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Assessing the costs of the new collective bargaining agreements in the Chilean copper industry *page 3*

Since 2004, 15 collective bargaining agreements have been settled at mining operations in Chile. Most involved large compensation packages in the form of a bonus payment and wage increases. Strike action was limited to only seven operations. The settlements increased total costs at Chilean copper mines by some US\$8.1 million, equivalent to an increase of 0.07¢/lb. The effect on the competitiveness of the Chilean copper industry is examined in this article.

Future copper growth in Chile and Peru *page 7*

Continuing this month's South American theme, three visiting scholars from CESCO compare the problems slowing project development in Chile with those

in copper mining neighbour Peru. Both countries share a number of similar developmental problems; while currently some problems are more serious in one country than the other, it appears ever more likely that problems currently found in one country will soon be prevalent in the other. The article discusses Chile's current problems with water and power supply and with labour and sub-contracting issues – problems that look set to become more significant in Peru over the coming years. From a Peruvian perspective, the article discusses the country's current problems with socio-economic and environmental protests; and rampant foreign take-over activity – again problems that may soon become more common in a traditionally mining-friendly Chile.

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

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Three visiting scholars from CESCO compare energy supply issues in each of their respective countries, Brazil, Chile and Peru.

Power supply constraints are not a new threat to the South American copper industry. 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 copper mining projects, that will start-up in the next few years.

Each country is dealing with its power supply issues by different means. 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. Brazil is diversifying its energy matrix through bio-diesel and natural gas power generation.

Mining companies in all three countries are coming up with their own solutions as government initiatives will only show results in the medium term.

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 rents¹ 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, exceed the true economic costs of all inputs into the production process.

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.

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

harmful 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.

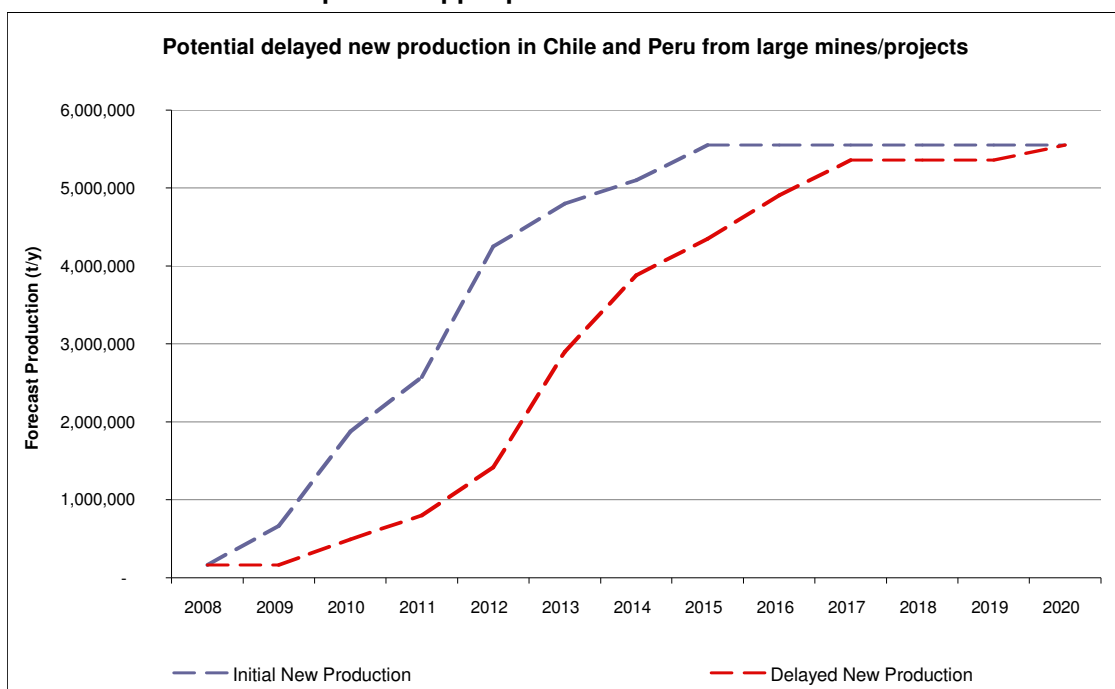
***Authors:** This article was co-written by Juan Ignacio Guzman and Cristián Barrientos Parant, both CESCO Scholars. Juan Ignacio Guzman has a Mining Engineering degree and is currently completing his PhD in Mineral Economics at the Catholic University of Chile in Santiago, Chile. Cristián Barrientos Parant has a Mining Engineering degree from the Catholic University of Chile and is currently working for Codelco in the Corporate Management Mineral Resource Office in Santiago, Chile.*

