Hilfe2

Materials Science & Technology

ICTs: from Cradle to e-Waste

A Life Cycle Assessment Study of Desktop PC Systems

M.Sc. Martin Eugster
Technology and Society Lab (TSL)
Empa – Swiss Federal Laboratories for Materials Testing and Research
St. Gallen, Switzerland

www.empa.ch/tsl

Slide 1

Hilfe2

Diese Folie enthält zwei Mastergruppen (Master und Titelmaster), welche den Corporate-Design-konformen Auftritt definieren. Der jetzt zugewiesene Empa-Master 1 sieht für die Titelfolie das Empa-Logo vor. Den weiteren Folien ist kein Logo zugewiesen. Für längere Vorträge mit Zwischentiteln empfehlen wir, den Folien mit Zwischentiteln den Empa-Master 2 (mit Logo unten rechts) zuzuweisen. Dazu öffnen Sie via Ansicht > Aufgabenbereich > Foliendesign-Entwurfsvorlage rechts die Masterauswahl. Nun markieren Sie im linken Ansichtsfenster die Folien, denen Empa-Master 2 zugewiesen werden soll (mindestens zwei, ansonsten für den ganzen Satz Empa-Master 1 verwendet wird). Weitere Hilfe erhalten Sie bei Monika Ernst, 4995 (Empa, Dübendorf)

M. Ernst, 04/02/2005

EMPA
Materials Science & Technology

Problem:
Society is overusing the services provided by Nature → What is the role of ICT?

ICT is a necessary part of the solution

ICT is part of the problem

EMPA
Materials Science & Technology

A Conceptual Framework

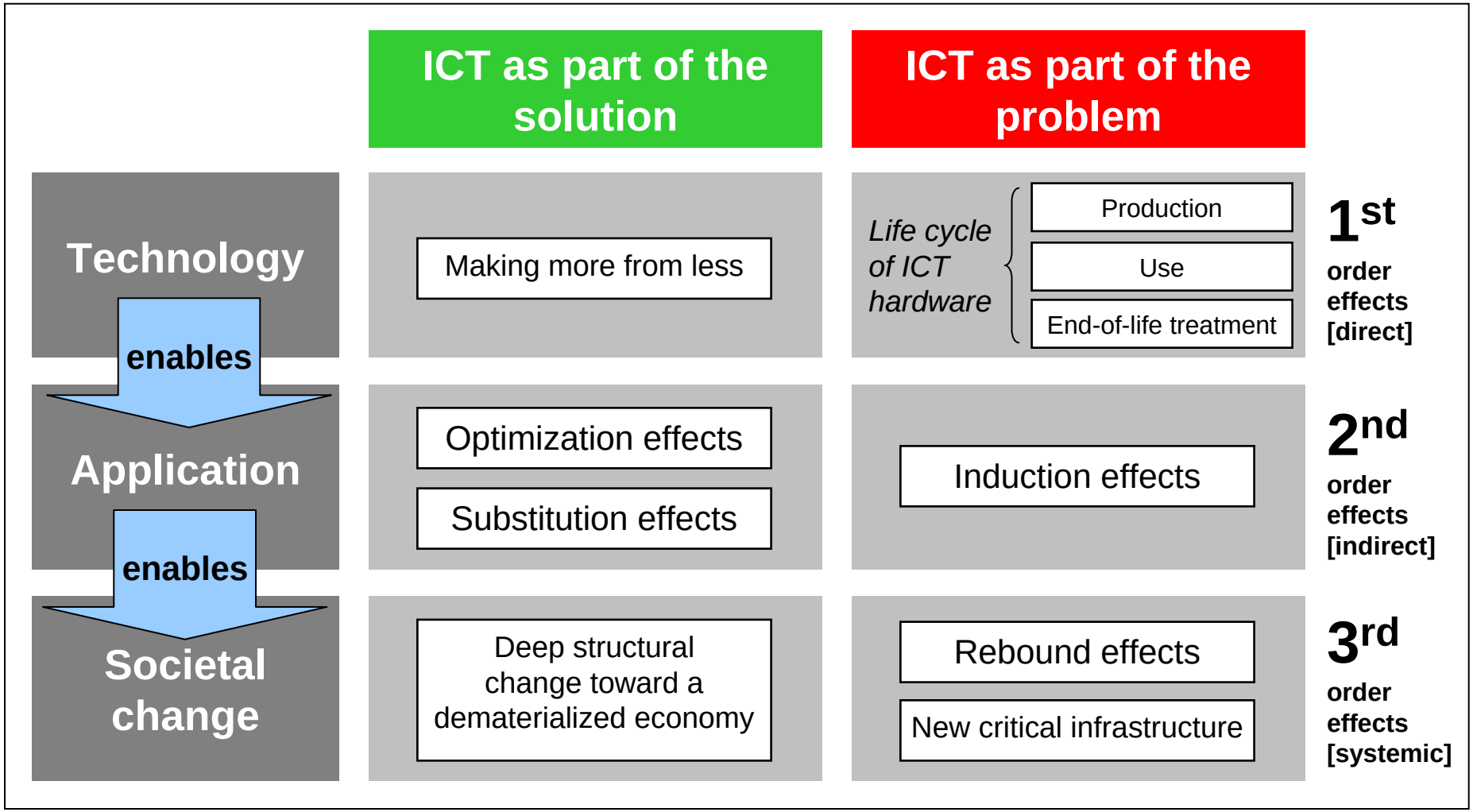
LCA of Desktop PC Systems

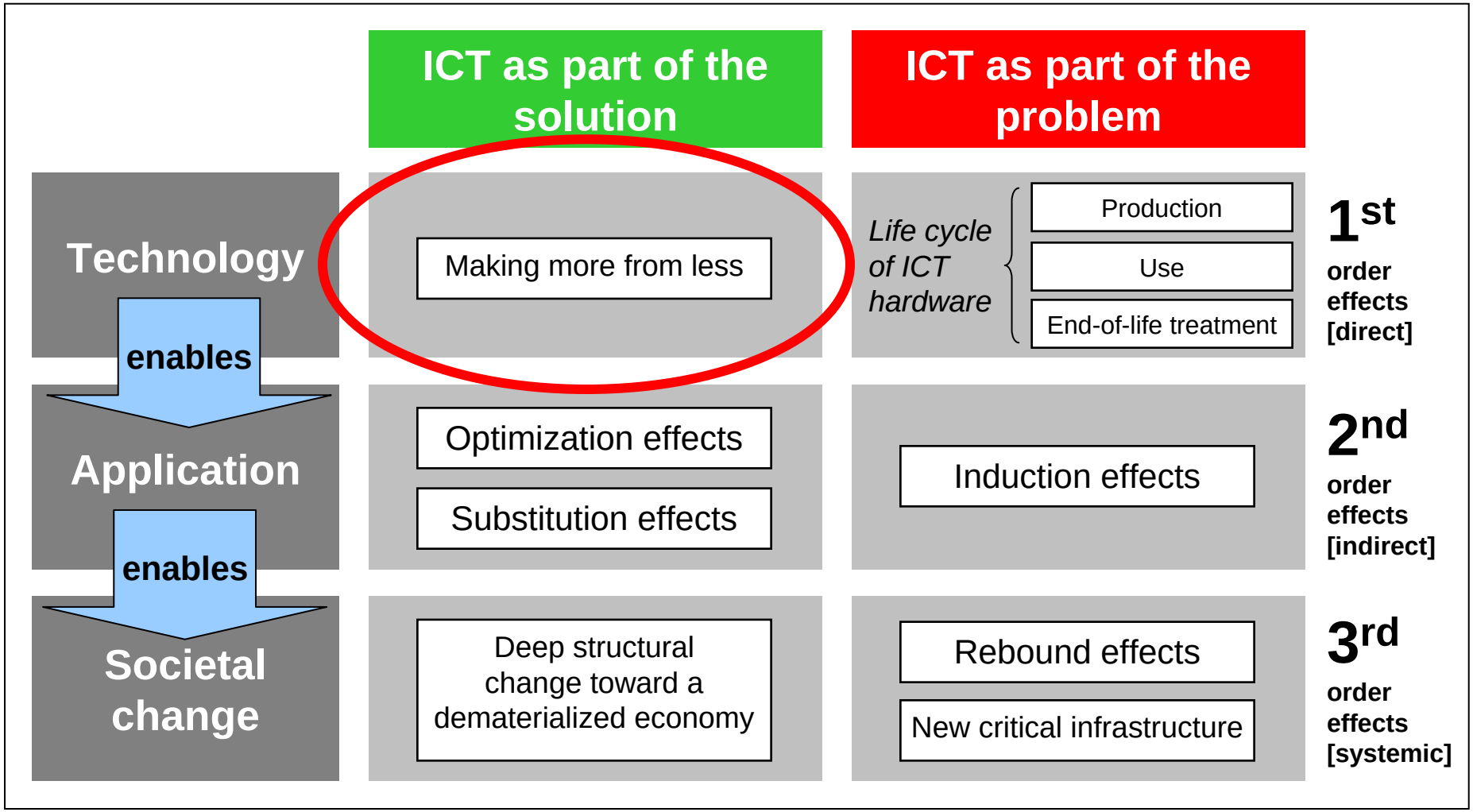
e-Waste – the Key Problem

Findings and Conclusions

EMPA
Materials Science & Technology

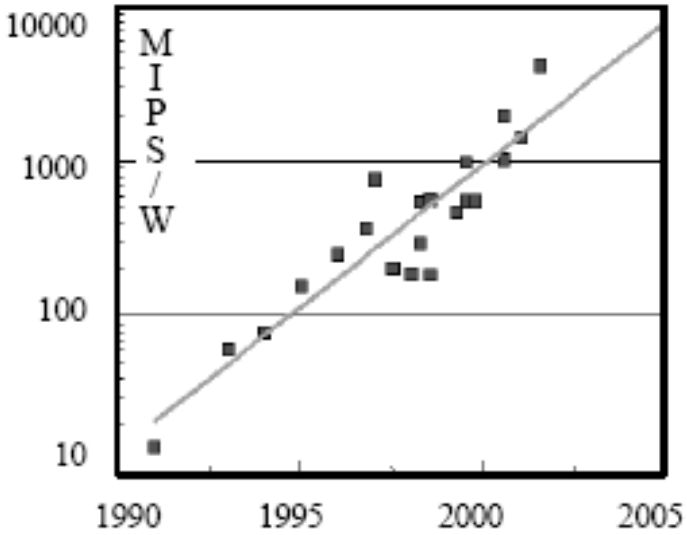
Conceptual Framework




ICT as part of the solution
ICT as part of the problem
Technology
enables
Application
enables
Societal change
Making more from less
Optimization effects
Substitution effects
Deep structural change toward a dematerialized economy
Life cycle of ICT hardware
Production
Use
End-of-life treatment
Induction effects
Rebound effects
New critical infrastructure
1st order effects [direct]
2nd order effects [indirect]
3rd order effects [systemic]

Making More from Less

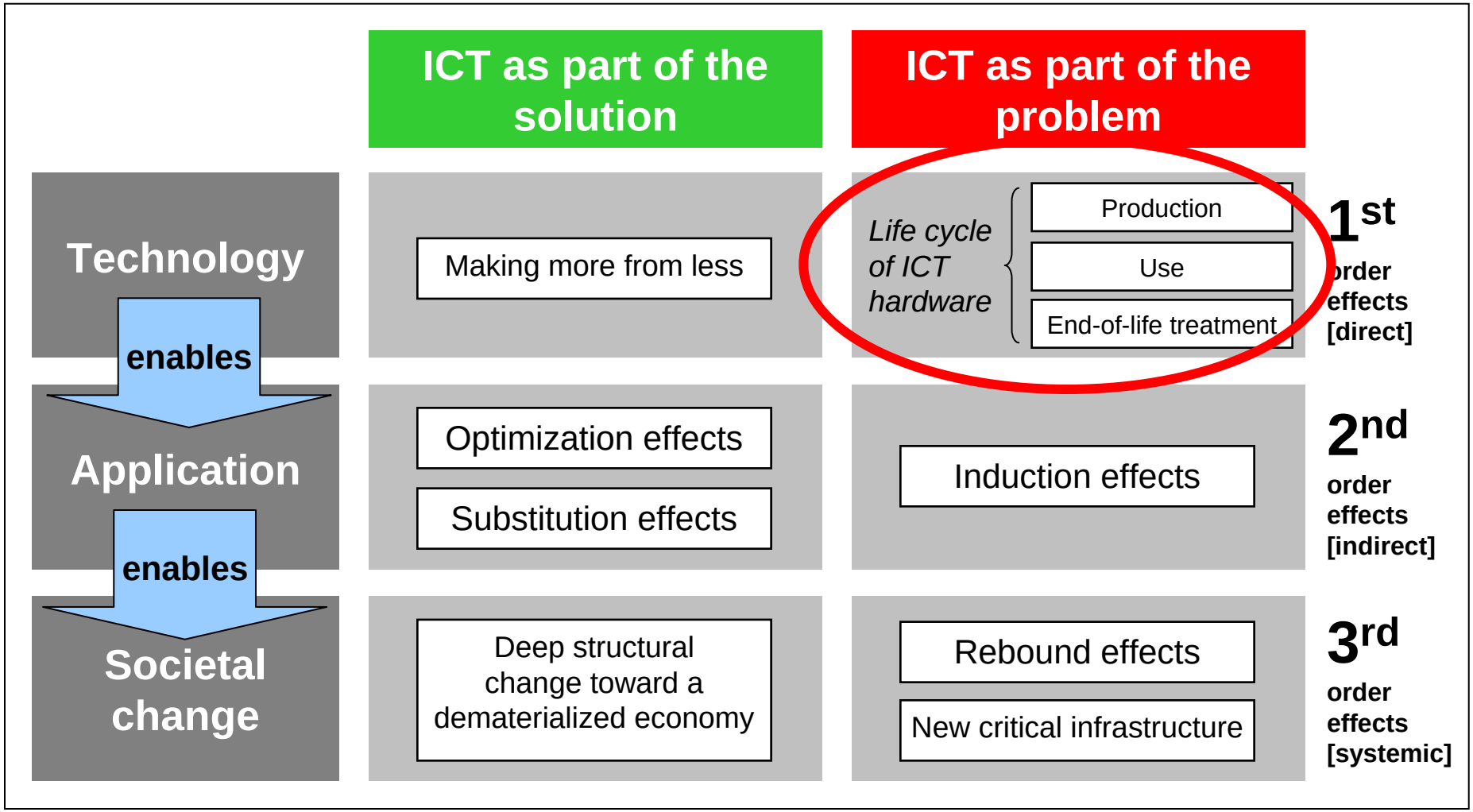
Moore‘s Law (Source: Mattern, 2005)



