

# **DEVELOPMENT OF A METHODOLOGY THAT INTEGRATES ENVIRONMENTAL AND SOCIAL VARIABLES IN THE INVESTMENT DECISION PROCESS FOR MINING PROJECTS**

*This presentation draws from the preprint “Development of a Methodology that Integrates Environmental and Social Variable in the Investment Decisión Process for Mining Projects” (Preprint 13-031. SME Annual Meeting. Feb. 24 - 27, 2013, Denver, CO*

Methodology that

**integrates sustainability**

to the **block model**

and **valuation of the project**

(Why?)

Where is the project **defined**?

```
graph LR; A[Planning] --> B[Design]; B --> C[Construction & Operation]; C --> D[Closing];
```

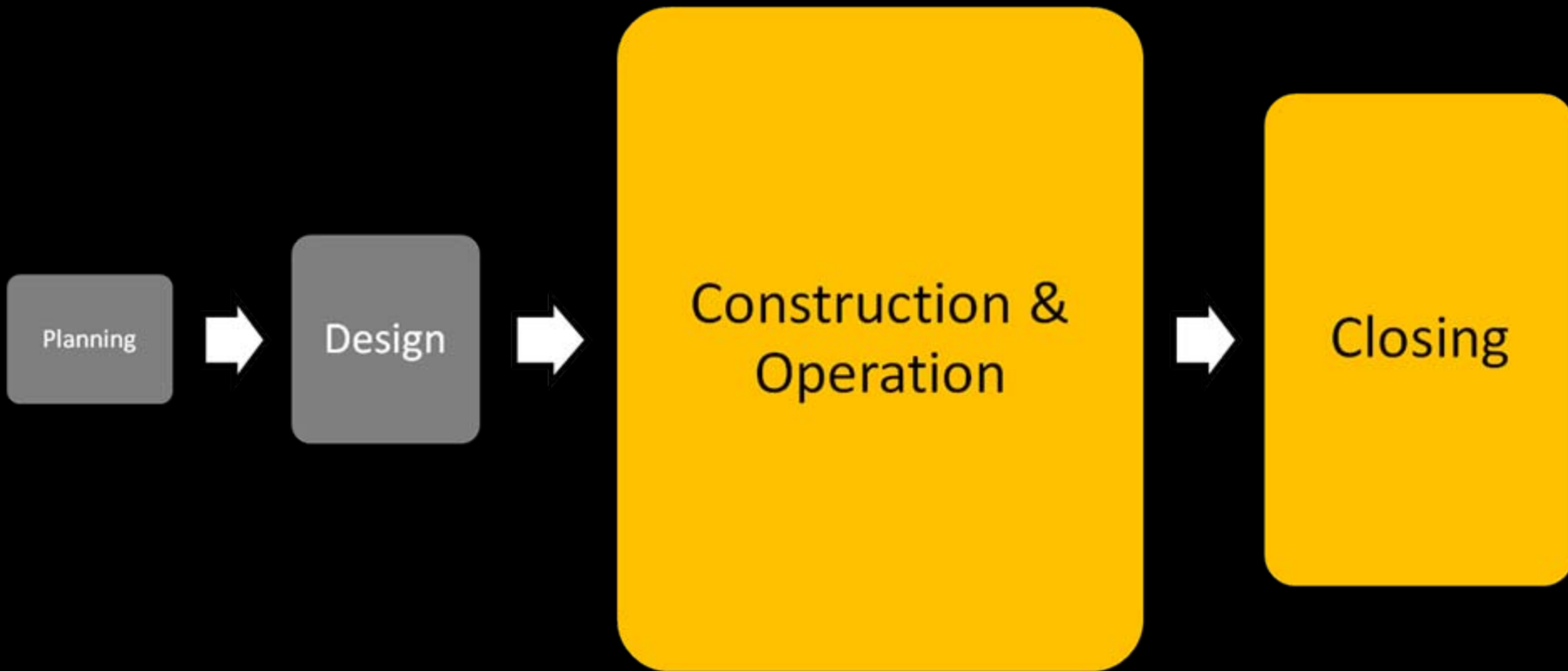
Planning

Design

Construction &  
Operation

Closing

Where is **sustainability** incorporated?



Where **should it be** incorporated?

