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.

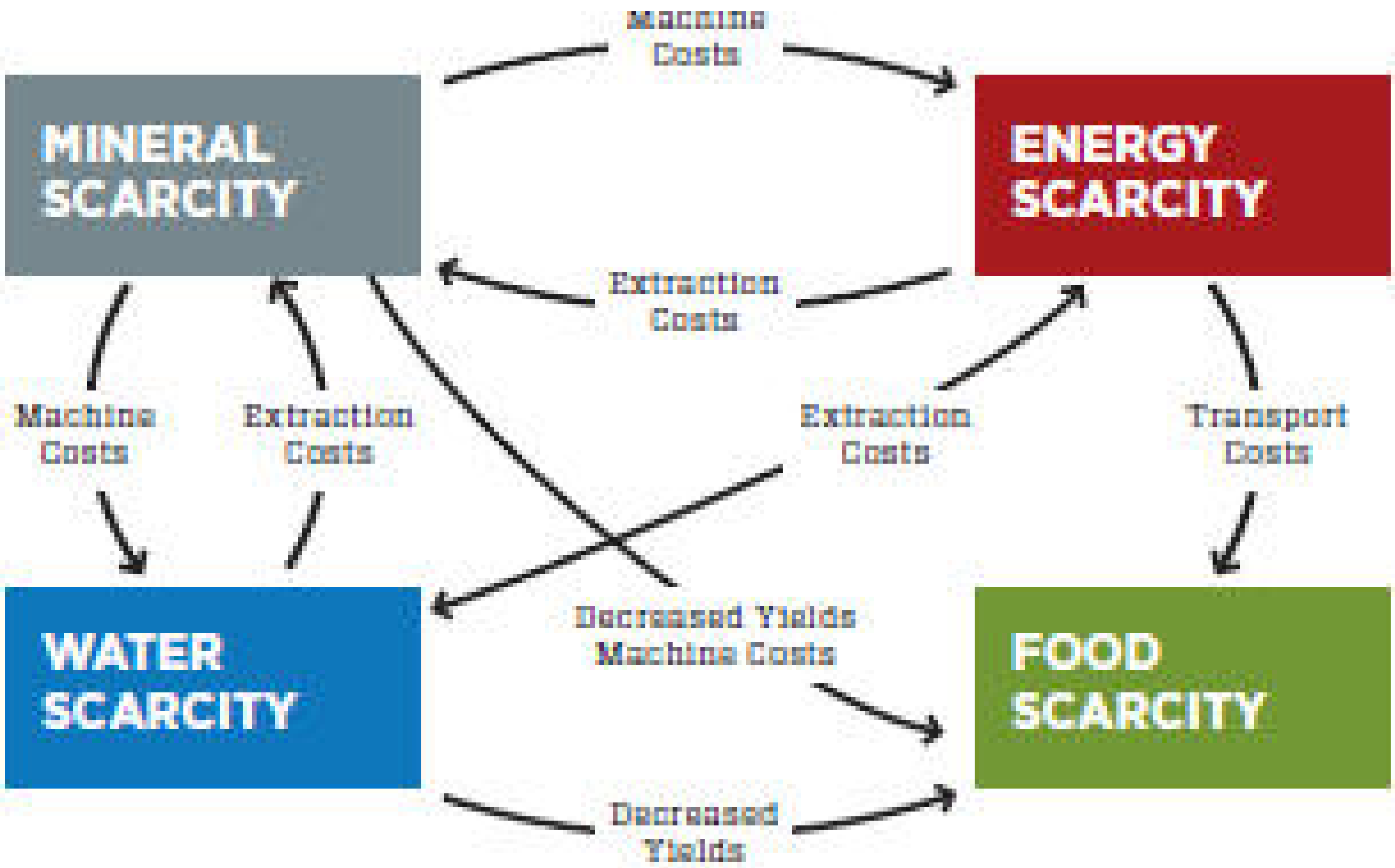
Climate change and its effects on resource scarcity

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.

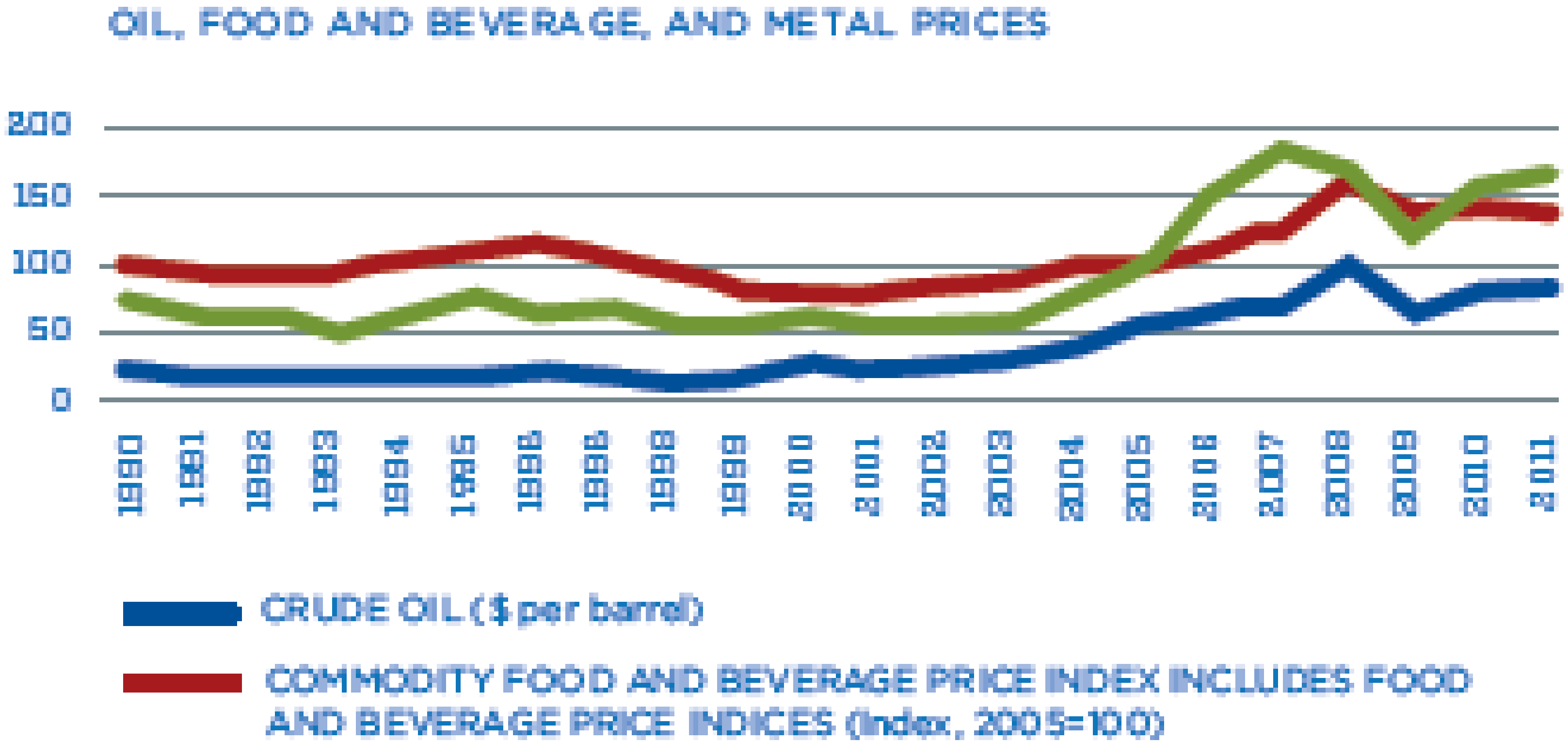
Do they interfere with each other?