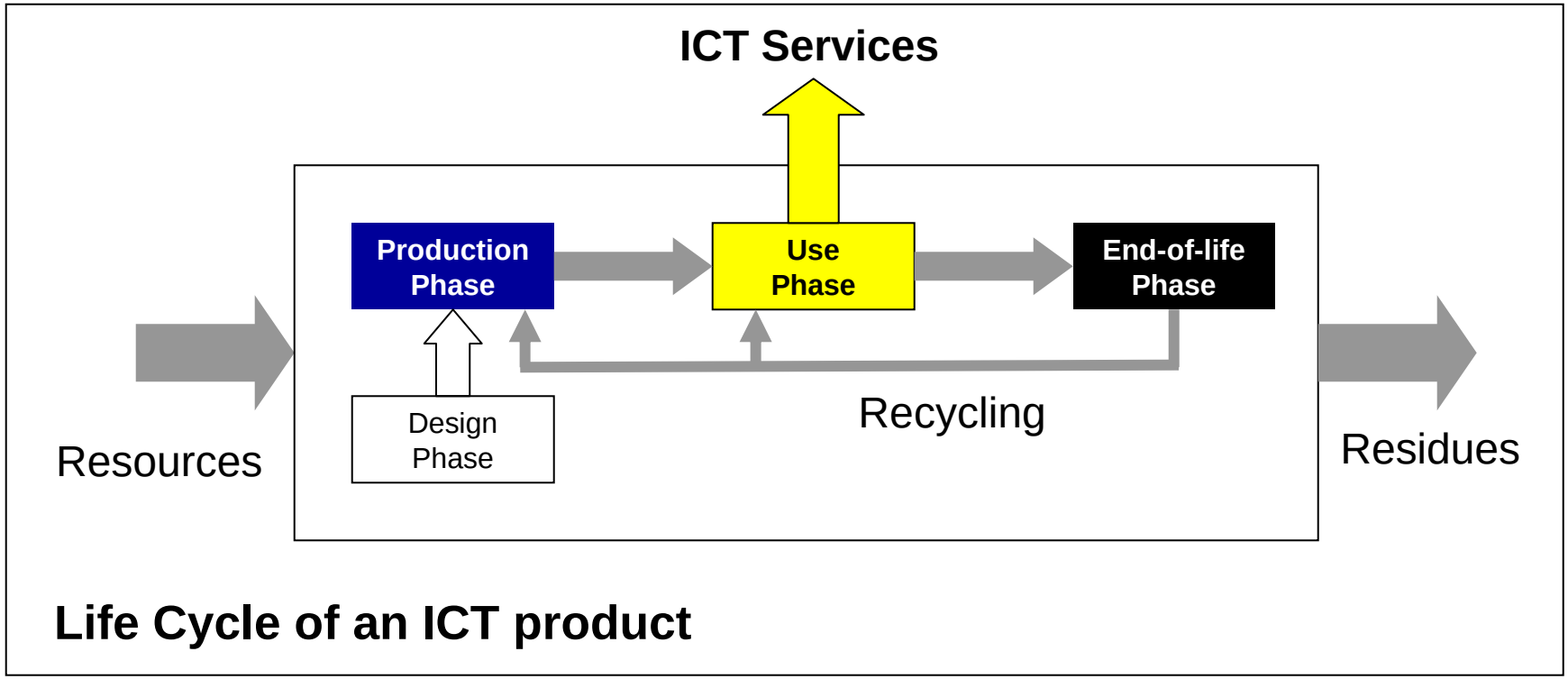
Moore‘s Law in terms of **energy** efficiency (Source: Mattern, 2005)

If other industries would make the same progress in efficiency…

EMPA
Materials Science & Technology



The Life Cycle of ICT Hardware



Life Cycle Assessment (LCA) studies calculate the relevant environmental impacts of the life cycle per functional unit.

EMPA

Materials Science & Technology

A Conceptual Framework

LCA of Desktop PC Systems

e-Waste – the Key Problem

Findings and Conclusions

Method

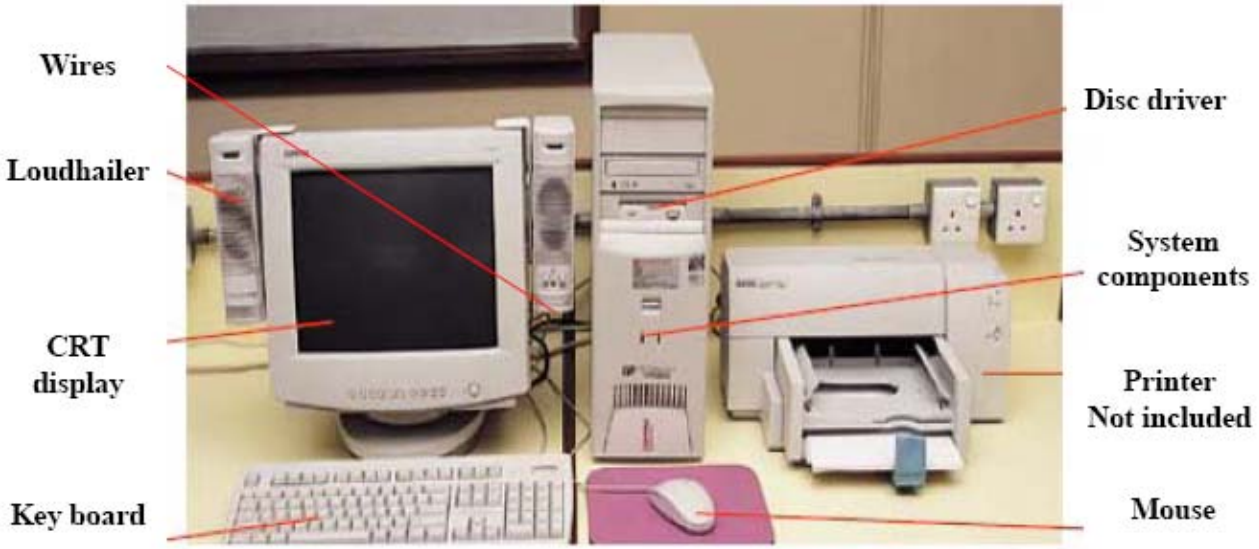
Life Cycle Assessment (LCA) is a method/tool for the **estimation** of the **ecological effects** that are connected with a product / with a service / with a process / with a technology / etc.

Basic principle is a 2-step procedure with:

- ***(i) Collection*** of the ***interactions*** of a system with its own environment (*Input-Output-Analysis*), plus
- ***(ii) Assessment*** of each single environmental impact

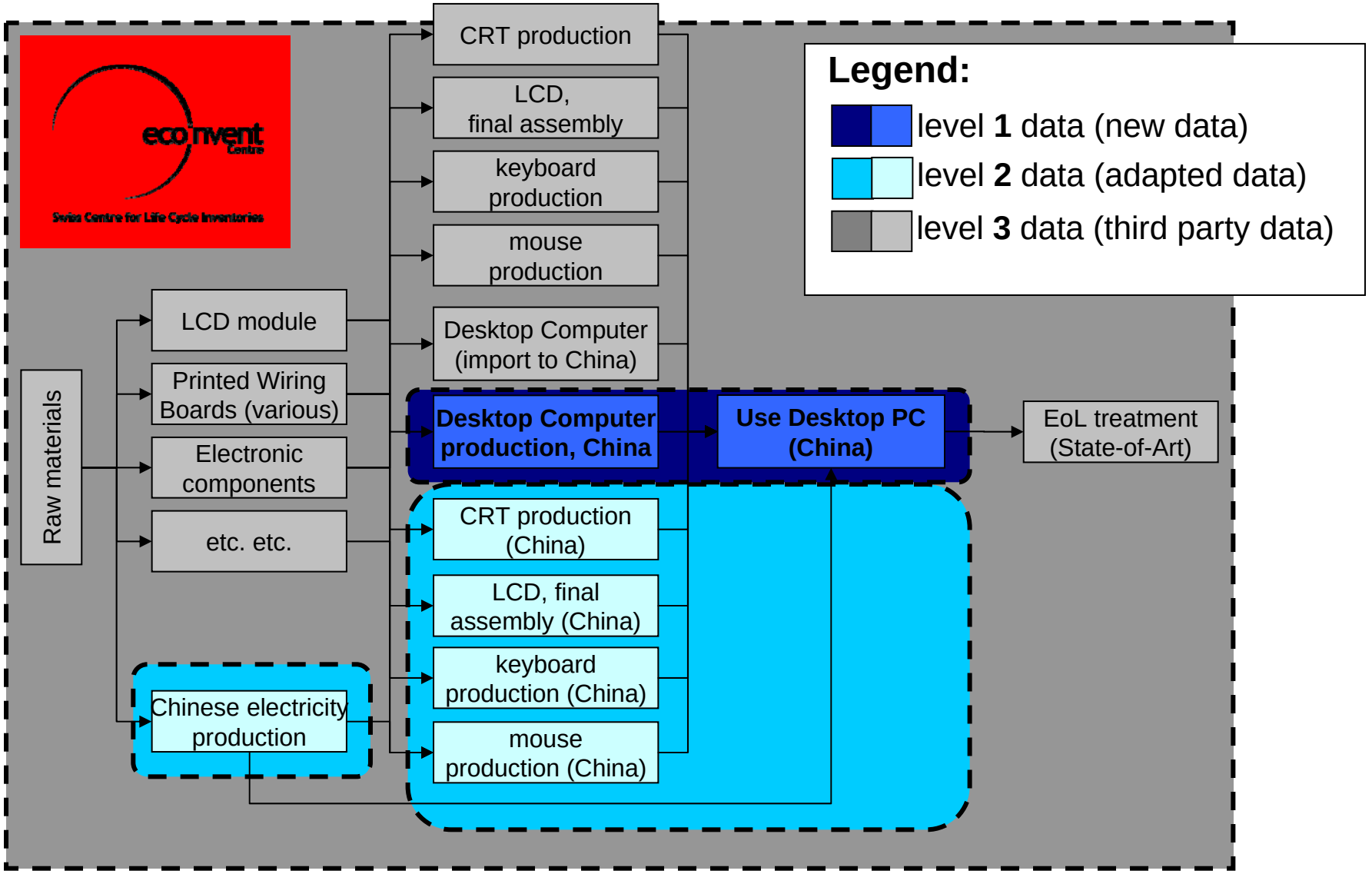
Functional Unit

The complete life cycle of a desktop PC system (50% CRT, 50% LCD screen), used in China during 6 years, including e-waste treatment (state-of-art).



