



São Paulo University
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GP2

Pollution Prevention
Group

Hydropower Life-Cycle Inventory: A Brazilian case study

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InLCA/LCM 2006

Business and Government Moving Ahead

Introduction

- **LCA in Brazil:** increase interest, but no database;
 - GP2/USP: start to develop Brazilian LCI 's;
- **Electricity:**
 - Important on different product's life-cycles;
 - Brazilian electricity consumption: 84,3% from hydropower;
 - Very few hydropower LCA available/ different conditions;
- **Hydropower in Brazil:**
 - Itaipu Power Plant: second largest energy facility in the world;
 - 22,4% of all Brazilian consumption;



Itaipu LCI was developed as a first attempt to establish a Brazilian electricity database

Product System Modelling

- Hydropower: very diverse one from another, depending on:
 - Size of the dam;
 - Construction materials;
 - “type” of the dam;
 - Local conditions;
 - River diversion method;
 - etc...



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www.atcold.at/talsperren

- It was not possible to establish common parameters;



“attributional” approach:
single plant LCI (of the most contributing plant)
representing the whole system

Itaipu Power Plant



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- 12,6 GW installed/ 18 turbines;
Projected expansion to 14,0 GW
- 230 GWh/day (2000);
~1/3 of all USA's hydropower generation
- Constructed from 1974 to 1984;

- 478,000 t of steel;
- $12,6 \cdot 10^6$ m³ of concrete;
- 32.000 m³ rock excavation;
- 24.000 m³ earth works;

**Envir. burdens are not only
Greenhouse Gas Emissions !**

LCI definitions

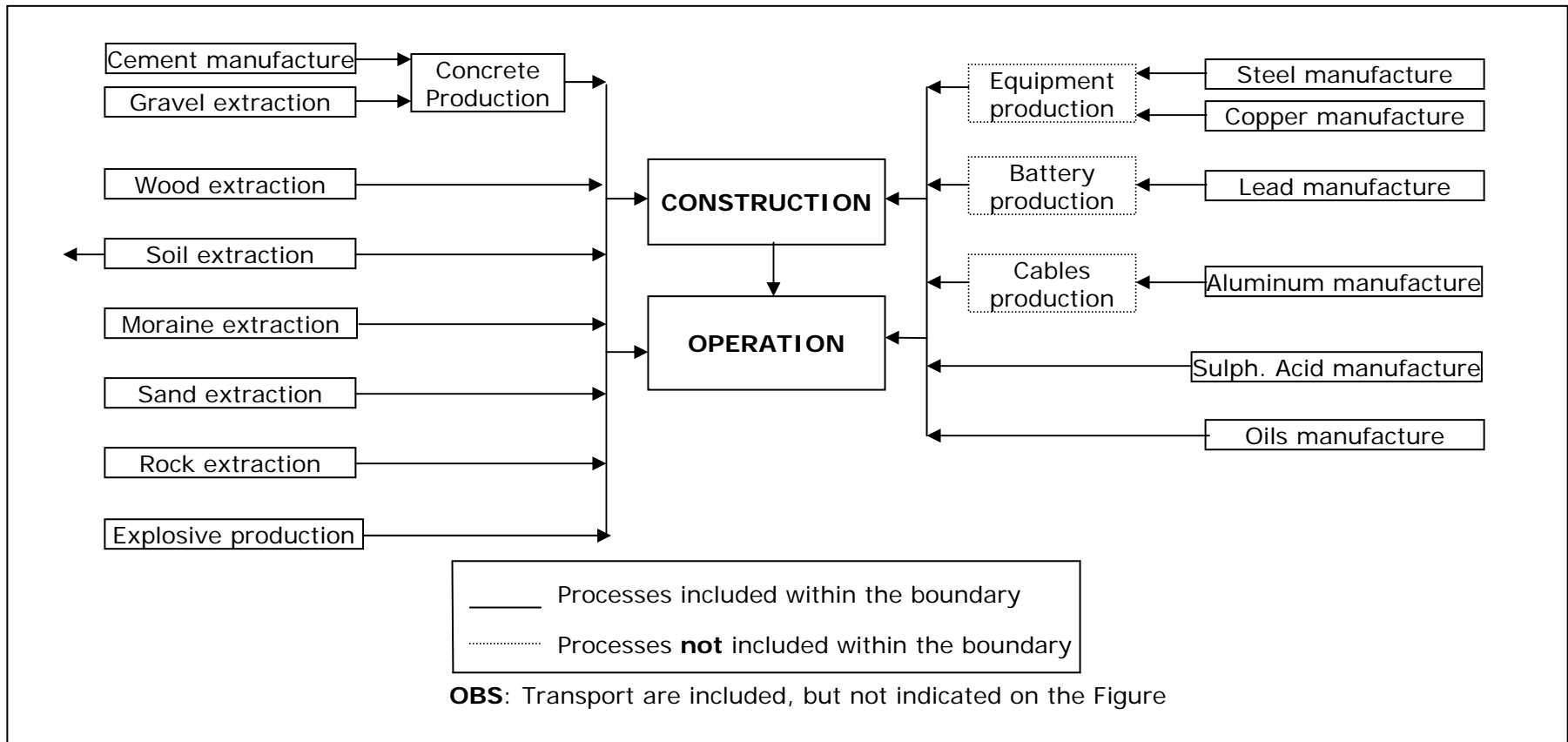
- Function: generates electricity;
- Function Unit: 1 MWh of electricity to the grid;
(no transportation – parallel study)
- Time boundary: based on literature;
 - Dismantling of the dam: not included;
 - Difficulty to determines dam's life:
Use of a fixed value: **100 year**
(international assumption, not scientific based!)