Planning



Design



Construction  
& Operation



Closing

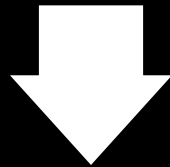
**A new approach** is needed

(How?)





**Sustainability**



**Block Model**

Methodology that

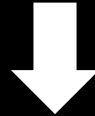
**integrates sustainability**

to the **block model**

and **valuation of the project**

**1**

Select Sustainable  
Variables (SV)



**2**

Incorporation to the  
Block Model (BM)



**3**

Incorporation to the  
Valuation

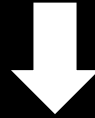


**4**

Test it

**1**

Select Sustainable  
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Block Model (BM)



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Incorporation to the  
Valuation



**4**

Test it

# Selection of SV

**Energy**

**Water**

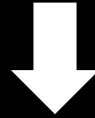
**GHG  
Emissions**

**AMD  
Generation**

**Labor**

**1**

Select Sustainable  
Variables (SV)



**2**

Incorporation to the  
Block Model (BM)



**3**

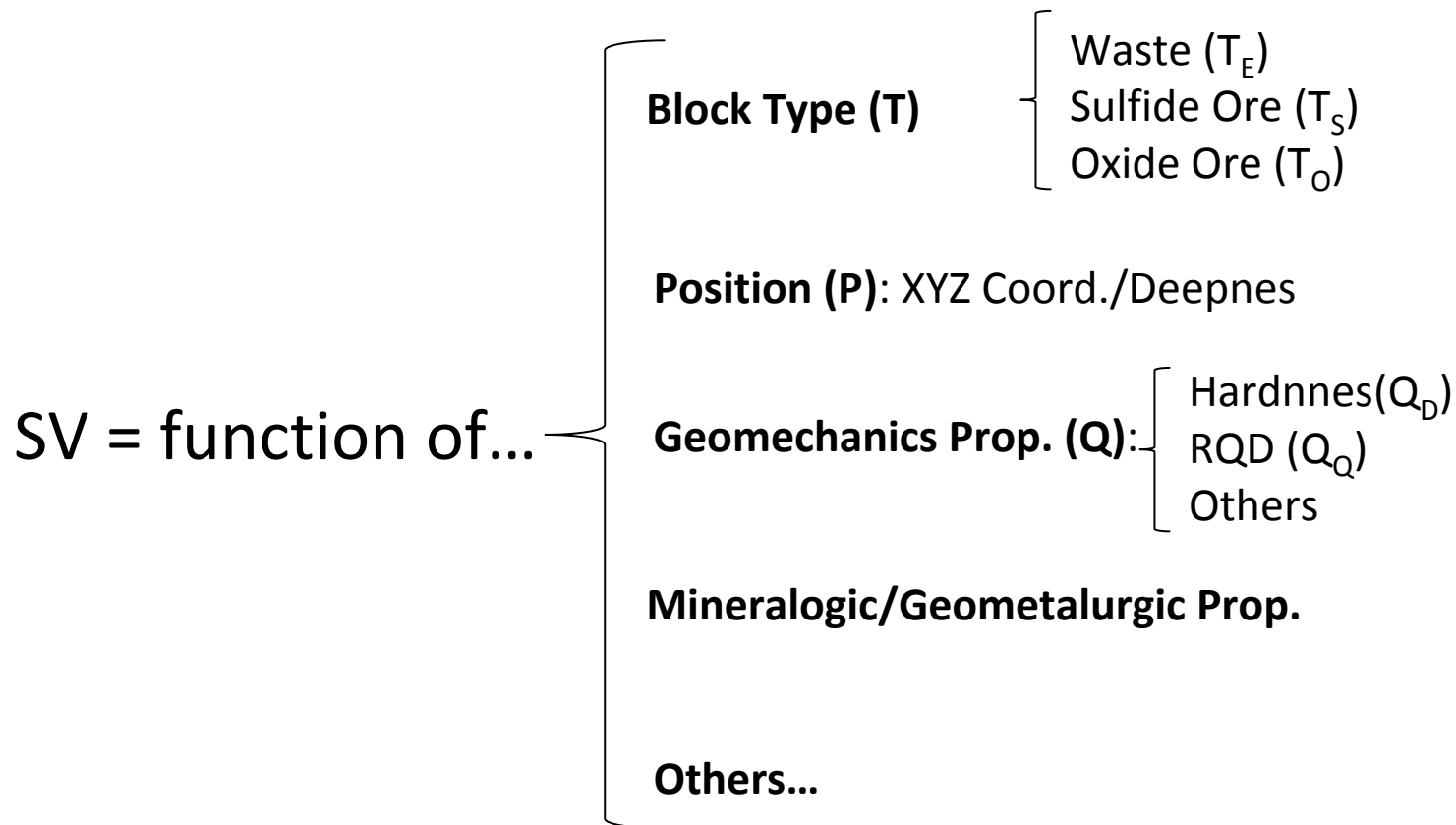
Incorporation to the  
Valuation



**4**

Test it

# Incorporation to the BM



\*You can go to the paper for more detail in the incorporation methodology of each variable

**1**

Select Sustainable  
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Incorporation to the  
Valuation



**4**

Test it



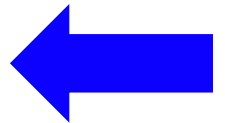
# Incorporation to the Valuation

Optimization Model

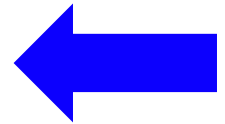


