MINExcellence2018

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Operational Excellence in Mining

The Use of Carbon Footprint as an Eco-Efficiency Indicator in Mining Operations

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I. GENERAL CONCEPT OF ECO-EFFICIENCY INDICATORS

	Resource use-oriented		Environmental impact-oriented	
	Domestic resource use *(resources directly used for domestic production and consumption)*	*Global resource demand* *(domestic resource use plus resource use embodied in trade)*	*Environmental impacts related to domestic resource use*	*Environmental impacts related to global resource demand*
Material use	Domestic material use **Domestic Material Consumption**	Global material demand **Raw Material Consumption**	***Territorial part of*** **Life-Cycle Resource Indicator** (of ***Environmentally-weighted Material Consumption)****	**Life-Cycle Resource Indicator** ***(Environmentally-weighted Material Consumption)****
Energy use and climate change	Domestic energy use **Gross Inland Energy Consumption**	Global energy demand **Energy Footprint**	Domestic GHG emissions **Territorial GHG Emissions**	Global GHG emissions **Carbon Footprint**
Water use	Domestic water use **Water consumption** ***(Water abstraction)****	Global water demand **Water Footprint**	Domestic water exploit. **Water Exploitation Index**	Global water exploit. **Global Water Consumption Index**
Land use	Domestic land use **Domestic Land Demand**	Global land demand **Actual Land Demand (Land Footprint)**	Domestic LU intensity **Human Appropriation of Net Primary Production**	Global LU intensity ***eHANPP, LEAC and other indicators on ecosystem quality***

Note: * ... short-term proxy indicator for the medium-term desired indicator

Source: BIO Intelligence Services, “Assessment of resource efficiency indicators and targets”, Final report ; European Commission, DG Environment , 06/2012