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LCI definitions

- Process Boundary: initially: screening from literatura (Vattenfall's AB, Lule River EPD)



- Afterwards: refinement;

LCI methodology

$$\text{Final LCI burdens} \quad (\text{/MWh}) = \frac{\text{Total construction burdens} + \text{100-year operation burdens}}{\text{Total electricity generated on 100-year period (MWh)}}$$

- Data collection:

1st: primary data on plant consumptions (earth works, diesel, cement, steel, copper, transportation, etc)

2nd: literature data of materials/energy life-cycles (absence of local databases)



LCI results

- 115 environmental burdens- cut criteria: 17;

	Unit (/ MWh)	Total	Construction	Operation (100-year)
Material resources consumption				
Water	kg	8,90E+00	7,16E+00	1,74E+00
Sand	kg	4,12E-01	4,12E-01	x
Basalt	kg	5,47E+00	5,47E+00	x
Calcite	kg	4,86E-01	4,70E-01	1,62E-02
Iron Ore	kg	1,66E-01	1,05E-01	6,10E-02
Earth	kg	3,05E+00	3,05E+00	x
Energetic resources consumption				
Coal	MJ	1,65335	1,038186	0,615164
Hydropower	MJ	1,46E+00	1,36E+00	9,61E-02
Natural gas	MJ	0,285592	0,23958	0,045512
Oil	MJ	5,4753	4,7862	0,69368
Atmospheric emissions				
CH ₄	kg	1,32E-01	4,50E-04	1,32E-01
CO	kg	1,12E-01	7,12E-02	4,08E-02
CO ₂	kg	1,56E+00	4,45E-01	1,12E+00
Particulate	kg	2,49E-02	1,96E-02	5,32E-03
NO _x	kg	2,98E-03	2,71E-03	2,70E-04
SO _x	kg	3,76E-03	2,10E-03	1,66E-03
Non-material burdens				
Land use	m ²	1,52E-01	6,64E-04	1,52E-01

LCI interpretation/ Conclusions

- LCI: extremely sensitive to the considered lifetime confirms that the main source of burdens is the dam construction
- Itaipu has a good environmental performance compared to other hydro plants LCI, due to its high capacity factor and installed power (specially on energy pay-back);
- **Hot-spots** are:
 - reservoir filling (greenhouse gas emissions);
 - steel and cement life cycle, and
 - operation of construction machines;
- Transport activities are of no relevance, however the steel consumption on permanent equipment is.

Limitations of this project

- lack of LCA methodology to “land use modification”;
(undoubtedly the most important source of environmental and social burdens)
- data quality, mainly on:
 - greenhouse gas emission from reservoir filling;
 - electricity production forecasting;
- some processes not included within the boundaries;
(equipment production, explosives use, other materials, etc)
- absence of Impact Assessment to apply the cut criteria;

THANKS FOR YOUR ATTENTION !

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Complete report (only in Portuguese) available for download at:
[www.teses.usp.br/teses/disponiveis/86/86131/tde-23082004-123349/
publico/MestradoFlavio.pdf](http://www.teses.usp.br/teses/disponiveis/86/86131/tde-23082004-123349/publico/MestradoFlavio.pdf)