"Material Flows and Climate Change" Conference of the Finnish Society for Industrial Ecology in cooperation with Finnish Geological Survey
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Material Flow Analysis for Sustainable Resource Management - A multi-level approach

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The presentation

- Policy Background: Towards Sustainable Resource Management
- Development of MFA research and statistics
- The "systems perspective" and types of MFA
- Highlighted trends - macro
- Sectoral insights - meso
- Potentials of products - micro
- Conclusions

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Sustainable Resource Management (SRM) Policy Developments

- 6th EAP: SRM and waste minimization one of four priority issues
- Thematic Strategy on Sustainable Use of Natural Resources (TSURE) Dec 2005
- International Panel for Sustainable Resource Management, Budapest Nov 2007
- Parallel: Marrakesh process on Sustainable Consumption and Production (SCP)

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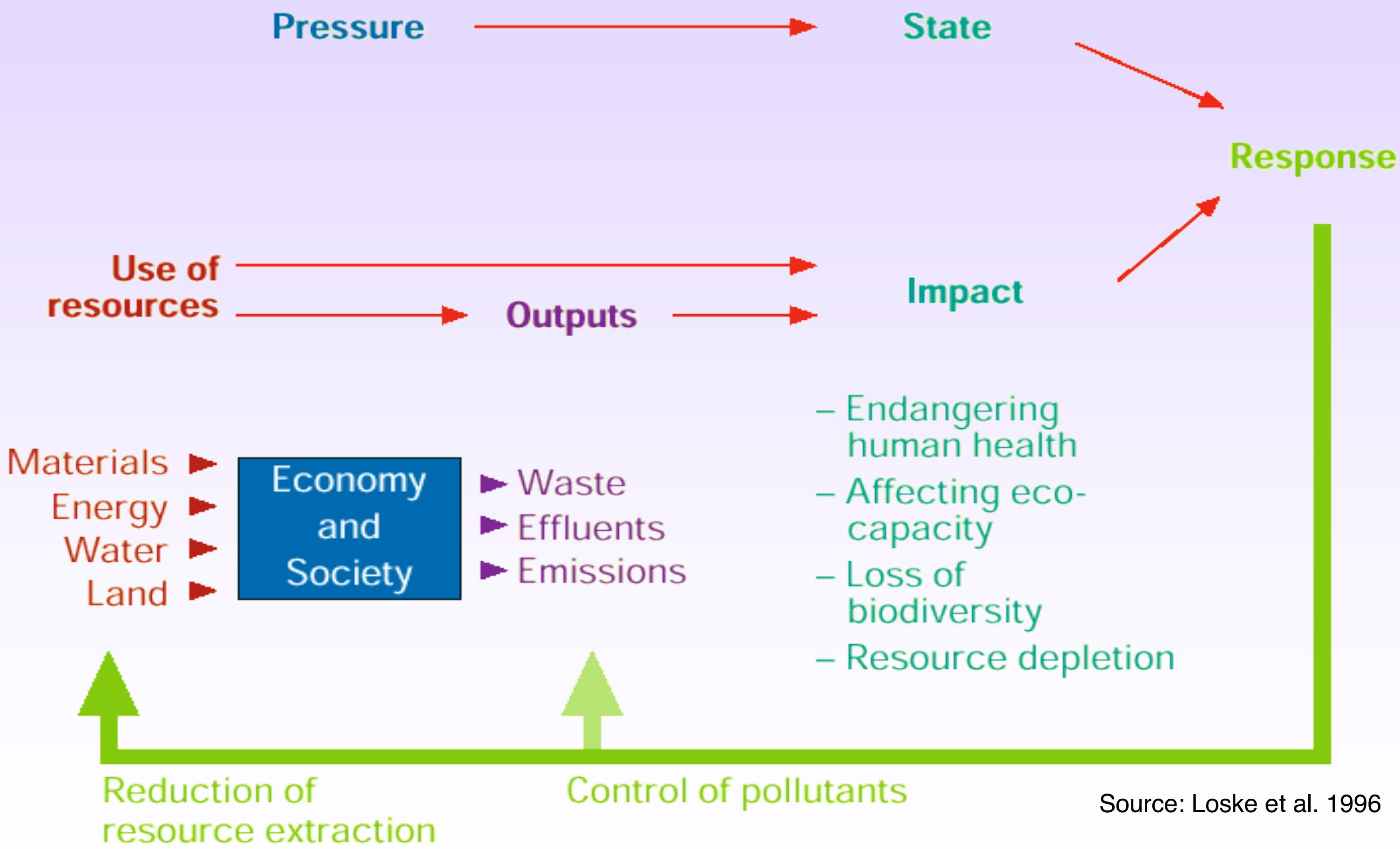
Supporting policy debate in the EU

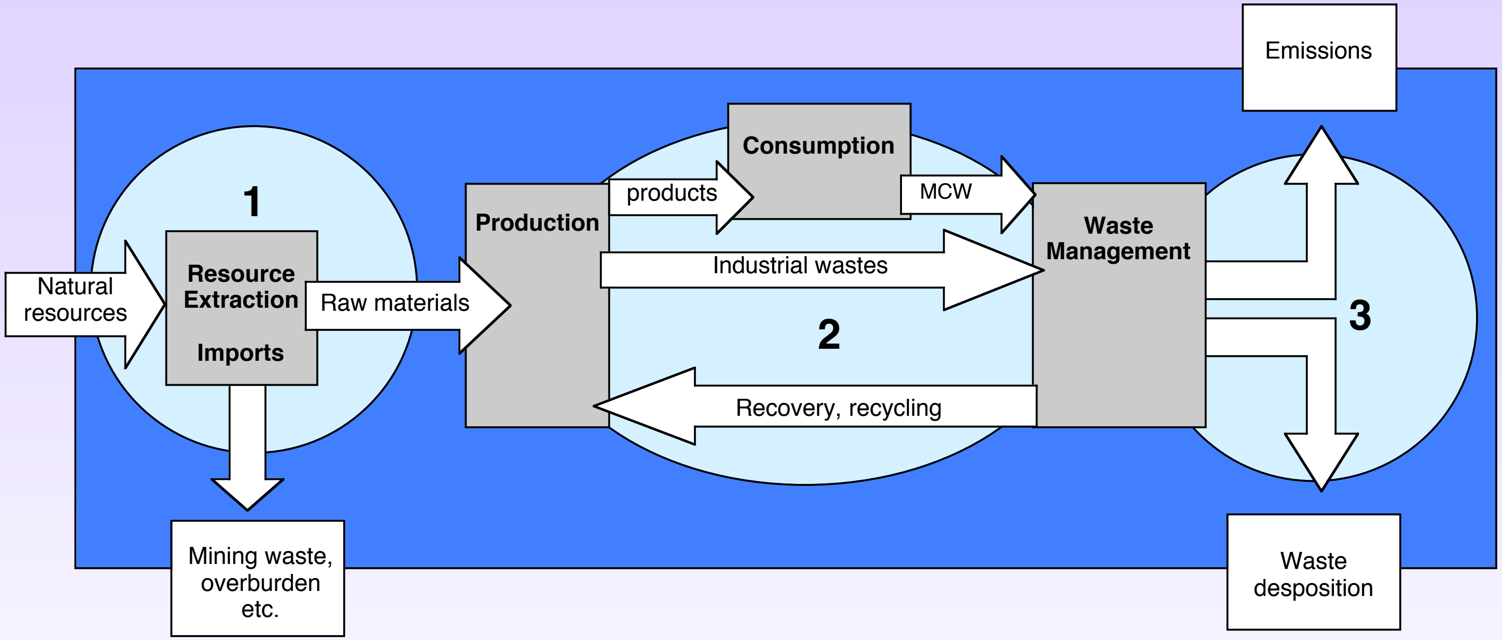
- Thematic Strategy on Sustainable Use of Resources (Dec 2005)
- EEA Report No. 9/2005

Background: Development of environmental policy



Source: Loske et al. 1996

Target areas of a balanced material flow policy



1. Raw material taxes, licencing, agreements
2. Integrated Product Policy, quota for recycled inputs
3. Landfill & pollution taxes, technical standards

Sustainable resource management should

1. Secure **adequate supply and efficient use** of materials, energy and land resources as reliable physical basis for creation of wealth and well-being in industry and society

2. Not overload or destroy **nature´s capacities** of reproduction and regeneration of resources and absorption of residuals

3. Contribute to safe-guard the **co-existence of society and nature**

4. Minimize risks for national and **international security** and economic turmoil due to dependance on resources

... cont

Source: Bringezu (2006)

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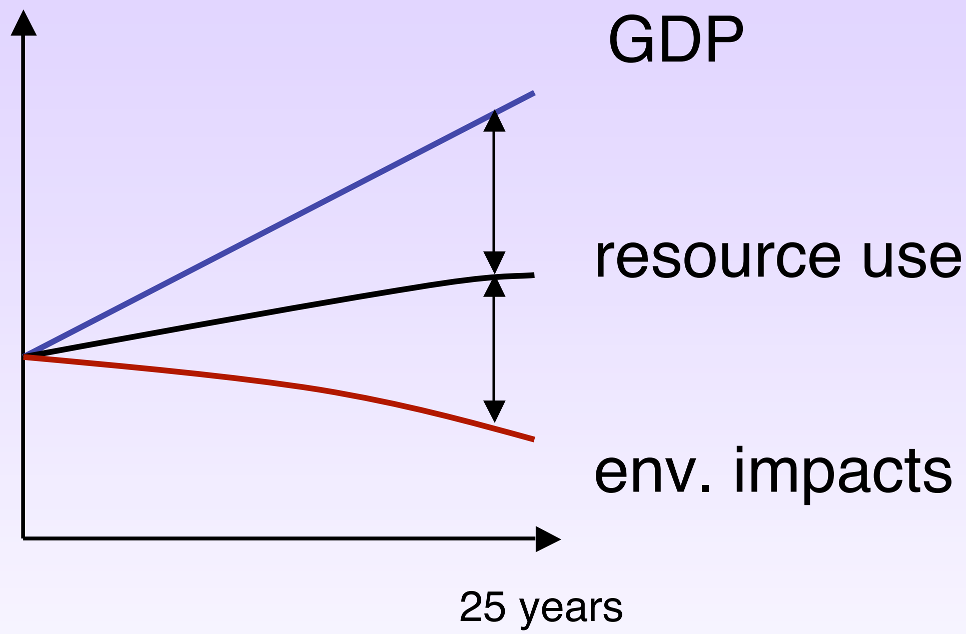
Sustainable resource management should

5. Contribute to a **globally fair distribution** of resource use and an adequate burden sharing

6. **Minimize problem shifting** between
   - environmental media,
   - economic sectors,
   - regions,
   - generations

7. **Drive technological and institutional change** in a way and towards a direction which also provides economic and social benefits

Objectives of the EU resource strategy



increase of resource efficiency

eco-efficiency

reduction of resource specific impacts

⇒ How to effectively decouple impacts of resource use from economic development?!

Three pillars of a sustainable resource use policy

Goals (e.g. Dematerialisiation),
objectives (e.g. decoupling),
targets (e.g. Factor 4/10)
- broad discussion
- indicators for orientation and monitoring

Improved information

- EU, national, regional, communities, firms, households
- institutional + technological potentials for improvement
- good-practice examples
- education and training

Incentive framework

- market based instruments (adjust subsidies, taxes etc.)
- planning (e.g. extraction licenses, construction standards)
- standards for sustainable cultivation (e.g. organic farming, FSC)
- no go zones for mining (e.g. national parks)
- no use materials (e.g. Hg, U)

Source : Stefan Bringezu

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Under development: Elements of a Program for Economy-wide Sustainable Resource Management

mapping the potential

- quantified potential (where, how much)
- driving forces, obstacles, incentives

developing a road map

- specific public-private measures
- extended regulatory impact assessment
- consensus among opinion makers

Validation in pilot projects

e.g. R&D-funding, innovation policy

e.g. targets, monitoring and VAs

e.g. know-how transfer via agencies and networks

e.g. global resource certificates

Source: Wuppertal Institute

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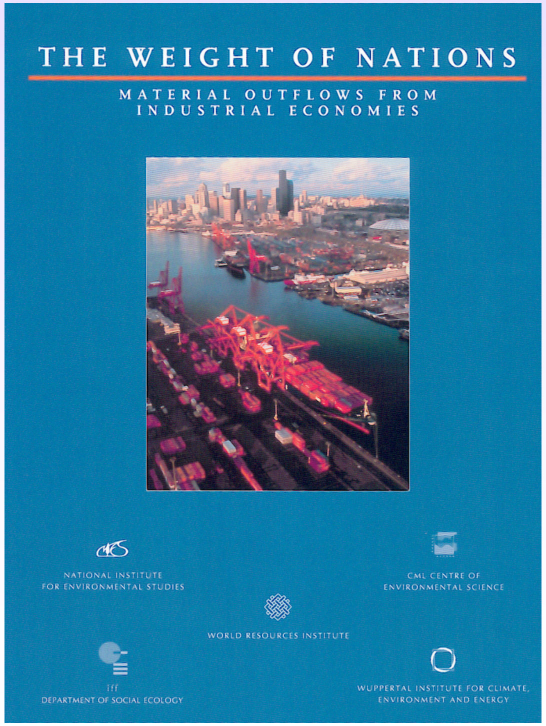
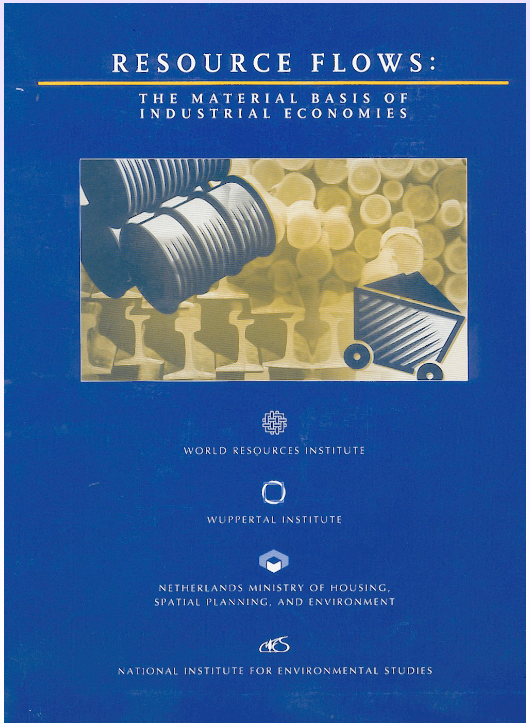
Material Flow Analysis - recent history