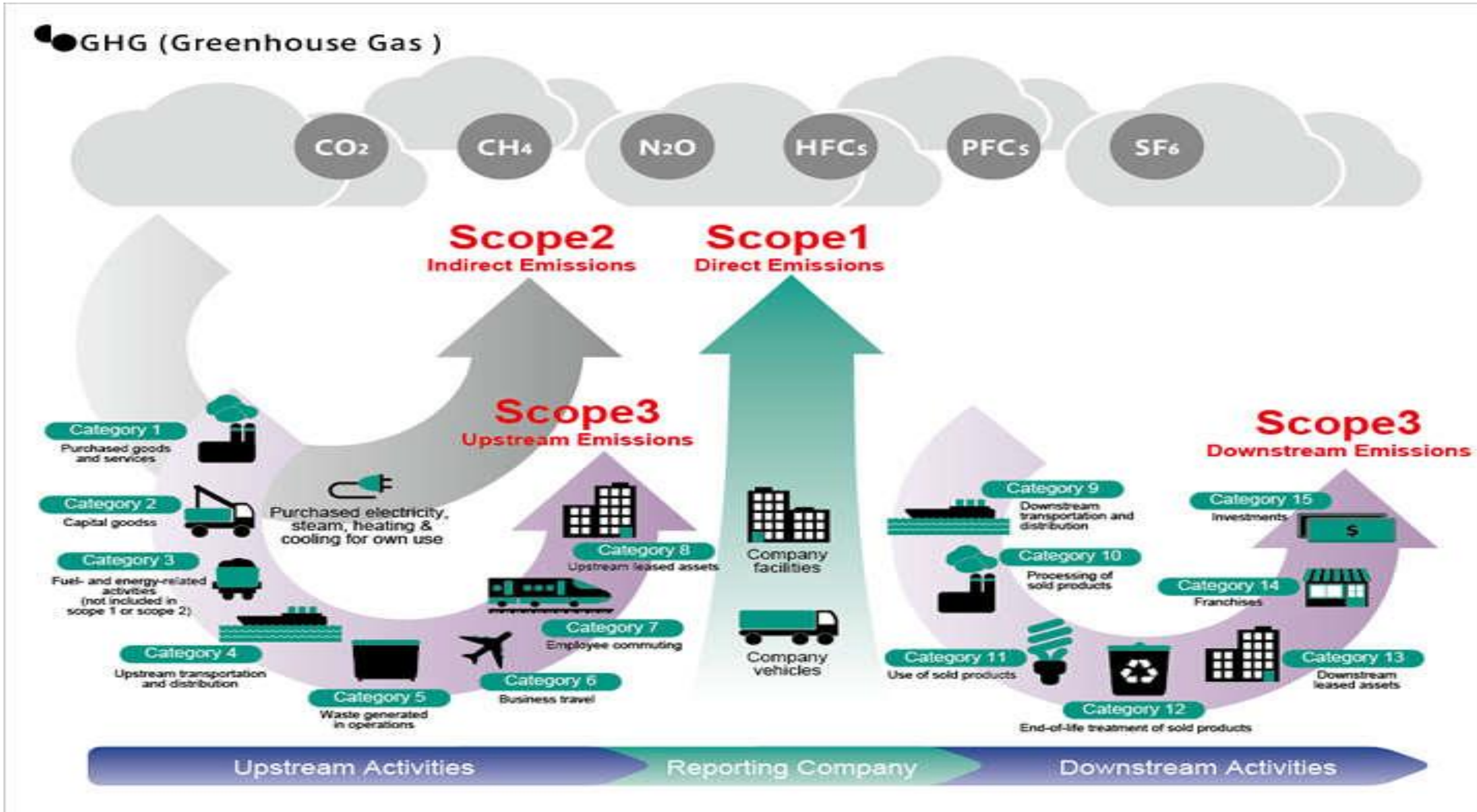
II. CARBON FOOTPRINT

The concept of Carbon Footprint (CF) originates from "ecological footprint" which was proposed by Wackernagel and Rees (1996), a concept well established amongst ecological economists.

Current use of the Carbon Footprint Calculation (CFC) for **organizations** is