
DO RIO

A MODEL FOR ESTIMATION OF POTENTIAL GENERATION OF WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT IN BRAZIL

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CONTENT

- Introduction
- Electrical and Electronic market in Brazil
- Penetration of EEE in Brazilian households in 2001 and 2008
- Estimating stock for non mature EEE
- Computer and Cell phone stock in use
- A model for WEEE generation
- Generation estimates for selected WEEE for 2008 in Brazil
- Conclusion

Introduction

- Goal: estimate and validate the volumes of WEEE in Brazil.

- Sales of electrical and electronic equipment are increasing dramatically in developing countries. Usually, there are no reliable data about quantities of the waste generated.
- A new law for solid waste management was enacted in Brazil in 2010, and the infrastructure to treat this waste must be planned.

Electrical and Electronic market in Brazil

- The Brazilian EEE market has been growing strongly. There was a 23% increase in revenues in the electrical and electronic equipment sector from 2007 to 2010 (ABINEE, 2011).
- The Brazilian Institute of Geography and Statistics (IBGE) conducts an annual household survey called the PNAD (IBGE, 2002 and 2009). Among the data gathered is the percentage of households that have various types of electrical and electronic equipment, as shown in Table 1.

Penetration of EEE in Brazilian households in 2001 and 2008

Equipments	% Household			Units (million)		
	2001	2008	Increase %	2001	2008	Increase %
Televisions	89%	95%	7%	38,6	54,8	42%
Refrigerators	85%	92%	8%	36,9	53,0	43%
Freezers	19%	16%	-16%	8,2	9,2	13%
Telephones	59%	82%	39%	25,6	47,2	84%
Washmachines	34%	42%	22%	14,6	23,9	63%
Audio Systems	88%	89%	1%	38,2	51,2	34%
Computers	13%	35%	172%	5,5	20,3	271%
Cell Phones	8%	42%	424%	3,4	24,1	612%

Sources: IBGE 2002 and 2009.

Estimating stock for non mature EEE

- PNAD: number of households that possess the items (household may have more than one device). Does not reflect business usage. PNAD numbers are conservative, particularly for electronic devices like computer and cell.

- Annual survey of households and offices is conducted by Meireles (2010), estimating the stock of computers in use. Cell phone stock is based on the number of cell phone lines in use, obtained from operators (Associação Brasileira de Telecomunicações – TELEBRASIL, 2010).

Computer and Cell phone stock in use

	Computer		Cell Phones	
	Sales (1) million units	Stock (2) million units	Sales (1) million units	Stock (3) million units
2000	2,9	10,0	2,60	23,20
2001	3,1	13,0	5,20	28,70
2002	3,1	16,0	11,30	34,90
2003	3,2	19,0	16,40	46,40
2004	4,1	23,0	33,30	65,60
2005	5,6	28,0	36,60	86,20
2006	8,2	34,0	37,10	99,90
2007	10,0	41,5	49,70	121,00
2008	12,0	50,0	55,10	150,60
2009	12,0	60,0	50,00	174,00

Sources: (1) ABINEE, 2009; (2) Meirelles, 2009, (3) TELEBRASIL, 2010.

A model for WEEE generation

- Different methods since non-mature market products need a different approach.
  - Mature markets are those that are increasing almost at the same rate as the population. Sales are basically for replacement of products after the end of their useful life.
  - Non-mature market products are those where demand is growing faster than population or those that undergo sudden waves of technological change, with the resulting shortening of the lifetime of old technology products. Sales are both to new users and for replacement of old products due to new technological features.

A model for WEEE generation

- A - For mature market products: refrigerators, washing machines, televisions, freezers and audio systems (Consumption and Use Method):

  Generation of $WEEE_i$ = stocks in use_i / average life time
  $Stock_i$ is the number of devices in use in year i.

- B - For non-mature markets: computers and cell phones (Time-step Method):

  Generation of $WEEE_i$ = sales in $year_i$ - (stock in $year_i$ – stock in $year_{i-1}$)

  $Sales_i$ includes local production and importation during a year. $Stock_i$ is the number of devices in use.

Generation estimates for selected WEEE for 2008 in Brazil

Equipments	Weight (kg)	Lifetime (years)	WEEE (tonnes/year)	WEEE per capita (kg/year)
Televisions	30,0	12,0	136.883	0,73
Refrigerators	65,0	12,0	287.024	1,53
Freezers	50,0	15,0	30.787	0,16
Washing machines	40,0	10,0	95.596	0,51
Audio Systems	10,0	10,0	51.173	0,27
Mature market Sub total			**601.462**	**3,20**
Computers	30,0	-	105.000	0,56
Cell phones	0,1	-	2.550	0,01
Non-mature market Sub total			**107.550**	**0,57**
Total			**709.012**	**3,77**

CONCLUSION

- Need of a different methodology to estimated WEEE generation for non-mature market products, such as computers and cell phones, since average lifetime for such products is not constant
- Total yearly WEEE generation per capita for the seven selected products is 3.77 kg per year. This estimate is a rough indication for 2008 of the generation of selected WEEE items.
- The most important variable is the product lifetime, and that information demands a thorough understanding of consumer behavior.

THANK YOU FOR YOUR ...

Claudio Fernando Mahler

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Group of Waste Treatment Studies


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Community Research

SEVENTH FRAMEWORK PROGRAMME

RISKCYCLE

Life cycle assessment on printed matter (paper)

focus on additives

RISKCYCLE

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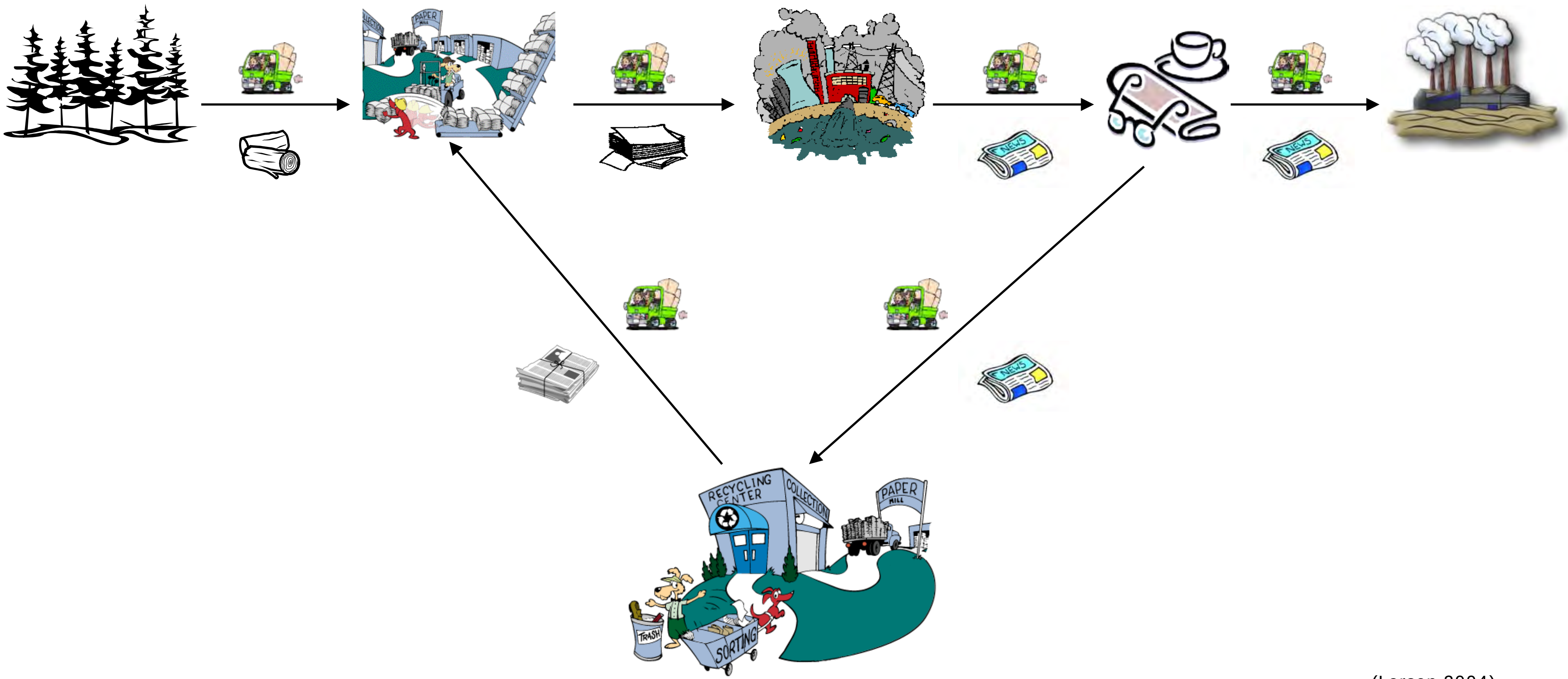
Outline

