



“Life Cycle Inventory of the Primary Copper Production”

Claudia A. Peña¹, Claudio A. Zaror²,
Mauricio Bustamante³, Mabel Vega⁴.

^{1,3}Research Center of Mining and Metallurgy (CIMM)

^{2,4}University of Concepción, Chile

e-mail: czaror@udec.cl; cpena@cimm.cl



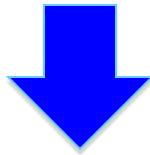
Importance of Cu

Copper is a very valuable material for society:

- It is used as: *construction material, pipes, wires for electric devices, electricity distribution, engines, paints, etc.*;
- but also it is important for *Health*, because of its antibacterial and antifungal properties, and because above all, copper is an *essential micronutrient*;
- due to its wide range of applications, population and environment are very usually exposed to Cu \implies environmental risk assessment (DW Guideline 1993, WHO: precautionary principle).
- But, since environmental concerns are increasing continuously in the world, **reliable data of the environmental burden of copper production start to be required through all the value chain, up to the manufacturers who use copper as a component material of their own products.**

LCI of Cu Production

LCA is a rigorous tool which provides an standard methodology to produce this information, and habilitates its continue use in a coherent and comprehensive way, throughout all the following stages of the lifecycle of Cu (use and final disposal or recycling).



**National LCI
of Cu production in Chile**
((bio)hydrometallurgical line)



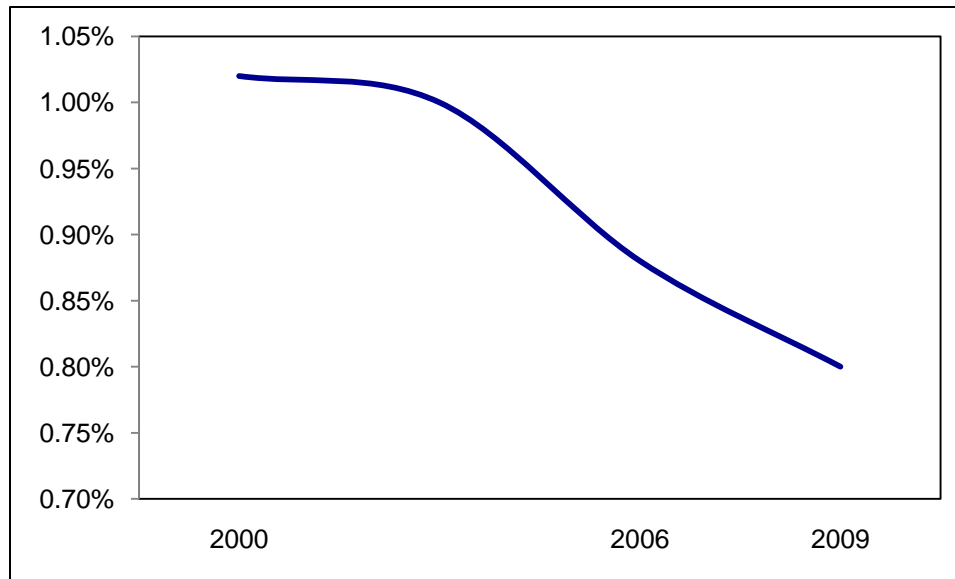
- **Chile** is the major copper producer worldwide (19% refined Cu, and 34% mine-Cu) and accounts for 40% of the global reserves.
- Copper exports are a key component of the Chilean GDP.
- In recent years, copper production from copper oxide ores has increased, and this trend is expected to be maintained during the next decade. It accounts for the 50% of Chilean copper production.

Mining Industry by Size

| Mining Industry | Mineral MT/day | Mineral MT/year |
|------------------------|-----------------------|---------------------------------------|
| Big* | > 8.000 | 50.000.000 |
| Medium | 300 - 8.000 | 100.000 - 3.000.000 (50.000 MT Cu) |
| Small | < 300 | 100.000 (<1.500 MT Cu) |

*Codelco, year 2006: 200.000.000 MT mineral; 1.700.000 MT Cu.

Average grade of Cu ore mineral



Medium ore grade of Codelco mines is 0,88%.

Escondida (BHP) medium ore grade was 1.59% of Cu, 2006.

New reserve discover by Anglo American: 1.46% ore grade and 1200 millions MT Cu mineral, 2009.

Cut off ore grade for the high graded Cu sulphurated minerals 0.7% (pyro route).

