Resource Efficiency

Dr. Bernd Kopacek, MSc.

Educational Background

1987-1993	Diploma-Study “Mechanical Engineering“ at Vienna University of Technology
1995/1996	Postgraduate Study “Master of Science in Engineering Management“ at Oakland University in Rochester, Michigan, USA in cooperation with Vienna University of Technology
1994-1999	PhD-Study at Vienna University of Technology

First Step in professional career

BIT - Bureau for International Research and Technology Cooperation
(public consultancy for research and innovation):

06.1996-12.1997 Head of Unit "Industrial Technologies"
Responsible for the EU-Programmes "Industrial and Material Technologies", "Transport", CRAFT (special funding programme for SME) and EUREKA
Consultancy and Support during Proposal preparation of hundreds of Austrian companies and research organisations in Brussels

01.1994-06.1996 CRAFT – Project Manager
Responsible for the Austrian Small and Medium Enterprises
- EU-Expert for "Automation" within the „CRAFT Stimulation Action" of DG Research, 1996-1998
- Coordinator of the „Multinational Stimulation Action" of the European Commission and the Austrian Federal Ministry for Economic Affairs 1997/98

R&D in electronics & environment

Austrian Society for Systems Engineering and Automation (non-profit):

09.1997- Vice-President and Managing Director

Building up a research organisation from scratch, international Positioning on top of environmental research for the electronics industry, more than 60 members (e.g. **Alcatel, Apple, Electrolux, Fujitsu, HP, IBM, Lenovo, Mitsubishi, Motorola, Nokia, Panasonic, Philips, Siemens, Sony, Fraunhofer, …**)

- Chairperson of the Steering Board of the EUREKA umbrella project CARE Electronics and Manager of the „International CARE Electronics Office" in Vienna since 02.1998

-Project Coordinator of more than 10 EU projects and networks

- Chairman of the EUREKA/EU-Cluster projects-Group (MEDEA, EURIMUS, SCARE, PIDEA, ITEA, EUROFOREST, FACTORY – total funding volume for research 6 billion Euro) 2000-2003

- Member of the Board of the "Austrian Center of Excellence for Electronics and the Environment" in Vienna 2001/2002

- Project Coordinator of the Strategic EUREKA/EU-Project „Strategic CARE project SCARE" 1999-2005

Entrepreneurial activities

05.2005-12.2006 **EARN Elektroaltgeräte Service GmbH**
Founder and Managing Director

02.2002-08.2006 **Ecotronics Eco-efficient Electronics and Services GmbH**
(since 12.2005 **STENA Technoworld GmbH**)

05.2000-08.2006 **ReUse Elektron(nik)produkte und –bauteileverwertung GmbH** (since 02.2002 100% daughter of Ecotronics/STENA Technoworld)
Founder and Managing Partner

Entrepreneurial activities

04.1999- **ISL - Innovative System Solutions** (consultancy)
Managing Partner

08.2007- **Greentronics Srl** (electronics recycling and re-use)
Partner

10.2007- **IFC International Finance Corporation** (Worldbank group)
Business Development Consultant for the Recycling Linkage Program in South-East-Europe and India

Agenda

April 11	**Background and Motivation**
April 12	**Understanding Eco-efficiency** **Exploring Eco-efficiency** **Implementing Eco-efficiency**
April 13	**Environmental Impacts of electronic products** **Exam**

Grading

Exclusively based on results from open-book Exam!

No influence of

- **Participation/Involvement during the lecture**
- **Project Presentation**

Background and Motivation

Which resources do you think of?

- **Minerals / Materials**
- **Energy**
- **Water**
- **Food**
- **Land**
- **Air**
- **People**
- **….**

Increased consumption

- The World Bank has projected that **demand for food will rise by 50% by 2030, and for meat by 85% by the same year**;
- The reference scenario in the International Energy Agency's 2009 World Energy Outlook projects a **rise in oil demand of 1% a year between now and 2030** (from 85 million barrels a day now to 105 mb/d in 2030, with all of the growth in demand from non-OECD sources) and
- UNESCO projects that total **global water use will rise by 32% between 2000 and 2025**, while UNDP notes that global water use has been growing nearly twice as fast as population for over a century, and will continue to do so.

Why?

Median projections of global population growth suggest a rise **from 6.9 billion today to around 9.1 billion in 2050, an increase of 32%.** While the global rate of growth has slowed significantly since its peak in 1963, much of the growth projected between now and 2050 will be in low income countries, including many – such as Pakistan, Nigeria, Bangladesh, the Democratic Republic of the Congo, Ethiopia and Kenya – that are politically fragile, regionally significant, or both.

Why?

- Increasing demand for resources also derives from more affluent consumers, primarily in OECD countries, but increasingly also in **emerging economies such as China, Brazil and India**.
- Particularly important in the natural resource scarcity context is **rising demand in developed and emerging economies for energy** (including biofuels – which effectively create an arbitrage relationship between food and fuel), and **diets rich in meat and dairy products** (which tend to be proportionately more resource-intensive than other diets).

How does the supply develop?

On food, the yield increases of the 20th century 'Green Revolution' have shown diminishing returns in recent years: average productivity growth rates of 2.0% between 1970 and 1990 fell to **1.1% between 1990 and 2007 and are projected to continue to decline, and global food consumption outstripped production in seven of the eight years between 2000 and 2008.**

How does the supply develop?

The food outlook is further complicated by potential constraints on the availability of land. While the Food and Agricultural Organization and the UN Environment Programme have suggested that 12% more arable land is available globally, they also estimate that 16% of the arable land used now is degraded. Intensifying competition between different land uses is likely to emerge in future, including food crops; livestock (both pastureland for grazing and arable land to produce feedstock); biofuels; fibre (such as paper and timber); conservation; carbon sequestration; and the world’s expanding cities.

How does the supply develop?

Current rates of water extraction from rivers, groundwater and other sources are already unsustainable in many parts of the world. **1.2 billion people live in water basins in which the physical scarcity of water is absolute; by 2025, the figure is projected to rise 50% to 1.8 billion, with up to two thirds of the world's population living in water-stressed conditions** (mainly in non-OECD countries).

While water scarcity will more often be a regional than a global issue, the concept of 'embedded' or 'virtual' water in crops that are then traded internationally means that water is in effect also traded (1kg of wheat effectively 'contains' the 900 litres of water required to produce it, for example).

How does the supply develop?

On oil, finally, the International Energy Agency has warned consistently that with investment in new oil production having fallen sharply as a result of the financial crisis and subsequent downturn, there is a significant risk of a new “supply crunch” as the global economy recovers. There is also an unresolved public debate over when global oil production is likely to peak: while some commentators insist that proven reserves are adequate to meet projected demand for decades, others (including the IEA’s chief economist) suggest that **peak production could take place by 2020**.

Climate change and its effects on resource scarcity

All of these potential limitations to supply growth are **before climate change** is considered, which is likely to be the most important long-term driver of change on all of the above sectors.

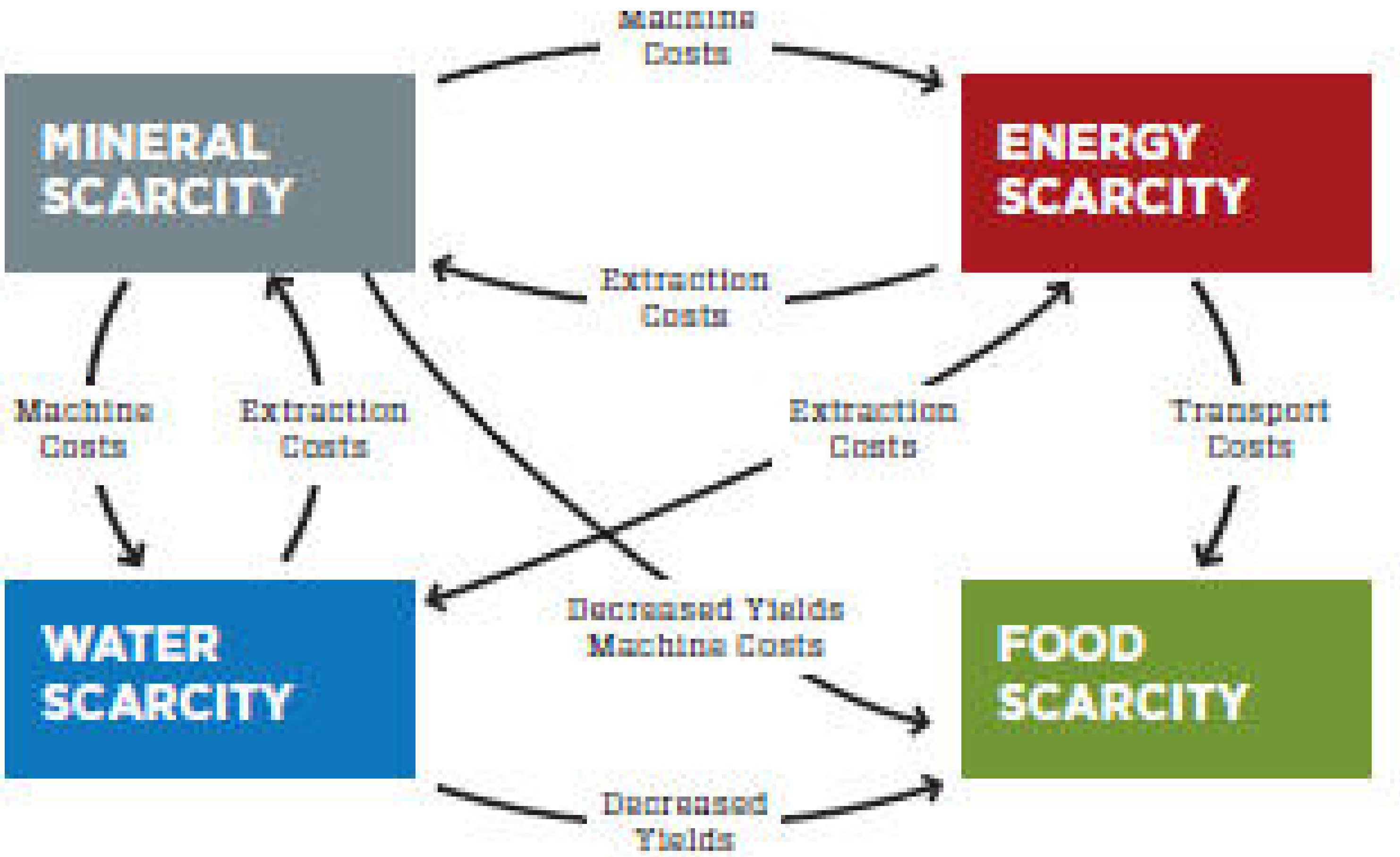
Climate change and its effects on resource scarcity

Since pre-industrial times, global average temperatures have increase by 0.7° Celsius, and **emissions already in the atmosphere mean that the world is committed to a further increase of 0.6° Celsius**. Overall, even stringent global mitigation action may not be enough to avoid a 2.0° Celsius increase on pre-industrial temperatures. Even if the 2009 Copenhagen summit had agreed that **global emissions would peak in 2015** and decline by 3% a year thereafter, this would still have left the world with an even chance of exceeding a 2° Celsius temperature increase. As it is, the summit's outcome appears **insufficient to prevent warming of 3° Celsius or more**.

Climate change and its effects on resource scarcity

Most of the key near-term impacts of climate change will result from **reduced freshwater availability**, which will expose hundreds of millions of people to additional water stress. **Decreased crop yields** (in all areas except mid and high latitudes, and in all areas above 2.0° Celsius), will also be particularly important, and will expose tens to hundreds of millions more people to the risk of hunger.

Do they interfere with each other?



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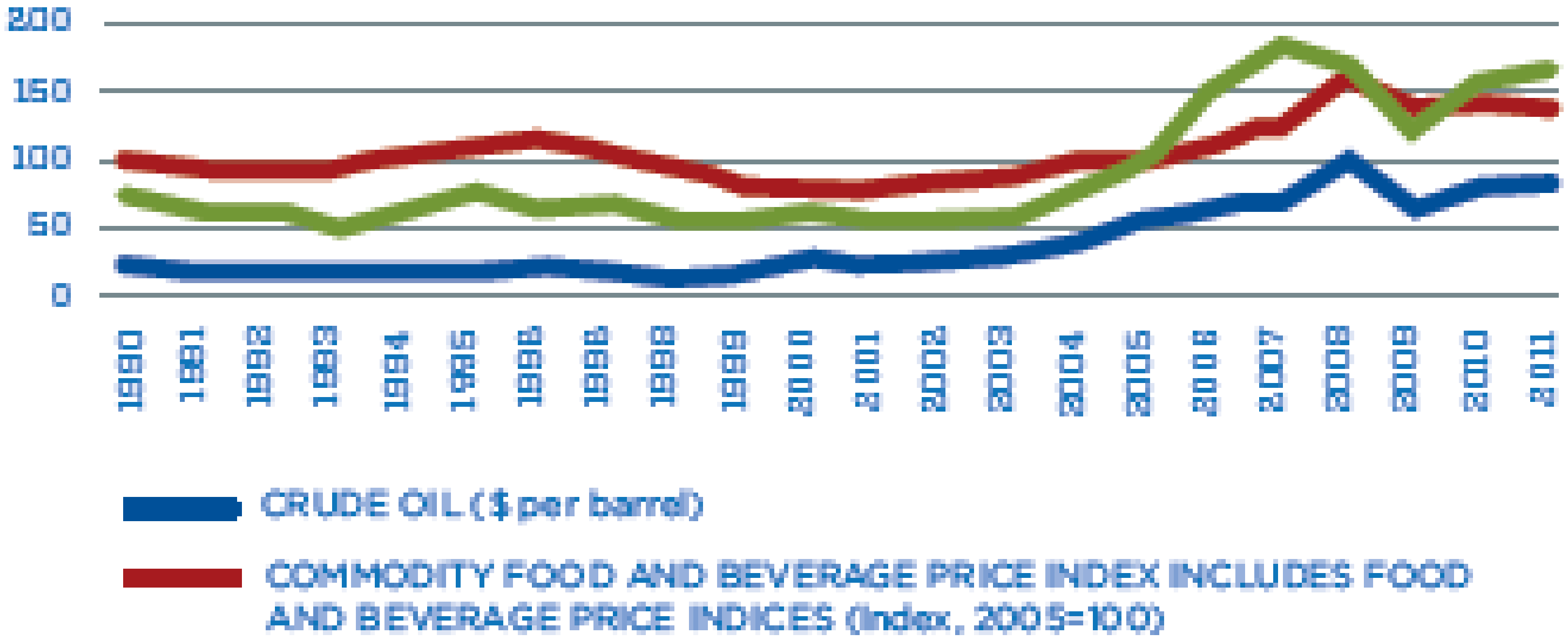
Food and Water

The agriculture sector is the largest consumer of water. According to the Food and Agriculture Organization of the United Nations , almost 70% of water drawn from rivers and groundwater is used for irrigation, and is projected to increase by 14% between 2000 and 2030 in order to meet future food demands.

Energy and Food

OIL, FOOD AND BEVERAGE, AND METAL PRICES



FIGUUR 2: WORLD COMMODITY PRICES 1980 - 2011. SOURCE: IMF DATA AND STATISTICS

Minerals and Energy

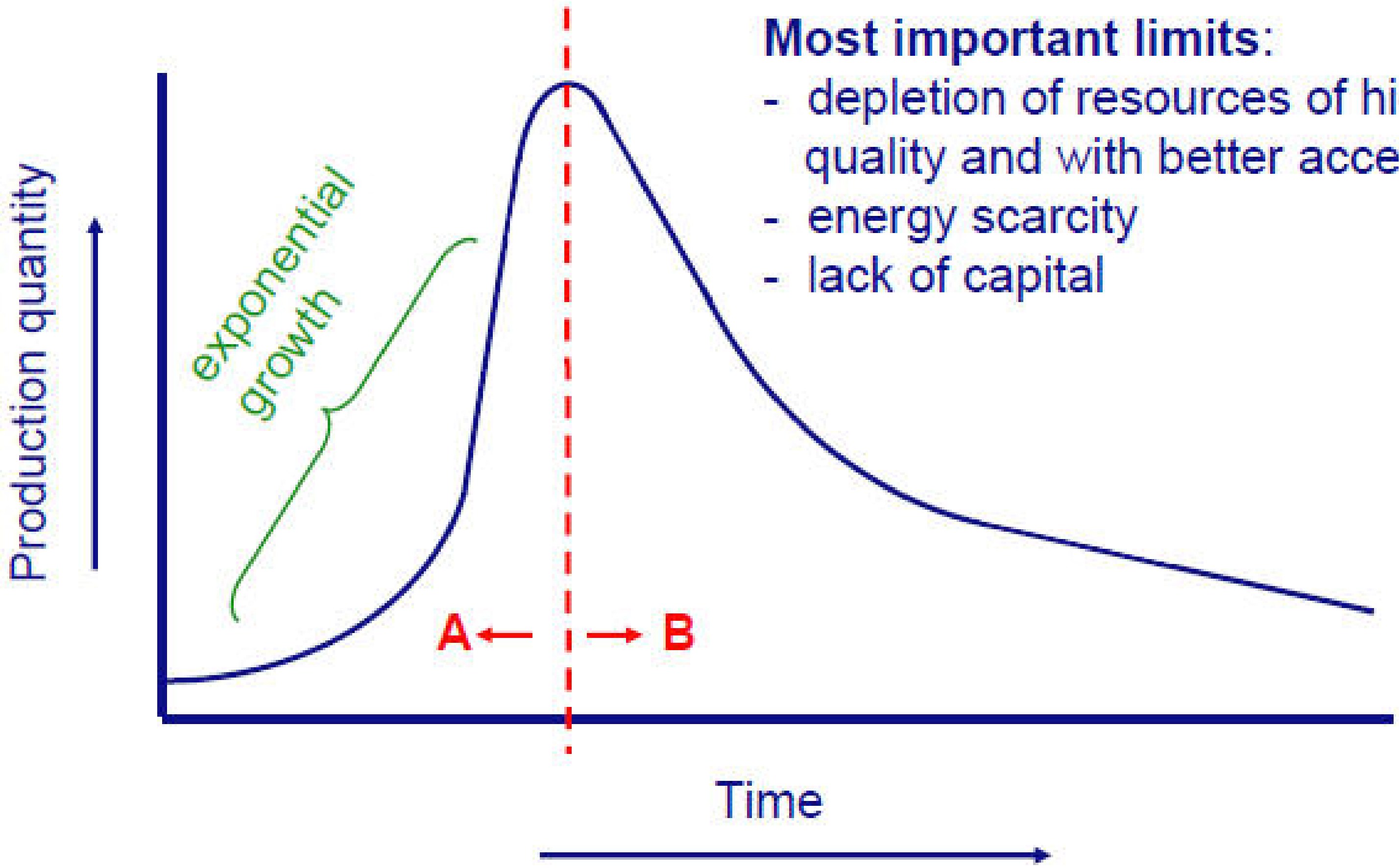
Mineral resources, while depending on fossil fuels, especially oil, for their extraction, are also critical inputs in green technology, which is important not only for reducing greenhouse gas emissions, but also for boosting energy efficiency. Mining and extraction require significant amounts of energy, which increase exponentially with lower ore grades.

In the past, when metal minerals were short in supply, the availability of cheap and abundant fossil fuels, especially oil, made it feasible to extract minerals.

However, today, due to energy constraints, many mineral deposits are out of reach for economically viable exploitation.

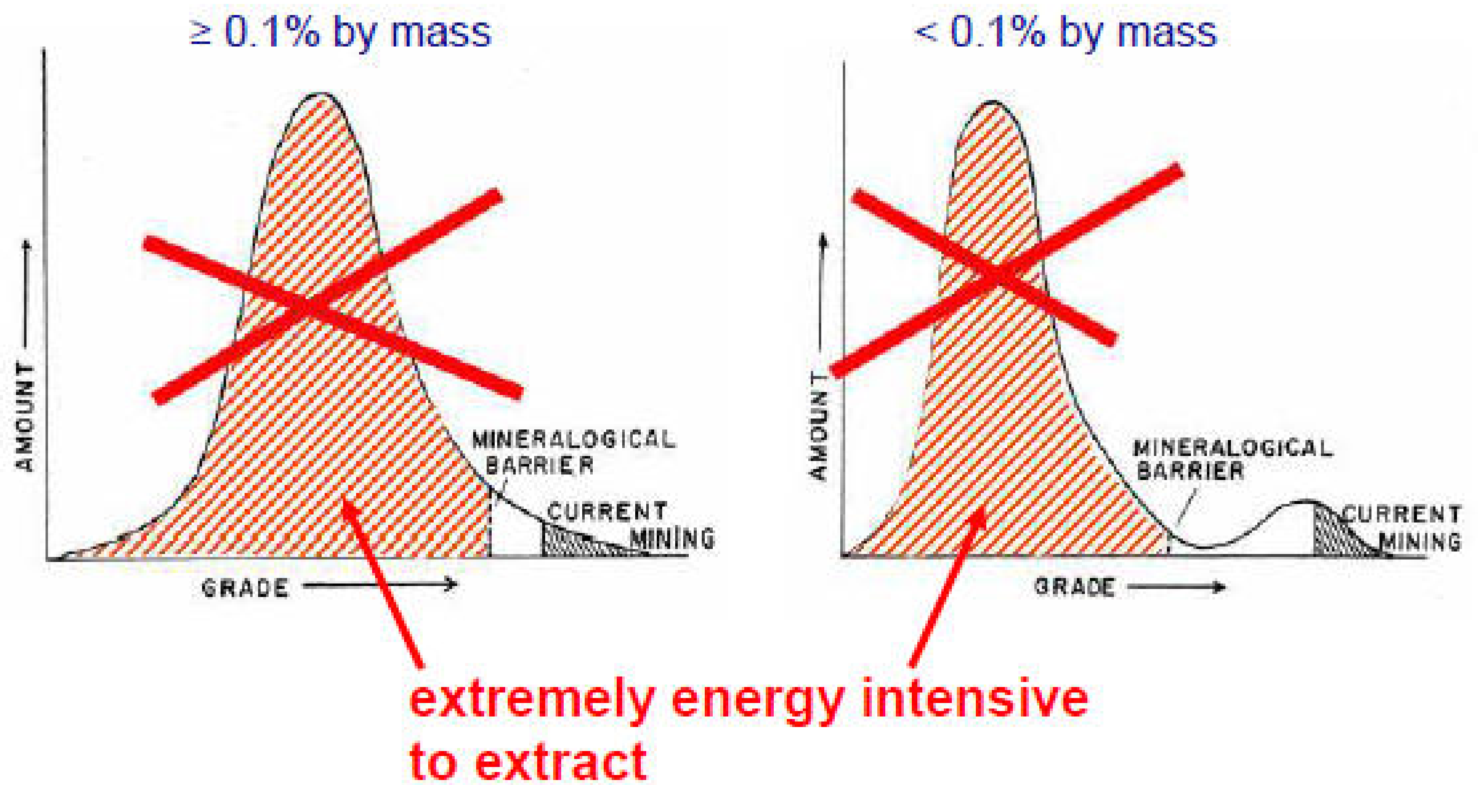
Minerals ?

Materials scarcity: what matters is production*rate*



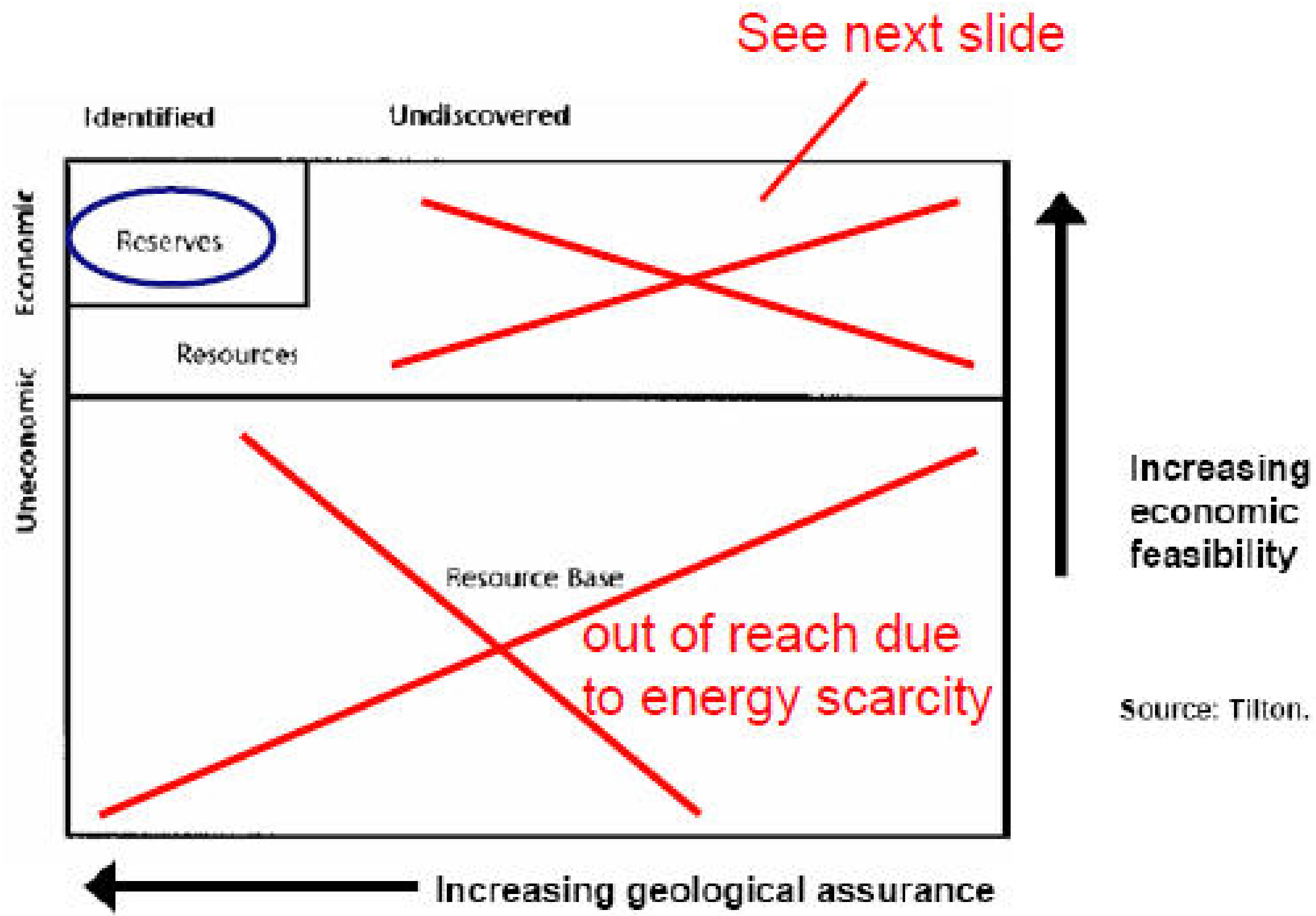
Most important limits:
- depletion of resources of higher quality and with better accessibility
- energy scarcity
- lack of capital

Elements of the Earth's crust: the bulk is out of reach



Source: "Exploring the resource base"
Brian J. Skinner, Yale University, 2001

"The Earth's crust is so big" is true and at the same quite useless information



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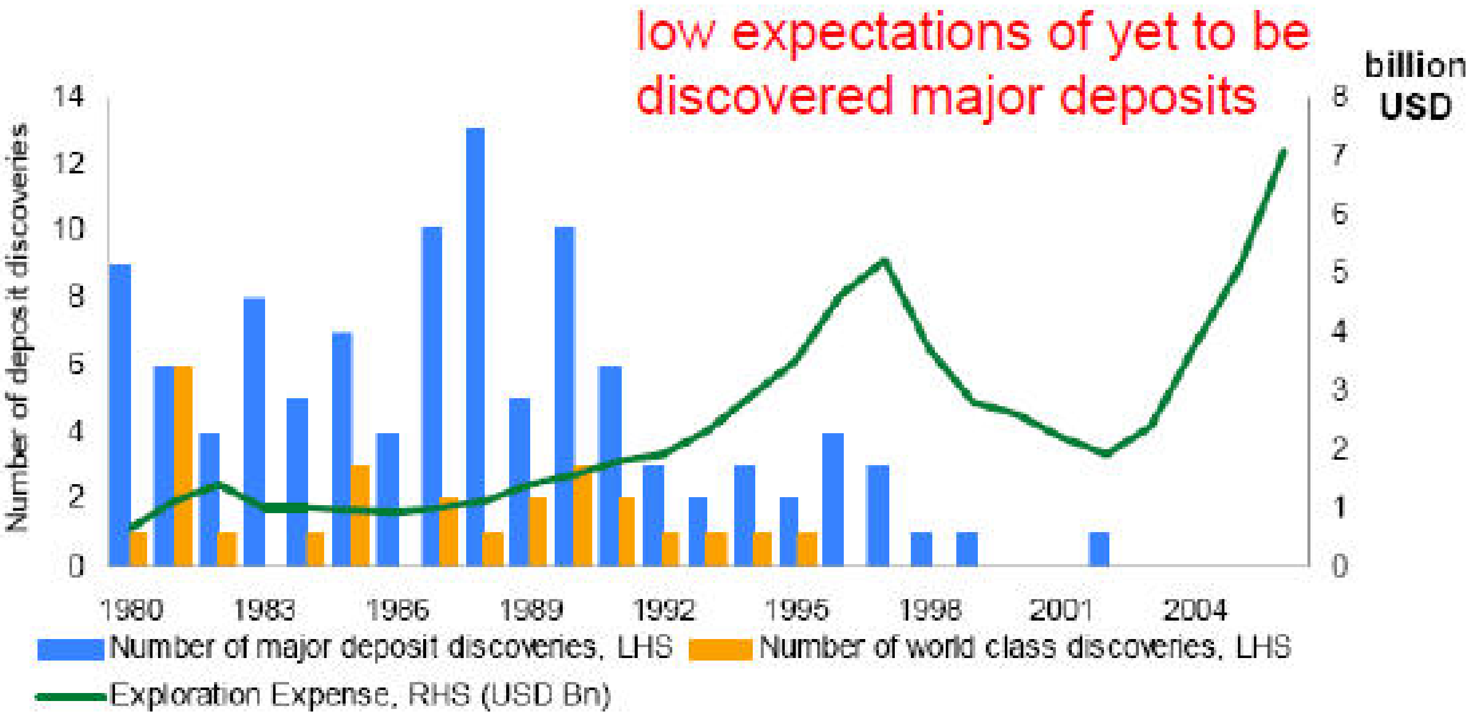
Exploration of major mineral deposits and the "Law of diminishing returns"



Sources: BHP Billiton, MEG, UBS WMR.

Graph: Raw Materials Group, Sweden

Metals scarcity

- Current / Short term demand > supply:

  precious metals (Ag,Au,most platinum group metals), most rare earth metals (lanthanides), a number of minor metals (Ga,Ge,In,Te), "tungsten group" metals (W,Ta,Zr,Nb,Mo), ...