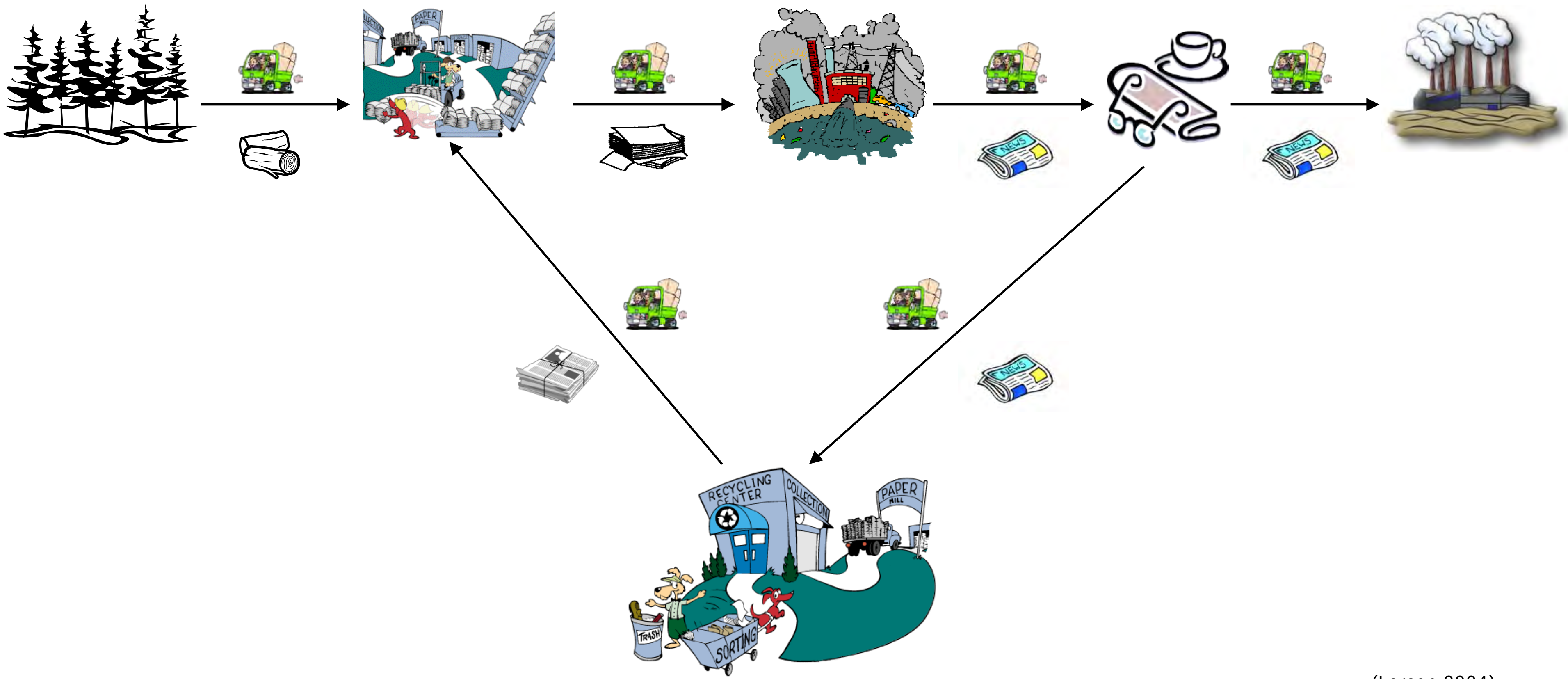
- What is LCA: characteristics, elements; goal and scope, inventory, life cycle impact assessment (LCIA)
- LCA impact profile on printed matter
  - Significant contributing chemical emissions
  - Data lack regarding additives, impurities etc.
- Examples on potential “additives” in recycled paper: Hazardous substances found in the Danish printing industry
- Conclusions and further research