*Max{Objective Function}*

*s. t. ...  $\sum_{\substack{> \\ < \\ \sim}}$  Cnt*



&/or



# 1. In the objective function

## Traditional Block Value:

Ore:

$$V_B = m_B * [(p - r) * g_B * R - MCAF * C_m - PCAF * C_p]$$

Waste:

$$V_B = m_B * [-MCAF * C_m]$$

## Proposed Block Value\*:

Ore:

$$V_B = m_B * [(p - r) * g_B * R - (C_m^{others} + E_m^B * C_{Energy} + WC_m^B * C_{water}) - (C_p^{others} + E_p^B * C_{Energy} + WC_p^B * C_{water}) - T_{GHG} * GHG^B]$$

Waste:

$$V_B = m_B * [-(C_m^{others} + E_m^B * C_{Energy} + WC_m^B * C_{water}) - T_{GHG} * GHG^B - C_{AMDP}^B * AMD_{Pot}]$$

\*Including just environmental variables

Not just costs...

$$V_B = m_B * [(p - r) * g_B * R - (C_m^{others} + E_m^B * C_{Energy} + WC_m^B * C_{water}) - (C_p^{others} + E_p^B * C_{Energy} + WC_p^B * C_{water}) - T_{GHG} * GHG^B \pm V_{MH} * MH^B]$$

Benefit/Cost for Employment Generation (MH)

Award to the price due “sustainable” product

## 2. As restrictions to the model

**Energy** restriction:

$$\sum_{i \in I_t^W} E_{i,t}^W + \sum_{i \in I_t^S} E_{i,t}^S + \sum_{i \in I_t^O} E_{i,t}^O \leq \bar{E}_t, \forall t \in [0, T]$$

**Employment** restriction:

$$\sum_{i \in I_t^W} MH_{i,t}^W + \sum_{i \in I_t^S} MH_{i,t}^S + \sum_{i \in I_t^O} MH_{i,t}^O \leq \bar{MH}_t$$

1

Select Sustainable  
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Block Model (BM)



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4

Test it

(So, concluding)