- Long term demand > supply:

  all metals except Elements of Hope (include Fe,Al,Mg)

Metals scarcity interferes with energy transition

Scientific American, November 2009

➔ false sense of security!

replace ALL fossil fuels by 2030 using:

- 490,000 1MW tidal turbines +
- 5,350 100MW geothermal plants +
- 900 1,300MW hydroelectric plants +
- 3,800,000 5MW wind turbines +
- 720,000 0.75MW wave converters +
- 1,700,000,000 0.003MW rooftop photovoltaic systems +
- 49,000 300MW concentrated solar power plants +
- 40,000 300MW photovoltaic power plants

Requires around 3 million tons of neodymium; current annual production rate: 18,000 tons

Metals scarcity interferes with energy transition

replace ALL fossil fuels by 2030 using:

- 490,000 1MW tidal turbines +
- 5,350 100MW geothermal plants +
- 900 1,300MW hydroelectric plants +
- 3,800,000 5MW wind turbines +
- 720,000 0.75MW wave converters +
- 1,700,000,000 0.003MW rooftop photovoltaic systems +
- 49,000 300MW concentrated solar power plants +
- 40,000 300MW photovoltaic power plants

Requires around 90,000 tons (net) of gallium and 500,000 tons (net) of indium
(2µm CIGS panels)
or
around 800,000 tons (net) of tellurium (2µm CdTe panels)
or
around 17,000 tons (net) of ruthenium (dye-sensitized panels)

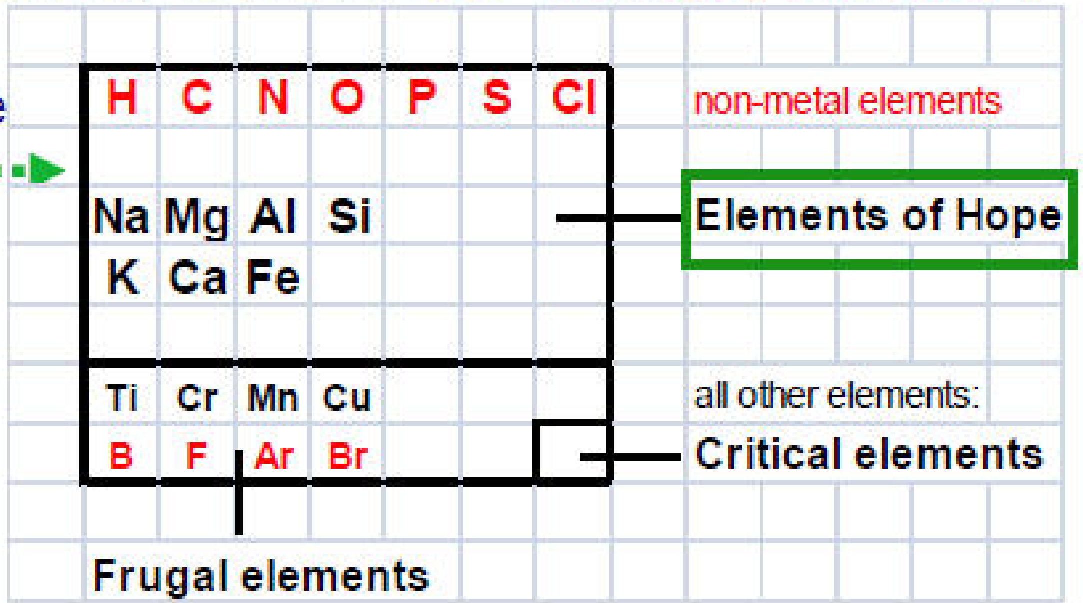
Current annual primary production rates (*estimates*):
gallium: around 100 tons
indium: around 600 tons
tellurium: around 450 tons
ruthenium: around 40 tons

Technology softens the consequences, don't expect miracles

- Timeliness?
  (think in decades, not years)
- Economic scaleability?
- Technology has to abide with the laws of thermodynamics!
- 'Solutions' increase risks and efforts related to next level of problems
- Are we making the right choices?

Adaptation framework with intrinsic benefits, applicable to energy as well as metals

1. Use less (*involves human behaviour and "**managed austerity**"*)
2. Longer life
3. Re-use and recycle
4. Substitute
5. Product and process (re)design
6. Buffers



Source: Global Resource Depletion, Managed Austerity and the Elements of Hope (2010), ISBN 9789059724259

How does industry react?

Raw Materials – The Next Big Battle?

Klaus Hieronymi
Chairman of the Environmental Board
Hewlett Packard Europe, Middle East and Africa

… lets focus on metals today..

Electronics have significant impact on „techno“ metals demand

Important EEE metals		world mine production	demand for EEE		expected to run short in mining	Main uses in electro/ electronics
		t/ a	t/ a		years * - **	
Silver	Ag	20.000	6.000	30%	9 - 29	contacts, switches, leadfree solders, conductors, etc.
Gold	Au	2.500	300	12%	36 - 45	bonding wire, contacts, IC's, etc.
Palladium	Pd	230	33	14%		multilayer capacitors, connectors, PWB plating, etc.
Platinum	Pt	210	13	6%	15	hard disks, thermocouple wires, fuel cells
Ruthenium	Ru	32	27	84%		hard disks, resistors, conductive plates, plasme displays
Copper	Cu	15.000.000	4.500.000	30%	35 -40	cables, wires, connectors, printed curcuit boards, transformers, etc.
Tin	Sn	275.000	90.000	33%	17 - 40	leadfree solders
Antimony	Sb	130.000	65.000	50%	13 - 30	flame retardants
Cobalt	Co	58.000	11.000	19%		rechargable batteries,
Bismuth	Bi	5.600	900	16%		leadfree solders, capacitors, heat sinks, electrostatic screening, etc.
Selenium	Se	1.400	240	17%		electrooptics, copiers, solar cells, etc.
Indium	In	480	380	79%	4 - 13	LCD panels, semiconductors, LED's, etc.

sources: USGS Mineral commodity summaries 2007, US/ New Scientist May 2007

* duration if the world consumes at half the US consumption rate
** duration if the world consumes at today's rate

A very common view in the IT-Industry:

Raw materials …. who the hell cares where they are coming from …?

.. we are not buying any….

.. we buy parts, assemblies, complete products … !

… this is going to change …

… the ITC industry needs to take care about raw materials…

- Higher demand → higher prices

.. higher demand

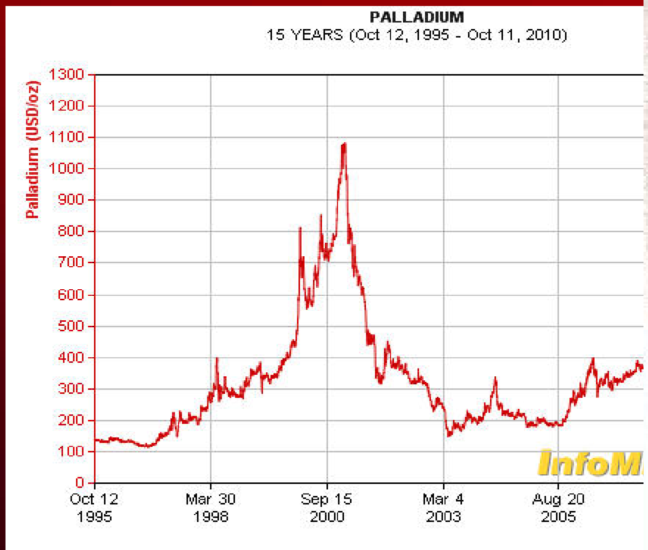
	World Population	Population with income to buy electronic products / cars
1952	2.2	0.3
2009	6.7	3.0
2039	9.0	6- 7.5

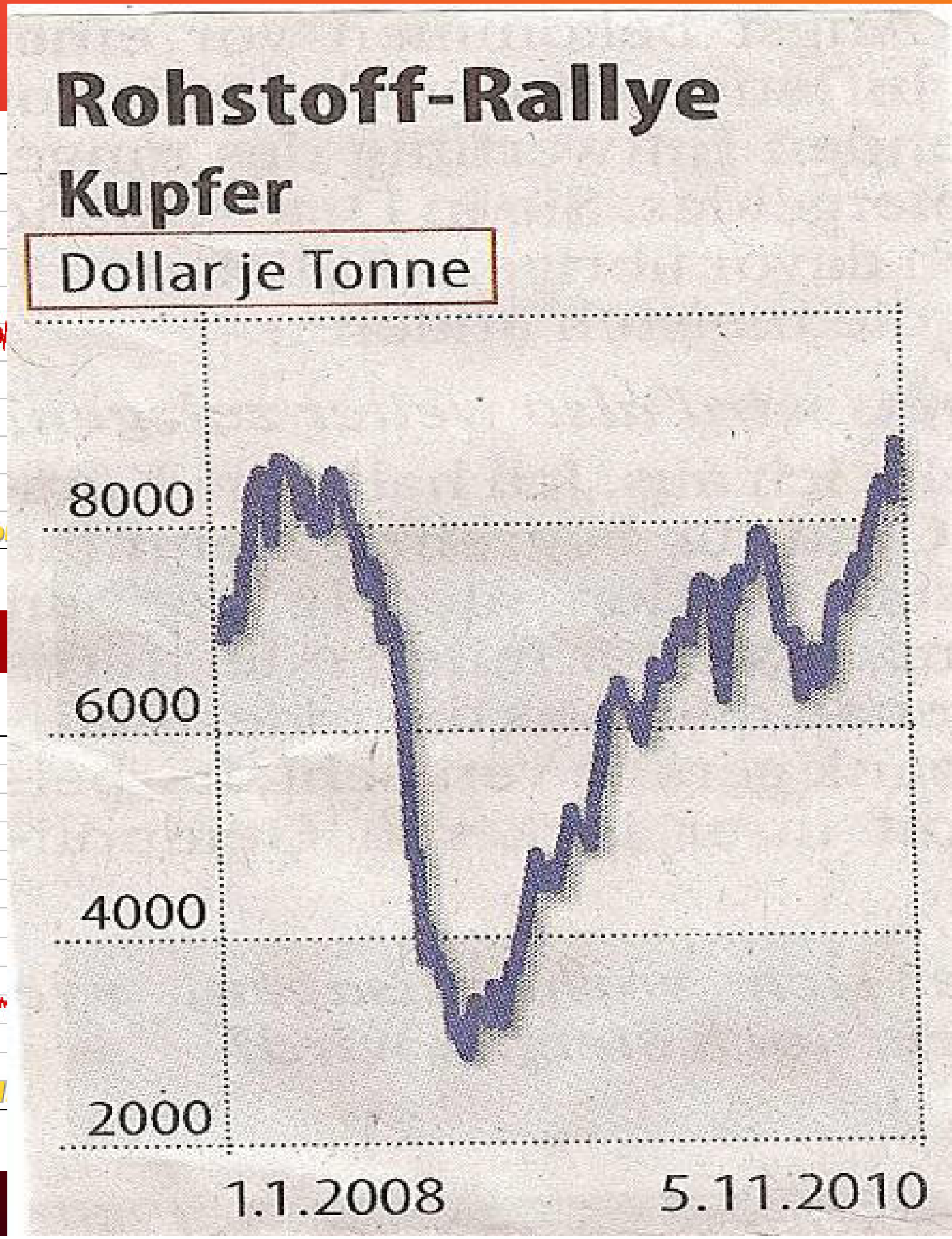
billion

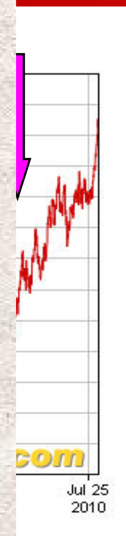
Demand for Raw Materials will increase

... by ??% in 201x

Indicators on increasing prices







Financial crisis

Cost for production will grow

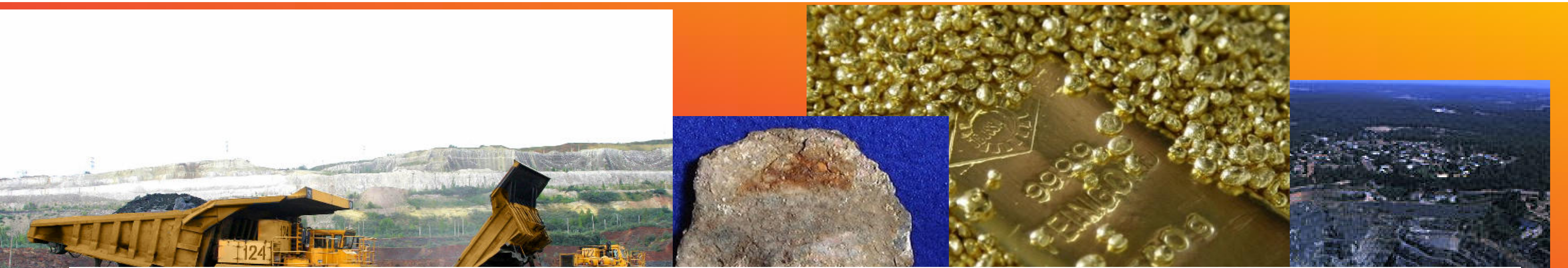
Example: Copper

year	Content
1900	7 %
[illegible]	2 %
[illegible]	<1 %

7 times the amount of ore to be processed to produce 1 ton of copper compared to 100 years ago

* for profitable mining

Energy Cost are a major element now..



… the IT industry needs to take care about raw materials…

- Higher demand → higher prices
- Competition between Industry Sectors

… more electronic components in ‘non electronic’ products ……

What do all these cars have in common ?

... a 400 - 700 kg battery ...
equivialent of
2,000 – 3,500 laptop batteries

Competition from other sectors

Goal of the German Government:
1 mil electrical cars by 2020

By 2020, 9% of the cars (→ 7 mil) will be powered by electricity. Most of them by batteries of the same kind as used for laptops *.

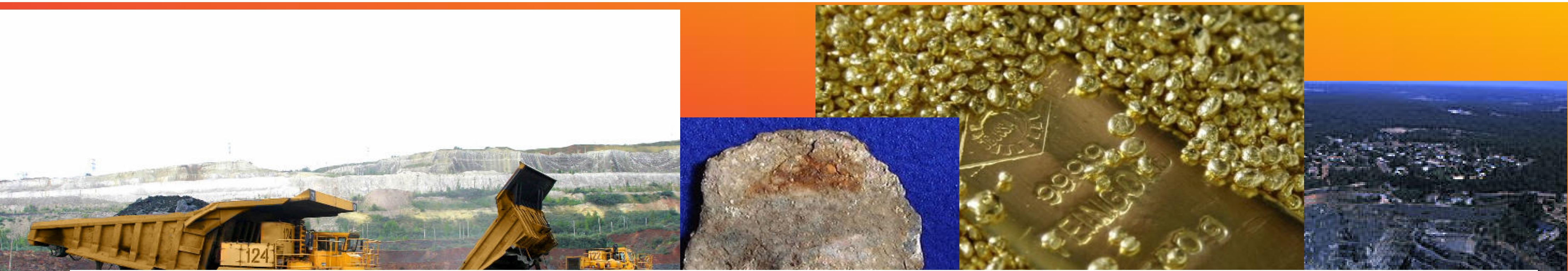
* Source: http://www.mckinsey.de/html/presse/2009/20090901_elektromobilitaet.asp

Competition from other sectors

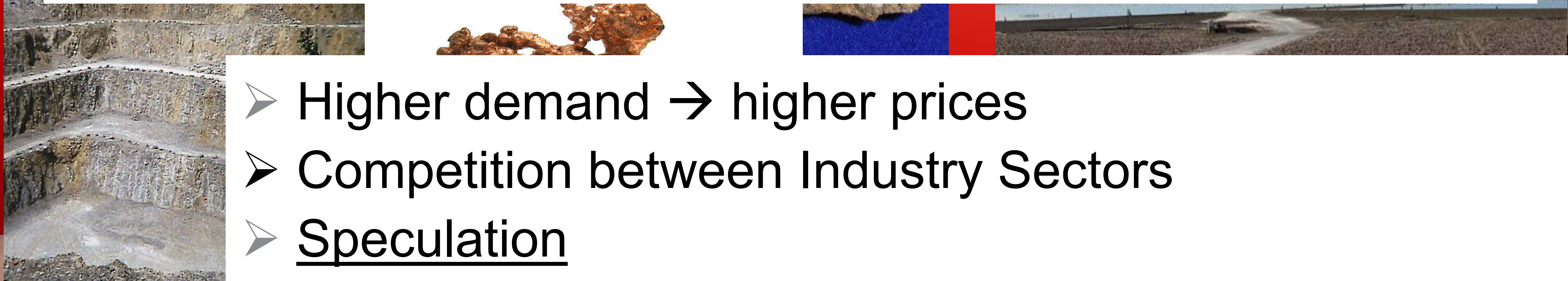
7 mil electrical cars require a similar amount of materials to produce batteries for

7,000,000,000 Laptops

400kg/car, 0.4 kg/laptop

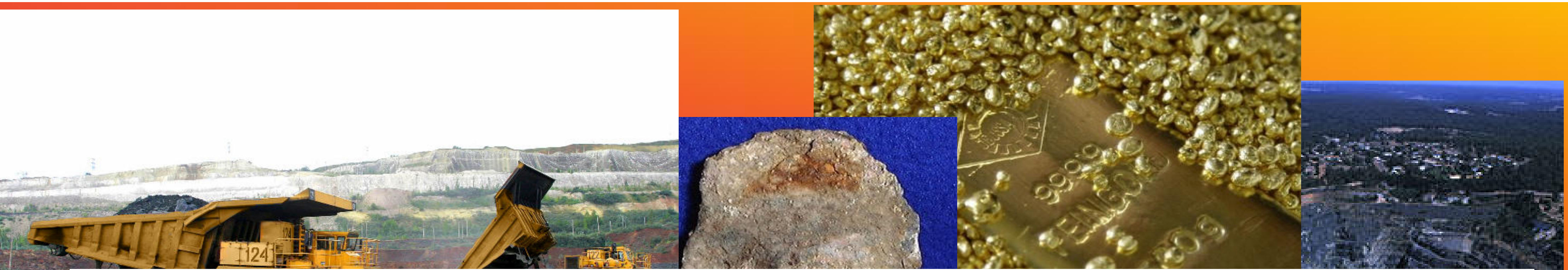


... the ITC industry needs to take care about raw materials...



- Higher demand → higher prices
- Competition between Industry Sectors
- Speculation

According to the CEO of Thyssen-Krupp, 2 out of 5 transactions with Iron Ore are performed by ‚banks'



… the ITC industry needs to take care about raw materials…

- Higher demand → higher prices
- Competition between Industry Sectors
- Speculation
- **Raw Materials may be used as a ‘political instrument’**

Control on mines/rare minerals in very few hands

	Chinese Primary Production in relation to global production
Steel	40%
Magnesium (metal)	86%
Molybdenum	29%
Rare Earth Metals	97%
Silver	12%
Tin	42%
Tungsten	76%
Vanadium	32%
Yttrium	99%
Indium	58%
Bismuth	52%
Gold	13% (south Africa 11%)
Lithium	12%
Copper	6%

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TECHNOLOGY FORECASTERS INC.

Strategic Environmental and Manufacturing Consulting

The Future of the EMS Industry

TFI's dynamic and perspective-shifting presentation on the past, present, and future of the Electronics Manufacturing Services (EMS) industry has been given to clients' executive summits and association meetings. It's ideal for encouraging managers, customers, and suppliers to use a 10-year strategic view when making global outsourcing and manufacturing decisions today.

by Takako Kawakami, TFI Japan-based Consultant

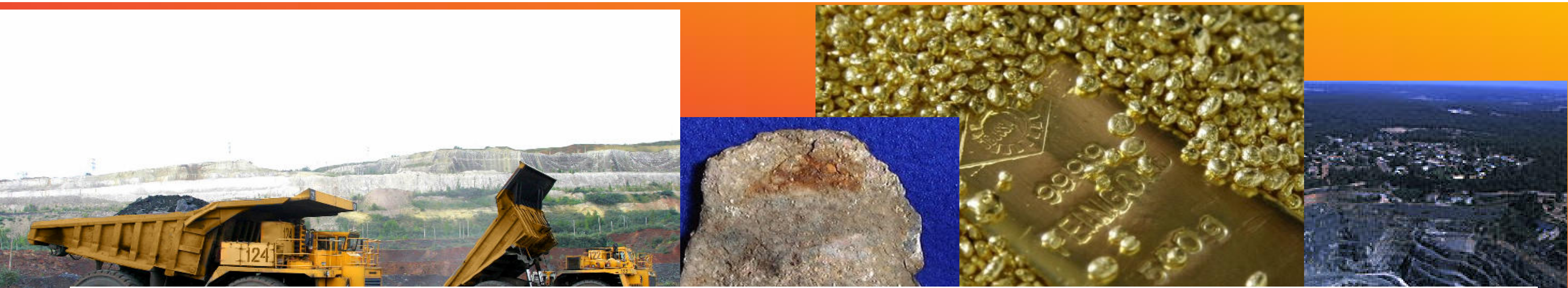
Urban mining softens the blow of restricted supply of precious and rare-earth metals for electronics

The Japanese electronics industry screeched to a halt when China stopped shipping rare-earth minerals to Japan due to a recent diplomatic dispute. As rare-earth minerals are used not only by the electronics industry but also by other manufacturing sectors (e.g., various types of motors), all Japanese industries are affected.

China mines more than 90% of the world's rare-earth minerals. Last July, China announced a reduction of its rare-earths exports by 72%. Chinese domestic consumption has been increasing rapidly and China does not appear to have excess capacity to satisfy the world demand.

In response to this crisis, some Japanese electronics companies have been stock-piling rare-earth minerals, or turning to suppliers in countries such as Vietnam and Mongolia. Other Japanese manufacturers are investing in new technologies to reduce the use of precious metals (such as gold) and rare-earth minerals. However, these alternative solutions will take time to bear meaningful results and don't address immediate needs.

08.11.2010



… the IT industry needs to take care about raw materials…

- Higher demand → higher prices
- Competition between Industry Sectors
- Speculation
- Raw Materials may be used as a ‘political instrument’
- Ban of ‘Conflict Minerals’ (US Law)

„conflict minerals“

(No blood on my Cellphone)

Issue of „conflict minerals“

- Labour conditions
- Profits used to finance Civil Wars

- Coltan (Tantalium)
- Gold
- Tin
- Cobalt
- (Diamonds)

Mitigation strategies for the ITC Industry…

- Increased mining / direct contracts with mines *

* Automotive industry is securing acess to Platinum/Rhodium (for catalyst converters) directly with the mines

Mitigation strategies for the ITC Industry…

- Increased mining / direct contracts with mines *
- Further miniaturization

* Automotive industry is securing acess to Platinum/Rhodium (for catalyst converters) directly with the mines

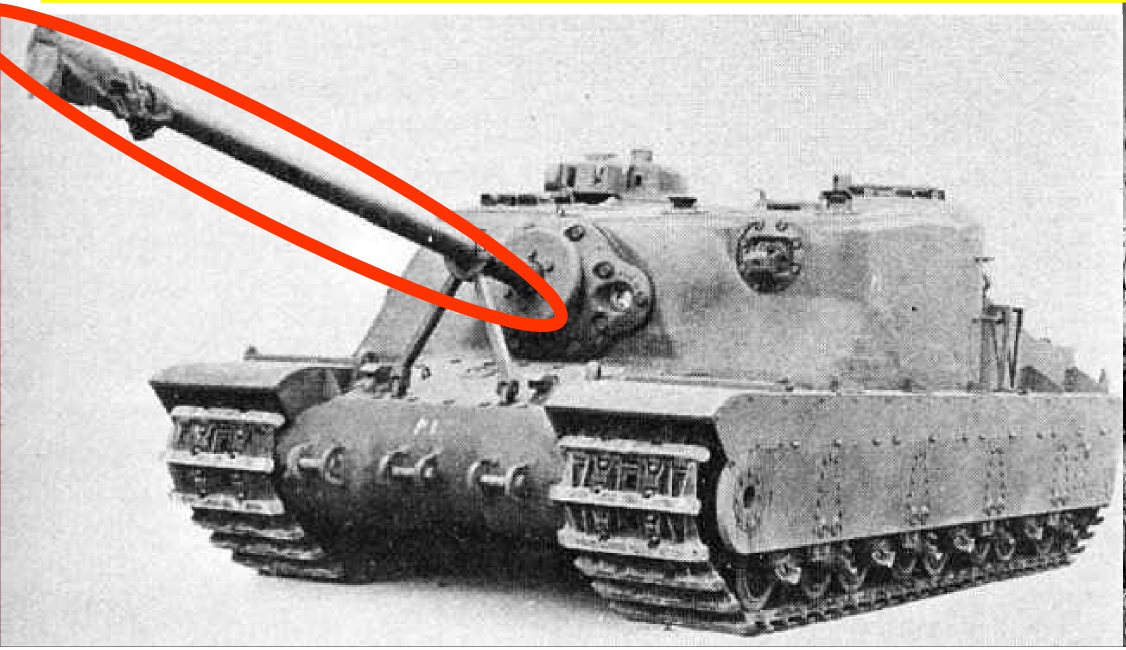
Mitigation strategies for the ITC Industry…

- Increased mining / direct contracts with mines *
- Further miniaturization
- Substitution
  - by mechanical design

* Automotive industry is securing acess to Platinum/Rhodium (for catalyst converters) directly with the mines

... an old example for ‚Design Out‘

In the 2nd World War, Germany did not have similar access to steel hardening materials like the US / Britain.
As a consequence, their canons had to reduced powder loads. To achieve similar speed of the granates, they used longer barrels.



Mitigation strategies for the ITC Industry…

- Increased mining / direct contracts with mines*
- Further miniaturization
- Substitution
  - by mechanical design
  - with other materials

* Automotive industry is securing acess to Platinum/Rhodium (for catalyst converters) directly with the mines

Material Substitution

HP Lab project: replace copper lines with optical lines

.... within computers / in chips.......

- 2012: Servers
  Annual savings: 13 TeraWatt hours of electricity
- 2017: Servers + Chips
  Annual savings: 110 TWh of electricity
- Reduce the need to mine, smelt copper

Mitigation strategies for the ITC Industry…

- Increased mining / direct contracts with mines
- Further miniaturization
- Substitution
  - by mechanical design
  - with other materials
  - with recycling materials

* Automotive industry is securing acess to Platinum/Rhodium (for catalyst converters) directly with the mines

Recycled plastics

HP Deskjet D2545 Printer

- 83% recycled plastic content by weight

-100% of the outer casing and tray parts made from recycled content

- ENERGY STAR® compliant, power consumption decreased by 40% (from previous Deskjet models)

- Packing and storage

Outlook in the mid-term future (2015 and beyond)

Production cost for raw materials will significantly increase

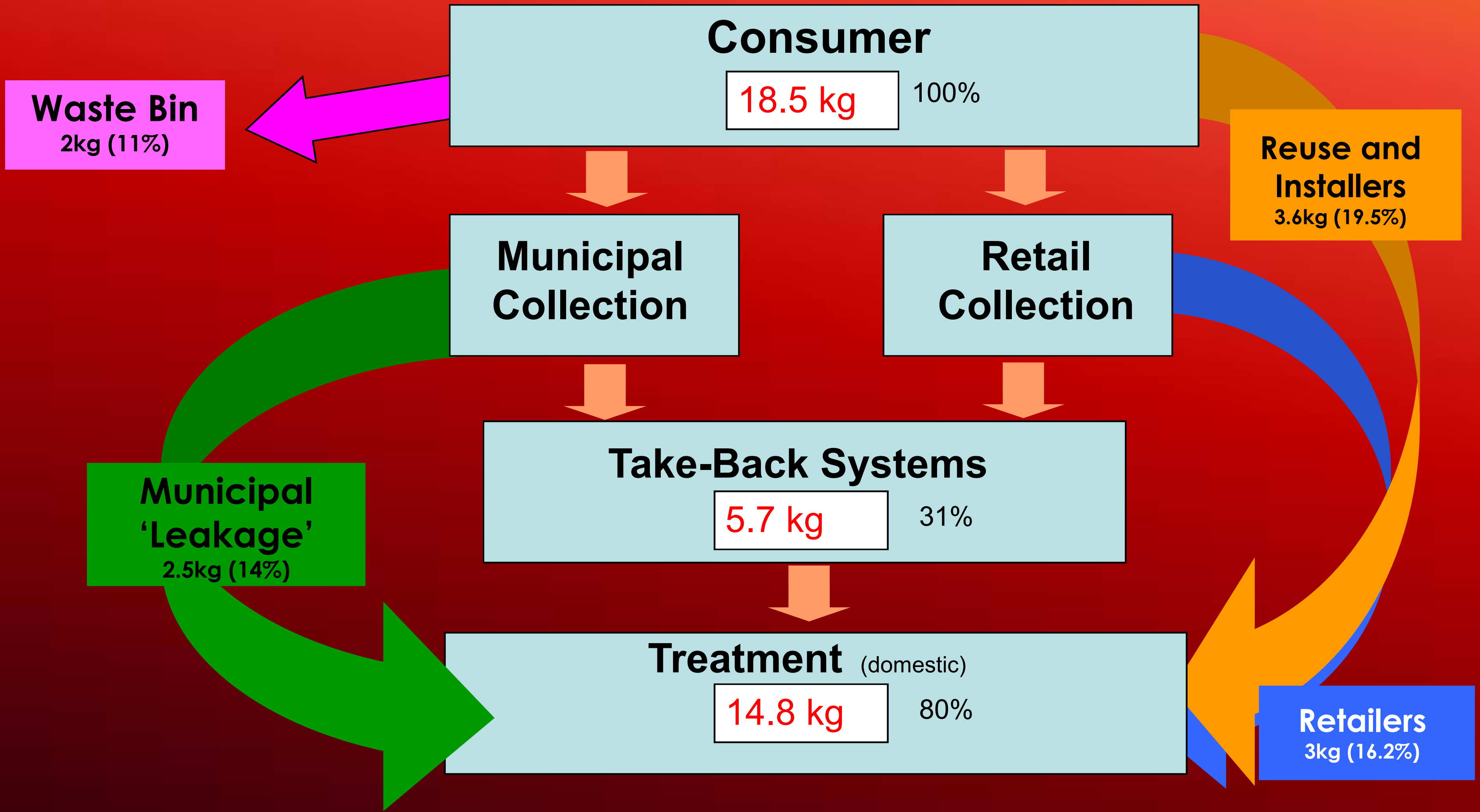
Prices for raw materials will significantly increase

Scrap prices will increase significantly

Collection & Recycling will be a profitable business

Reverse Supply Chain: NL 2007

60% of E-waste collection happens outside of the E-Waste systems today



Source: Witteveen+Bos, Onderzoek naar complementaire afvalstromen voor e-waste in Nederland, 10 April 2008

Outlook in the mid-term future (2015 and beyond)

Production cost for raw materials will significantly increase

Prices for raw materials will significantly increase

Scrap prices will significantly increase

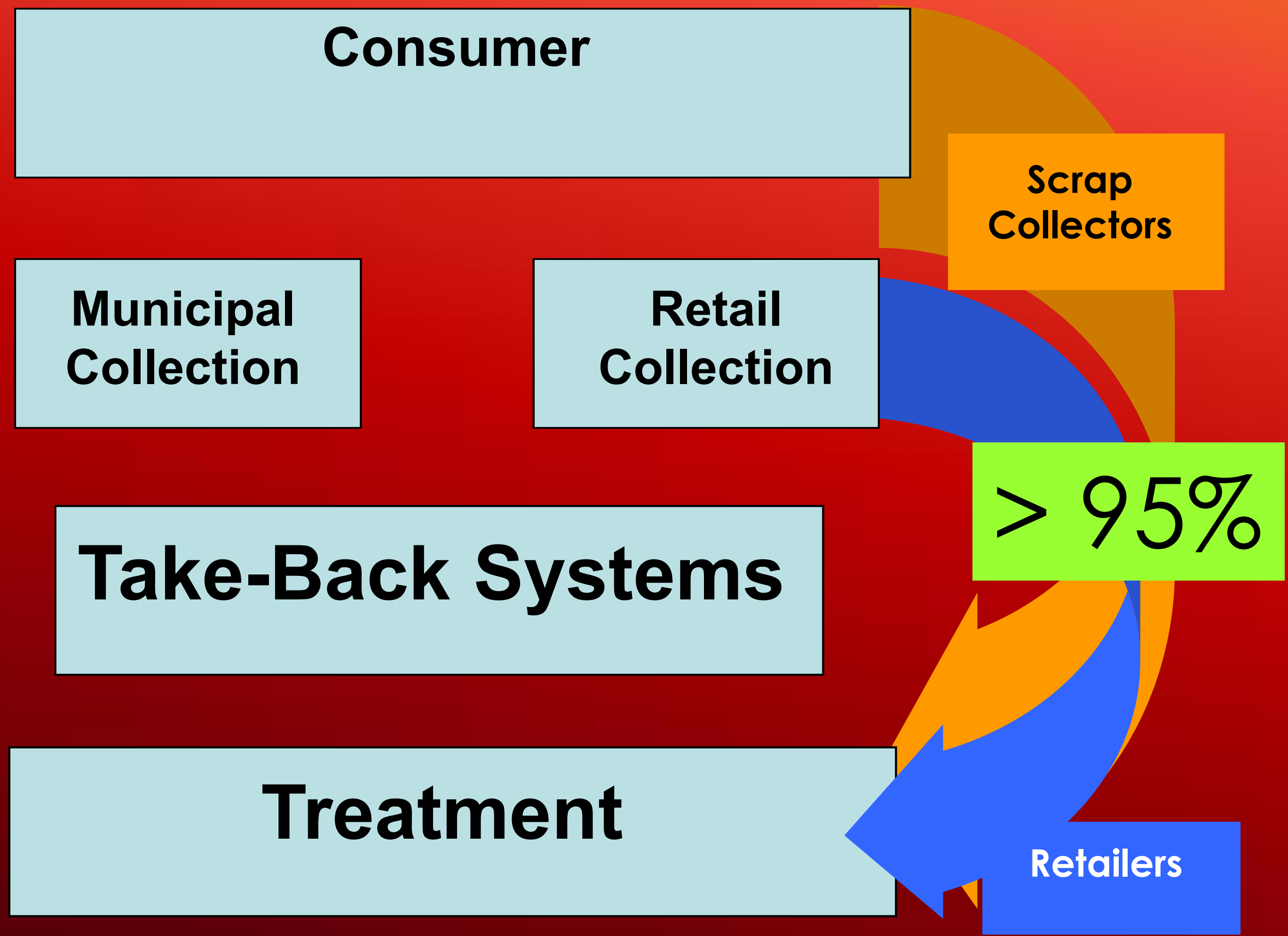
Collection & Recycling will be a profitable business

Collection will happen outside of current structures

‚side effects' („backyard recycling", theft,...)