typically applied to estimate carbon emissions over a relatively long period (at least one year) and publish annual results for investors and the public.

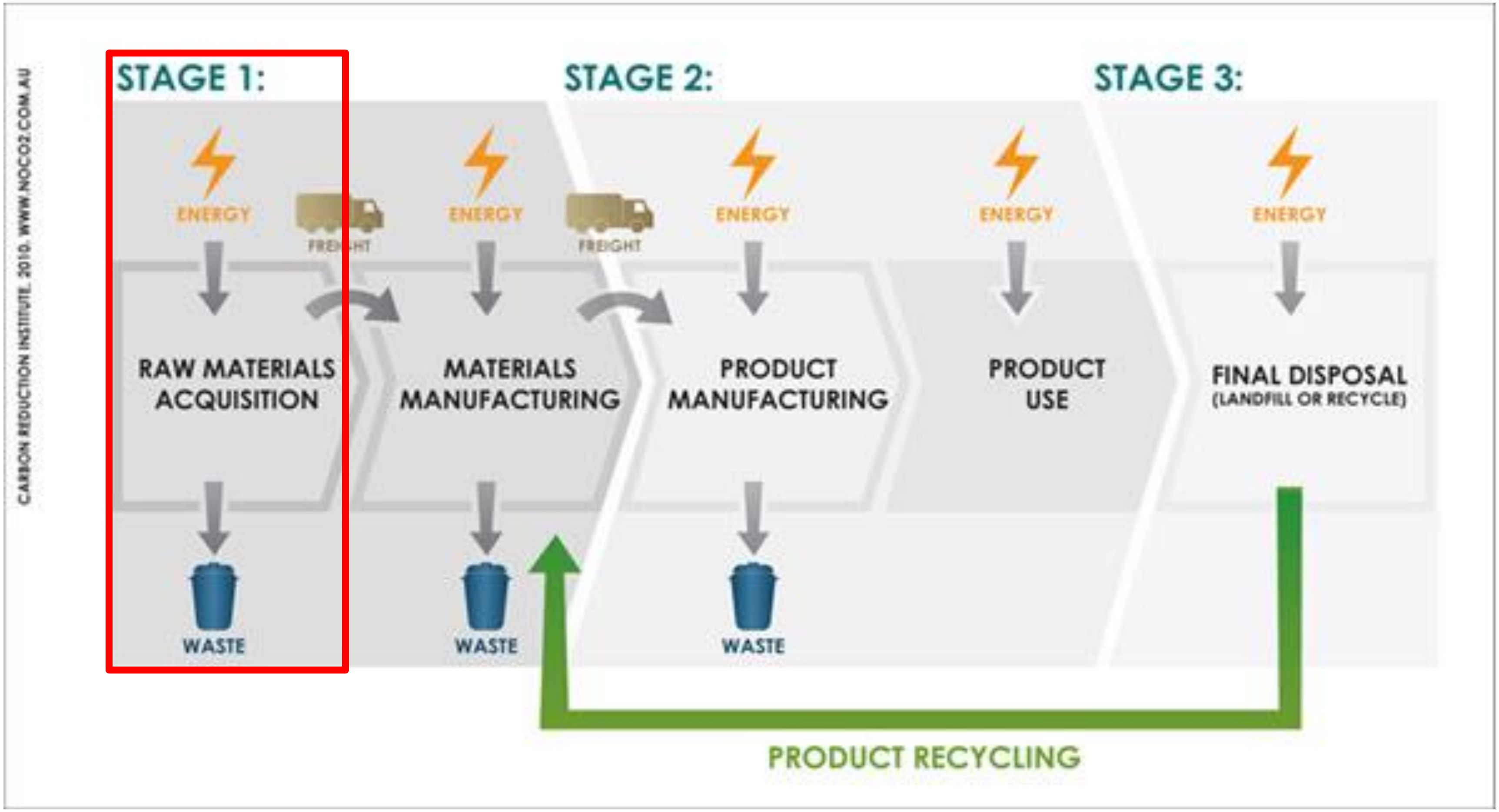
In comparison, the focus of ISO 14.067 standard (2013) is on life cycle analysis (LCA) and the Carbon Footprint of Products (CFP).