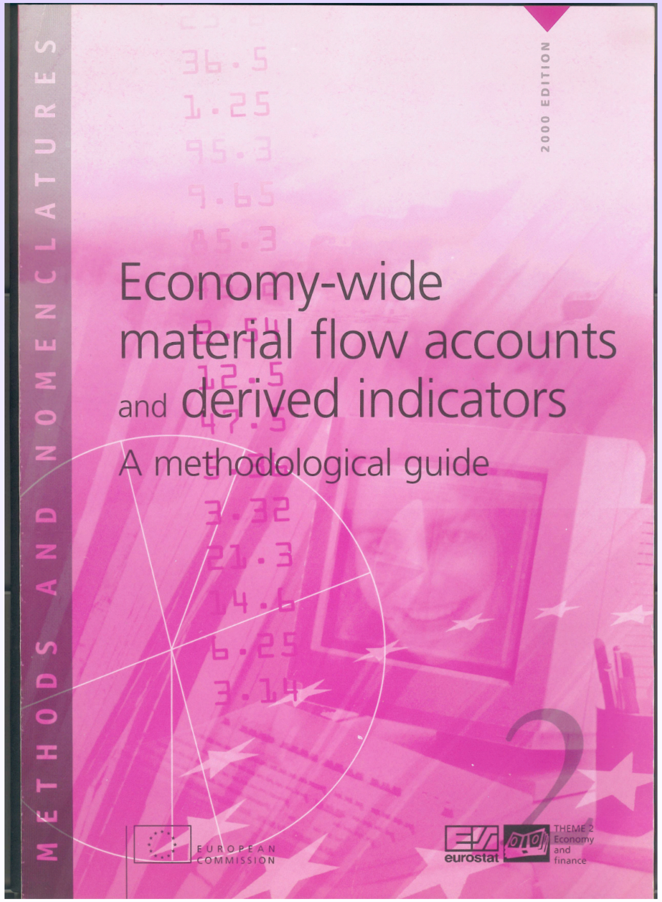
- Ayres and Kneese, late 1960s
- MFA “re-invented” since 1992, Austria, Germany, Japan
- The ConAccount network, since 1997 **(www.conaccount.net)**
- International projects such as Resource Flows (1997) and Weight of Nations Report (2000)
- International Society for Industrial Ecology, since 2000 **(www.is4ie.org)**





Relevance to statistics in the European Union

- EEA - reports considering resource flows (e.g. Environmental Signals 2000, 2002; „Kiev Report“ 2003; Outlook report 2005; "Belgrade Report" 2007)
- EUROSTAT (2001): „Material Flow Accounts and derived indicators - A methodological guide“
- EUROSTAT (2001) (Ed.): Material use indicators for the European Union 1980-1997; and subsequent up-dates
- Official MFA in EU Member States, e.g. Austria, Belgium (parts), Denmark, Germany, Italy, Portugal, Finland, Spain, United Kingdom



The OECD process:
Measuring material flows and resource productivity

- Start 2003 (Tokyo)
- Council Recommendations 2004, 2008
- Series of workshops (Helsinki, Berlin, Rome, Tokyo)
- Products (4/2008):
  - Sythesis report
  - Vol. I: The OECD guide
  - Vol. II: The accounting framework
  - Vol. III: Inventory of country activities (coop. with EEA)
  - Vol. IV: Implementing national MF Accounts ("guide light", jointly with Eurostat)

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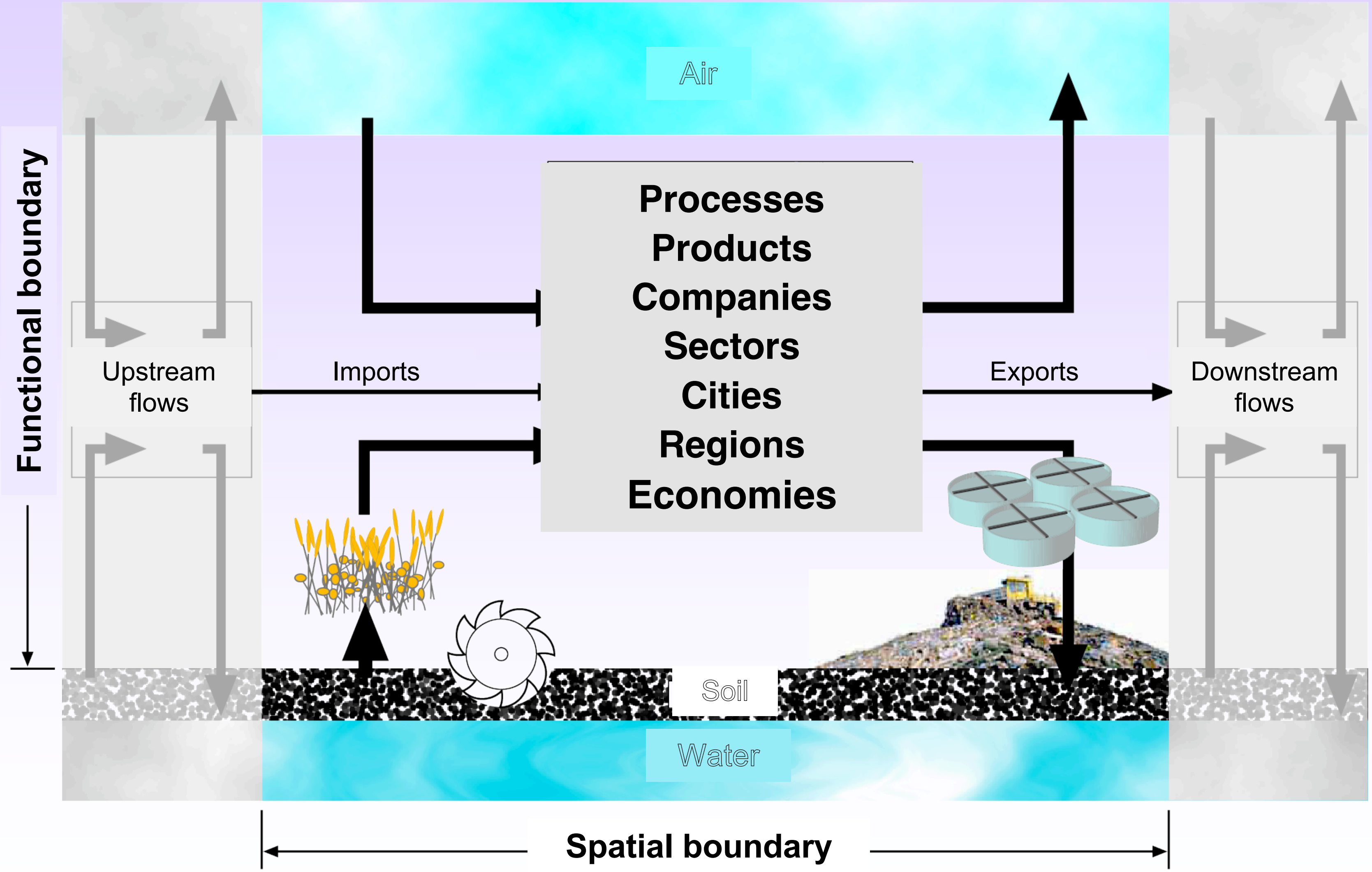
A basic perspective

Source: Stefan Bringezu

Systems perspective(s) on the metabolism



Source :Stefan Bringezu

Types of material flow related analysis

Specific environmental problems related to certain impacts per unit of flow of			Problems of environmental concern related to the throughput of		
Substances	**Materials**	**Products**	**Firms**	**Sectors**	**Regions**
e.g.	e.g.	e.g.	e.g.	e.g.	e.g.
Cd, Cl, Pb, Zn, Hg, N, P, C, CO2, CFC	wooden products, energy carriers, excavation, biomass, plastics	diapers, batteries, cars	single plants, medium and big companies	production sectors, chemical industry, construc-tion	total or main throughput, mass flow balance, total material requirement
within certain firms, sectors, regions			associated with substances, materials, products		

Source: Bringezu and Moriguchi (2002)

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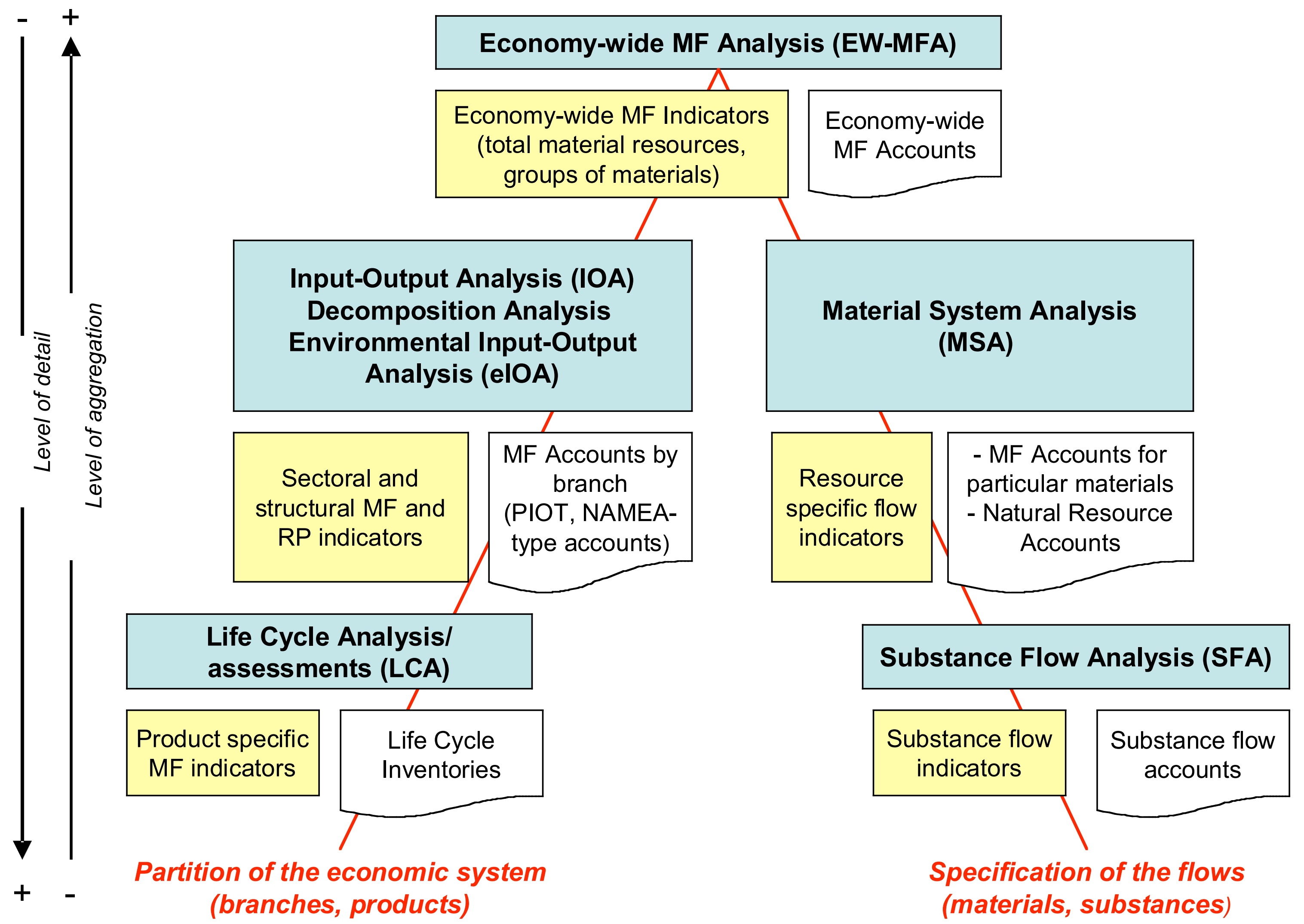
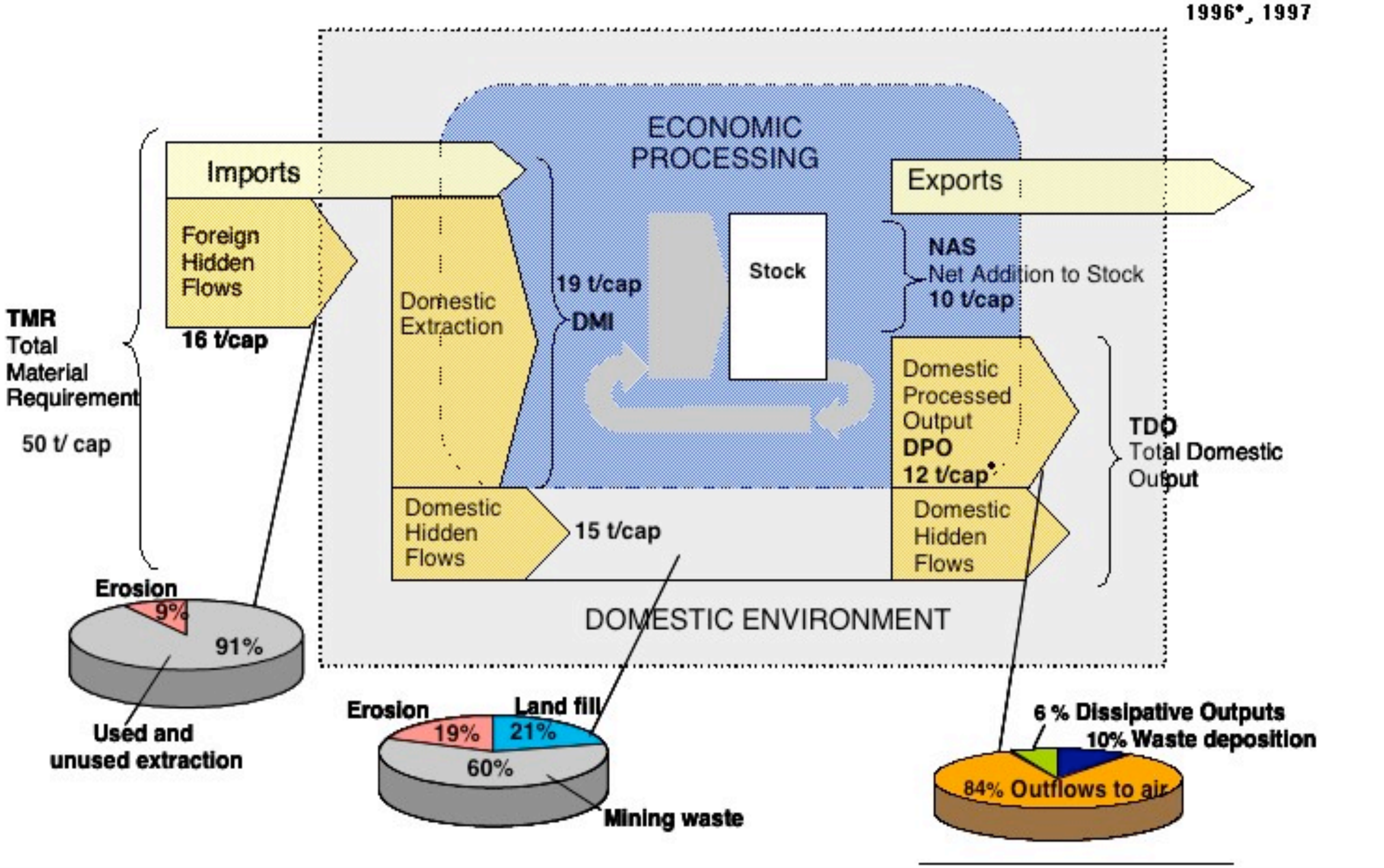
Multi-level accounting and indicator system