The life cycle of printed matter

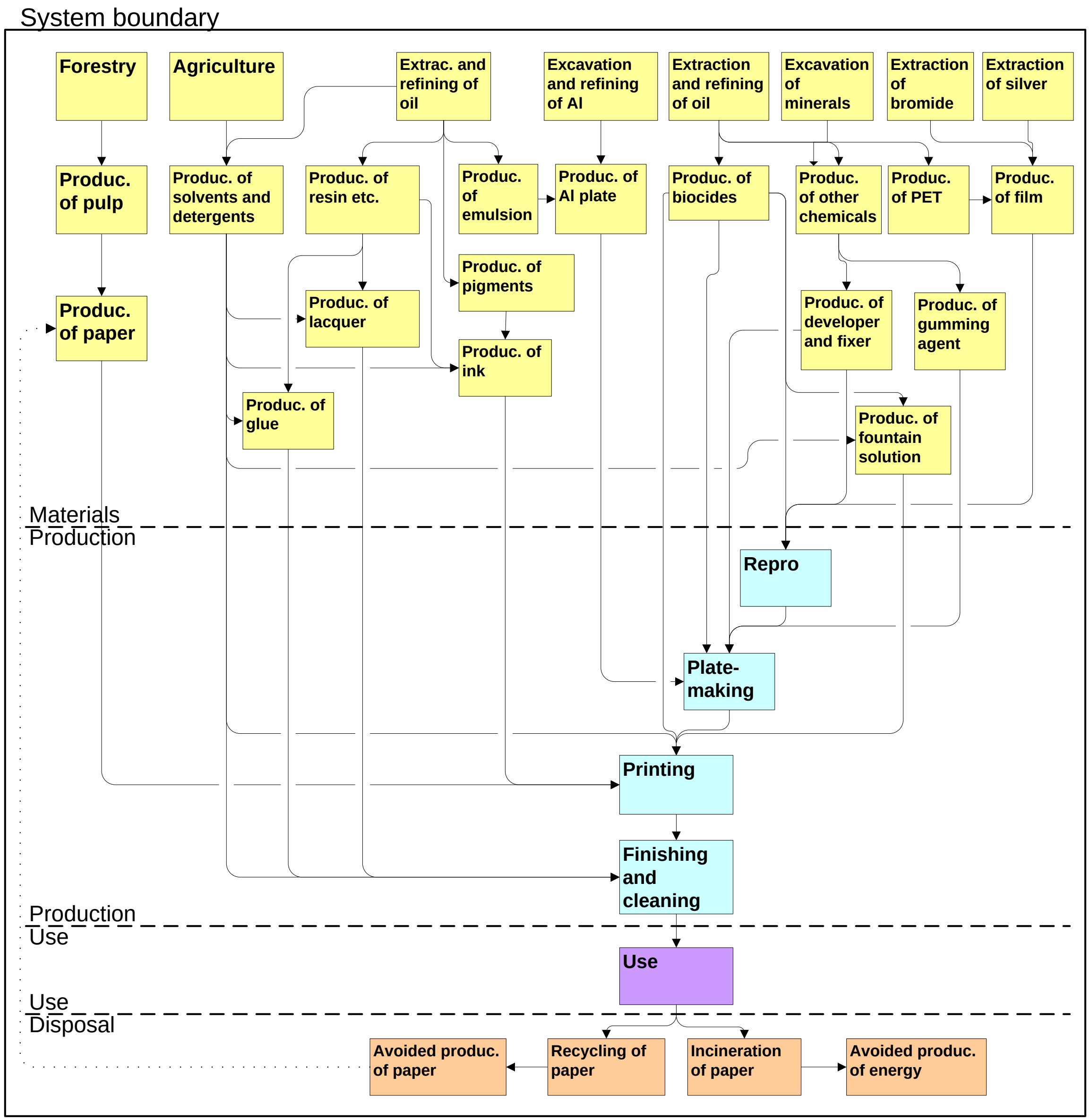


(Larsen 2004)

The life cycle of printed matter



(Larsen 2004)



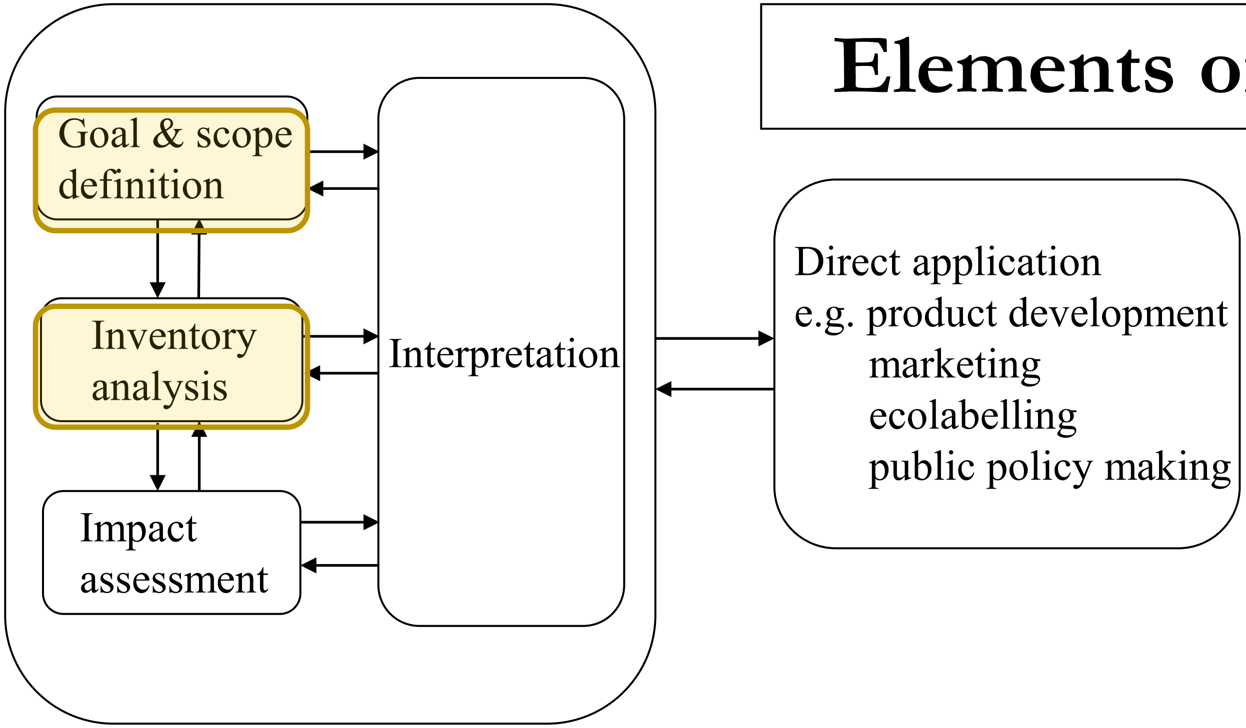
(Larsen et al. 2009)

What is Life Cycle Assessment, LCA?

Characteristic features of LCA:

- A decision supporting tool
- Focus on services typically represented by a product (the "functional unit") For example: 1 ton printed matter
- Comparative (relative statements). For example: Distribution of relative impacts from emissions and resource consumption during the life cycle
- Holistic perspective
  - life cycle from cradle to grave
  - all relevant environmental impacts, e.g. Global warming, acidification, ecotoxicity…….
  - resource consumption (biotic and abiotic), e.g. Kaolin, Al, Ag, coal….
- Aggregation over time and space
  - life cycle is global
  - life cycle may span over decades or even centuries

Elements of LCA (I)