Reverse Supply Chain: scrap prices 2 x of today

...... what is the role of manufacturers in such a structure ?



Source: Witteveen+Bos, Onderzoek naar complementaire afvalstromen voor e-waste in Nederland, 10 April 2008

The future is already happening today

Collection & Recycling
of most E-Waste
is profitable
in countries with
low labour rates *

* even with 'western' recycling standards

.... to be proofed in an HP study in Morroco and Kenya

CRS 存取款一体机
Cash Recycling System
银行卡余额查询
Bank Card Balance Inquiries
现金存、取款
Cash Dispenser Deposit
转帐汇款
Transfers And Remittances
信用卡还款
Credit Card Repayment
无卡存款
No Card Deposit
MasterCard
VISA
UnionPay
银联

Does the IT industry need to take care about raw materials ?

<u>The answer is certainly:</u> yes !

We need to include ‚raw materials' into our design & supply chain strategies

Examples from youtube

- **BAN:** **http://www.youtube.com/watch?v=a0xpRk7MYNg&feature=related**
- **BBC News:** **http://www.youtube.com/watch?v=dJ8nL2RBF4E&feature=related**
- **China:** **http://www.youtube.com/watch?v=ZHTWRYXy2gE&NR=1&feature=fvwp**

- Ghana: http://www.youtube.com/watch?v=pr1zQrXM_7s
- India: http://www.youtube.com/watch?v=0JZey9GJQP0
- Cebit: http://www.youtube.com/watch?v=4mLtheejM30&feature=relmfu

umicore
Precious Metals Refining

How WEEE recycling can improve access to critical raw materials

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Going Green
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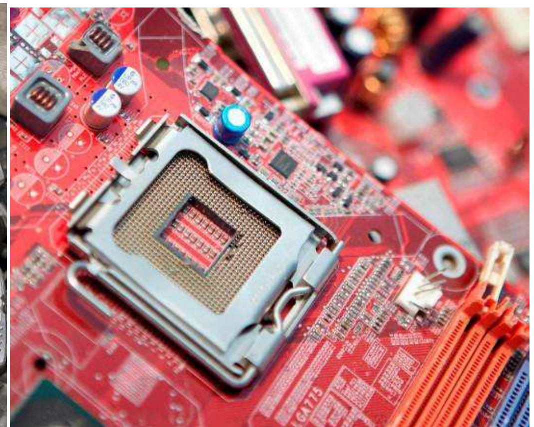
Two ways of raw materials supply

- “ore grade” in some e-scrap fractions by factor 50 higher

Primary production @ ≈5 g/t Au in ore
Similar for PGMs

Kalgold Gold Mine, South Africa
Quelle: www.mining-technology.com

Recycling: 200-250 g/t Au in PC circuit boards
300-350 g/t Au in cell phones,



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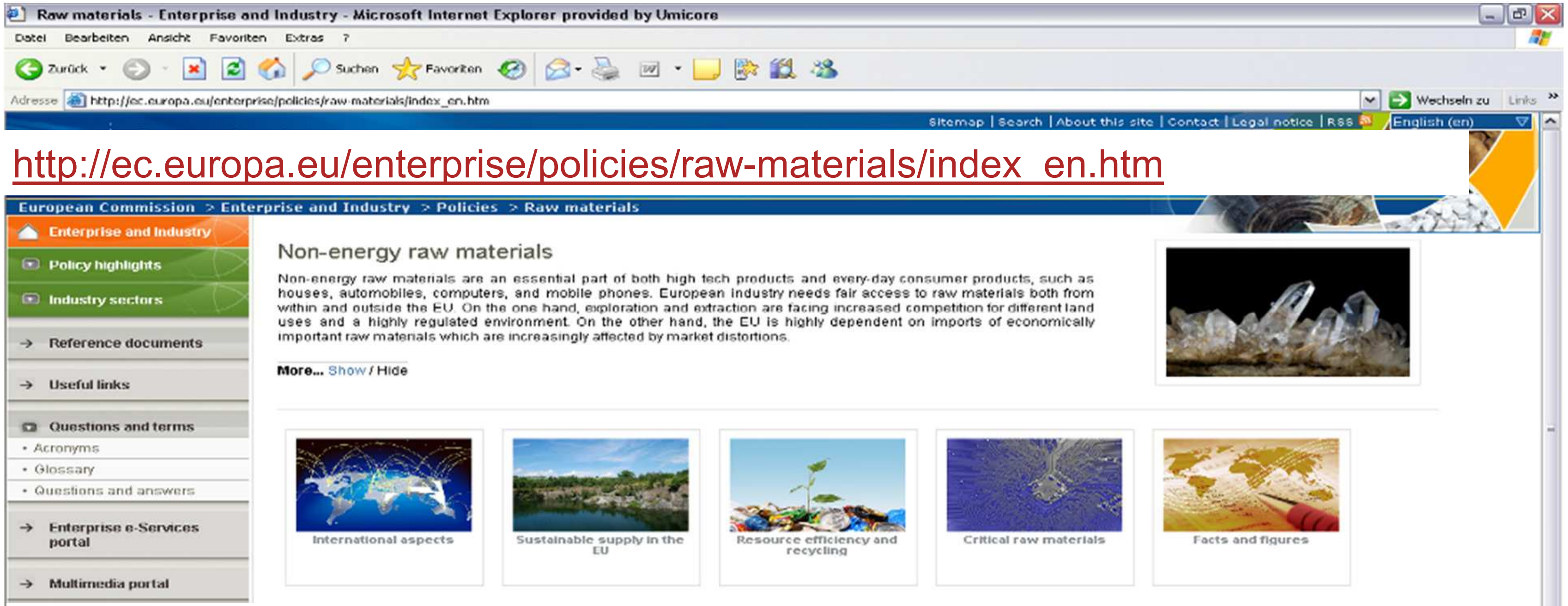
The EU Raw Materials Initiative (RMI)



Communication (2008) 699: "The raw materials initiative – meeting our critical needs for growth and jobs in Europe", Staff Working Document SEC (2008) 2741

1. *Ensure access to raw materials … etc*
2. *Set the right framework conditions … etc*
3. Boost overall resource efficiency and promote recycling to reduce the EU's consumption of primary raw materials and decrease the relative import.

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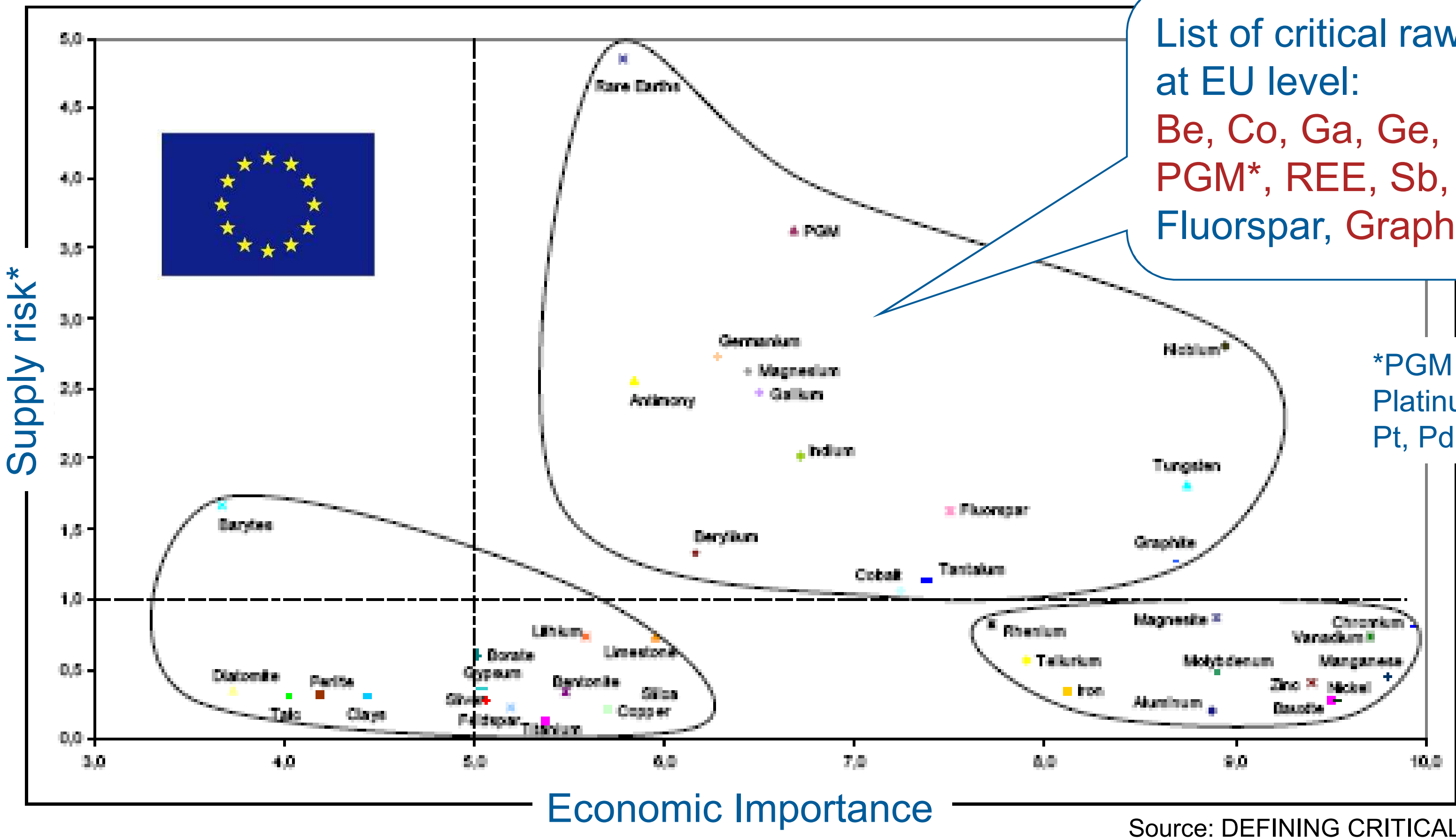
EU RMI - 14 raw materials identified as critical

– most of them needed for EEE



List of critical raw materials at EU level:
Be, Co, Ga, Ge, In, Mg, Nb, PGM*, REE, Sb, Ta, W, Fluorspar, Graphite

*PGM =
Platinum Group Metals
Pt, Pd, Rh, Ru, Ir, Os

* depending on: level of concentration of ww production (HHI) linked with World Bank “ww governance indicator” + potential for substitution + current recycling rate

Source: DEFINING CRITICAL RAW MATERIALS FOR THE EU: A Report from the Raw Materials Supply Group ad hoc working group defining critical raw materials; July 30, 2010

Metal use in electronics – volume counts

Global sales, 2008 (2009):

a) Mobile phones:

1300 Million units

x 250 mg Ag ≈ 325 t Ag

x 24 mg Au ≈ 31 t Au

x 9 mg Pd ≈ 12 t Pd

x 9 g Cu ≈ 12,000 t Cu

1300 M batteries*

x 3.8 g Co ≈ 4900 t Co

* Li-Ion type

b) PC & laptops:

300 Million units

x 1000 mg Ag ≈ 300 t Ag

x 220 mg Au ≈ 66 t Au

x 80 mg Pd ≈ 24 t Pd

x ≈ 500 g Cu ≈ 150,000 t Cu

≈140 M laptop batteries*

x 65 g Co ≈ 9100 t Co

** Li-Ion type

World mine / a+b production / share

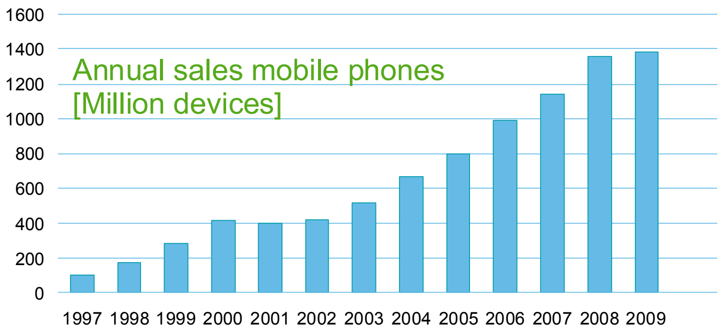
Ag: 21,000 t/a ► 3%

Au: 2,400 t/a ► 4%

Pd: 220 t/a ► 16%

Cu: 16 Mt/a ► <1%

Co: 75,000 t/a ► 19%



Cumulated sales of mobile phones:

8.6 billion devices with 2100 t Ag, 200 t Au, 80 t Pd
Precious metal value at June 2010 prices ≈ 8,5 billion €

How much of this will finally be recycled ?

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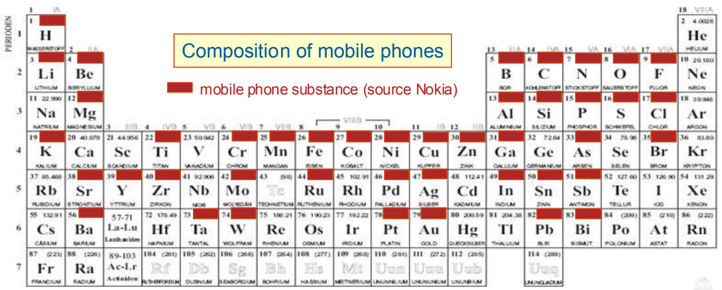
The challenge: The good, the bad and the ugly
- recovering valuables while taking care of hazards



E-scrap, a complex mix …

- Ag, Au, Pd… (precious metals)
- Cu, Al, Ni, Sn, Zn, Fe, Bi, Sb, In… (base- & special metals)
- Hg, Be, Pb, Cd, As, …(substances of concern)
- Halogens (Br, F, Cl...)
- Plastics & other organics
- Glass, ceramics

⇨ Environmental risk in case of landfill & inappropriate recycling

⇨ Valuable metal resource

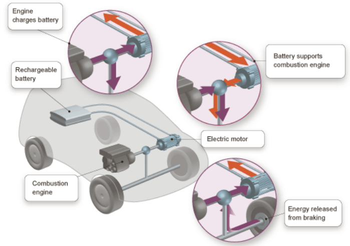
EEE - huge impact on metal demand

	% used in EEE*	Main application(s)	By-product from
• Indium:	80%	LCD glass	Zn, Pb
• Ruthenium:	> 80%	hard disks	PGM
• Antimony:	~ 50%	flame retardants	(Cu, Pb, Zn)
• Tin:	~ 35%	solder	
• Copper:	30%	cables, wires, e-motors	
• Silver:	30%	contacts, solder, MLCC	(Pb, Zn)
• Cobalt:	20%	rechargeable batteries	(Ni, Cu)
• Selenium:	~ 20%	electro-optics	Cu
• Palladium:	~ 15%	MLCC, connectors	PGM
• Gold	~ 10%	bonding wire, contacts, IC	(Cu)

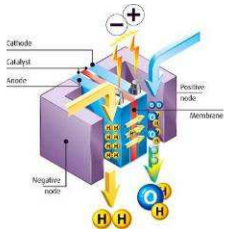
* rounded based on 2007 sales

Emerging technologies further increase pressure on demand for technology metals

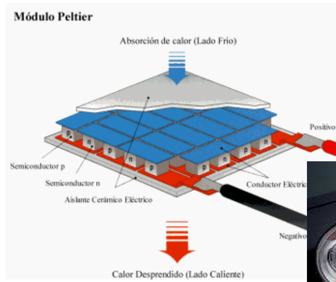
Examples:



- Electric vehicles & batteries:
  cobalt, lithium, rare earth elements, copper



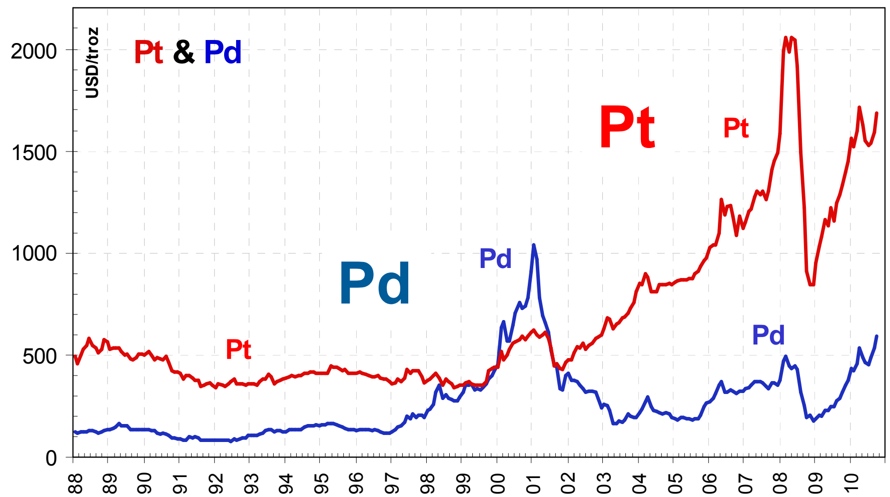
- Fuel cells:
  platinum, (ruthenium, palladium, gold)

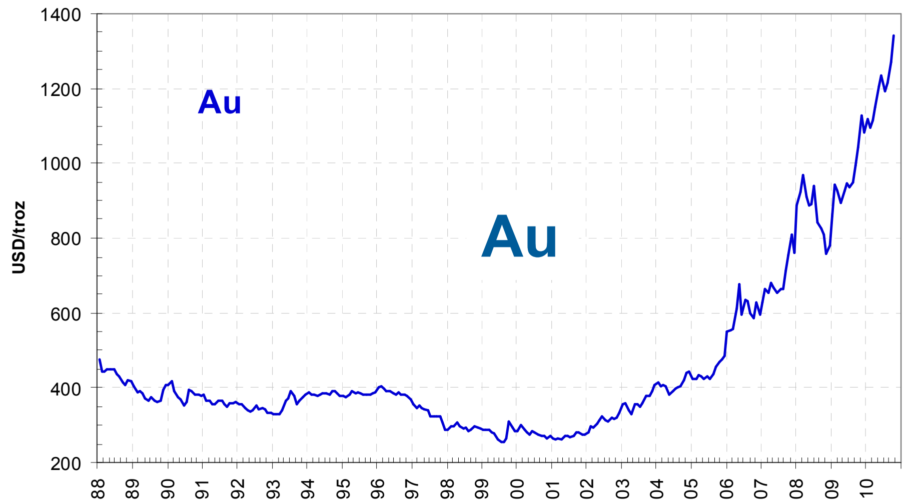


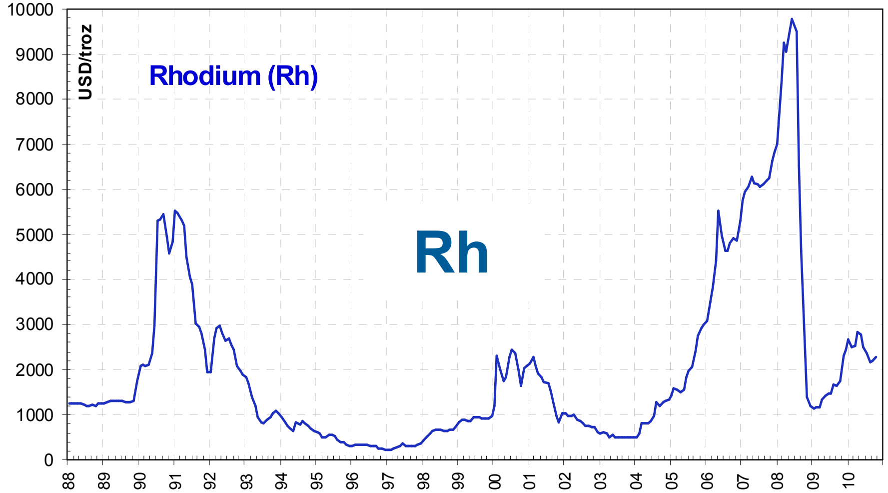
- Thermo-electrics, opto-electronics, LEDs, ….:
  bismuth, tellurium, silicon, indium, gallium, arsenic, selenium, germanium, antimony, …

- Photovoltaic (solar cells):
  silicon, silver, indium, gallium, selenium, germanium

Precious Metal prices 1988-2010/10 – just short impact of economic crisis







Recycling recommendations developed by the RMI critical metals group

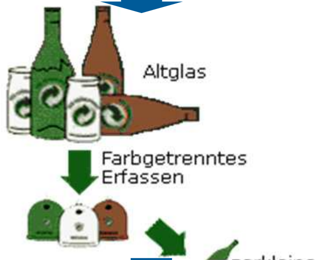
Undertake policy actions to make recycling of critical raw materials more efficient, in particular by:

- Mobilising relevant EoL products for proper collection instead of stocking, landfill or incineration
- Improving overall organisation, logistics & efficiency of recycling chains by focussing on interfaces and system approach
- Preventing illegal exports of relevant EoL products & increasing transparency in flows
- Promoting research on system optimisation & recycling of technically challenging products & substances

Source: DEFINING CRITICAL RAW MATERIALS FOR THE EU: A Report from the Raw Materials Supply Group ad hoc working group defining critical raw materials; July 30, 2010 http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm

How to recycle: spot the difference
- Mass materials recycling doesn‘t fit for technology metals

Bottle glass:



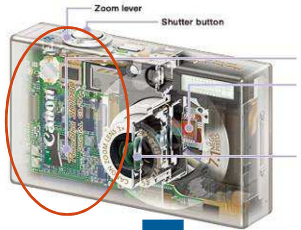
- Green glass
- white glass
- brown glass

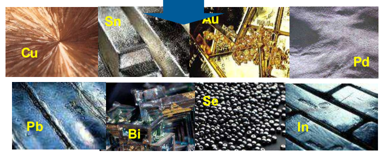
Steel scrap:

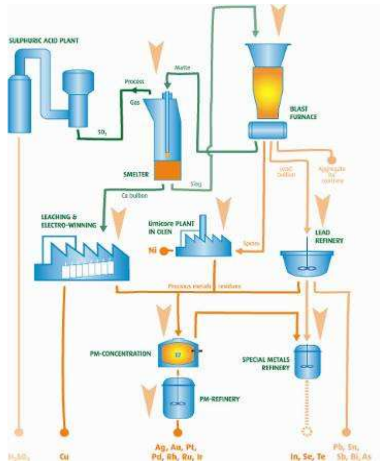
+

- **“mono-substance”** materials without hazards
- trace elements remain part of alloys/glass
- Recycling focus on mass and costs

circuit boards or mobile phones:





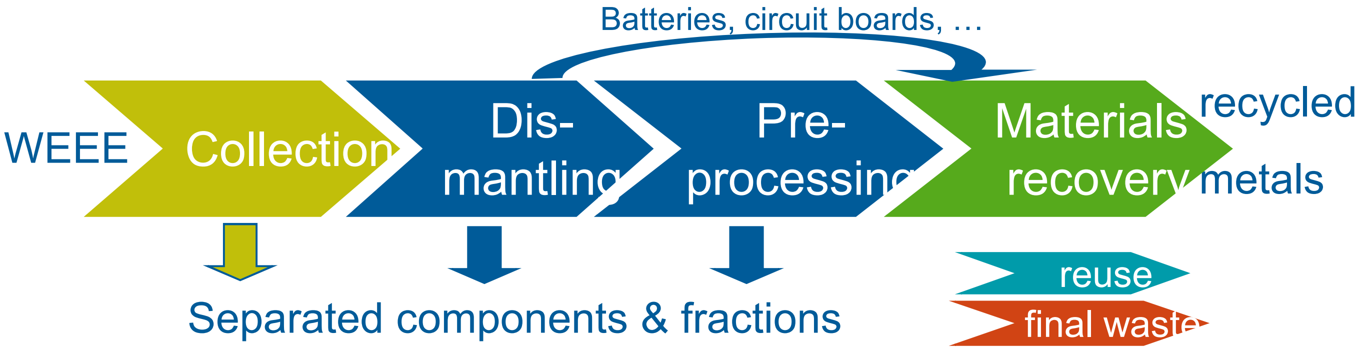


High-tech metallurgical refining processes needed

- **“poly-substance”** materials, incl. hazardous elements
- complex components as part of complex products
- recycling focus on value recovery from trace element

Recycling chain
- system approach is key for technology metals

Example: 50% x 90% x 80% x 95% = 34%

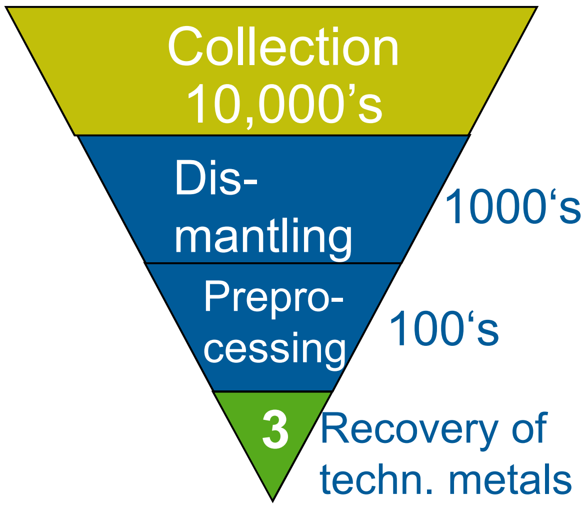


- Consider entire chain & its interdependences
- Mass flows ≠ flows of technology metals

➲ interface optimisation, economies of scale, specialisation

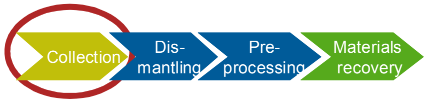
Total efficiency determined by weakest step in the chain

Number of actors in Europe

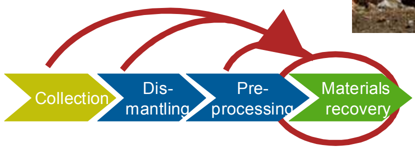


- Significant downstream increase of Investments & technology requirements
- Sufficient capacity for recovery of technology metals available
- Make sure that critical fractions reach these plants!

Main flaws in EU WEEE recycling



a) Poor collection



b) Deviation of collected materials ➪ dubious exports ➪backyard treatment

fotos;: Ökopol

foto: EMPA/CH

Losses are losses, no matter where they occur
- significant potential for system optimisation

Collection → Dis-mantling → Pre-processing → Materials recovery

„There“

Au recycling efficiency*:

80 %	x 50 %	x 50 % = 20 %*
Collection	**dismantling/pre-processing**	**metals recovery**

*Illustrative figures with gold as example

DEDICATED TO MAKING A DIFFERENCE

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Learning objectives

- Understand characteristics of eco-efficiency and how it has emerged
- Recognise the business case for eco-efficiency

Structure

- Definition and drivers
- The business case
- Implementing
- Measuring and reporting
- Beyond eco-efficiency

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The challenge

"The growth of world population and production combined with unsustainable consumption patterns places increasingly severe stress on the life-supporting capacities of our planet."

Agenda 21

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The challenge

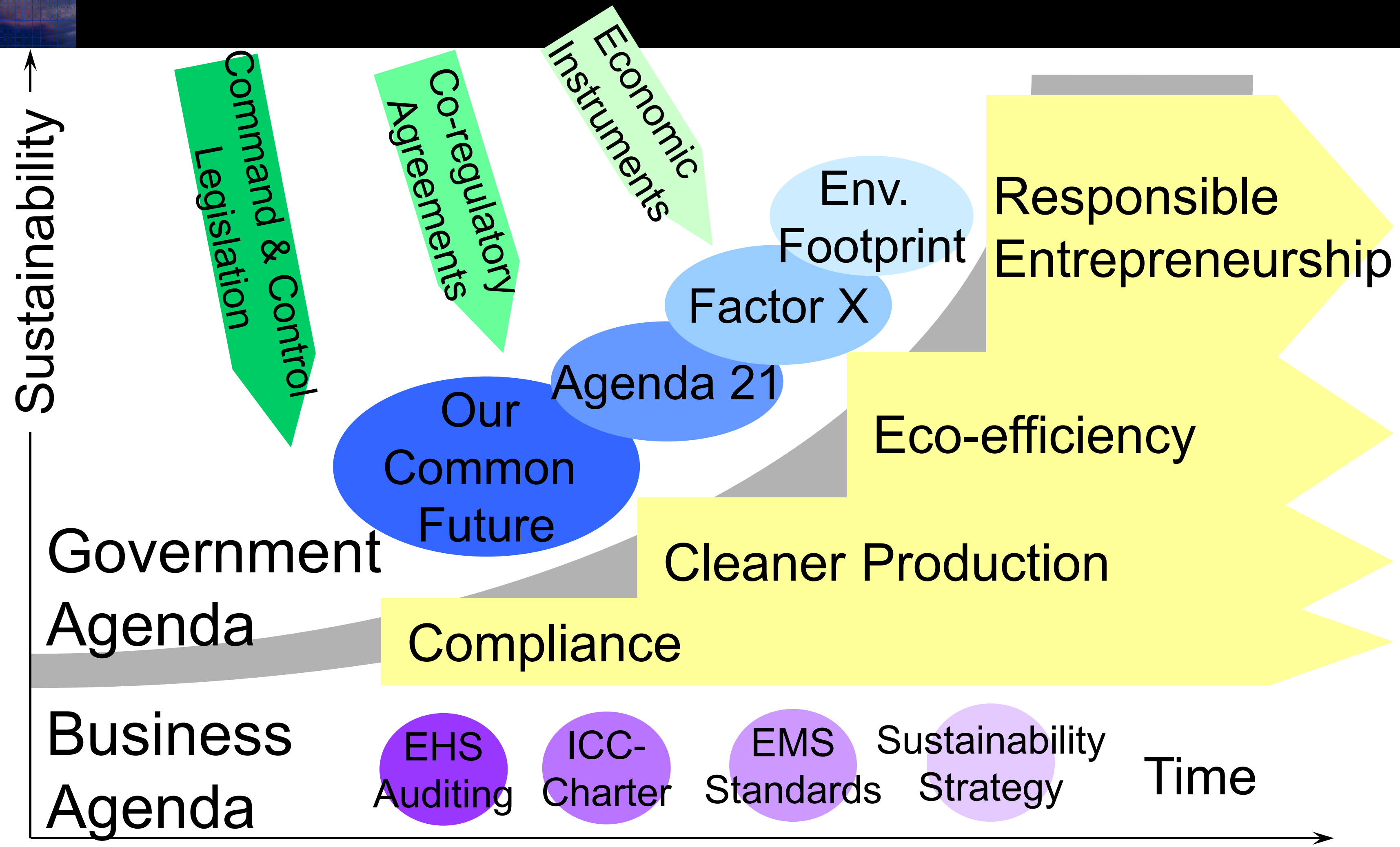
- To provide more value with less environmental impact
- To de-link growth of welfare from the use of nature
- To improve both economic and ecological efficiency

= ECO-EFFICIENCY

Definition

"The delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle, to a level at least in line with the Earth's estimated carrying capacity."