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



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

Minerals and Energy

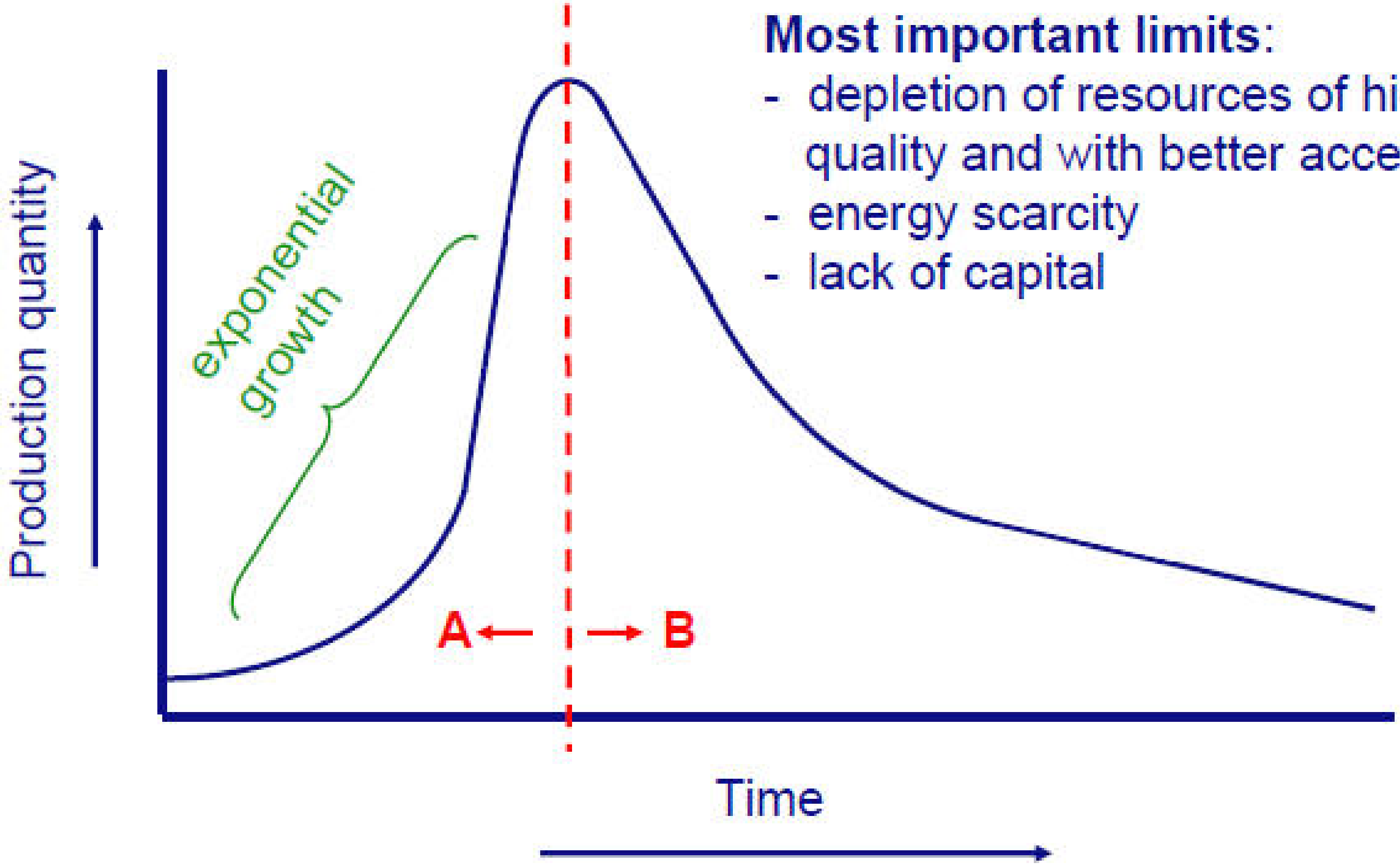
Mineral resources, while depending on fossil fuels, especially oil, for their extraction, are also critical inputs in green technology, which is important not only for reducing greenhouse gas emissions, but also for boosting energy efficiency. Mining and extraction require significant amounts of energy,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