This is just a **first step**

A new **reserves**  
**classification** is needed



**A new discount rate is needed:**

**Sustainable discount rate**

**Thank you**  
**for your kind attention**

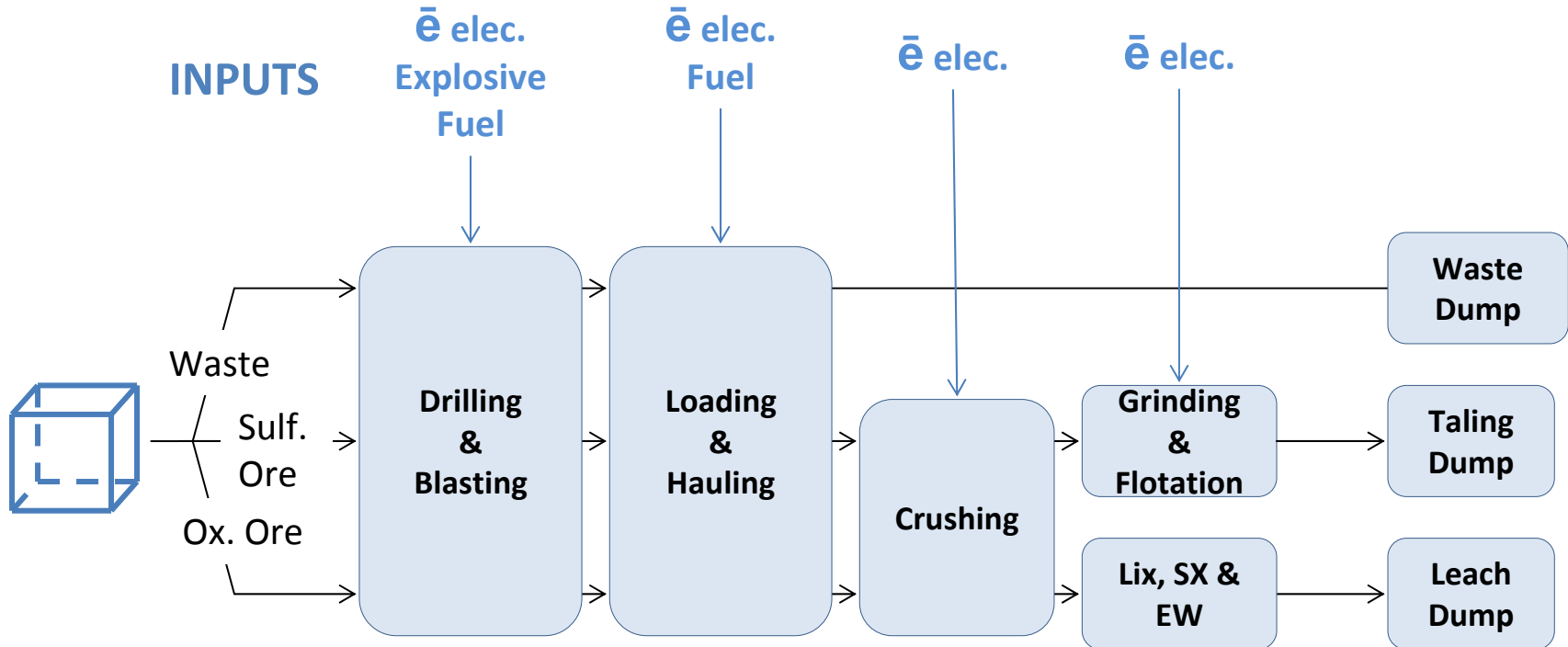


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# Annexes

# Incorporation to the Block Model

# Energy

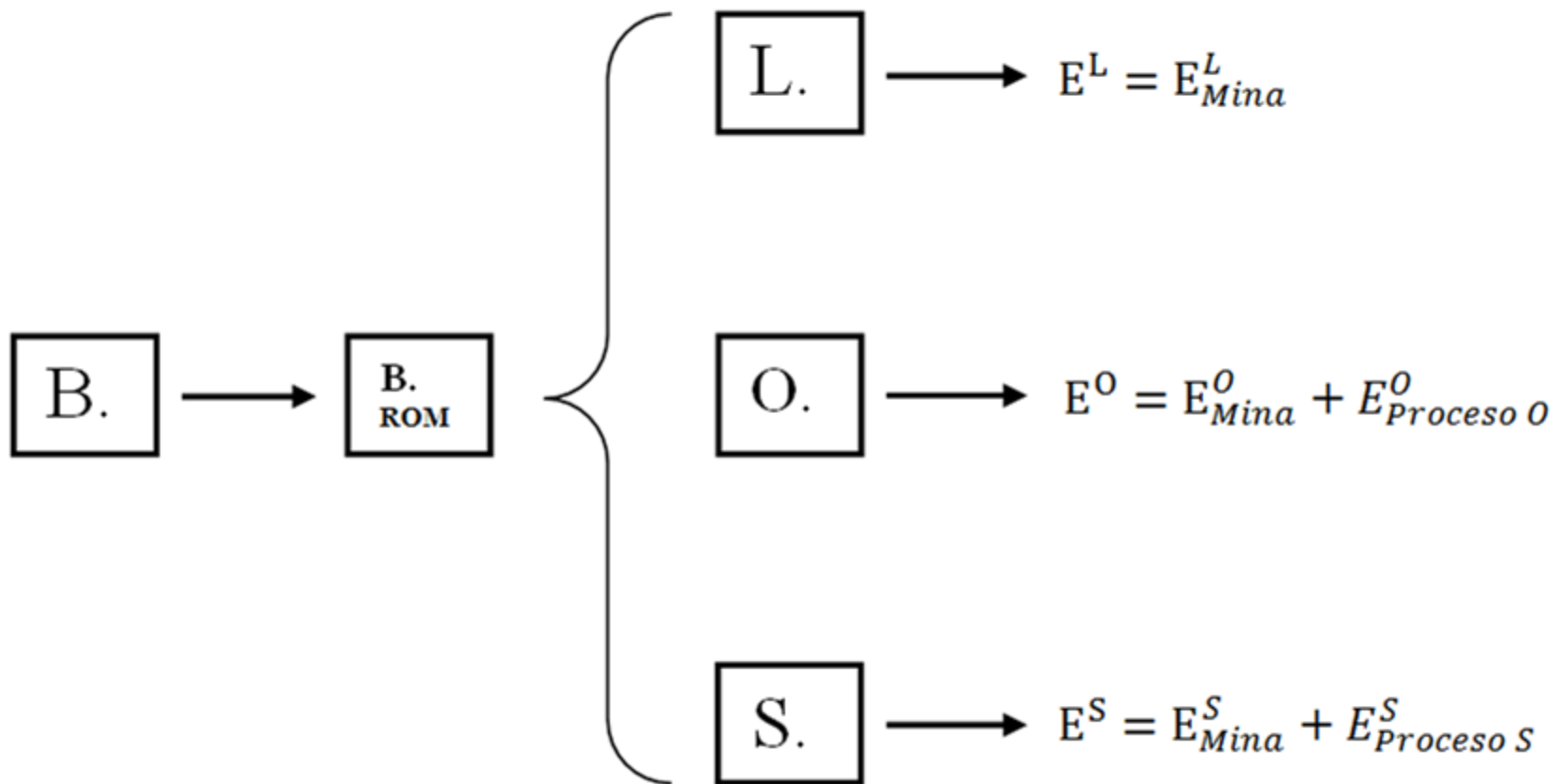


$$\text{Consumo Energía BLOQUE} = \sum (\bar{e}_{Elec. Process_i} + \bar{e}_{Explosive Process_i} + \bar{e}_{Fuel Process_i})$$