EMPA
Materials Science & Technology

Inventory Analysis



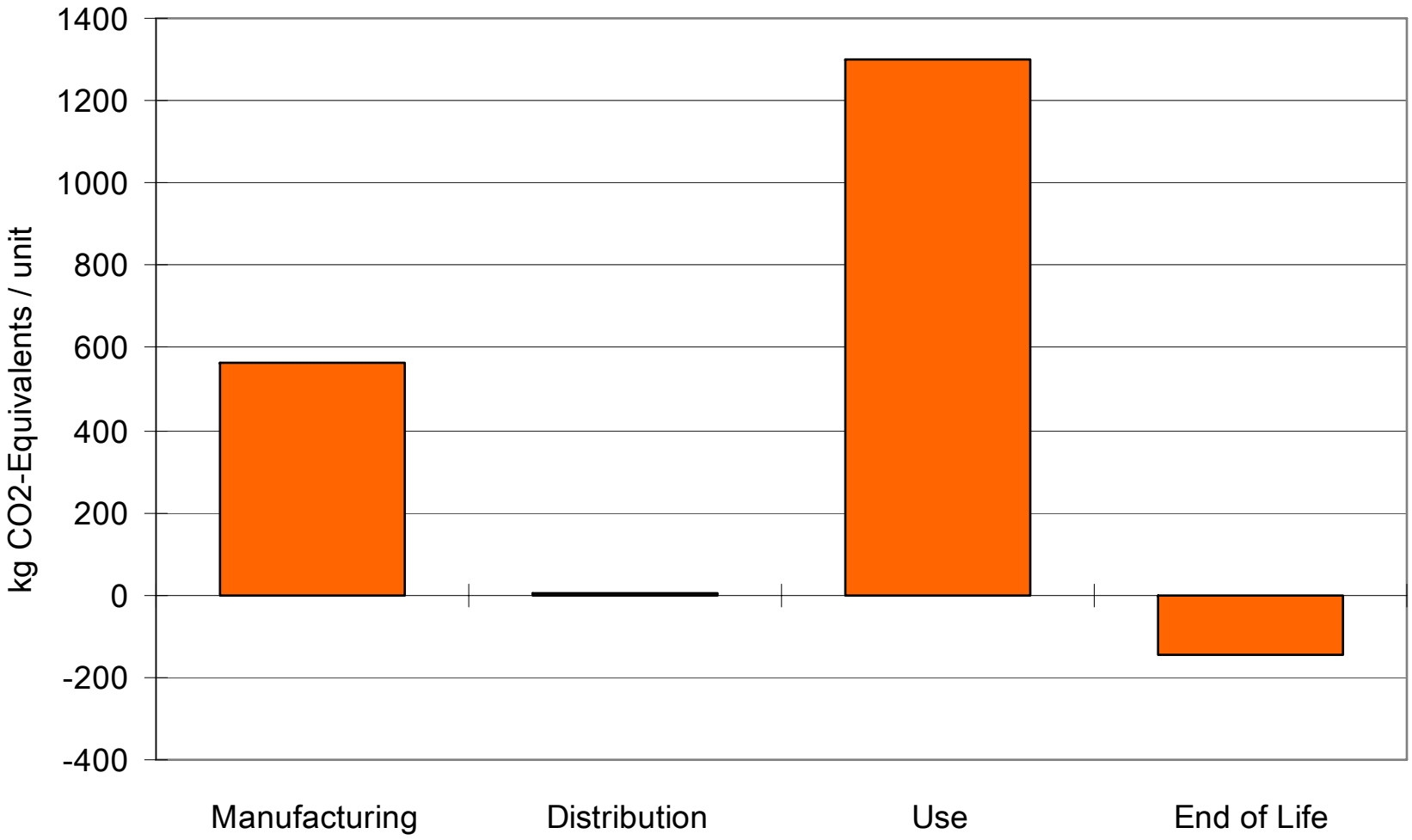
The Life Cycle's Cumulative Energy Demand

Example: 81 Mio desktop PCs produced in China in 2005

- **Production:** When these PCs are sold, they have already consumed **54'000 GWh** of energy
- **Use:** When they are used under average conditions, they consume **18'000 GWh/a**
- **End-of-Life:** Material recycling can theoretically save **20-25%** of the production energy, mainly by avoiding primary production of the metals recovered.