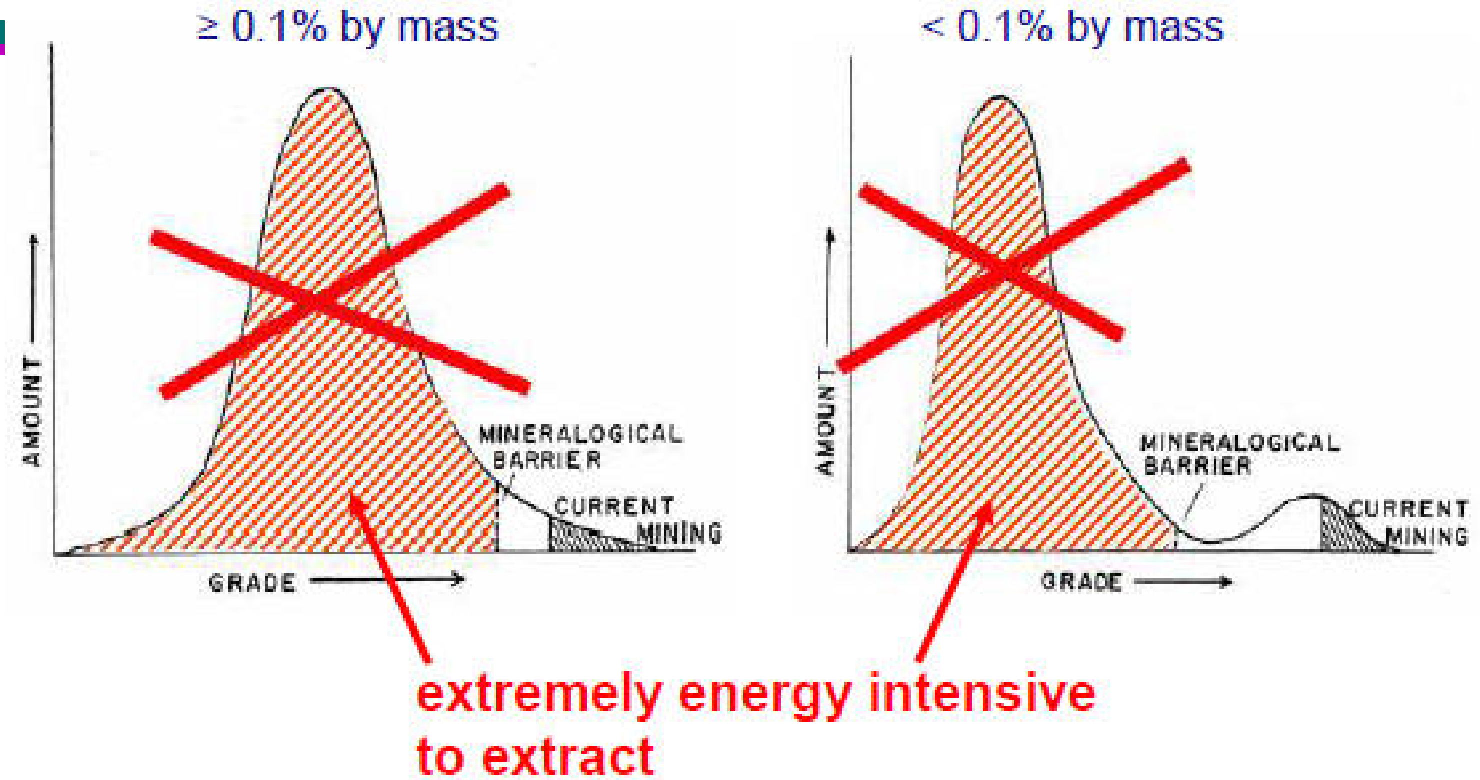


Most important limits:
- depletion of resources of higher quality and with better accessibility
- energy scarcity
- lack of capital