Source: after Moll and Femia 2005

Stefan Bringezu | www.wupperinst.org | Espoo 29-04-2008

The industrial metabolism with indicators for EU-15



Source: Bringezu und Schütz 2001

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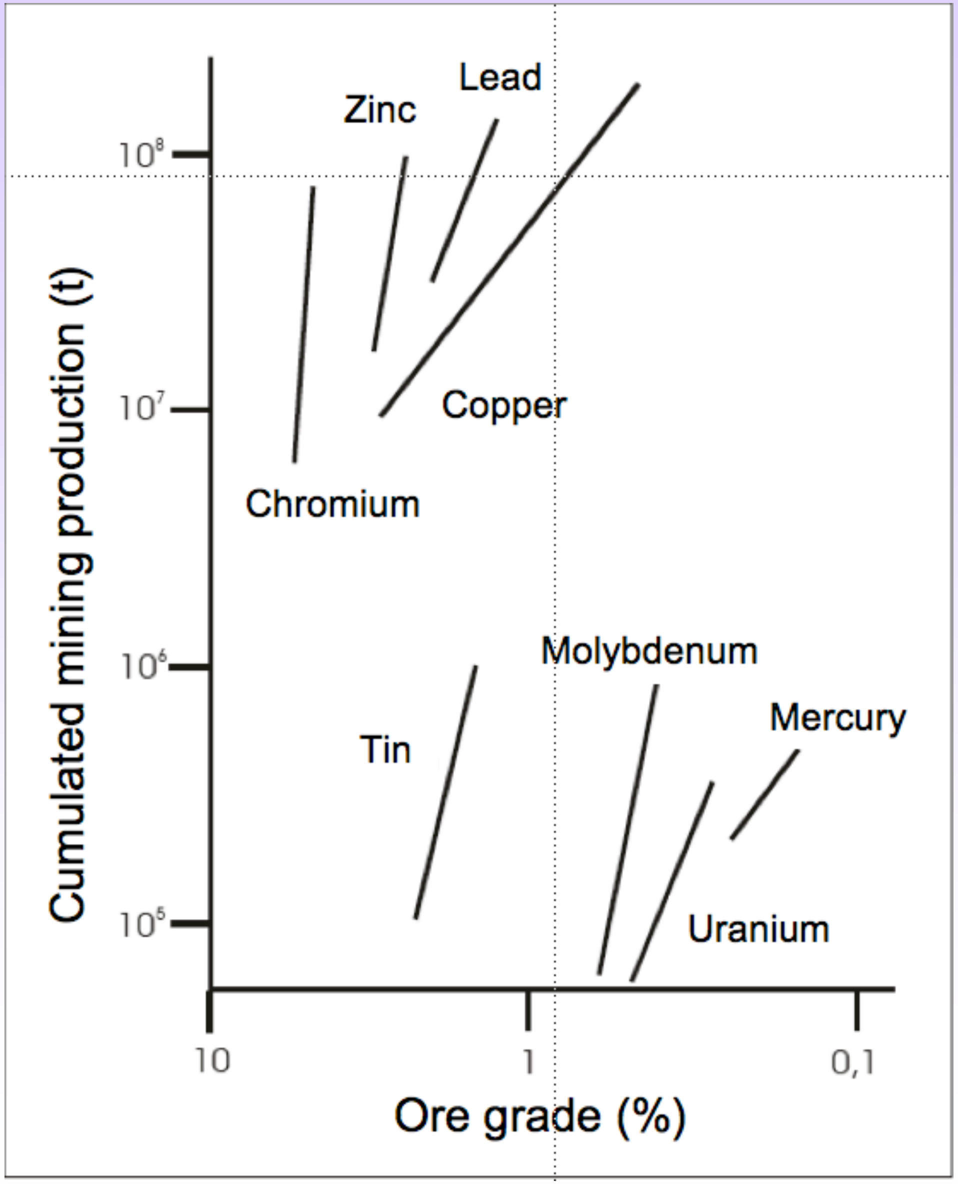
Environmental Impact of Copper Mine
Ok Tedi Mine, Papua New Guinea

These images show environmental impact of the mine

- 1990: Both the mine and township of Tabubil, are clearly visible

- 2004: Raised river beds, forest damage and decline in biodiversity are some impacts

Ever decreasing ore grades are going to be used



Source: U. Dorner after
PreConsultants 2002

Unused extraction and mining waste

...are therefore
expected to grow

Sources:

http://www.spreewald-info.com/tour_tagebaue.html 1999-2002 AOD-Media
Sonja Valivia (2004), Foto Edga Llamoca

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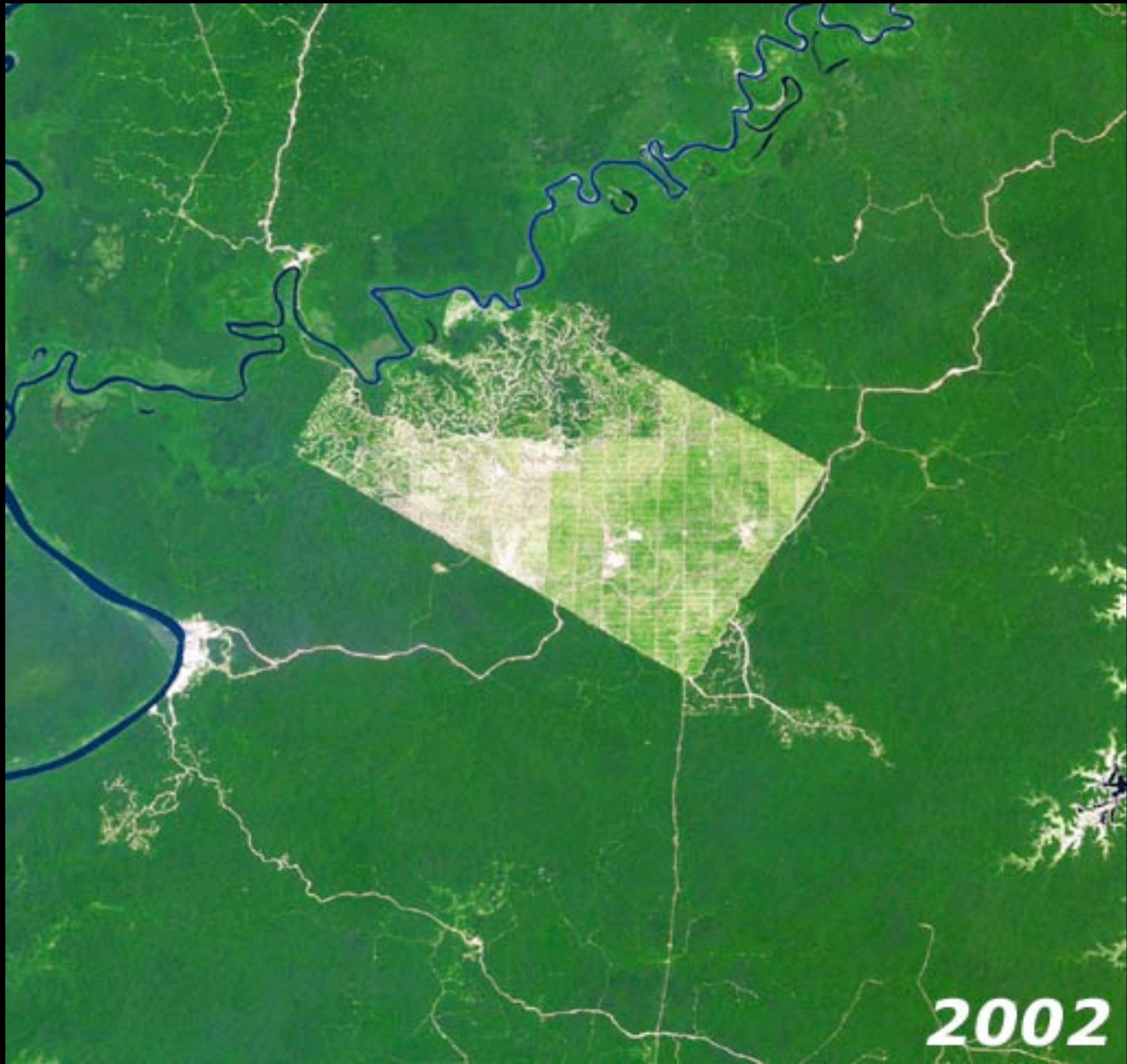
Conversion of forests into palm plantations in Papua, Indonesia



- 1990: a new human presence, earth colored roads provide access to the forest

- 2000: rectilinear patterns cover 10,000 ha

- 2002: Cleared area nearly doubles since 2000

Structure and volume of TMR unsustainable

Continuous global change through dominance of non-renewables

(t/cap)

Component	EU-15 1997	USA 1994	Japan 1994
Domestic used extraction	16	23	10
Imports	4	3	6
Sum (=DMI)	19	25	16
Domestic HF	15	57	10
Foreign HF	16	3	20
Sum (=TMR)	51	85	45
Renewable Proportion (%)	12	7	6
Share for energy supply (%)	29	37	28
Domestic share (%)	61	93	44

Global adoption of industrial countries´ resource requirements would increase earth crust transformation 2-5 times

Country	Period	TMR per capita			TMC per capita			TMC as % of TMR			Source
		Median	Min	Max	Median	Min	Max	Median	Min	Max	
USA	1991	84			74			88			Adriaanse et al. 1997
Germany	1991	90			74			83			Adriaanse et al. 1997
Finland	1970-99	78	64	98	48	40	59	62	47	74	Mäenpää and Juutinen 1999, 2001
Netherlands	1975,80,85,90-93	69	62	76	55	48	64	84	68	85	Adriaanse et al. 1997
Denmark	1981,90,97	66	55	70	43	41	48	72	61	75	Pedersen 2002
United Kingdom	1970-99	37	34	43	31	27	34	83	72	90	Bringezu and Schütz 2001
West Germany	1970,77,80,82,84,87,89-90	67	60	74	45	43	53	69	64	71	Bringezu and Schütz 1995