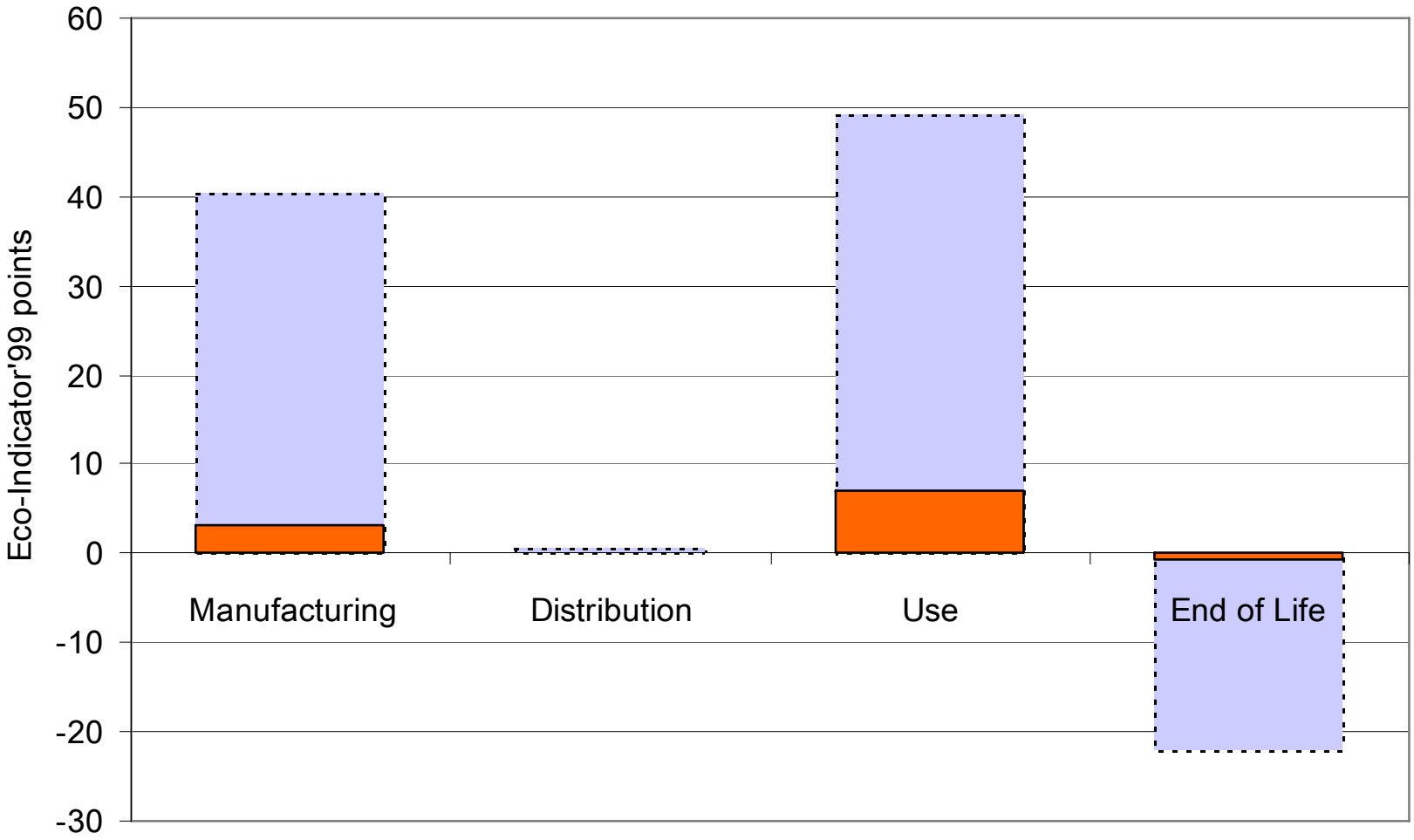
EMPA
Materials Science & Technology

The Life Cycle's Greenhouse Warming Potential



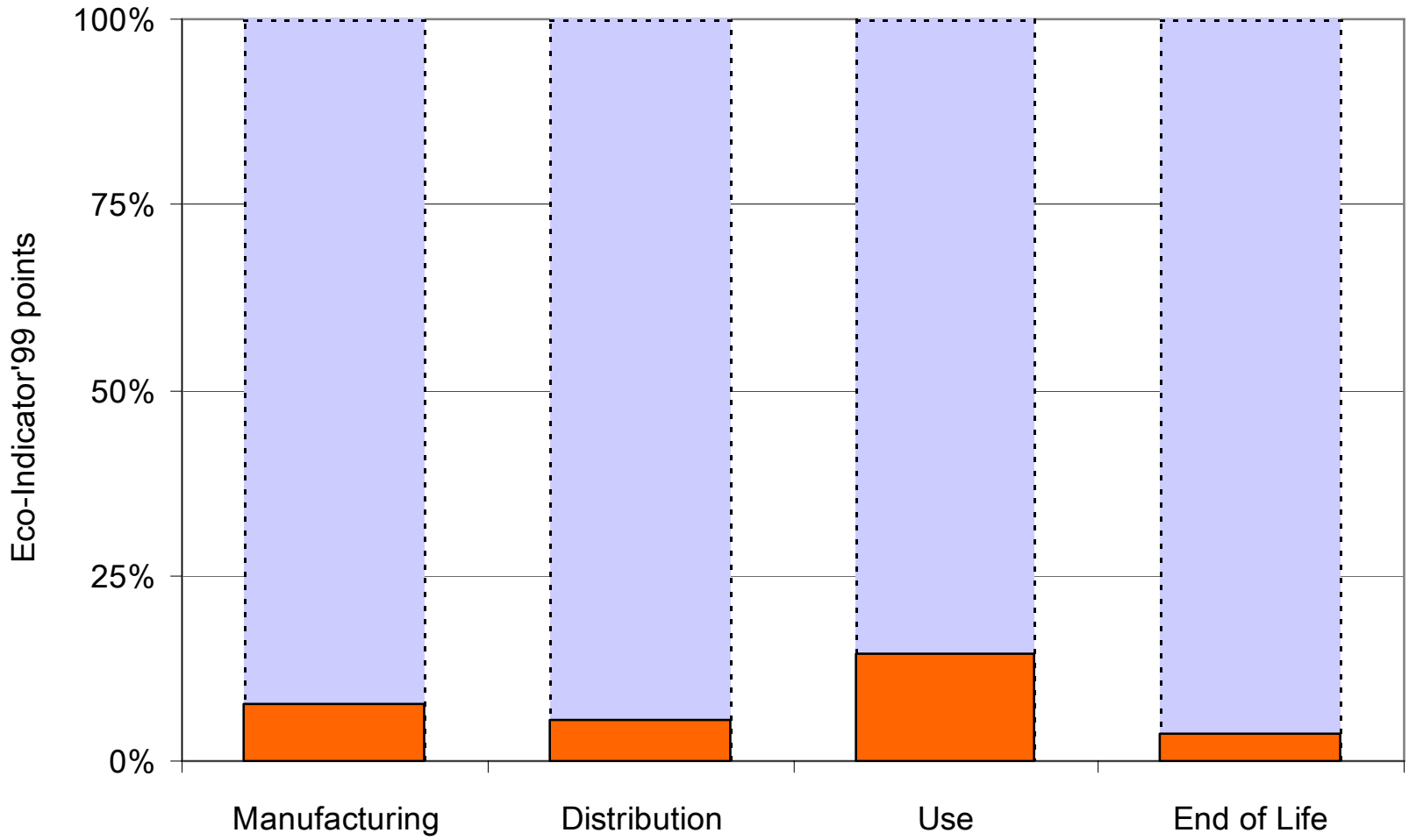
Materials Science & Technology

The Life Cycle's Greenhouse Warming Potential vs EIP-Total



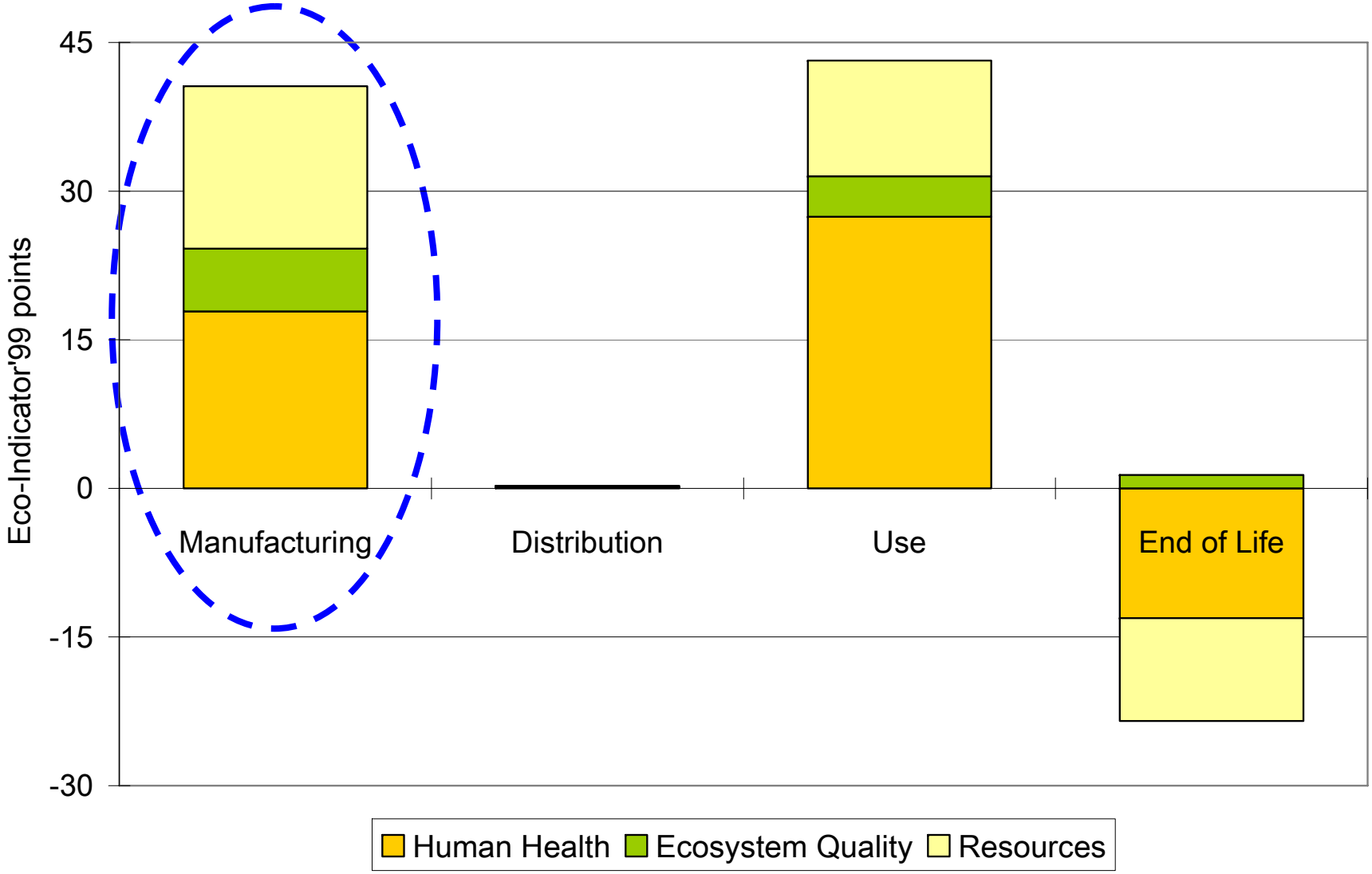
EMPA
Materials Science & Technology

The Life Cycle's Greenhouse Warming Potential vs EIP-Total

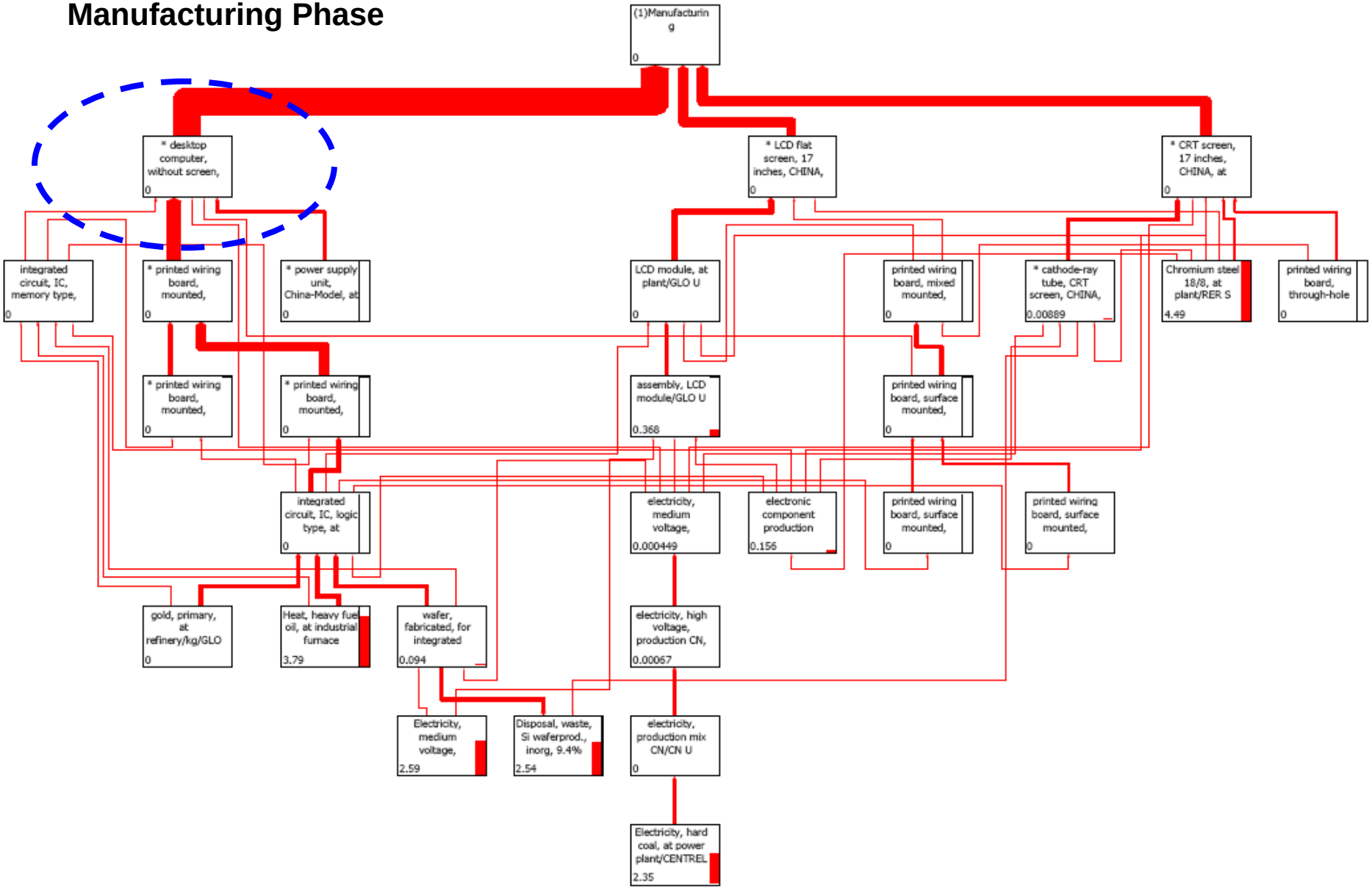


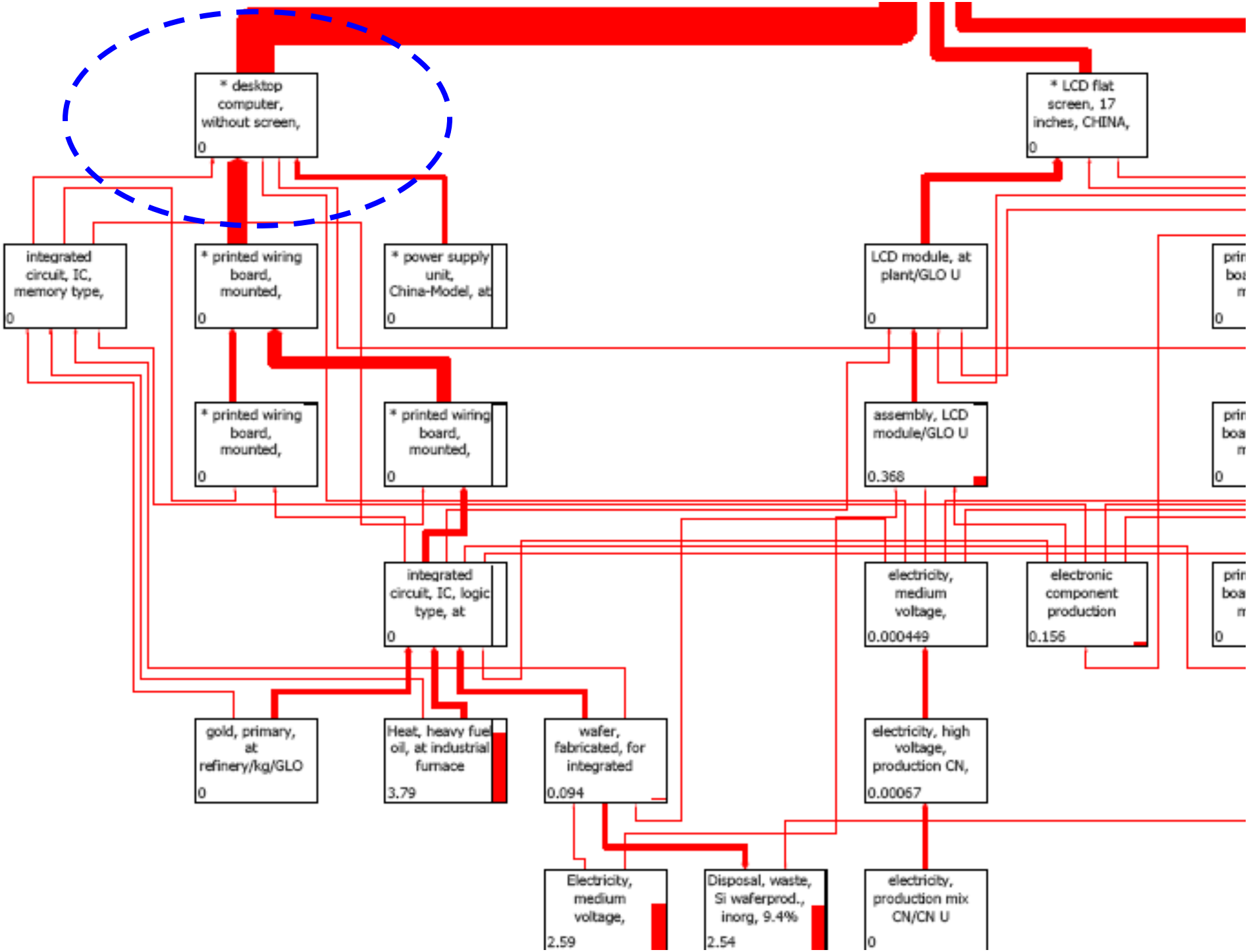
EMPA
Materials Science & Technology

The Life Cycle's Aggregated Environmental Impacts



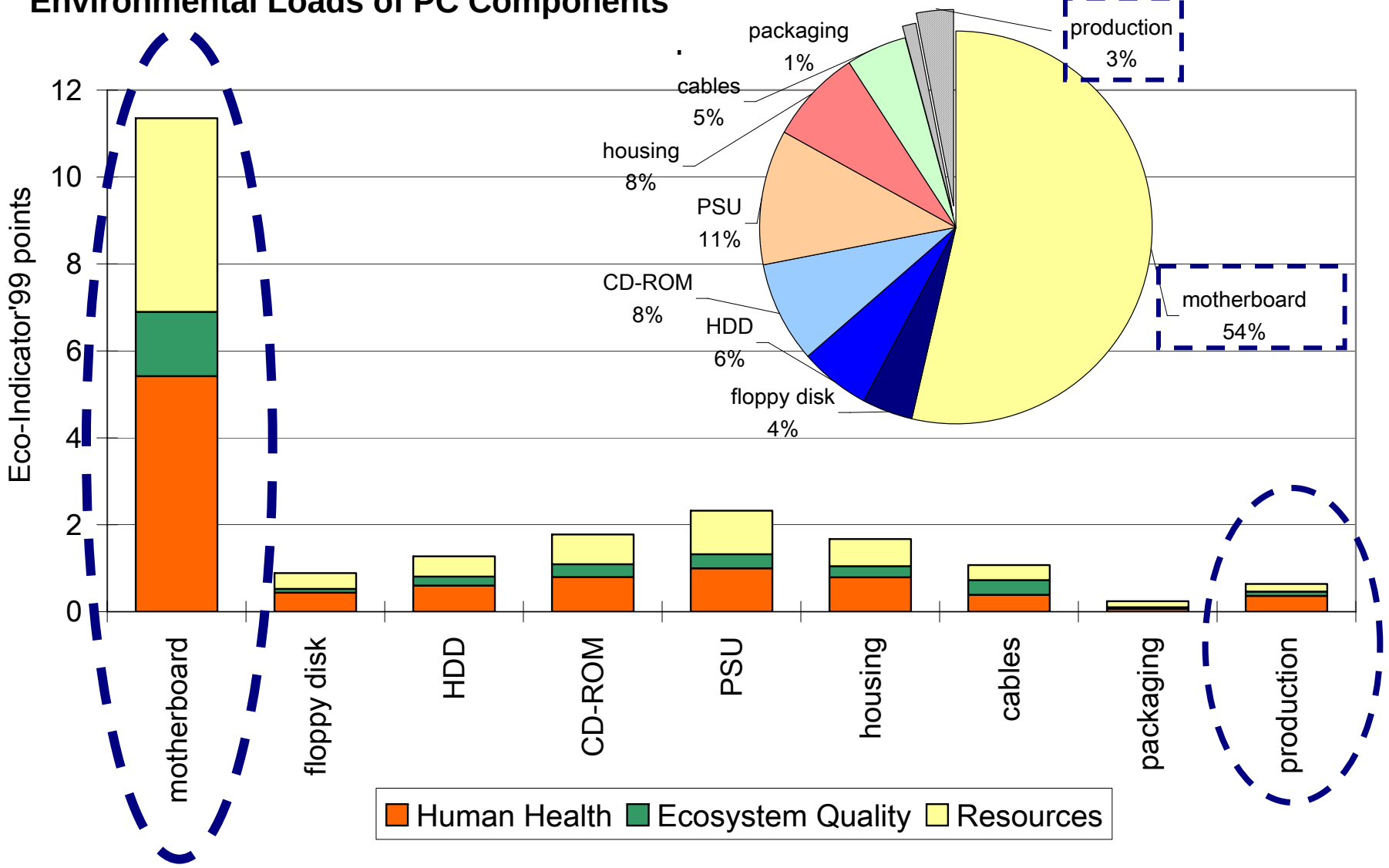
Manufacturing Phase




* desktop computer, without screen,
0
* LCD flat screen, 17 inches, CHINA,
0
integrated circuit, IC, memory type,
0
* printed wiring board, mounted,
0
* power supply unit, China-Model, at
0
LCD module, at plant/GLO U
0
* printed wiring board, mounted,
0
* printed wiring board, mounted,
0
assembly, LCD module/GLO U
0.368
integrated circuit, IC, logic type, at
0
electricity, medium voltage,
0.000449
electronic component production
0.156
gold, primary, at refinery/kg/GLO
0
Heat, heavy fuel oil, at industrial furnace
3.79
wafer, fabricated, for integrated
0.094
electricity, high voltage, production CN,
0.00067
Electricity, medium voltage,
2.59
Disposal, waste, Si waferprod., inorg, 9.4%
2.54
electricity, production mix CN/CN U
0