A.M. Diederen: Materials Scarcity, Managed Austerity and the Elements of Hope

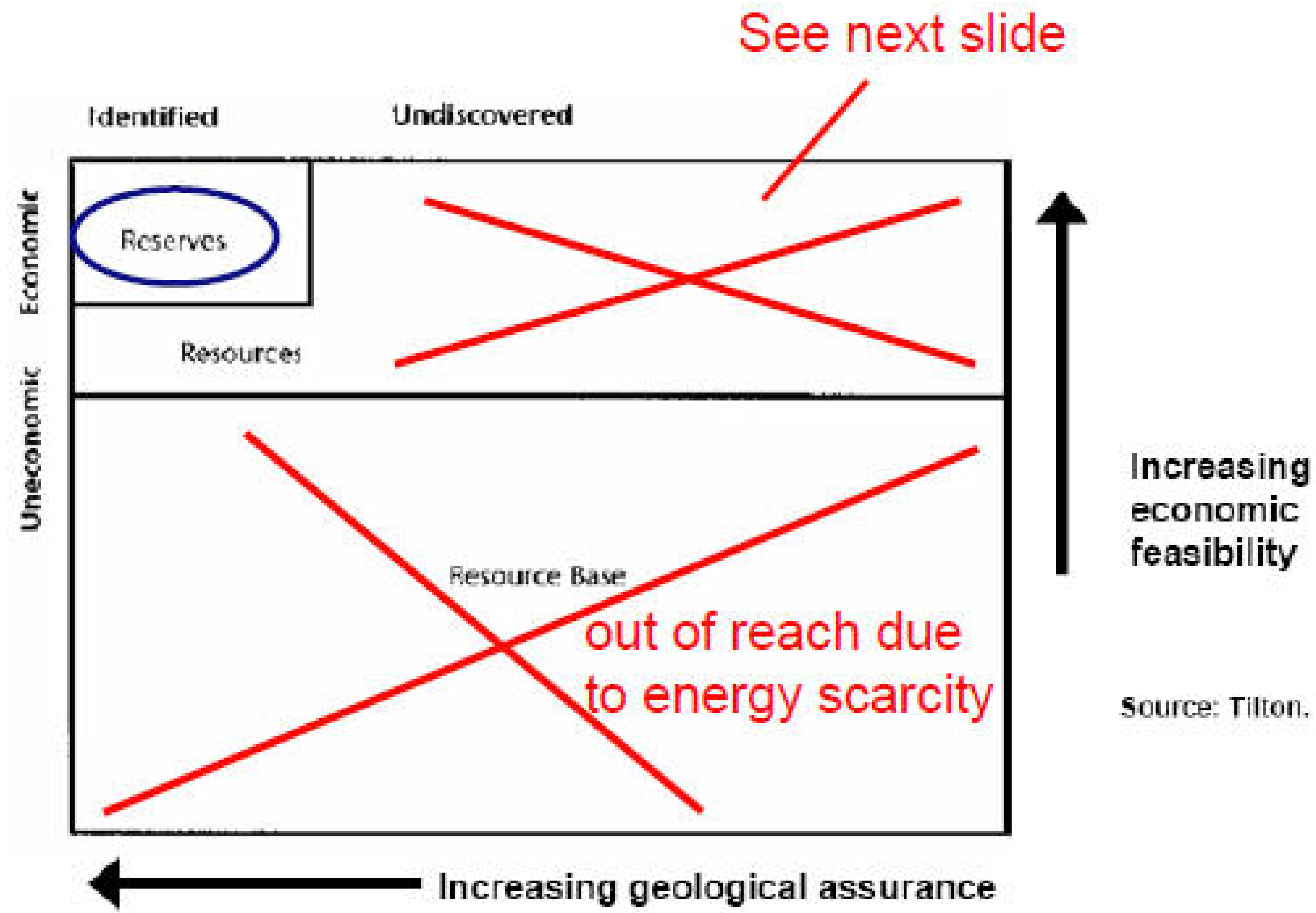
Vienna, October 11, 2010

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

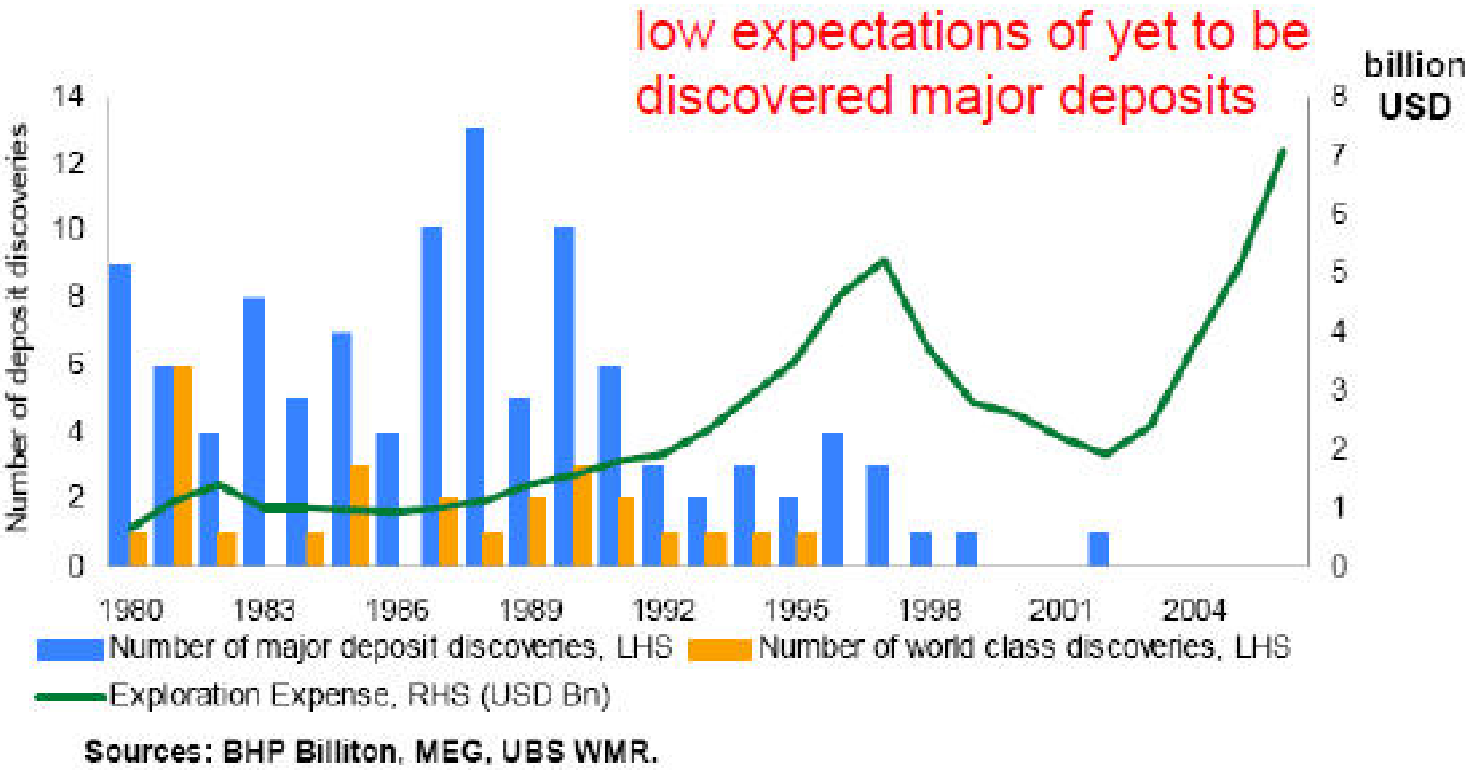


Source: "Exploring the resource base"
Brian J. Skinner, Yale University, 2001

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



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



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)

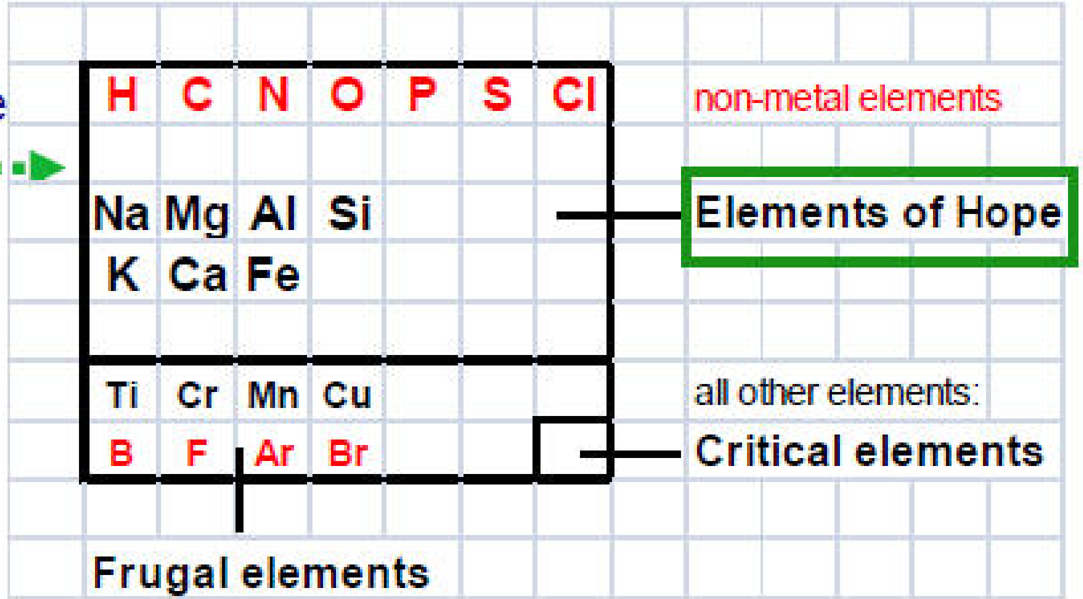
Current annual primary production rates (*estimates*):
gallium: around 100 tons
indium: around 600 tons
tellurium: around 450 tons
ruthenium: around 40 tons

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….