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,

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

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.

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”

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

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	?	x
Management & operational risk	?	x
	√ = likely	? = potential
		x = unlikely

This article was written by three visiting, CRU-sponsored CESCO scholars:

Alicia Maria Polo y La Borda Cavero is a Peruvian economist. Masters Degree in mineral law and policy has been complemented by experience at UNEP and at the University of Witwatersrand. Currently serves as Director of Mining Promotion at the Ministry of Energy and Mines of Peru.

Patricio Enrique Pérez Oportus is a Chilean economist. Masters degree in economics, plus Diplomas in macroeconomics, project evaluation, complements a Degree in business administration. Currently serves as Economist in the Research and Policy Planning Department at the Chilean Copper Commission.

Juan José Rodríguez Arestizábal is a Chilean mining engineer currently serving with Chilean firm NCL Ingeniería y Construcción S.A. Also has Masters Degree and Diploma in mineral economics.

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

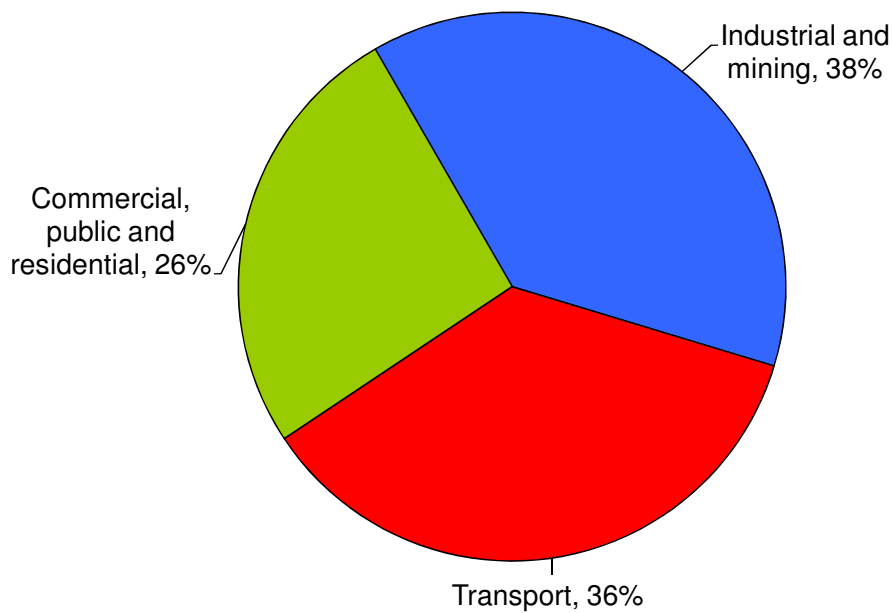
This article focuses on the SING and SIC grids as these are the main suppliers to the copper industry and they account for over 95% of the installed capacity.

- 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.