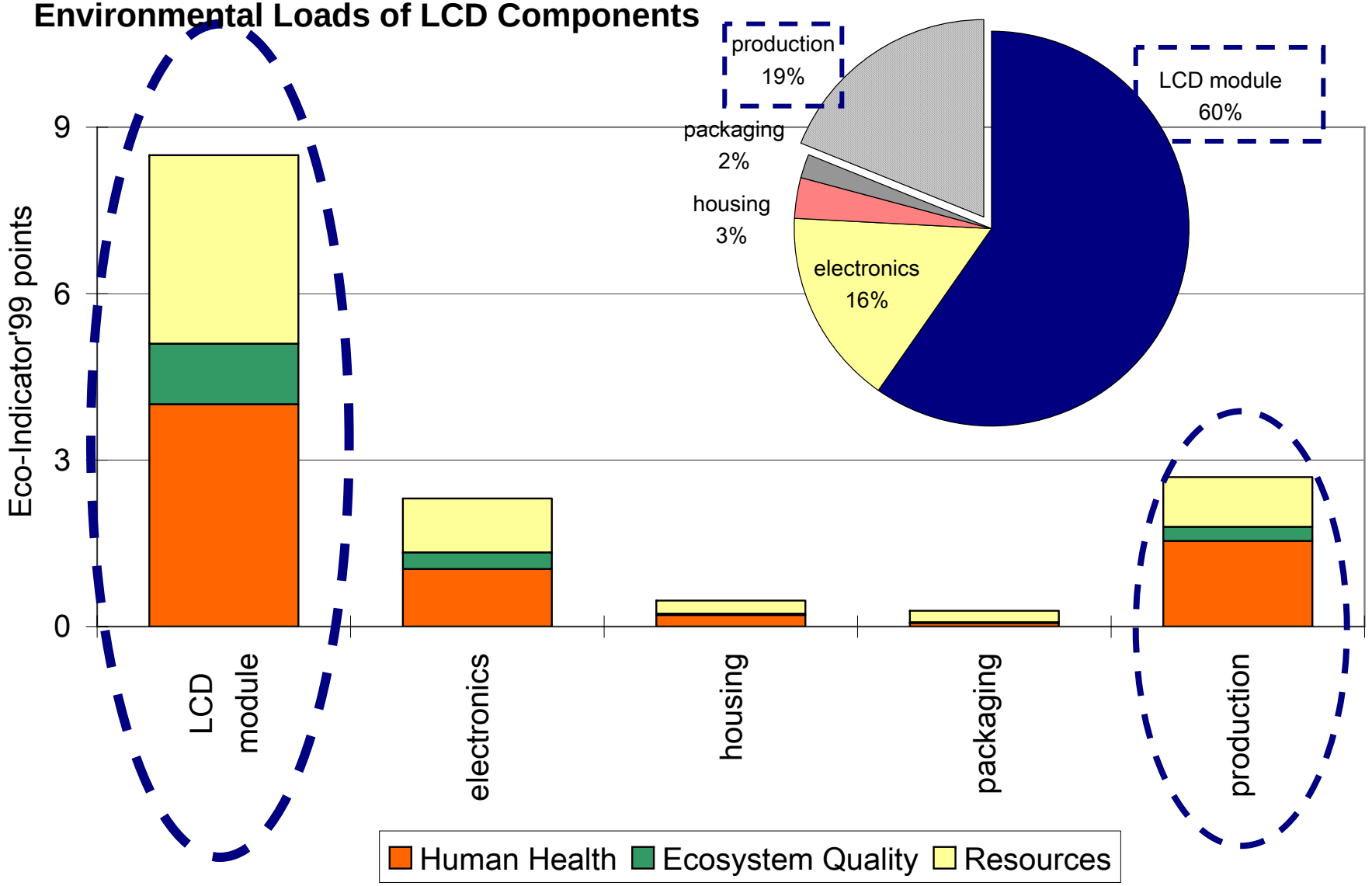
EMPA
Materials Science & Technology

Environmental Loads of PC Components



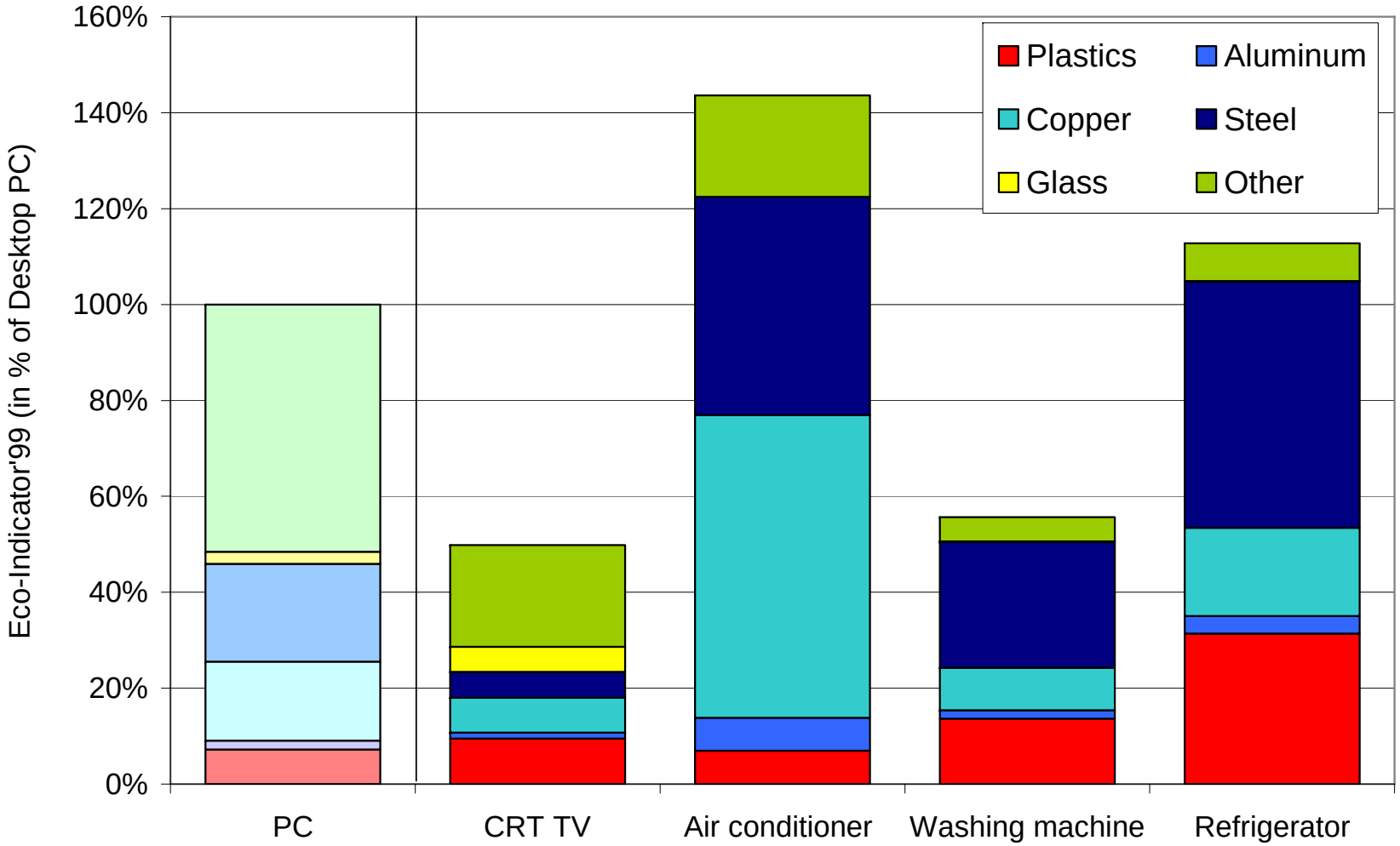
EMPA
Materials Science & Technology

Environmental Loads of LCD Components



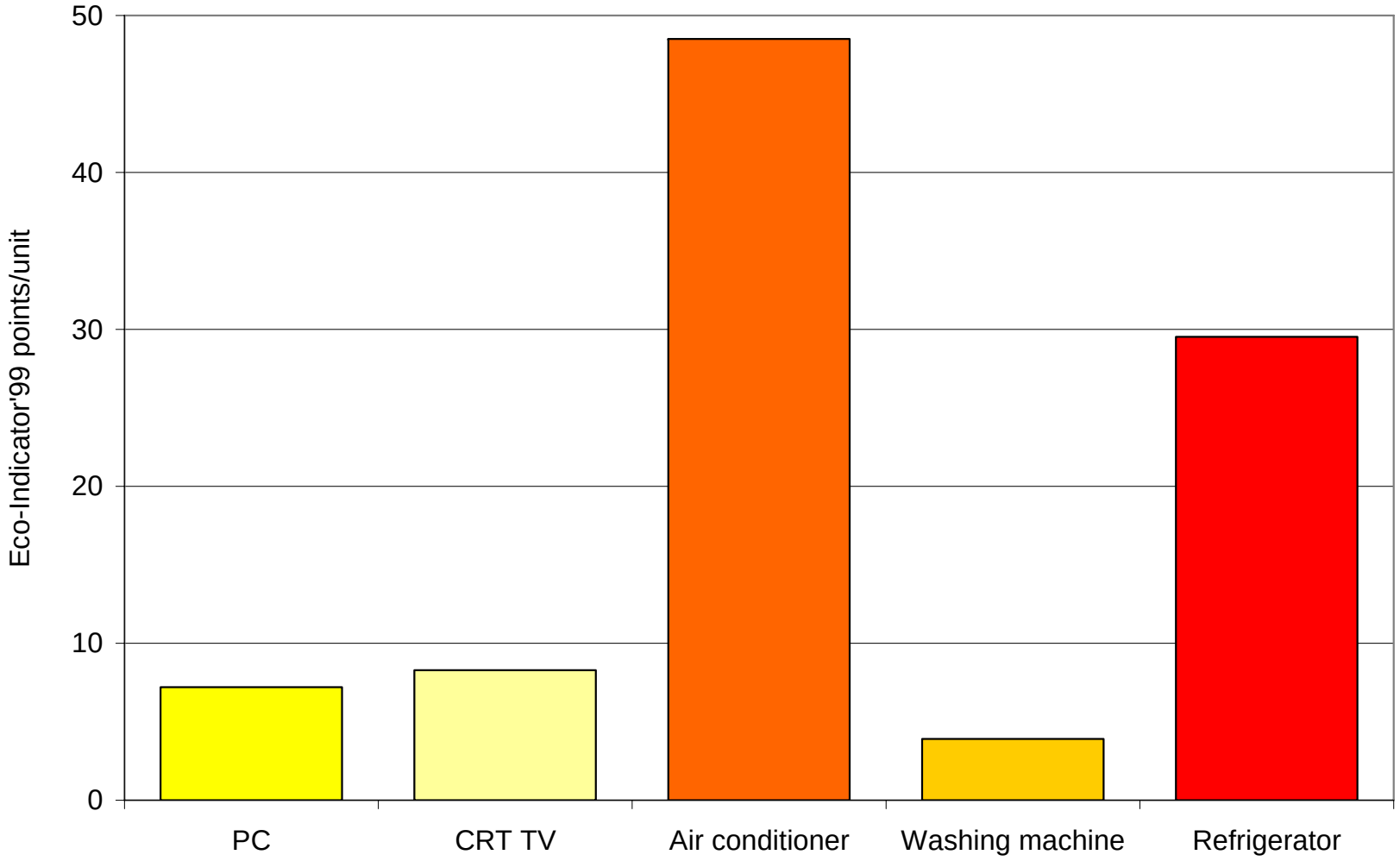
EMPA
Materials Science & Technology

Environmental Loads of other Devices



EMPA
Materials Science & Technology

Environmental Impacts of other Devices in the Use Phase



EMPA

Materials Science & Technology

A Conceptual Framework

LCA of Desktop PC Systems

e-Waste – the Key Problem

Findings and Conclusions

EMPA
Materials Science & Technology

e-Waste Categories

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7. Toys, leisure and sports equipment
8. Medical devices (with the exception of all implanted and infected products)
9. Monitoring and control instruments
10. Automatic dispensers

Source: EU WEEE Directive. (2003)