II. FOCUS ON ORGANIZATION



Source: GHG Protocol

II. LIFE-CYCLE ANALYSIS CARBON FOOTPRINT (ISO 14.067)



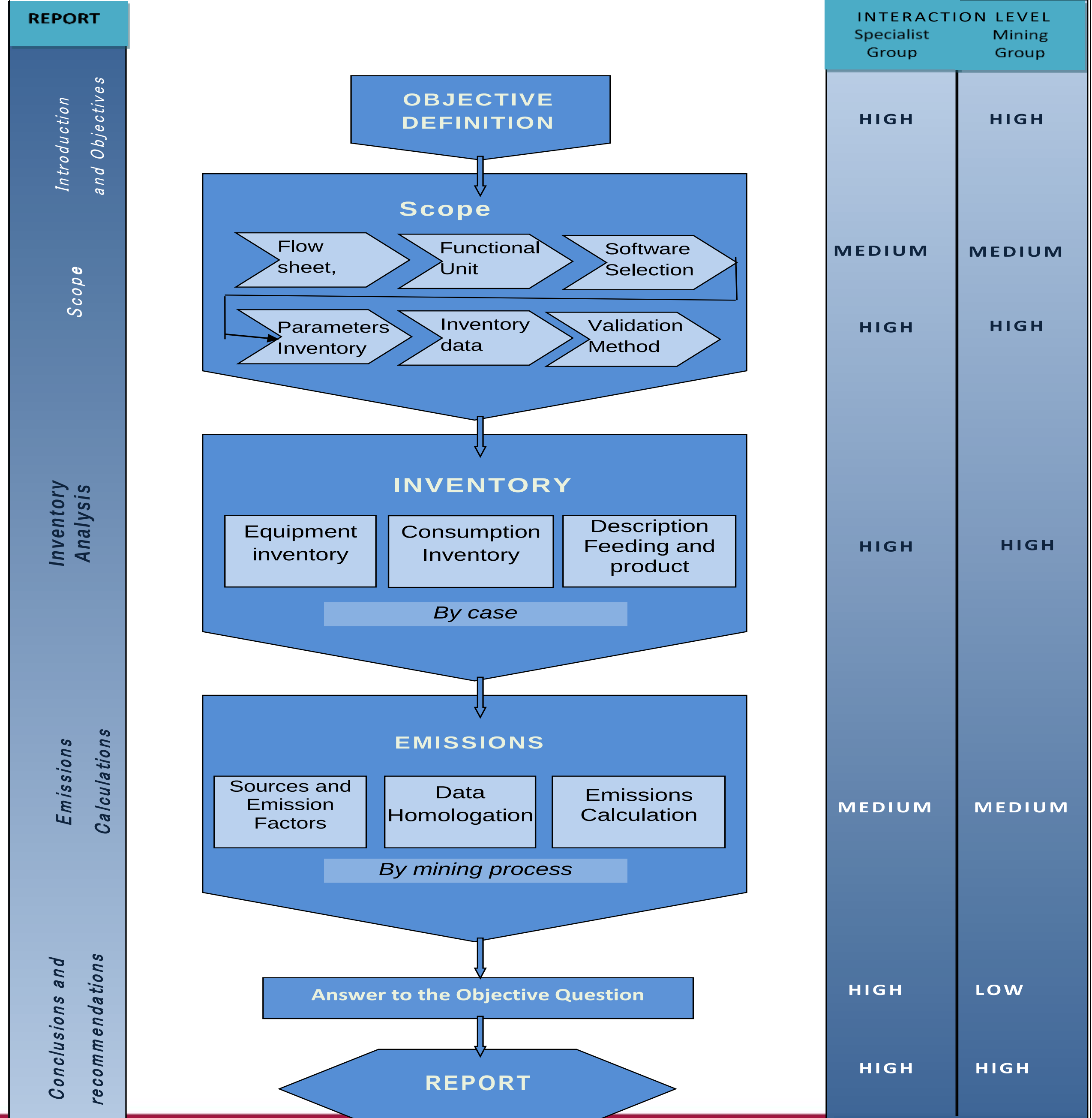
III. METHODOLOGY OF CFA FOR MINING AND MINERAL PROCESSING

Identification and quantification of the energy and raw materials used in development stages for intermediate products from unit processes or the final product, as well as the emissions released into the environment. It should include the inputs and outputs of the system that describe the life cycle of the product. .

Evaluation of potential environmental impacts; in the case of CF, this component is not considered since the only environmental impact is climate change.

Interpretation of environmental impacts based on the objectives of the study and assessment of the opportunities to improve the environmental profile of the product, process or activity. In our case, the impact of different optimisation alternatives on the CF of the product will be estimated.

III. METHODOLOGY OF CFA FOR MINING AND MINERAL PROCESSING (Powell, R., 2014)



III. METHODOLOGY OF CFA FOR MINING AND MINERAL PROCESSING

Electric Consumption

X_1
$+X_2$
...
$+Xi$
$= \sum X_{1..i}$
x Conversion factor (Ce_e)

Fuel Consumption

Y_1
$+ Y_2$
...
$+Y_j$
$= \sum Y_{1..i}$
x Conversion factor (CE_f)=

Total Carbon Emissions (e.g. process plant)

Unit Process	**Carbon Emissions**
P_1	**x EF_e= CE_1**
$+ P_2$	**x EF_e= CE_2**
...	...
$+ P_j$	
$= \sum P_{1..i}$	$= \sum CE_{1..i}$

ETC.

/ Production (tpd)

= ton CO_2 eq/ton of product

III. METHODOLOGY OF CFA FOR MINING AND MINERAL PROCESSING

What is **measured** → Will be **managed**

Why look for a third party for auditing?

- ✓ Impartiality
- ✓ Look from a different (external) perspective on your process
- ✓ No "day to day" restrictions

Source: CDP, Expomin, 04/2012

IV. PRACTICAL APPLICATIONS

Greenfield Projects:

- In the pre-feasibility and feasibility stage of a mining project, alternatives for production processes and/or equipment can be analysed based on economic, technical and environmental variables;
- In the Environmental Impact Study, alternative processes are presented or a proposed design is justified. CFA can be used as a quantitative tool to quantify and compare the impact associated with an environmental indicator; and
- In the evaluation of alternative sources of energy (solar, wind or hydroelectric).

