COPPER CONCENTRATES:
SMELTING TECHNOLOGIES UPDATE AND CUCONS MARKET

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INTRODUCTION

• Sulphide copper accounts for almost 80 percent of world mine production and more than 2/3 of Chilean production and its expected to grow its share over the time.

• Smelting arise as a strategic process for copper producer countries. Chile maintains around 9 percent of global smelting production.

• New technology developments and higher competition for copper concentrates motivates this study.

• Market does not show great escenario
WORLD COPPER PRODUCTION

Grow rate yoy
2003-2016 = 3%
2017-2020 = 2.8%

[Bar chart showing copper production from 2003 to 2020 with projected growth rates for 2017 to 2020.]
CUCONS BALANCE

Balance


-134 180 586 24 -17 244 164 683 -119 84 32 -50

Forecast

TC Nominal (US$/TMS)
BACKGROUND AND CONTEXT
# MAIN TECHNOLOGIES

<table>
<thead>
<tr>
<th>Stage</th>
<th>Input</th>
<th>Output</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smelting</td>
<td>Concentrate</td>
<td>Matte, smelting slag and gases</td>
<td><strong>Mainly Bath and Flash</strong></td>
</tr>
<tr>
<td>Converting</td>
<td>Matte</td>
<td>Blister, converting slag and gases</td>
<td>Mainly Peirce-Smith</td>
</tr>
<tr>
<td>Refining</td>
<td>Blister</td>
<td>Anodic Copper, refining slag and gases</td>
<td>Anode Furnace</td>
</tr>
<tr>
<td>Slag treatment</td>
<td>Slag</td>
<td>Matte, discard slag and gases</td>
<td>Milling-flotation, Electric furnace, Slag furnace</td>
</tr>
</tbody>
</table>

**Recent developments**

- Chinese reactors (BBS, SBS), bath technology.
- Chilean packed bed converting technology.
- Ausmelt C3 Converting®

CHILEAN CHALLENGE: COMPLEX CUCON

• Mineralogical composition affects concentrates market performance.

• Arsenic compounds arise in northern Chile and some mines in Peru.

• Mixing concentrates from various sources and penalties charges could cost more than 200 $US/DMT.

SMELTING TECHNOLOGIES
### OPERATING SMELTERS

- 57 operating smelter database, accounts for **88 percent of world anode capacity** in 2016.

<table>
<thead>
<tr>
<th>Zone</th>
<th># Smelters</th>
<th>Anode Capacity 2016 (000’ tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile</td>
<td>7</td>
<td>2,008</td>
</tr>
<tr>
<td>Rest of America</td>
<td>8</td>
<td>2,226</td>
</tr>
<tr>
<td>China</td>
<td>16</td>
<td>5,834</td>
</tr>
<tr>
<td>Japan</td>
<td>5</td>
<td>1,923</td>
</tr>
<tr>
<td>Rest of Asia</td>
<td>5</td>
<td>2,732</td>
</tr>
<tr>
<td>Europe</td>
<td>9</td>
<td>2,685</td>
</tr>
<tr>
<td>Rest of the World</td>
<td>7</td>
<td>1,643</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>57</strong></td>
<td><strong>19,051</strong></td>
</tr>
</tbody>
</table>

*Source: Wood Mackenzie (2016), World Metal Statistics (20016)*
SMELTING TECHNOLOGIES

- 24 Bath smelters
- 23 Flash smelters
- 7 mixed smelters
- 3 other smelters

CHANGING PREFERENCES

• Until 2000’s **flash smelting technology** represent most of the smelting preferences in new operations.

• Since, most of the new smelter prefer **bath smelter**, mostly Ausmelt/Isasmelt® furnaces and Chinese reactors.

![Smelting technologies through time](chart.png)

SMELTING COSTS

- Average direct **cash cost was 19 c/lb** un 2015. Almost 40% of total capacity was above that cost.

- Energy (power and fuel) is responsible for more than one third of average costs.

![Direct Cash Costs Chart]

COST COMPARISON BY TECHNOLOGY

Smelting capacity and direct cash costs*

**FLASH capacity (44%)**
Average cost: 15.2 c/lb
Range: 9 to 31 c/lb

**BATH capacity (36%)**
Average cost: 18.8 c/lb
Range: 9 to 45 c/lb

**MIXED capacity (17%)**
Average cost: 25.6 c/lb
Range: 13 to 68 c/lb

**OTHER capacity (3%)**
Average cost: 26.6 c/lb
Range: 19-36 c/lb

*Including labour, energy, maintenance, consumables and services.

• Great differences between bath technologies.

• Teniente/Noranda technology appears to be less competitive as other bath smelters.

• Chinese technology climb on better positions in the cost curve.

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THE BUSINESS MODEL IMPLICATION

- Integrated smelters appears in the **last position** in terms of costs.

- High-price cycle decrease competitiveness of integrated smelters. **Effort and investment to mines** to increase profitability.

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04 CONCLUDING REMARKS
CONCLUDING REMARKS

- New developments in China appears **attractive** but need **validation in Western countries**.

- New smelting capacity would tend to consider bath technology. But not any.

- Change in technology is not the only driver. Non-integrated smelters appears as a better business model.

- Chile in the center of a major challenge: **Teniente bath smelting and integrated smelters** are less competitive than any other.

- This is only an additional information, but the decision must be made weighting strategic issues as well as technical issues.
THANK YOU!

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