Materials Science & Technology

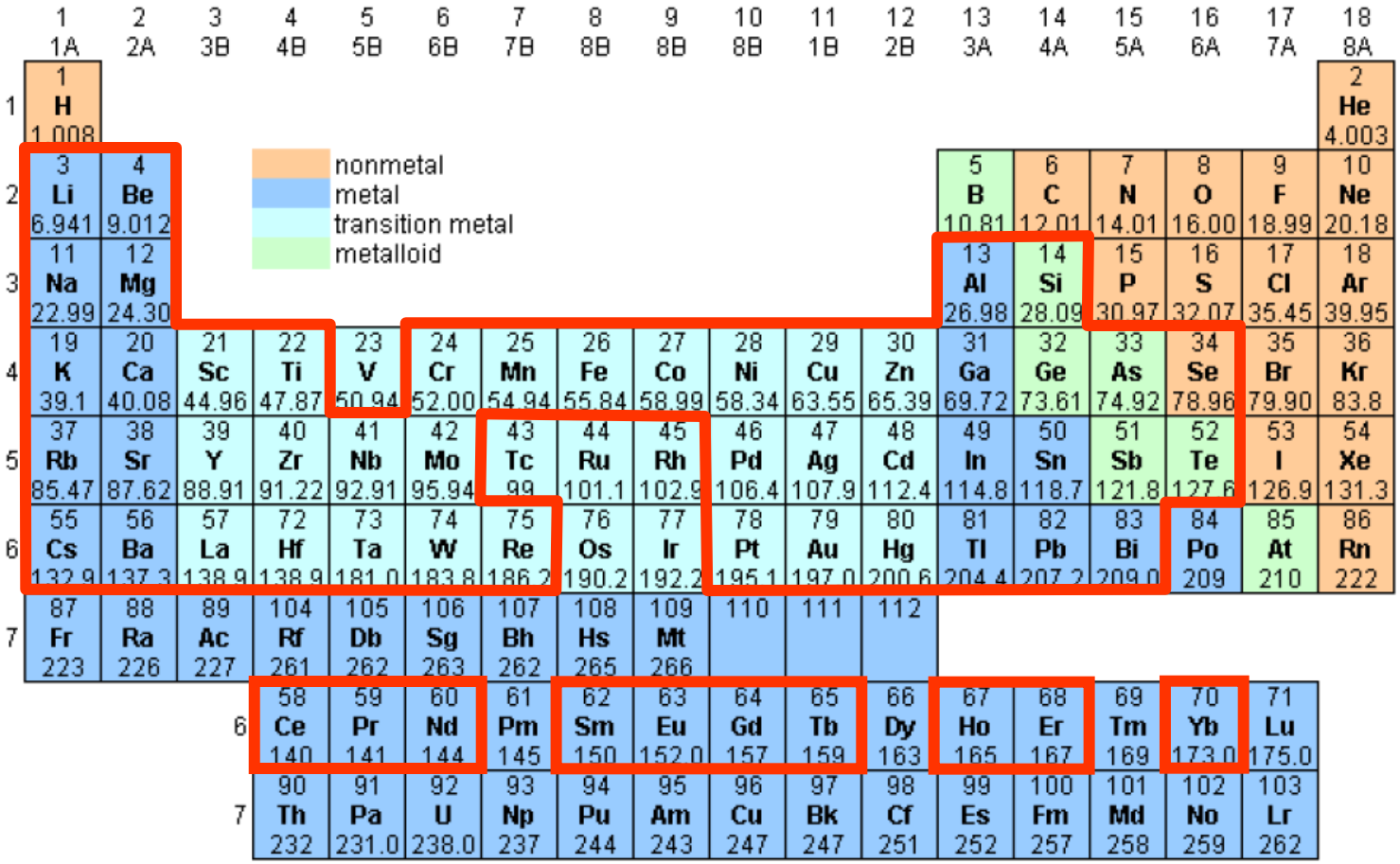
e-Waste Categories

1994: ~ 20 Millionen PCs obsolete
2004: ~ 100 Millionen PCs obsolete
180 Millionen PCs sold

1. Large household appliances
2. Small household appliances
3. **IT and telecommunications equipment**
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7. Toys, leisure and sports equipment
8. Medical devices (with the exception of all implanted and infected products)
9. Monitoring and control instruments
10. Automatic dispensers

EMPA
Materials Science & Technology

Elements Used in Electronics



Source: Behrendt et al. (2007)

57 elements

EMPA
Materials Science & Technology

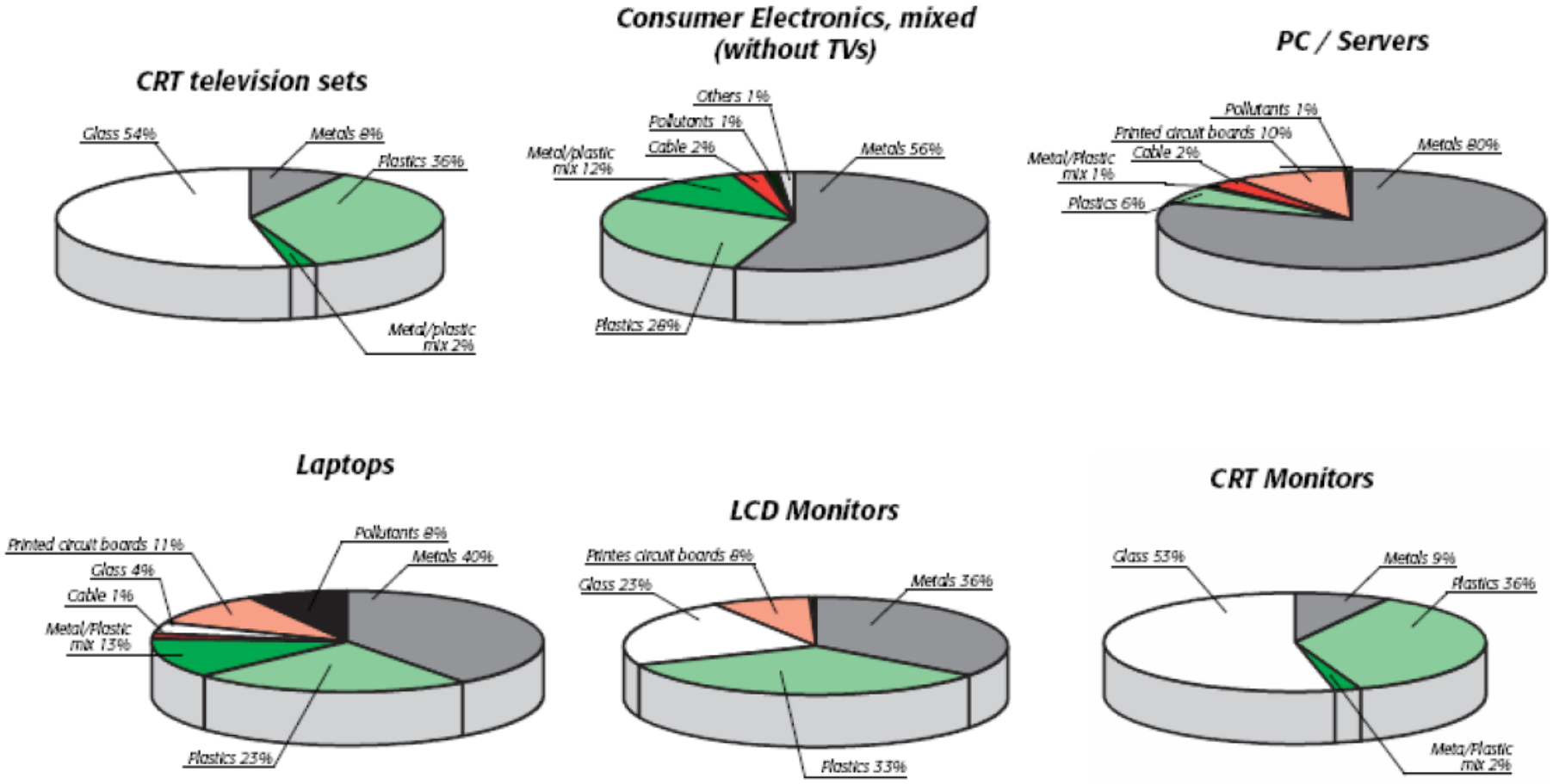
Composition of e-Waste (WEEE)

Ferrous Metals	39.1 %
Non-Fe Metals (Aluminium, Copper, Silver, Gold…)	21.0 %
Plastics	14.2 %
CRT Glass	13.4 %
Mixed Materials with Plastics	5.8 %
Cables	2.2 %
Printed Circuit Boards	1.9 %
Others	1.6 %
Hazardous Fractions	0.8 %

Source: Empa

Materials Science & Technology

Composition of e-Waste (WEEE)



Source: Empa

EMPA
Materials Science & Technology

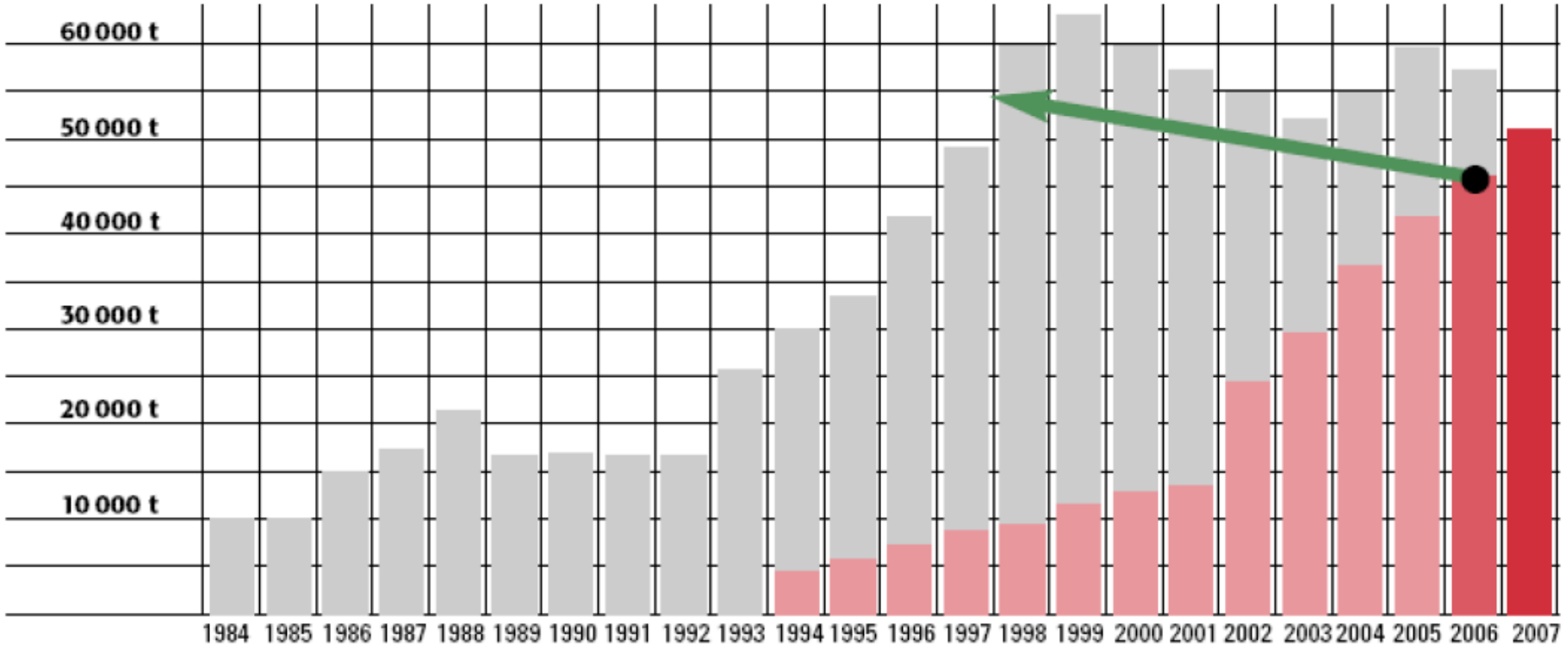
e-Waste in Switzerland (Electronics)

	Quantity	Average weight in kg	Metals in t	Plastics in t	Metal-plastic mix in t	Cable in t	Glass in t	Printed circuit boards in t	Pollutants in t	Others in t	Total in t	%
CRT television sets	247000	29,86	592	2690	161	8	3925		7		7383	16,0
CE, other equipment	798000	4,34	1909	989	408	80		17	42	23	3468	7,5
CRT Monitors	581000	15,87	726	3292	194	10	4804		8		9034	19,6
LCD Monitors	79000	5,72	160	151			102	38	2		453	1,0
PC / servers	419000	13,39	4517	325	29	179		530	31		5611	12,2
Laptops	54000	3,51	77	44	24	3	7	21	15		191	0,4
Printers	615000	11,70	4355	2078	380	49	86	230	15	5	7198	15,7
Large-scale copiers	23700	90,96	1888	154		35	19	51		9	2156	4,7
Other equipments			5785	3007	1232	241	6	54	127	54	10506	22,9
Total			20009	12730	2428	605	8949	941	247	91	46000	
Total in %			43,5	27,7	5,5	1,3	19,4	2,0	0,6	0,2		

Source: Swico (2007)