$$\bar{e}_{Elec. Process_i} = f(T, P, Q, \text{others})$$

$$\bar{e}_{Explosive, Process_i} = f(T, Q, \text{others})$$

$$\bar{e}_{Fuel Process_i} = f(T, P, \text{others})$$



$$E_{Mina}^i = \frac{A * E_v * L * N * 9,81}{\eta_{perfo} * m_B} + FC * E_{Anfo} + \frac{P_c * T}{\eta_{cargador} * m_{Camión}}$$

$$+ \frac{9,81 * S * (m_{Camión} * i\% + (R_s\% + R_i\%) * (2 * M_{Camión} - m_{Camión}))}{m_{Camión}}$$

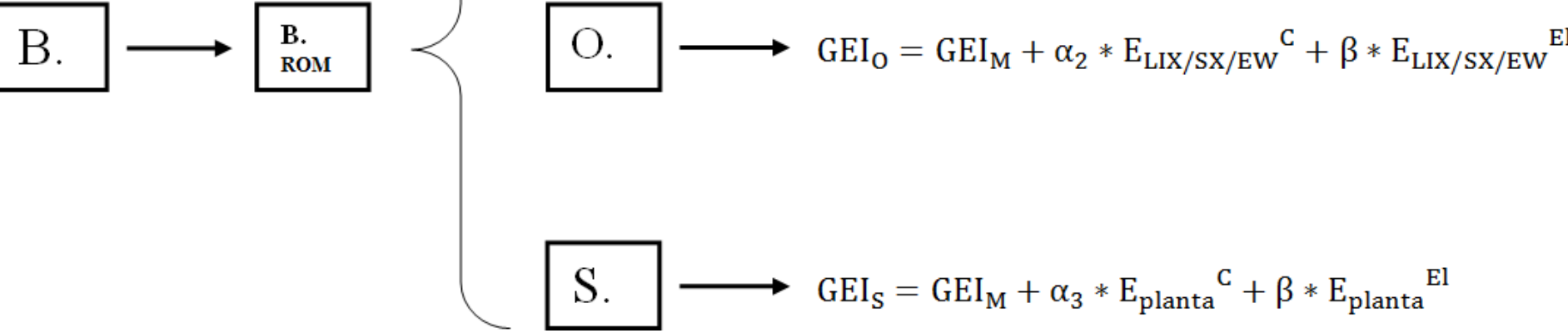
$$+ 3,6 * 10 * W_i * \left( \frac{1}{\sqrt{P_{80}^{Ch}}} - \frac{1}{\sqrt{F_{80}^{Ch}}} \right) [MJ/ton minada]$$