Evolution



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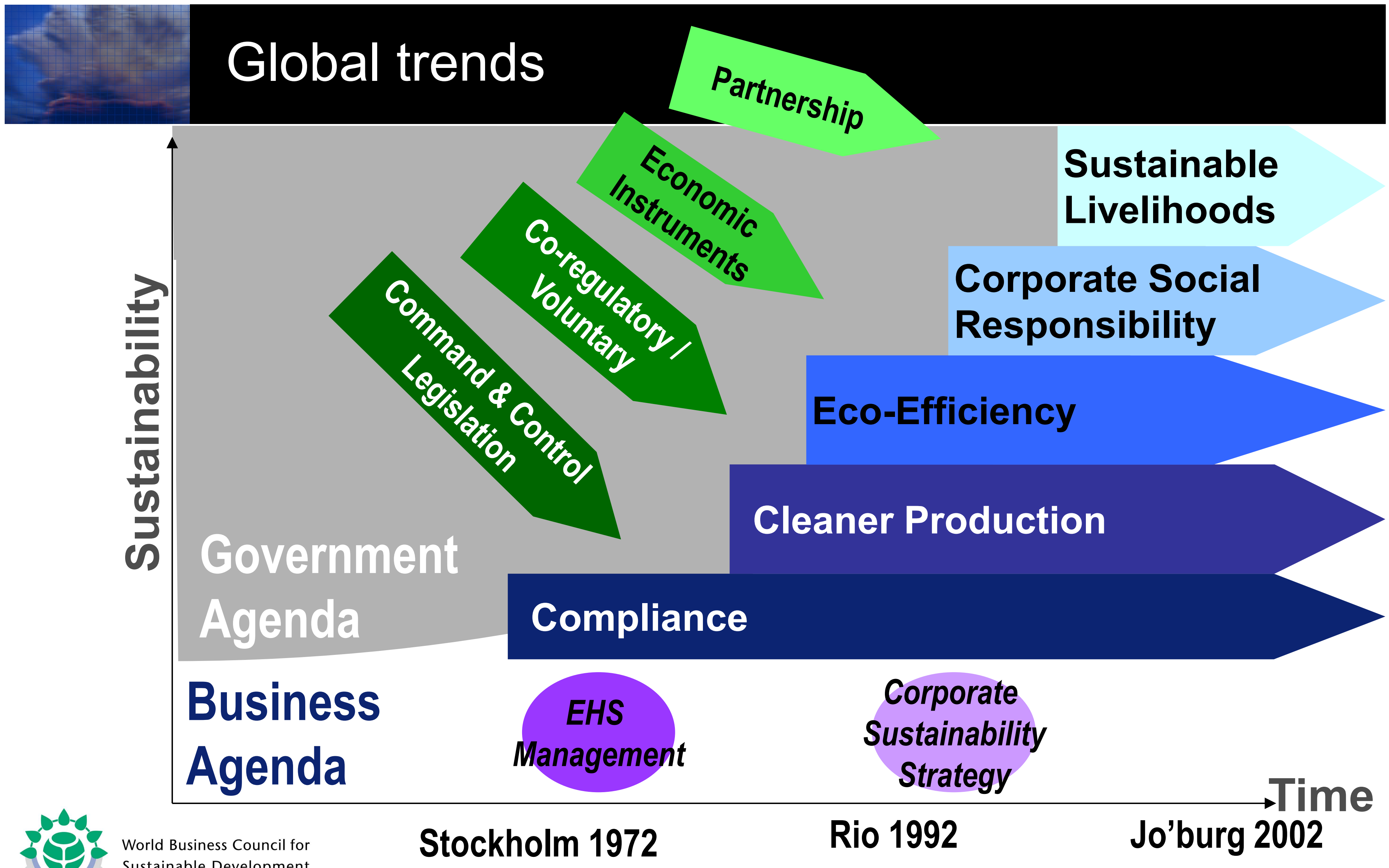


Global trends
Partnership
Economic Instruments
Co-regulatory / Voluntary
Command & Control Legislation
Sustainable Livelihoods
Corporate Social Responsibility
Eco-Efficiency
Cleaner Production
Compliance
Sustainability
Government Agenda
Business Agenda
EHS Management
Corporate Sustainability Strategy
Time
Stockholm 1972
Rio 1992
Jo'burg 2002

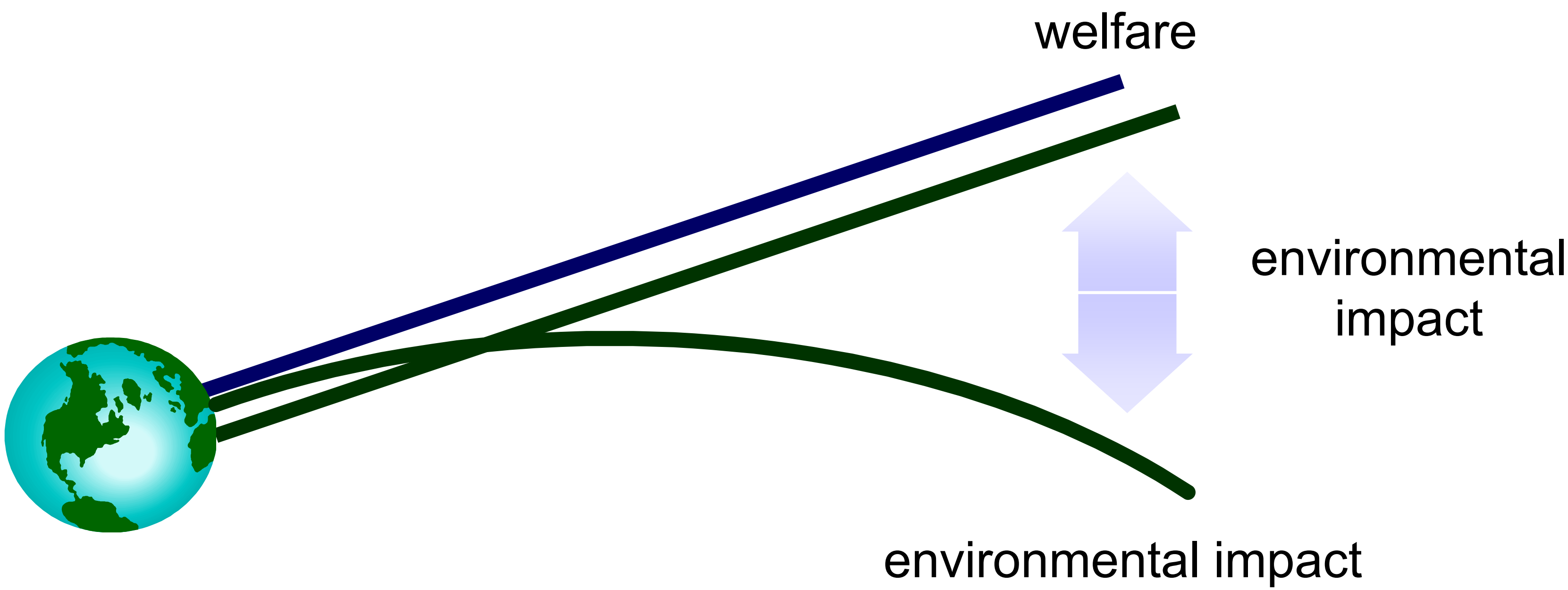
Why businesses are embracing eco-efficiency

Because it is a management tool which:

- focuses on opportunities
- improves performance
- makes businesses more competitive

It speaks the language of business leaders.

Why governments are embracing eco-efficiency



It de-links welfare from use of nature.

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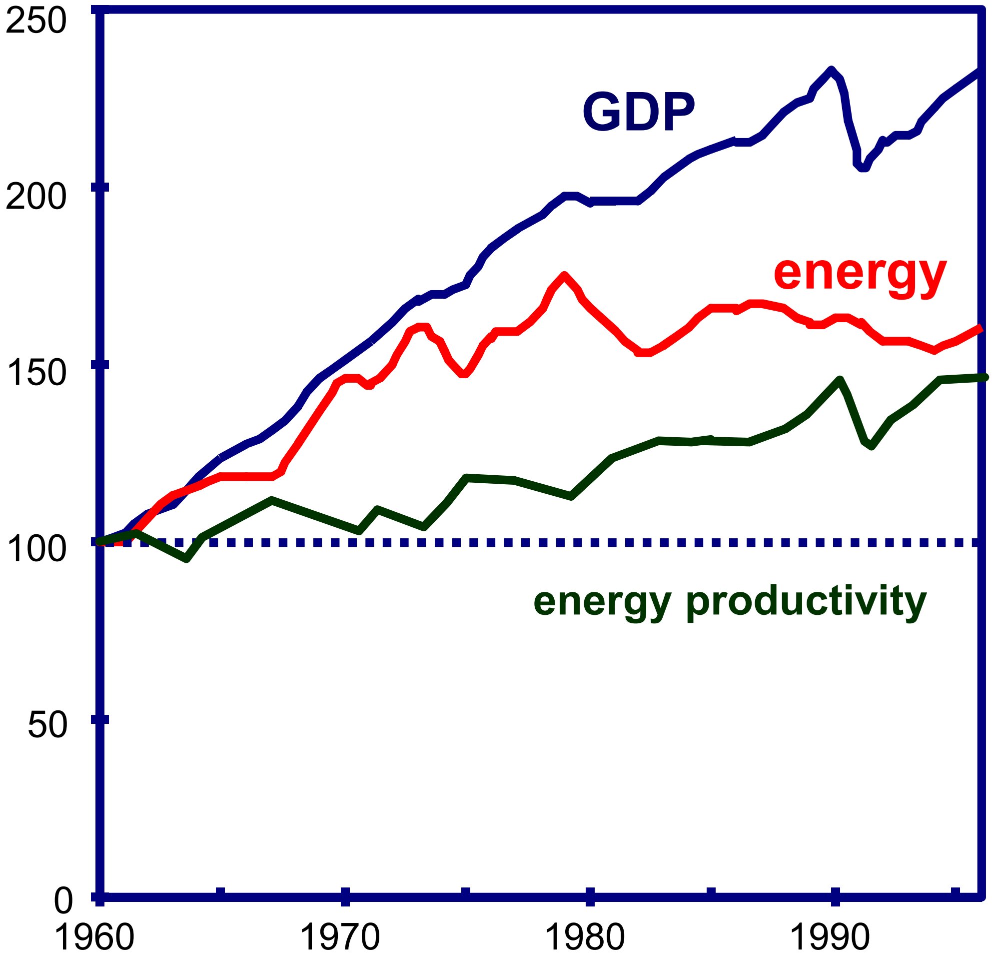
Energy production: Germany



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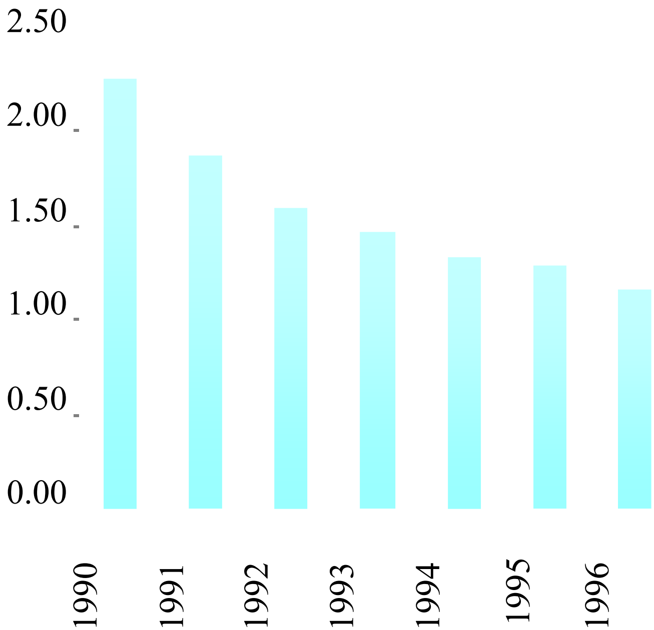
index base 1960

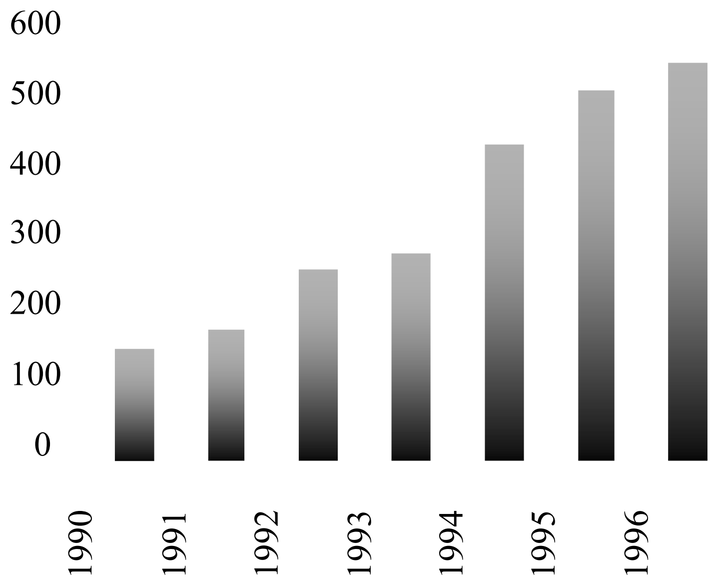
Source - European Environment Agency

In developing countries too...

WATER m³ consumed per unit of product



$ of value added per m³ of water consumed

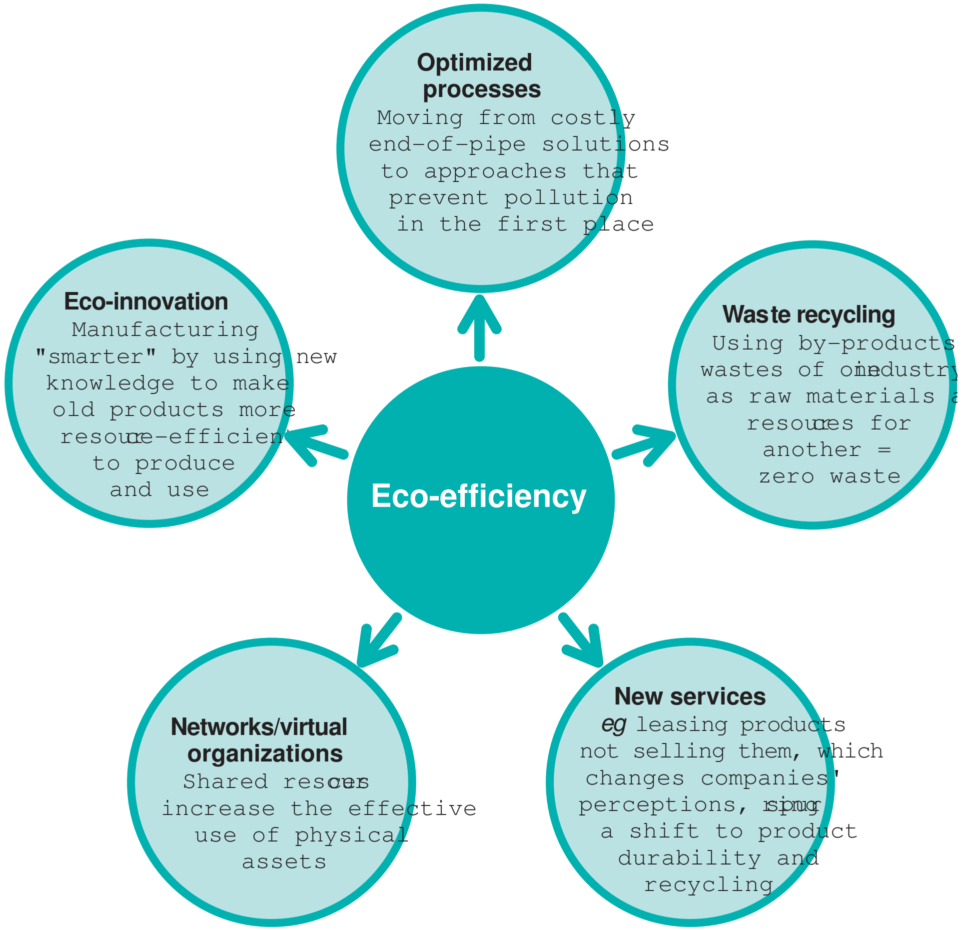


Source – BCSD Colombia

Structure

- Definition and drivers
- **The business case**
- Implementing
- Measuring and reporting
- Beyond eco-efficiency

Business case



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Example: Optimised processes

CEMEX
Building the future™

CEMEX Eco-efficiency Program (CEP)

– Program formally launched in 1994 to leverage experience and innovation in eco-efficiency
– Economic impact of 2000 performance

	$USM
• Optimised materials & natural resource use	9.2
• Use of alternative fuels & wastes	4.1
• Reduction of emissions & wastes	2.2
• Optimised energy use	19.3
• Office paper recycling	0.3
• **Total**	**$35.1M**

– Since 1994 benefits more than $60M
– CO_2 emissions reduced by about 2.5M tonnes

Example: Waste recycling

- Cevolution: new carbon fibers business for ConocoPhillips
  - Working to extend life cycle of crude oil production:
    - Using 'bottom-of-the-barrel' sludge in production of new fibers
      - Sludge previously considered a waste with handling and disposal costs
      - New fibers stronger, lighter and more durable

Example: New services

- Dow Chemical ‘leases’ chlorinated solvents in a closed-loop system instead of selling them:
  - Offers safe delivery and take-back of solvents
  - Provides customer assistance in product use

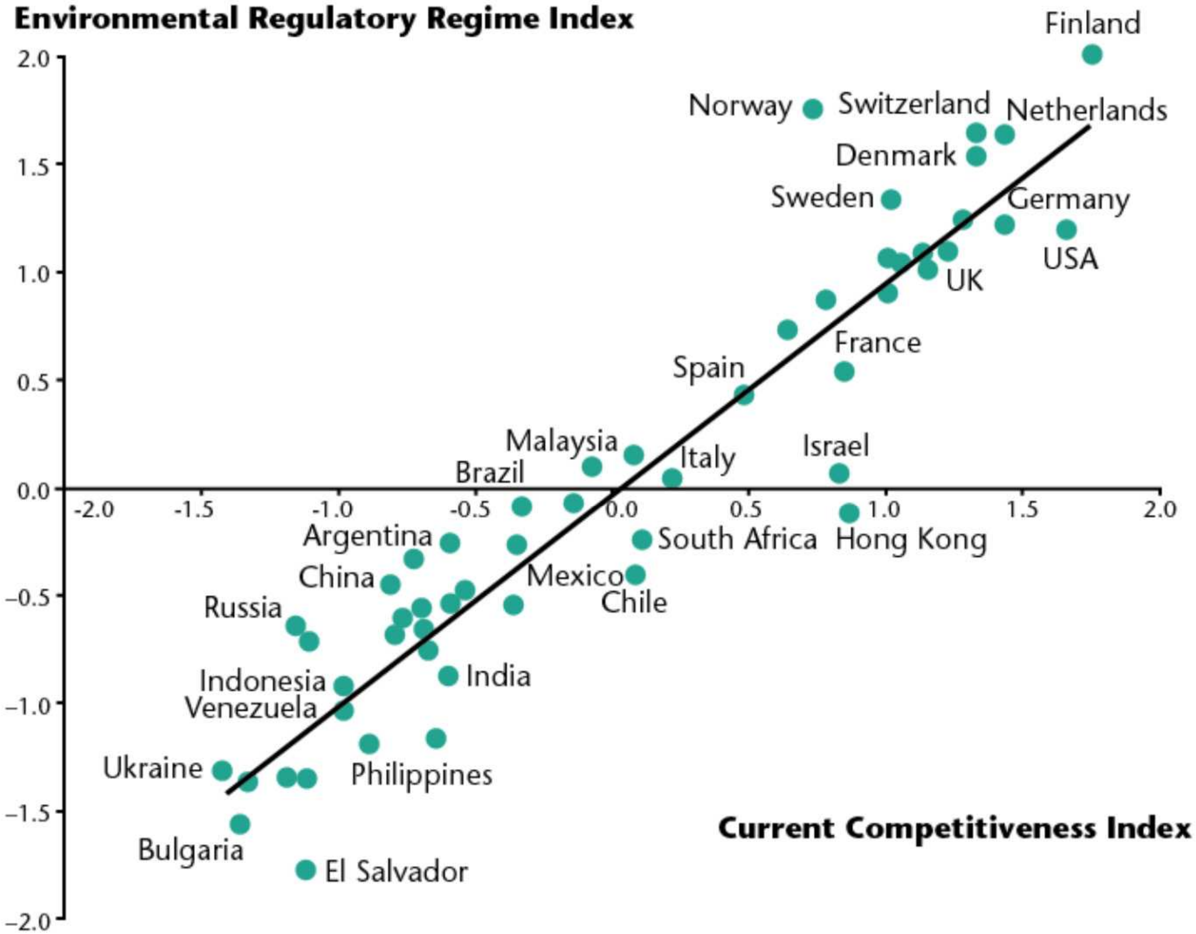
Example: Networks and partnerships

HYDRO

DaimlerChrysler

- Testing world's first hydrogen economy:
  - The 3 multinationals are teaming with the Icelandic consortium, Vistorka, to form Icelandic New Energy Ltd (INE). The INE group, comprising business, government and academic institutions, is looking to turn Arnason's dream into a reality and facilitate Iceland's transition from a fossil-based economy to a non-fossil-based economy
  - Idea to make the nation a testing ground for hydrogen vehicles and hydrogen refuelling infrastructure and producing hydrogen using electricity from renewable sources
  - Ultimately aims to make nation energy self-sufficient
  - While achieving Kyoto Protocol goals

Competitive advantage for nations



Source: D.C. Esty and M.E. Porter, "Measuring National Environmental Performance and its Determinants," *The Global Competiveness Report 2000*, Geneva: World Economic Forum

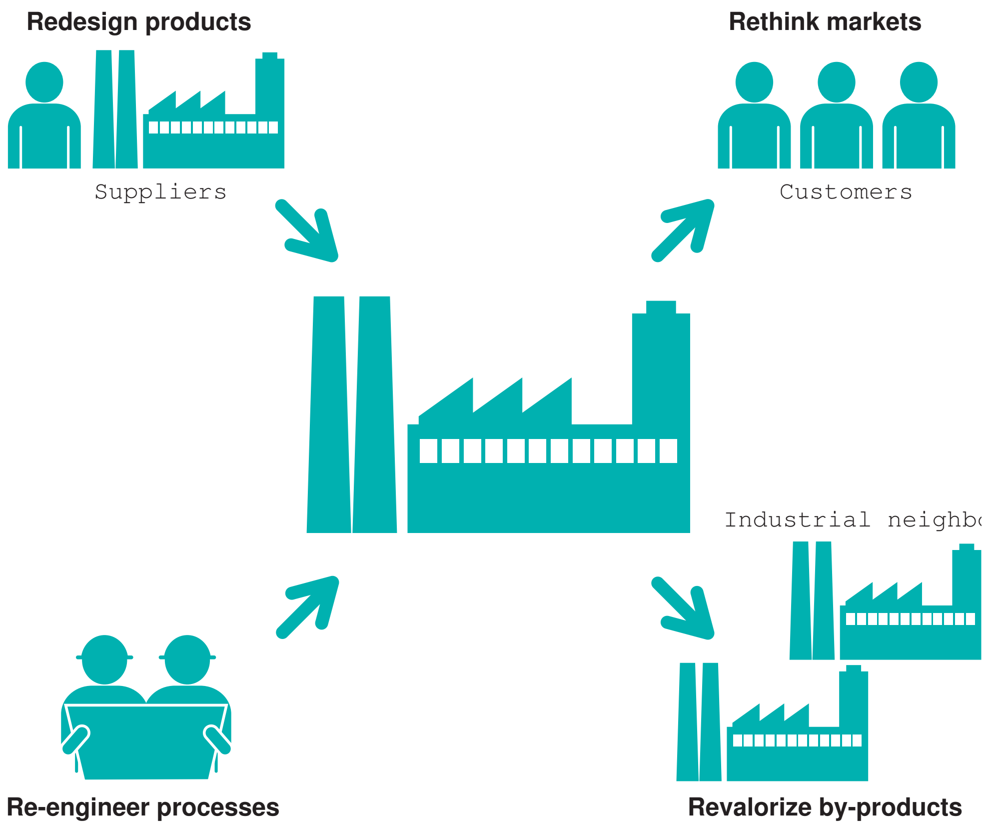
Structure

- Definition and drivers
- The business case
- Implementing eco-efficiency
- Measuring and reporting
- Beyond eco-efficiency

Explore entire areas within value chain for opportunities

Market Opportunities

- Know the customer
- Sell functional (rather than material) offerings
- Provide users with comprehensive solutions
- Create new businesses with add-on services
- Improve customers' eco-efficiency



Companies can identify business opportunities in eco-efficiency in four different areas.

Principle approach

Reduces material intensity

Energy intensity is minimized

Dispersion of toxic substances is reduced

Undertakes recycling

Capitalizes on use of renewables

Extends product durability

Service intensity is increased

Getting started in your company

- Understand the full life cycle of your products.
- Establish eco-efficiency as a prominent target and evaluation screen in your innovation process.
- Test your key technologies and markets against changing trends in societal acceptance.
- Set eco-efficiency measurements and targets for your current operations and products.
- Develop a communication concept including dialogues, partnerships with stakeholders, and others.
- Evaluate which business lines would benefit from planned resource-based economic instruments.
- Explore how you could mitigate negative impacts through product innovation.

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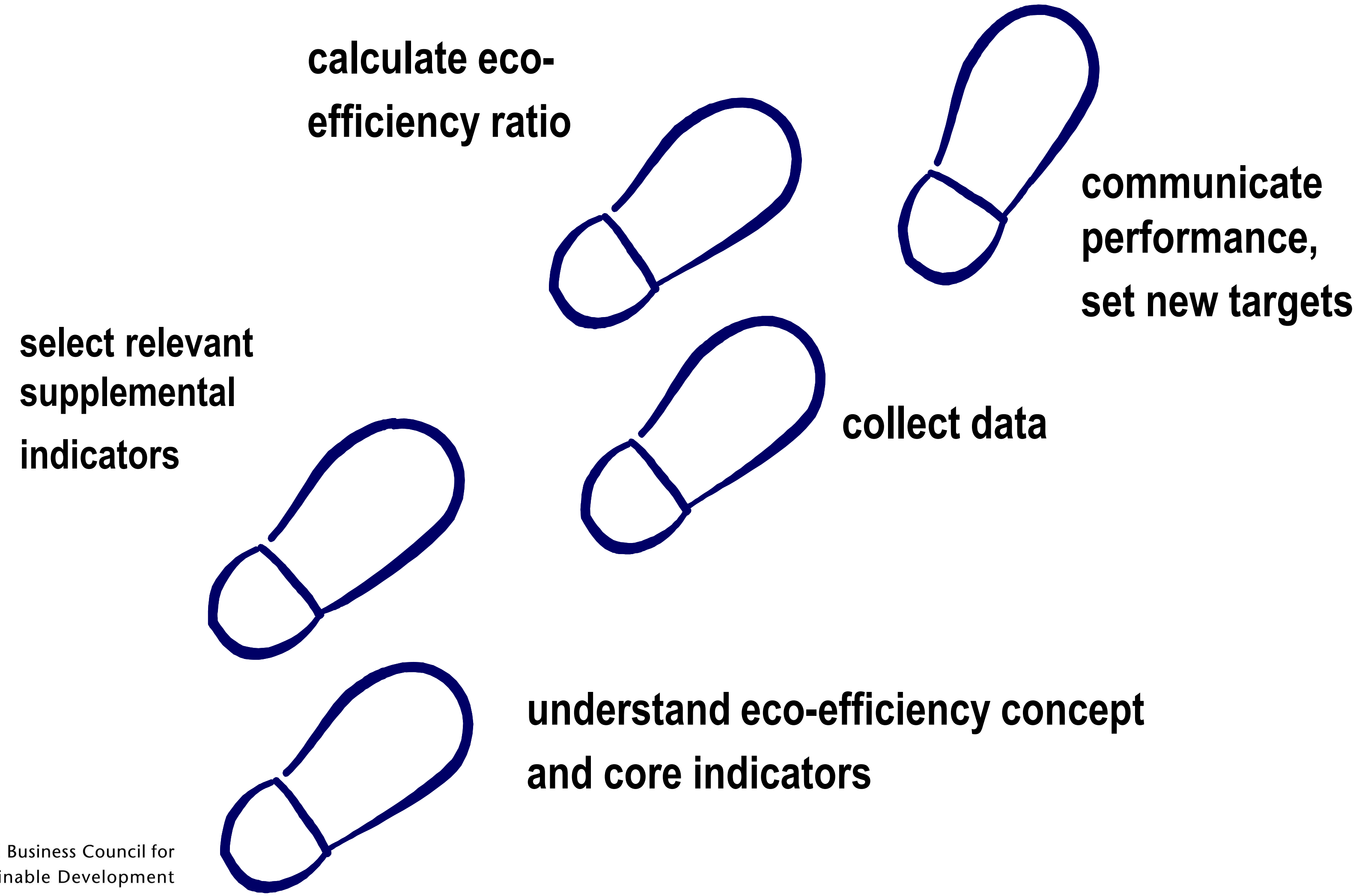
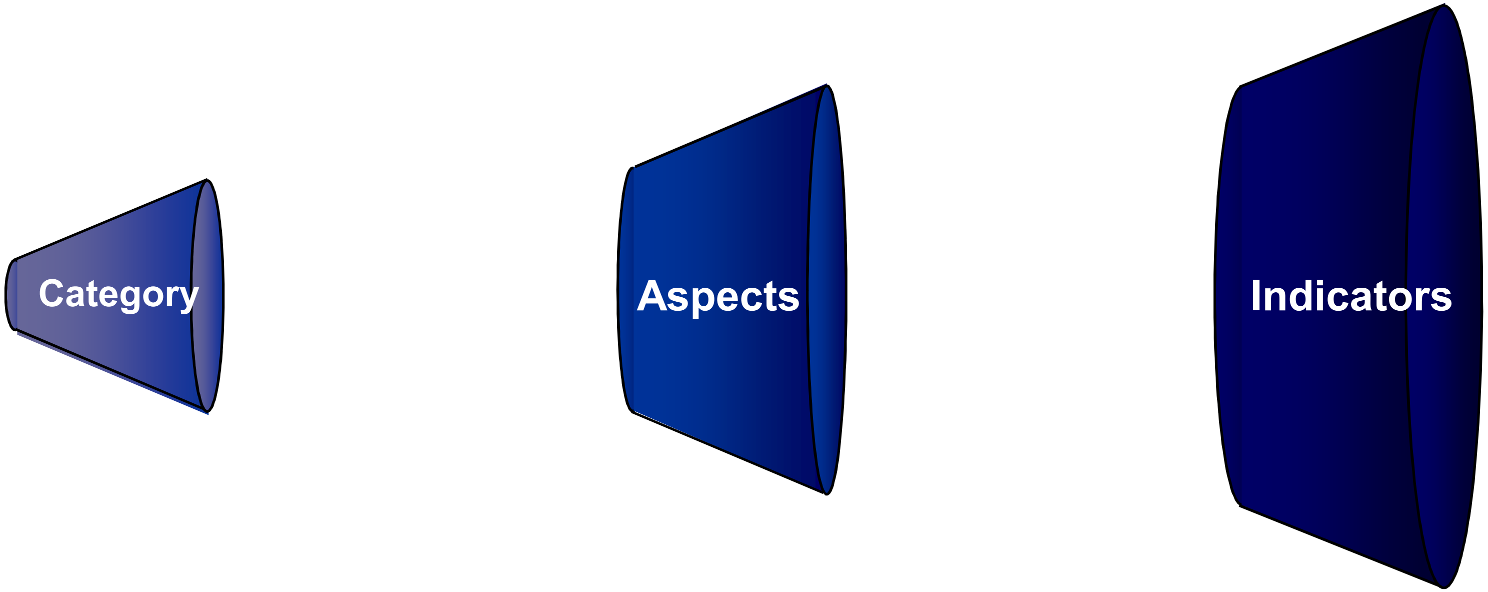
Steps to measuring and reporting