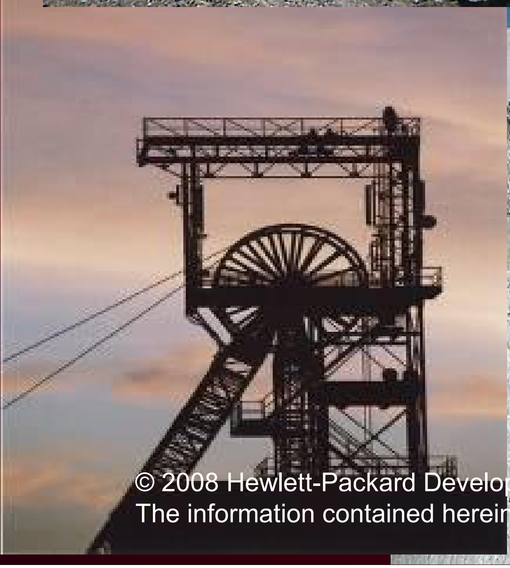
.. we buy parts, assemblies, complete products … !




… this is going to change …








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

- ➢Higher demand → higher prices

.. higher demand

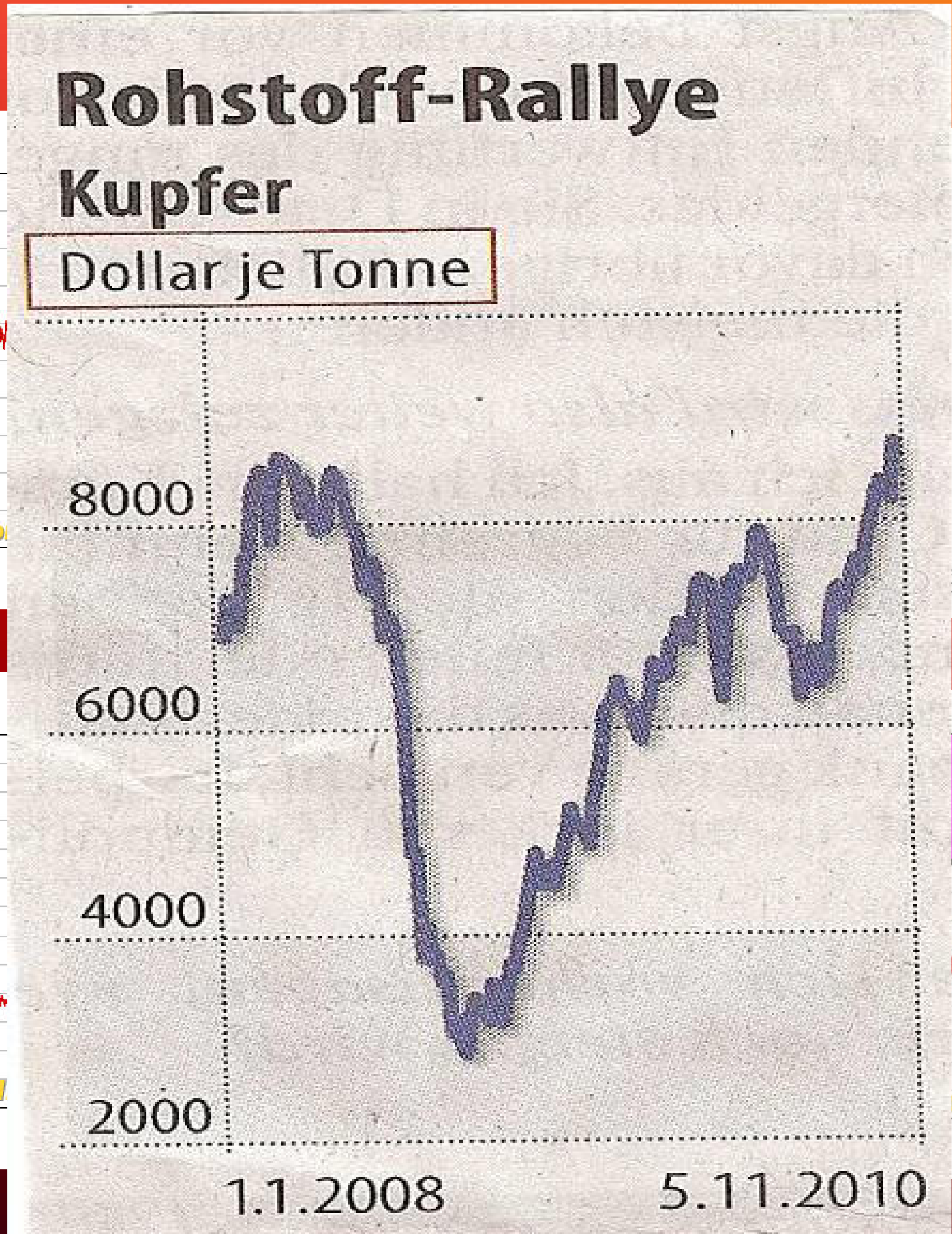
	World Population	Population with income to buy electronic products / cars
1952	2.2	0.3
2009	6.7	3.0
2039	9.0	6- 7.5