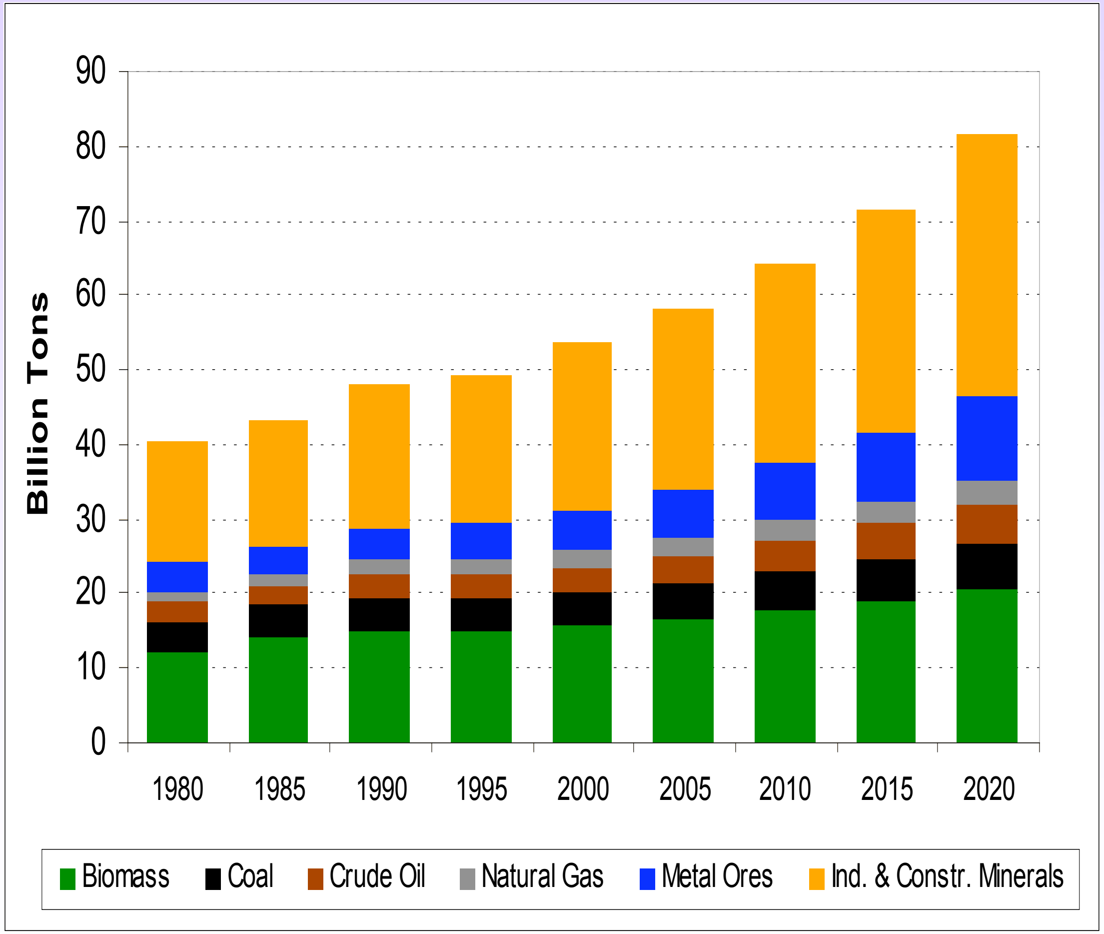
Source: Different sources and Bringezu und Schütz 2001

Worldwide used extraction of resources

Projected increase of used extraction from 2000 to 2020: 1,5 times

Unused extraction adds at least the same amount*

MOSUS Baseline scenario DEU



Source: SERI; Giljum et al. 2007

*not shown

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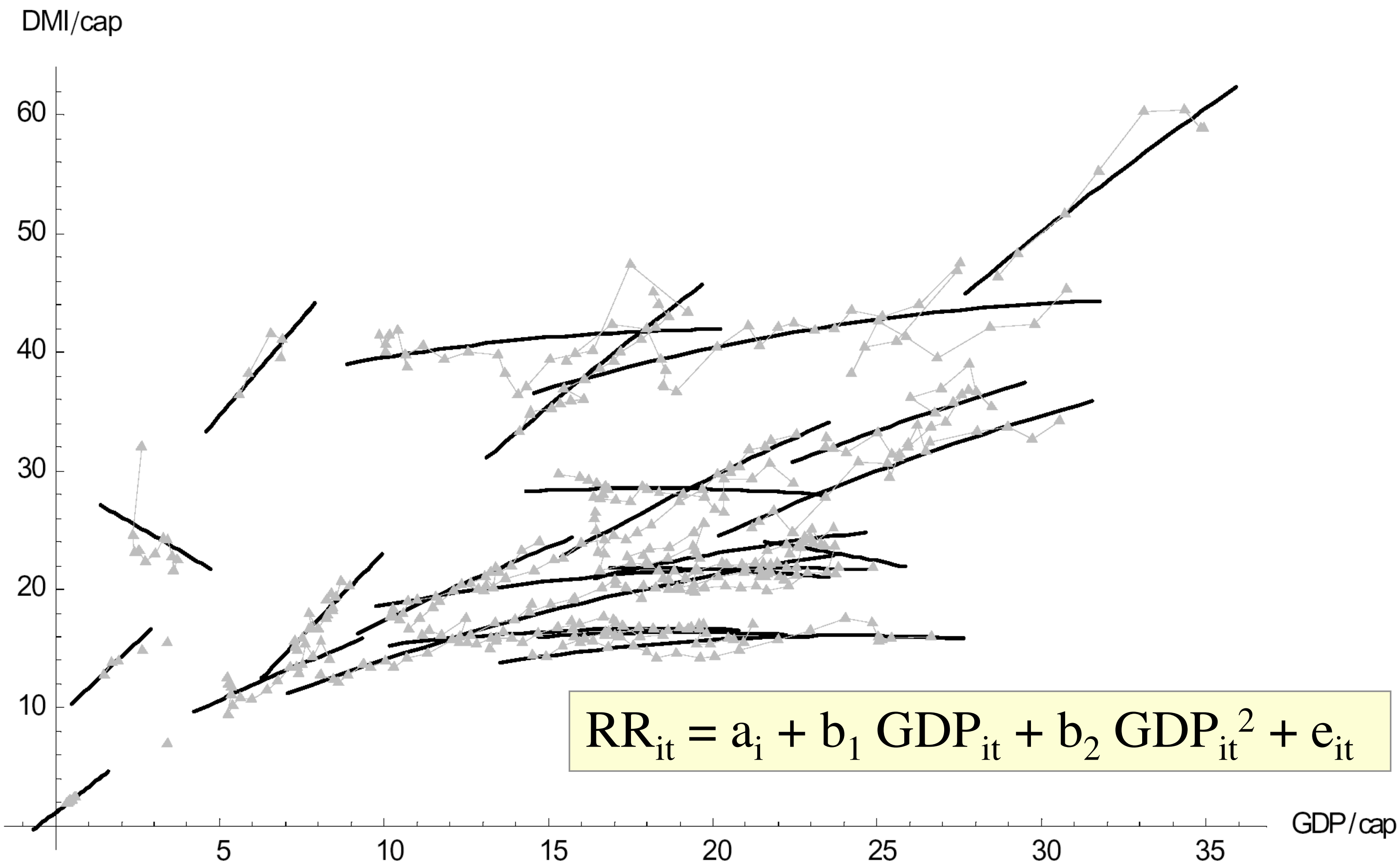
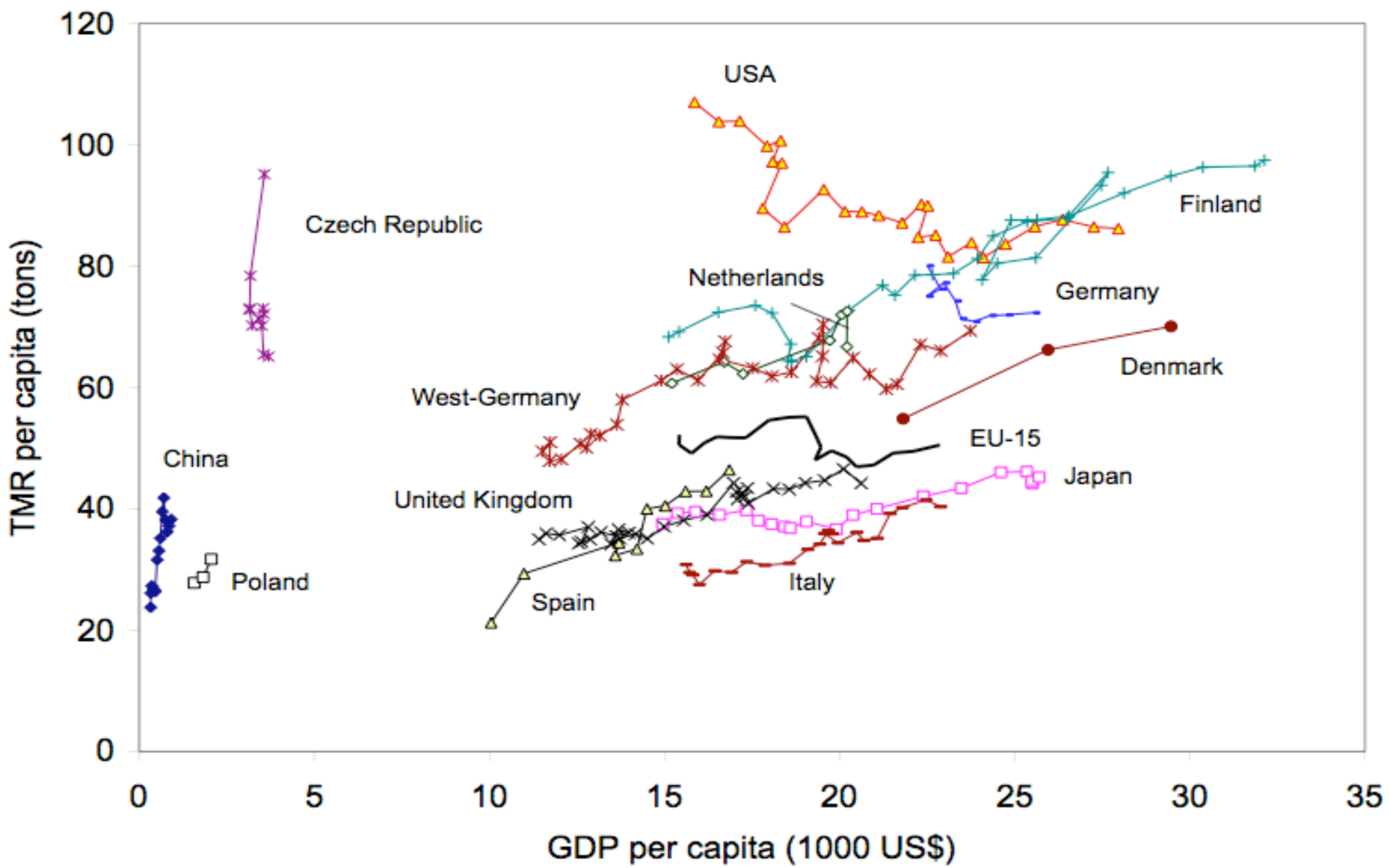
DMI and GDP: no general trend of absolute decoupling