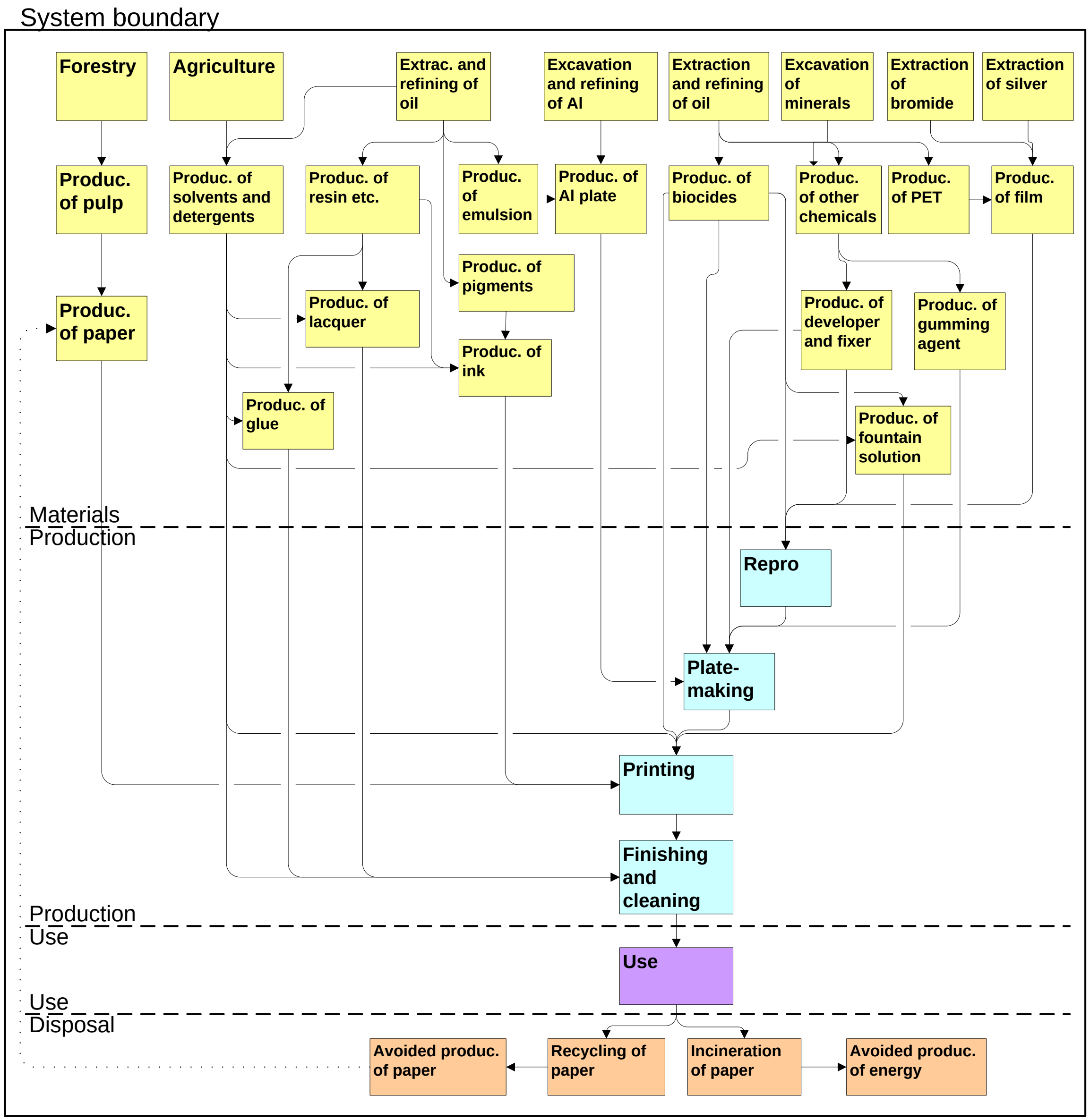


Goal and Scope definition

- defining goal: For example identify the distribution of potential impacts… defining scope: For example cradle to grave including recycling
- decisive for interpretation and use of results: For example identifying the importance of additives for the impact profile when recycling resources like paper

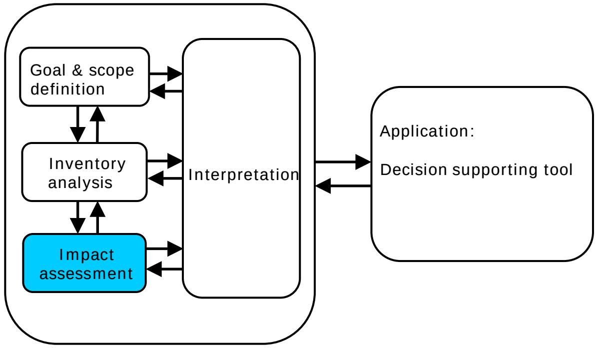
Inventory analysis (LCI)

- collecting in- and output data for all processes



(Larsen et al. 2009)

Life cycle impact assessment (LCIA)



Classification: *"What does this emission contribute to?"*

- Assignment of emissions to impact categories according to their potential effects
  - Global warming (e.g. CO_2, CH_4)
  - Acidification (e.g. NO_2, SO_3)
  - Ecotoxicity (e.g. phthalates, heavy metals)
  - Human toxicity (e.g. benzene, PAH's)
  - ....

Characterisation: *"How much may it contribute?"*

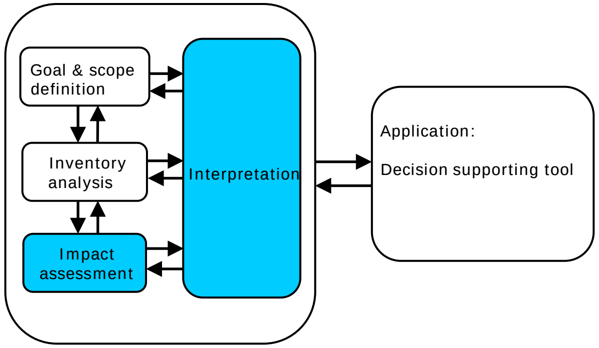
- Quantification of contributions to the different impact categories by estimating impact potentials, IPs (e.g. multiplying the characterisation factors (CFs) for each chemical by the emitted amount (Q) per functional unit (fu)):

$$IP = Q*CF$$

- Example (GWP):

Substance	Q (g/fu)	CF (g CO_2-eq/g)	IP (g CO_2-eq/fu)
Carbon dioxid (CO_2)	250	1	250
Methane (CH_4)	10	25	250
Total			500

Life cycle impact assessment (LCIA) and interpretation



Normalisation: *"Is that much?"*

- Expression of the impact potentials relative to a reference situation (person-equivalence, PE), e.g. normalisation reference (NR) for GWP: 8,700 kg CO_2-eq/pers/year. The normalised impact potential (nIP):

$$nIP = IP/NR$$

Impact category	NR (kg CO_2-eq/pers/year)	IP/fu (kg CO_2-eq/fu)	nIP (mPE/fu)
Global warming (GWP)	8700	0,5	0,057

Valuation: *"Is it important?"*

- Ranking, grouping or assignment of weights (weighting factors, WFs) to the different impact potentials (EDIP: political reduction targets), e.g. for global warming a targeted 10 years reduction of 20% => WF=1/(1-0.2) = 1.3. The weighted impact potential (wIP):