$$E_{Proceso S}^S = 3,6 * 10 * W_i * \left( \frac{1}{\sqrt{P_{80}^{Mol}}} - \frac{1}{\sqrt{F_{80}^{Mol}}} \right) [MJ/ton procesada]$$

$$E_{Proceso O}^O = \frac{V_c * n * F * l_{Cu}^s}{PM_{Cu} * \eta_c} [MJ/ton procesada]$$



# GHG Emissions



# Employment Generation

Mina	Tipo	Año Datos	Ton Mineral O (MM tpa promedio)	Ton Mineral S (MM tpa promedio)	Ton Estéril (MM tpa promedio)	Mano Obra Operación (interno y contratistas)
Antucoya	Proyecto	-	40,5	0,0	24,8	1.400
Caserones	Proyecto	-	15,0	41,0	25,0	2.632
Esperanza	Proyecto	-	0,0	35,3	96,0	1.580
MMH	Proyecto	-	2,3	18,0	108,0	1.404
Cerro Colorado	Operación	2009	19,1	0	49,0	1.595
Chuquicamata	Operación	2011	9,6	38,6	156,1	11.453
El Soldado	Operación	2010	0,1	7,6	57,1	1.095
El Tesoro	Operación	2010	14,4	0	66,0	935
Escondida	Operación	2010	82,8	77,7	253,7	6.064
Gaby	Operación	2011	29,1	0	27,8	769
Lomas Bayas	Operación	2011	14,5	0,0	10,2	1.521
Los Bronces	Operación	2010	?	18,9	40,7	1.597
Manto Verde	Operación	2010	9,2	0,0	15,5	498
Mantos Blancos	Operación	2010	5,5	5,5	34,5	618
Pelambres	Operación	2011	0,0	63,0	66,2	1.269
Radomiro Tomic	Operación	2011	54,3	18,8	157,1	1.772
Spence	Operación	2009	25,0	0,0	26,2	1.662
Collahuasi	Operación	2011	9,9	50,4	204,3	4.885

Proceso Productivo	Dotación Interna (personas)	%
Mina rajo	8.014	64%
Planta S	2.531	20%
Planta O	1.930	15%
<b>Total</b>	<b>12.475</b>	<b>100%</b>

# Employment Generation

Mina	Tipo	Mano Obra Mina (HH/ton minada)	Mano Obra Planta (HH/ton sulfuros procesada)	Mano Obra Lix-SX-EW (HH/ton óxidos procesada)
Antucoya	Proyecto	0,07	-	0,02
Caserones	Proyecto	0,05	0,03	0,06
Esperanza	Proyecto	0,02	0,03	-
MMH	Proyecto	0,02	0,04	0,22
Cerro Colorado	Operación	0,04	-	0,04
Chuquicamata	Operación	0,10	0,17	-
El Soldado	Operación	0,03	0,07	5,66
El Tesoro	Operación	0,02	-	0,03
Escondida	Operación	0,02	0,04	0,03
Gaby	Operación	0,03	-	0,01
Lomas Bayas	Operación	0,12	-	0,05
Los Bronces	Operación	0,04	0,04	#¡Div/0!
Manto Verde	Operación	0,04	-	0,02
Mantos Blancos	Operación	0,02	0,05	0,04
Pelambres	Operación	0,02	0,01	-
Radomiro Tomic	Operación	0,01	0,04	0,01
Spence	Operación	0,06	-	0,03
Collahuasi	Operación	0,03	0,05	0,04

