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Assessing the costs of the new collective bargaining agreements in the Chilean copper industry

Introduction

The current boom in copper prices has coincided with the renewal of labour contracts at many Chilean copper mining operations. In fact, 15 collective bargaining agreements have taken place in Chile since 2004. While seven of them ended in strikes before agreement between unions and companies could be reached, most of them resulted in large compensation payments being made to miners. This raises the question of the future competitiveness of Chile in the world copper industry.

In this article we assess the direct costs of both bonuses and wage increases. Possible implications for the competitiveness of the copper industry in Chile are also discussed; in light of past experiences particularly the strikes in the US copper industry in 1977. While the latter were responsible, at least in part, for the major reduction in competitiveness of the USA in the world copper market, key differences enable us to conclude this should not be the case in Chile in the coming years.

Although other collective bargaining agreements have been concluded worldwide in recent years (in Peru, Canada and the USA, among others), this article focuses on the Chilean experience.

Economic rents as motivation of strikes

Classical resource economics tell us that when profits or economic rents[1] are generated, stakeholders – owners, government, communities and workers – seek a share of them. Therefore, when commodity prices rise, other stakeholders – in addition to owners – begin to press for a piece of the cake.

Copper provides a good example of this rent-seeking behaviour. While governments have many ways of taking part (or all) of the economic rents – through nationalisation, royalties or increasing taxes – workers have one strong and credible means of exerting pressure during boom periods – strikes.

Strikes are particularly powerful tools during a boom period because the effect that any loss of production has on any mining operation. For example, full closure of all production facilities at Escondida would have cost around US$7 million per day (at a copper price of 350 ¢/lb). Even the partial strike at Escondida in August 2006 (the mine was producing at 40% to 60% of capacity during strike days) represented a considerable loss for the company, mainly associated with lower revenues resulting from lower production.

[1] Economic rents are generated when revenues generated from an economic activity, in this case mining,

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Collective bargaining agreements in Chile since 2004

Operation	Company	Strike days	Date
El Abra	Phelps Dodge	23	Nov 5-29, 2004
Zaldivar	Barrick Gold	9	Jul 4-12, 2005
Andina	Codelco	no strike	Sep-Oct, 2005
FCAB	Antofagasta Minerals	11	Dec 6-17, 2005
Ventanas	Codelco	no strike	Dec, 2005-Jan, 2006
Ventanas	Codelco	no strike	Dec, 2005-Jan, 2006
Codelco (Contractors)	Codelco	partial strike	Jan 4-Feb 7, 2006
Lomas Bayas	Xstrata	no strike	May, 2006
Escondida	BHP Billiton	25	Aug 7-31, 2006
Salvador	Codelco	no strike	Aug-Sep, 2006
El Teniente	Codelco	no strike	Sep-Oct, 2006
Codelco Norte	Codelco	9	Oct 8-17, 2006
Altonorte	Xstrata	2	Dec 18-20, 2006
Cerro Colorado	BHP Billiton	7	Feb 1-7, 2007

Data: Industry sources

Assessing the costs of Chilean collective bargaining agreements

The first strike in Chile in the current boom in copper prices occurred in November 2004, when 485 workers stopped work at the El Abra mine. Phelps Dodge, the operator of El Abra, replaced unionised workers with hired external workers. This action was illegal under Chilean legislation, and a fine of around US$100,000 (60 million of Chilean pesos) was imposed on Phelps Dodge. In addition, the company was forced to stop the replacement of workers. Hence, Phelps Dodge was forced to negotiate with the union and, after 23 days of strike, finally reached an agreement with its workers, consisting of a bonus of approximately US$3,300 per worker (2 million of Chilean pesos) and a wage increase 4% above inflation.

What is significant in El Abra's negotiating process is the fact that the fine imposed on Phelps Dodge set a precedent for other mining companies in future collective bargaining agreements. In fact, no union workers on strike have been replaced since El Abra.

Since El Abra, a further 14 collective bargaining agreements have taken place in Chile. The table on page 16 summarises the mines and companies involved. Half of these ended in strikes, lasting between two days in the case of Altonorte smelter and 25 days in the case of Escondida.

The strike that attracted most attention was without doubt Escondida. Besides being the largest copper mine in the world, the benefits solicited by Escondida's workers (although the highest) set a precedent for future bargaining at Codelco, the state-owned company with the largest number of unionised workers in Chile. After 25 days on strike, Escondida's workers received a bonus of approximately US$17,000 (9 million Chilean pesos) and an increase in wages of 5% above inflation. Total bonuses paid at Escondida had a value of US$34.9 million (18.47 billion Chilean pesos) and over the following three years Escondida committed to an increase in wages of approximately US$1.8 million.

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Bonuses and wage increases resulting of collective bargaining agreements in Chile since 2004

Operation	Company	Number of employees	Bonus (US$ / worker)	Wage increase %	Bonus (US$ million)
El Abra	Phelps Dodge	485	3300	4.0	1.6
Zaldivar	Barrick Gold	500	n	n	n
Andina	Codelco	1029	12000	3.0	12.3
FCAB	Antofagasta Minerals	365	n	n	n
Ventanas	Codelco	315	4246	2.8	1.3
Ventanas	Codelco	600	3692	2.8	2.2
Codelco (Contractors)	Codelco	28000	n	0.0	n
Lomas Bayas	Xstrata	300	6481	8.0	1.9
Escondida	BHP Billiton	2052	17000	5.0	34.9
Salvador	Codelco	180	7385	2.5	1.3
El Teniente	Codelco	398	12000	3.0	4.8
Codelco Norte	Codelco	6143	4431	3.15 & 3.8	27.2
Altonorte	Xstrata	340	4630	2.5 & 7.5	1.6
Cerro Colorado	BHP Billiton	594	13333	4.8	7.9

Notes: n = no public information
Data: Industry sources

What is important in Escondida's collective bargaining agreement is that while the bonuses were considered high because they were, on average, equivalent to around 70% of annual salaries, bonuses can be considered as a redistribution of profits, and not an increase in costs. Although at first sight the bonuses seem large, they represented only 0.66% of Escondida's profits for 2006 (US$5.33 billion).

On the other hand, wage rises must be considered as an increment in costs and therefore they need to be considered when evaluating competitiveness in the near future. CRU estimates, however, that the increment in costs attributable to wage increases is not higher than 0.06 ¢/lb copper for Escondida.

The table above shows the benefits obtained for workers under collective bargaining agreements in Chile since 2004, except for Los Pelambres whose bonuses and wage adjustments are not public information. As a result of collective bargaining agreements and strikes during 2006, more than US$75 million were paid in bonuses to 10,328 workers (these figures exclude Los Pelambres's collective bargaining and Codelco's contractors). Even though this figure looks large, it represents just 0.23% of revenues from Chilean copper exports in 2006 (US$33.34 billion).

The Codelco example is similar to that of Escondida. As the table on the previous page shows, Codelco paid some US$50 million in bonuses during 2006, representing 0.53% of company profits in the same year (US$9.5 billion). Codelco also committed to higher salaries costing approximately US$4.8 million per year (2.6 billion Chilean pesos) for the following three years, equivalent to an increase of 0.12 ¢/lb copper.

Could Chile lose its competitiveness?

In 1977, the US copper industry was affected by a number of strikes. Despite the low copper price, workers demanded both higher wages and job security provisions. CRU estimated then (***Copper Studies,*** Volume 5, No.2, June 15th, 1977) that major costs due to both policies were between 3 and 6 ¢/lb copper in nominal terms. Taking into account that the US copper price in 1977 was 67 ¢/lb, the potential increment in costs at US copper mines would have been at least 5%. US competitiveness was so badly

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harmed by this event (and others of similar nature), that it almost caused the collapse of the US copper industry during the early eighties.

Collective bargaining agreements have increased total costs at Chilean copper mines by no more than US$8.1 million per year, which is equivalent to an increment of just 0.07 ¢/lb copper, or less than 0.01% of the increase in today's costs. Comparing the latter figure with the 5% increase in costs resulting from the US strikes in 1977, it seems very unlikely that Chilean competitiveness will be harmed by the increase in wages resulting from collective bargaining agreements since 2004.

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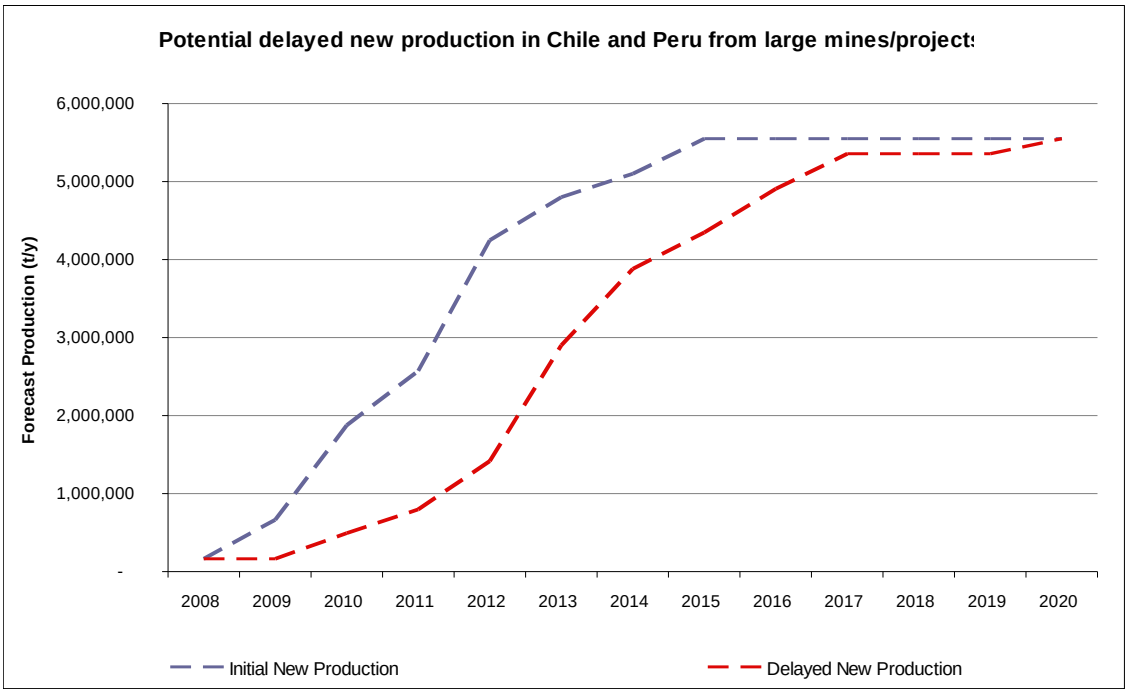
Future copper growth in Peru and Chile

Introduction

Chile and Peru are ranked first and third respectively as world copper producers according to CRU's recent "Copper Quarterly – January 2008 Edition", making them critical to the world's future copper supply. Over 25 new mining projects in Peru and Chile are planned to together produce over 5.6 million t/y of contained copper when they come on-stream. Given the current record copper prices, this should be the right time for these projects to start-up. Delays currently seem to be a very popular announcement, however. According to CRU's **"Copper: The Long Term Outlook – 2008 Edition"**, project start-ups have been delayed by 20 months on average. These delays represent delayed potential new production of around 6 million tonnes of contained copper through 2020.

Postponed copper production in Chile and Peru



Source: CRU Analysis – "Copper: The Long Term Outlook – 2008 Edition"

Although Chile mainly produces copper whilst Peruvian production is diversified (copper, gold, zinc, silver, lead, among others), the Chilean and Peruvian mining industries have many things in common. Both countries have similar deposit geology with high copper potential, similar mining experience and tradition, strong copper production, similar taxation regimens, and high growth potential. Differences arise, however, because growth in Chilean copper production is based on brownfield expansions, whilst Peru depends mainly upon the start-up of greenfield projects, most of which are still currently at the exploration stage.

Chilean copper production used to be dominated by the state owned Corporacion Nacional del Cobre (Codelco). Today, 70% of copper in Chile is produced by private investors, including BHP Billiton (which operates Escondida and represents 24% of Chilean copper production), Anglo American,

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Antofagasta Minerals, Xstrata Copper and Freeport McMoRan Copper & Gold. The remaining 30% is produced by Codelco's operations: Codelco Norte (Chuquicamata, Radomiro Tomic and Mina Sur), El Teniente, Andina and El Salvador.

In Peru, state-owned production stopped during the privatisation process of the 1990s. In 2007, four producers accounted for 92% of Peruvian copper production – Southern Copper Corporation (Grupo Mexico), Compañía Minera Antamina (Xstrata Copper, BHP Billiton, Teck-Cominco and Mitsubishi Corporation), Sociedad Minera Cerro Verde (Freeport and Compañía de Minas Buenaventura) and Xstrata Tintaya (Xstrata Copper). It is therefore not surprising that new projects depend on private investment, and the government is trying to encourage private enterprise by providing a competitive regulatory and business framework.

Considering only those projects that are planning to produce over 100,000t/y of contained copper, 15 projects are planned in Chile and 10 in Peru, as listed in the table below.

Projects with planned production over 100,000t/y of contained copper/EW cathode in Chile and Peru

CHILEAN PROJECTS		PERUVIAN PROJECTS	
Project	**Production (t/y)***	**Project**	**Production (t/y)***
Escondida Concentrator III	750,000	Toromocho	260,000
Collahuasi Expansions I & II	545,000	La Granja	250,000
Andina Exp. & Nueva Andina	430,000	Quellaveco	200,000
Chuquicamata Underground	300,000	Rio Blanco	191,000
El Teniente New Level	250,000	Las Bambas	178,200
Toqui (Toki)	200,000	Galeno	150,000
Alejandro Hales	188,000	Michiquillay	150,000
Esperanza	180,000	Marcona	118,200
Los Bronces Expansion	175,000	Antapaccay	100,000
Gabriela Mistral	165,000	Los Chancas	100,000
El Morro	160,000	**Total:**	**1,697,400**
Cerro Casale (Aldebaran)	158,000		
Relincho	150,000		
El Abra II	148,800		
Caserones (Regalito)	130,000		
Total:	**3,929,800**		

* Production is for copper only and does not include other potential metal credits

Data: CRU Analysis – "Copper: The Long Term Outlook -- 2008 Edition"

Several issues are contributing to the delays in these projects, many of which can be identified in both countries although the characteristics and features may vary. The most common issues are identified below:

Peru

Socio-economic conflicts: These are currently a key issue in the Peruvian mining industry. For the last three or four years, claims from populations surrounding the mining projects have arisen, demanding more economic benefits from mining activity. Conflicts are related to the industry as a whole, although projects under exploration tend to be more subject to protest. This situation has contributed to the

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changes and improvements currently underway in the Peruvian regulatory system, encouraging more responsible behaviour from mining companies and aiming for the sustainable development of the surrounding areas.

Differences arise regarding the reasons and organisation of such conflicts. Broadly speaking, however, the main stakeholders involved are the surrounding populations, the government (at national and local levels), non-governmental organisations (NGOs), mining companies and members of the Catholic Church. The reasons or justifications for such protests tend to be demands and concerns over the environmental and social responsibilities of the mining companies; as well as claims for greater economic benefits. It should be pointed out that it is likely that many of these conflicts channel general dissatisfaction within the different populations into opposition to the mining projects.

Experience shows that projects under exploration are more commonly subject to these conflicts rather than mines currently under exploitation. It is likely that the major companies have developed their knowledge to achieve the high social and environmental standards required to avoid these conflicts. Such standards are usually a combination of regulations from the national government and the companies themselves.