Cut off ore grade for the low graded Cu sulphurated minerals: 0.3% (hydro route).

Cut off ore grade for the Cu oxide minerals: 0.3% (hydro route).

LCI of Cu Production

Goal

The main goal of this study was to develop a unified and rigorous LCI for copper primary production in Chile, according to the ISO14040/14044 series, to provide to customers and other stakeholders with reliable data.

In addition, to improve the international environmental credibility of the Chilean copper, and to develop expertise on this subject in Chile and specially, in mining industry.

- The LCI database will be used as starting point for mining companies and government agencies to establish their own LCI database.
- The LCI will allow mining companies to develop their own LCI or to compare their LCI-works with a validated LCI. And the government could use this LCI database in the area of the environmental policies related to mining.

Scope

Route: all the processes units of the (bio)hydrometallurgical process;

- It contains units of standard processes, valid for the common primary copper production process of the (bio)hydrometallurgical line, including: open pit mine, crushing, leaching (bioleaching), solvent extraction, and electro-winning.
- But also, the main supporting plants and systems:
 - sulfuric acid plant,
 - transportation systems,
 - electricity production and distribution.
 - The project includes the development of a LCI database of the current configuration of the electric matrixes (of Central and Northern Chile).

The functional unit was defined as the production of **1 metric ton of copper cathode grade A**.

When the electro-winning process is completed, the copper cathode, which is the product of this process unit, has a weight of 70 - 80 kilograms.

System boundaries

It is 'cradle to gate' study and comprises all the production steps ((bio)hydro) from ore extraction to copper cathode at the seaport , ready to be transport to other countries.

All major materials and energy inputs are considered: emissions to air (gases and particulate material), emissions to water and the solid wastes. Land use as an input flow of material, was not considered in the study, due to lack of information.

System Boundary

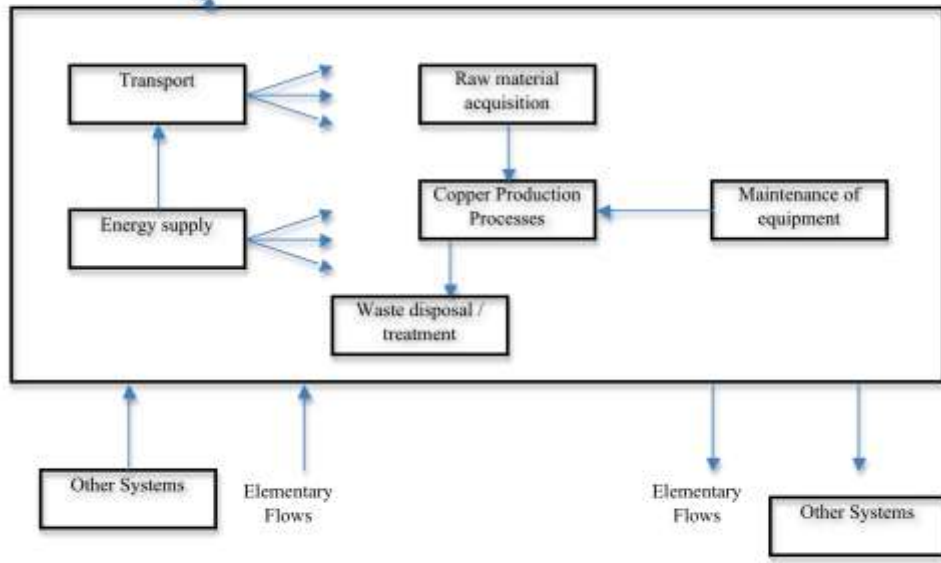
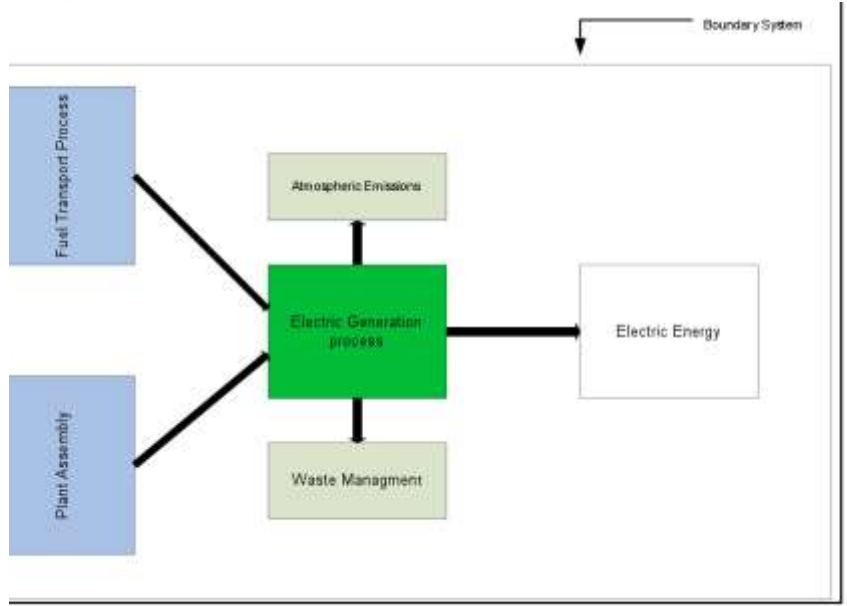
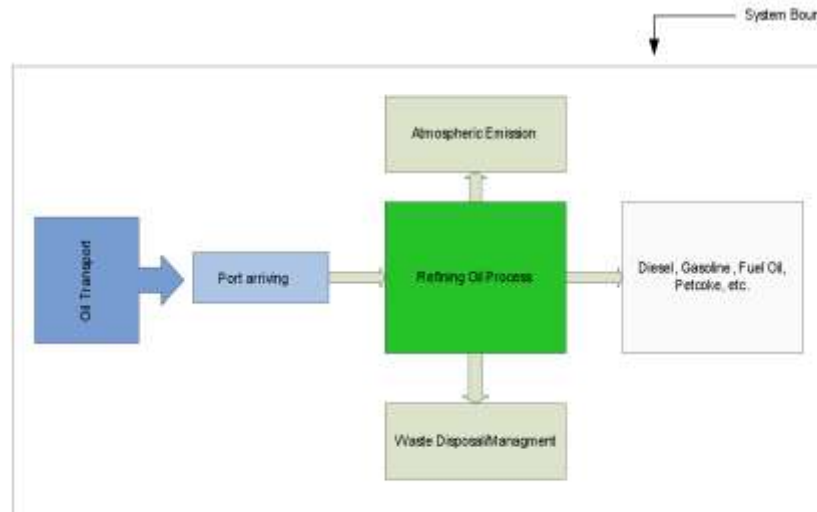