- 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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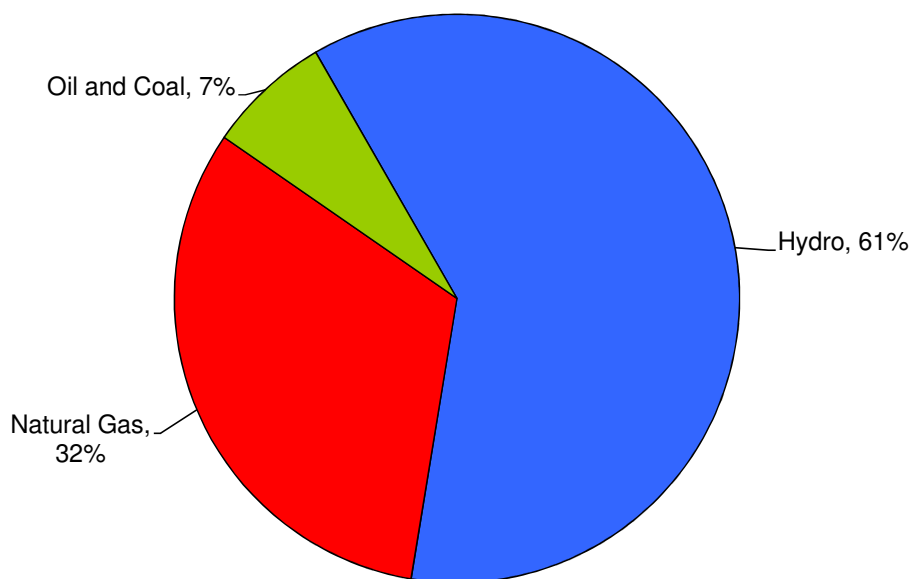
Given this situation, Chile is looking at ways to achieve greater energy independence and to increase its power sources. The Chilean government and the country’s private sector are working on several initiatives; including construction of re-gasification facilities at the ports and non-conventional renewable 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.

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. The energy sector is monitored by the Supervisor Office for Investment in Energy and Mining (Organismo Supervisor de la Inversión en Energía y Minería – 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).

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%	
	Consortio 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

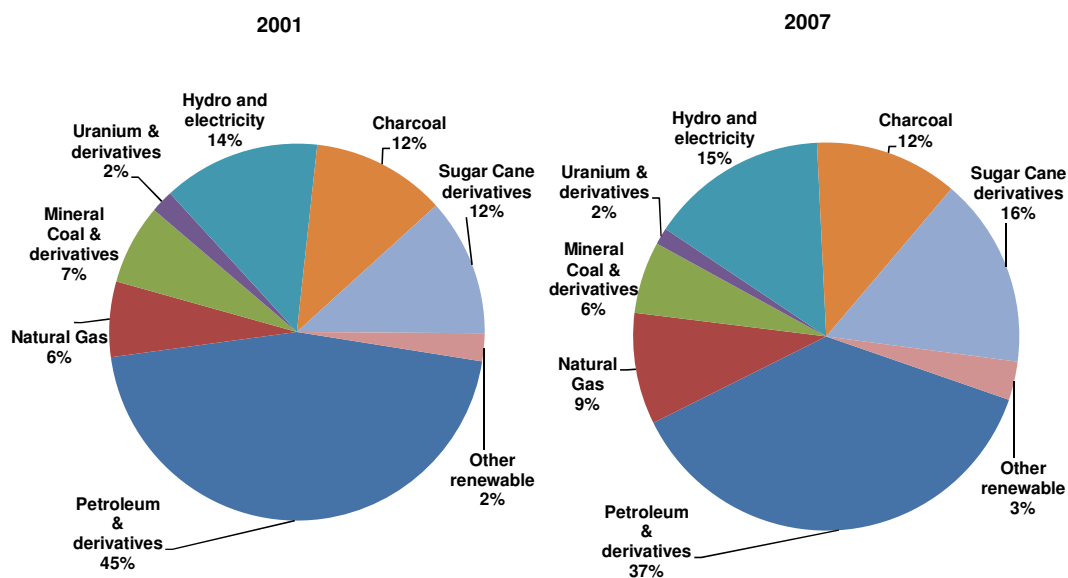
Brazil's energy matrix has two main characteristics: i) it is still heavily based on petroleum and water, and ii) most generation plants are owned by the federal or state governments. These characteristics are at the same time both strengths and weaknesses for the country. Although Brazil has announced 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 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.

Brazilian Energy Matrix By source



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Data: BNE 2008, MME

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Figure 3. Brazilian Energy Matrix

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

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.