$$RR_{it} = a_i + b_1\ GDP_{it} + b_2\ GDP_{it}^{\ 2} + e_{it}$$

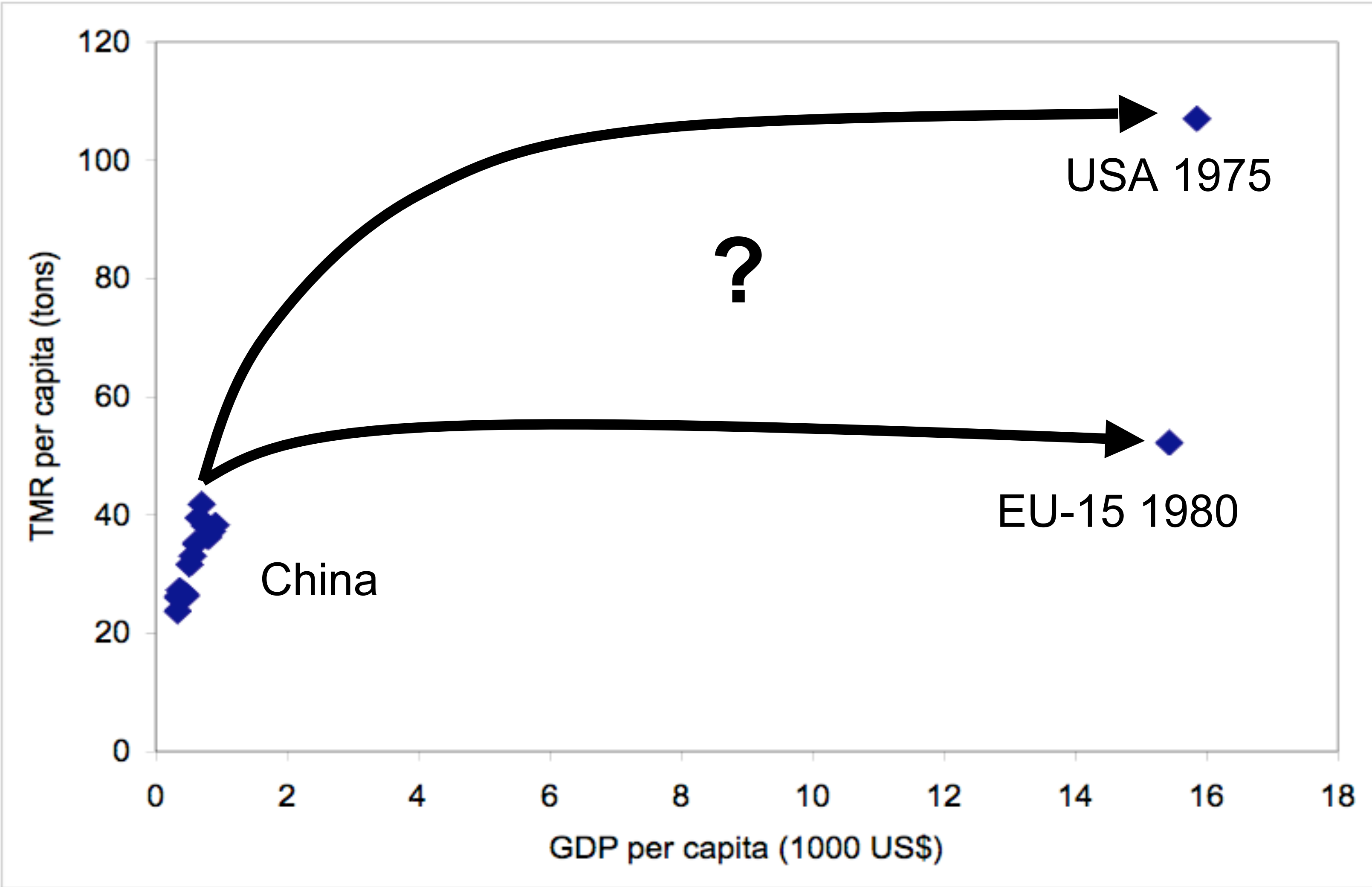
Source: Bringezu, S., et. al. 2004

Total Material Requirement and economic growth



Source: Bringezu et al. based on various studies

Which way is China going to take?



Source: Bringezu after Liu pers. comm., Bringezu/Schütz and Matthews et al. 1997

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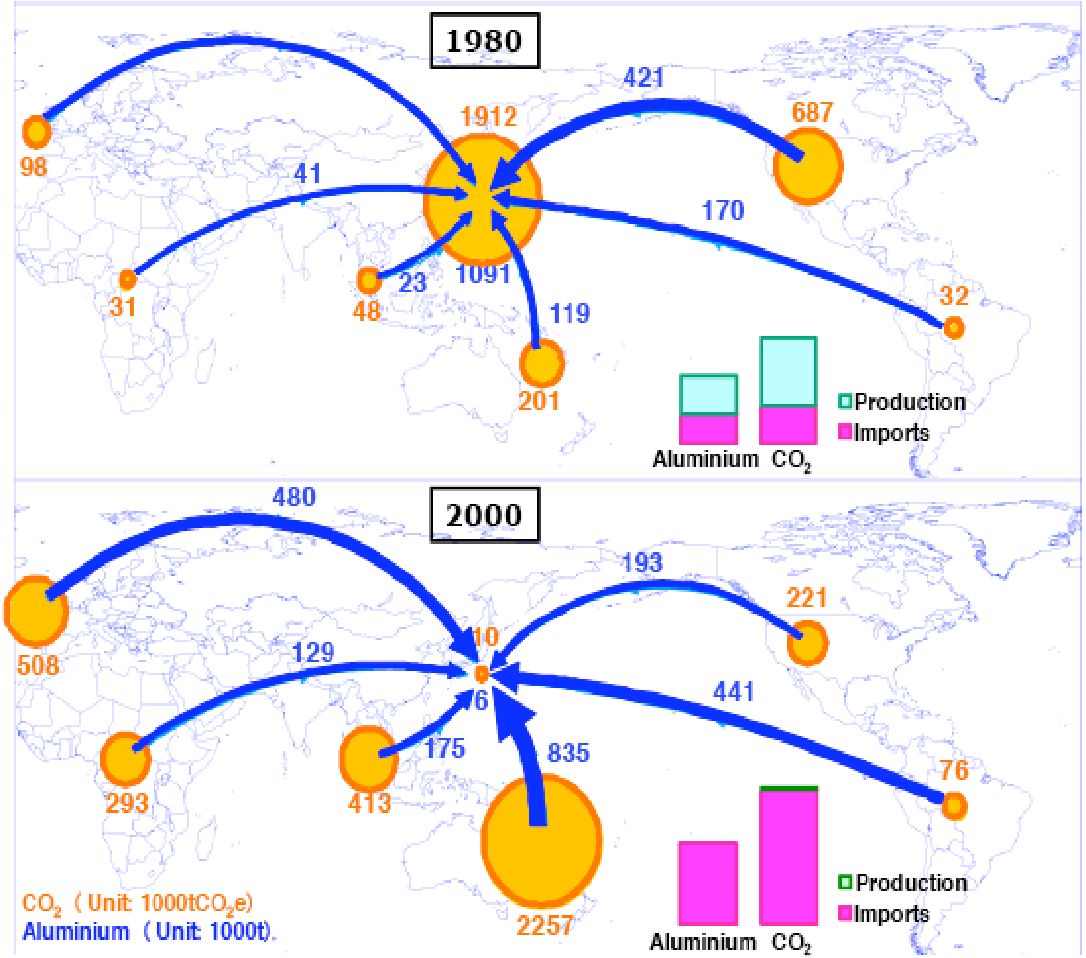
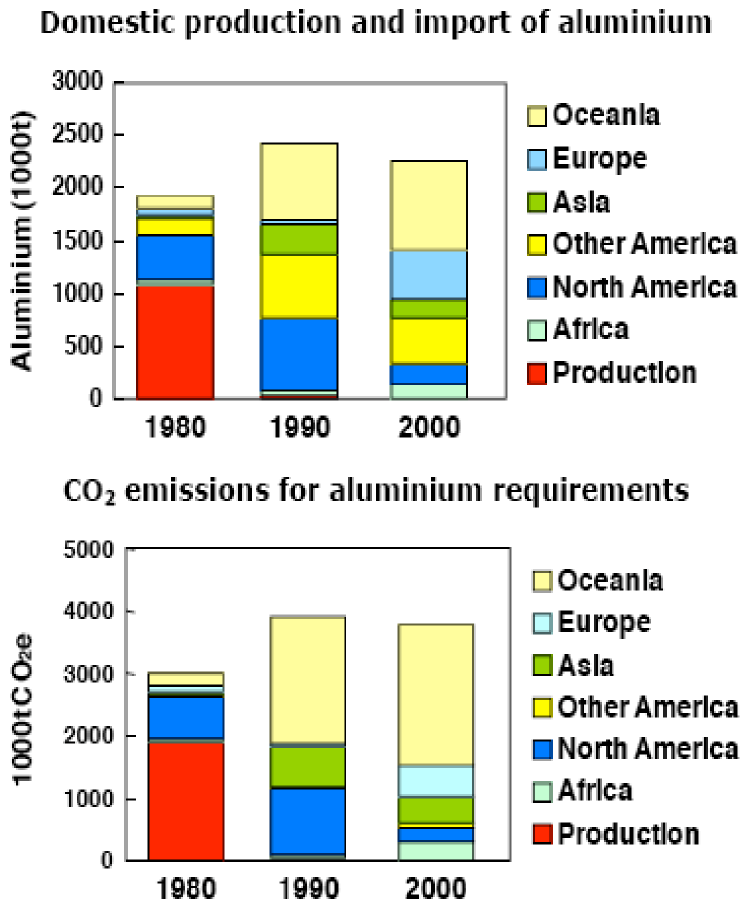
The importance of indirect flows is growing

Domestic production and import of primary aluminium and related CO_2 emissions, 1980-2000, Japan