Selecting indicators

- be relevant and meaningful with respect to environment, health and welfare
- inform decision making to improve the performance of the organization
- recognize the inherent diversity of business
- support benchmarking and monitoring over time
- be clearly defined, measurable, transparent and verifiable
- be understandable and meaningful to identified stakeholders
- focus on areas under direct management control
- recognize upstream and downstream aspects of a company's activities

Eco-efficiency indicators framework

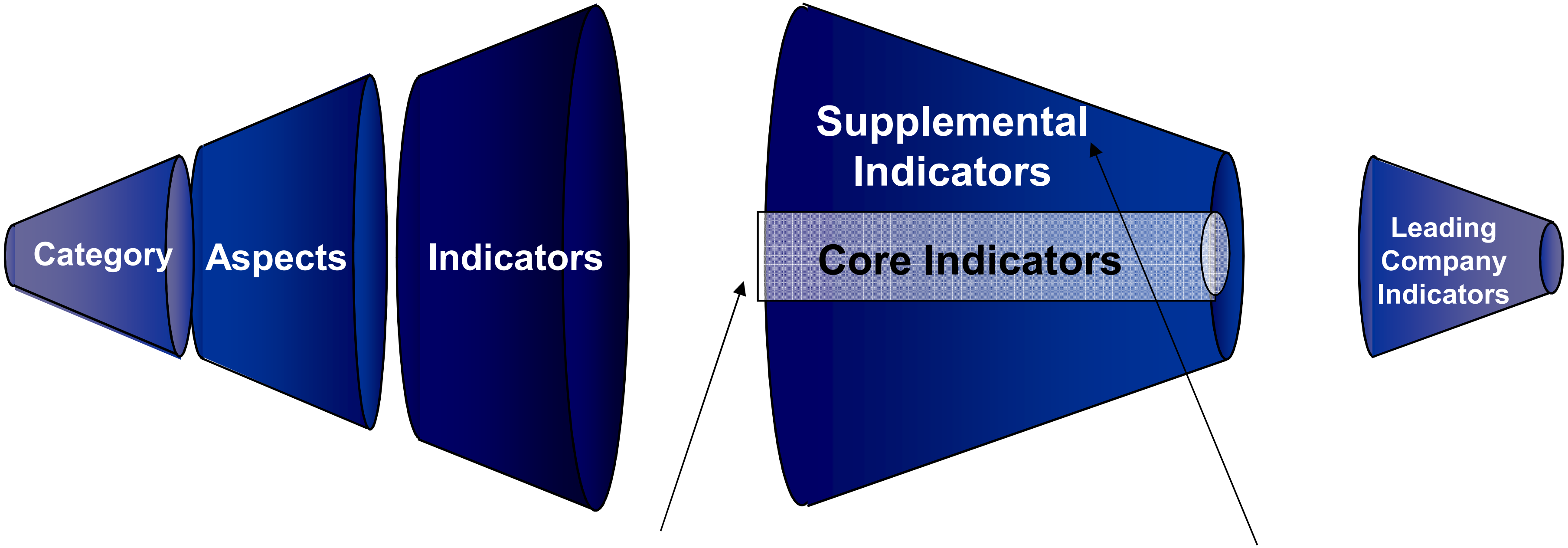


Multiply broad area of environmental influence or business value
e.g. environmental influence in creation of product

General information related to category (the "what")
e.g. material consumption, waste output

Specific measurement of aspect (the "how")
e.g. tonnes material consumed, tonnes CO_2 emitted

Eco-efficiency indicators - framework



Highly relevant and meaningful on global scale to virtually all businesses
e.g. energy consumption, GHG emissions

Will look different depending on sector, region, etc.
e.g. VOC to air, PHM to surface water

Calculating the eco-efficiency ratio

- **On the micro-level (company):**

$$\textbf{Eco-efficiency} = \frac{\textbf{product/service value}}{\textbf{environmental influence}}$$

- **On a macro-level (government):**

$$\textbf{Resource productivity} = \frac{\textbf{more welfare}}{\textbf{less resource use}}$$

Reporting eco-efficiency

Includes five elements:

- Organization Profile
- Value Profile
- Environmental Profile
- Eco-efficiency Ratios
- Methodological Information

$$EE = \frac{\text{product/service value}}{\text{environmental influence}}$$

Structure

- Definition and drivers
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- **Beyond eco-efficiency**

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Action points (1)

Government leaders & civil servants	Civil society leaders & consumers	Educators
• Set macro-economic EE targets • Integrate policy measures to strengthen EE (e.g. eliminating subsidies, internalising externalities, effecting shifts in tax policy) • Work toward international policy and systems for trade, financial transactions, etc. for higher productivity, emissions reductions and improvements for underprivileged	• Encourage consumer preference for more eco-efficient products and services • Support political measures to create framework conditions which reward EE	• Include eco-efficiency and sustainability in educational curricula and build into research and development programs

Action points (2)

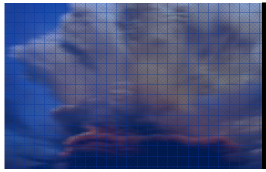
Financial markets & investors	Business leaders
• Recognize and reward eco-efficiency and sustainability as investment criteria • Help eco-efficient companies to communicate their progress • Promote and use assessment tools and sustainability ratings to support markets and widen understanding of eco-efficiency's benefits	• Integrate eco-efficiency into business strategy, including operational, product innovation and marketing strategies • Report company eco-efficiency and sustainability performance openly to stakeholders • Support policy measures which reward eco-efficiency • Foster eco-efficiency in supply chain, including SMEs

Limitations of eco-efficiency

- Lacks social side
  - Meant as a complementary tool within an SD corporate strategy
- Not a rigid framework or single strategy
- Not a certifiable standard
- Not an off-the-shelf solution
  - A flexible method to improve practices compatible with a variety of corporate strategies
  - Needs company-specific interpretation and implementation

Beyond eco-efficiency

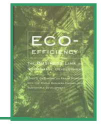
1. Innovate
2. Practice eco-efficiency
3. Move from stakeholder dialogues to partnerships for progress
4. Inform consumer choice
5. Improve market framework conditions
6. Establish the worth of Earth
7. Make the market work for everyone



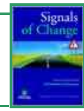
WBCSD work on eco-efficiency

1992-1997 Eco-efficiency

1995-1997 Environmental Performance & Shareholder Value



1997 Eco-efficiency: the business link to SD



1997 Signals of Change

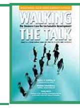
1996-2002 Sustainability through the Market

1997-2000 Eco-efficiency Metrics & Reporting

1998-2000 European Eco-efficiency Initiative

2000-2002 Sustainable Development Reporting

2001 The Business Case for Sustainable Development



2002 Walking the Talk

Take-away messages

- Eco-efficiency emerged as a logical approach for environmental and economical improvement
- Through examples and experiences presented here, companies continue to recognize the business case for eco-efficiency and capitalize on the opportunities

Understanding a life-cycle approach

Learning unit B: exploring eco-efficiency

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Did you know…

- Producing one ton of recycled steel saves the energy equivalent of 3.6 barrels of oil and 1.5 tons of iron ore, compared to the production of new steel?

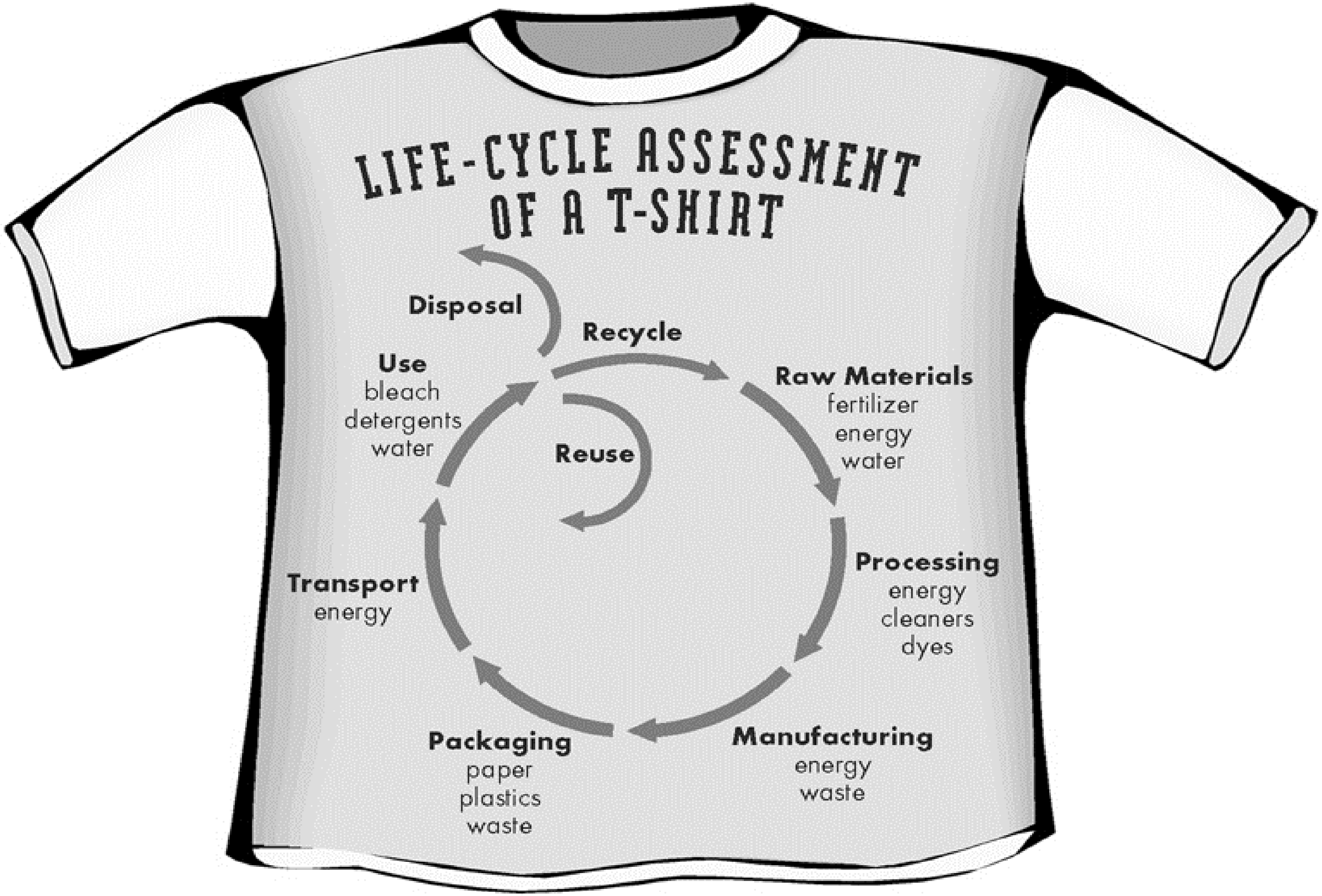
- Producing paper using a chlorine-free process uses between 20 and 25 percent less water than conventional chlorine-based paper production processes?

Learning objectives

- Recognize where products come from and where they go after use – *life-cycle*
- Think about a product's impacts on the environment and economy throughout
  - Qualify impacts
  - Quantify impacts

Structure

- Life-cycle – what is it?
- Choosing boundaries and shifting issues
- A life-cycle approach
- Life-cycle assessment – one tool
- Segue to life-cycle exercise



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Worldwatch Institute, Worldwatch Paper 166: Purchasing Power: Harnessing Institutional Procurement for People and the Planet, July 2003, www.worldwatch.org

Life-cycle stages

- Products can be evaluated through each stage of their life-cycle:
  - Extraction or acquisition of raw materials
  - Manufacturing and processing
  - Distribution and transportation
  - Use and reuse
  - Recycling
  - Disposal
- For each stage, identify inputs of materials and energy received; outputs of useful product and waste emissions
- Find optimal points for improvement – eco-efficiency

A life-cycle approach

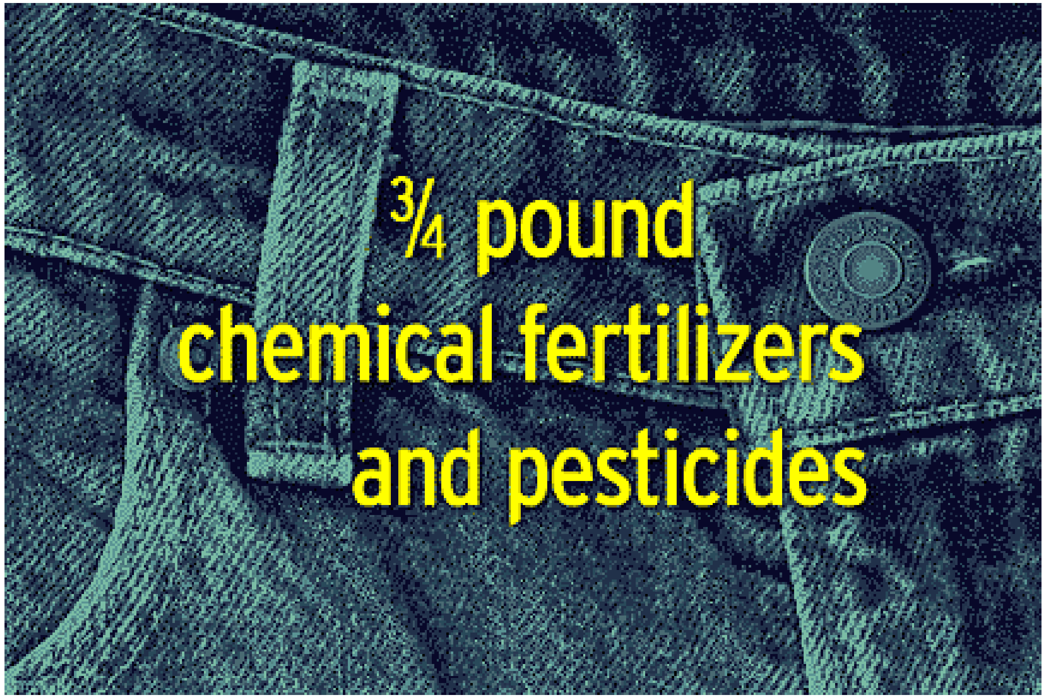
- Ensures companies identify the multiple environmental and resource issues across the entire life-cycle of the product

- Knowledge of these issues informs business activities:
  - planning, procurement, design, marketing & sales

- Rather than just looking at the amount of waste that ends up in a landfill or an incinerator, a life-cycle approach identifies energy use, material inputs and waste generated from the time raw materials are obtained to the final disposal of the product *

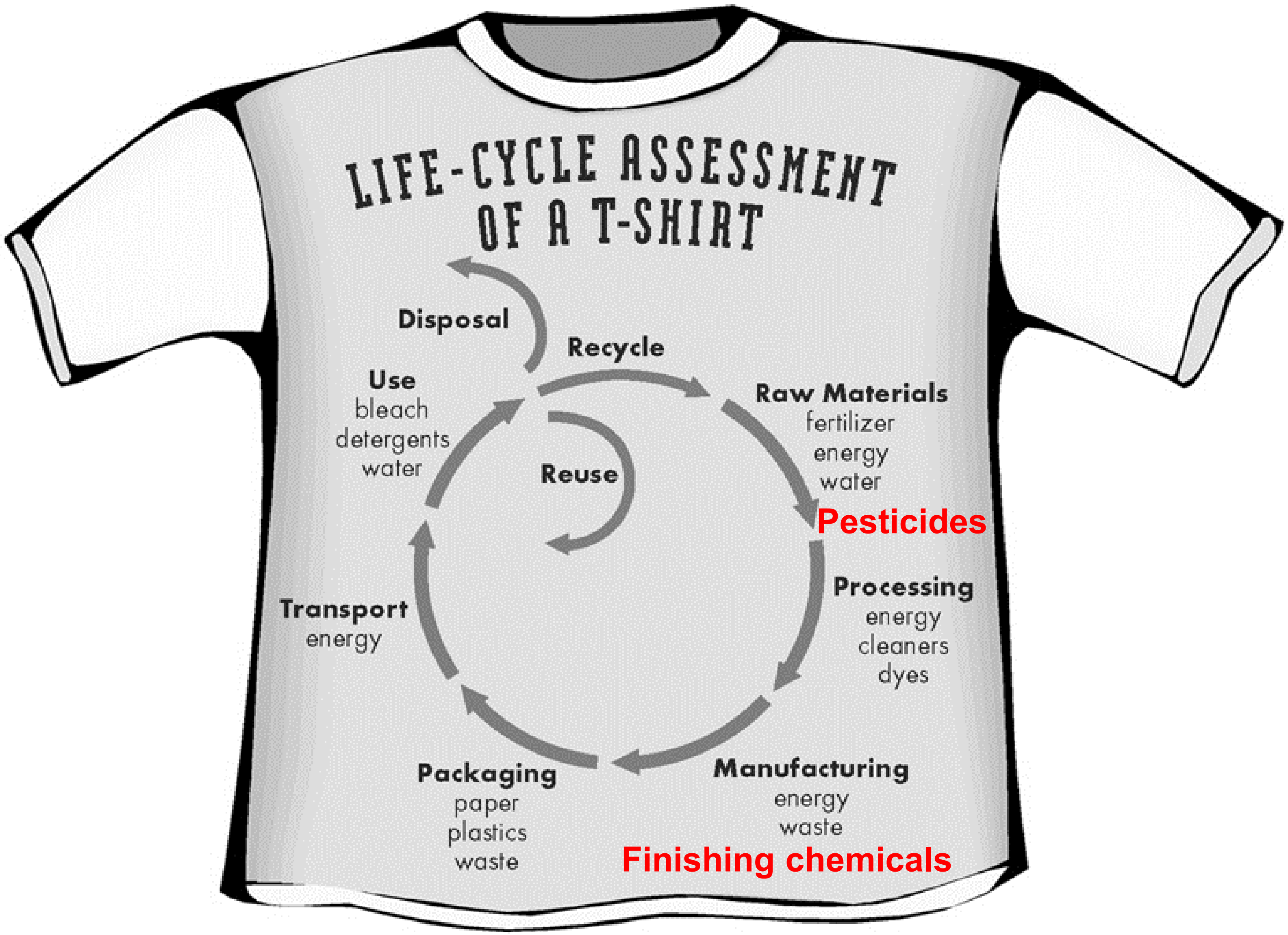
** Product Life-Cycle Analysis: Environmental activities for the classroom,*
Waste Management and Research Center, Champaign, IL, 1999

Identifying issues at each life-cycle stage



Estimated amount of synthetic fertilizers and pesticides it takes to produce the cotton for a conventional pair of jeans.

Source: “The Organic Cotton Site: Ten good reasons”



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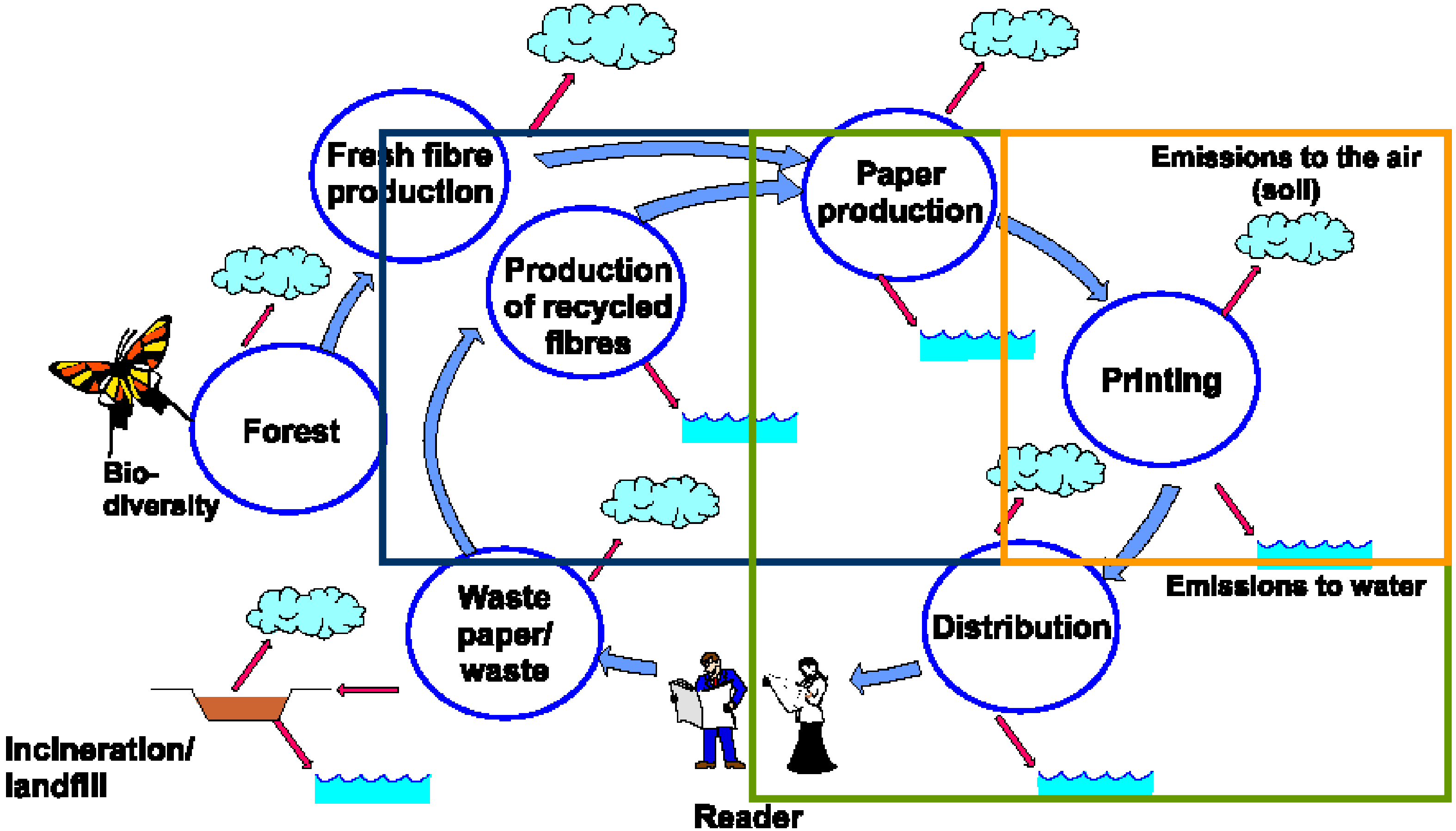
Worldwatch Institute, Worldwatch Paper 166: Purchasing Power: Harnessing Institutional Procurement for People and the Planet, July 2003, www.worldwatch.org

Life-cycle – identify the boundaries



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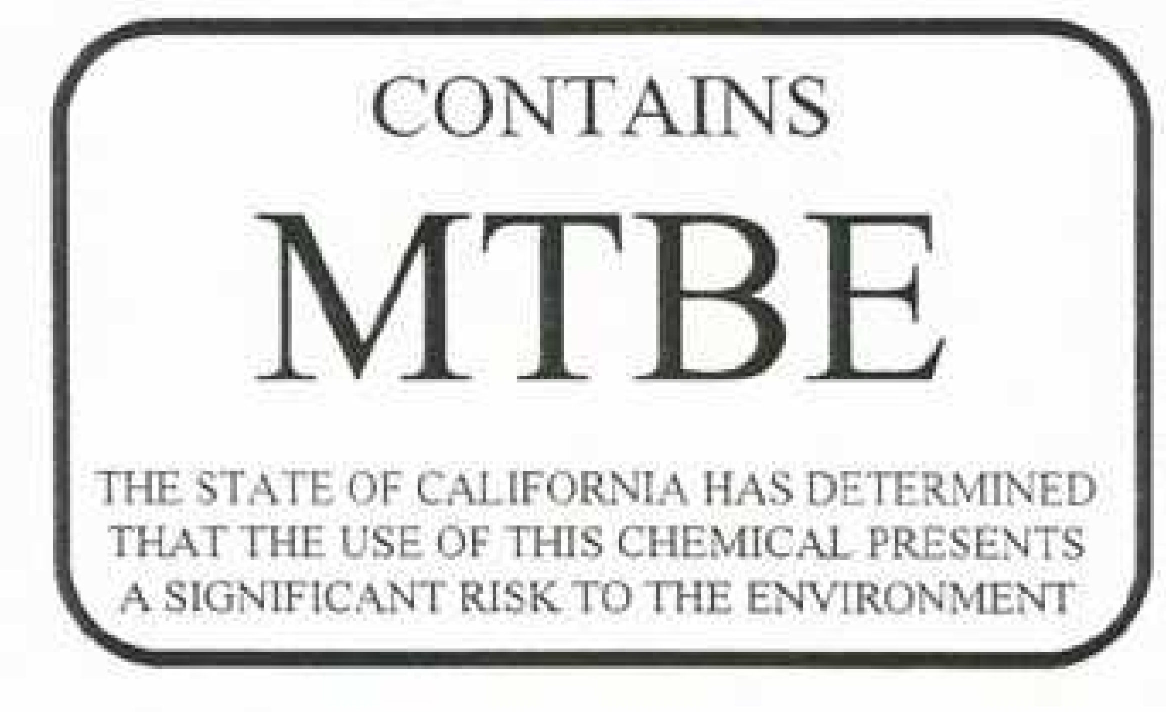
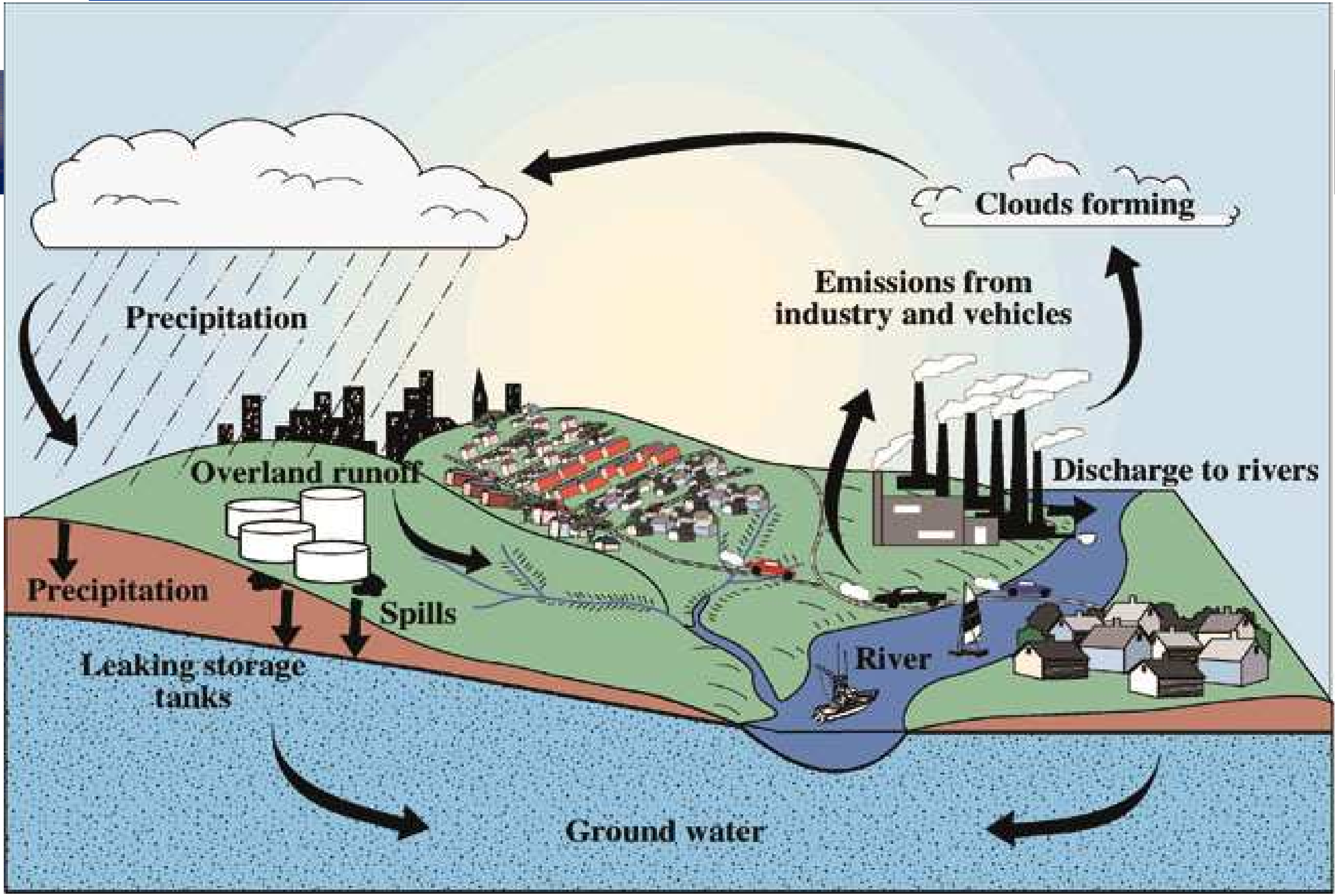
Life-cycle – helps avoid shifting the issues

- Looking at the entire life-cycle helps ensure reducing waste at one point does not simply create more waste at another point in the life-cycle
- Issues may be shifted – intentionally or inadvertently – among:
  - Processes or manufacturing sites
  - Geographic locale
  - Different budgets and planning cycles (first cost)
  - Environmental media – air, water, soil (MTBE)
  - Sustainability dimension: economic, social, environmental burdens
- Depends on “boundaries”
- Be conscious of what is shifted and to where!
- For example, MTBE…