Energy supply: This is a potential risk for projects planned to start-up from 2010 onwards, particularly in southern Peru where a bottleneck in the supply of electricity is forecast. In fact, even the current production levels might not be guaranteed to continue if new investment in energy supply is postponed.

Labour and sub-contracting: Peru has a long mining tradition that provides a considerable workforce for this industry. In addition, under-employment is widespread in Peru and it is generally believed that the mining industry will provide more jobs in future. The recent commodities price boom has raised demand for labour at the mining projects but there are no signs to indicate that labour supply is constrained. The labour supply for skilled positions may be a different story, however. Nevertheless, there have been several strikes demanding greater financial rewards from some specific companies, although these have been resolved so far.

Under Peruvian regulation, sub-contracting companies must register with the Ministry of Energy and Mines before starting to operate. The recent increase in mining activity has triggered greater sub-contracting activity. The proliferation of sub-contracting companies has challenged the authorities' ability to control their performance and health and safety standards have not been met appropriately. The Ministry of Energy and Mines has therefore recently introduced more demanding standards for sub-contracting companies (mainly related to the size and experience of the sub-contractor).

Mergers and acquisitions: Many of the new projects are in the hands of junior mining companies, which have been actively exploring with many favourable results. These companies are subject to major shareholder changes, mergers or take-overs, however. Such activity may be necessary to raise capital; but it may also delay decision-making in terms of developing the project. Some of the other projects are owned by the major mining companies which are also dealing with merger and acquisition issues (eg. BHP Billiton-Rio Tinto and Vale-Xstrata). This again might affect the decision-making process. The potential effect of current and possible future mergers and acquisitions upon future major copper projects in Chile and Peru can be seen in the table below.

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Chile

Socio-economic conflicts: Mining activity has been present in Chile throughout its history, and its known relationship with growth and economic wealth is a helpful indicator to understand why mining operations do not or at least have not generated considerable conflicts with local communities to date. Recently this situation seems to be changing, however, because of problems associated with a specific gold project operated by Barrick Gold (Pascua Lama) where glaciers need to be altered. This is considered unacceptable by many people in Chile, who have started to ask why a foreign company should be allowed to take their resources and destroy their environment.

Projects involved in recent M&A activity in Chile and Peru

CHILEAN PROJECTS		
Project	**Production (t/y)***	**Major Owners**
Escondida Concentrator III	750,000	Owners BHP Billiton (57.5%) & Rio Tinto (30%) possibly merging
Collahuasi Expansions I & II	545,000	Part-owner Xstrata (44%) recently discussed merger with Vale
Andina Exp. & Nueva Andina	430,000	Codelco (100%) – no recent M&A activity
Chuquicamata Underground	300,000	Codelco (100%) – no recent M&A activity
El Teniente New Level	250,000	Codelco (100%) – no recent M&A activity
Toqui (Toki)	200,000	Codelco (100%) – no recent M&A activity
Alejandro Hales	188,000	Codelco (100%) – no recent M&A activity
Esperanza	180,000	Antofagasta (70%); Marubeni acquired 30% in Apr. 2008
Los Bronces Expansion	175,000	Anglo American (100%) – no recent M&A activity
Gabriela Mistral	165,000	Codelco 100% owner but China Minmetals has option for 25%
El Morro	160,000	Xstrata (70% owner) recently discussed merger with Vale
Cerro Casale (Aldebaran)	158,000	Barrick Gold bought 51% owner Arizona Star in Aug. 2007
Relincho	150,000	Teck Cominco buying owner Global Copper Corp. (Apr. 2008)
El Abra II	148,800	Freeport McMoRan (51%); Codelco (49%) – no recent M&A
Caserones (Regalito)	130,000	Pan Pacific Copper Corp. (100%) – no recent M&A activity
Total:	**3,929,800**	
Potentially affected by mergers:	***2,108,000 or 53.6%***	

PERUVIAN PROJECTS		
Project	**Production (t/y)***	**Major Owners**
Toromocho	260,000	100% owner Peru Copper Inc. bought by Chinalco in Jun. 2007
La Granja	250,000	100% owner Rio Tinto possibly merging with BHP Billiton
Quellaveco	200,000	Anglo American (80%); other (20%) – no recent M&A activity
Rio Blanco	191,000	100% owner Monterrico Metals bought by Zijin Corp. in Apr. 2007
Las Bambas	178,200	100% owner Xstrata recently discussed merger with Vale
Galeno	150,000	Owner N. Peru Co. bought by Jiangxi & Minmetals in Dec. 2007
Michiquillay	150,000	Anglo American (100%) – no recent M&A activity
Marcona	118,200	Chariot Resources (70%); others (30%) – no recent M&A activity
Antapaccay	100,000	Xstrata (98.43% owner) recently discussed merger with Vale
Los Chancas	100,000	Southern Copper Corp. (100%) – no recent M&A activity
Total:	**1,697,400**	
Potentially affected by mergers:	***1,129,200 or 66.5%)***	

*Production is for copper only and does not include other potential metal credits

Data: CRU Analysis – "Copper: The Long Term Outlook – 2008 Edition"

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Misinformation about mining (even though Chile has been historically a mining country) is a new potential risk for the industry, but it is important to remember that these problems are generally related to environmental issues on which only certain companies come under focus. For this reason, Codelco's role in the industry is (and has been) extremely important as its presence generates a positive view of mining among the Chilean population. The same can be inferred about sustainable development programmes run by other mining companies, such as BHP Billiton's Minera Escondida Foundation.

Energy and water supply: Energy and water shortages have been a severe problem for the present government in Chile, as a result of the increasing gap between supply and demand. Supply has not grown at the same rate as demand. In 2008, gas and electricity rationing is a real possibility on the energy policy agenda; and mining will not be excluded from this policy. Electricity is a critical input in mining and mineral processing operations; it represents, for example, over 20% of the total operating costs for a sulphides project. Some new power projects are planned in northern Chile, such as the Mejillones power plant located in Region II. This plant already has environmental permits approved, but with 400MW of capacity it can only supply 20% of the electricity demand in northern Chile. Policies for efficient energy use and contracts ensuring a reliable power supply will be key issues for mining companies in Chile over the next few years, not only due to the risk of shortages but also because electricity prices have been rising dramatically over the last four years due to the increased demand.

Non-traditional energy sources, such as wind power, are beginning to appear in Codelco's project portfolio. As a renewable source of energy wind e has good potential as an alternative source, but currently it can only act as a complement to coal and oil power plants that are the principal source of energy, due to the hydroelectric power deficit in the north of Chile. At Codelco Norte wind power could only meet about 10% of the division's energy needs. Added to the hydroelectric power shortage, this gives an insight into the critical conditions for electricity supply in the north of Chile where most of the mining activity is located.

As mentioned before, the water shortage is also a critical issue in northern Chile due to two combined factors: the Atacama Desert is one of the most arid deserts on earth and it has the highest concentration of copper mining activity in the world. New technologies need to be introduced to increase the water supply, such as seawater desalination. At Antofagasta's Esperanza project two desalination plants will provide around 10% of total water requirements for the future operations.

Labour and sub-contracting: This seems to be the critical problem in Chile currently. Organised labour unions in the outsourced companies are pressing the principal mining companies for equal employment conditions. Codelco's experience in 2007 is an example of the existing problem with sub-contractors. The problem has not been solved by the new sub-contracting law promulgated in early 2007, which is still interpreted differently by workers and employers. This problem, in conjunction with the 15 collective bargaining agreements entered into by Codelco and private companies between 2004 and 2006 (a period of rising copper prices) suggests that labour and sub-contracting issues will persist even if copper prices fall, a situation which may become critical for companies with strong unions.

Technology: The decrease in ore grades throughout mining history has motivated technological innovations that convert non-profitable resources into economic reserves, such as the SX/EW mines in the 1980s. Unlike Peru, Chile has low-grade ore bodies, or at least decreasing grades, which means that mining costs will rise in the Chilean industry. Technological advance is essential because of the impact

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on costs and reserves. Development of new ore bodies in Chile is now highly dependent on technological improvements, such as bio-leaching mineral processing technology and improved understanding of rock mechanics.

Management and operational risks: Chile is developing many projects that could be considered as marginal for their scale, for example Esperanza and Toki. These projects tend to share some similar characteristics such as considerable pre-stripping (up to 300m), geological and metallurgical uncertainty, and above all, low ore grades. In order to maintain low costs, the projects need to meet demanding production rates and show high operational efficiency through the use of highly qualified employees.

Conclusion

Whilst Chile and Peru in general face common risks, the principal issues in each country seem to be different. Chile faces more technical difficulties due to the low grade of its deposits, as well as energy supply shortages. Peru's critical problems are related to local community opposition to new projects, and also to mining and exploration policies. Despite the differences between the two countries, all the risks mentioned in this article are present in both Chile and Peru, in addition to other problems common across the global industry, such as issues related to collective bargaining agreements. It is important to note that the risks described could become more significant in one country than the other, for example possible future energy problems in Peru or future socio-economic conflicts in Chile.

Despite all the risks, both countries still have many advantages and good management should ensure projects will be developed. In Chile, most of the new projects are brownfield expansions of current operations. These have the expertise to deal with potential risks, such as local conflicts, through effective sustainable development programmes. They also have the skilled professionals that could (or at least should) manage energy problems using new solutions or technologies. Peru has an enormous natural resource potential that with good regulatory policies and a stable economic climate, should not only enable feasibility projects to be brought into operation, but should also attract further investment and new projects to the country.

Issues that may affect mining projects start-up in Chile & Peru

Issues	Chile	Peru
Socio-economic conflicts	?	√
Energy & water supply	√	?
Labour & sub-contracting	√	?
Mergers & acquisitions	?	√
Technology	?	×
Management & operational risk	?	×

√ = likely *? = potential* *× = unlikely*

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Energy supply in South America - Can supply keep up with planned copper mining projects?

Introduction

Power supply constraints are not a new threat to the South American copper industry. The delay of some copper projects will not significantly reduce the pressure to increase energy supply at least until 2012. While Chile is going ahead with initiatives related to renewable energy sources and supporting the efficient use of energy, Peru is focusing on promoting investment in hydroelectric power plants and transmission systems whilst Brazil diversifies its energy matrix through bio-diesel and natural gas power generation. However, government policy measures will show results only in the medium term. In the meantime, mining companies are coming up with their own solutions.

Supply Constraints

Chile

In Chile, the constraints on power supply have been at the top of the agenda since 2004. The restrictions imposed on natural gas imports from Argentina caused a change in the sources of primary energy, and power prices in the country were impacted by the high prices of alternative fuels, mainly coal and diesel. The use of coal rose to 20% in the Northern Zone and to 3% in the Central Zone by 2007. The consumption of diesel, used alongside natural gas in power stations, increased by 6% in the Northern Zone but growth remained unchanged in the Central Zone.

The Chilean power sector is organized into four grids located in different areas of the country. These grids are:

- Big North Grid (Sistema Interconectado del Norte Grande – SING, by its Spanish acronym)
- Central Grid (Sistema Interconectado Central – SIC, by its Spanish acronym)
- Aysen
- Magallanes

This article focuses on the SING and SIC grids as these are the main suppliers to the copper industry and they account for over 95% of the installed capacity.

- The SING grid provides energy to Regions I (Tarapaca) and II (Antofagasta), which jointly produce over 70% of Chilean copper. In these regions the copper industry is the largest consumer and capacity surpasses demand. However, the main constraint for power generation is likely to be that combined cycle power generation plants with are powered by coal, whereas they were intended to be mainly powered by natural gas. Currently, these generation plants work like thermopower plants, as their turbines have been adapted to use diesel, which increases the costs. This type of power generation accounts for 64% of the generation in the SING grid.

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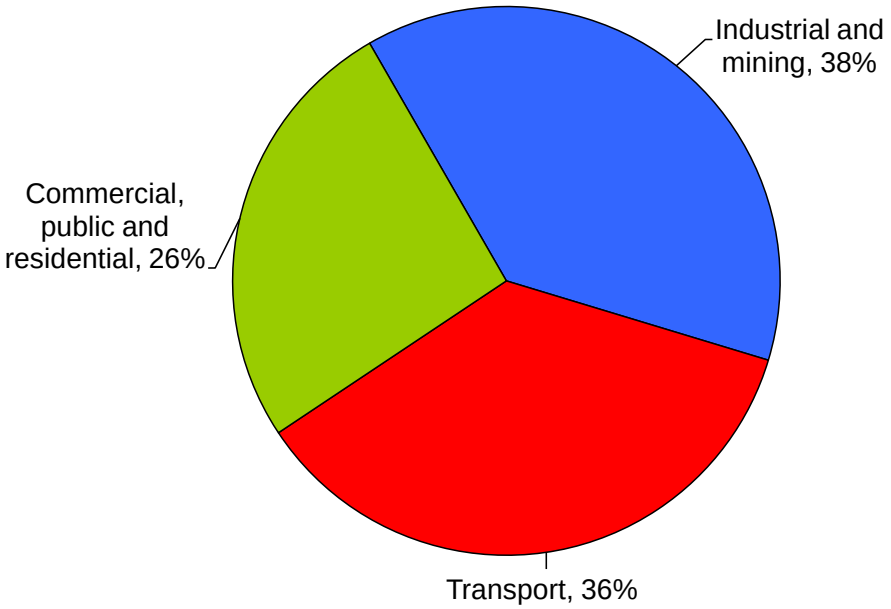
- The SIC grid is supplied with both thermal and hydroelectric power, and here the demand and the installed capacity are closely related.

These changes in primary energy sources are not new to the industrial and mining sectors. These sectors are the largest power consumers (see figure below), and the changes have increased production costs.

Energy consumption by main clients in Chile
By sector



CRU | ANALYSIS
Data: CNE Chile

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Given this situation, Chile is looking at ways to achieve greater energy independence and to increase its power sources. The Chilean government and the country's private sector are working on several initiatives; including construction of re-gasification facilities at the ports and non-conventional renewable energy projects appropriate to the climate of each zone of the country (for example, solar power in Northern Chile and wind power in Southern Chile). We examine these initiatives in greater detail later on in this article. In 2009, the Chilean government is to consider investments of around USD$3.7B in projects that will generate 1,426 MW, as well as completing 23 electric power stations that will enter into production this year, principally for the SIC grid.

Peru

Peru has an interconnected power grid with an installed capacity of 5 GW and coverage of over 79.5% of the population. Some of the remaining 20.5% have access to independent grids. A breakdown by power source is shown in the following chart.