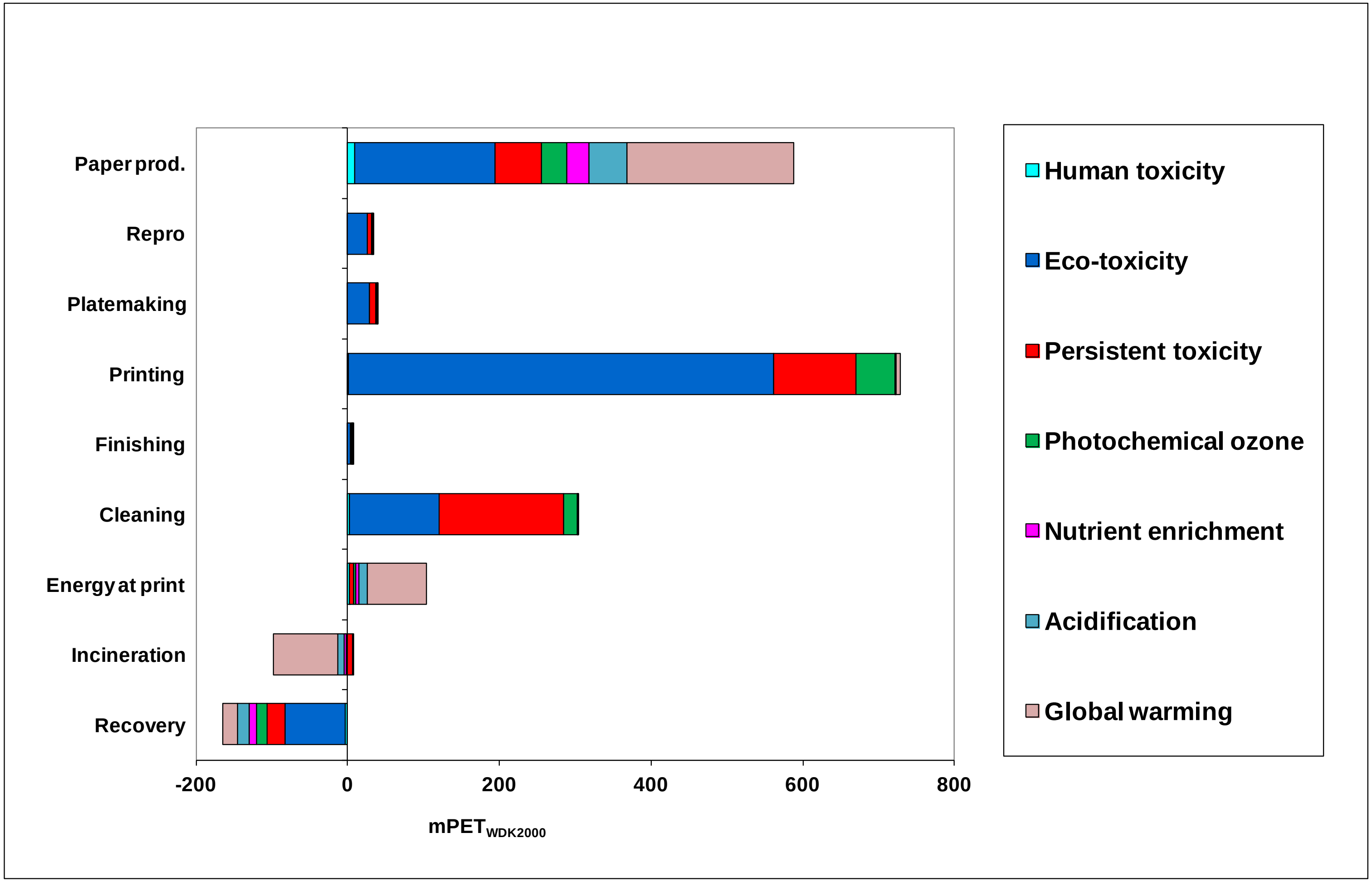
$$wIP = nIP*WF$$

Impact category	WF	nIP (mPE/fu)	wIP (mPET/fu)
Global warming (GWP)	1,3	0,057	0,074

Interpretation: *"Where is the hotspots in the life cycle and for what reason?"*

- Is paper production a hotspot for printed matter life cycle? Due to energy consumption?

Impact profile on printed matter



Functional unit:
1 ton sheet fed offset printed matter

(Larsen et al. 2006)

Significant contributing chemical emissions to the printed matter impact profile

- Emissions of ink residues (tetradecane) and cleaning agents (hexane, tetradecane) during the printing process and cleaning (35%)
- Emissions (dichlorobenzidine, chloroaniline, cuprous chloride) during pigment production (17-20%)
- Emissions of heavy metals and AOX (as dichloro benzene) during paper production (>3%)
- Emissions of fountain chemicals (i.e. isopropyl alcohol, IPA) during the printing process (6%)
- Emissions of biocides and hydroquinone from the repro- and plate making process (3%)

(Larsen et al. 2006)

Known additives/impurities/production emissions that might play an important role for the paper/printed matter LCA impact profile but for which knowledge/data is lacking

- Ink components (and their precursors) production: siccatives, antioxidants, pigments, dyes and more
- Water emissions from paper production: softeners (BPA), other phenolic compounds (NPE, APE), other surfactants (LAS), biocides (benzothiazoler, dibromo-compounds), wood extractions (terpenoids, resin acids), fluorescent whitening agents and more
- Recycling of paper: Fate of paper chemicals (wet strength agents, biocides, dyes), ink chemicals (phthalates, hydrocarbons), glue chemicals and more
- Treatment of chemical waste: Fate of (hazardous) waste from printing (ink waste, used cleaning agents, used rinsing water etc.) and from recycling of paper (sludge from repulping)

(Ginebreda et al. 2012, Larsen et al. 2006 and more)

Substances of very high concern (SVHC) appearing on the recently updated EU REACH Annex XIV candidate list and found in the Danish printing industry

Name	CAS No.	Annex XIV criteria	Use
Chromtrioxide	1333-82-0	Carc 1, mut 2	Chrome plating (gravure)
Trichloroethylene	79-01-6	Carc 2	Inks
Cobalt-siccatives *	(10124-43-3)	(Carc 2, rep 2)	Inks (off-set, screen printing)
Acrylamide	79-06-1	Carc 2, mut 2	Unknown (impurity?)
Pigment Yellow 34 (lead-chromate)	1344-37-2	Carc 2, rep 1	Inks (screen printing)
Pigment Red 104 (lead-chromate)	12656-85-8	Carc 2, rep 1	Inks (screen printing)
2-Methoxy ethanol	109-86-4	Rep 2	Photochemistry
Di(2-ethylhexyl)phthalate, DEHP	117-81-7	Rep 2, EDS-list	Inks
Dibutylphthalate, DBP	84-74-2	Rep 2, EDS-list	Inks (screen printing, flexo)
Benzylbutylphthalate, BBP	85-68-7	Rep 2, EDS-list	Inks
Boric acid and borax	10043-35-3 and 1303-96-4	Rep 2, EDS-list	Photochemistry

* Possible content of soluble cobalt(II)salts. Cobalt(II)sulphate, cobalt dichloride, cobalt(II)carbonate, cobalt(II)dinitrate and cobalt(II)diacetate all appears on the recently updated REACH Annex XIV candidate list . IARC classify all soluble cobalt(II)salts as possible carcinogenic, i.e. group 2B (http://monographs.iarc.fr/ENG/Monographs/vol86/mono86.pdf)

(Larsen 2012)

Substances meeting Annex XIV candidate list criteria and found in the Danish printing industry (not listed on the REACH Annex XIV candidate list but potential candidates that may be listed in the future)

Name	CAS No.	Annex XIV criteria	Use
Benzene	71-43-2	Carc 1, mut 2	Inks, cleaning agents
Epichlorohydrin	106-89-8	Carc 2, EDS-list	Unknown (impurity?)
2-Methylaziridine	75-55-8	Carc 2	Inks (flexo)
Aziridine	151-56-4	Carc 2, mut 2	Inks (flexo, screen printing)
Propylenoxide	75-56-9	Carc 2, mut 2	Inks, cleaning agents
2-Methoxy propylacetate	70657-70-4	Rep 2	Inks (screen printing)
Triethylene glycol dimethylether	112-49-2	Rep 2	Brake fluid
2-Methoxypropan-1-ol	1589-47-5	Rep 2	Unknown
Alkylphenolethoxylates	(25154-52-3)	EDS-list	Inks, cleaning agents
Chloroalkanes, C14-17	85535-85-9	EDS-list . Possible PBT/vPvB-substance	Chain oil
Octamethylcyclotetrasiloxane (polydimethylsiloxane)	556-67-2 (9016-00-6)	Possible PBT/vPvB-substance	Inks
Bisphenol A	80-05-7	EDS-list	Inks, thermal paper
Resorcinol	108-46-3	EDS-list	Glue
Styrene	100-42-5	EDS-list	Inks, glue
Decamethyl-cyclopentasiloxane	541-02-6	Possible PBT/vPvB-substance	Inks
Stoddard solvent	8052-41-3	Carc 2	Unknown
Solventnaphtha (crude oil), hydrogen treated light naphthen- (benzene >= 0.1%)	92062-15-2	Carc 2	Cleaning agent

(Larsen 2012)

Conclusions and further research

Conclusions

- There is a general lack of relevant inventory data on e.g. production and fate in products, for almost all additives used in printed matter/paper
- Also characterization factors on additives is to a large degree missing
- However, a few existing case studies indicate that emissions related to the production and use of additives may play an important role for the LCA impact profile of printed matter/paper
- Furthermore, a survey on the use of hazardous chemicals in the printing industry and measurements of additives/impurities in recycled paper indicate that some of these substances may accumulate in the recycled paper and potentially contribute significantly to the printed matter/paper LCA impact profile

