Smelting and refining: Chilean situation at 2018

Chilean Copper Commission

April, 2018 –ICSG

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Smelting and refining in Chile

There are 7 smelters in Chile, and 3 of them also have refinery (Chuquicamata, Potrerillos, and Ventanas).

5 are state-owned, while 2 are private (Alto Norte and Chagres)
## Smelting and refining in Chile

### Annual capacities in thousand tones (2018)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Altonorte</td>
<td>1.160</td>
<td>-</td>
<td>1.000</td>
</tr>
<tr>
<td>Chuquicamata</td>
<td>1.400</td>
<td>540</td>
<td>970</td>
</tr>
<tr>
<td>Potrerillos</td>
<td>680</td>
<td>130</td>
<td>460</td>
</tr>
<tr>
<td>Hernán Videla Lira</td>
<td>450</td>
<td>-</td>
<td>253</td>
</tr>
<tr>
<td>Chagres</td>
<td>660</td>
<td>-</td>
<td>500</td>
</tr>
<tr>
<td>Ventanas</td>
<td>430</td>
<td>410</td>
<td>330</td>
</tr>
<tr>
<td>Caletones</td>
<td>1.370</td>
<td>-</td>
<td>1.200</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>6.150</strong></td>
<td><strong>1.080</strong></td>
<td><strong>4.713</strong></td>
</tr>
</tbody>
</table>

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International context

Installed fusion capacity has migrated from developed to developing economies (47 and 24% in 1992 and 2016, respectively, of participation in developed economies)
Economic context: Direct cash costs in smelter (c/lb)

Fuente: Wood Mackenzie, 2018
Environmental context: Emission standard in smelters

Emission standard in copper smelters and other arsenic emission sources (DS 28/2013)

Goals:
Article 1º.- To protect human and environmental health in all national territory. As a result of its implementation air emissions of particular matter ($\text{PM}$), sulfur dioxide ($\text{SO}_2$), arsenic ($\text{As}$) and mercury ($\text{Hg}$) will be reduced.
Environmental context: SO$_2$ emissions in Chile

Smelters emit four times as much as all Chilean thermoelectric plants together (2008 estimations).

**SO$_2$ (Ktons/year)**

- Thermoeléctricas C/N: 68 Ktons/year
- Thermoeléctricas S/N: 57 Ktons/year
- Altonorte: 24 Ktons/year
- Ventanas: 21 Ktons/year
- Chagres: 12 Ktons/year
- Caletones: 108 Ktons/year
- Potrerillos: 87 Ktons/year
- Chuquicamata: 68 Ktons/year
- Hernán Videla Lira: 24 Ktons/year
- Chagres: 109 Ktons/year

Source: Environmental Ministry
Emission standard in smelters

Maximum limits:

<table>
<thead>
<tr>
<th>Emission source</th>
<th>SO2 (ton/y)</th>
<th>As (ton/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altonorte</td>
<td>24.000</td>
<td>126</td>
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<tr>
<td>Caletones</td>
<td>47.680</td>
<td>130</td>
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<tr>
<td>Chagres</td>
<td>14.400</td>
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</tr>
<tr>
<td>Chuquicamata</td>
<td>49.700</td>
<td>476</td>
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<tr>
<td>Hernán Videla Lira</td>
<td>12.880</td>
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<td>Potrerillos</td>
<td>24.400</td>
<td>157</td>
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<tr>
<td>Ventanas</td>
<td>14.650</td>
<td>48</td>
</tr>
</tbody>
</table>

Maximum limits in existing smelters: **Sulfur** and **Arsenic** capture and fixation percentage must be equal or superior to **95%**

- Specific emission limit of SO2 and As for **acid plant**
- PM emission limit in **dryers and furnaces**
- Arsenic emission limit in **slag cleaning furnaces**
- Smoke opacity limit in **refining furnaces**
Emission standard in smelters

For old smelters:

- Smelters with **double contact acid plant**: Ventanas, Chagres and Altonorte must meet in **2016**
- Smelters **without** double contact acid plant: Chuquicamata, Potrerillos, HVL and Caletones must meet in **2018**

For new smelters:

- Compliance with **SO$_2$** capture greater or equal to **98%**
- Compliance with **As** capture greater or equal to **99.97%**.
- Chimney emission limits for unit operations: dryer (PM), slag cleaning furnace (MP, As), acid plant (SO2, Hg).
Future of smelters and refineries in Chile