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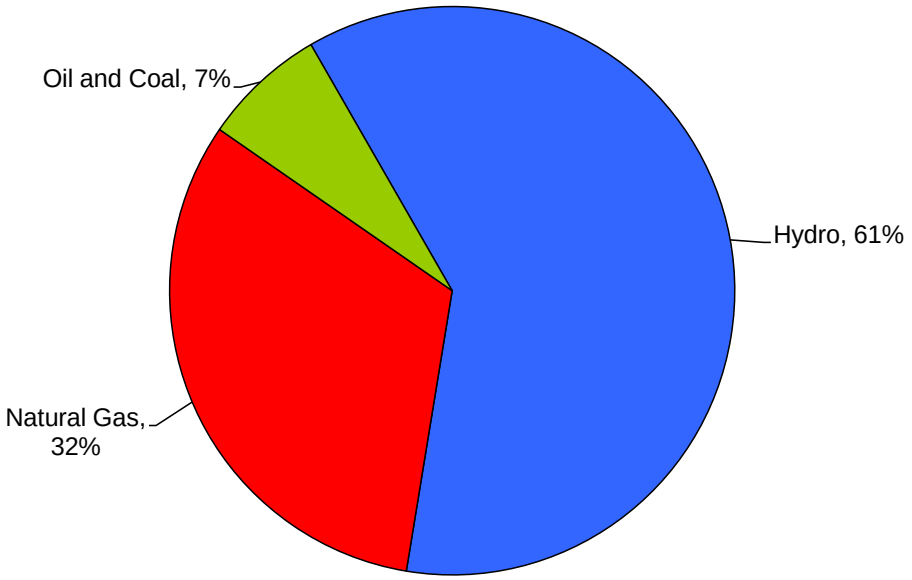
Electricity generation in Peru
By resource, 2008



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Data: COES

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The Peruvian power sector has been making substantial changes to its legislation and infrastructure since the 1990s. The most important ones in each stage are: i) generation: free competition, ii) transmission: competition for awarding build-own-operate-and-transfer contracts (BOOT contracts), and iii) distribution: local monopolies. Currently, the private sector owns 71% of generation capacity and 100% of the main transmission lines. T he energy sector is monitored by the Supervisor Office for Investment in Energy and Mining (Organismo Supervisor de la Inversion en Energía y Mineria – Osinergmin) which is the independent regulator, while the Ministry of Energy and Mines (Ministerio de Energía y Minas – MEM) is the policy authority.

In the last nine years, power production grew at an annual average rate of 6%, reaching 29,558 GWh in 2008. Meanwhile, generation capacity has grown on average by 2% annually.

The National Electricity System grid (Sistema Eléctrico Interconectado Nacional – SEIN) is in a vulnerable position as power demand has increased at a higher rate than power supply, reducing the reserve margin and making it insufficient if difficulties arise. Power supply restrictions stem mainly from two situations: i) temporary restrictions in the effective capacity of hydroelectric power stations (dry season) and ii) gas supply restrictions for generation companies that do not have firm transportation contracts, because of the congestion in the coastal pipeline (Humay-Lurín stretch).

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Main electricity companies in Peru

Activity	Company	Group	% Installed power	% Production
Generation	Edegel S.A.A.	Endesa	27.8%	28.4%
	Electroperú S.A.	State own	18.2%	26.1%
	Energía del Sur S.A.	Suez	16.1%	14.1%
	Duke Energy S en C por A	Duke Energy	9.3%	8.0%
			% Length of line voltage	
Transmission	Red de Energía del Perú S.A.	ISA	65.0%	
	Consorcio Trasmantaro S.A.	ISA	9.0%	
			% Number of clients	% Energy sales
Disitribution	Edelnor S.A.A.	Endesa	22.6%	31.8%
	Luz del Sur S.A.	Sempra and AEI	17.8%	33.2%
	Electro Norte Medio S.A.	State own	10.8%	6.9%
	Electrocentro S.A.	State own	9.9%	4.0%

Source: Minem

In 2009, the critical months could be June and July as the reserve margin could fall to 5%. The following options are being considered in order to mitigate the risk of rationing: i) move Egasa's turbines (approximately 100 MW) closer to the gas field (Ica), for which the turbines have already been relocated (construction works have not been completed), ii) lease diesel turbines (25 MW each) (installation will take between 4 and 6 months), and iii) use of power generation sets.

A schedule of periodic rationing is not foreseen, but it is very likely that there could be sporadic power cuts if problems occur in the system. In such cases, regulated clients (residential, commercial, medium and small industries) and some free market clients (e.g. hospitals) will take priority. The Operational Committee of the Electric System (Comite de Operacion Economica del Sistema Interconectado Nacional - COES) has asked the free market clients to restrict their consumption; considering that they can use back-up systems (generators powered with diesel or residual fuel). Any possible temporary rationing would take place in peak hours (6:30 pm - 9:00 pm), when free market clients use 10% of their daily consumption and residential clients use 18% of their daily consumption.

This situation will affect power prices, which are scheduled to be reviewed in April 2009 and will probably increase as a consequence of the combination of higher demand and lower supply (changes in the programmed amount of new power stations).

The equilibrium of demand and supply will depend on the expansion of current capacity of the gas pipeline (the objective is to triple the capacity by 2010) and the development of hydropower projects by 2011. Some small and medium scale stations could come on stream within this time frame. In any case, it is an urgent requirement in Peru to diversify and expand the sources of power generation.

Brazil

Brazil's energy matrix has two main characteristics: i) it is still heavily based on petroleum and water, and ii) most generation plants are owned by the federal or state governments. These characteristics are at the same time both strengths and weaknesses for the country. Although Brazil has announced it has enough petroleum reserves to support itself, this source of energy is non-renewable. The country also holds the largest water reserve in the world, but the hydropower plants are heavily dependant on rain

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water. The Brazilian Government has budgeted to invest in new plants, but bureaucracy and lack of knowledge often prevent projects from coming to fruition.

In 2001, more than 90% of the power in Brazil was produced by hydropower plants, which are highly dependant on rain water. That year, there was a prolonged period without rain, leading Brazil into a significant power crisis, also known as "the blackout" (o apagão). Since then, Brazil has been trying to diversify its energy matrix in order to be less dependant on hydropower as well non-renewable energy sources.

As part of Brazil's attempt to diversify its energy sources, Brazil and Bolivia commissioned the Gaspol project in order to transport natural gas from Bolivia to Brazil. This line supplies natural gas to the industrial hub in the Southeast of Brazil, but in 2006/2007, the reliability of this power source was also questioned, as Bolivia ran short on production and could not supply the quantity agreed for both Brazil and Argentina. At that time, Brazil announced a new natural gas reserve in Santos, now known as the Pré-Sal project.

In 2007, Brazil's internal energy supply reached 238.8Mtep (petroleum equivalent tons)[2], according to the National Energy Balance 2008 (Balanco Nacional de Energia – BEN 2008). Renewable energy represented around 46% of supply.

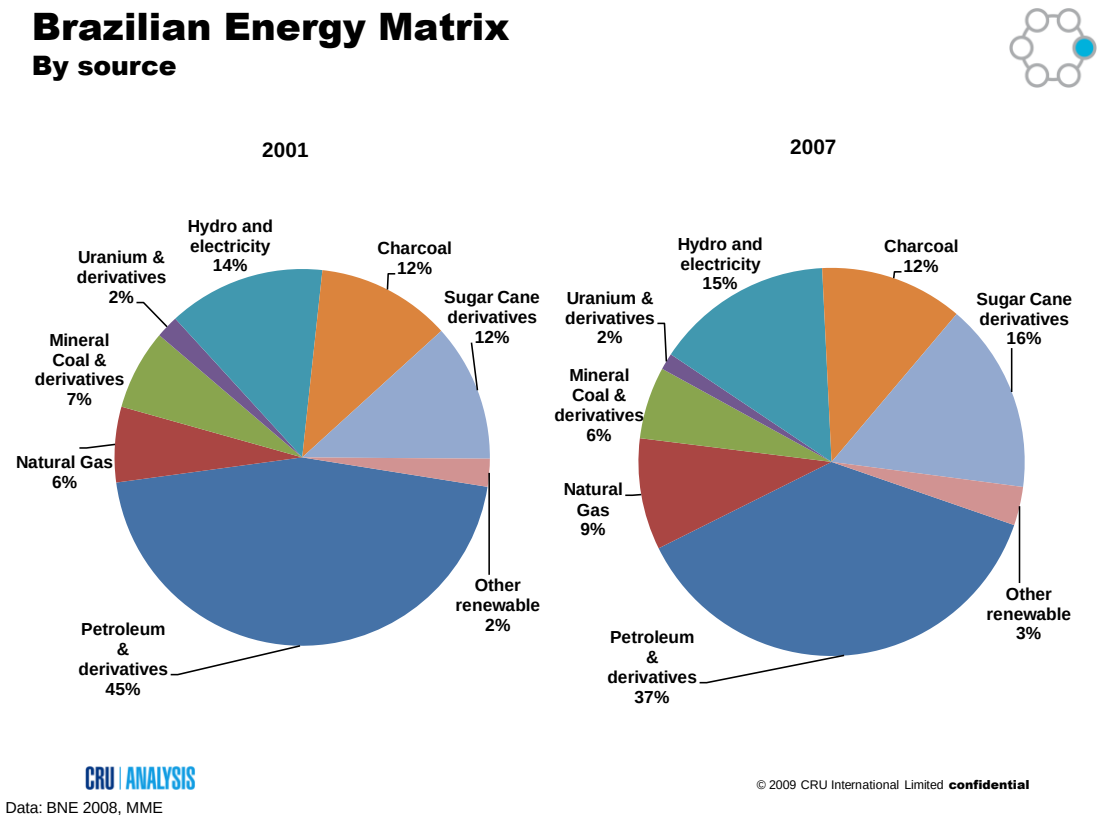

Figure 3. Brazilian Energy Matrix

[2] 1 tep = 10,800 kcal/kg = 3.448276 MWh, and 1 MWh = 0.29 tep

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New energy policies

Chile

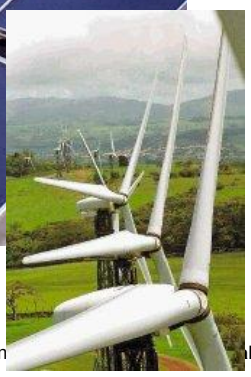
In the last five years, Chile has been concerned about the diversification of its energy supplies. The country's government has prepared investment projects in new sources of power which are both conventional and non-conventional. According to the Chairman-Minister of the National Energy Commission, Mr. Marcelo Tokman, "from an energy point of view, the country needs to replace the fuels that nowadays it imports, for fuels produced internally".

The main initiatives being developed by Chile include:

- A target of 30% of power generation using non-conventional renewable energy sources by 2025.
- Separation of the Ministry of Energy and Mines into two ministries, to allow greater focus on energy concerns. The new ministry will commence operations in 2010.
- Incentives/subsidies for the installation of solar collectors.
- Support for research and development of biofuels from microalgae.
- Biomass, which takes advantage of the heating power of a by-product from the paper making process (also known as "black liquor").
- Wind and hydropower plants.
- Development of the geothermal energy sources.

Wind power is the non-conventional form that is most attractive for mining companies, but without discarding other options. Current initiatives in studies include:

i. CODELCO's Northern Division is restarting a study of a 20 MW wind farm to complement the current power supply to Chuquicamata, and aims to have 5 % or more of its power consumption satisfied by non-conventional renewable energy form.
ii. Barrick has the intention of developing a wind farm at Punta Colorada with a US$19.5M investment. It would be located in the coastal region of Coquimbo.
iii. In the Atacama region, PUCOBRE is developing a 9 MW wind farm project.



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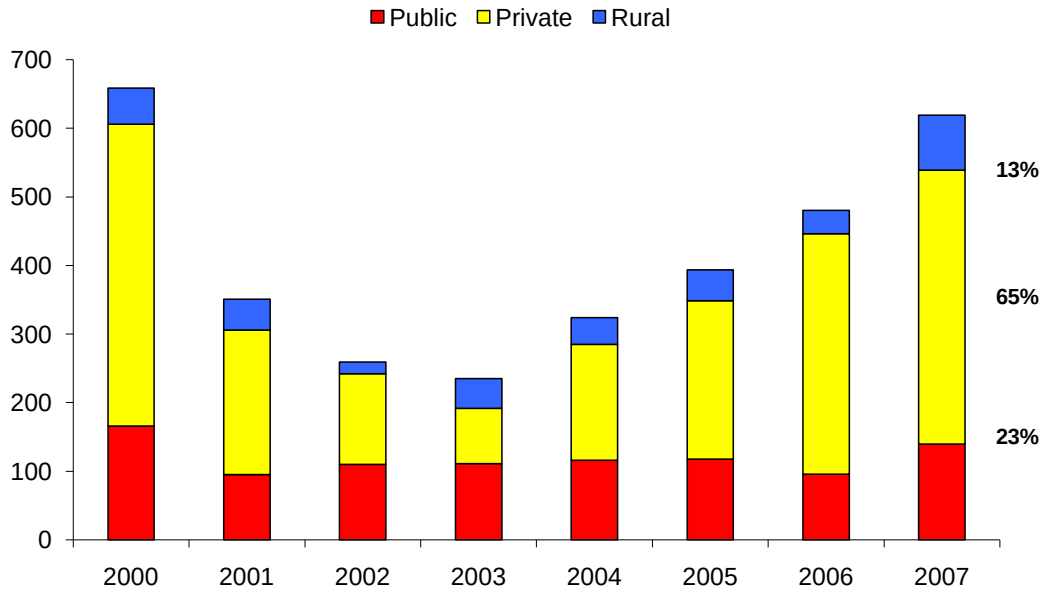
Peru

In June 2008, the Peruvian Government presented a series of measures aiming to improve the Peruvian energy supplies on three fronts. Firstly, in the central regions of the country there are an important number of generation projects to be powered with natural gas, which represents 80% of the additional generation capacity forecast to start commissioning in the 2009-2010 period. However, the gas pipeline is already at full capacity, and therefore those plants will not be able to operate until this pipeline is debottlenecked (expected for 2011). To offset this trend, the Peruvian Government established some benefits to encourage investment in hydropower plants: i) accelerating depreciation to 20% annually, (previously it was 3% for buildings and 5%-10% for equipment); ii) discount the prices offered to power distribution companies in electricity supply tenders.

In addition, to promote investment in other renewable energy sources, the Peruvian Government has pledged that 5% of total power demand will be produced by renewable sources other than hydropower. However, the regulations to put this target into force are still pending. In the particular case of wind power, even though the number of temporary concessions for studies reached 58 in the last two years, this source of energy is relatively new in Peru, so it requires deeper research.

Investment in Peru's electricity sector
US$ Million



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Data: Minem

Secondly, the Peruvian Government is looking to relieve congestion in the Humay (Ica)-Lurin (Lima) stretch of their gas pipeline, which represents a risk to the supply of natural gas to thermal generation plants (accounting for 31% of power generation). Therefore, the Government is setting up an incentive

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for the efficient use of natural gas, which would give priority to the companies that: i) contract a minimum transport capacity (this will guarantee the necessary demand to the gas pipeline expansion); ii) use natural gas efficiently (combined cycle gas turbine plant); and iii) have dual fuel plants. It is worth mentioning that the Government has not yet defined the amount of the incentive.

Thirdly, the Private Investment Promotion Agency of Peru (Agencia de Promocion a la Inversion Privada - Proinversion), which is an independent governmental agency, offered four transmission grids for tender as requested by the central government. These grids are key to easing congestion in the transmission of energy generated by natural gas in the central regions of the country (Chilca, Lima), heading out towards the northern and southern regions of Peru, where important copper mining projects will be developed in the coming years.

Transmission grid concessions in 2008

Project	Investment (US$ Million)	Company	Current Stage	Start-up year
Línea Carhuamayo-Paragsha-Conococha-Huallanca-Cajamarca; Cerro Corona-Carhuaquero (220 kV, 692 km)	106	Abengoa	Granted Feb-08	2010/2011
Línea Machupicchu-Cotaruse (220 kV, 60 km)	35	Isonor, Elecnor, Isolux Corsan	Granted Apr-08	2010/2011
Línea Mantaro-Caravelí-Montalvo (220/500 kV, 761 km)	146	Isonor, Elecnor, Isolux Corsan	Granted Apr-08	2010/2011
Línea Chilca-La Planicie-Zapallal (220/500 kV, 93 km)	52	ISA	Granted Jun-08	2010/2011

Source: Proinversion

Likewise in 2009, the central government has requested Proinversion to offer tenders for 500 MW of new hydropower plants. The objective is to ensure a firm price for the sale of electricity in the medium-term, better than the regulated tariff, which will reduce the financing cost of the project. Moreover, the Government supports the investors operations in order to avoid cancellations or delays to the project due to the issuing of licenses, authorizations or social conflicts.