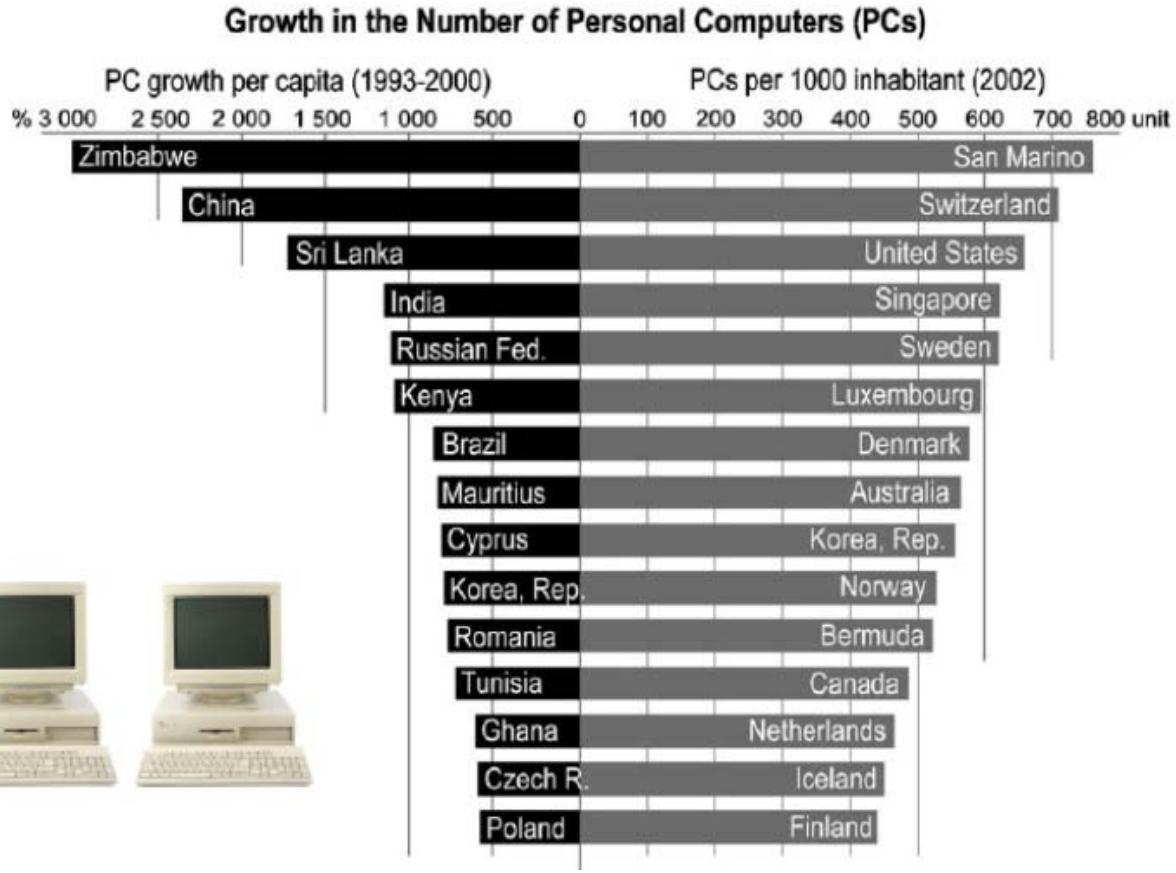
Materials Science & Technology

Imports and e-Waste Generation in Switzerland



Source: Swico (2007)

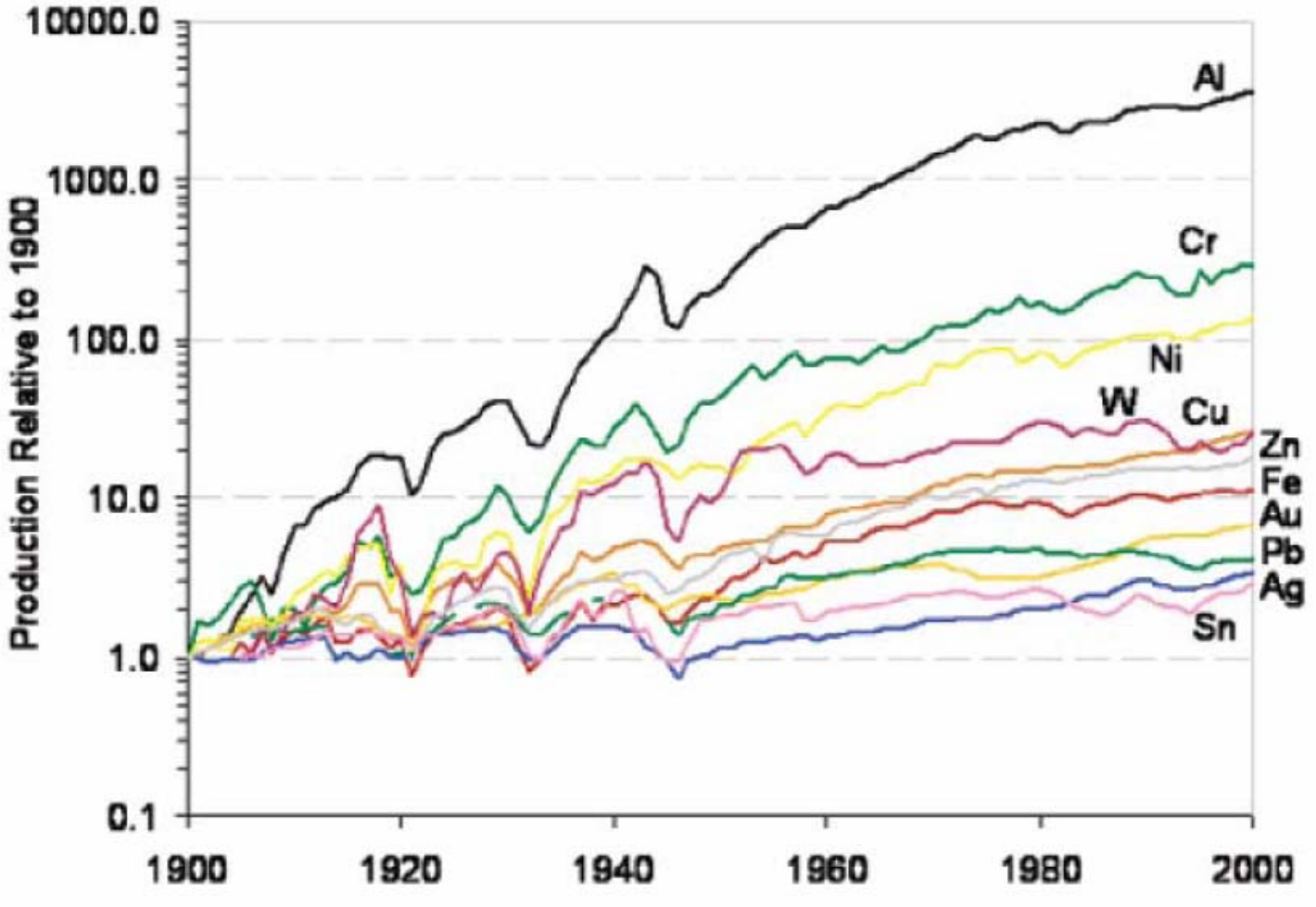
Growth and Saturation



Source: World Bank (2004)

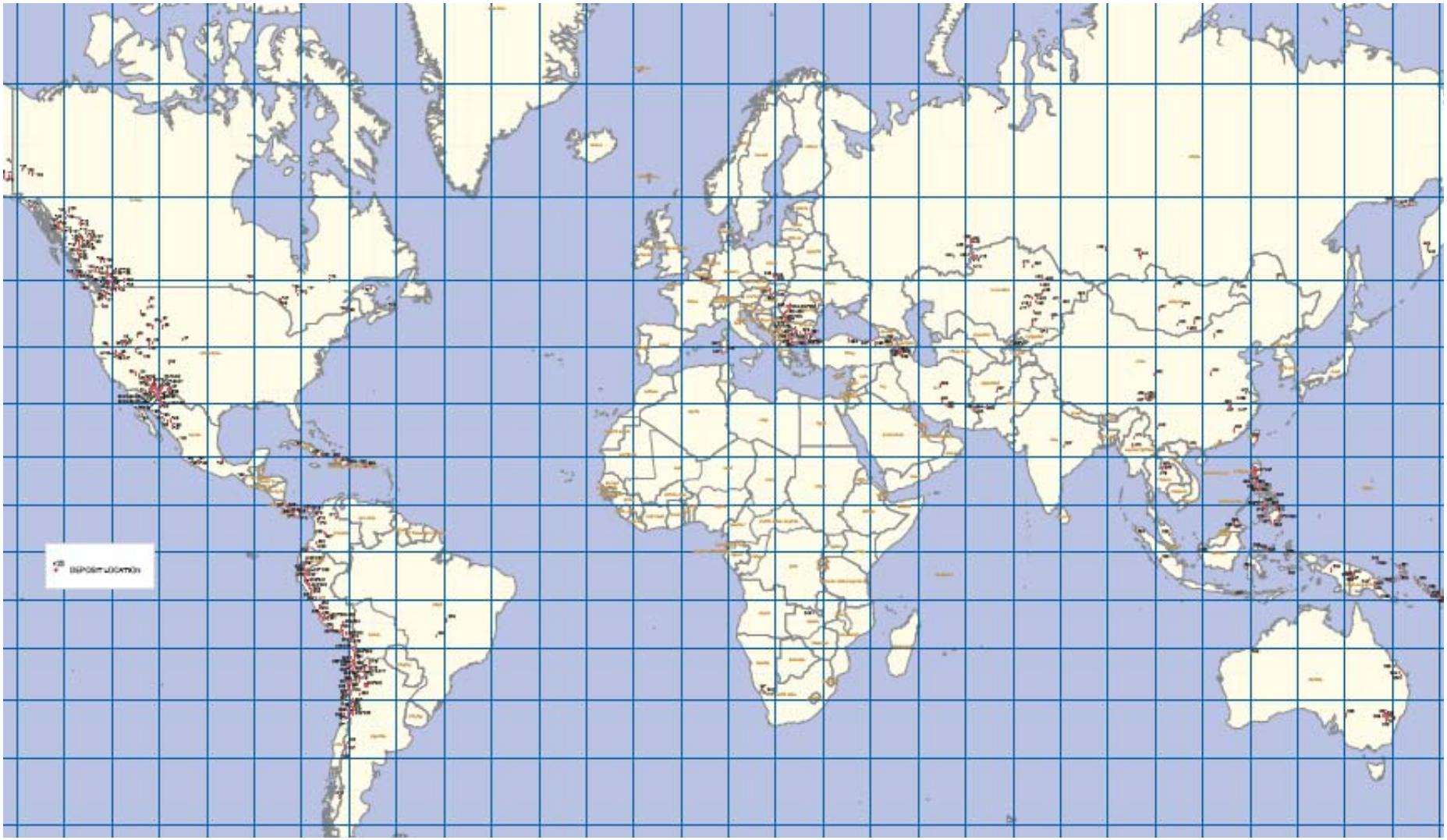
EMPA
Materials Science & Technology

Metals Production since 1900

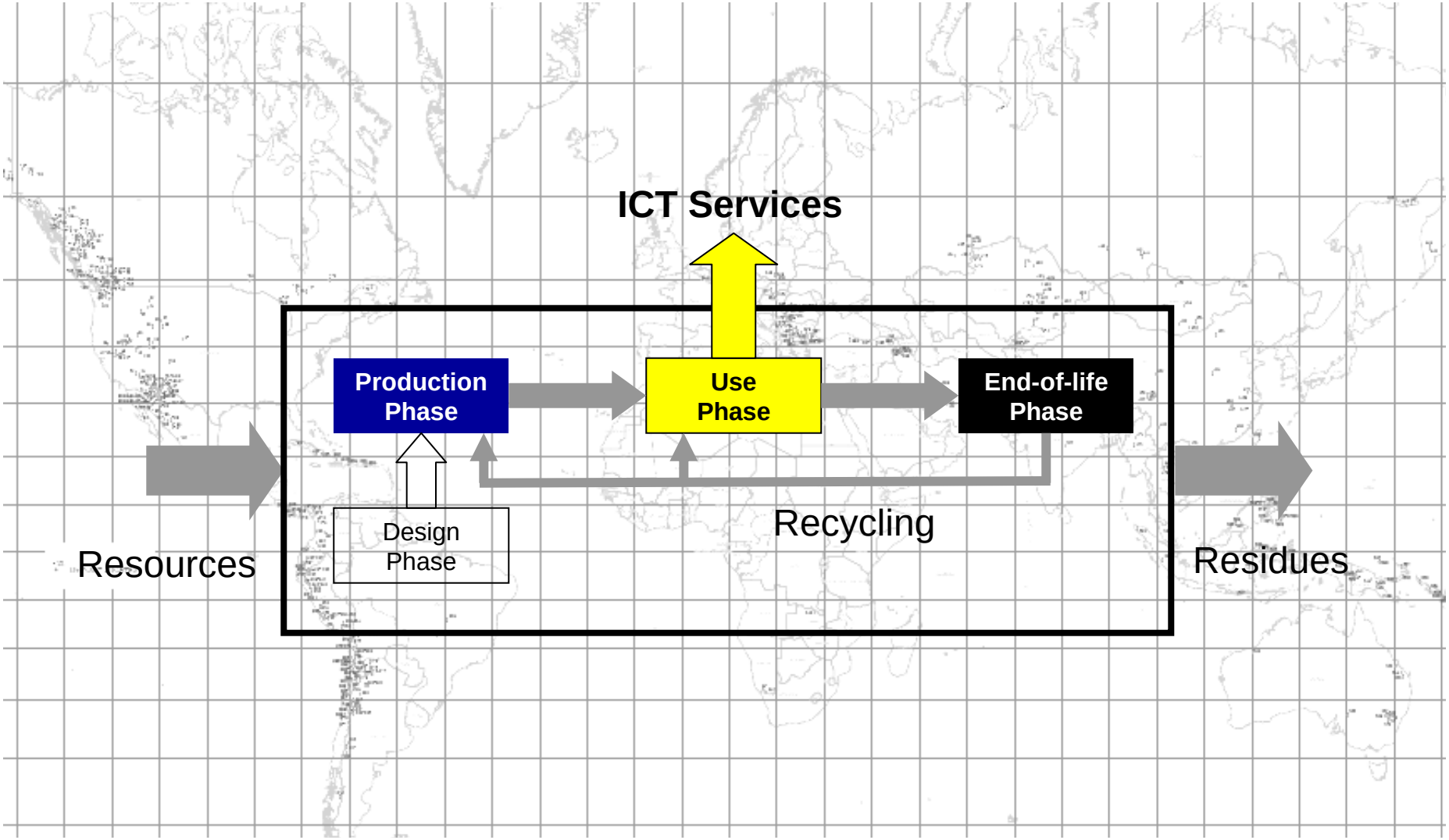


Source: Johnson et al. (2007)

World‘s Copper Deposits



Source: Singer et al. (2002)


ICT Services
Production Phase
Use Phase
End-of-life Phase
Design Phase
Recycling
Resources
Residues

e-Waste Recycling

e-Waste is valuable ...