Figure 1 - System Boundary of Copper Primary Production



Standard Process

We defined a standard flow sheet (**)

- Process Units
- Operation units and equipment

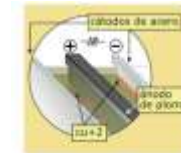
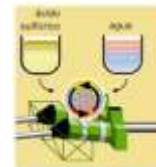
Discussed it with Codelco (Corporación Nacional del Cobre)
Consultation to the big and medium size mining companies
(Key process experts)

- (**)
- Environmental declarations of mining industry, regarding new and ongoing projects (National Environmental Commission).
 - Publications made by mining companies.
 - Direct information from plants (T&S and Biosigma of Codelco).
 - Questionnaires

Main Operations and Process Units

Mineral Extraction:

- Drilling
- Blasting
- Loading
- Transport



Mineral Processing:

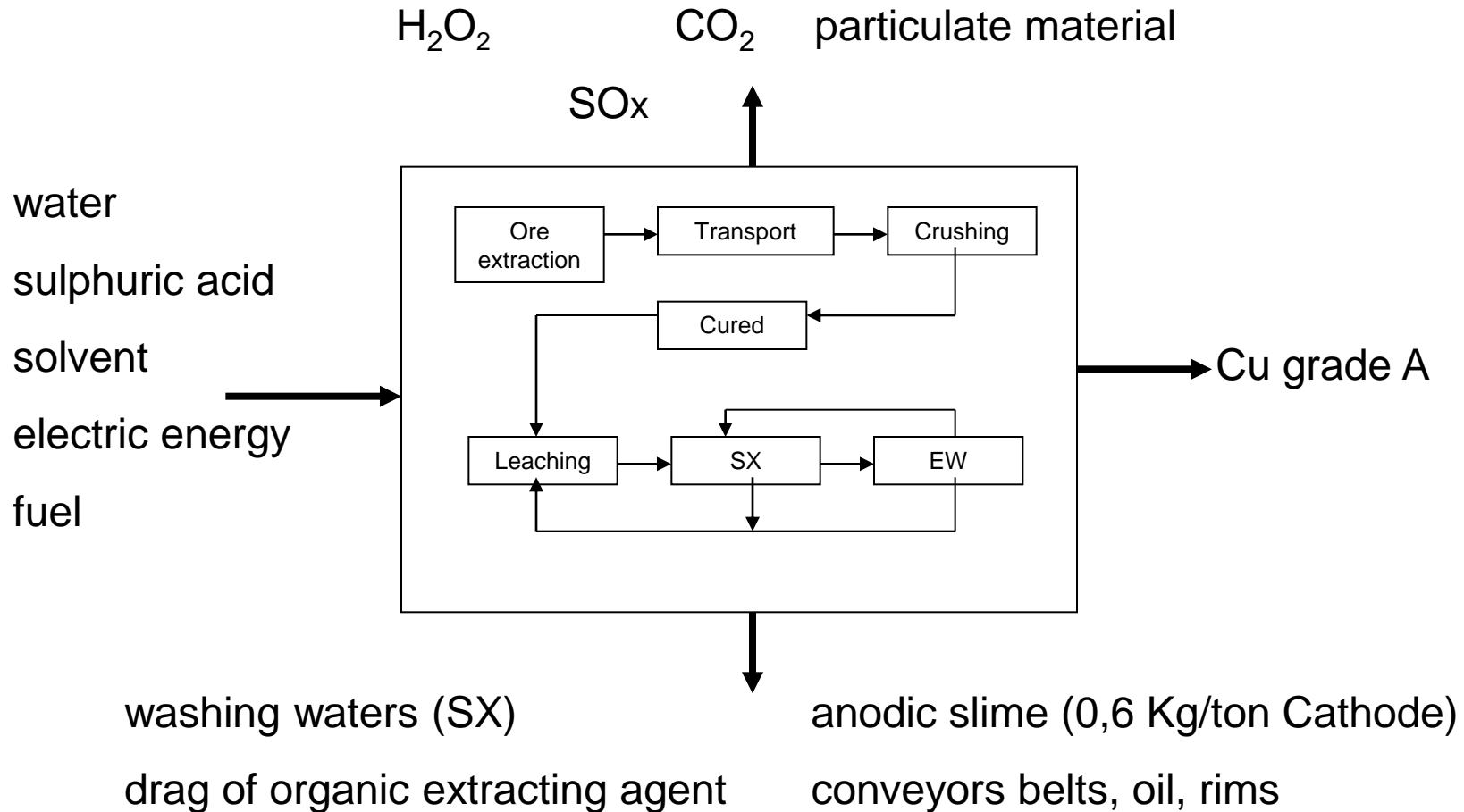
- Crushing
- Leaching
- Solvent Extraction (SX)
- Electro-Winning (EW)

Auxiliary Process:

- Sulfuric Acid Plant
- Electricity Generation



General Flowsheet



Data Quality

- Ecoinvent Guideline (Santiago, Workshop 2008)
- Environmental declarations of mining industry, regarding new and ongoing projects (National Environmental Commission).
- Publications made by mining companies.
- Direct information from plants (T&S and Biosigma of Codelco).

For information respect to material or equipment which is not produced in Chile, we take data from Ecoinvent (trucks, sulphuric acid made from sulphur ore).

Allocation

- Mineral Extraction
 - There is no by products, all environmental burdens are charge to mineral extracted
- Mineral Processing
 - Just one product: Cu cathodes, and no significant by-products (considering mass or economic value: such as anodic slimes : 0,6Kg/ton Cu cathode and around US\$5,000/100,000 ton Cu/year)
- Transport
 - For the moment all environmental burdens are associated to copper production, since there is not other by products, but if conveyors belt and rimes start to be selling as fuel, we must consider a new allocation method.

Methodology

The LCI study will be reported in accordance with ISO 14040/14044.



Independent Critical Review Panel

integrated by at least three international experts.

We have made a call to institutions and organisms, which work in LCA and/or ISO accreditations, to submit a technical and economical proposal.

- The peer review process will improve the credibility and transparency of the LCI of copper production in Chile and is a valuable contribution to the methodology used.
- The results of the peer review process will be published in an international journal.