Even though these measures have been created to promote the investment in renewable energy sources and the efficient use of natural gas, they do not completely solve the market distortion introduced by the current electricity tariff and natural gas price. For that reason, these measures have not yet triggered the announcement of necessary investment projects. Moreover, the rationing risk for 2009 and 2010 remains due to the pre-operating period (design, licences and construction) which usually lasts two or three years.

Brazil

In order to support growth in the coming years, the Brazilian Government has been providing incentives for investment in infrastructure, mainly through the Growth Accelerating Plan (Plano de Aceleração do Crescimento – PAC). Investment projects in power will benefit the most from the PAC, especially because of fiscal benefits. It was announced that R$78.4B will be invested (~USD 32.9B) in the electric sector until 2010, from a total of R$504B (~USD 211.6B). The Brazilian National Bank of Development (Banco Nacional de Desenvolvimento – BNDES) has been providing funds with attractive conditions, such as financing 80% of construction costs at taxes lower than that in the market, to be paid over 25 years. In order to support renewable energy projects and accelerate petroleum exploration and refining,

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the government has been setting up partnerships with private companies and providing financing, as well as increasing Petrobras' exploration budget.

In 2008, investments made in the Southeast of Para State - where most of the copper projects are located - totalled around R$71 million (/≈ US$29.8 million - the second largest amount in the State). The transmission line LT Norte – Sul III, which connects Marabá (PA) to Serra da Mesa (TO) was completed last year.

Recently, the Brazilian Government has announced its energy plan for the next 10 years (Plano Decenal de Energia – PDE), which includes projects covering all sources of energy and transformation plants.

Nevertheless, there are regulatory barriers in Brazil that make private investment in power generation even more difficult, for instance hydropower projects. Through tenders organized by the Brazilian Government, private investors can receive concessions for the construction of hydropower plants to operate in the regulated and free markets. The concession contracts impose very strict rules on the winner that, generally, benefit the regulated market (distributors). The private investor has to sell 70% of the energy produced to the regulated market (distributors), at a fixed price established by the government, and can sell the remaining 30% to the free market at any price. Generally, private investors have to realise higher prices at the free market in order to reach the financial break-even point of its project.

The Brazilian mining industry believes that the government plays an important role in the power supply of the country, as they are responsible for establishing policies for the sector. It is through these policies that government allows or denies investments in energy projects.

Increasing demand: a focus on the mining industry - how are the mining companies responding?

Chile

In times of crisis, everything is uncertain, investments are stopped and projects suffer cutbacks, delays or closures. In the case of power, with or without a crisis, there is a real necessity to invest in power generation in order to support mining production as well as consumption in domestic and other sectors.

Over the next few years, the Chilean copper industry has a considerable number of projects due to be commissioned. Although some could be suspended or delayed, it is likely that many will eventually come on stream, and so sooner or later there will increase in demand on the electrical grid. The following table shows the copper projects pipeline for Chile and estimates of their demand.

The breakdown of energy supply to the mining sector can be summarized as follows:

A. Principal projects in the SIC grid zone:

- Expansion Codelco Teniente, Nuevo Nivel Mina (430kt/y Cu Conc)
- Expansion Codelco Andina, Nueva Andina (400kt/y Cu Conc)
- Expansion Los Pelambres, (90kt/y Cu Conc)
- Expansion Los Bronces (170kt/y Cu Conc)
- Development, Caserones (150kt/y Cu Conc & Cathode Sx-Ew)

These projects represent 30% of the demand on the SIC grid.

B. Principal projects in the SING grid zone:

- Codelco Norte, Chuquicamata Underground (340kt/y Cu Conc)

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- Codelco Norte, Mina Ministro Hales (200kt/y Cu Conc)
- Codelco Norte, Sulphides Radomiro Tomic (250kt/y Cu Conc y Biolix Sx-EW)
- Gaby (165kt/y Cathode Sx-Ew)
- Esperanza (195kt/y Cu Conc)
- Expansion Collahuasi (430kt/y Cu Conc)

In this grid the mining industry requires more than the 90% of the generated electricity, and the related copper production represents more than 60% of Chile's total production.

Chilean mining projects

Project	Reservas MTM	Ley CU %	Investment US$M	Design Cap kt/y	Initial Production
Exp. Collahuasi	n.d.	n.d.	3,200	430	2014
Andina Fase II ampliación	5,562	0.85	3,700	400	2014
Sulfuros R. Tomic	n.d.	n.d.	700	250	2014
Spence (SxEw)	310	1.23	990	200	2006
Mina Ministro Hales	219	1.13	835	200	2013
Escondida SBL (SxEw)	1,093	0.52	750	180	2006
Esperanza (conc)	540	0.64	1,100	195	2010
Gaby (SxEw)	618	0.41	970	165	2008
El Abra Lix Sulfuros (SxEw)	800	0.53	350	148	2011
Caserones (SxEw)	628	0.43	700	130	2010
Los Bronces ampliacion (conc)	761	0.55	1,744	170	2011
Cerro casale (conc)	1,114	0.26	2,300	134	2012
El Morro (conc)	479	0.64	1,400	195	2013
Los Pelambres, ampl. (conc)	818	0.76	600	90	2013
Andacollo Sulfuro (conc)	421	0.41	312	81	2009
Fortuna de Cobre (SxEw)	470	0.31	150	70	2008
Total Chile	13833		19801	3038	

1/ Updated March 2009. *Source: Cochilco*

The tables below show estimates of power consumption by copper mines until 2012. In total, the copper mining industry will require around 20,000 GWh. This demand continues to be mainly requested from the SING grid zone.

Estimates of electricity demand of copper mines in the SIC

Demand (GWH)	2007	2008	2009	2010	2011	2012
In force operations	6,384	6,419	6,210	6,209	6,059	5,920
new operations	343	467	700	1,109	2,288	2,609
Total SIC (copper mines)	6,728	6,885	6,910	7,318	8,347	8,529

Source: CNE Chile

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Estimates of electricity demand of copper mines in the SING

Demand (GWH)	2007	2008	2009	2010	2011	2012
In force operations	10,859	11,091	11,350	10,124	10,162	9,949
New operations	0	310	610	725	1,437	1,653
Total SIC (copper mines)	10,859	11,401	11,961	10,849	11,599	11,602

Source: CNE Chile

With this looming situation of undersupply in mind, the Chilean government and private companies have decided to develop expansion projects and focus on sustainability in the long term.

Securing Energy Supplies to the Mining Sector

With regards to secure power supplies, mining companies are aware that they must take immediate action to continue with their projects. Here we present three case studies on power projects demonstrating efforts by mining companies to secure this vital input for any industry:

Codelco

The state-owned companies Codelco and National Company of Petroleum (Empresa Nacional de Peroleo – ENAP) have developed two investment projects: i) Quinteros Port: Facilities to receive, store and re-gasify natural gas. Start-up scheduled for March 2009. ii) Mejillones Port: This project delivers natural gas to region II, and is designed to deliver 1100 electrical MW permanently. The idea is that a ship works as a re-gasification plant. Start-up in March of the project end, 2009.

In both projects, the two companies do not have direct intervention with the mentioned ports. Codelco's supply relies on the existing production and transmission companies, and would not consider its own energy project for any of his divisions.

Minera Escondida

Since 2005, BHP Billiton has been analysing the gas supply situation and considering the option of alternative fuels. In order to have a reliable power supply in the medium term which will not obstruct the development of their mining operations, the company is considering the following measures:

- Supporting the construction of a natural gas terminal to be built in Mejillones, in Northern Chile.
- Installing a new coal powered generating station, of 540MW. Start-up: 2011.

Compania Dona Ines de Collahuasi

Collahuasi is currently working on its expansion, and the operating company has prepared a plan of action to avoid supply constraints. Collahuasi currently operates with an electricity supply of around 180MW, powered by coal and diesel, in order to produce 550,000t/y of copper. In the medium term, the operation will use both coal and liquefied natural gas (LNG) (replacing the Argentinian gas supply), alongside the cogeneration from a new US$117M combined cycle plant producing 44MW that will start-up in April 2009. For the final stages of the project a mixture of supply types is being considered, including non-conventional coal, cogeneration, and to a lesser extent LNG.

Peru

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The mining industry in Peru accounts for around 24% of national power consumption (6,888 GWh). I n mid-2008, before the onset of the international financial crisis, it was expected that the Peruvian mining industry would increase its electricity consumption by almost 60% (4,000 GWh), considering planned expansions and new mines that would start operating in the period 2009-2012. The increase in total electricity demand was expected to be around 4,800 GWh, which would mean that the mining industry would account for 85% of the new power requirements.

Since Q4 2008, the deepening international financial crisis has caused some mining companies to delay their projects, the majority of which have been copper. The main reasons are: i) dramatic fall of metal prices, ii) difficult financing conditions, and iii) increased uncertainty in the short and medium term.

Peruvian mining projects and energy consumption

N°	Project	Company	Metal	Capacity (kt/y)	Power Consumption (GWh)	Investment (US$ Mill.)	Current Stage 1/	Start-up year
1	Toromocho	Chinalco (Peru Copper)	Cobre	273	1,498	2,150	EIA	2012
2	Antapaccay	Xstrata Copper	Cobre	150	1,051	1,500	Feasibility	2011/2012
3	Galeno	Northern Peru Copper Corp.	Cobre	144	750	960	Feasibility	2012
4	Tia Maria	Southern Copper Corp	Cobre	120	557	934	EIA	2011
5	Exp. Toquepala	Southern Copper Corp	Cobre	100	199	600	EIA	2011
6	Exp. Cuajone	Southern Copper Corp	Cobre	50	136	374	EIA	2011
7	Exp. Ilo Refinery	Southern Copper Corp	Cobre, oro y plata	360	144	200	EIA	2011
8	Exp. Antamina	Antamina	Cobre, zinc	n.d.	n.d	n.d.	Feasibility	2011
9	Bayóvar	Vale	Fosfatos	3,9 (tpa)	54	479	Construction	2010
10	La Zanja	Buenaventura	Oro, plata	100 (kozpa)	12	60	EIA	2010
11	Tantahuatay	Buenaventura / SCC	Oro, plata y cobre	100 (kozpa)	180	56	Feasibility	2010/2011
12	Exp. Zinc Refinery	Votorantim Metais	Zinc	320	907	520	Construction	2009
13	Hilarión	Milpo	Zinc, plomo,	n.d.	250	200	EIA	2011
Total energy consumption					5,738			

1/ Updated March 2009. *Source: Companies, media, APOYO Consultoría*

Currently, thirteen mining projects are planning to start operations in the 2009-2012 period; nine of these are copper projects (see table). These projects alone would increase the power demand of the mining industry to 3,300GWh[3] (54%), which is 20% less than that expected in the middle of 2008.

The lower than expected increase in the mining industry's electricity demand plus the slowdown in the Peruvian economy will provide some relief to the pressure to build power generation plants. As a result, the startup of these mining projects could coincide with the start-up of the power plants. Nevertheless, the balance between energy supply and demand will remain tight in 2011 and 2012.

[3] In 2012 some mining projects will not work at full capacity yet.

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Taking this into account, mining companies are taking measures to ensure the power supply for their brownfield and greenfield projects. First of all, mining companies, such as Southern Copper Corp and Cerro Verde, have signed long term power supply agreements with power generation companies and have set efficient prices. Nevertheless, in some contracts, mining companies take the risk of disruption to the power supply due to congestion in the transmission grid or disruption of natural gas supply for thermal generation plants. In other words, if any of these events occur, mining companies will have to purchase electricity in the spot market where the price is three times higher than in long term contracts.

In the face of the above situation, mining companies, such as Antamina, are studying the option to include diesel turbines in their investment budgets, as a backup in case of power supply disruption, mainly during demand peak hours.

In addition, mining companies, such as Antamina and Xstrata Copper, are financing studies in the reinforcement of transmission grid and forecast power demand for the next years. These studies would seek to ease congestion to the transmission grid and to supply the required power.

Brazil

The demand side reacted rapidly after the energy crisis in 2001. Industrial hubs in Brazil have been substituting industrial equipment fed by electric energy for ones fed by natural gas. It is expected that this change will also reduce energy costs.

The mining and pellet industries represent approximately 2.5-3.0% of total Brazilian energy consumption. In 2007, copper operations (Jaguarari, Sossego and Chapada) represented 0.1% of total energy consumption. By 2014, copper operations should consume approximately 0.3% of total Brazilian energy consumption.

Brazilian energy consumption by sector (10^6 tep)

Sector	2001	2002	2003	2004	2005	2006	2007
Non-energetic	13.5	12.6	12.5	13.0	13.2	14.3	14.2
Energetic	13.6	14.4	15.8	16.4	17.6	18.8	21.0
Residential	20.1	20.7	20.9	21.4	21.8	22.1	22.3
Commercial	4.8	4.9	5.0	5.2	5.5	5.6	5.9
Public	3.1	3.2	3.2	3.3	3.5	3.5	3.6
Agricultural	7.7	7.8	8.2	8.3	8.4	8.6	9.1
Transportation	47.8	49.2	48.2	51.5	52.5	53.3	57.6
Industrial	55.3	58.5	60.9	64.3	65.2	68.1	72.6
Mining & Pellet	*2.3*	*2.4*	*2.5*	*2.6*	*2.9*	*3.0*	*3.3*
Non-ferrous & other metallics	*4.0*	*4.5*	*5.0*	*5.3*	*5.4*	*5.7*	*6.0*
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	172.2	178.2	182.1	191.2	195.9	202.9	215.6

Source: BNE 2008, MME

Vale, Brazil's biggest mining company, has seven hydroelectric plants in operation, which guarantee 25% of all energy consumed by the company in Brazil. In order to reduce its dependency on this raw material, the company has been investing in both hydro and thermo power generation projects in Brazil. Vale has adopted the strategy to generate its own energy. This strategic control will protect the company

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from the instability of prices and guarantees a continuous power supply. Vale's minority stake in several energy projects aims at ensuring they have adequate power for their primary business - mining.

More than 90% of the energy produced by Vale comes from hydroelectric power stations, with the rest generated by co-generation and liquid fuel, especially in those operations that are disconnected from the grid (Brazil's electric system). Of the energy provided by external suppliers, 75% is hydroelectrically produced.

In order to reduce its dependency on hydroelectric energy, Vale is implementing a thermoelectric project, which will be fed by mineral coal from the State of Pará. The 600 MW project will double Vale's energy generation capacity. The company has also been studying renewable energy: the production of biodiesel in the State of Pará, which will substitute the consumption of fossil energy and the wind power in the Northeast Region of Brazil, where there is a considerable potential to generate this type of energy.

However, Vale's new mining project's feasibility studies must consider future energy costs that will properly pay back the company's investments.

In 2007, copper projects represented 2.34 % of Vale´s total energy consumption in Brazil. By 2014, this share should rise to 8.56%.