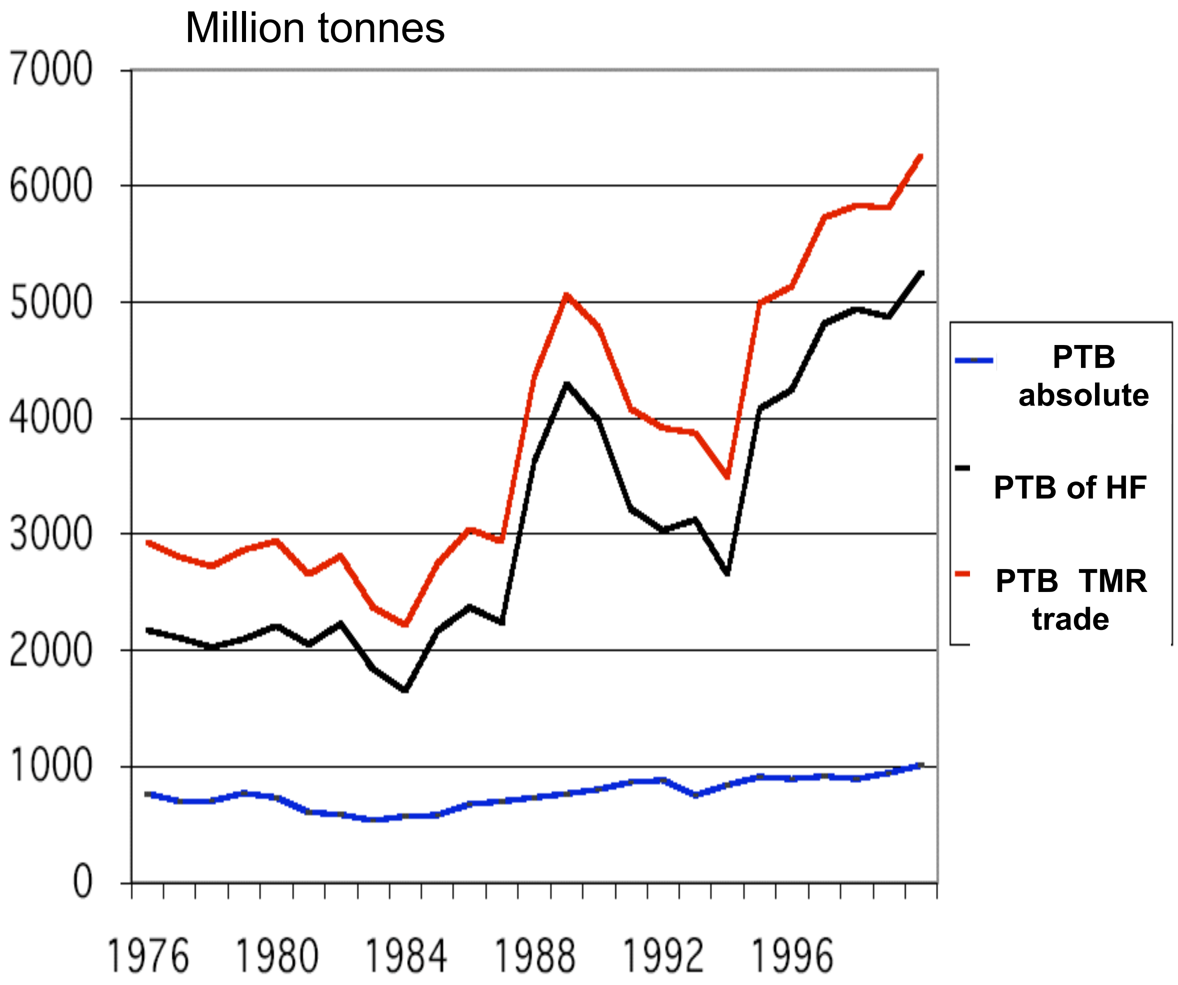




Source: NIES

Physical trade balance of EC/EU considering hidden flows

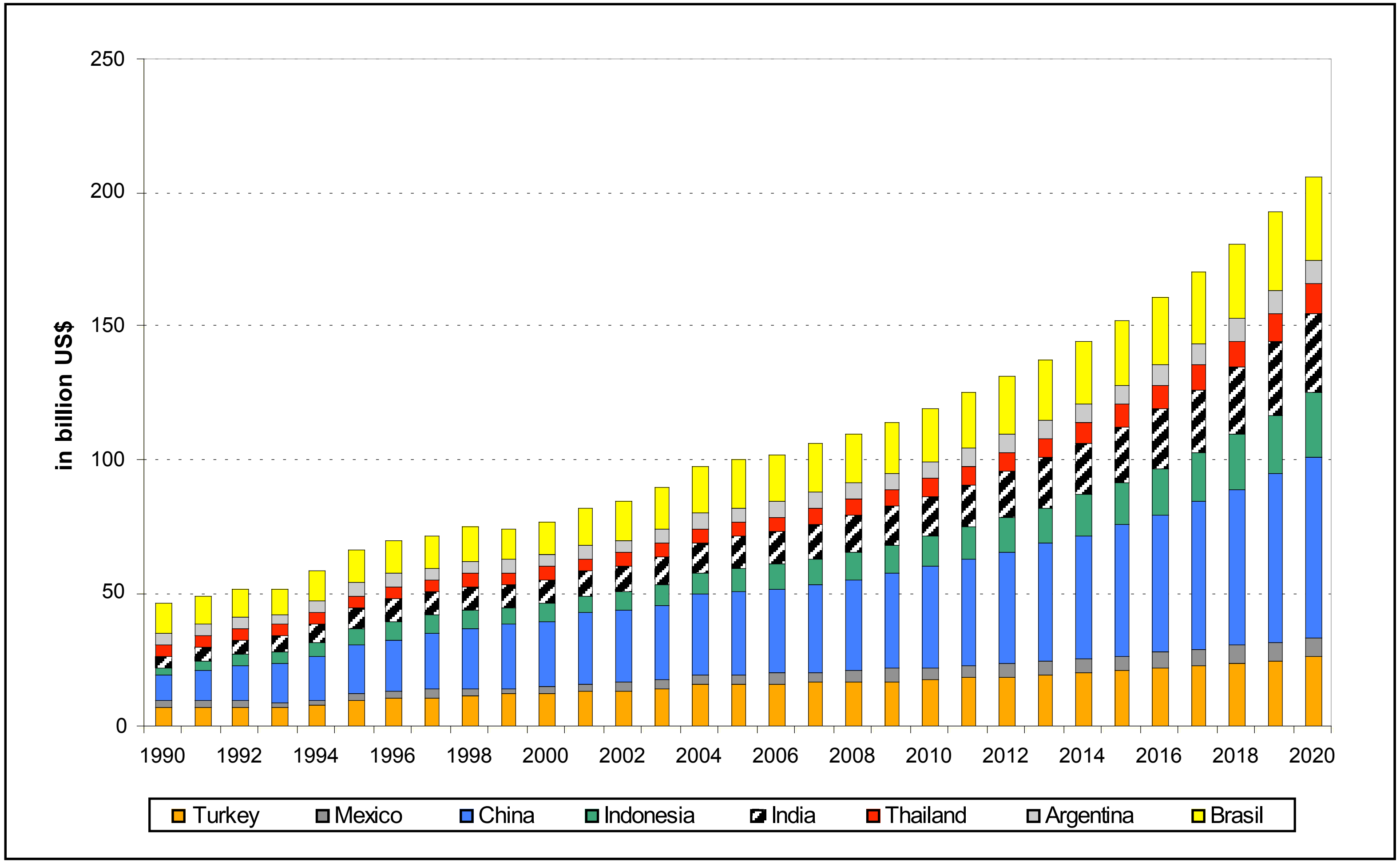
The EU increasingly uses foreign resources (import surplus)



Source: Schütz et al (2003)

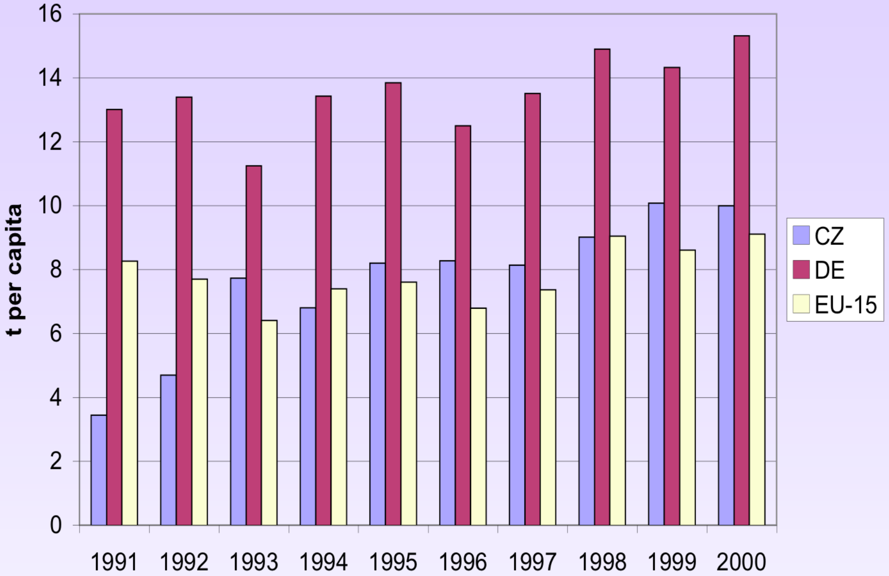
Industrial regions: Resource intensive imports will increase

Resource-intensive imports from “Anchor countries”- MOSUS baseline EU-25



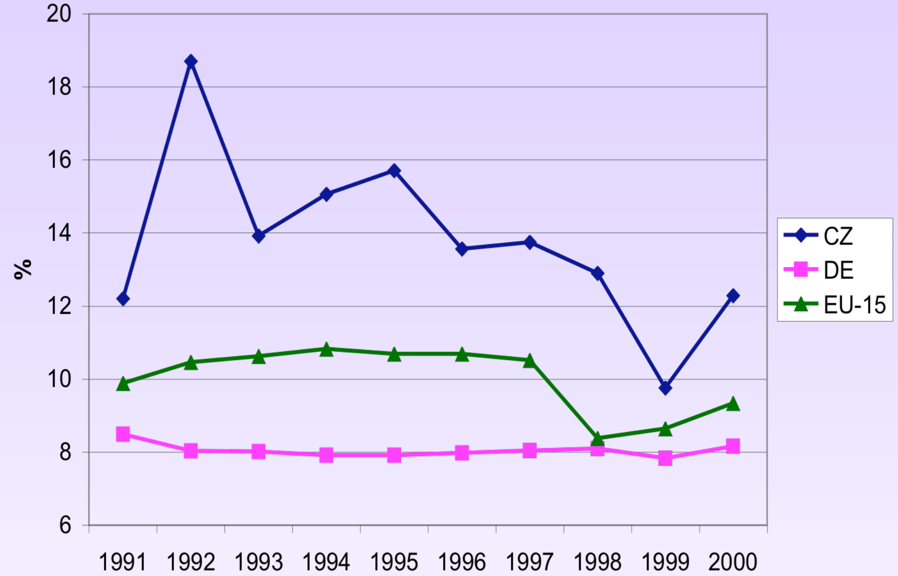
Source: SERI; Giljum et al. 2007

The enlargement of the EU and technogy convergence
Czech case study: TMR of metals



TMR of metal materials per capita, Czech Republic, Germany and EU-15, 1991-2000

- TMR of metals in Cz increasing



Share of direct input of metal materials in Total Material Requirements for metal materials, Czech Republic, Germany and EU-15, 1991-2000

- tendency for convergence for the CZ
- Share of indirect flows is increasing

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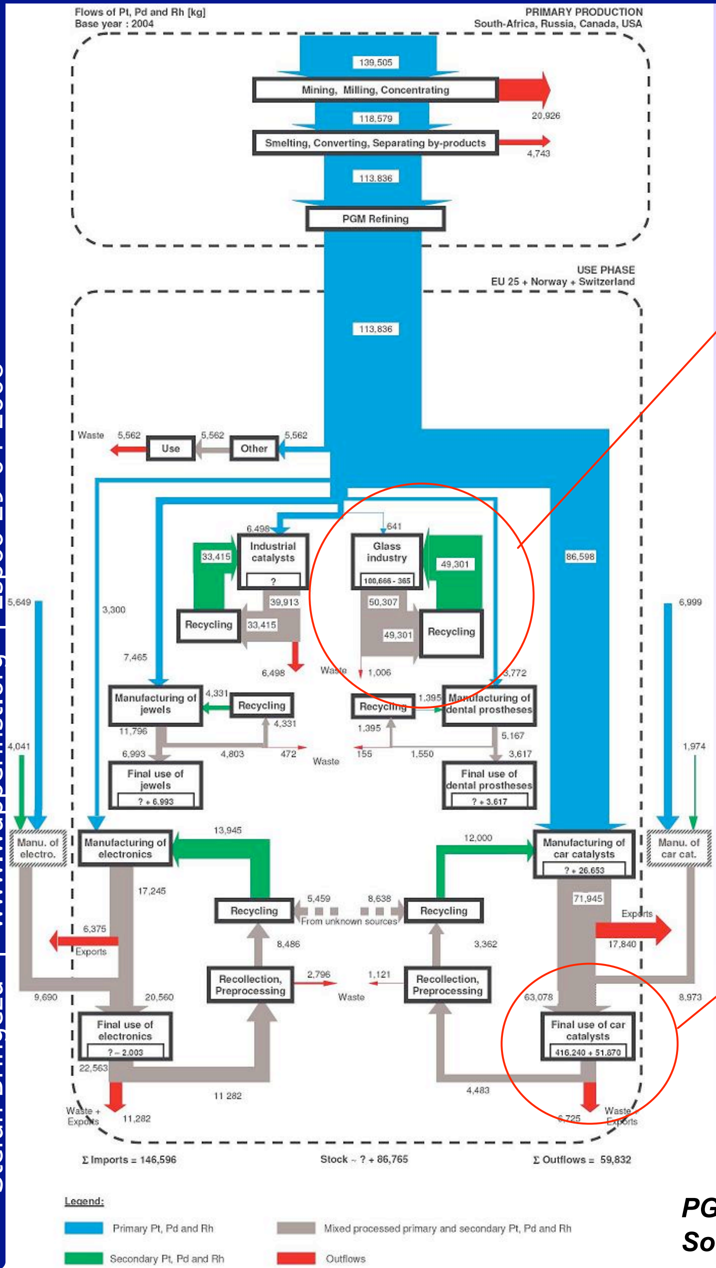
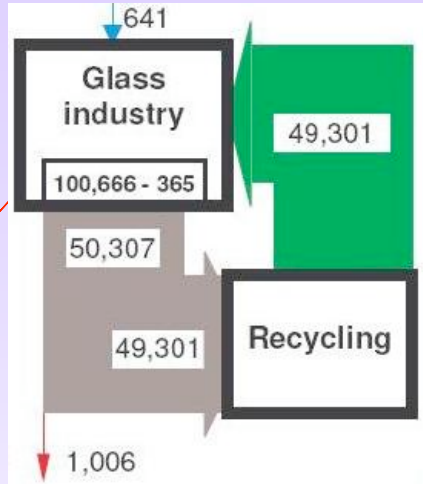
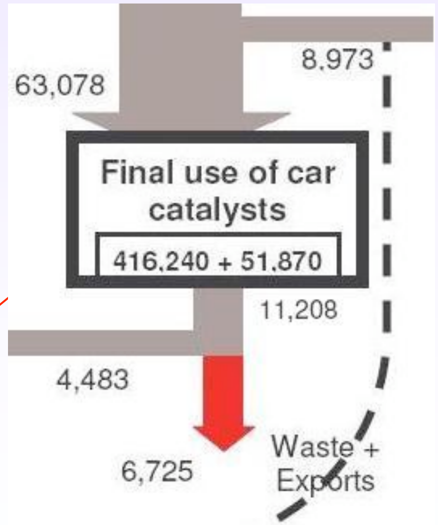
Material system analysis: PGM flows in Europe







PGMs in glass industry:

- organized in closed loop
- secondary PGM input represent ~ 43 % of European secondary input
- primary input represent only 0.5 % of European primary input

PGMs in car catalysts:

- low recycling rate (~30 %), mainly due to exports
- expanding car fleet, growing average cylinder capacity, stricter emissions standards

=> The automotive industry represents 76 % of PGM primary input to Europe

PGM flows in EU 25 + Norway + Switzerland in 2004
Source: Mathieu Saurat and Stefan Bringezu

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Shifting problems: the case of PGMs

1 t primary PGMs used in car catalysts* would help to avoid

- 82 300 t NO_x — equivalent to → 57 600 t SO_{2eq}
- 3 200 t CH_4 (73 600 t CO_{2eq})

+ increased fuel cons. net effect — equivalent to → 27 900 t CO_{2eq}

… diffusely emitted in Europe

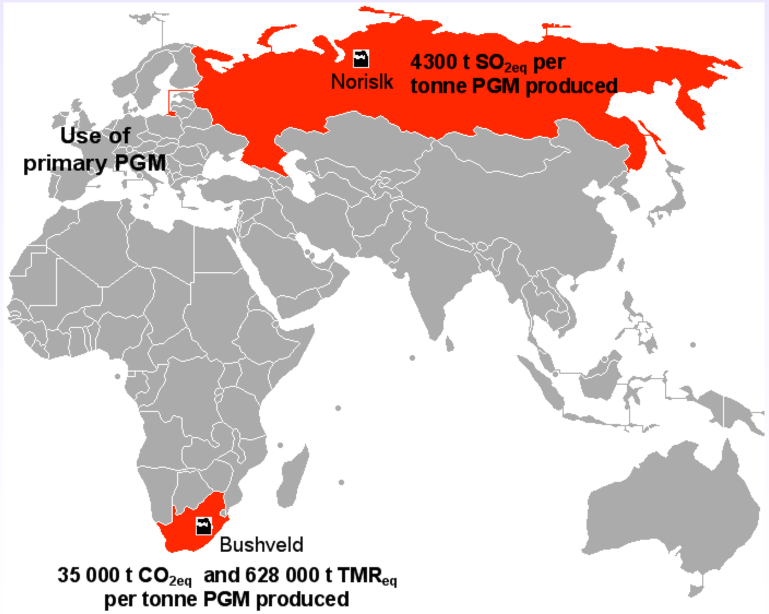
For the production of 1 t primary PGMs

- 1 700 t SO_{2eq} emissions
- 15 000 t CO_{2eq} emissions
- 237 800 t TMR

… occur concentrated in other regions

The use of primary PGMs in Europe implies:

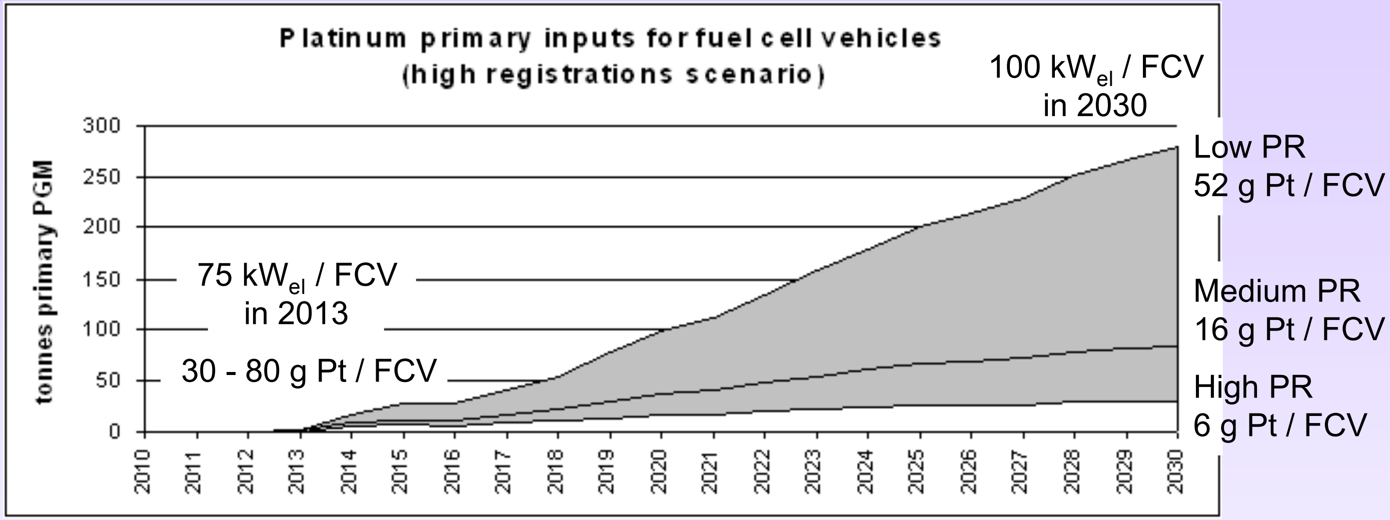
- extremely high SO_2 emissions in Siberia (outdated technology for the smelting process)
- high CO_2 emissions in South Africa (92 % of power generation from coal)
- extreme amounts of TMR and related mining waste



* *Assumptions:* petrol car, 1.4-2 L cylinder capacity, Euro III, 3.5 g PGMs / car, 160 000 km / car during lifetime, -1.8 g NO_x / km, -0.07 g CH_4 / km, +1 g CO_2 / km

Source: Mathieu Saurat and Stefan Bringezu

Future PGM demand for fuel cell vehicles



Scenario for Europe

Learning curves: *cumulative production* combined with *progress ratios (PR)*

=> A range of possible technological developments

Modelling results 2010 – 2050	Cumulative primary platinum input	**Share of world identified resources**
Low PR (40 g Pt / FCV in 2050)	43 560 t	**150 %**
Medium PR (16 g Pt / FCV in 2050)	18 150 t	**63 %**
High PR (5 g Pt / FCV in 2050)	5160 t	**18 %**

Scenario for the world

FCVs represent 36% of a 2 billion world passenger car fleet in 2050

⇒ Need of important technological improvements to limit the use of platinum per FCV

Source: Mathieu Saurat and Stefan Bringezu

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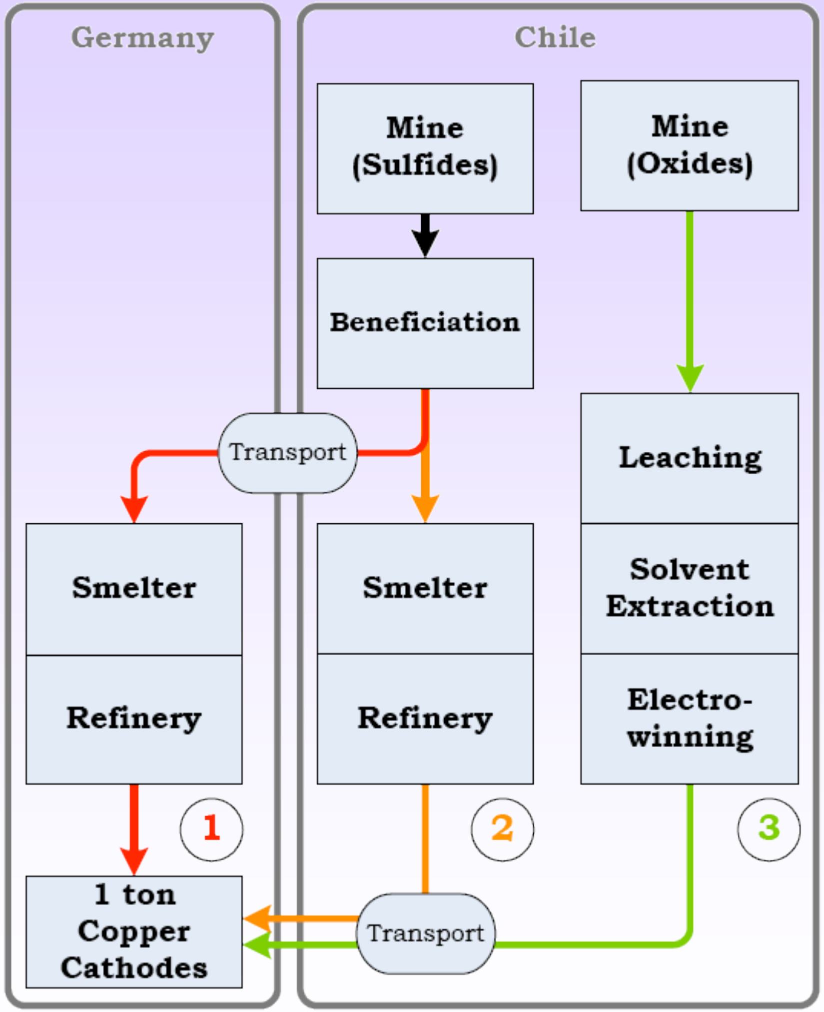
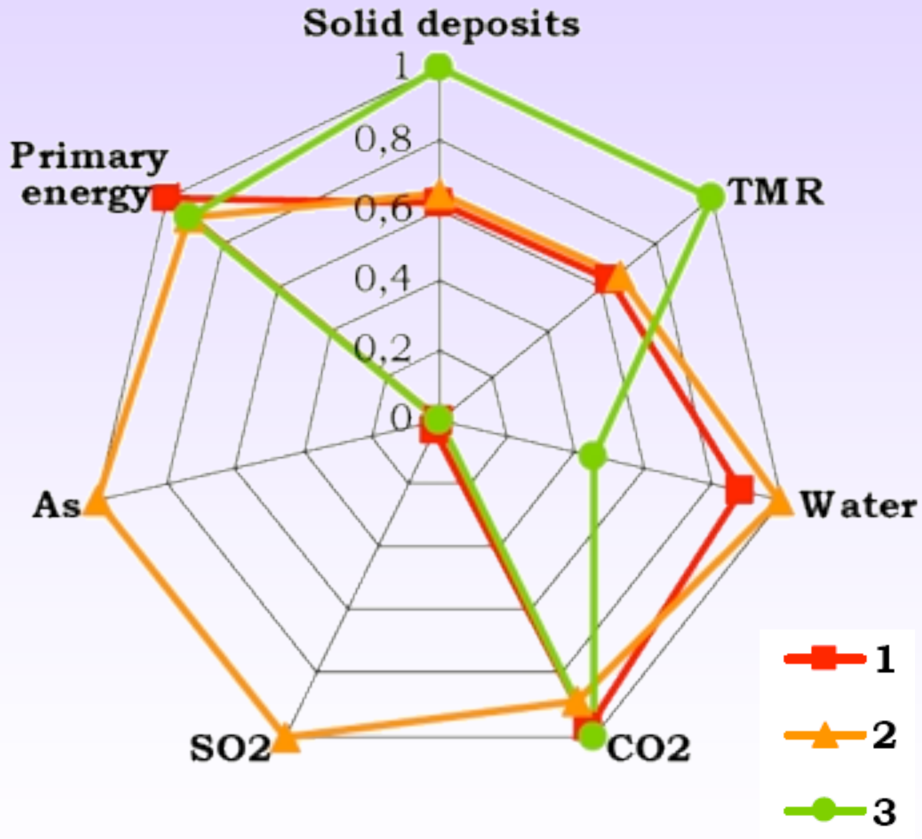
Comparison of production routes of copper

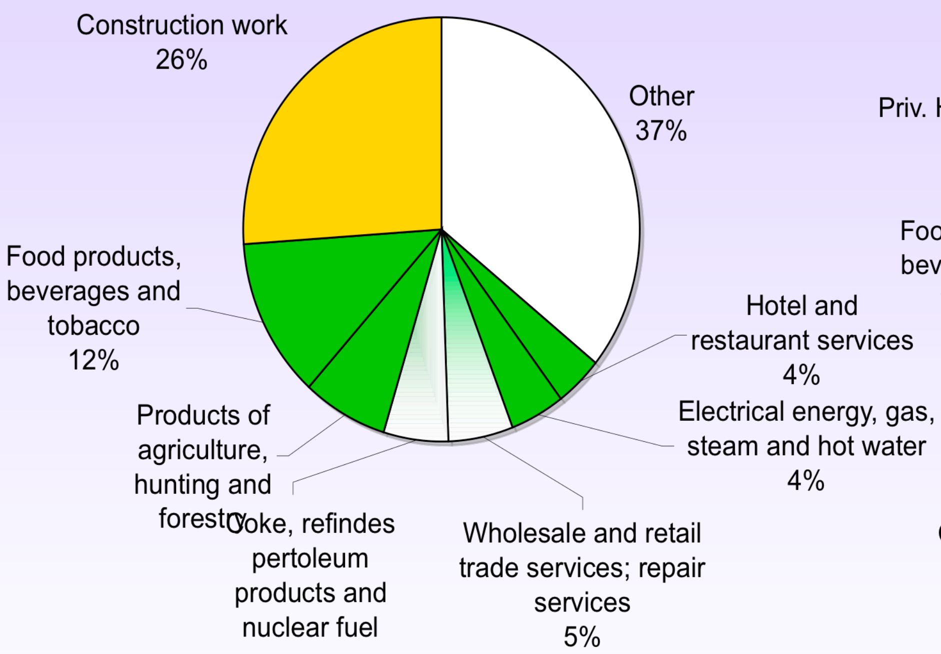




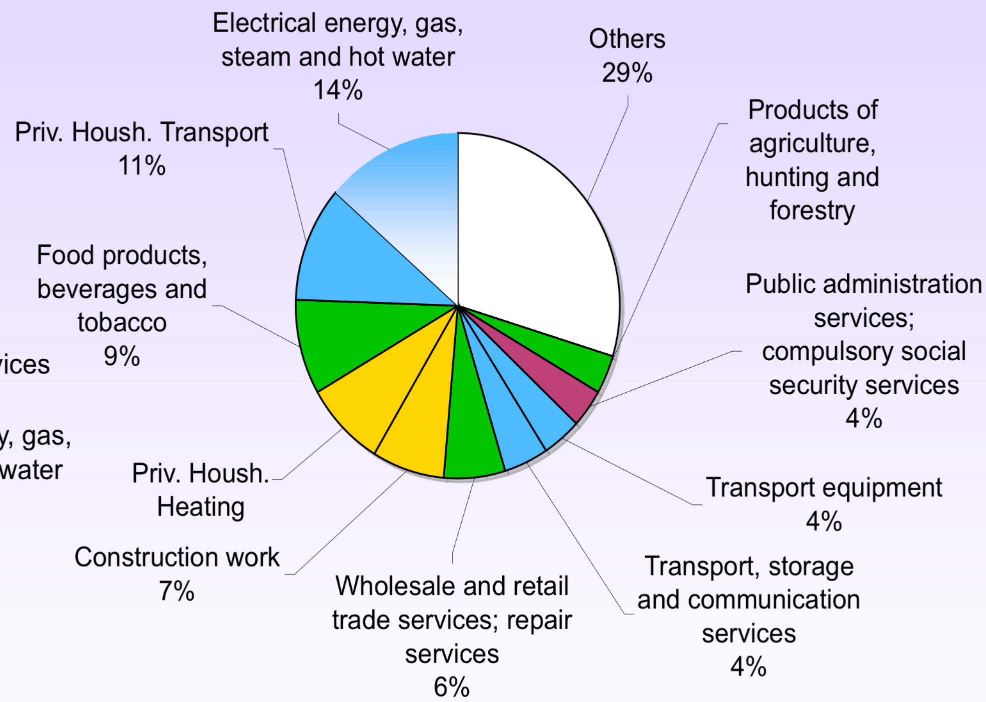
Source: Schüller, Estrada, Bringezu 2008

Direct and indirect environmental pressure through product groups of final demand

Material Use



Global Warming Potential



Basic needs:

Eating and Drinking
Housing and infrastuctures
Transport of persons and goods

8 EU countries

Source: Moll et al. 2007; ETC/RWM

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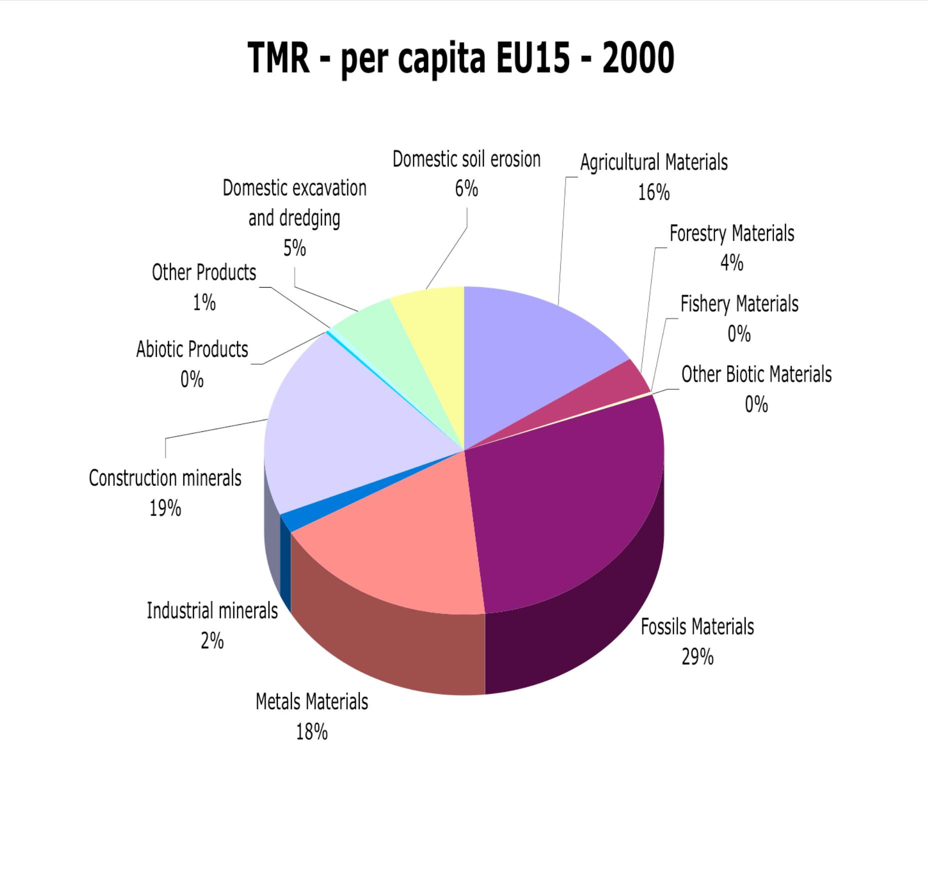
MFA allows to set priorities for resource productivity enhancement in industry

Components of TMR EU-15



Top ten branches inducing German TMR

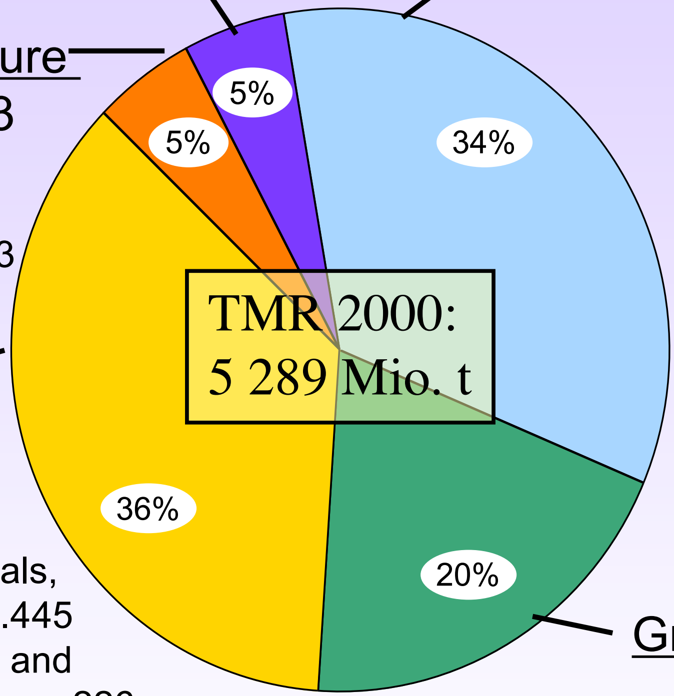
	Economic Branches
1	**Construction**
2	Food products and beverages
3	**Basic Metals and fabricated metal products**
4	Electricity, gas, steam, hot water supply
5	**Motor vehicles, trailers and semi- trailers**
6	Chemicals and chemical products
7	Machinery and equipment
8	Coal and lignite, peat
9	Agriculture, hunting
10	Coke, refined petroleum products, nuclear fuel

Direct and indirect TMR activated by final use

(Germany, in Mio. t)

Other 260

Final consumption expenditure by government 273
public administration, defence services, compulsory social security services. 123



Final consumption expenditure by households 1812
electrical energy, gas steam and hot water 386
food products and beverages............................382
coal and lignite, peat 133
products of agriculture, hunting and related services.............116
hotel and restaurant services.95
real estate services................85

Exports 1912
basic metals (iron and steel and first processing thereof, precious and non-ferrous metals, foundry work services)............445
chemicals, chemical products and man-made fibres..........................226
motor vehicles, trailers and semi-trailers 223
machinery and equipment n.e.c..136
other mining and quarrying products (stone, sand, clay, salt).119
other non metallic mineral products (glass and glass products, ceramics, bricks, cement etc.)..109

Gross fixed capital formation 1032
construction work...........939

Source: J. Acosta Fernández/S. Bringezu based on Tab. 3a,b of the preliminary results of JA in the BMBF-Project as at 8.12.2005

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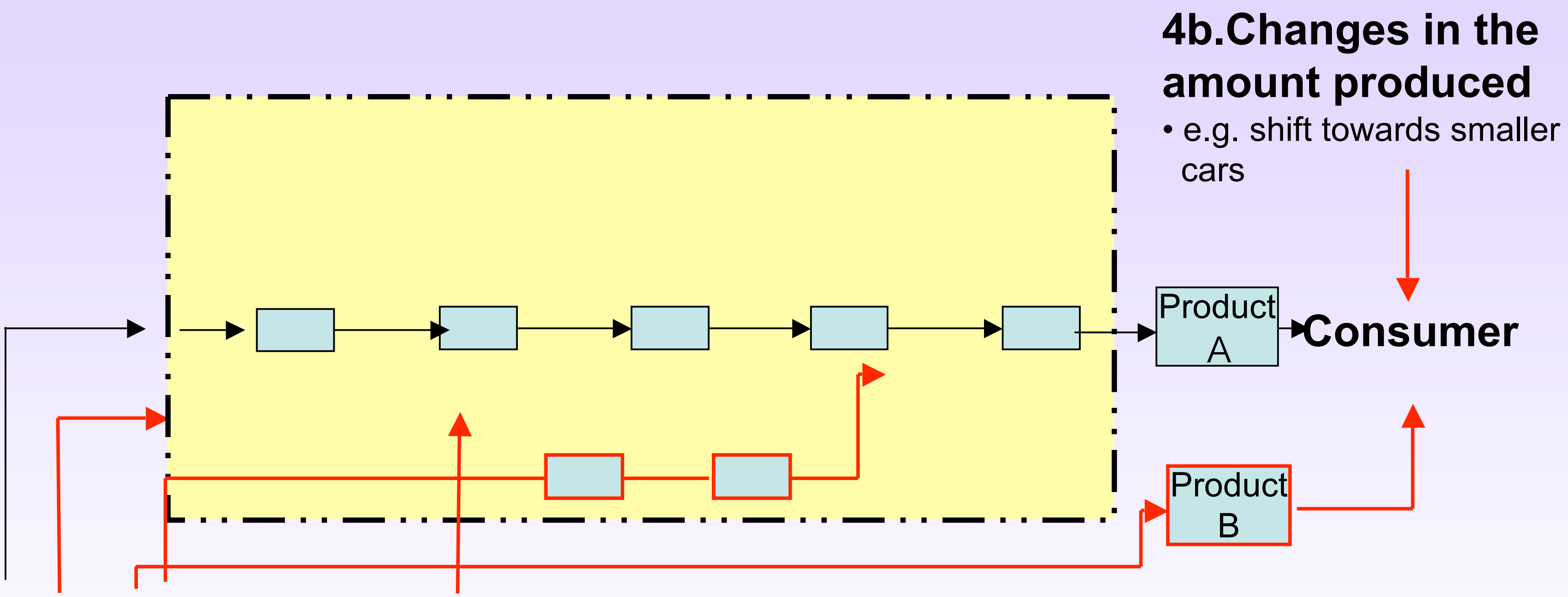
Where are the greatest potentials for minimizing resource use for automobiles?



1. Extraction

2. Material Efficiency

• 10-15% reduction

3. Substitution

• e.g. aluminium vs steel
• high risk of burden shifting

4a. Changes in product design

• e.g. new forms of car design

•Greater potentials?

Micro level: Where are the greatest potentials for minimizing resource use for automobiles?

Substitution

Golf A4

Aluminium vs Steel

Dependent on pimary:secondary ratio

- 1:9 15% to 19% savings vs steel car
- 1:1 -9% to - 11% savings vs steel car
- 9:1 -34% to - 41% savings vs steel car

Carbon fibre vs Steel

- Up to 10% savings vs steel car

Multi-Material Mix

(15% Mg, 65% Al, 20% carbon fibre)

- 9% savings vs steel car

Source: van de Sand and Bringezu (2007)

Where are the greatest potentials for minimizing resource use for automobiles?

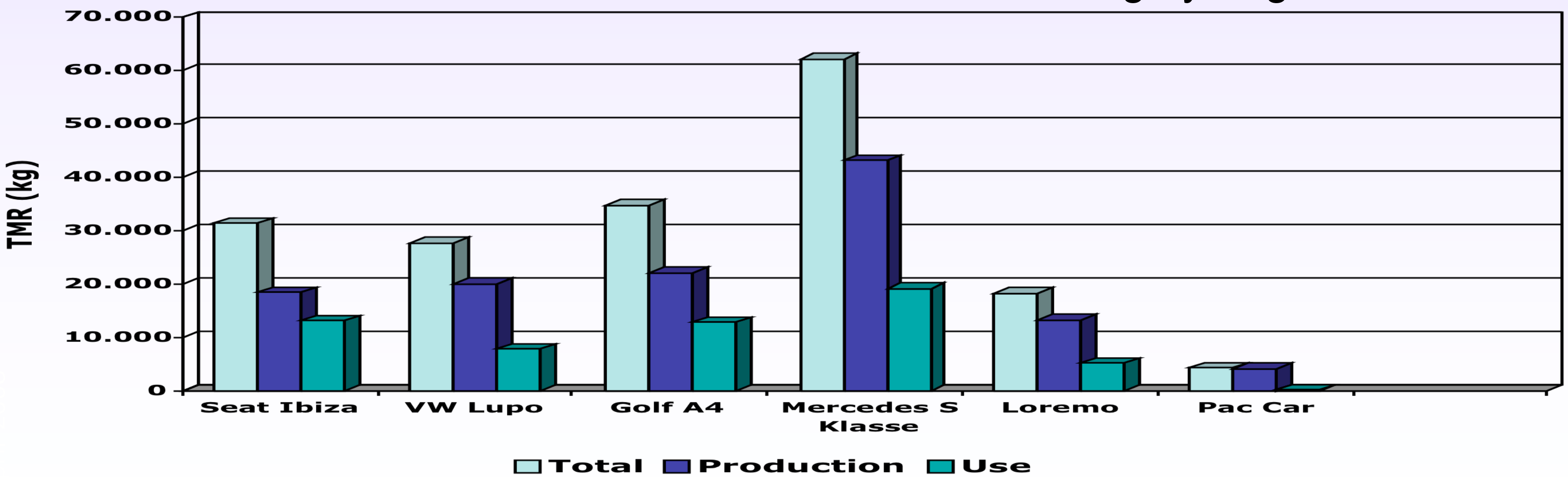
Changes in Product design

short-medium term

Loremo:
- 450 kg
- 1.5 l/km

long term

Pac car:
- 32 kg
- 4.8 g hydrogen/100km



Source: van de Sand and Bringezu (2007)

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Where are the greatest potentials for minimizing resource use for automobiles?

Changes in the automobile fleet

- **100% Lupo**
  - 31% savings vs current fleet

- **100% Loremo**
  - 54% savings vs current fleet

- **100% Pac Car**
  - Up to 89% vs current fleet

- **Current approaches for greening cars insufficient**
- **Profound changes towards dematerialized design would offer significant potentials for resource and climate protection**

Source: van de Sand and Bringezu (2007)

- Policy Background: Towards Sustainable Resource Management
- Development of MFA research and statistics
- The "systems perspective" and types of MFA
- Highlighted trends - macro
- Sectoral insights - meso
- Potentials of products - micro
- Conclusions

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The MFA toolbox allows

- a **comprehensive view** of the resource basis of the economy
- capturing **used and unused flows**
- reveal **shifts of environmental burden between countries and env. media**
- **priority setting** for resource productivity enhancement
- determine **relevant potentials** for overall improvement at sectoral and product level

Thank you for your attention

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