	5.9
DRC	18.3	-	-	1.8	-	5.4
Dominican Republic	-	-	-	3.0	-	17.9
Egypt	-	-	-	4.0	-	46.4
EU28	**35.7**	**107.0**	**30.6**	**242.3**	**7.0**	**52.7**
Ghana	-	-	-	3.0	-	17.9
Guatemala	-	-	-	1.0	-	3.6
Guinea	-	-	-	6.0	-	57.1
India	-	-	34.2	-	-	81.8
Indonesia	32.3	53.5	-	11.3	-	44.7
Kazakhstan	61.2	-	-	-	-	100.0
Kyrgyzstan	-	-	-	6.3	-	71.4
Madagascar	-	121.9	-	-	-	41.2
Mali	-	-	-	5.6	-	53.6
Mauritania	46.6	-	-	3.0	-	78.8
Mexico	25.3	-	29.9	25.8	-	35.5
Mongolia	28.3	-	-	-	-	30.0
Namibia	-	-	13.0	-	-	9.1
PNG	61.1	146.3	-	2.9	-	79.6
Peru	37.9	-	27.6	14.8	1.1	43.3
Philippines	37.3	137.9	-	-	-	49.8
Russia	-	145.0	-	3.6	5.9	42.5
South Africa	29.1	269.0	-	2.5	-	34.7
Suriname	-	-	-	6.0	-	57.1
Tanzania	-	-	-	11.4	-	82.1
Turkey	39.5	-	-	17.6	-	81.6
Ukraine	-	-	-	-	10.6	80.0
USA	22.8	257.8	31.3	3.3	5.0	26.7
Zambia	39.0	-	-	-	-	70.0
Zimbabwe	-	281.8	-	-	-	94.1

Source: SNL Financial (2016)

Royalty and production taxes per country (2015)

Country	Copper c/lb	Nickel c/lb	Lead/Zinc c/lb	Gold $/oz	Iron Ore $/t	SCORE
Argentina	85.4	-	-	48.9	-	91.4
Australia	11.6	13.4	2.9	33.1	2.5	57.7
Bolivia	-	-	-	-	-	0.0
Botswana	-	23.0	-	-	-	69.2
Brazil	6.1	10.7	-	13.8	2.6	32.2
Burkina Faso	-	-	-	46.0	-	42.9
Canada	5.5	28.4	1.3	30.5	3.8	36.2
Chile	2.6	-	0.0	44.0	1.3	13.5
China	-	-	-	70.2	-	85.7
Colombia	-	66.6	-	-	-	100.0
DRC	8.9	-	-	47.0	-	45.2
Dominican Republic	-	-	-	40.1	-	35.7
EU28	**27.5**	**3.3**	**0.6**	**27.6**	**-**	**59.7**
Ghana	-	-	-	52.9	-	60.7
Guatemala	-	-	-	90.8	-	96.4
Guinea	-	-	-	79.7	-	92.9
India	-	-	10.7	-	-	100.0
Indonesia	22.9	20.4	-	59.0	-	70.2
Kazakhstan	7.2	-	-	-	-	30.0
Kyrgyzstan	-	-	-	162.5	-	100.0
Madagascar	-	12.3	-	-	-	38.5
Mali	-	-	-	56.9	-	67.9
Mauritania	9.6	-	-	58.0	-	53.7
Mexico	0.4	-	2.5	61.3	-	25.7
Mongolia	28.2	-	-	-	-	90.0
Namibia	-	-	1.9	-	-	50.0
PNG	8.3	9.6	-	25.4	-	33.6
Peru	7.5	-	2.7	53.6	6.6	57.3
Philippines	10.9	-	-	-	-	55.0
Russia	-	24.0	-	73.7	2.2	61.9
South Africa	35.1	-	-	49.4	-	87.9
Tanzania	-	-	-	50.0	-	57.1
Turkey	23.5	-	-	17.2	-	63.3
Ukraine	-	-	-	-	4.6	88.9
USA	3.0	49.3	10.5	28.8	2.0	33.2
Zambia	23.7	-	-	-	-	80.0
Zimbabwe	-	11.3	-	-	-	30.8

Source: SNL Financial (2016)

By-product costs per country (2015)

Country	Copper c/lb	Nickel c/lb	Lead/Zinc c/lb	Gold $/oz	SCORE
Argentina	(169.8)	-	-	(101.7)	16.9
Australia	(56.0)	(37.4)	(29.5)	(111.8)	50.3
Bolivia	-	-	(58.6)	-	36.4
Botswana	-	(368.6)	-	-	28.6
Brazil	(58.5)	(25.9)	-	(1.0)	53.1
Burkina Faso	-	-	-	-	100.0
Canada	(48.8)	(389.4)	(84.0)	(19.2)	48.9
Chile	(12.4)	-	(25.1)	(228.6)	79.9
China	-	-	-	(0.6)	100.0
Colombia	-	-	-	-	100.0
DRC	(36.9)	-	-	-	70.0
Dominican Republic	-	-	-	(38.2)	39.1
EU28	(71.0)	(226.6)	(63.9)	(254.4)	31.2
Ghana	-	-	-	(4.0)	69.6
Guatemala	-	-	-	(613.1)	4.3
Guinea	-	-	-	-	100.0
India	-	-	(23.2)	-	81.8
Indonesia	(184.6)	-	-	(19.8)	16.5
Kazakhstan	(39.7)	-	-	-	65.0
Kyrgyzstan	-	-	-	(5.4)	65.2
Madagascar	-	(88.4)	-	-	64.3
Mali	-	-	-	(0.9)	82.6
Mauritania	(68.9)	-	-	-	40.0
Mexico	(25.8)	-	(100.3)	(315.7)	59.9
Mongolia	(167.4)	-	-	-	20.0
Namibia	-	-	(4.6)	-	100.0
PNG	(164.2)	(94.9)	-	(17.9)	31.8
Peru	(32.7)	-	(57.4)	(78.2)	66.5
Philippines	(118.1)	(76.8)	-	-	33.3
Russia	-	(897.8)	-	(52.8)	26.6
South Africa	(353.5)	(385.9)	-	(0.8)	20.0
Tanzania	-	-	-	(37.9)	43.5
Turkey	(50.6)	-	-	-	55.0
Ukraine	-	-	-	-	100.0
USA	(22.5)	(244.0)	(14.4)	(15.6)	83.3
Zambia	(10.3)	-	-	-	100.0
Zimbabwe	-	(21.4)	-	-	92.9

Source: SNL Financial (2016)