Application of rare earths in consumer electronics and challenges for recycling

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Ran Liu
Matthias Buchert
Stefanie Dittrich
Andreas Manhart
Cornelia Merz
Doris Schüler

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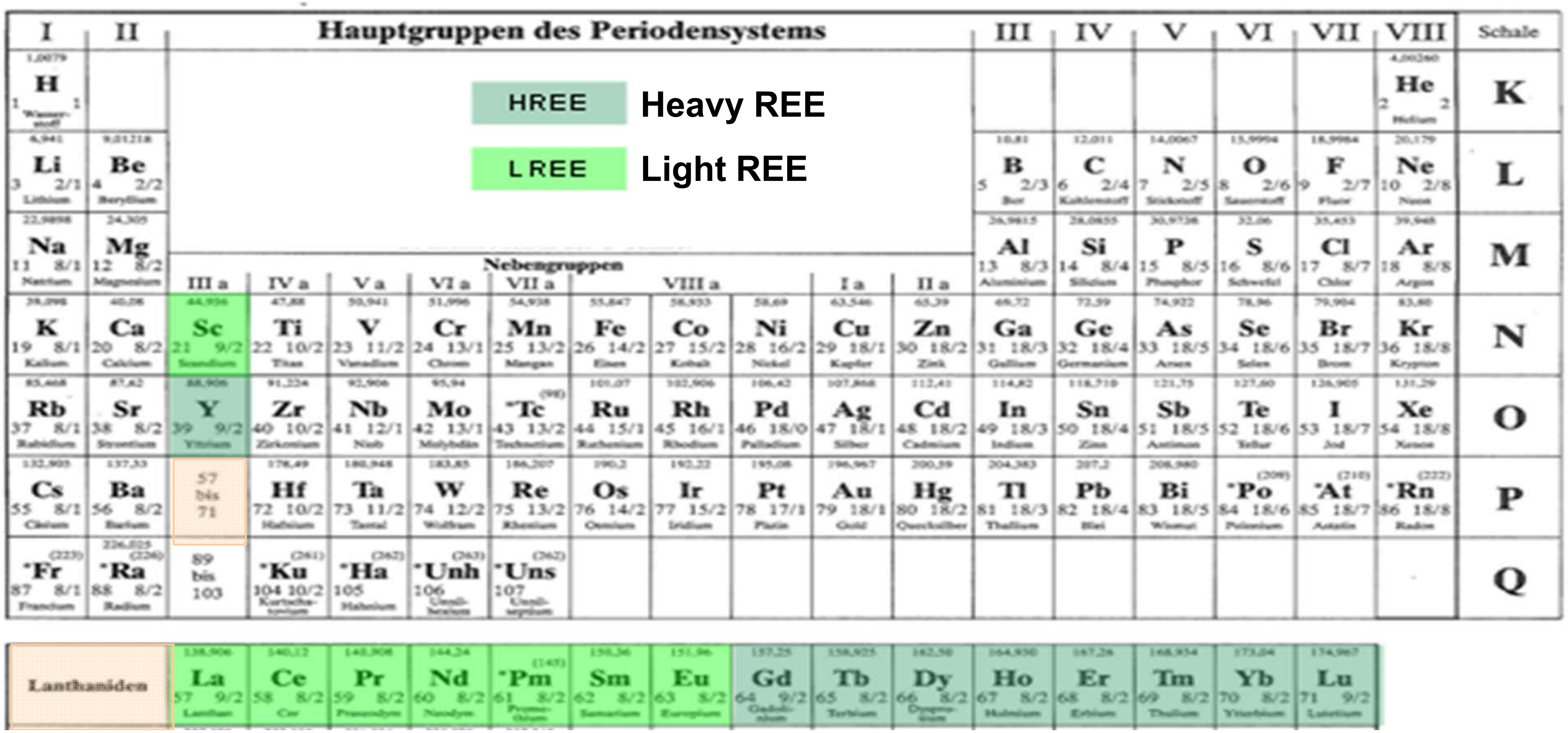
Rare Earth Elements (REEs)



LREE: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), and scandium (Sc)

HREE: yttrium (Y), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), lutetium (Lu)

Global production and reserves

- Global production in 2010: 133 600 t
- Reserves according to USGS: 110 000 000 t (factor 823)

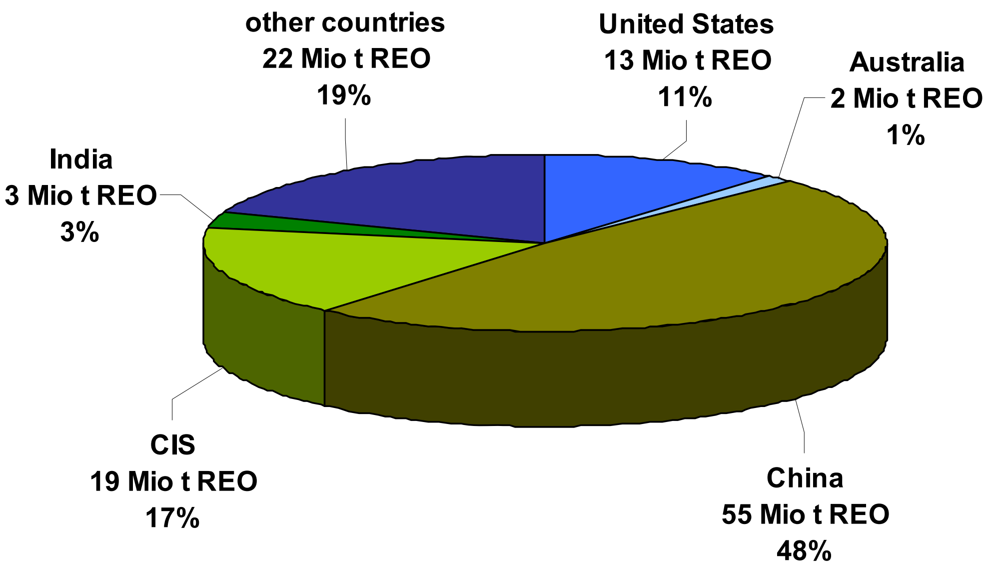
  (reserve which can be economically extracted)