Research needs

- Better coverage of upstream processes, e.g.
  - Ink components (and their precursors) production: pigments, softeners, siccatives, antioxidants etc.
  - Water emissions from paper production: softeners (BPA), other phenolic compounds (NPE, APE), other surfactants (LAS), biocides (benzothiazoler, dibromo-compounds), wood extractions (terpenoids, resin acids) and more
- Better coverage of downstream processes including recycling, e.g.
  - Recycling of paper: Fate of paper chemicals, ink chemicals, glue chemicals etc.
  - Treatment of chemical waste: Fate of (hazardous) waste from printing (ink waste, used cleaning agents, used rinsing water etc.) and from recycling of paper (sludge from repulping)

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- *Ginebreda A, Guillén D, Barceló D, Darbra R (2012). Additives in the Paper Industry. Chapter in: Global Risk-Based Management of Chemical Additives, Volume I.* Production, usage and environmental occurrence. Editors: Billitewski B, Darbra PM, Barcelo D. The Handbook of Environmental Chemistry Volume 18, 2012. *Springer Verlag.*

Thank you for your attention

Assessing Plastics Additives in Life Cycle Assessment

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Content

- Introduction: LCA in RiskCycle
- Method: Life Cycle Assessment
- Results: plastics and additives in LCA
- conclusions and recommendations

introduction: LCA in Riskcycle

- Life Cycle Assessment: environmental impacts of toxic additives in large context:
  - total of environmental problems
  - total process chain related to the application
- Survey of LCA case studies of plastics:
  - additives do NOT show up as important
- really unimportant,
  or not taken into account properly?
- illustration:
  case study on additives (DEHP) in PVC flooring

DEHP: di(2-ethylhexyl)phthalate

Life Cycle Assessment

- Standardized methodology
  - ISO 14040 standard
  - European guide book ILCD

- Methodological steps:
  - Goal and scope definition
  - Life Cycle Inventory
  - Life Cycle Impact Assessment
  - Interpretation

ILCD: International Reference Life Cycle Data System (EC JRC-IES)

plastics and additives in LCA, results from the RiskCycle project

- literature survey of
  -LCI databases,
  -LCIA impact factors and
  -published LCA case studies

- LCA case study on PVC flooring, supplemented with emission data based on SFA studies

literature survey of LCI databases

- 30 LCI databases studied
- focus on plastics and additives
- conclusions:
  - production additives: NOT available
  - production polymers: available
    - aggregated data (Plastics Europe)
    - uncompounded resins, excl. additives
  - use phase: emissions are lacking
  - recycling of plastics: NOT available
  - waste treatment:
    - emission depends on material
    - databases are supplemented by tool
    - coarse models, additives lacking

1. LCA resources directory by JRC-IES
2. Database Registry by UNEP/SETAC

LCIA impact factors

- especially data on toxicity are lacking
- Toxicity: Usetox (Rosenbaum et al., 2008),
  - recommended IA model of ILCD
  - CF based on pathways via environment, so do not include direct contact (e.g. migration from food packaging) or indoor emissions
- characterisation factors are available for some additives (e.g. metals, some phthalates)
- however there are many different (plastics) additives
- this too makes it difficult to include additives in LCA studies

published LCA case studies

- 110 LCA case studies of plastics
- 25 mention additives
- In none of the articles the additives are identified as an important issue
  - waste treatment: only qualitative
  - comparative LCAs:
    flooring (3) and window frames (1)
    production (4) and emission (2)

the case study

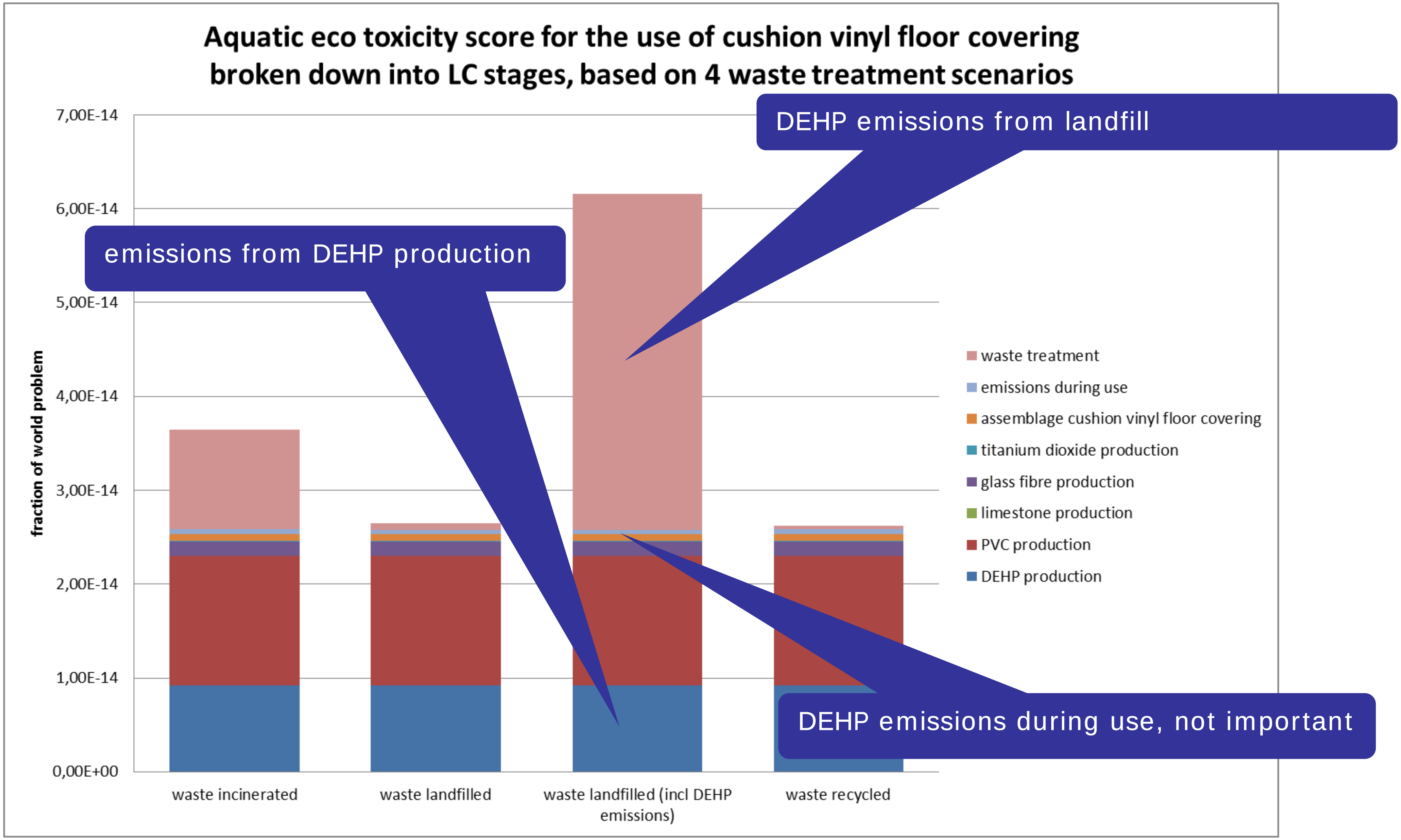
- cushion vinyl floor covering:
  PVC and phthalates (DEHP)
- FU: the use of 1 m2 cushion vinyl floor covering, with a lifetime of 15 years

cushion vinyl floor covering	kg	%
PVC	0.84	48.4
DEHP	0.505	29.1
limestone	0.25	14.4
Stabilizer[1]	0.05	2.88
pigment	0.005	0.29
other materials (PUR?, flame retardents?)[1]	0.03	1.73
glass fiber	0.055	3.17
cushion vinyl floor covering	1.735	100