Site or mining specific characteristics

- Energetic matrix.
- Local process of fuel refinement.
- Distance from the supply centres of raw materials and kind of transportation used.
- Dimensions and loading capacities of the trucks and other equipments used in the big mining industry .

Project Activities

PHASE 1: Boundaries Definitions

Preliminary Quality Guidelines Database

PHASE 2: Conceptual Definition of LCI Database

Flow sheet for Hydrometallurgy copper Production

Collecting and Processing Data

Data Analysis

Development of LCI models of each processing unit

PHASE 3: Operational Model System

Database in an adequate platform (SimaPro)

Validation of the database

Final Quality Guidelines Database

Technological transference and spreading

Promotion and public relationship

Software LCI for Mining Production

LCI

"Life Cycle Inventory for Mining Production".



[Desing](#)



[Evaluation](#)



[Import / Export](#)

[System Description](#)

Desing -> Select Process

Select Configuration Process:

1 Global Process

Select Process

[Report](#)

2 Singular Process

Select Process
Extraction
Loading
Crushing
Leaching
Solvent Extraction (SX)
Electro-Wining (EW)

Select Unit
Drilling
Blasting
Loading
Transport

3 [Continue](#)

Software LCI for Mining Production: Chilean Research Center for Mining

Software LCI for Mining Production

LCI

"Life Cycle Inventory for Mining Production".



[Desing](#)

Process: **Mine**

- [Drilling](#)
- [Blasting](#)
- [Loading](#)
- [Shipping](#)



[Evaluate](#)



[Import / Export](#)

Desing -> Select Process -> Drilling

Drilling Unit: [Documentation](#)

Input:

| | | | | |
|-------------|-----------------------------------|--------|------------|-------------------|
| Electricity | <input type="text" value="2000"/> | [KW-H] | 1,62 [E-M] | (4,3,2,1,4,5); E. |
|-------------|-----------------------------------|--------|------------|-------------------|

Output:

| | | | | |
|---------------|------------------------------------|------------|------------|-------------------|
| Drilling Area | <input type="text" value="81"/> | [m^2] | 1,62 [E-M] | (4,3,2,1,4,5); E. |
| Drillings | <input type="text" value="99"/> | [Unidades] | 1,62 [E-M] | (4,3,2,1,4,5); E. |
| PM-10 | <input type="text" value="58.41"/> | [Kg] | 1,62 [E-M] | (4,3,2,1,4,5); E. |
| CO2 | <input type="text" value="1800"/> | [Kg] | 1,62 [E-M] | (4,3,2,1,4,5); E. |

Fill your Data:

Develop an interface

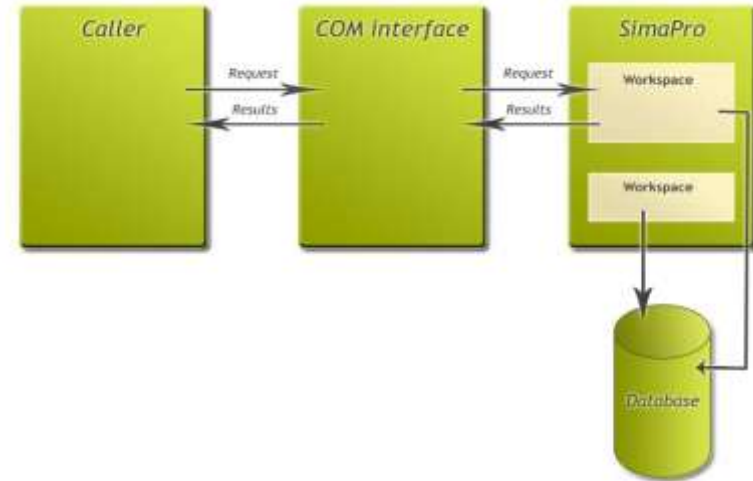
SimaPro Connector v1.0
Demonstrates access via the COM interface

Home About Contact

- Project
- Inventory
- Impact assessment
- General data

Welcome to the SimaPro Connector Desktop Application

- First, you need to login with your SimaPro user data.
- Then, you can navigate through the SimaPro data with the menu on the left side (e.g. you can see the substances from the SimaPro database).
- You can calculate a process or product stage by selecting the "Calculate" option in the context menu of the process table.
- Finally, you can model a product as an assembly of single SimaPro processes and calculate the contributions of the respective process categories and processes.



Developed by
Pré Consultants