Brazilian copper projects and energy consumption

Project	Company	Capacity (kt/y)	Current Stage	Start-up year	Power consumption (GWh)	10^6 tep
Jaguarari	Caraiba Mineracao	25	Operation	1986	105	0.03
Sossego	Vale	120	Operation	2004	370	0.11
Chapada	Yamana Gold	55	Operation	2006	230	0.07
Salobo I	Vale	100	Confirmed	2010	470	0.14
Salobo Expansion (II)	Vale	100	Confirmed	2011	460	0.13
Cristalino	Vale	90	Probable	2013	438	0.13
Alemao	Vale	80	Probable	2013	305	0.09
118 Project	Vale	36	Probable	2014	155	0.04
Total energy consumption					2533	0.74

Source: Vale and CRU Analysis

Conclusion

Chile, Peru and Brazil all have the need to diversify their energy matrices and increase their energy supply to satisfy the requirements of new projects, among them mining projects, that will start-up in the next few years.

These three countries have a tight energy supply-demand balance. Chile has already suffered production cuts due to energy shortages and, currently, this country's efforts are focused on avoiding such a scenario again. Peru needs the pace of investments in generation and transmission electricity to coincide with the pace of mining investments to ensure the smooth start-up of brownfield and greenfield

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projects. In Brazil, power restrictions are not imminent due to Government efforts to increase total capacity and a slowdown in power consumption, but the consumer could face high spot prices due to a decrease in rainfall.

The governments of these three countries have intervened through state investment (the Brazilian federal governments and Chile's government through Codelco), the promotion of private investment (mainly Peru) and the promotion of efficient use of energy (mainly Chile). Nevertheless, due to energy costs accounting for a sizeable share of the total production cost of copper mining companies (around 20%) most of them have started paying special attention to power problems and developing their own solutions.

The mining companies' strategies to ensure energy supply to their projects include signing long term supply contracts, self generating part of their power needs with backup plants, using available power in an efficient way and providing technical and financial support to develop new power generation and transmission projects.

Energy integration in South America through projects such as the "Energy Ring" or the "South Gas Pipeline" have been proposed as common solutions to the energy problem in this part of the world. In theory, with these projects, South America could take advantage of the natural complements of its countries (Venezuela, Bolivia and Peru are net exporters of natural gas, while Chile and Brazil are importers, although Brazil has natural gas reserves) and could increase the efficient use of energy in the region and ensure sufficient supply.

In practice, there are diverse issues that make the development of this ambitious initiative difficult, namely: i) diplomatic problems between Chile and Peru, and between Chile and Bolivia, ii) prior default on gas supply contracts by Argentina and Bolivia, iii) the difficult task of standardizing energy market regulation in the region as a whole, iv) complicated distribution of investment costs between countries, and iv) it is still unconfirmed if the natural gas reserve of Peru (Camisea) will be enough to supply this country for more than 20 years, and thus more uncertain if it will be enough to supply the whole region.

Nevertheless, South American countries have become strong commercial partners. There is a lot of profitable business between private companies in the region and the Gaspol project (Brazilian–Bolivian transmission line) is a successful example of energy integration. It is, therefore, still possible that some day energy integration in South America will be successful.

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Sulphuric acid – Logistics of Chilean supply

Introduction

Sulphuric acid is one of the most important industrial chemicals with a wide range of applications. It is used in the production of agricultural fertilizers including phosphates and ammonium sulphate; in the production of rayon, dyes, alcohols, plastics, rubber, ether, glue, film, explosives, drugs, paint, detergents, pharmaceutical products and paper; and in water treatment, petroleum refining, iron and steel pickling, electroplating baths and metal processing and refining.

Worldwide, the largest market for sulphuric acid is in the production of fertilizers, while a small amount is used to leach ores in copper production. In contrast, in Chile and Peru almost all sulphuric acid production is used to produce copper, and as domestic production is insufficient to meet demand, large volumes are also imported from other regions. Very large quantities of sulphuric acid are transported throughout the year, most arriving in the northern part of Chile. The logistics of the supply of sulphuric acid are important as consumers need the raw material in their plants at the right time and, of course, at minimum cost.

This article concentrates on the supply of sulphuric acid in I, II and III Regions of Chile, where the main consumers are located. It does not consider Peru in detail because the country has a surplus supply of sulphuric acid, most of which is supplied to Chile.

Sulphuric acid market in Chile

In the Chile-Peru region, sulphuric acid production is estimated at 7.04 million tonnes in 2010. Around 98% is smelter production. This represents 12% of world smelter sulphuric acid output, with Codelco alone accounting for 6%. In contrast, around 58% of world production of 193.39 million tonnes of sulphuric acid comes from sulphur burners.

World consumption of sulphuric acid is estimated at 197.81 million tonnes in 2010. Around 63% is used in the fertilizer industry, 8% in metallurgical applications and the balance in chemical/industrial markets. In contrast, in the Chile-Peru region 7.5 million tonnes of sulphuric acid are estimated to be consumed in copper leaching in 2010, which represents 97% of regional consumption.

Total refined copper production in Chile reached 3.2 million tonnes in 2009. SXEW refined copper production was approximately 2.1 million tonnes, 66% of the total.

Consumption of sulphuric acid in the Chile-Peru region has risen significantly from some 1.5 million tonnes in 1995 to a projected 7.5 million tonnes in 2010 due to the development of the mining industry. Over this period, copper production using the hydrometallurgical process rose by 530%.

Sulphuric acid production will continue to increase over the next few years to meet growth in demand. In March 2010, for example, Outotec signed a Euro 116 million contract with Codelco for the design and delivery of a copper concentrates roasting plant, gas cleaning system and sulphuric acid plant for Codelco's new Mina Ministro Hales mine near Calama in northern Chile. The plant, scheduled to be commissioned in early 2012, will produce 250,000t/y sulphuric acid.

The main sulphuric acid consumers are located in northern Chile, in the I, II and III Regions. Because of the strong demand, Chile has developed logistics infrastructure in these areas. There are four terminals in the North (one terminal in Patache, two in Mejillones and one in Barquito). In addition, there are large fleets of trucks, a railroad and shipping services.

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World sulphuric acid market, 2010		
	(tonnes)	(%age)
World production from:		
- Smelter production	60,950	31.5
- Sulphur burner production	112,441	58.1
- Others	19,999	10.3
Total World production	**193,389**	**100.0**
World consumption by end use:		
- Metallurgical uses**	16,262	8.2
- Fertilizers	124,578	63.0
- Chemical/Industrial	56,969	28.8
Total World consumption	**197,810**	**100.0**
Balance	**-4,420**	
Recycled supply	4,605	
Balance	**185**	
Chile - Peru smelter production	**7,042**	**11.6 ***
Codelco smelter production	**3,431**	**5.6 ***

Notes: * Percentage of world smelter production **Copper, nickel, uranium leaching

Data: British Sulphur

Regional market analysis

I Region

Consumption of sulphuric acid in I Region is around 800,000t/y, 11% of national consumption, and is forecast to decrease to approximately 600,000t/y towards 2012. Despite the expansion of leaching operations at Collahuasi between 2012 and 2017, demand is forecast at 800,000t/y.

The main consumers in the region are:

Collahuasi	230,000t
Cerro Colorado	220,000t
Sagasca	145,000t
Quebrada Blanca	130,000t
Quiborax	70,000t

Codelco is the main supplier in the area. The balance is imported or brought from Haldeman Mining's sulphur burner. Punta Patache is the terminal in the area with a storage capacity of 40,000 tonnes and port facilities.

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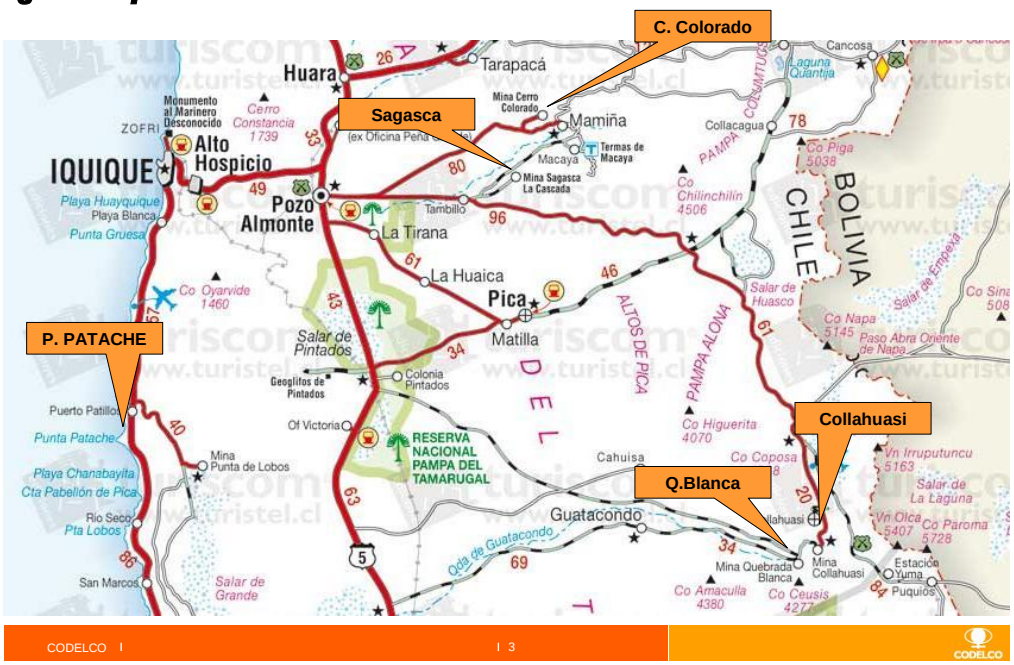
I Region Map



II Region

Demand for sulphuric acid in Chile is concentrated in II Region. Regional consumption is estimated at about 5 million tonnes in 2010. This represents over 70% of total Chilean demand for sulphuric acid in copper leaching. The main consumers in this region are Codelco Norte, Gaby, El Abra, Escondida, Spence, Tesoro, Michilla, Zaldivar, Lomas Bayas, Mantos Blancos and Mantos de la Luna. Material is also exported to Argentina and Bolivia by truck.

In this region, Codelco and Xstrata together produce approximately 2.4 million t/y of sulphuric acid, which partially meets regional demand. A sulphur burner project is planned for 2011, with a production of 720,000t/y of sulphuric acid, led by Antofagasta Minerals, BHP, Zaldivar and El Abra.

The balance of demand is supplied by material from the Central Region of Chile, by direct imports or by traders.

The region has two terminals in Mejillones that receive sulphuric acid arriving by vessel. These terminals have 180,000 tonnes of storage capacity: Interacid with capacity of 80,000 tonnes and Puerto de Mejillones with capacity of 100,000 tonnes.

III Region

There are small, medium and large mining operations in III Region and sulphuric acid demand is rising strongly. Consumption in 2010 is projected at 1.2 million tonnes, 17% of the Chilean total, mostly used in copper mineral leaching.

The main consumers in this region are currently:

Codelco	250,000t
Quadra Mining, Franke mine	300,000t
Anglo American, Mantoverde division	400,000t

Codelco's Potrerillos smelter and Enami's Paipote smelter together produce approximately 830,000t/y of sulphuric acid. The balance is imported from Codelco and/or Anglo American's operations in the Central Region. The latter's Mantoverdi operation is thought to be closing in 2014. Regional demand is

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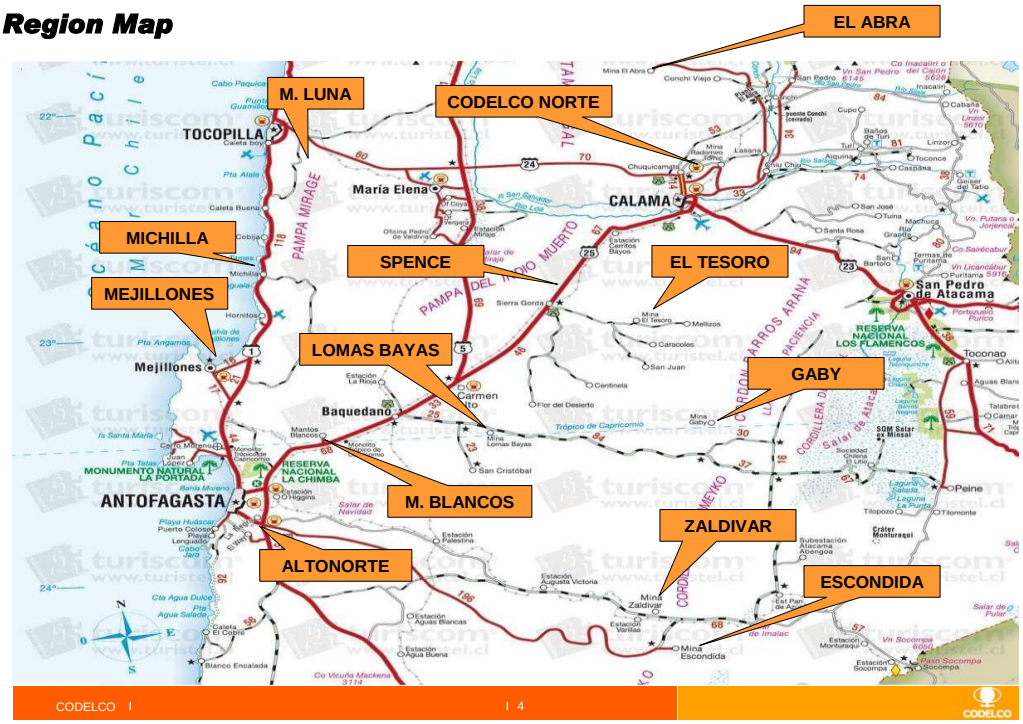
expected to increase as several medium operations come on-stream. San Antonio alone could raise demand by 200,000t/y.

The region's terminal at Barquito is owned and operated by Codelco and has a storage capacity of 30,000 tonnes.

II Region Map



III Region Map

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Sulphuric acid market trends

Late 2007 was a critical period for numerous sulphuric acid consumers in Chile. The tight market in the region meant some consumers had to partially or totally stop copper production and sulphuric acid prices reached unexpected levels of more than US$400/t, a level never seen before in this region.

In contrast, at the end of 2008 up to eleven vessels were waiting in Mejillones bay to download their material, but no room was available. Some of these vessels had to wait for more than two months to download, resulting in costs of more than US$3 million for some companies.

2009 was a difficult year for the copper industry because of the economic crisis. At the beginning of the year the copper price was around 1.46¢/lb. Projects were delayed and some mines were closed, either stopping or reducing their SXEW copper production. As a result, sulphuric acid consumption fell. The fertilizer market was also affected by the global crisis and demand for sulphuric acid from that sector fell as well. At one time, sulphuric acid prices reached levels close to zero especially in Europe, Korea and Japan. Smelters paid for their acid to be taken away because they did not have enough storage for their sulphuric acid output. At the end of 2008 and into the first quarter of 2009, some vessels were used to store sulphuric acid at sea.

Following these critical periods, consumers in the region have realised the importance of the logistics of their sulphuric acid supply and started to make changes to their operations. They have started to form agreements with terminals regarding storage capacity, for example, and are diversifying their sources of supply.

Future sulphuric acid logistics

Punta Patache Terminal

Nowadays Punta Patache terminal in I Region is operated by Interacid and has a storage capacity of 40,000 tonnes. The dock is shared with salt and coke vessels and is a very congested terminal. In addition, it faces swells frequently because of the weather conditions. Interacid is planning to build a new terminal, including pipelines and a dock, with the same capacity of 40,000 tonnes but construction will take about two years.