billion

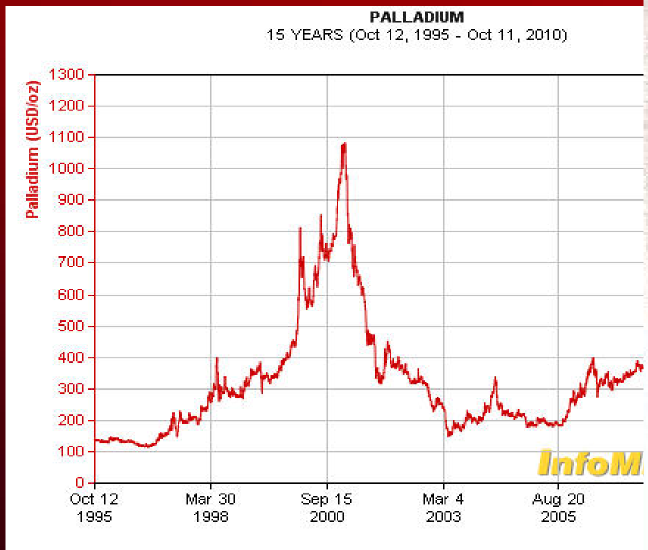
Demand for Raw Materials will increase

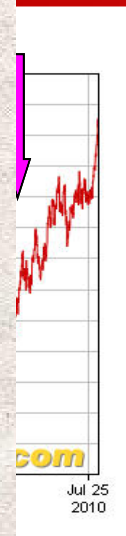
... by ??% in 201x

Indicators on increasing prices



Financial crisis





Cost for production will grow

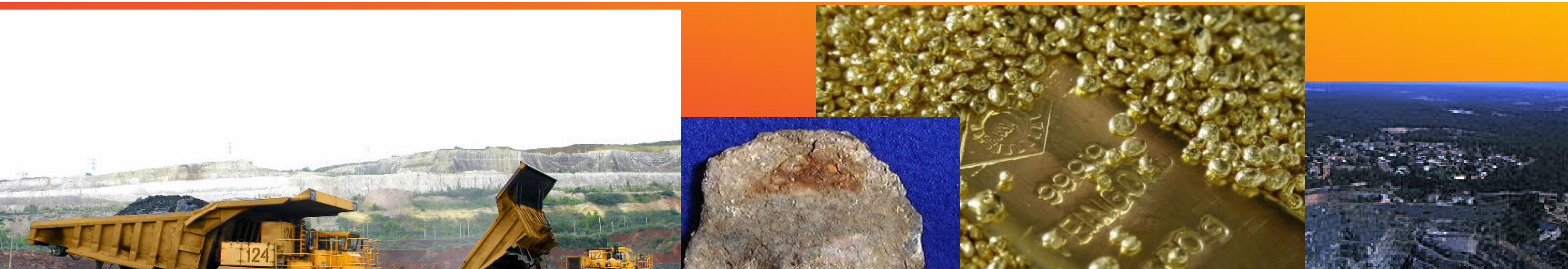
Example: Copper

year	Content
1900	7 %
	2 %
	<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

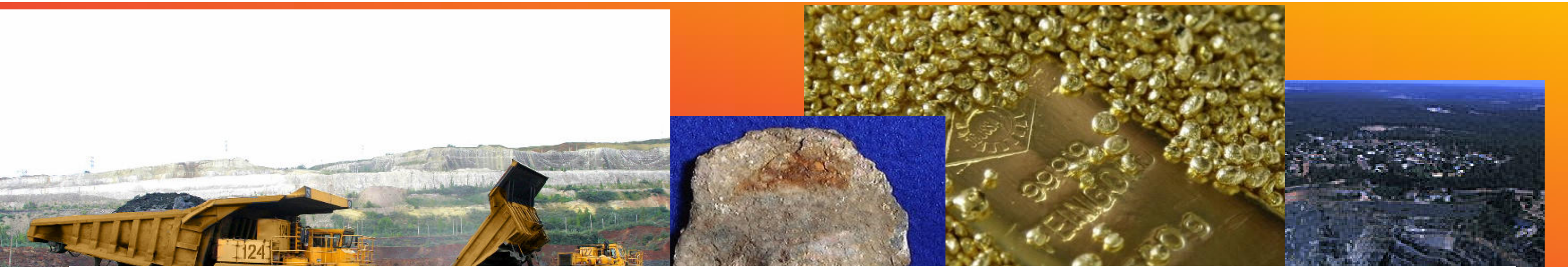
7,000,000,000 Laptops

400kg/car, 0.4 kg/laptop

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

- Higher demand → higher prices
- Competition between Industry Sectors
- <u>Speculation</u>

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.

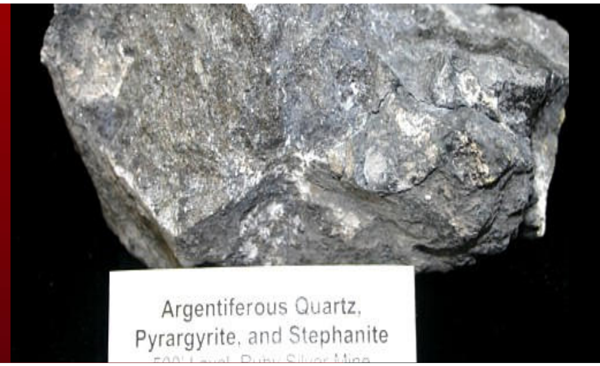
China mines more than 90% of the world's rare-earth minerals. Last July, China announced a reduction of its rare-earths exports by 72%. Chinese domestic consumption has been increasing rapidly and China does not appear to have excess capacity to satisfy the world demand.

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

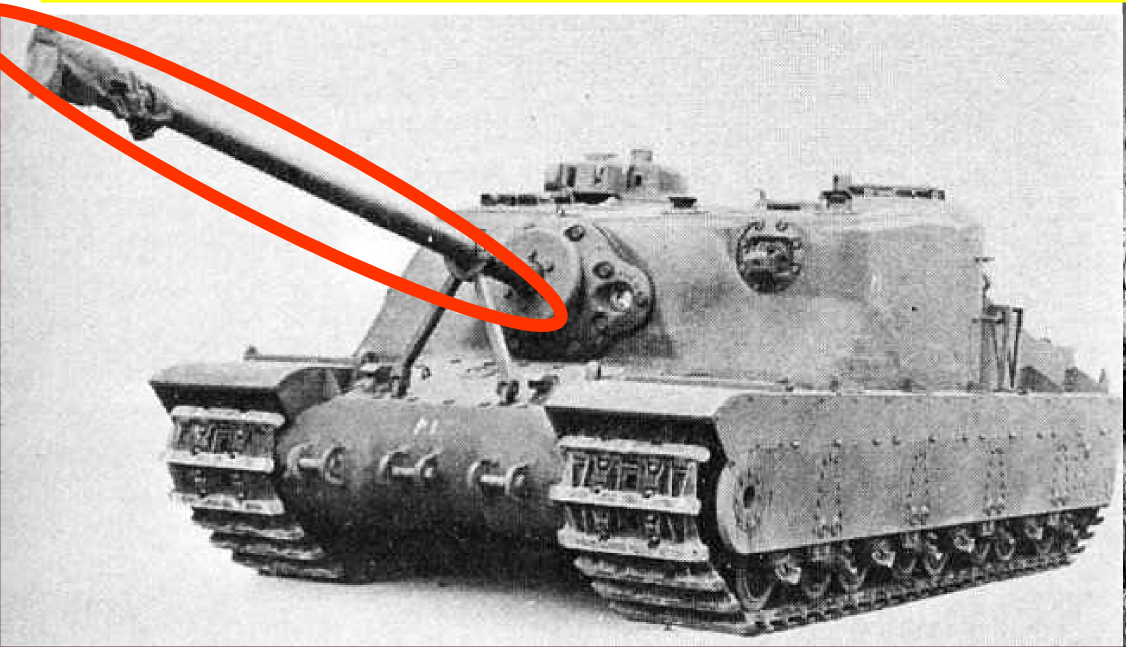
Mitigation strategies for the ITC Industry…