Methyl tertiary butyl ether - MTBE

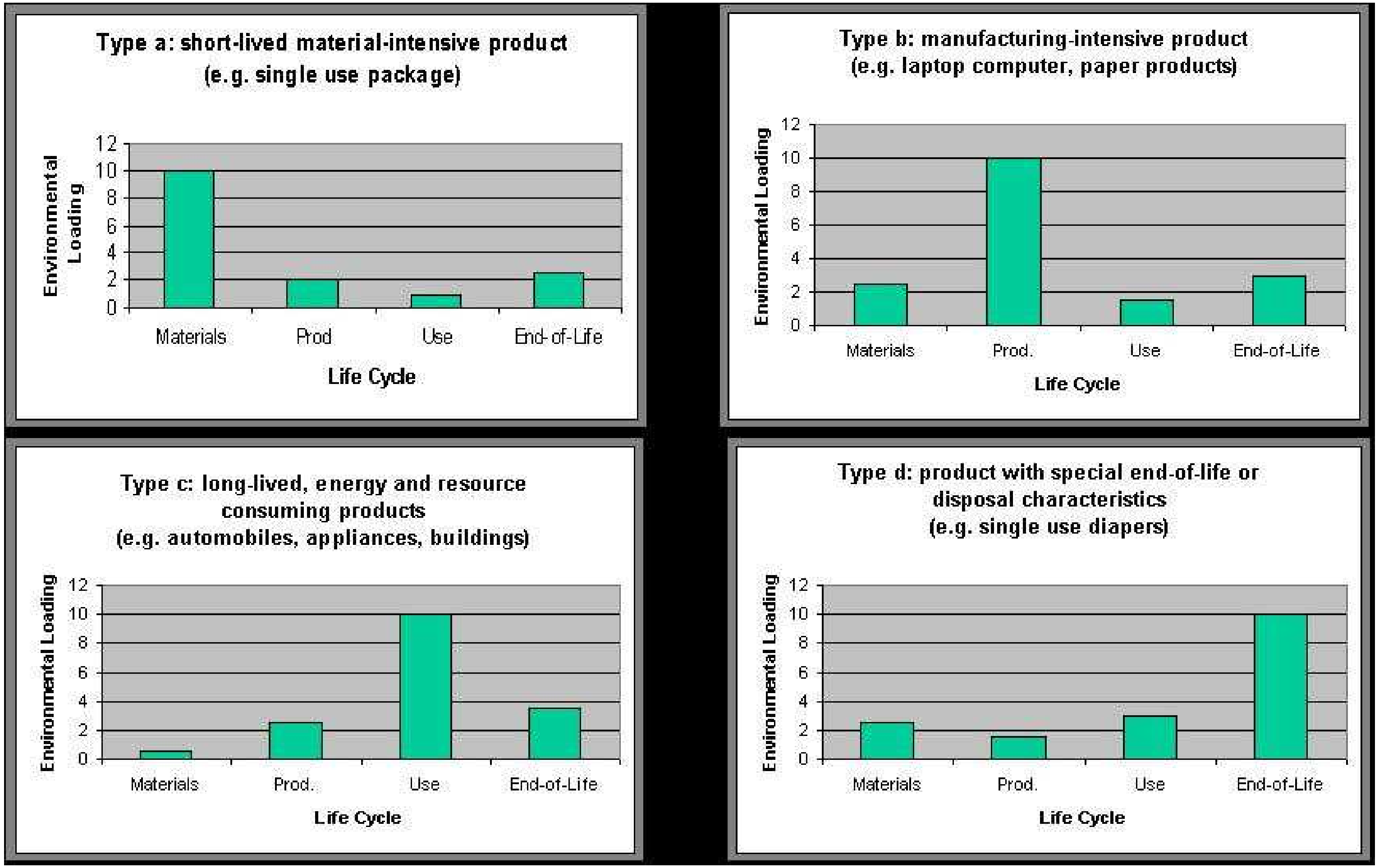
Methyl tertiary butyl ether - MTBE



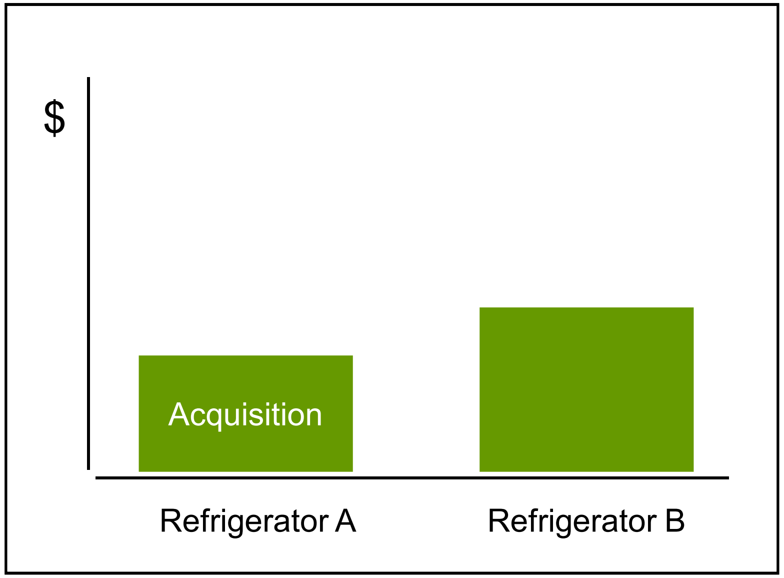


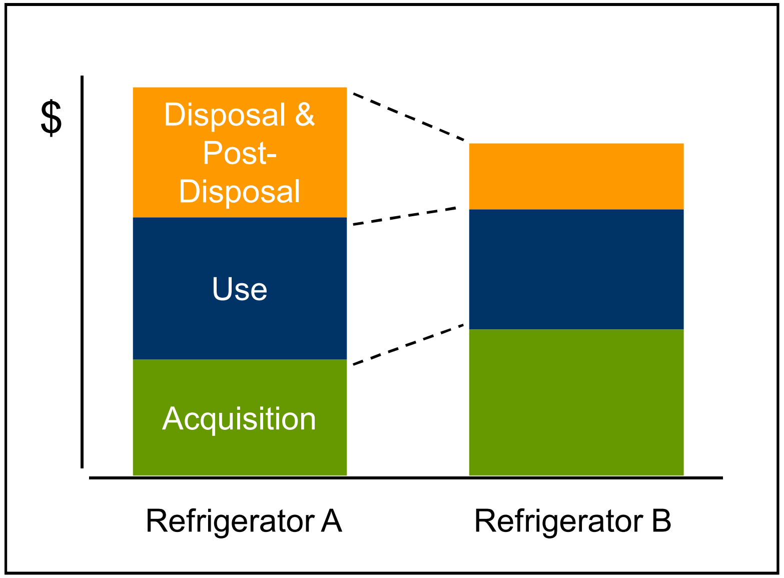
US Geological Survey, http://www.nwrc.usgs.gov/world/content/water1.html

Different products have impacts at different life-cycle stages



Life-cycle – identify issues and costs





Purchase Price

Refrigerator A appears cheaper

Price + Life-Cycle Costs

Refrigerator B costs less overall

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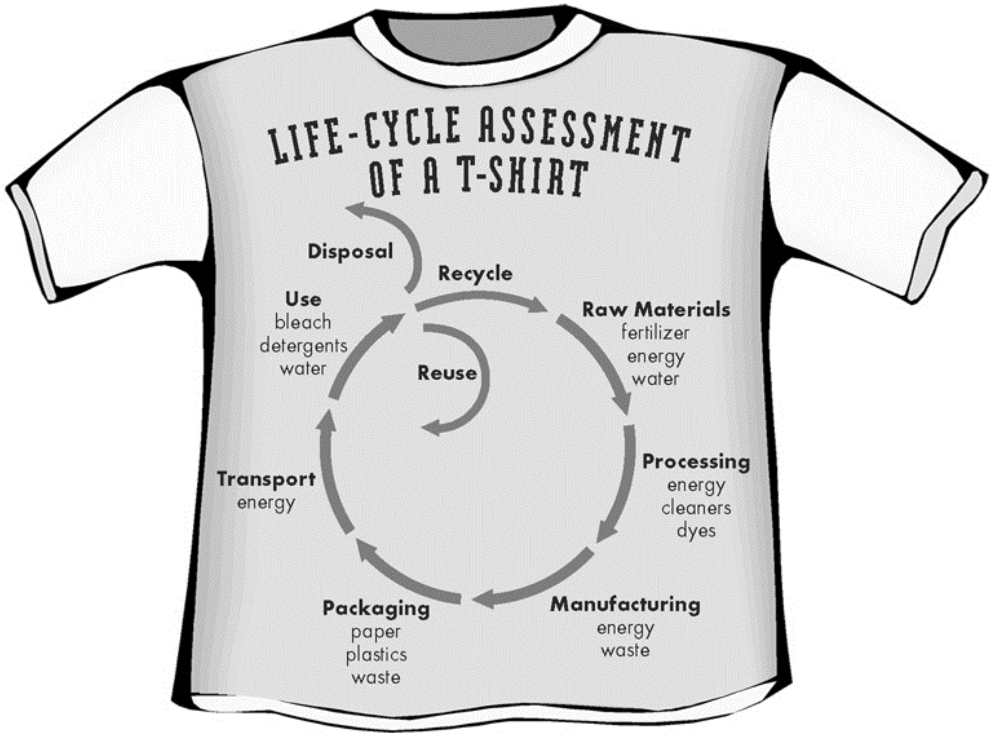
A life-cycle approach

- With a life-cycle approach, companies employ the tools they need to:
  - Reduce impacts across the life-cycle
  - Capitalize on opportunities for their business

- Tools range from simple mapping of life-cycle stages to comprehensive quantitative assessments

Life-cycle assessment

- LCA is a tool to systematically measure the environmental impacts associated with each stage of a product's life-cycle



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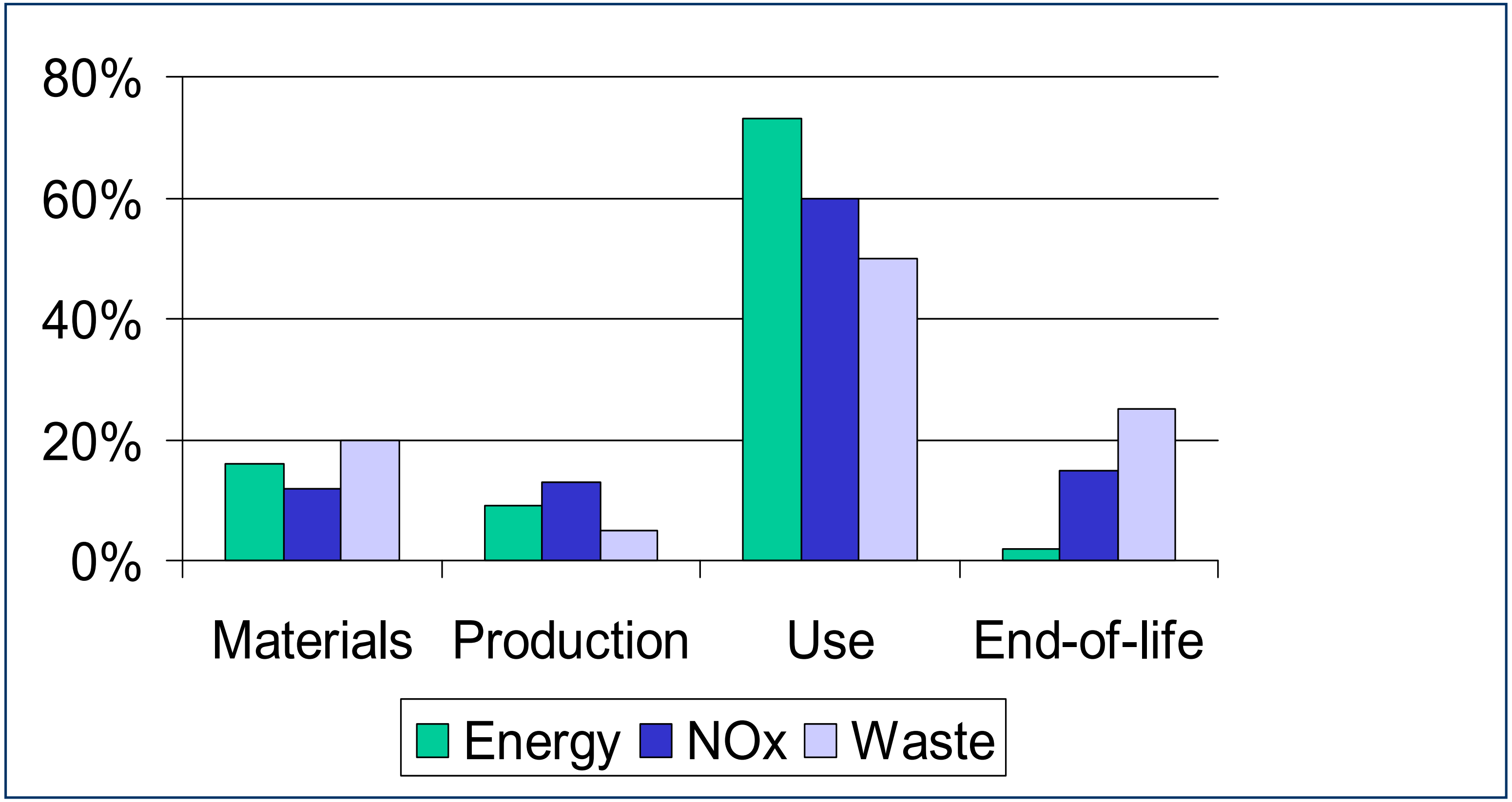
Life-cycle assessment

Assessment of relative impacts across life-cycle – 3 issues are included



Life-cycle assessment

- Two attributes make LCA distinct and useful as an analytical tool:
  - whole system consideration of the total product life-cycle
  - presentation of tradeoffs among multiple environmental issues

- LCA is quantitative

How to do LCA

1. Determine scope and system boundaries
   - functional unit
   - life-cycle stages
   - define “unit processes”
2. Data collection
3. Analysis of inputs and outputs
4. Assessment of numerous environmental issues
5. Interpretation
   - LCA principles and framework are standardized by the Organization for International Standardization’s 14040 series of standards (ISO14040)

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Conclusions – why take a life-cycle approach?

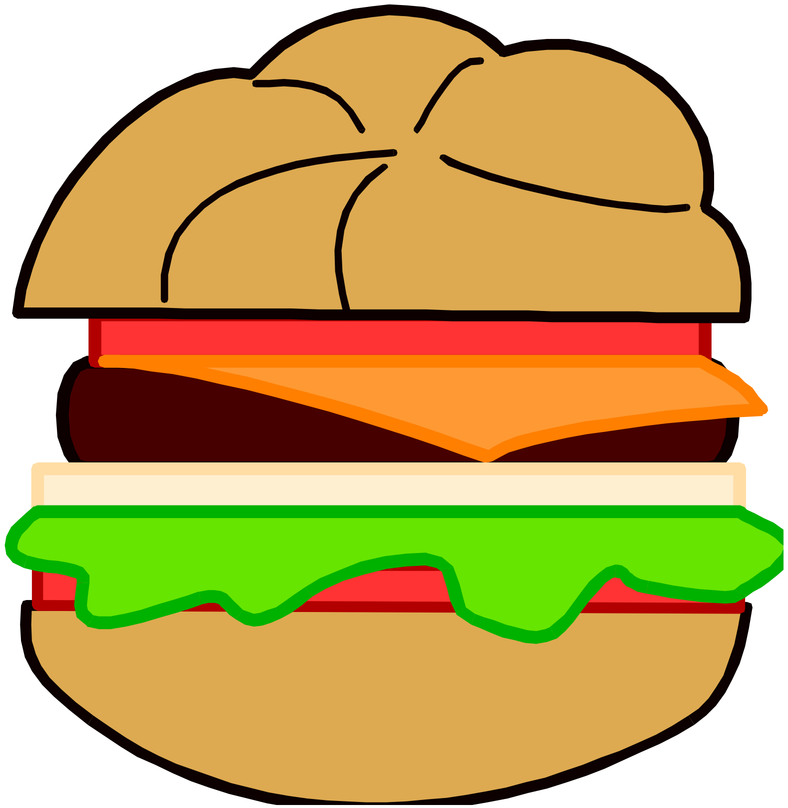
- Systems perspective
- Integrates environment into core business issues
- Efficiency
- Innovation
- Better return on investment – identify point of "biggest bang for the buck" *
- Engage stakeholders – investors, customers, employees
- Environment is not a cost center for the company, but a business opportunity

* www.ciwmb.ca.gov/EPP/LifeCycle/default.htm

Conclusions – why take a life-cycle approach?

- Systems perspective
- Integrates environment into core business issues
- Efficiency
- Innovation
- Better return on investment
- Engage stakeholders
- Environment is not a cost center for the company, but a business opportunity
  - Look beyond the company's gate
  - Expose trade-offs and and opportunities
  - Expand analysis of products, projects, policies and programs – what is the function, what are the boundaries, what are the impacts, where are the opportunities?

Hamburger exercise – life-cycle stages, inputs, outputs and issues …



Eco-efficiency tool box

Learning unit C: implementing eco-efficiency

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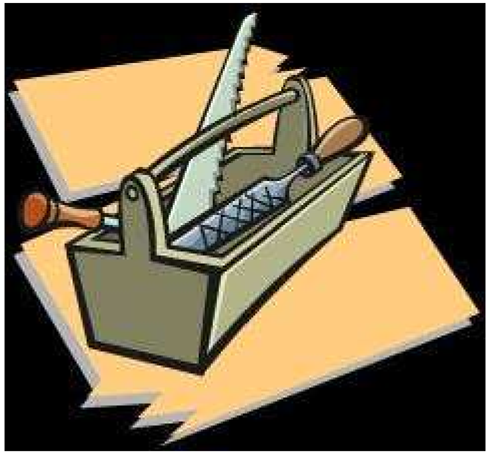
Learning objectives

- Become familiar with existing tools and emerging tools and what they do
- Learn a few of the tools in further detail
- Recognize how a particular tool may be applied (or adapted) within different business decisions

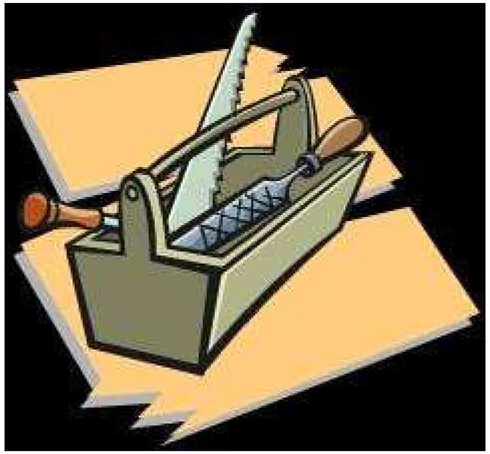


Structure

- Overview
- Description of common tools
- Quiz
- Responses
- Discussion

Tools for eco-efficiency

- Sustainability mindset has led to an explosion of concepts and tools
- Academics, NGO's, consultants, industrial researchers all working on solutions
- Result is a proliferation of tools with some overlap
- This can create confusion in the marketplace of ideas – but this is understandable – living in a beta/VHS/DVD/digital world – the winning approach is evolving



Labeling concepts and tools may be an impediment – the key is to understand the problem you are trying to solve and select the appropriate tool for the job and/or modify tools as needed

Typical tools for implementing eco-efficiency

- Organizational/Management
  - Environmental Management Systems
  - Stakeholder Engagement
  - Corporate Environmental Reporting
  - Life-Cycle Management

- Product Design & Development
  - Design for Environment
  - Eco-Efficiency Analysis
  - Life-Cycle Assessment
  - Environmental Risk Assessment
  - Integrated Product Policy (IPP)

- Suppliers/Purchasing
  - Environmental Supply Chain Management
  - Green Procurement

- Marketing and Communications
  - Corporate Environmental Reporting
  - Eco-Labelling
  - Stakeholder Engagement

- Production & Distribution
  - Eco-Efficiency Analysis
  - Industrial Ecology
  - Pollution Prevention
  - Life-Cycle Costing

- Facilities Management/Project Development
  - Green Building Design
  - Environmental Impact Assessment
  - Environmental Management Systems
  - Stakeholder Engagement

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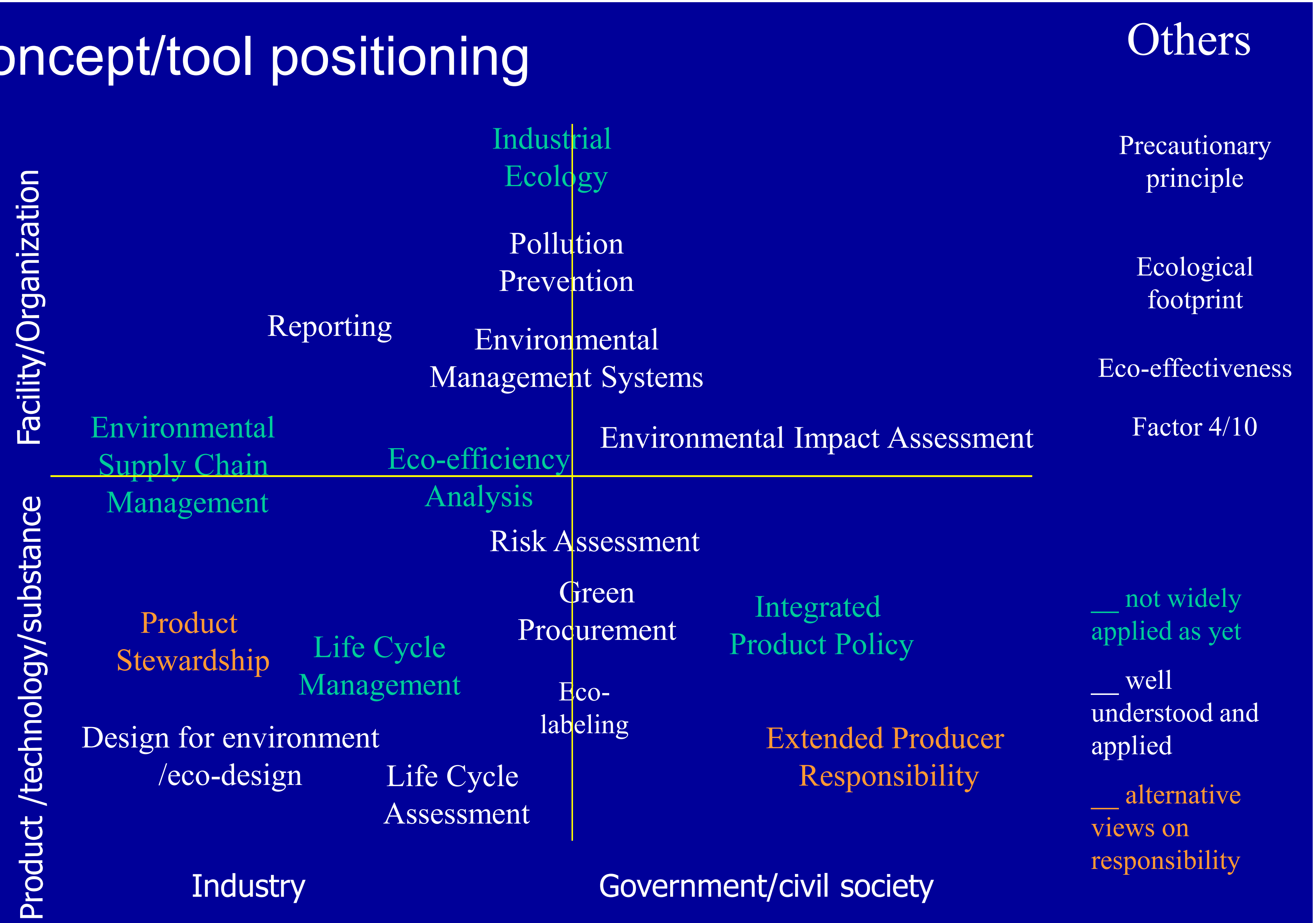
- Note - Some tools cross over (e.g., eco-efficiency analysis and stakeholder engagement could apply across all functions)

Concept/tool positioning



Source: Pollution Probe - Environmental Sustainability Policy Framework Project

Observations on the tool box

- Adoption of tools being driven by:
  - Market factors (e.g. EMS in automotive, labelling)
  - Stakeholder expectations (e.g. reporting, stakeholder engagement)
  - Regulatory influences (e.g. pollution prevention, ERA, EIA)
  - Internal business factors including efficiency, cost reduction, innovation (e.g. DfE, LCA, Green Building Design)
  - Combination of the above (e.g. procurement, eco-efficiency)
- Tool box varies for different parts of value chain
- Culture, drivers, strategy, awareness all factors in adoption and depth of integration in organizations
- Tools apply at different levels (corporate, operational, product) and selection is specific to the organization
- Many tools have inherent value judgments and users need to be aware of this (e.g. eco-labels can reflect values of those who develop the selection criteria)

Business case

- Innovation – the application of a number of tools (DfE, LCA, Eco-efficiency Analysis) fosters development of new or alternative project, product or technology designs
- Improved stakeholder relations through better communication internally and externally around environmental issues, performance, projects and management practices
- Strengthened brand image and reputation as seen by regulators, the public, peers, employees and other stakeholders who recognize the value of the company's environmental efforts
- In many cases there is a clear and measurable reduction in operating costs
- Many companies attribute increased sales to the use of these concepts and tools
- Indirect savings are realized through the avoidance of environmental risk

Eco-efficiency tool box

Descriptions of common tools

Life-Cycle Assessment (LCA)

- A decision-making tool to identify environmental burdens and evaluate the environmental consequences of a product, process or service over its life-cycle from cradle to grave
  - standardized by the International Organization for Standardization
  - forms the conceptual basis for a number of management approaches that consider a product across its life-cycle, covering resource acquisition, product manufacturing, product use, and end-of-life

LCA – key elements

- Consideration of multiple life cycle stages
  - the physical sequence of operations in a product system, cradle-to-cradle or earth-to-earth
  - the primary stages are materials acquisition and processing, manufacturing, use and end-of-life disposal
  - within each of these stages, sub stages or unit processes are defined
- Consideration of multiple environment and resource issues
  - LCA studies expose trade-offs by analyzing significant inputs from the earth and outputs to the environment across the various life-cycle states
- An assessment or interpretation of the significance of the results
  - can vary from aggregation of data into a set of simple indicators to the consolidation of the data into a core set of indicators using a variety of weighting or scoring methods

When to apply LCA

LCA can help decision-makers to:

- Identify unintentional impacts of actions (e.g. upstream GHG emissions that may offset perceived benefits of a new technology)
- Ensure consideration of all environmental media across the life-cycle (e.g. equal consideration of emissions to air, water and land during project construction, operation and decommissioning)
- Avoid shifting problems from one life-cycle stage to another, from one geographic area to another and from one environmental medium to another (e.g. ensuring an air pollution mitigation measure does not create a water pollution problem elsewhere in the system)
- Identify opportunities to improve the environmental and economic performance of the technology, project, product or service in question (e.g. identifying "hotspots" that need to be addressed)
- Communicate more effectively with stakeholders on the system wide consequences of project or technology options (e.g. to communicate full impacts and/or benefits of changes to a product system)

Design for Environment (DfE) or Eco-design

- The integration of environmental considerations into product and process design
  - Fundamental to DfE is the use of tools and practices that encourage environmental responsibility and simultaneously reduce costs, promote competitiveness and enhance innovation
  - DfE practices are meant to develop more environmentally compatible products and processes while maintaining (and in some cases even exceeding) price, performance and quality standards

DfE - key elements

- Selection of low-impact materials
- Reduction of energy use
- Optimization of production techniques
- Optimization of distribution system
- Reduction of use phase impacts
- Optimization of initial lifetime
- Optimization of end-of-life system

- In addition, designers are encouraged to produce products which lead to less material use (e.g. dematerialization), to pursue shared product use (e.g. car clubs or rental services), to integrate product functions (e.g. combined scanner, printer, copier, fax), and to optimize functions (e.g. better design to reduce over packaging)

When to apply DfE/eco-design

- At the front end of the product development process (e.g. at the planning and conceptual design phase)
- Often the design strategies are informed by prior analytical work on the life cycle cost and environmental impacts of the previous generation of products
- In innovation processes DfE may be used to inform product design (e.g. material selection) through the use of design checklists

Environmental labelling

- A broad range of activities ranging from business to business transfer of product specific environmental information to environmental labelling in retail marketing

- The overall goal of eco-labelling is to encourage the demand for, and supply of, products and services that are environmentally preferable through the provision of verifiable, accurate and non-deceptive information on environmental aspects of products and services

Types of labelling

- “Seal of approval” eco-labelling programs through product category definition, development of award criteria and product evaluation
- Self-declaration eco-labels are based on a manufacturer’s self-declared claim about a product’s environmental performance
- Product declarations are informational labels that provide environmental data and information on a variety of measures or indicators

When to apply eco-labelling

- When communicating the environmental performance of the product or service is of value to customers or other important stakeholders
- The choice of which type of label to use should be informed by an understanding of your customer/stakeholder information needs
- Receiving or creating the label may involve a considerable amount of data collection

Cleaner production/pollution prevention

- The continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase eco-efficiency and reduce risk for humans and the environment
  - For processes, cleaner production includes conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes before they leave a process
  - For products, the strategy focuses on reducing impacts along the entire life-cycle of the product, from raw material extraction to the ultimate disposal of the product

Source: *Cleaner Production*, UNEP Industry and Environment, UNEP 1994

Cleaner production – key elements

- Cleaner production is a broad term encompassing the following concepts:
  - Waste minimization and avoidance
  - Pollution should be prevented or reduced at the source whenever feasible
  - Environmental management
  - Substitutions for toxic and hazardous materials
  - Process and product modifications
  - Internal reuse of waste products

When to apply cleaner production

- When the company has set a strategic direction to improve the overall eco-efficiency performance of its products and processes

- Adopting a cleaner production approach involves considerable adjustment to decision-making across a range of business processes and functions

Green procurement

- The procurement of goods and services that have less impact on the environment (e.g. conserve energy, reduce waste, etc.) than other products or services meeting similar performance requirements

Green procurement – key elements

- Incorporate environmental considerations as part of the normal purchasing process
- Incorporate pollution prevention principles early in purchasing process
- Examine total multiple environmental impact throughout the product and service's life-cycle
- Environmental impacts should be compared when selecting products and services
- Comprehensive, accurate and meaningful information about the environmental performance of products and services should be collected in order to facilitate environmentally sound decision-making

When to apply green procurement

- When there is a clear opportunity to reduce risks, integrate broader cost considerations or leverage environmental performance through procurement

- Pursuing green procurement may involve adjusting tendering processes, altering contract language, training procurement officers and developing evaluation criteria and tools

Environmental supply chain management

- A range of detailed environmental requirements companies (in particular manufacturers) are placing on their suppliers, including Environmental Management Systems and Design-for-Environment programs, restricted material lists, component take-back commitments, requests for life-cycle data and performance disclosures

ESCM – key elements

- Environmental supply chain programs are aimed at achieving:
  - Improved efficiency of energy
  - Appropriate materials – ensuring the supplier uses environmentally appropriate materials
  - Clean production – ensuring the supplier has safe and clean production practices in place
  - Optimize distribution and logistics to reduce environmental impact and cost
  - Responsible use – ensuring the “buyer” understands how to use the product or material responsibly
  - End-of-life stewardship – where the supplier takes back their product at the end of its useful life

When to apply ESCM

- ESCM is most important when the suppliers' product or service is an integral component of your product or service (e.g. automotive supplier that provides entire subsystems of an automobile or contract manufacturers in the apparel industry)

- Implementing ESCM may involve the development of evaluation and auditing procedures for existing suppliers as well as screening criteria for potential new suppliers

- Many companies form partnerships with key suppliers to improve eco-efficiency performance as it is in both their interests

Environmental Management System (EMS)

- The organizational structure, responsibilities, practices, procedures, processes and resources for implementing and managing an organization's environmental affairs while ensuring conformity to its policies, standards and stakeholders' expectations

EMS – key elements

- The foundation of an EMS includes:
  - Purpose – an organization should have an identifiable purpose, which is usually stated as its goals and objectives and encapsulated in the organization's environmental policy
  - Commitment – there should be a sense of commitment and accountability among the people in the organization with respect to taking the appropriate action in support of the EMS
  - Capability – the organization should have the necessary resources (human, physical and financial) as well as the knowledge and skills to achieve the organization's environmental policy
  - Learning – the organization should strive to continuously learn to improve its own management and learning processes through monitoring and measurement of environmental performance, efficient internal and external communication as well as review of the EMS by senior management

When to apply EMS

- When the systematic management of environmental issues is 1) of importance to customers, 2) critical to your business success, or 3) required to ensure common awareness and performance across your organization

- While there has been an increased awareness of EMS due to the creation of the international standard on EMS (ISO 14001) it is important to understand there are a variety of EMS's in use by industry such as Responsible Care in the chemical industry, the EU standard EMAS (Eco-audit and Management Scheme) and others

- Typically implementing an EMS requires: management commitment, active engagement and training at all levels of the organization, open communication with regulatory agencies, in-depth aspects and impacts assessment and energetic EMS champions

Life-Cycle Management (LCM)

"A flexible integrated framework of concepts, techniques and procedures to address environmental, economic, technological and social aspects of products and organizations to achieve continuous environmental improvement from a life-cycle perspective"

Source: *Life Cycle Management: Definitions, Cases Studies and Corporate Applications*. Society of Environmental Toxicology and Chemistry (SETAC), Working Group on Life Cycle Management.