Puerto de Mejillones Terminal

This terminal is located in II Region, in Mejillones zone where national sulphuric acid consumption is concentrated. Puerto de Mejillones currently has a storage capacity of 100,000 tonnes in five tanks. Puerto de Mejillones has entered into agreements with traders and consumers with the aim of reaching storage capacity of 180,000-200,000 tonnes, as follows:

- **BCT**

  This trading company has an agreement with Puerto de Mejillones for the construction of a tank with a capacity of 20,000 tonnes, to come into operation at the beginning of 2011. The company used to have a service contract to operate a tank in this terminal.

- **Trans Sud**

  This trading company has an agreement with Puerto de Mejillones for the construction of a tank with a capacity of 20,000 tonnes, to be operational towards March 2011.

- **Noracid**

  Noracid plans to install a sulphur burner in Mejillones with capacity to produce about 720,000t/y of sulphuric acid, which would come on-stream at the beginning of 2011. It also has an agreement for the construction of two tanks each with a storage capacity of 20,000 tonnes.

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Traders operating in the region are trying to raise their market share by improving their logistics as consumers have recently bought directly from smelters that offer a better and safer service.

Interacid Mejillones Terminal

This terminal, located in Mejillones area in II Region, is operated by Interacid and has an operating storage capacity of 60,000 tonnes distributed between three tanks. Toward mid-2010, a fifth tank with a 20,000 tonnes storage capacity plus a 15,000 tonnes tank damaged during an earthquake are due to come into operation. Total storage capacity at the terminal will rise to 95,000 tonnes.

Terquim

Already operating with Codelco in San Antonio port, Terquim is building a small terminal in Mejillones area, located between Interacid Mejillones Terminal and Puerto de Mejillones Terminal. The dock is currently under construction. Initially this terminal will handle other chemicals.

Barquito

Located in the III Region, Barquito Terminal has a storage capacity of 30,000 tonnes. It will be operated by Codelco from April; at this time there are no plans to increase the storage capacity.

Future capacity

On completion of the new infrastructure, storage capacity in Mejillones bay is planned to rise to 275,000 tonnes by 2011. If Michilla is included, there will be 310,000 of storage capacity in 17 tanks. Consumption of sulphuric acid in Mejillones zone is forecast at 5.3 million tonnes in 2011, over 70% of the Chilean total.

Sulphuric acid logistics forecast

Region	Terminal	Owner	Total capacity (t)	Number of tanks	Capacity per tank (t)	Agreement with	On-stream
I	Punta Patache	Interacid	40,000	2	20,000	Codelco/Collahuasi/Interacid/ BHP	
	Punta Patache	***Interacid***	***40,000***	***-***	***-***		***2012***
II	Interacid Mej.	Interacid	40,000	2	20,000	AM/BHP/Anglo / Interacid	
	Interacid Mej.	Interacid	20,000	1	20,000	Codelco	
	Interacid Mej.	***Interacid***	***15,000***	***1***	***15,000***	***AM/BHP/Anglo / Interacid***	***Q2 2010***
	Interacid Mej.	***Interacid***	***20,000***	***1***	***20,000***		
	Mejillones	Puerto Mejillones	60,000	3	20,000	El Abra	
	Mejillones	Puerto Mejillones	20,000	1	20,000	Codelco	
	Mejillones	Puerto Mejillones	20,000	1	20,000	Zaldivar	
	Mejillones	***Puerto Mejillones***	***20,000***	***1***	***20,000***	***BCT***	***early 2011***
	Mejillones	***Puerto Mejillones***	***20,000***	***1***	***20,000***	***Trans Sud***	***Q1 2011***
	Mejillones	***Puerto Mejillones***	***40,000***	***2***	***20,000***	***Noracid***	***2011***
	Michilla	Michilla	15,000	2	7,500	Michilla/AM	
	Michilla	Michilla	20,000	1	20,000	Michilla/AM	
III	Barquito	Codelco	30,000	3	10,000	Codelco/Anglo	
			420,000	**>22**			

Data: Author

Market balance for sulphuric acid

The market for sulphuric acid in Chile is estimated to show a deficit of around 1.6 million tonnes in 2010, as illustrated in the table below. The deficit in the Chile-Peru region is estimated at 0.7 million tonnes. The deficit could be higher in 2010 if demand for sulphuric acid continues to pick-up as copper producers raise output in line with higher copper prices. It is forecast to decrease through 2014, however, as processing of oxide minerals falls.

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Chile-Peru - Sulphuric acid balance, 2007-2017 (000t)											
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Chile											
Production	4874	4824	5274	5457	5824	6250	6250	6250	6250	6292	6292
Consumption:	6186	7322	6973	7075	7212	7283	6926	6972	6775	6509	6379
SXEW	5981	7122	6788	6883	7015	7078	6711	6747	6541	6267	6137
Other	205	200	186	192	197	205	215	225	234	242	242
Balance	**-1312**	**-2498**	**-1699**	**-1617**	**-1387**	**-1032**	**-675**	**-721**	**-525**	**-216**	**-86**
Peru											
Production	1,041	1,317	1,359	1,585	1,795	1,858	2,064	2,065	2,065	2,065	2,065
Consumption:	619	663	609	677	968	1450	1451	1452	1328	1250	1238
SXEW	569	625	572	639	928	1408	1408	1408	1283	1204	1192
Other	50	38	37	38	40	42	43	44	45	46	46
Balance	**422**	**654**	**750**	**908**	**827**	**408**	**613**	**613**	**737**	**815**	**827**
Net Balance	**-890**	**-1,844**	**-949**	**-709**	**-561**	**-624**	**-62**	**-108**	**212**	**599**	**740**

Data: British Sulphur

Conclusion

The logistics of Chile's sulphuric acid supply have become a key issue for consumers, traders and producers because the country is a large consumer of sulphuric acid and it has a structural deficit of 1.6 million tonnes in 2010. Consumers with a strong supply chain and logistics infrastructure will be able to cope better with market fluctuations and ensure their supply of sulphuric acid raw materials for copper production.

The investment in infrastructure currently planned will improve Chile's logistics. Although the market deficit for sulphuric acid is forecast to fall, consumers will still need to manage their supply chain throughout the year. If a group of vessels arrives at Mejillones bay or another terminal at the same time, the infrastructure may still be insufficient. Further factors that could affect the logistics of sulphuric acid supply are the timing of the start-up and the extent of the ramp-up of sulphur burner projects at Mejillones and at Tia Maria and Doe Run in Peru. Copper prices will be a main factor in these decisions and the sulphuric acid deficit could be larger than expected.

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Greenhouse gas emissions – The effect of legislation on long run copper prices focusing on Chile

Introduction

Climate change is currently one of the biggest concerns worldwide. The path established by the Kyoto Protocol, and continued by the 2009 Copenhagen Accord, aimed to reduce total emissions of greenhouse gases worldwide, and will impact on the cost structure of every industry. The copper industry, as an energy-intensive sector, will be affected on two levels: directly through increased costs due to emissions from mine operations; and indirectly due to increased power prices associated with emissions from electric energy generation.

The copper industry will play a major role in this topic, especially in developing countries such as Chile. This article is a continuation of the analysis of carbon emission legislation published in CRU's Copper Studies, February 2010 edition. It provides a brief description of legislation on greenhouse gas emissions focusing on Chile, an evaluation of the cost structure of Chilean copper companies and an analysis of the potential effect on the long term copper price. Finally the study outlines some projects and initiatives in the mining market than could be developed by copper producers.

Measures to reduce greenhouse gas emissions

World legislation

Legislation on greenhouse gas emission is not standard across the world. A number of Emission Trading Schemes (ETS) are in operation or under discussion, and are summarised in the table below. A full description was given in the February edition of CRU's Copper Studies.

One of the main accords from the 2009 Copenhagen Conference includes a target to limit the rise in global temperature to no more than 2°C above pre-industrial levels. To meet this target each country will take voluntary measures to reduce its emissions and its progress will be measured, reported and verified by the UN.

Mining industry policy

As an energy-intensive sector, the mining industry is a large producer of greenhouse gases. Many multinational mining industries include a social responsibility and environmental commitment in their strategies and in October 2009 the ICMM[4] developed and published its 'Policy on climate change'. In this Policy the members of the ICMM expressed their commitment to making a contribution to developing and implementing a global solution to managing climate change. Their global policy approach aims to:

- encourage, rather than discourage, governments to act early to reduce greenhouse gas emissions
- provide governments with confidence that well targeted unilateral action within their own borders can be environmentally effective and socially acceptable without compromising the international trade-competitiveness of their industries
- minimise any prospect of carbon leakage where industrial activity migrates to jurisdictions that do not impose comparable constraints on greenhouse gas emissions
- provide a long term, equitable and stable regulatory framework, providing greater certainty for industry to invest in multi-decade operations and the development of new technologies

[4] ICMM = International Council on Mining and Metals – www.icmm/climatechangepolicy

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Emission trading schemes around the world

Features	Schemes				
	EU ETS III	Australian CPRS[1]	RGGI[2] USA	NZ scheme	USA ACESA
Caps	-20% on 1990 emissions[3]	-5% on 2000 emissions[4]	-10% on 2009 emissions[5]	Between -10 and -20% on '90 levels	-17% on 2005 levels
Start date	January 2013	July 2010[10]	January 2009	July 2010	2012
Target date	2020	2020	2018	2020	2020
Auctioning	Gradually to full[6]	Full with allocations[7]	Full	n/a	15%
Effect on metal producers	Direct + Indirect	Direct + Indirect	Indirect	Direct + Indirect	Direct + Indirect
Use of CER[8] credits	Yes with limits	Yes	Yes	Yes	Yes with limits
Price caps	No	No[9]	Yes	Yes	No

Notes: (1) Carbon Pollution Reduction Scheme; (2) Regional Greenhouse Gas Initiative; (3) The caps suggested by the EU are: -20% over 1990 emissions or -30% if other developed nations commit to comparable emission cuts; (4) The caps suggested by the Australian government are -5% over 2000 levels or up to -25% if there is a global agreement on carbon caps; (5) The scheme will have fixed emissions for the period 2009 - 2014 while for subsequent years emissions will decline by 2.5% per year for 4 years; (6) In 2013, 60% of allocations will be auctioned with the power sector seeing full auctioning; the scheme will move gradually to full auctioning by 2020; (7) The scheme is developed with full auctioning from the start but there are provisions to limit the impact on exposed industries and to avoid carbon leakage; the Australian government proposed that activities that emit more than 2,000 tonnes of CO_2 per million A$ in revenue will be compensated by getting enough free emission permits to cover 90% of that industry's average emissions measured in emissions per unit of output; (8) Certified Emission Reductions; (9) The Australian government identified a A$10 fixed price for the first year of the scheme (from July 2011) moving to full trading from mid 2012; (10) Currently the Australian government is evaluating the postponement of the start of the scheme to 2011.

Source: CRU Analysis

- encourage global collaboration and co-investment between industries and governments in the development and deployment of breakthrough low emissions technologies
- promote the development and dissemination of technologies that build the capacity to adapt to climate change, particularly in developing countries

The ICMM members support the development of market-based policy measures that are based on the following principles:

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Clear, predictable and long term	Provide clear, predictable and long term incentives to invest in low emissions technologies and abatement measures
Environmentally effective	Seek to achieve substantial emissions reductions at the lowest economic cost and be sustainable over the long term
Economically efficient and socially acceptable	Provide for a measured transition to a price on carbon so as to avoid adverse economic and social consequences and optimise the price signal effects in changing behaviour
Sustainable development	Encourage resource use efficiency, and support sustainable economic, social and environmental goals and activities
International competitiveness	Be designed to incentivise emissions reductions without creating distortions in trade and investment flows or compromising the international trade competitiveness of industry
International linkages	Be designed to facilitate linkages across international borders, including international carbon markets and/or the development of offset markets which can reduce the cost of greenhouse gas emissions reductions while promoting low emissions technologies and carbon sinks
Global technology co-operation	Policy measures should encourage and reward sharing in the development and deployment of low emission technologies, especially in developing countries

In this context, country-wide legislation will play a major role in the results of measure to reduce greenhouse gas emissions, but the commitment of mining companies will also be a major factor in areas where mining is the most important activity.

Chilean legislation

Following its recent entry to the OECD, Chile will need to improve its performance regarding greenhouse gas emissions. At the 2009 Copenhagen Conference, Chile voluntarily committed to a reduction of 20% based on 2007 emission levels. This will be confirmed by the recently elected government.

The current law N 20.417 recognises climate change as "a change in the climate produced by direct or indirect human activity…". In 2008 the Chilean Government presented an official National Action Plan on Climate Change, with the main objective of minimising the effect of climate change through integrated actions that take into account the vulnerability of the country to these effects. The Plan proposes actions based along three main lines:

- adaptation to the effects of climate change
- mitigation of greenhouse gas emissions
- development and building of capacity to address the problem

With regard to the copper industry, Cochilco undertook the first survey to quantify carbon emissions from the copper industry in Chile, based on information from 95% of the mining companies.

As Chile is a non-Annex I country to the Kyoto Protocol, a cap and trade scheme seems one of the most probable options to be adopted. In this scenario, the cost associated with carbon emission reduction initiatives would be compensated, totally or partially, by Certified Emission Reductions (CER) credit for greenhouse gas emissions under the Clean Development Mechanism (CDM). In the best case this credit would be equivalent to the cost associated with emission reductions for each individual company, and the long term price and the cost curve would be unchanged. In the case of mining companies that do not reduce, or only partly reduce, their emission levels, they would pay a greenhouse gas charge correlating to

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actual emission levels. The costs for each company will therefore increase by a different magnitude, resulting in a potential change in the structure of the cost curve and rise in prices in order to meet demand. In this analysis we will consider the worst scenario in greenhouse gas control, where costs are not offset by greenhouse gas credit.

Greenhouse gas effect on the copper cost structure

In a broad sense, the greenhouse gas effect can be considered as an external factor categorised as one of the following alternatives:

- Additional operational cost – which has a direct effect on the cost structure of companies, and consequently, on the cost structure of the market.
- Additional tax – in this alternative, a clear government position and an accurate quantification of the potential impact associated with the emission are necessary, in order to avoid re-calculation of the tax rate. The problem with this alternative is the need for one policy agreement between all countries to avoid tax problems for multinational companies.

This article will analyse the first alternative, considering the greenhouse gas effect as an additional cost, with the associated increase in costs for each individual company. Emission levels are highly dependent on the source of the emission and on the ability of the company to develop measures to control that emission – essentially, whether the emission is internal or external to the mining company.

Direct or Internal Emission – Emissions from the pit, flotation area and or SXEW operation. The main source of internal emissions is fuel consumption.
Indirect or External Emission – Emissions associated with supplies. In the case of the mining and copper industries, the main source is electrical energy emissions.

Internal emission levels are mostly dependent on the management of an individual company, especially in regard to energy-efficiency initiatives aimed at reducing energy and fuel consumption. The main factor influencing external emissions is the source of electrical energy in the country, which is more dependent on a country's energy source and geographical location than on company management. Mining companies have the opportunity to generate a change in the energy matrix of each country, however, which requires companies, government and other organisations working together to find ways of reducing total greenhouse gas emissions.

Potential effect on the mining cost curve

In theory, if mining companies (copper producers) incur an additional cost that takes into account direct and indirect emissions, that will produce a non-linear effect on the industry cost curve, as illustrated below.