- 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

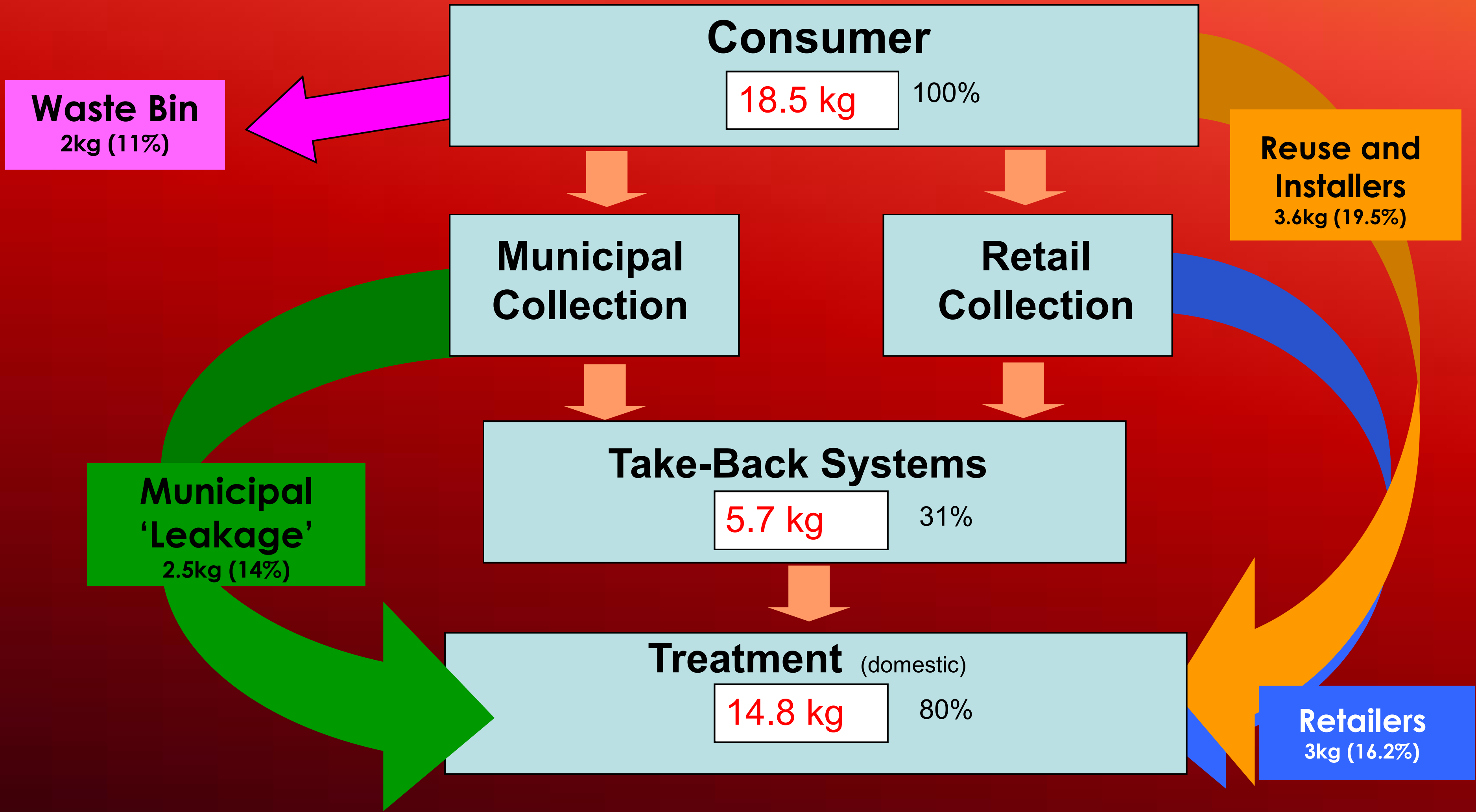
Prices for raw materials will significantly increase