Component reuse in China

Iron

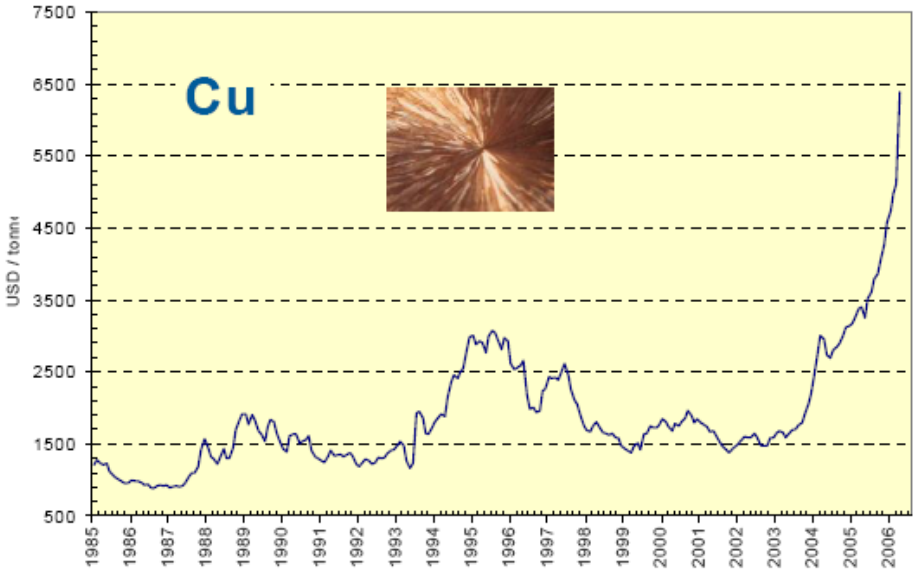
e-Waste is valuable ...

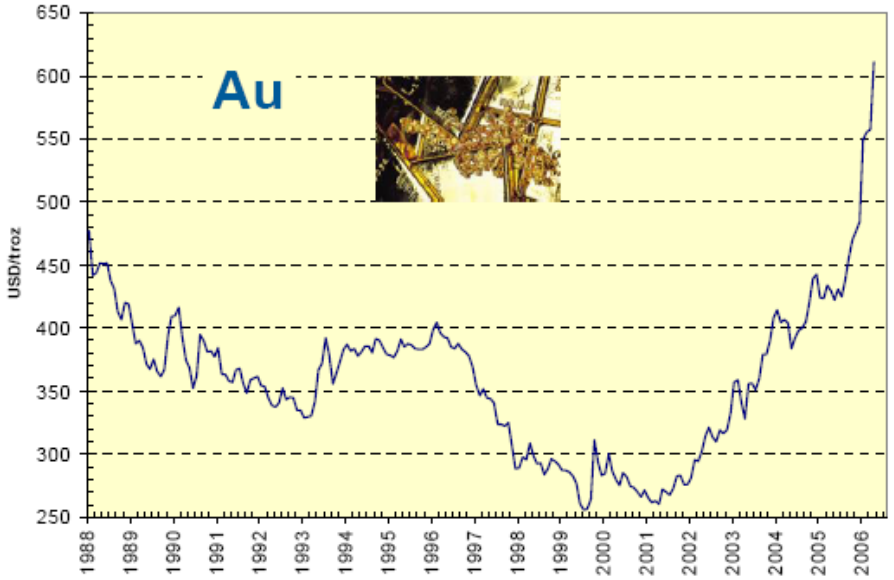
Copper sludge

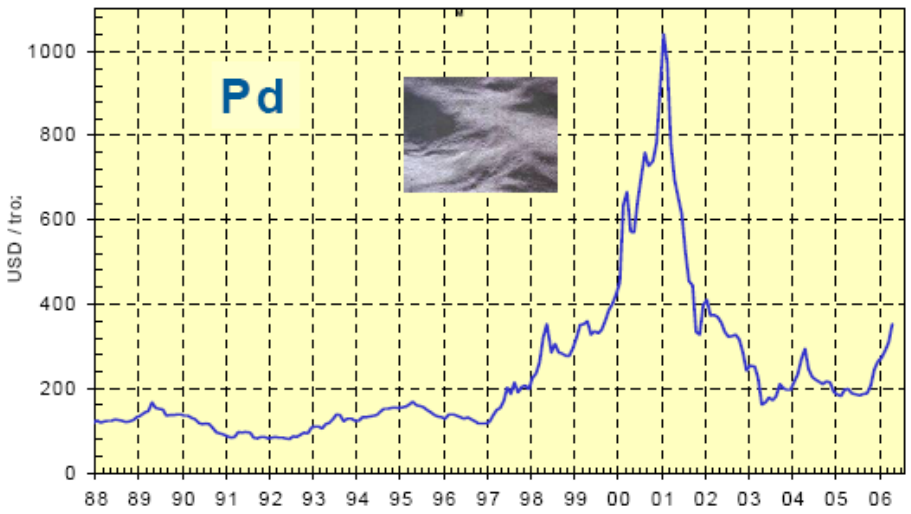
Precious Metals

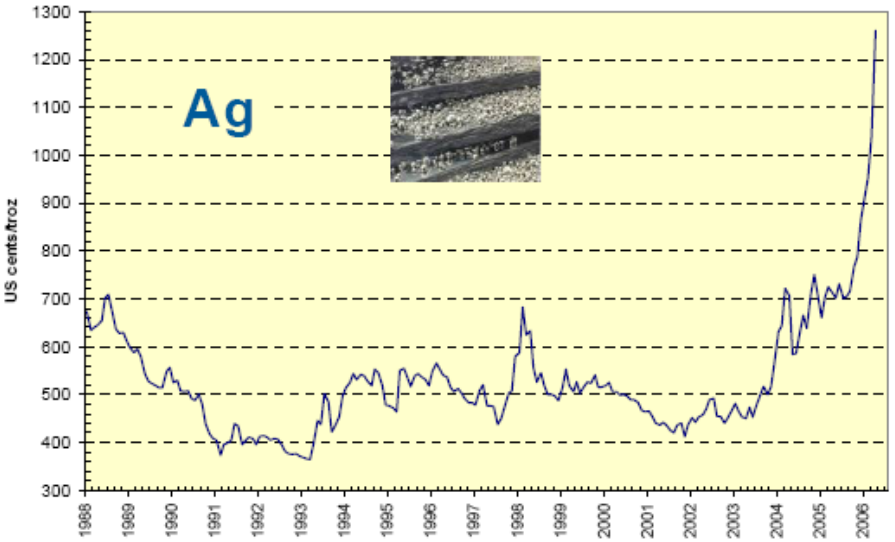
EMPA

Materials Science & Technology









... creates employment ...

Plastic sorting

Disassembling of devices / components

... can be dangerous …

Sorting of valuable fractions from burning residues

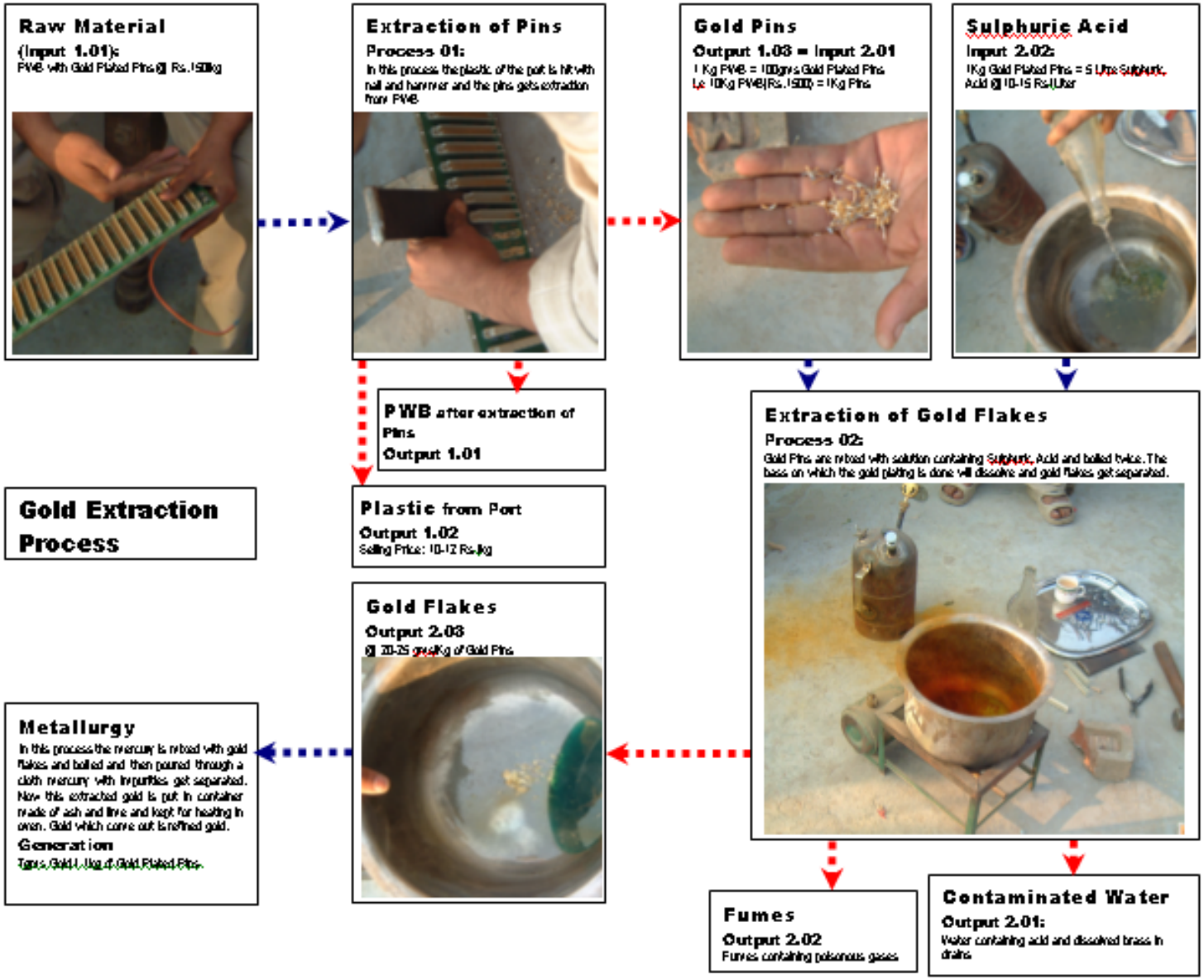
De-soldering of components from printed circuit boards

... and is polluting.

Water pollution

Emission to air

Informal e-Waste Recycling: Gold Extraction Process



A Conceptual Framework
LCA of Desktop PC Systems
e-Waste – the Key Problem

Findings and Conclusions

Findings

- ‘Desktop PC Production’ to ‘1 year of use’ is ~ 3:1 for energy and ~ 6:1 for aggregated environmental impacts.
- Recycling of e-waste clearly pays off in environmental terms due to the metals recovered, saving energy otherwise used for their primary production.
- There are substantial concerns regarding health and safety risks in informal recycling and recovery processes.
- The ICT life cycle problems are global, but developing and emerging economies are particularly affected since
  - e-waste volumes are growing on rapid pace,
  - often large e-waste quantities are imported,
  - there are generally many low skilled and cheap labor forces and,
  - rules and regulations are not clear or poorly implemented.

Conclusions

- Energy efficiency in the production and use phase should be improved in order to reduce the overall ecological footprint of electronics. Nevertheless, the type of energy used is also crucial and may be more relevant with regard to the overall environmental impacts.
- Recycling the metals contained in electronic waste can contribute to the reduction of the overall environmental impacts because the primary production of these metals is avoided. But uncontrolled, critical processes should be phased out.
- The dissipation of scarce metals contained in electronic products will become a much greater problem in the long run than the energy consumed over the whole life cycle.

Conclusions

- As a consequence, the antroposhere will become a more and more important source of material resources. Cities will be the mines in the future.
- However, globally, the collected e-waste quantities are still on a low level and there are large efficiency losses.
- For avoiding unsound e-waste treatment practices, the e-waste flows must be monitored and the processes controlled.
- Reducing the ICTs environmental impacts requires a global multi-stakeholder problem solving process including the producers, importers, consumers / NGOs, recyclers and the government.

EMPA
Materials Science & Technology

Thank you!

Martin Eugster
Sustainable Technology Cooperation (sustec)

TSL - Technology & Society Lab
Empa - Materials Science & Technology
Lerchenfeldstrasse 5
CH-9014 St. Gallen

phone +41 71 274 78 55
mobile +41 79 691 38 00

skype eugster
martin.eugster@empa.ch
www.empa.ch - www.empa.ch/sustec - www.e-wasteguide.info