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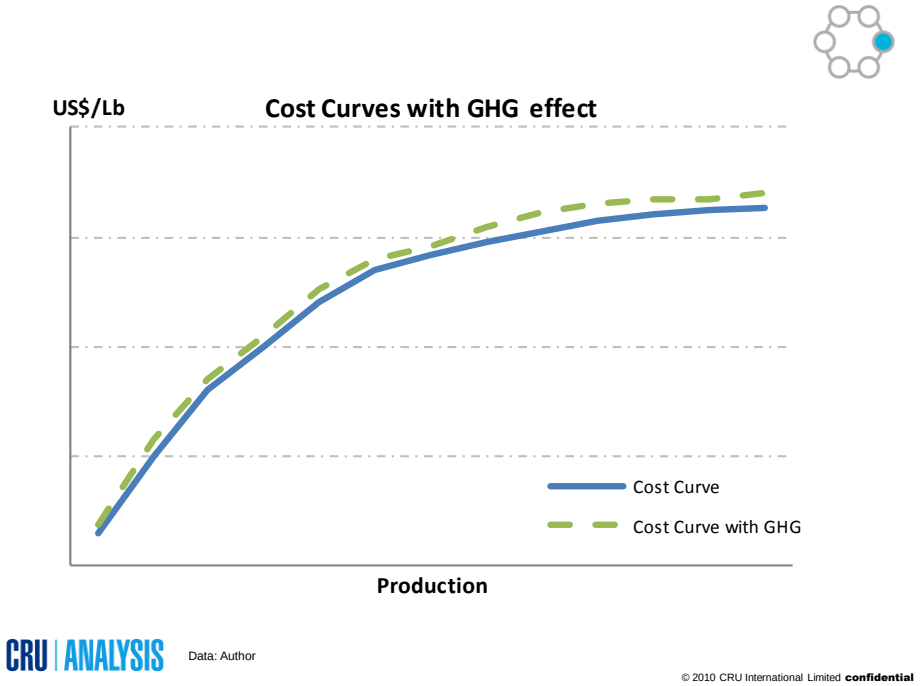

To quantify the impact of the greenhouse gas effect on the cost curve, we will take into account only fuel and energy consumption. Considering the high levels of consumption by mining companies, the greenhouse gas effect will be directly related to the cost and level of emissions associated with fuel and electrical energy.

Chilean power generation system

Power generation in Chile is organised around four grid systems:

- Sistema Interconectado del Norte Grande (SING) – the northern grid, which accounts for about 19% of national generation
- Central Interconnected System (SIC) – the central region grid, which accounts for 68.5% of national generation and serves 93% of Chile's population
- Aysén Grid – in southern Chile, which accounts for 0.3% of total generation and
- Magallanes Grid – also in southern Chile, which accounts for 0.8% of total generation

Electricity is transmitted and distributed through the four grids, as well as the electricity distribution companies. All of the mining companies are located in the SING and SIC grids. In the copper industry, around 70% of mining assets are located in the SING system. The source of energy for the SIC and SING grid systems in 2009 was as follows:

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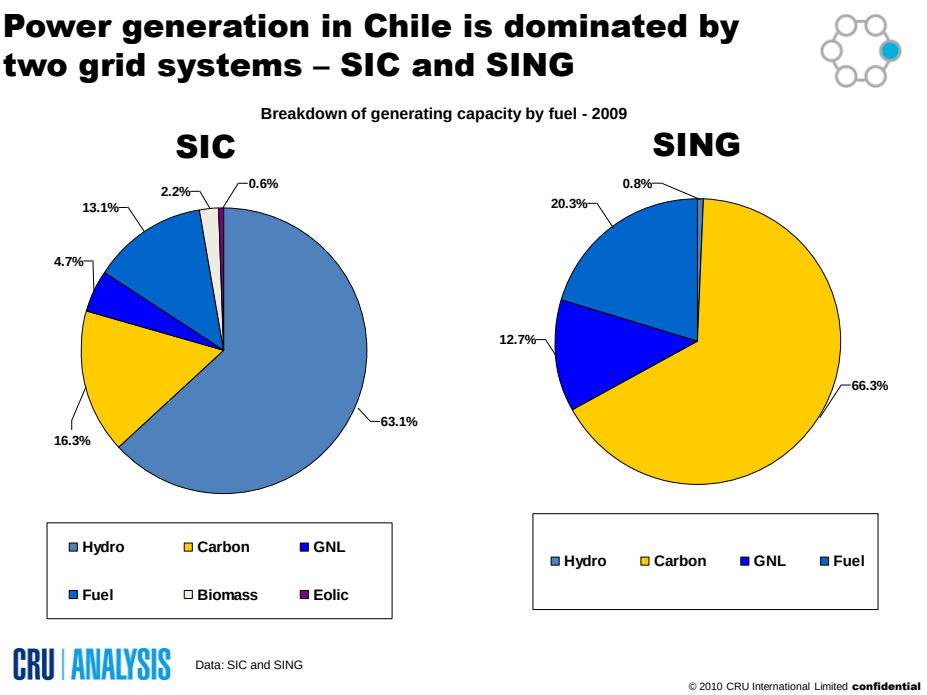

A study on energy sources by Cochilco, based on plans of the Chilean National Energy Commission (CNE), presents an analysis for 2020 for each grid. The main changes in the SING grid will be the replacement of fuel/petrol energy by coal (which will increase its share from 66% in 2009 to 88% in 2020), and the use of geothermal (6%) and wind energy (3.5%) instead of natural gas. In the case of the SIC system, the main change for 2020 will be an increase in coal (to 28%), wind (to 3%) and geothermal (to 3%) energy and a decrease in fuel/petrol (to 0.3%) and hydro (to 57%) sources. This forecast for the Chilean energy sector indicates that greenhouse gas emissions from power supply will increase compared with curent levels.

Cost effect on Chilean mining companies

Assuming a strategy of "emit and pay" and the energy scenario presented above, the cost of the greenhouse gas effect for Chilean copper mining companies will be as follows:

Cost effect in Chilean mining industry

	SIC	SING
Indirect - Energy consumption		
Emissions (tonne CO2 / GWh CO2	394	998

	Emissions (US$ / tonne Cu)
Direct - Fuel consumption	29
Indirect - Energy consumption	220
Total cost effect	**249**

Data: CRU Analysis

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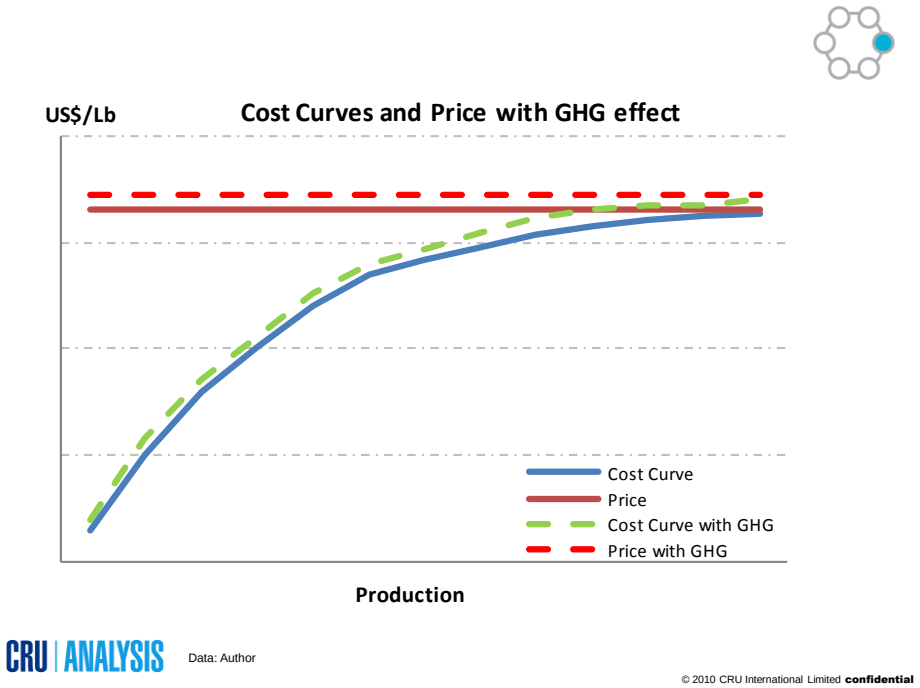
Greenhouse gas effect on long run copper prices

Considering the source of energy as an indirect emission, internal fuel consumption as a direct emission and using CRU's production forecasts for copper, we can evaluate the effect on the cost structure for Chilean copper mining companies. In all the valuations we have used a long term emission price of US$50/tonne CO_2 equivalent.

In an analysis of the effect on long run prices, some marginal producers (blue line in the following chart) would be pushed out of the market with the new cost (green line in the chart) as total costs would be higher than prices (red continuous line) and the operation would be unprofitable. In that scenario, demand for copper would exceed supply, resulting in an increase in price (red segmented line). The rise in price for marginal producers would be equivalent to the increase in costs and total world production of copper would be unaffected by the cost of production for marginal producers, with or without the greenhouse gas effect.



The marginal copper producer will be affected by both direct and indirect emissions. Under a strategy of "emit and pay", the effect on costs can be calculated at around US$341/tonne Cu, as illustrated in the table below.

Cost effect for marginal producer

	Emissions (US$ / tonne Cu)
Direct - Fuel consumption	50
Indirect - Energy consumption	291
Total cost effect	**341**

Data: CRU Analysis

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Projects and initiatives

As previously stated, the increase in cost for the marginal producer will be compensated by an increase in the copper price. This will not be sustainable, however, if the company does not take additional measures to reduce greenhouse gas emissions in the long term. The market perceives this externality as the responsibility of the producer and in addition, every company's strategy is to operate with the least effect on the environment. The main reason for future increases in emissions is the nature of the mining process, which consumes more energy in the mature phase. As mining distances increase, diesel consumption rises; and as ore grades fall, more energy is consumed per unit of copper produced.

A carbon reduction project is a project that will result in a reduction in greenhouse gas emissions. Chile will be an interesting case for the Clean Development Mechanism (CDM), considering its status as a non-Annex I country to the Kyoto Protocol and the potential for increased use of renewal energy, particularly in the north of the country.

There are several initiatives aimed at reducing total emissions in the mining industry, which can be classified in two categories:

- **Energy-efficiency initiatives –** These initiatives aim to reduce energy consumption rates, while maintaining the same productivity levels, to generate a reduction in greenhouse gas emissions. This would be considered cost saving when the base case is business-as-usual (BAU). Examples of this kind of initiative are a reduction in diesel consumption rates or optimisation of electricity consumption in SXEW or flotation operations.
  Practical examples of these initiatives in the mining industry include the Aluminium Production (AP) technology developed by Rio Tinto; the company has reduced emissions in aluminium production by 46% since 1990. Nippon Mining & Metals has reduced CO_2 emissions in its smelting operations to 60% of 1990 levels through energy conservation measures such as conducting copper smelting in a single flash furnace. High-powered chillers have been introduced and compressor operations have been streamlined.
- **Power generation opportunities –** There are several examples of projects aimed at increasing the use of clean energy in the mining industry. One example is the world's first commercial power plant that generates electricity using the extremely dilute methane gas found in coal mine ventilation air. Now known as BHP Billiton's West Cliff Ventilation Air Methane Project (WestVAMP), the plant is located at BHP Billiton Illawarra Coal's West Cliff Mine in NSW, Australia and was officially opened in September 2007.

Examples of renewable energy projects include the high-altitude wind turbine installed by Barrick in Chile, Codelco's planned wind farm at its Gaby mine also in Chile and Tarmac's use of tyre chips, previously considered as waste materials, to generate 50% of the company's energy needs while reducing NO_2 emissions by 15% at its UK cement plant. At Lihir Gold in Papua New Guinea, wells initially drilled to cool and de-pressure the mine provide steam for the 56MW geothermal power plant. Lihir Gold was the first project in Papua New Guinea to register under the Clean Development Mechanism (CDM), enabling the company to claim carbon credits over the next ten years and to sell these credits in the global market.

In order to undertake similar projects in the Chilean market, it would be necessary to review the legislation on electricity supply. The Chilean mining industry has started to take action, however. Studies have begun on current greenhouse gas emission levels[3], on ways to reduce energy consumption rates and on the development of renewable energy sources such as wind or solar. As the mining sector in Chile is one of the most profitable and also one of the main energy consumers, actions taken by this

[3] Minera Escondida "Reporte de Sustentabilidad 2008

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industry will affect directly the achievement of Chile's commitment to reduce total greenhouse gas emissions.

Conclusions

The greenhouse gas issue has dominated world news in the past months and will remain an important issue in future. The last Copenhagen Conference left the responsibility for the implementation of the first measures to individual countries. In the case of Chile, the copper industry will play a major role in the implementation of policies and in greenhouse gas emission reduction.

Under an "emit and pay" strategy, the potential long term indirect emission cost will be around US$220/t Cu for the Chilean copper industry. This is a similar level to the average for world copper producers presented in the February 2010 issue of CRU's Copper Studies, even taking into account the high level of dependence on coal and fossil fuel energy in Chile. The high use of fossil fuel-sourced energy is offset by the higher level of productivity in the Chilean copper industry than in other regions. In terms of copper prices, the increase in cost for the marginal producer (US$341/t Cu) will potentially generate a positive margin for other copper producers, and the associated opportunity to offset the effect of this new cost. The cost is non-linear due to economies of scale and the importance of fixed costs to the marginal producer.

The opportunity for Chile lies in the development of projects enabling greater use of green technology in the mining sector and the generation of green energy. The additional opportunity to claim carbon credits under the CDM, with their trading potential, is good news for major investment especially in the north of Chile.

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Chinese mining investment in Peru – Adapting and resourcing for the future

Introduction

It is well known that China is hungry for minerals and metals. According to CRU's **"Copper Quarterly Report – January 2010"** edition, Chinese demand will continue to grow in the coming years, although maybe at a slower pace. Certainly, the country needs to secure raw materials to meet short- and long-term domestic demand for electric power, transportation, communications and construction, in order to support its continued and rapid growth. Although China has a large internal mining industry, mine production is still insufficient to satisfy domestic consumption. Moreover, China, as one of the main "factories of the world", requires resources to produce the products it exports to the rest of the world. China's current government policy is to secure mineral resources for the future; as the former President of Chinalco, Xiao Yaqing, said in 2008, "We [China] have long been providing products to other countries with our own natural resources. Now it's time to contribute to the world economy with world resources".

Peru ranks as a leading mineral producer and has an immense mineral potential both for base and precious metals. In the 1990s, China started to see Peru as one of the countries from where it could directly obtain the raw materials needed to support growth – an interest that has grown again since 2006.

Several questions arise when this situation is assessed in more detail, however. Have Chinese mining companies adapted themselves to invest outside China, and particularly in Peru? What challenges and opportunities does China face in Peru? Is Peru prepared to host Chinese investment?

Resource seeking – Changing policies and choosing countries

It is China's state policy, as mentioned in its 11th Five-Year Plan (2006-2010), to secure an international supply of raw materials to guarantee the continuity of growth and development of its economy in the long-term. In that context, one of the main objectives of the Chinese government regarding the mining sector is to encourage Chinese companies to list on foreign stock exchanges, find new external resources, acquire existing companies and develop new projects.

China has several options to meet its demand for minerals and metals, ranging from internal grassroots exploration to joint developments overseas. Internally, China is working on promoting greenfield and brownfield exploration; increasing current mine and processing capacities; promoting consolidation to reduce the number of small-scale mines; and enhancing productivity. Externally, China is undertaking greenfield exploration; making overseas acquisitions, strategic investments and joint developments; and signing direct contracts and agreements both with governments and private companies. The effect of all these measures will not be seen simultaneously.