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

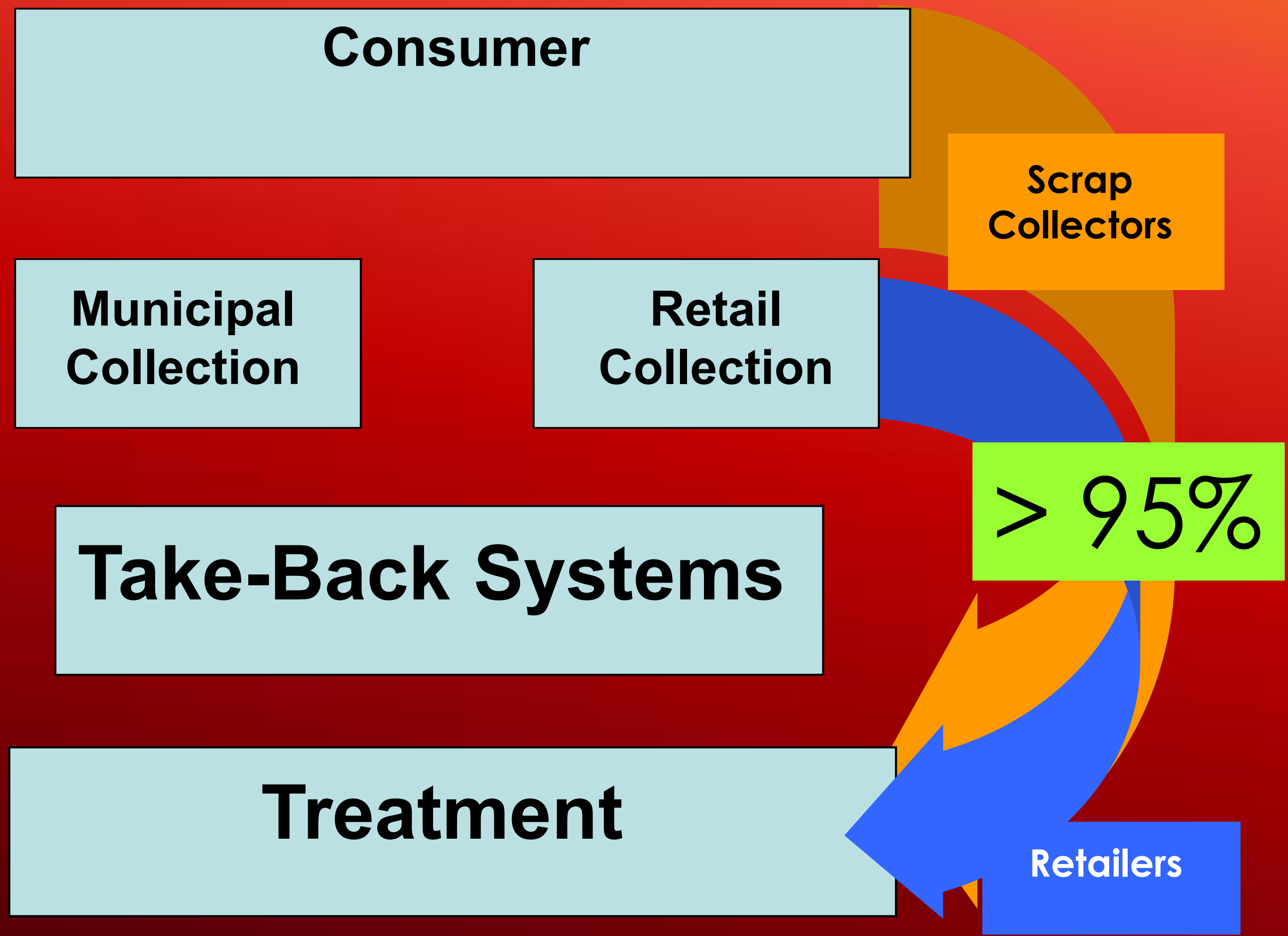
Collection & Recycling will be a profitable business

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 ?



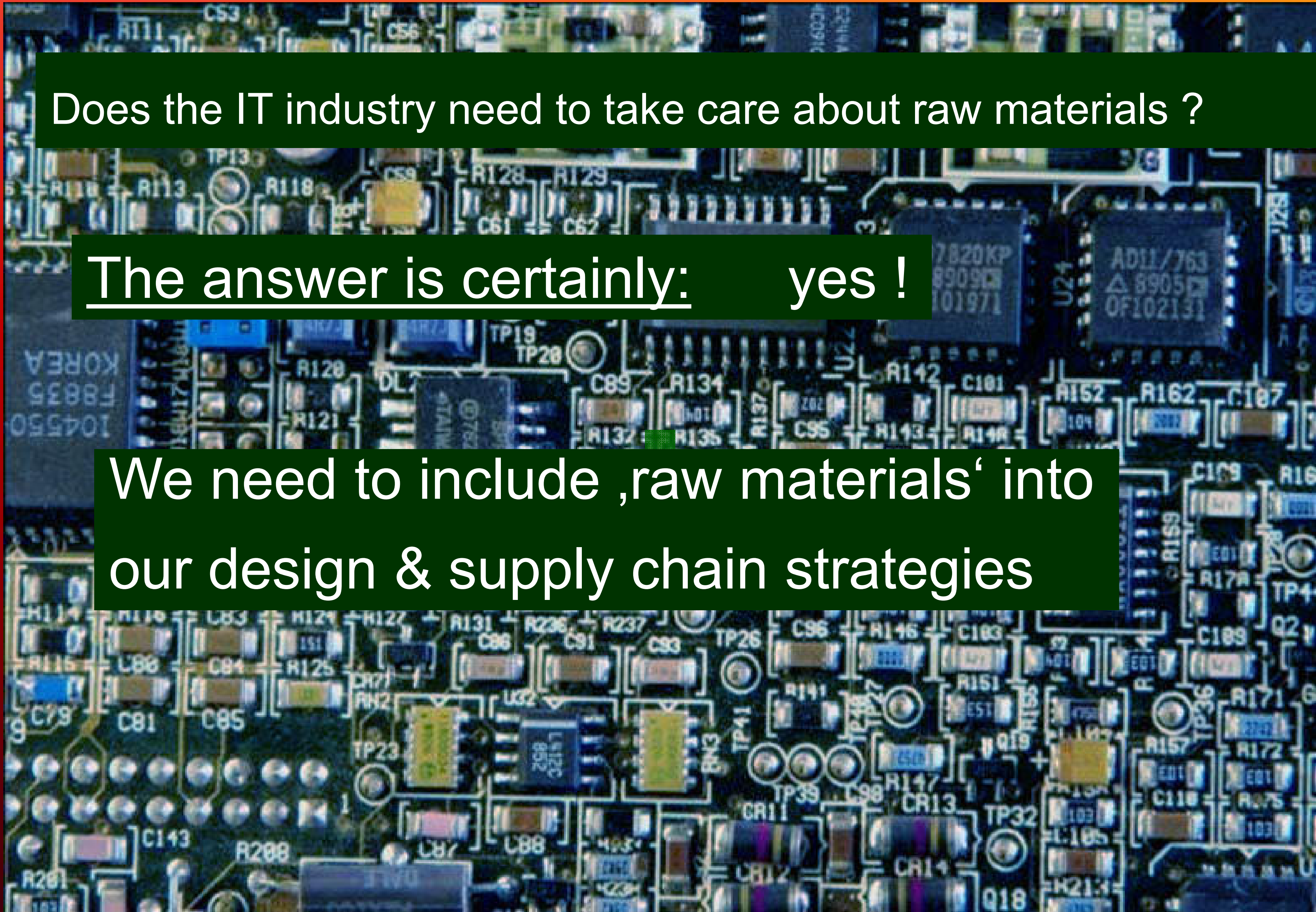
Source: Witteveen+Bos, Onderzoek naar complementaire afvalstromen voor e-waste in Nederland, 10 April 2008

The future is already happening today

* 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 ?

The answer is certainly: 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