LCM – key elements

- Understanding full product system
- See outside traditional boundaries
  - Beyond gates, after sales
  - Beyond compliance
- Determine drivers
- Take responsibility
- Manage it as a business initiative – integrate into business decision-making processes

When to apply LCM

- When you want to better understand the business risks and opportunities of upstream and downstream aspects of your activities and are ready to integrate consideration of these risks and opportunities into core business processes and functions

- Integrating life-cycle management considerations can involve applying a range of tools (e.g. LCA, DfE) but more importantly involves ensuring the organizational decision-making processes and measurement systems reflect and integrate life-cycle considerations (e.g. managers are responsible and accountable for ensuring life-cycle aspects of decisions are considered and acted on)

Environmental Impacts of electronic products

Dr. Bernd Kopacek, MSc.

Do electronic products influence our environment?

Bernd Kopacek

Environmental Impacts (1)

- Google pays 50 million € per year for electricity
- Only for the operation of computing centers about 14 large power plants with a capacity of 1000 MW each are needed worldwide. This is equivalent to nearly 100 power plants „Freudenau“ in Vienna with 145 MW each.
- More than 1000 hazardous substances are used to manufacture electronic products.

Environmental Impacts (2)

- Shortages of water supply in the Silicon Valley caused by increased chip production
- 2009 more than 12 million tons of electronic scrap occured with the EU27
- 2010 more than 300 million computers and monitors will be exchanged in the US alone
- More than half of the obsolete IT will be exported to China and India

How do legislators react?

Legal Framework EU

- **WEEE** (Waste from Electrical and Electronic Equipment)
- **RoHS** (Reduction of Hazarduous Substances)
- **EuP** (Energy using Products)
- **REACH** (Registration, Evaluation and Authorisation of Chemicals)
- ....

WEEE - Directive

- **Producer (=Importer) has been made responsible for the total life cycle**
- **4 kg WEEE per inhabitant per year has to be collected from private households** (Rev: 65% of the average weight of EEE placed on the market over the last 3 years or 85% of WEEE generated)
- **Recycling and recovery quota for 10 different product categories** (Rev: +5%)
- **Obligations for treatment, reporting and information**

RoHS - Directive

- Ban of hazardous substances since July 2006
  - Lead
  - Mercury
  - Cadmium
  - hexavalent Chromium
  - brominated flame retardants (PBB, PBDE)

- Exceptions for certain applications!

EuP - Directive

- Defining Ecodesign-requirements for Energy using Products (EuP)
- For all products that use electricity, fossile fuels or renewable energies to funtion properly
- Exempted are vehicles for the transport of passengers or goods
- Conformity will be checked in the framework of the CE marking by a declaration

EuP - Directive

- Framework Directive
  => the real requirements and criteria will be defined in „implementing measures“ for each product group
- The following criteria are valid for defining implementing measures:

  - significant volume of more than 200.000 products sold or traded per year within the EU
  - the product has a significant environmental impact
  - the EuP shall present significant potential for improvement in terms of its enviuronmental impact without entailing excessive costs

REACH - Directive

- The REACH-Directive deals with the **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emical substances since July 2007

- The following stakeholders are affected by the REACH-Directive
  - Producer and importers of chemical substances
  - Professional users of chemicals (Downstream user)
  - Traders of chemicals

REACH - Directive

- From June 2008 the following chemical substances must be registered:

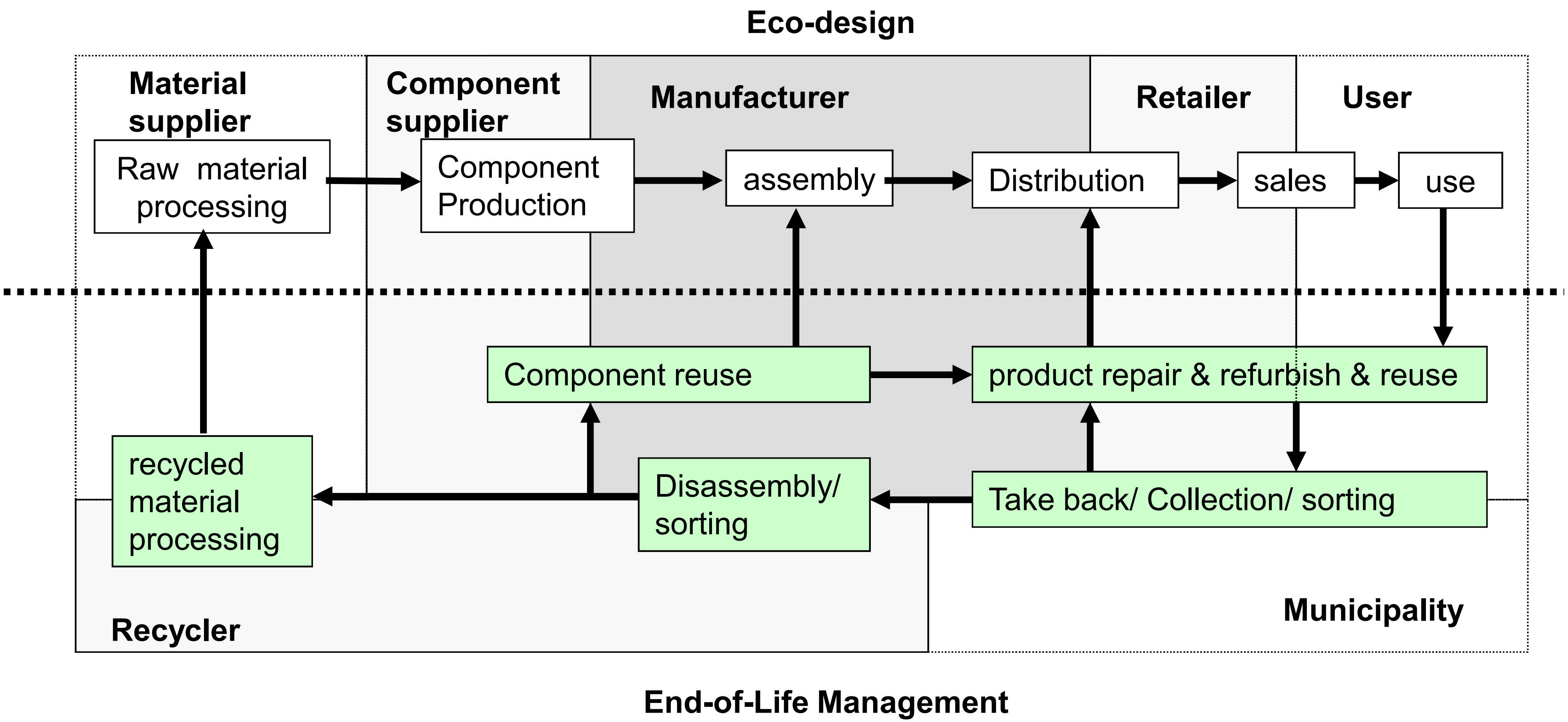
  - substances that are produced in quantities bigger than 1000 tons per year
  - substances with a risk potential R50 to R53 that are produced in annual quantities bigger than 1000 tons
  - substances with CMR properties that are produced in annual quantities bigger than 1 ton

- The registration contains:

  - safety data sheets
  - technical dossiers
  - defined release scenarios
  - risk assessments

Who has to act?

Involved Stakeholders



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What can be done?

Product Re-design

Design methods for sustainable products
- Design for Environment
- Design for Disassembly
- Design for Sustainability
- Ecodesign

Design tools
- LCA –Tools
- Ecodesign-Checklists
- Guidelines for Design for Disassembly
- Supply chain analysis

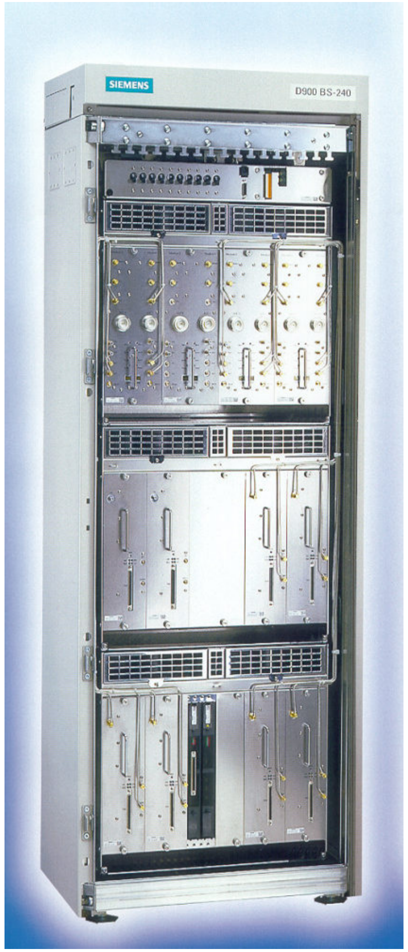
Eco-efficient Technologies
- Energy efficiency
- Dematerialization
- Substitution of hazardous substances
- Sustainable Production of Service Oriented Products

Eco-efficient materials and processes
- Benchmark
- Investigate potential materials/processes, future aspects
- Estimation of environmental impact

Practical Approaches
Motorola – Green Phone

- Use of lead-free solder
- Bromium-free PWB
- Housing of recycled plastic
- Energy-efficient charger (stand-by)

Practical Approaches
Siemens – Base station



→ Base station

- Volume reduction: 8 transmission units instead of 6
- New air condition system without outdoor system
- Al + chem oxidized + coated + printed replaced by noble steel + laser inscription

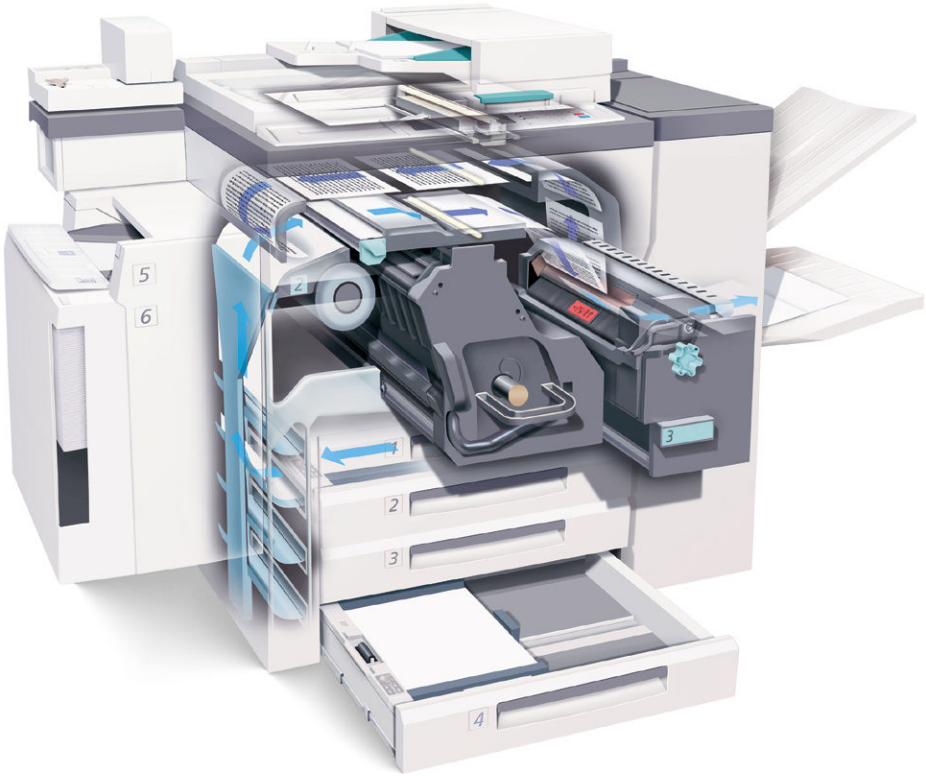
→ Subrack

- 17 instead of 66 parts
- 1 pure material instead of 4
- Costs 22% instead of 100%

→ Cooling system

- Weight reduction 50%
- Volume reduction 38%
- Energy consumption reduction

Practical Approaches
Xerox – Green Line Copiers



→ Design for easy dismantling in order to maximize reusability of components in Green Line Copiers
→ Re-use on the highest possible level
→ Through remanufacture diverted 67.000 tonnes of material from landfill in 1999
→ Cartridge return programme diverted 3700 tonnes for remanufacture or recycling during 1999
→ Zero landfill design goal
→ To date 92% recovery rate of returned products

Function Innovation

Technology shift

- Substitute/eliminate functions
- New functions with lower environmental impact
- Classification
- Reduction potential

Product-service-shift

- Systematic development of eco-efficient product service systems
- Handle unexpected innovations
- Obstacles/risks in bringing PSS to market

IT on Demand –
Towards an Environmental Conscious Service System for Vienna (AT)

Bernd Kopacek

Project Partners

funded by:

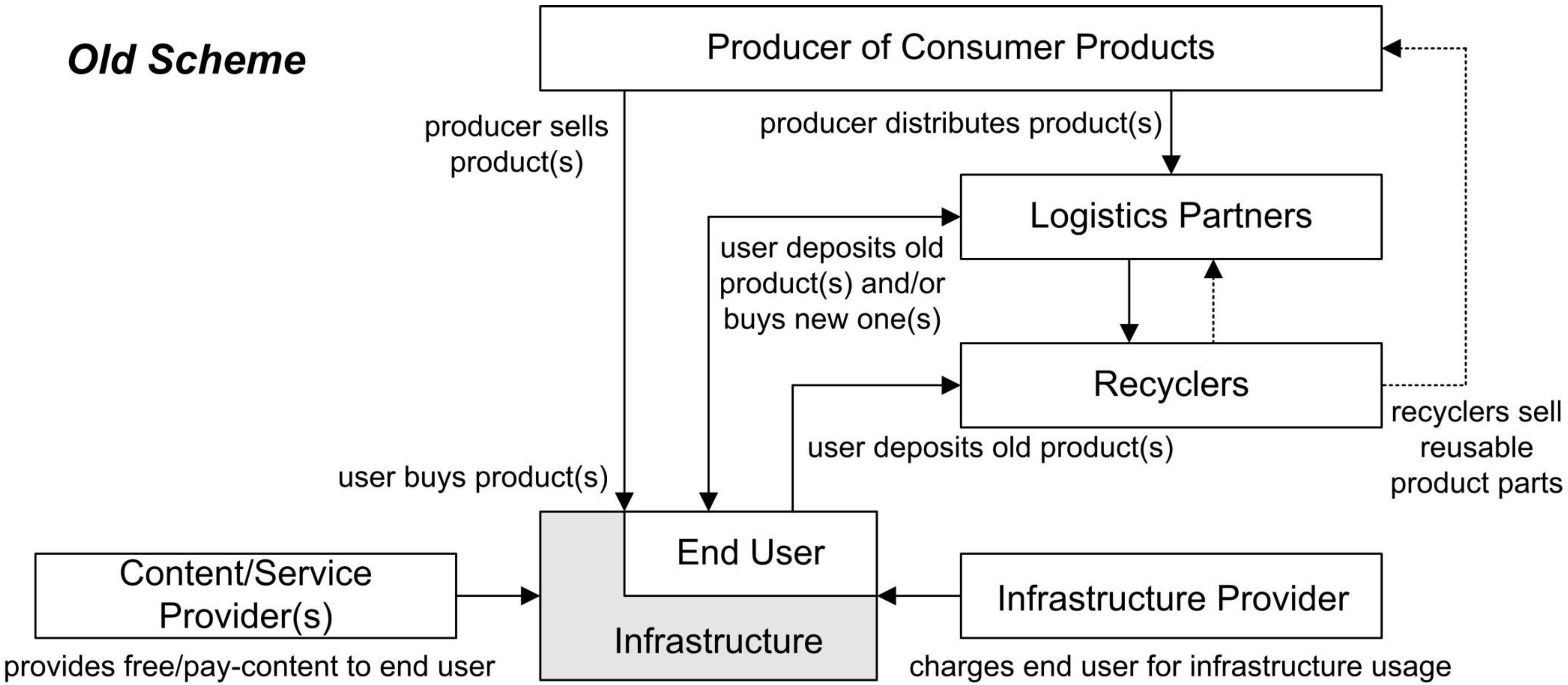
Motivation

- Overcome the trend of shortening life times of ICT products
- Finding new ways to fulfil consumer needs
- Implementation of multi life cycle use of ICT equipment
- By means of new service systems reducing the amount of generated waste
- Understanding the main drivers and barriers for PSS

B2C: ICT sector today

- Currently every user owns his hard and software
- Usage time approximately 2-5 years
- Fast technology pace, trend to decreasing life times
- Value of PC lies primarily in easier, faster and cheaper accomplishment of tasks
- For this purpose a user does not need to own the ICT equipment

Today products and services are offered separately



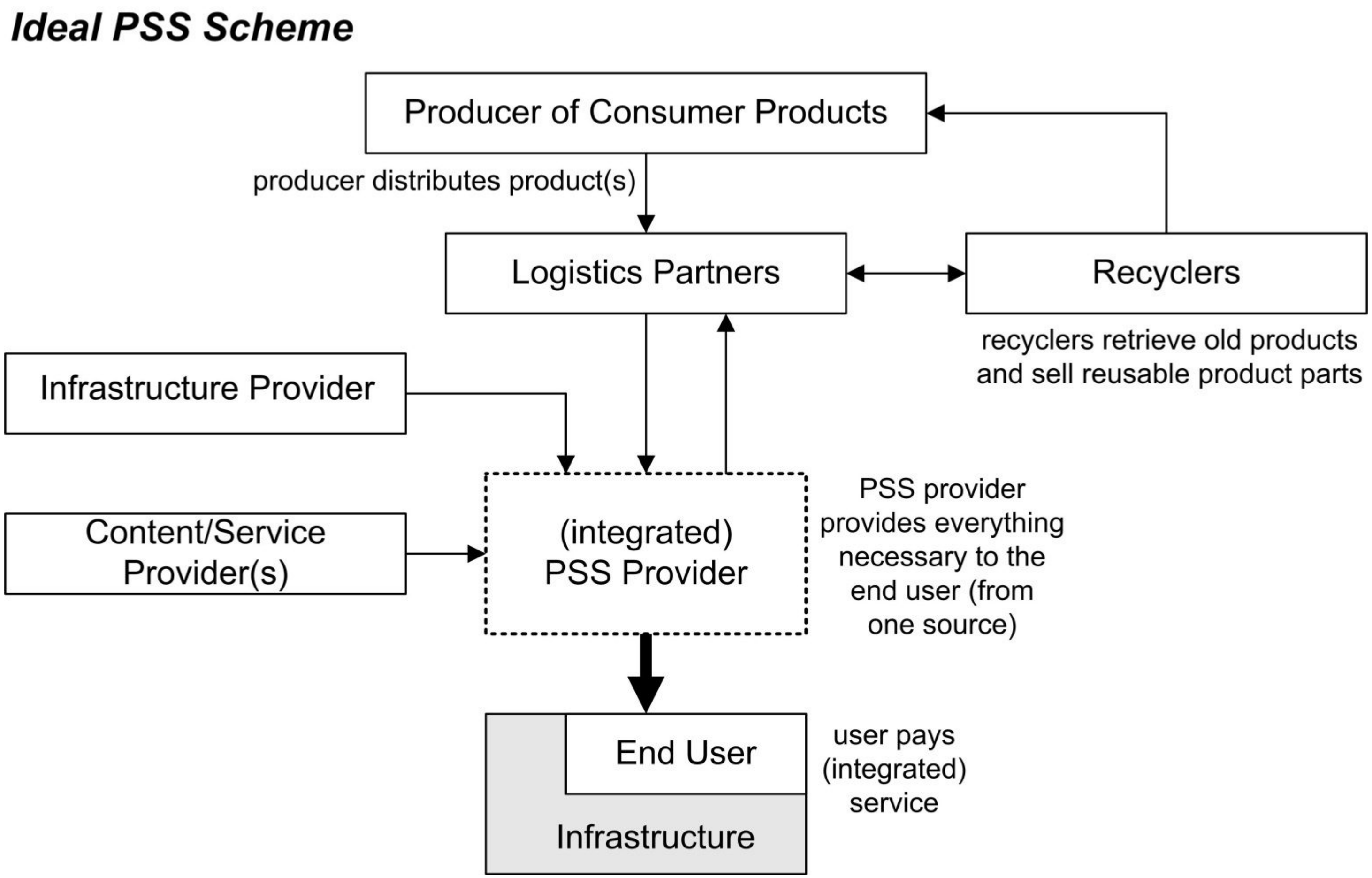
Pros and cons

- Customers have to organize the providers by themselves, difficult to control costs (real costs)
- Average (low experienced) user has to deal with a lot of functions he does not need
- User is in charge to keep updated and dispose of products at EOL appropriately
- But: product ownership gives the user high flexibility (e.g. availability)

Definition of PSS

A Product-Service System consists of tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific customers needs.

The integrated approach of PSS



Framework for IT on demand

Offering tailor made ICT services for the consumers in Vienna

Consumer does not own the required equipment

IT on demand

Payment according to consumed service
e.g. writing a letter, printing a graphic, …

Using refurbished hardware whenever possible

Open questions

- What is the best location of the equipment for which purpose?
- Which needs and services should be bundled to raise consumer acceptance and bring down costs?
- Which target groups can be identified for these kind of services?
- Feasibility of the developed scenarios

Our approach to new ICT based Service Systems

1. Analyze already existing PSS in order to identify main drivers and barriers
2. Identify consumer needs in the ICT sector
3. Analysis of the local general requirements towards customers, infrastructure, companies, …
4. Identification of PSS opportunities
5. Scenario building, evaluation and selection of best ideas

Step 1: Analysis of (existing) Systems

- **Siemens EXTRA-Rent (Austria)**
- **Xerox (photocopiers)**
- **Kodak (single use camera)**
- **Electrolux (Euroclean)**
- **PC E@sy**
- **Aon.tv (Austria)**
- **UMTS networks and applications in Austria**
- **...**

Step 2: Main barriers for PSS

Don't harm traditional selling points

Sales force not educated and prepared offering flexible contracts

Finding the right partners

Provider perspective

No adequate accounting system

Lack of information on consumer behaviour (does he understand the service and know the price?)

Main barriers for PSS

System not flexible enough
(want to use it at any time)

Trustworthiness of the provider

Data security

Customer perspective

Afraid of higher costs

Wanted to own products

Step 3: Identify consumer needs in ICT

Need for esteem

Physiological/ basic needs

Need for change/ alternation

Need for safety/security

Need for self-actualisation

Need for comfort

Need for socialisation

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7 consumer needs in the ICT area (1)

- **Physiological/Basic Needs**
  - → need for satisfying hunger, thirst
  - → need for sleep
  - → need for avoiding pain
  - → need for realising one's sexual instinct
  - → "need for an adequate home (e.g. a clean apartment, heating) (depends on standard of living)"
  - → "need for physical health and well-being (i.e. no injuries)"
  - → "need for mental health and well-being (i.e. no stress)"

7 consumer needs in the ICT area (2)

- **Need for safety/security**
  - → need for a safe job
  - → "need for financial independence (e.g. a high income, shares)"
  - → need for order/organisation
  - → "need for individual time management (i.e. organise my day)"
  - → "need for phases of recreation"
  - → "need for phases of work"
  - → need for control
  - → need for retraction and isolation (e.g. anonymity)
  - → "independence from others (i.e. no need to be dependent from persons and their services)"

7 consumer needs in the ICT area (3)

- **Need for comfort**
  - → "need for low physical (and/or mental) stress (e.g. no hard or monotonous work)"
  - → "need for enough time for own interests (e.g. hobbies, friends)"
  - → "need for (simple) communication and information acquisition (e.g. use a mobile phone)"
  - → "need for permanent availability of information, goods and services (e.g. adequate infrastructure in surroundings like shops, banks etc.)"
  - → "need for mobility (e.g. by using a car or public transportation)"
  - → "need for entertainment (e.g. TV, books, theatre)"

7 consumer needs in the ICT area (4)

- **Need for socialisation**
  - → need for human contact and interaction (e.g. friendships, colleagues)
  - → need for exchanging ideas with others (e.g. intellectual development and suggestion)
  - → need for acceptance
  - → need for social affiliation (e.g. need for acceptance by society, being member of a social group)
  - → need for responsibility
  - → need for helping others
  - → need for admiration
  - → need for love (e.g. family, relationship)

7 consumer needs in the ICT area (5)

- **Need for self-actualisation**
  - → need for autonomy (i.e. to decide autonomously on sthg)
  - → "need for independence and freedom (e.g. financial independence)"
  - → "need for freedom from pressure of opening hours (e.g. flexible closing time of shops) "
  - → "need for individuality (e.g. design your own T-shirt)"
  - → need for creation (e.g. being an architect) and implementing one's creativity (e.g. painting a picture, writing a book)
  - → need for power over and influence on other people (e.g. being member of political party)
  - → need for status and prestige
  - → need for respect

7 consumer needs in the ICT area (6)

- **Need for change/alternation**
  - → need for broadening one's horizon (e.g. learning a new language, travelling, job-related development)
  - → need for eagerness for knowledge (e.g. questioning new things, need for knowledge and understanding)
  - → need for entertainment (e.g. visiting a concert, watching TV)
  - → need for satisfying one's play instinct (e.g. playing computer games, parlor games)

7 consumer needs in the ICT area (7)

- **Need for esteem**
  - → Need for achievement, accomplishment, activity
  - → Need for competition
  - → Need for impressing
  - → Need for avoiding/minimising failures/flops

Step 4: Analysis of needs and identification of opportunities for ICT

1. **Identification of main application areas for ICT by analysing current products**
2. **Link with consumer needs**
3. **Analysis of consumer behaviour and marketing data**
4. **Identification of opportunity areas**

Application areas for IT on demand (1)

- **Several dimensions to be considered for an ICT Service System:**
  - → **Supply of a service**
    - Self provision: allocation of hard-, software and infrastructure, customer uses the equipment according to his needs (e.g. writing an email)
    - External provision: Customer is only interested in the result of a service (e.g. what is the cheapest price for product xyz)
  - → **Local availability**
    - Within flat
    - Within apartment house
    - Outside house (within certain distances)
    - Mobile

Application areas for IT on demand (2)

→ **Temporary availability**
- At any time
- one hour, day, weekend, …

→ **Use frequency**
- frequently (e.g. every hour, day)
- Rarely (once a year)

→ **Functionality of required equipment**
- High: computer → more difficult to handle
- Low: TV set
- Usability of required equipment

Application areas for IT on demand (3)

→ **Required space and design**

→ **Maintenance efforts**

→ **Energy consumption**

→ **Costs of equipment**

→ **User Demographic**

- Age
- Income
- Education
- Mobility
- Value of time
- Early adapter, fast follower, …

Step 5: Development of scenarios

- **Based on consumer needs and location of service provision:**
  - → **In the flat**
    - Banking and administration
    - eLearning
    - Entertainment
  - → **Within the apartment house**
    - Home office
    - Mobility and itinerary
    - Surf & (local) Information station, reservation tool
  - → **Mobile**
    - City Guide
    - Leisure information service
    - Appointment service

Scenario: apartment house

- **Application varieties (including printing and scanning):**
  - → email on demand
  - → Internet + email on demand
  - → Internet + email + office on demand
- **Workstations located in an extra room**
- **On average 23 user for 5 workstations (one typical apartment house)**
  - → Higher utilisation of workstations compared to single user - single workstation system
- **Amortisation after less than 2/3 year compared to traditional system**
- **Average monthly rate**
  - → new system around 45€
  - → Traditional system around 82€ (including software)

Overcome barriers for service system

Advantage of traditional system:	strategy for new system:
Availability and flexibility of owning the hardware	24h access and extra laptop service
Perception of higher price	Transparency of billing
Data security (hard disk)	Provision of secured virtual memory and/or memory stick

Scenario: apartment house

- „IT on demand“ in big apartment house
- Basic application „E-Mail on demand“
- 342 PCs for 2.270 users
- “Pooling-concept“ in combination with notebooks
- Cost calculation
- Internet portal for reservation and ordering
- Offering also service personal (Concierge)

Results „E-Mail on demand“

	WEEE	Electricity consumption during use	Electricity consumption during production
Private use: 2.270 PCs	300.000 kg	3.800.000 kWh	3.300.000 kWh
PSS: 342 PCs	45.000 kg	740.000 kWh	165.000 kWh
Savings potential	85%	81%	95%

What can be done at End-of-Life?