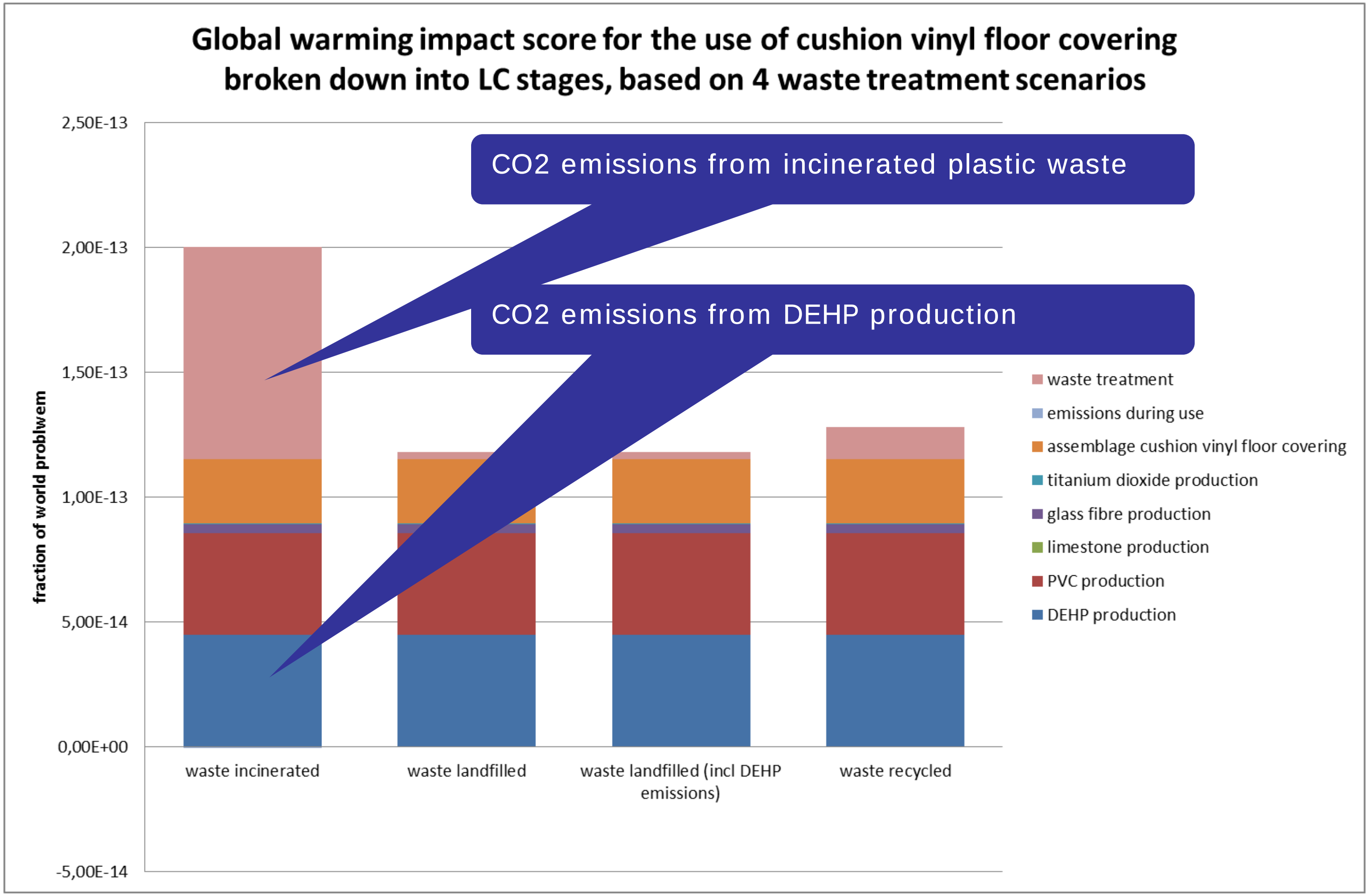
Table 1 Composition of 1 m^2 cushion vinyl floor covering (Potter & Blok, 1995)
.

- cradle-to grave life cycle of product, with
  4 different waste treatment scenarios: incineration, land fill (controlled, uncontrolled), recycling

normalised results, aquatic ecotoxicity



normalised results, global warming



conclusions case study CVFC and DEHP

- additives seem to contribute significantly to Life Cycle Impacts
  - emission in waste treatment
  - production of additive
    (CtG emissions, not only DEHP)

- so additives can not be ignored in case studies on plastics

Approaches used to estimate lacking data

- LCI data: emissions based on SFAs
  - e.g. Jenny Westerdahl, Henning Tien
  - the production, use, waste management and emissions of specific substances in a national economy are charted,
  - SFAs are used to derive emission factors
- LCIA data: toxicity characterization model
  - Usetox (Rosenbaum et al., 2008)
  - impact factors based on substance characteristics and exposure pathways
  - in the Riskcycle project, Usetox and QSAR models are used to derive characterization factors for 140 additives (Magnus Rahmberg)

general conclusions

- the literature survey shows that additives are by and large neglected in LCA studies
  - lack of data: LCI (production, use, waste) and LCIA
  - scope of LCA study: impact assessment often limited to global warming, notably toxicity impacts are often excluded
  - Failure to recognize additives:
    - aggregate data for plastics
    - additives ignored because of its small volume
- the CVFC case study shows that additives may contribute significantly, not just to toxic impacts but also to global warming, not just as emission but also as CtG compound
- data gaps in LCI and LCIA databases should be mended
- the plastics, together with additives, industry should play a key role in this process