IV. PRACTICAL APPLICATIONS

Brownfield Projects:

- Expansion projects;
- Replacement of equipment due to capacity limitations or change in mineral characteristics;
- Studies to introduce new circuits or modifications to existing circuits;
- Process optimisation projects;
- Recovery of mining waste (waste rock, tailings);
- Introduction of innovative technologies (e.g. "sensor based ore sorting"); and/or
- In the evaluation of alternative sources of energy (solar, wind or hydroelectric).

V. CASE STUDIES

Case A: Power Consumption and Carbon Emissions of Initial and Optimized Crushing Circuits

	Base Case	Scenario 1	Scenario 2
Secondary Crusher			
Equipment	MP1000	MP1250	MP1250
Power draw (kW)	396	460	518
Tertiary Crusher			
Equipment	MP1000	MP1250	MP1250
Power draw (kW)	824	950	940
Crushing Circuit (Overall)			
Equipment	MP1000	MP1250	MP1250
Bottleneck with screen	Not addressed	Not Addressed	Addressed
Throughput (tph)	1,327	1,630	1,900
Product P_{80}	11.6	11.6	13.2
Energy draw (kW)	1,220	1,410	1,458
CF per unit process (ton CO_2 eq/hr)*	0.464	0.535	0.554
CFP (kg CO_2 eq/ton)	0.349	0.329	0.292

* GHG emission factor of 0.38 kg CO_2 eq/Kwh (Sistema Interconectado Central - Chile)

Case B: Blasting

Charge = 175 ton

+ 30%

Charge = 230 ton

Case C: Salt mine, transport

Proposed Improvements:

- Use of B-Trains
- Replace Electrical generation by SIC

Year	Energy Generation	Transport Process	Transport Suppliers	Transport Staff	Sub-contractors	Total
2010	1.426,37	7.631,31	144,42	5.453,28	561,77	**15.217,15**
Reduction	**-453,55**	**- 2.289,39**				

Equivalent to 2.740 ton CO2 per year (18% reduction) .

V. CASE STUDIES

Typical problems

- Energy consumption is not monitored per unit process (requiring measurements)
- Fuel consumption per fleet (year, month), but not per unit of product (ton-km)
- Energy consumption of sub-contractors is not available (Scope 3)
- Available CF data does not reflect changing characteristics of minerals (ore grades, hardness, etc.)

VI. SUMMARY AND CONCLUSIONS

- Current use of Carbon Footprint in mining has been mainly focused on the publication of global emissions ("Focus on Organization"), highlighting the overall environmental efforts of a company for shareholders and the community.
- These studies are rather general in nature and the calculated emissions do not necessarily correspond to actual conditions of the mine site (unit processes), nor can the effects of specific optimization initiatives be evaluated (mine to mill or process innovation such as IPCC, SBOS and VRM/HPGR).

VI. SUMMARY AND CONCLUSIONS

The use of Carbon Footprint as an indicator of eco-efficiency in the raw materials industry has the following advantages:

- CF is widely accepted as an eco-efficiency indicator for organizations and already implemented in environmental management of many companies;
- GHG emissions are directly and proportionally associated with global climate change, therefore an appropriate indicator for the mining industry;
- Although third party verification of CFC is not compulsory, it is generally done in large mining companies and methods for estimating GHG emissions are standardized and relatively simple;
- Existing GHG inventories can serve as a base line; <u>breaking down the CF data to unit processes</u> is a comparatively minor effort and can be integrated into existing environmental management systems;

VI. SUMMARY AND CONCLUSIONS

- Improving energy and carbon efficiency will indirectly benefit other areas (water and waste generation) resulting in less waste which equates to less material transport and associated emissions.
- Likewise, CF lacks some of the limitations of ecological footprint indicators cited in literature (Moffat, I., 2000), as opposed to average biologically productive area ("footprint" in m^2) it is a flow unit (units/time), it considers technological changes (e.g. renewable energy sources), and it is subject to policy measures (energy, carbon taxes).
- As an efficiency indicator, CFP can be used not only for the optimization of existing operations, but also in the feasibility and pre-feasibility stages of greenfield projects (environmental impact assessment). In the evaluation of a mining project with a life of 20 or 30 years, cost-benefit analysis should incorporate future costs for carbon emissions

Thank you for your attention

GRUPO IASA

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ENGINEERING BUSINESS CONNECTIONS

metso