EOL Options for EEE

1) Re-use product as a whole

2) Re-use of subassemblies and components

3) Material recycling

5) Incineration

6) Disposal as waste

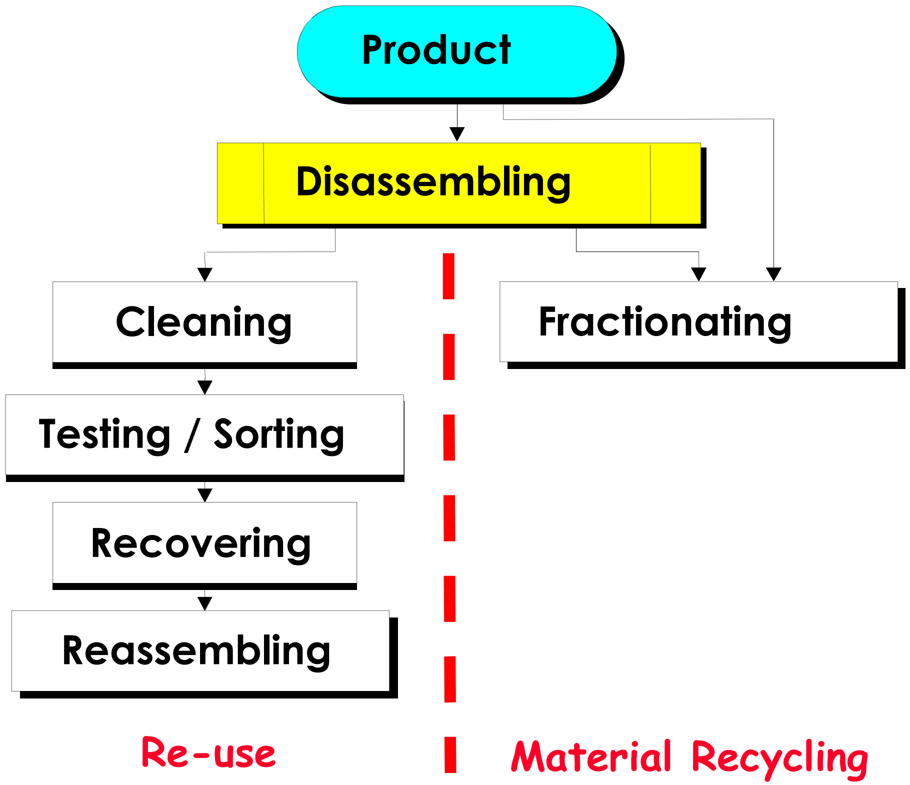
Highest level

↑

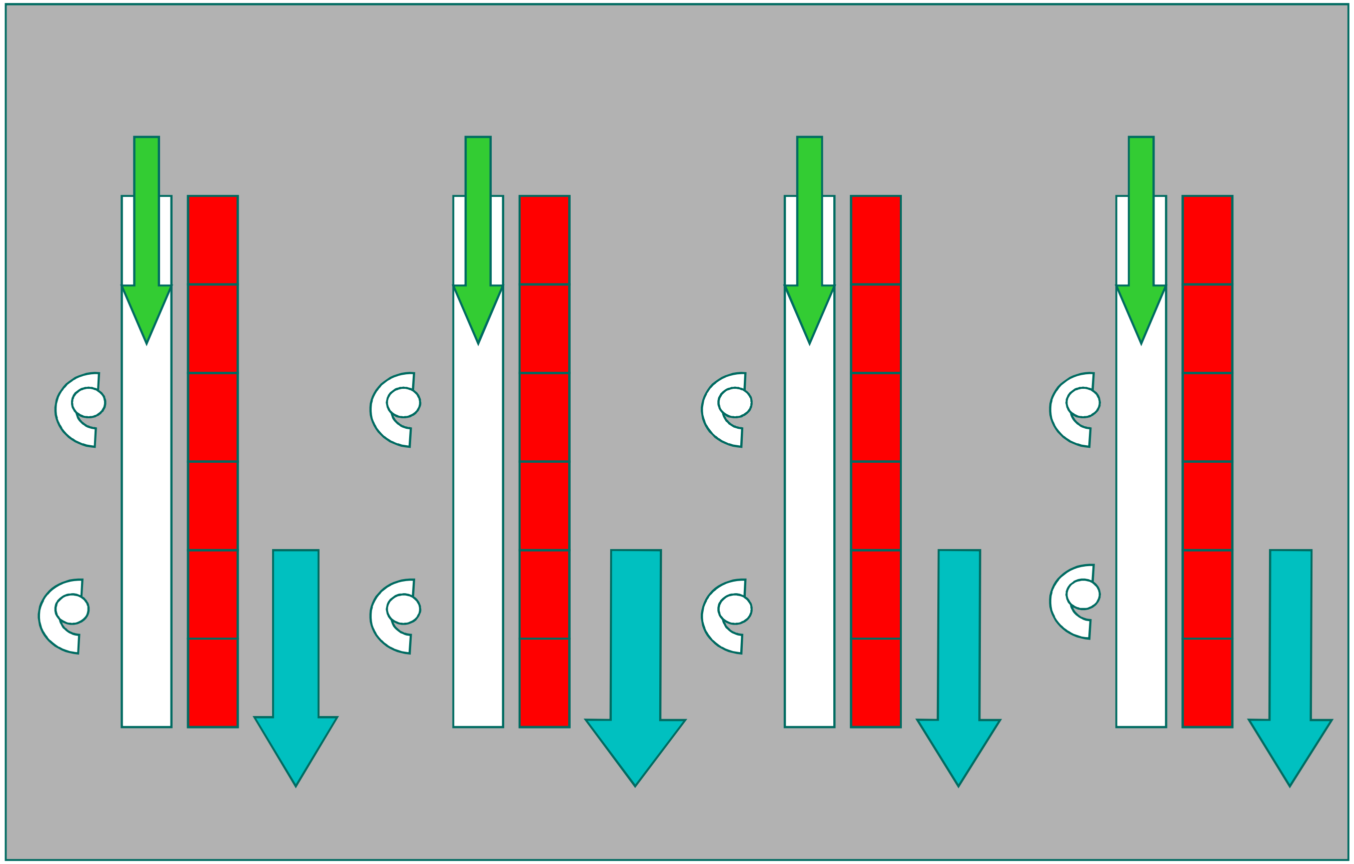
Lowest level

Disassembling

- Mainly a manual process
- Developments and perspectives:
  → Flexible Disassembly Cells
  → Active Disassembly using smart materials



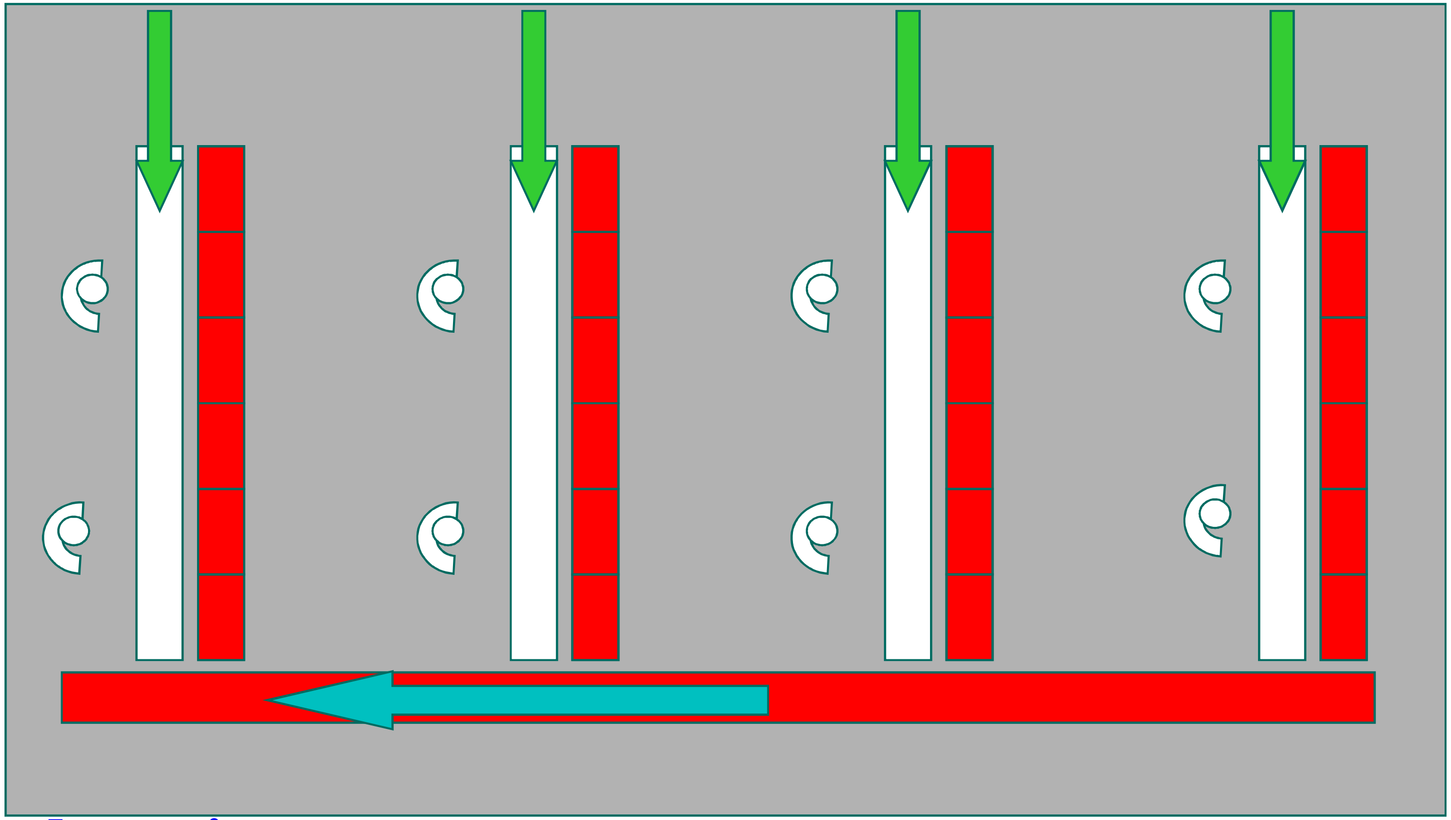
Manual Workplaces Layout



Products in

Fractions out

Manual Workplaces Layout

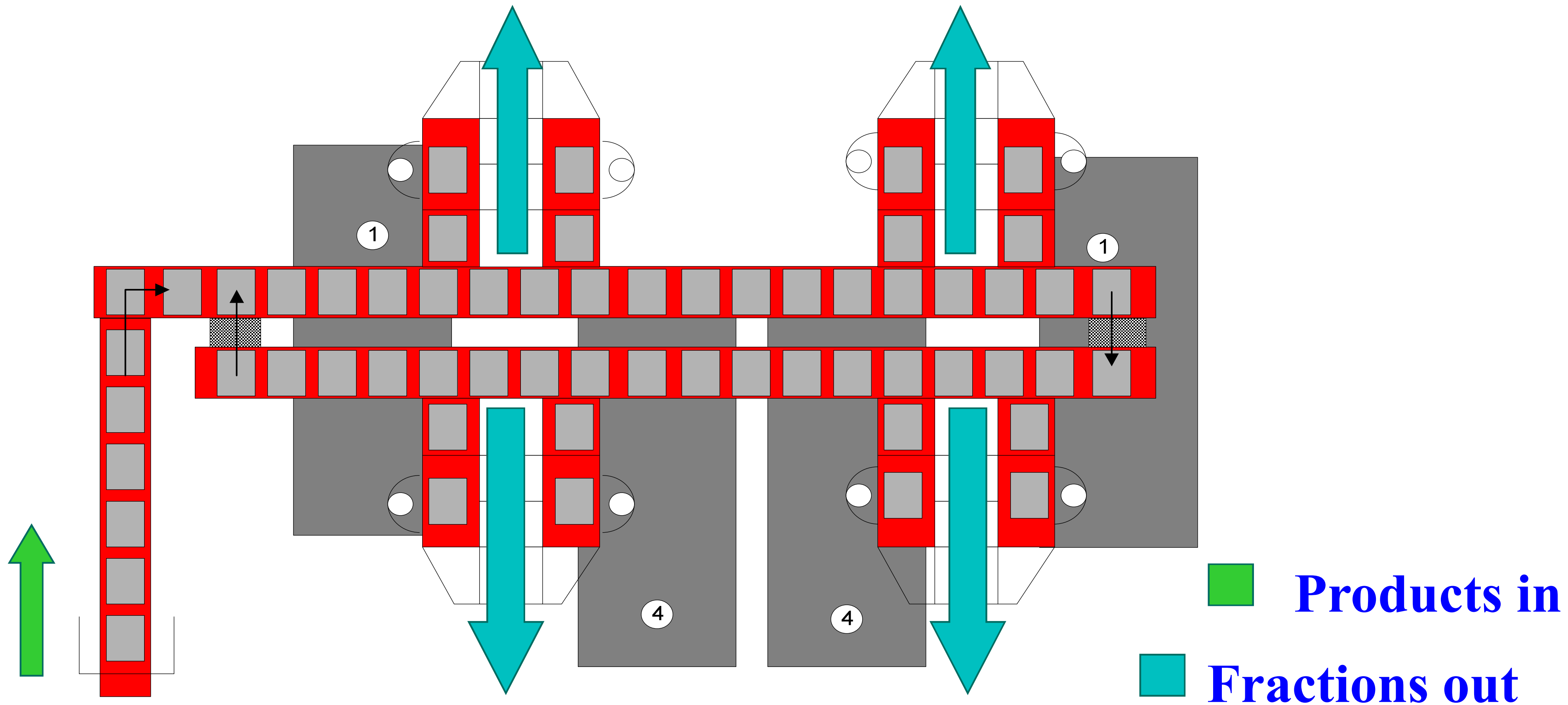


Products in

Fractions out

Sat ISL Greentronics

Manual Workplaces Layout



Material Recycling Technologies

- Shredding
- Separation Technologies
  - → Size separation
    - Rotary screens
    - Vibration screens
    - Disk screens
  - → Gravity separation
    - Gravity separation table
    - Pneumatic classifier

Material Recycling Technologies

- **Wet separation technologies**
  Technologies based on aerodynamic/hydrodynamic properties and density of the materials

- Elutriator
- Sink/float separation
- Floatation
- Hydrocyclone
- Shaking or wilfly table
- Centrifuge

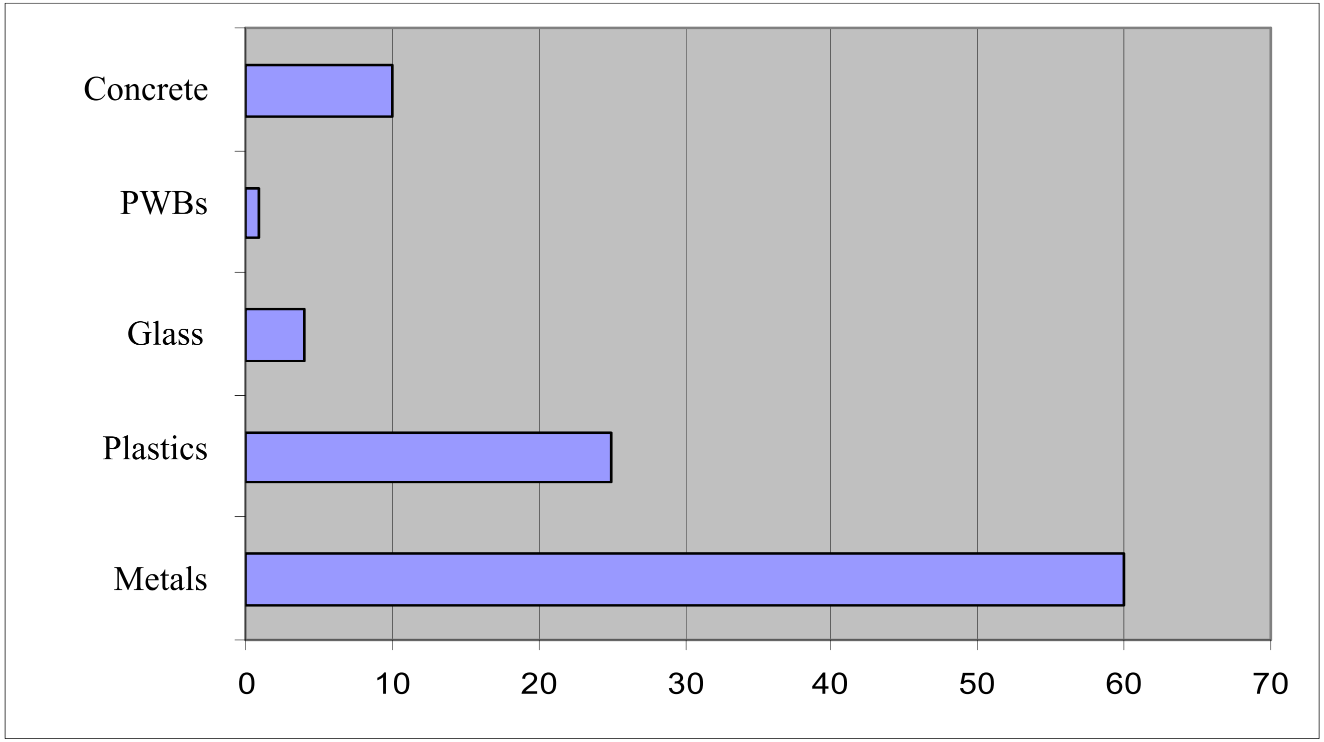
- Magnetic separation
- Eddy current separation
- Electrostatic separation
- Corona drum separator (metal-plastic separation)
- Triboelectric separator (plastic-plastic separation)
- …

White Goods (Washing machines,…)

- Characteristics: Constructed using mostly ferrous metals
- Decontamination: Possibility of the presence of hazardous components (PCB or oil capacitors)
- Treatment
  - → Manual removing of hazardous components
  - → Impact shredders / large car shredders

WEEE-Directive –
White Goods (Example: Washing Machine)

Fractions of a typical Washing Machine:



WEEE-Directive:

Rate of Recovery
At present: 85%
Required: 80%

Re-use and Recycling:
At present: 60%
Required: 75%

Refrigerators, Freezers,…

- Hazardous Waste according to the EWL (European Waste List) given in Community Decision 2000/532/EC
- Decontamination: Cooling circuits may contain

  → Oil + CFCs or HCFCs
  → Oil + HFCs or HCs
  → Ammoniac solution + Cr^{+6}

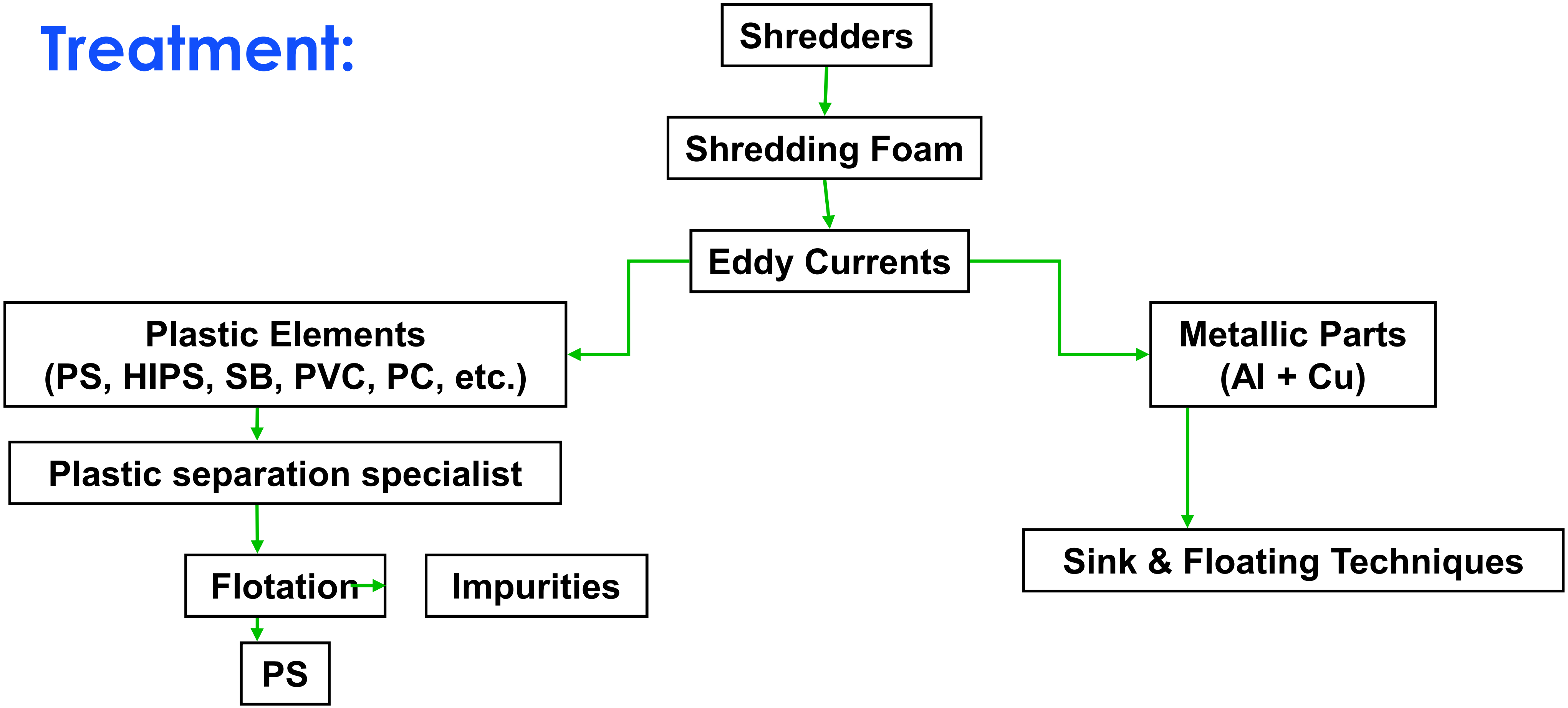
  To extract these substances small suction treatment plants are used.

  Perforating clamp + Evaporator + Condenser

- Treating of metals and plastics → like white goods

Refrigerators, Freezers,...

Treatment:

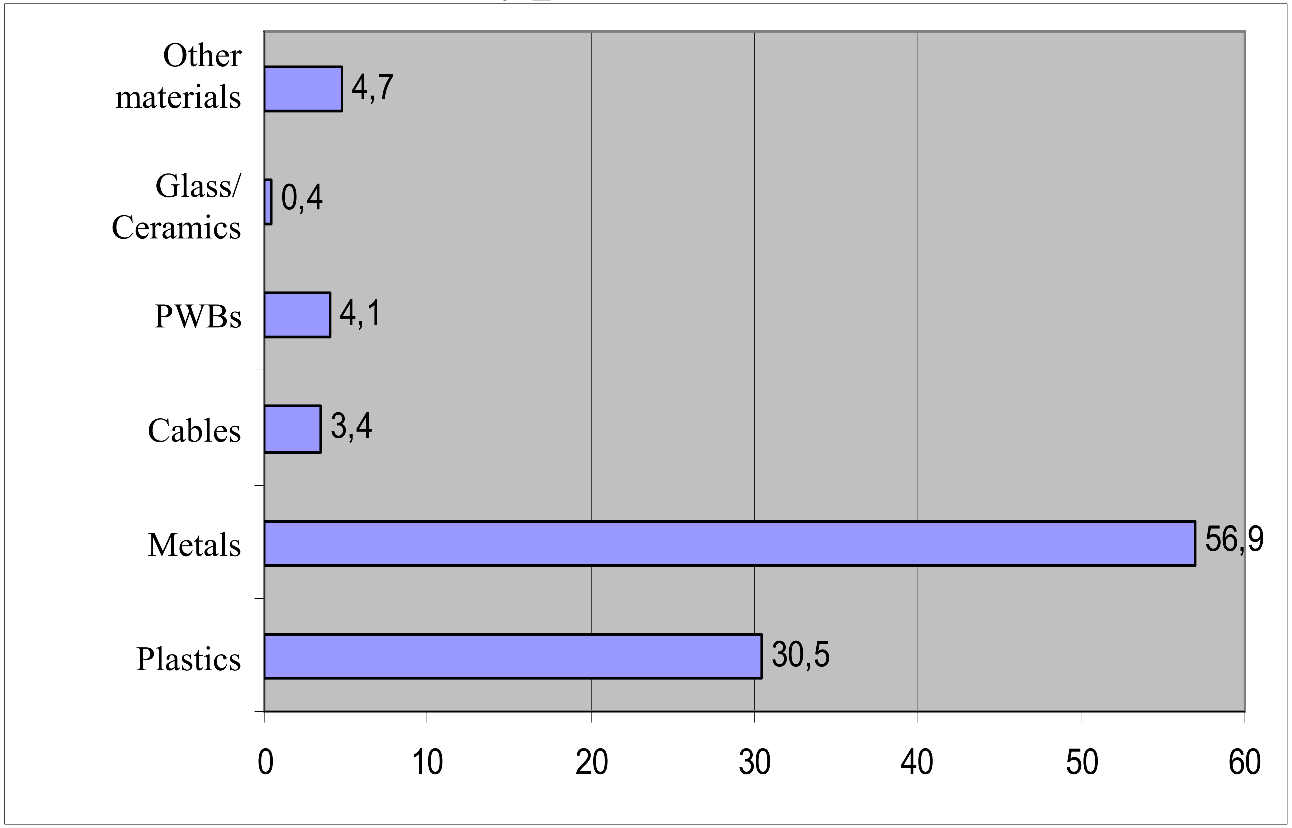


Brown goods (radio, video,…)

- Characteristics: Plastics and iron predominate in these category
- Decontamination: Different types of dangerous batteries
- Treatment:
  - → Manual disassembling
    - An operator frees the plastic casing from the screws or clips
    - The plastic case is treated in specialised installation
    - The PWBs, loudspeakers, peripherals cables, etc. are removed and treated by different methods already mentioned
  - → Shredding and material separation

WEEE-Directive – Brown Goods (Example: Radio Set)

Fractions of a typical Radio Set:



WEEE-Directive:

Rate of Recovery
At present: 85%
Required for consumer equipment: 75%

Re-use and Recycling:
At present: 60%
Required for consumer equipment: 65%

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TV Sets and Monitors (CRTs)

- products contain CRTs and in small quantities LCDs or TFTs
- Decontaminiation: CRTs ⇒ Dangerous waste on the EWL
- Treatment
  - → Disassembling – manual in most cases
  - → Automation difficult through the variety of sizes and models

Removing of the CRT

↓

Removing all non-glass material from the exterior of the CRT

↓

Releasing the vacuum of the CRT

↓

Crushing CRT

↓

Removing of phosphorescent Coatings and separation of funnel and panel glass

Dismantling of TV Sets

- Remove Back cover
- Take out PS, PCBs and cables
- Remove CRT
- Divide glasses
- Clean panel glass

TV Sets and Monitors (CRTs)

Technologies for CRT separation:

- → Hot wire separation
- → Separation by cutting with a circular saw
- → Separation by chemical attack
- → Engraving and thermal shock

Automation of Disassembling

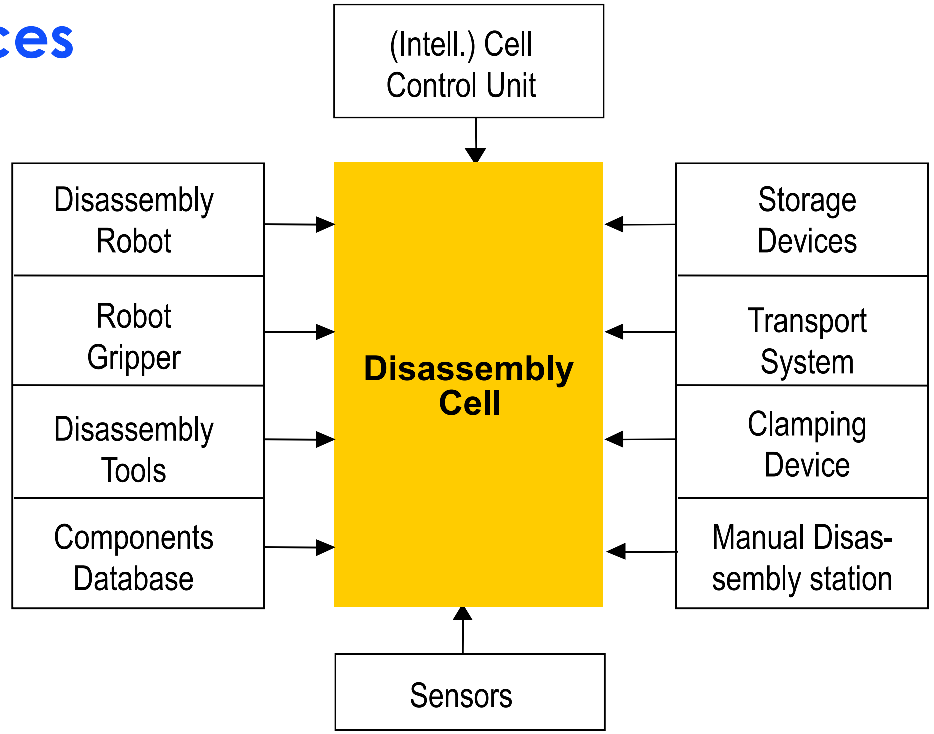
Main Goals

- reduce the costs of disassembling,
- extend the performance of the disassembling process,
- optimize the different recycling processes,
- extend the life cycle of a product because of the better possibility for reconditioning, and
- create a human working environment in disassembly factories.

Modular, Flexible Disassembly Cell

Main Modules:

- Industrial robots or handling devices
- Special gripping devices
- Disassembly tools
- Feeding and storage systems
- Transport systems
- Fixture systems
- Manual disassembly stations
- Intelligent control units
- („low cost“) vision systems for part recognition
- Various sensors
- Electronic components DB



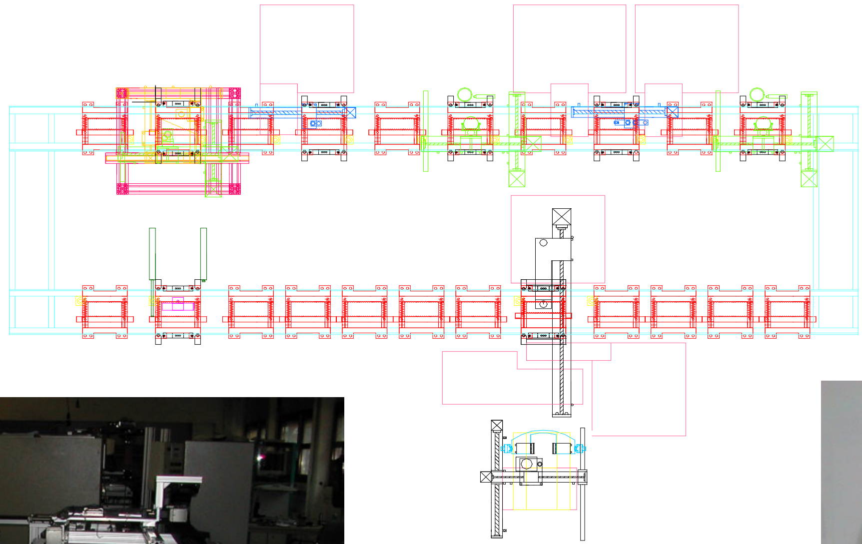
Example – Disassembly Cell for PWBs

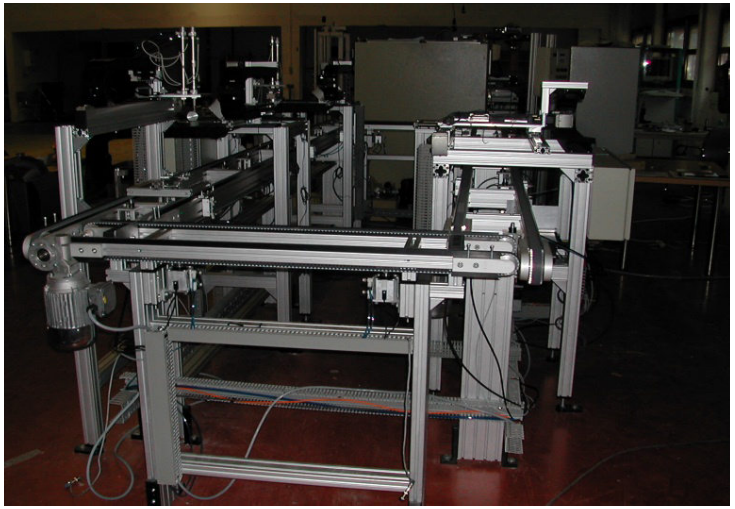
→ Recognition System
→ Laser de-soldering station
→ disassembly robot

- operation guided by market information
- minimal thermal stress for the components

↑ extended life-time for re-use components

Example –
Disassembly Cell for Mobile Phones





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Re-Use

- Re-Use Possibilities for products
  - → Second Hand
  - → Repair and Reconditioning
  - → Upgrading
- Re-Use possibilities for subassemblies and components
  - → Old for Old – use of used components as spare parts
  - → Old for New – use of used subassemblies and components for the production of new products
  - → "New" for New – use of overstock subassemblies and components for the production of new products

Example of a Re-Use Process

Re-Use process for IT equipment:

Collection

Registration, Inspection, Sorting

Testing, Data Erasure, Refurbishment

Manual and Automated (PCBs) Disassembling

Remarketing of whole products

Remarketing of subassemblies and components

Examples

- Coolrec (NL)
- Ecotronics / STENA Technoworld (AT)
- MüGu / METRAN / MBA Polymer http://www.youtube.com/watch?v=oaQp0fCQ-74&feature=related