Peru offers most of these external options to China, with both short- and long-term effects. Chinese mining investment in Peru started in 1992, when Shougang Corporation won an international bid for the state-owned company Hierro Peru located in southern Peru, thereby acquiring the only operating iron ore mine in the country. No further major interest or investment came from China until 2006, when Zijin Consortium (Zijin Mining Group Ltd., Tongling Nonferrous Metals Group Inc., Xiamen C&D Inc. and now LS-Nikko Copper Inc. from Korea) acquired the AIM-listed junior mining company Monterrico Metals, which owned the Majaz (today known as Rio Blanco) copper project in northern Peru.

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Mineral resources for China - Alternatives to secure resources and effects

Alternatives	Effects Short-term (< 5 years)	Medium-term (5-10 years)	Long-term (>10 years)
Internal market			
Grassroots exploration			X
Increase capacity	X		
Increase productivity	X		
Mergers and acquisitions	X		
External market			
Grassroots exploration			X
Acquisition of exploration projects		X	
Acquisition of advanced projects		X	
Acquisition of existing operations	X		
Joint ventures	X		
Contracts/agreements	X		

Source: Author

From just one Chinese mining company in 1992, today six other companies have a presence in the Peruvian mining sector (that number rises to nine if all the partners of Zijin Consortium are included). Between 1992 and 2010, Chinese mining companies have invested approximately US$1.87 billion in acquiring projects from both the government and junior mining companies in Peru (94% of this total came after 2006). Furthermore, these Chinese mining companies have announced investment of more than US$6.8 billion over the next five to ten years, mainly in copper and iron ore projects. Acquisitions made in Peru account for around 26% of all upstream mergers and acquisitions (M&A) completed by Chinese mining companies worldwide since 2000 (excluding Chinalco's acquisition of shares in Rio Tinto), and for around 34% of total M&A in Peru over the same period.

Regarding copper, Peru is one of eight countries where Chinese companies currently have an interest in mining projects. Of the twelve copper projects acquired outside China, four are located in Peru.

Chinese acquisitions of mining projects/operations in Peru

Chinese company	Year of transaction	Name of project/operation	Mineral	Acquired from	Acquisition cost (US$ million)	Announced investment (US$ million)
Shougang Corporation	1992	Marcona	Iron ore	Peruvian government	120(2)	1000
Zijin Consortium (1)	2006	Rio Blanco	Copper	Monterrico Metals	186	1440
Chinalco	2007	Toromocho	Copper	Peru Copper	792	2152
Minmetals/Jiangxi Copper	2007	El Galeno	Copper/Gold	Northern Peru Copper	432	1500
Nanjinzhao	2009	Pampa de Pongo	Iron ore	Cardero Resources	100	n.a. (3)
China Sci-Tech	2010	Mina Justa	Copper	Chariot Resources (4)	240	750

Notes: (1) Xiamen Zijin Tongguan Investment Development Co. Ltd.; (2) Plus an additional investment commitment of US$150 million; (3) The Ministry of Energy and Mines estimates an investment of more than US$3 billion; (4) The two companies entered into an agreement in March 2010 for the acquisition of Chariot Resources.

Source: CRU, Ministry of Energy and Mines of Peru, Company information

Why is China looking into Peru?

Trade between Latin America and China had a value of more than US$100 billion in 2008, making China the region's third largest trading partner. Peru and China have had an historical relationship since the 19th Century, although the Peruvian Embassy in China was not opened until 1972 and a Peruvian President first travelled to China in 1992. Nevertheless, in the last decade the countries have been strengthening their diplomatic and commercial relationships. Several high-level official visits to both countries have been undertaken with the objective of concluding concrete bilateral agreements, the most recent and important being the China-Peru Free Trade Agreement (FTA) signed in 2009.

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Globally, Peru ranks within the top five producers of gold, silver, copper, molybdenum, zinc, tin and lead, among others. In addition, Peru offers China a vast and diverse geological potential, a long mining history, human resources with mining expertise, political stability, a favourable investment environment, and clear legislation and property rights, which may not be offered in other mining regions where China is currently present such as Africa. Peru is also well ranked by the Fraser Institute "Annual Survey of Mining Companies 2008/2009" and by the World Bank's "Doing Business 2010" report. In December 2009, the country's sovereign debt rating was upgraded to investment grade by Moody's (Standard & Poor's and Fitch Ratings did the same in 2008), and Peru is a member of the Asia-Pacific Economic Cooperation (APEC). Peru will also host a country pavilion at Expo 2010 Shanghai China.

According to CRU's **"Copper: South America Monthly – February 2010"** edition, in 2009, Peru accounted for 17.9% of South American and 7.8% of world copper output, following Chile with 76.9% and 33.5%, respectively. Peru is the world's second largest copper producer after Chile.

Peru's current main investors in mining exploration are primarily junior mining companies listed on the Toronto Stock Exchange. According to Metals Economics Group's "World Exploration Trends" report (March 2010), US$520 million (7% of the world total) were invested in exploration in Peru during 2009. Peru therefore ranked third worldwide, just below Canada and Australia, as a destination for mining exploration investment. Capital from the UK accounts for the largest investment funds in the Peruvian mining sector. From a commercial perspective, Peru's main trading partner is the USA (with bilateral trade exceeding US$12 billion in 2008), followed by China. In 2008, trade between Peru and China totalled around US$7.7 billion; almost half of this comprised exports to China. Approximately 80% of those exports were mineral resources, mainly copper, lead, zinc and iron ores, which represent about 15% of total Peruvian mineral exports. In addition, trade between China and Peru represented 12.6% of all trade between Peru and the rest of the world. The recently signed FTA will definitely increase trade between the countries.

Chinese investment in Peru is not limited to mining; it is also present in the oil and gas and fishing sectors. Chinese direct foreign investment is still low, however, totalling US$261.7 million in 2008 – 48% in mining and 40% in fishing – which represented only 1.5% of total investment.

Adapting to a new environment – New players

China, as any other country, faces new challenges by investing in Peru, which may not be present in China or other mining regions – labour and human rights awareness; more comprehensive environmental legislation; higher community involvement; NGO scrutiny; a different political context; the need for resettlements; transparency; and media presence. Things may be done differently in China than in Peru. In addition, China's way of working in Peru and internationally, as perceived and publicly mentioned by some private and public stakeholders in Peru and other countries, still has room for improvement and adaptation.

When Shougang purchased Hierro Peru in the 1990s, it was the largest foreign investment by China in Latin America at that time and coincidentally the first privatisation in the Peruvian mining sector. Unfortunately for the Chinese newcomers, two decades later, as reported by the Peruvian media, Shougang has faced several strikes and civil complaints on labour and environmental issues made to the Peruvian government.

It is understood that several stakeholders consider China also has the opportunity to improve upon its existing perceived reputation built by working in other regions such as Africa, where some companies have publicly been accused of using child labour, poor HSE (health, safety and environment) standards, corruption and lack of transparency. In the interest of fairness, in the 1990s other mining companies working in Peru were also starting to adapt and improve their environmental and community relations practices.

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Business considerations in Peru	
Health, Safety and Environment (HSE)	Peru has comprehensive HSE legislation, specially in mining. The mining sector is considered as a pioneer in environmental legislation in Peru compared to other economic sectors. The Peruvian government has strengthened its enforcement by transferring responsibility from the Ministry of Energy and Mines to a special independent unit called OSINERGMIN. The Ministry of Environment was created in 2008 and will start assuming more responsibilities.
Labour	Even though labour unions' power diminished during the 1990s, their negotiating power still exists in major mining operations in Peru. Strikes could be expected, specially from related unions, such as in civil construction.
Non-governmental organisations (NGOs)	In the last decade, several local and international NGOs have become very active in the mining sector.
Media	The Peruvian Constitution supports freedom of speech and media. Peru has a large number of national and local printed, radio, TV and internet media, some with serious investigation teams, others with political agendas.
Community relations	Issues between mining companies and surrounding communities are present. Reasons for conflict may vary: land property, water usage, distribution of benefits, preference to use local labour and services, etc.
Multinational mining companies	Most major mining companies, such as BHP Billiton, Vale, Rio Tinto, Anglo American, among others, are present in Peru exploring, developing projects or operating mines. Their leading practices are creating several benchmarks for mining operations in Peru.
Government intervention and presence	The Peruvian government does not intervene in the markets, only as a regulator. All state-owned mines have already been sold to private entities. In additionally, the presence of few Peruvian government-provided basic services (health, education, etc.) demands more intervention of mining companies, with companies sometimes assuming the role of the state.
Resettlements	Although no major resettlements have so far taken place in mining projects; those that will need to undertake resettlements are using World Bank standards in preparing their future plans.

Source: Author

It has been widely reported in both Peruvian and international media that two of the main Chinese-run projects are facing community-related issues. One is an issue inherited by Zijin in the northern region of Piura at the Rio Blanco copper project, where its development has faced opposition from several local stakeholders since its early exploration phase. In 2009, the exploration camp, although with very limited activity at that time, was assaulted by a still-unknown group, and some security staff and employees were unfortunately killed; these events are still under investigation by the Peruvian authorities

Piura is a difficult region in which to mine legally nowadays. As a precedent, in 2003, another gold-copper project, Tambogrande, with no Chinese investment, was banned following political, community and NGO opposition. Ironically, however, illegal mining in Piura, with the resulting pollution, has grown in the last five years.

Minmetals/Jiangxi's El Galeno project, located in the northern region of Cajamarca, has reported it had its own community-related issues, which now appear to be finding solutions after intense engagement work done by its project team with surrounding communities.

Although it is true that several socio/political-environmental conflicts have arisen in recent years in several mining districts of Peru and that conflicts at the Rio Blanco and El Galeno projects may not have their origins in Chinese management, these examples have made several stakeholders in Peru raise the question of whether the Chinese companies have been conducting socio-political due diligence before acquiring their current mining properties or whether they proceeded with securing future mineral

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resources without any such assessments. This question is also applicable to other companies working in Peru.

Nevertheless, it appears that Chinese companies have also recognised that they are working in a new environment and are allowing their management teams to be formed from locals or non-Chinese expats with experience in Peru. That is the case in the Toromocho and El Galeno projects. The current CEOs of both projects are non-Chinese expats with broad expertise in the Peruvian mining sector. Chinalco's Toromocho project is managed by a former President of the world-class Antamina copper mine (co-owned by BHP Billiton, Xstrata, Teck and Mitsubishi Corporation). The El Galeno project is headed by the former General Manager of Gold Fields' Cerro Corona gold-copper project. In both cases, the project teams are almost 99% non-Chinese nationals.

Chinalco appears to be establishing a new image of Chinese investment in Peruvian mining. It has been intensively investing in environmental and social responsibility programmes, which are constantly publicised in the local and international media. For example, Chinalco is investing US$33 million in Kingsmill Tunnel's Acid Water Treatment Plant, which has been an unsolved environmental problem for years in the operating region (and for which no other company working in the area for decades has wanted to take responsibility). Chinalco is adapting and leaving the local expertise to work almost freely. It also appears to be showing a clear engagement with communities and employees, highlighting its Social Corporate Responsibility practices. Toromocho's development will mark a milestone for Chinese involvement in the Peruvian mining sector if it works well. One of the major challenges which Chinalco still needs to handle well is the relocation of an entire town of 1,800 families (around 5,000 people) in the next two years. The Toromocho project, with a 36-year mine-life, is currently under construction and start-up is planned for 2012.

Chinese companies' main challenges

Company	Project/Operation	Main issues
Shougang Corporation	Marcona	Labour, environmental
Zijin Consortium	Rio Blanco	Social, political, environmental
Chinalco	Toromocho	Resettlement
Minmetals/Jiangxi Copper	El Galeno	Social, political

Source: Author

Who controls who?

Chinese investment in Peru has not met with general nationwide political opposition as faced by Minmetals regarding its take over of Noranda in Canada or by Chinalco over several Rio Tinto assets in Australia, but as mentioned above, it has to become more vigilant of its own management of resources. Following both internal and external pressure, the Peruvian Mining, Petroleum and Energy Society (SNMPE by its Spanish acronym) is taking more care in enforcing its Code of Conduct. In early February 2010, for example, the SNMPE expelled the US mining company Doe Run because the Society considered the company was breaching its Code on ethical, environmental and labour grounds.

On its side, China has also been working internally to enhance its practices so that Chinese companies are better prepared for facing new challenges before going overseas. In 2008, the Chinese government upgraded its environmental agency by creating the Ministry of Environmental Protection. The government has also been working on improving safety conditions, having closed hundreds of mines in the last five years. As part of the reforms in the mining sector, China has announced better regulation and enforcement from the central government. These changes and enforcements will start showing their effectiveness in the medium to long term.

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Just starting…

Investment announced by Chinese mining companies represents around 30% of total investment publicised in the Peruvian mining sector for the next decade. The start-up of these projects is subject to several challenges, however, which will build China's reputation in Peru. Of the announced investment, the most certain project may be in Toromocho; the rest of the projects are still considered as possible or probable. Today, Chinese investment in Peru should be aimed at medium- to long-term results.

In any case, when these projects reach full production (of approximately 525,000t/y copper in 2020), they will meet a small but still important percentage of China's mineral needs (around 4%, assuming a yearly growth of 5% of China's current copper consumption levels). China should not only view Peru as a source of natural resources, but also as an opportunity to gain more knowledge of the mining business overseas and should take advantage of the positive externalities that can bring. Both countries could gain several benefits in terms of trade, resources, capacity building and knowledge sharing if their cooperation is successful.

Other questions which could be the subject of further analysis are:

- Which evaluation criteria are Chinese mining companies using to decide upon their investments?
- Are Chinese mining companies over/under-paying for the resources (US$ paid/proven reserves)?
- Is China introducing more competition in the M&A and exploration projects markets?
- What is the quality of the acquired assets?

Peru has a vast geological potential, but available deposits may be located in increasingly remote areas. Recent developments in Peru are the result of successful exploration undertaken more than 30 years ago. Moreover, deposits are nowadays more difficult to develop given their low grade, which makes them uneconomic. Technological development is therefore necessary to secure resources for the future. Chinese companies need to continue investing in improving productivity, in new technologies, and in enhancing HSE standards.

It appears that Peruvian authorities and other stakeholders still need to improve their understanding of how the decision-making process works inside Chinese mining companies. Maybe China better understands Peru than Peru understands China, language being one of the biggest barriers (in addition perhaps to the Chinese *guanxi* way of operating). Chinese investment in Peru is still young and it may be too early to judge, but lessons learnt from the past need to be taken into account by Peru in these new ventures. Peru needs strong government enforcement and a vigilant society for both national and foreign investment. Although it seems that China is taking more and more care of its corporate conduct and image, that role is the responsibility of both the host countries and China.

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CRU and CESCO Scholarship

The CRU-sponsored CESCO scholarship scheme is now in its fourth year. Since 2007, CRU has sponsored two or three CESCO Scholars each year to visit London and spend some time with CRU's Copper Team.

During the visit the scholars learn how CRU's Copper and other teams work. They also visit the London Metal Exchange and head offices of major companies involve with the mining industry. Atlantic Copper sponsors a visit to its head office in Madrid and to its smelter-refinery complex at Huelva.

Prior and during their visit to CRU, the scholars also research and write articles for ***Copper Studies***.

About CESCO

The Center for Copper and Mining Studies, CESCO, is an independent, non-profit organization created in Santiago in 1984. The members of CESCO work as executives or consultant for national and foreign mining companies, others as professors in local or foreign universities. Throughout its history, CESCO has positioned itself as a meeting place for diverse sectors interested in mining --business, academia, policymakers and professionals-- to promote ideas and discuss criteria about public policies related to economic and mining activities.

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