END

thank you

for your attention

Appendix

Extra information on

1. case study LCA CVFC
2. Literature survey LCI databases and LCA case studies

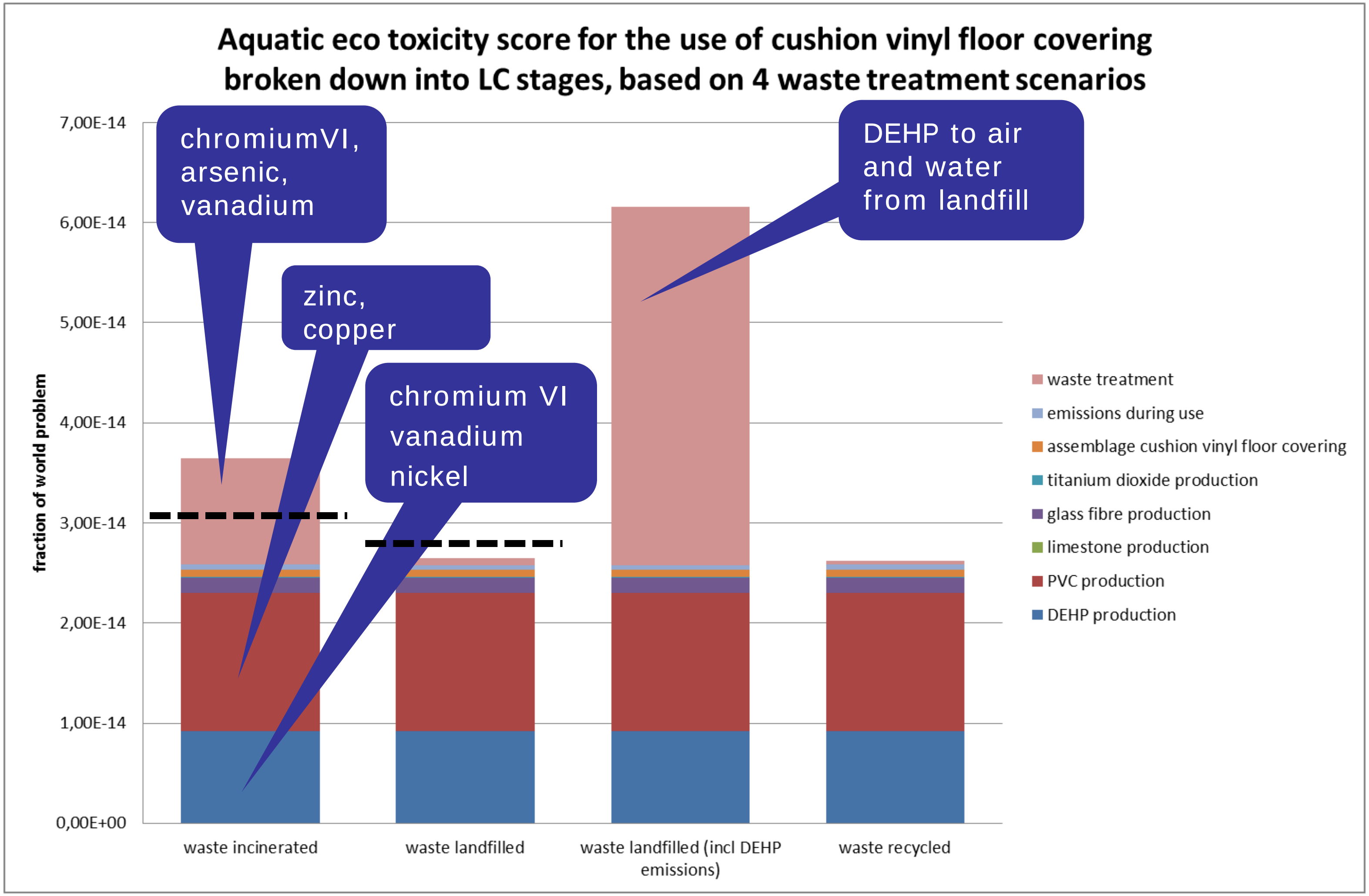
impact assessment

- baseline characterisation factors of (Dutch) Handbook on LCA (Guinée et al., 2002)
- impact categories toxicity: Usetox model (Rosenbaum et al., 2008)

Guinée, J.B. et al., 2002. Handbook on Life Cycle Assessment. Operational Guide to the ISO Standards. Springer,

Rosenbaum R.K., T.M. Bachmann, L.Swirsky Gold, M.A.J. Huijbregts, O. Jolliet, R. Juraske, A. Koehler, H.F. Larsen, M. MacLeod, M. Margni, T.E. McKone, J. Payet, M. Schumacher, D. van de Meent & M. Hauschild (2008). Usetox - the UNEP-SETAC toxicity model: recommended characterisation factors for human toxicity and fresh water ecotoxicity in life cycle impact assessment. Int J LCA (2008) 13:532-546

normalised results, aquatic ecotoxicity



discussion

- estimated process data for waste treatment
  - no detailed data, models with general characteristics
  - DEHP guestimates
  - data based on ‘high tech’ European processes
  - allocation waste incineration: all to waste treatment
  - landfill site: sewage water treatment IS taken into account

- outdated process data, for PVC and incineration
  - emission during electrolysis NaOH and Cl2 by mercury cell

- impact assessment human toxicity (Usetox)
  - indoor emission pathways not taken into account

conclusions (and remarks)

- waste treatment
  - waste incineration is worst option, others not far apart
  - however, incineration overestimated (allocation), landfill underestimated (if uncontrolled landfill site)

- PVC and phthalates
  - emission of DEHP from an uncontrolled landfill site has a substantial contribution to the environmental impact
  - contribution of DEHP emissions from other processes are negligible
  - however, indoor pathways are not considered

conclusions
(and remarks)

- LCA
  - LCA enables to put emissions (of DEHP) in context, total of emissions, total of processes
  - additional to RA: generic global versus actual local
  - process data recycling not available in LCA databases
  - process data 'low tech' processes not available in LCA databases
  - process data additives not available in LCA databases

LCI databases

1. LCA resources directory by JRC-IES
2. Database Registry by UNEP/SETAC

Joint Research Centre – Institute for Environment and Sustainability
United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC)

Database + version	Supplier	checked/decribed in this workbook
CPM LCA Database	Center for Environmental Assessment of Product and Material Systems - CPM	
DEAM™	Ecobilan - PricewaterhouseCoopers	
DEAM™ Impact	Ecobilan - PricewaterhouseCoopers	
DIM 1.0	ENEA - Italian National Agency for New Technology, Energy and the Environment	
ECODESIGN X-Pro database V1.0	EcoMundo	
ecoinvent Data v1.3	ecoinvent Centre	PlasticsEurope
EIME V8.0	CODDE	
EIME V9.0	CODDE	
esu-services database v1	ESU-services Ltd.	
Eurofer data sets	EUROFER	
Franklin U.S. LCI database	Franklin Associates, A Division of ERG	x
GaBi databases 2006	PE International GmbH	PlasticsEurope+
GEMIS 4.4	Oeko-Institut (Institute for applied Ecology), Darmstadt Office	
IO-database for Denmark 1999	2.-0 LCA consultants	
IVAM LCA Data 4.04	IVAM University of Amsterdam bv	PlasticsEurope (APME)???
KCL EcoData	Oy Keskuslaboratorio-Centrallaboratorium Ab, KCL	
LC Data	Forschungszentrum Karlsruhe	
LCA Database for the Forest Wood Sector	Bundesforschungsanstalt für Forst- und Holzwirtschaft (BFH)	not relevant
LCA_sostenipra_v.1.0	Universitat Autònoma de Barcelona (UAB)	
MFA_sostenipra_v.1.0	Universitat Autònoma de Barcelona (UAB)	
Option data pack	National Institute of Advanced Industrial Science and Technology (AIST)	
PlasticsEurope Eco-profiles	PlasticsEurope	x
ProBas	Umweltbundesamt	
Sabento library 1.1	ifu Hamburg GmbH	not relevant
SALCA 061	Agroscope Reckenholz-Tänikon Research Station ART	not relevant
SALCA 071	Agroscope Reckenholz-Tänikon Research Station ART	not relevant
SimaPro database	PRé Consultants B.V.	PlasticsEurope (Ecoinvent), IVAM
sirAdos 1.2.	LEGEP Software GmbH	not relevant
The Boustead Model 5.0.12	Boustead Consulting Limited	PlasticsEurope
Umberto library 5.5	ifu Hamburg GmbH	PlasticsEurope, waarschijnlijk????
US Life Cycle Inventory Database	Athena Sustainable Materials Institute	x
Waste Technologies Data Centre	UK Environment Agency	

Literature survey LCA case studies

Three Journals have been screened on relevant articles:

1) International Journal of Life Cycle Assessment; 265 hits
2) Journal of Industrial Ecology; 118 hits
3) Journal of Cleaner Production; 113 hits