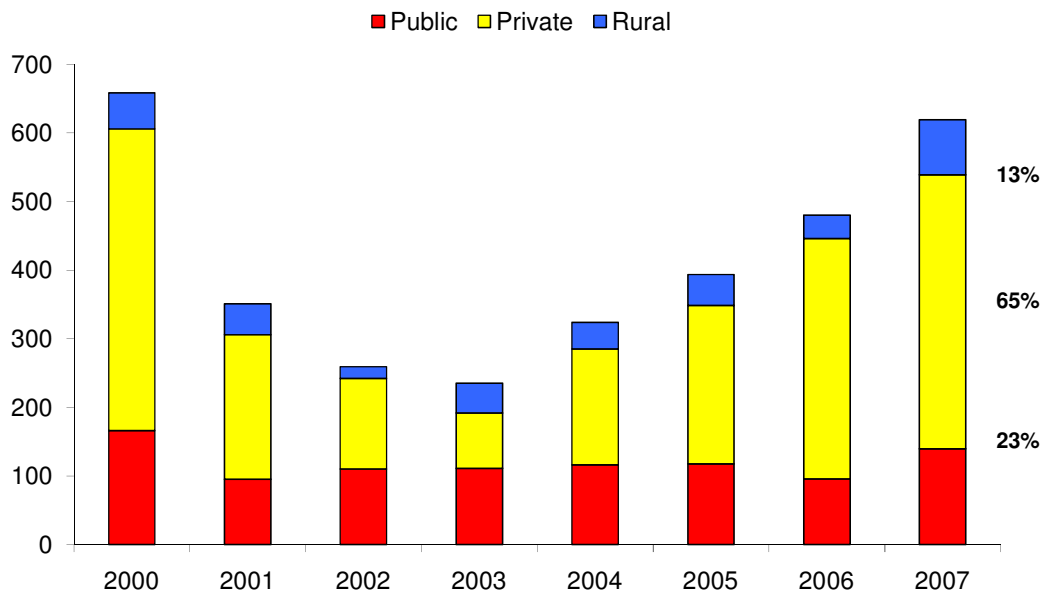


Peru

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



CRU ANALYSIS

Data: Minem

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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 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, 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 (\approx 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)
- 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

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

The mining industry in Peru accounts for around 24% of national power consumption (6,888 GWh). In 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 Consultoria

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 3,300GWh³ (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.

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 (10⁶ 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
<i>Mining & Pellet</i>	<i>2.3</i>	<i>2.4</i>	<i>2.5</i>	<i>2.6</i>	<i>2.9</i>	<i>3.0</i>	<i>3.3</i>
<i>Non-ferrous & other metallics</i>	<i>4.0</i>	<i>4.5</i>	<i>5.0</i>	<i>5.3</i>	<i>5.4</i>	<i>5.7</i>	<i>6.0</i>
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

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

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.

This article was written by three visiting, CRU-sponsored CESCO scholars:

Melissa Rita Paredes Pacora is a Peruvian Economist currently serving as Analyst in charge of mining sector at APOYO Consultoria, before she served as Analyst in the Ministry of Energy and Mines of Peru.

Talita Vieira Rodrigues is a Brazilian Business Administrator currently serving as Market Analyst at Companhia Vale do Rio Doce.

Ivonne Alejandra Mendez Munoz is a Chilean Electronic Engineer, Control Automatic currently serves as a Product Manager at ABB Chile.

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CRU

31 Mount Pleasant

London

WC1X 0AD

UK

Telephone +44 20 7903 2000

Fax +44 20 7837 0976

Email sales@crugroup.com

Website www.crugroup.com

Subscribers should address any comments or queries to:

David Duckworth

Tel: +44 (0)20 7903 2083

E-mail: david.duckworth@crugroup.com

For subscription enquiries, please telephone Customer Services on +44 (0) 20 7903 2147 or by email at customer.services@crugroup.com. Please visit us online at www.crumonitor.com

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CRU, 31 Mount Pleasant, London, WC1X 0AD, UK; Tel: +44 (0) 20 7903 2147; Fax: +44 (0) 20 7903 2172

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