Low technic-economic performance

+Higher environmental standards requirements

=Need of a change in the smelter and refinery industry in Chile to reach:

→Higher added value
→More sustainable industry
→Higher productivity and efficiency
→Recovery of valuable materials from concentrates
Current investments in smelters

- **Altonorte**: Budget: MUS$ 100, 97% SO2 and >95% As of capture by 2017
- **Chagres**: Budget: MUS$ 70,5, 98% SO2 and 95,54% As of capture by 2017
- **Ventanas**: Budget: MUS$ 159 (14 projects), 95% SO2 and 94,7% As of capture by 2017

→ No significant improvements in costs reductions
Current investments in smelters

Chuquicamata
- Improvements in dust and gas captures, replacement of equipment
- No significant improvements in cost reductions
- Budget: MUS$ 948

Potrerillos
- Improvements in capture and processing of gases, slag cleaning, and smoke treatment.
- No significant improvements in cost reductions
- Budget: MUS$ 523,48
Current investments in smelters

Current smelters state

Required standard for 2018

- **Hernán Videla Lira:**

**STAGE 1:** Compliance plan of DS 28 between 2018 and 2023.
- Improvement in gas capture
- No significant improvements in cost reductions
- Budget: MUS$ 57,96

**STAGE 2:** New smelter: Higher capacity, compliance with DS 28 for new smelters.
- Capacity: 700 mil ton/year (twice as much as current)
- **First quarter of competitiveness and costs**
- Budget: MUS$ 611,24
Current investments in smelters

Current smelters state

Required standard for 2018

- **Caletones**
  - Change of equipment for slag treatment, optimization of drying process for higher gas captures.
  - No significant improvements in cost reductions
  - Budget: MUS$ 573,27
### Summary 1/4

**Big Economic and environmental impact.**

<table>
<thead>
<tr>
<th>Name</th>
<th>SO2 capture in 2010 %</th>
<th>SO2 capture in 2014 %</th>
<th>SO2 capture in 2018 %</th>
<th>Investment Mill USD$</th>
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<tbody>
<tr>
<td>Codelco Chuquicamata</td>
<td>89,1</td>
<td>94</td>
<td>95</td>
<td>948</td>
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<tr>
<td>Codelco Potrerillos</td>
<td>85,7</td>
<td>86,4</td>
<td>95</td>
<td>523,48</td>
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<td>Codelco Ventanas</td>
<td>94,6</td>
<td>95</td>
<td>95</td>
<td>159</td>
</tr>
<tr>
<td>Codelco Caletones</td>
<td>86,2</td>
<td>91,6</td>
<td>95</td>
<td>573,27</td>
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<tr>
<td>Enami Hernán Videla Lira</td>
<td>90,7</td>
<td>86,8</td>
<td>95</td>
<td>57,96</td>
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<tr>
<td>Glencore Altonorte</td>
<td>91,7</td>
<td>95</td>
<td>97</td>
<td>100</td>
</tr>
<tr>
<td>Angloamerican Chagres</td>
<td>95,1</td>
<td>98</td>
<td>97</td>
<td>70,5</td>
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</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>SO2 capture in 2023 %</th>
<th>Investment Mill USD$</th>
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</thead>
<tbody>
<tr>
<td>Enami HVL Project</td>
<td>98</td>
<td>611,2</td>
</tr>
</tbody>
</table>

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Summary 2/4
Small Cucons supply impact.
Smelter alternatives

Complex concentrates Leaching Project

- Location: North District of Codelco (Chuquicamata and Ministro Hales)
- Capacity: 200 thousand tones of concentrates
- Produces: 61 thousand tones refined Cu
- Investment: MUS$ 324
- Autoclave technology: high temperature (220°C) and pressure (28 atm)
- **No atmospheric emission**; stable arsenic waste; consumes 25 times less water than alternatives
- Competitive costs; uses existing SxEw plants
• DS 28/2013 has started a great discussion regarding the role of Chile in smelting and refinery market.
• Changes in the copper production structure involves new challenges for Chilean industry.
• The answer would be
  • First: compliance with environmental rules is not under discussion.
  • Second: Big financial and technical efforts to achieve new regulations.
  • Third: because of this new scenario a new focus in technology development for smelting and hydrometallurgical solutions has started, even for sulphides
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