World Mine production in 2010
(USGS 2011). REO: rare earth oxide

Country	t REO	Share
China	130 000	97,3%
Brazil	550	0,4%
India	2 700	2,0%
Malaysia	350	0,3%
World Total*	**133 600**	**100,0%**

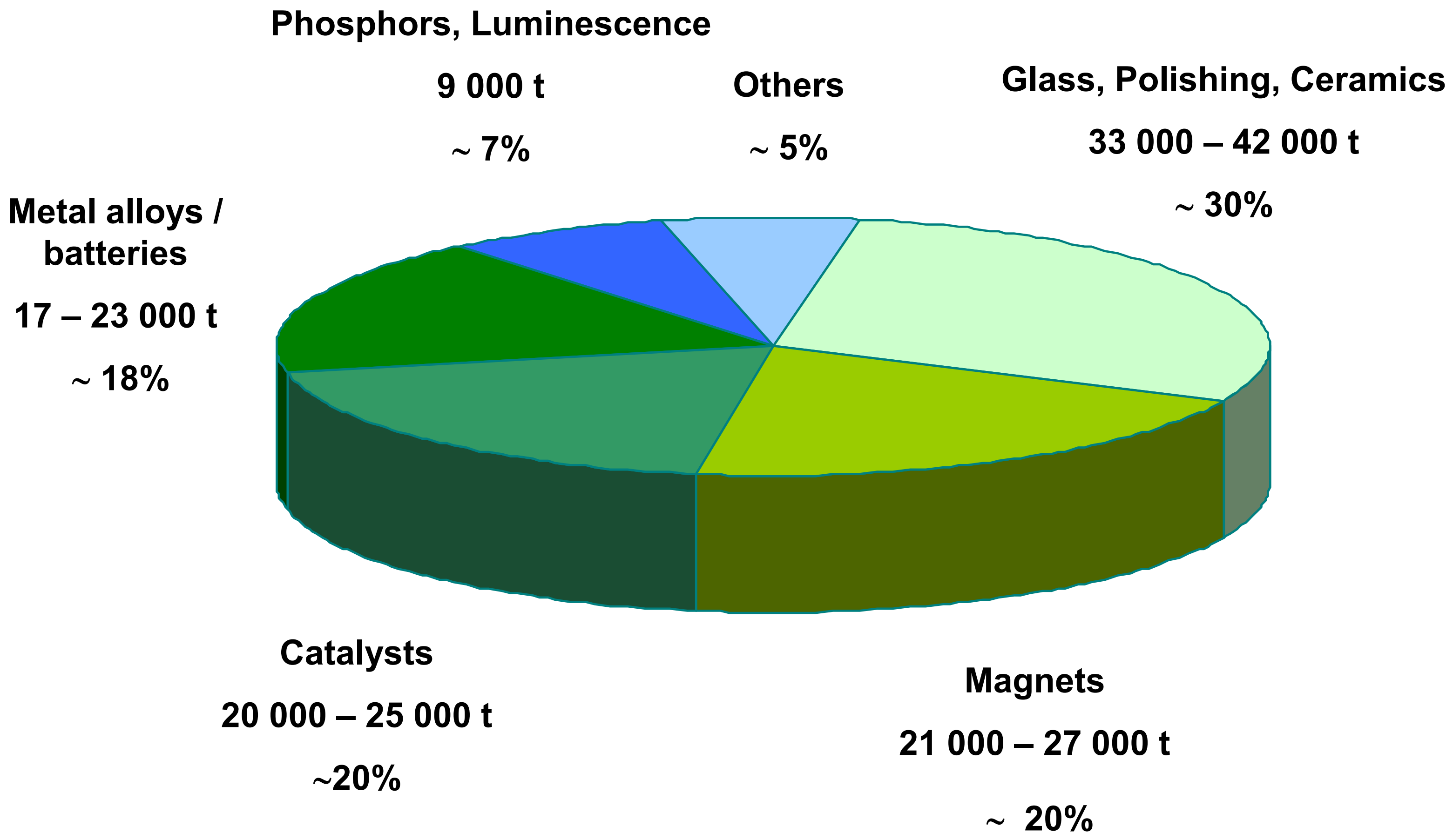
* without 20 000 t REO illegal mining

Rare earth reserves by countries (USGS 2011)



Global demand and development of the demand

2008



Unit: t REO per year

Source: Compiled by Oeko-Institut from the sources Jefferies 2010, Oakdene Hollins 2010, Kingsnorth 2010, GWMG 2010, BGR 2009 and Lynas 2010

Rare earths used in consumer electronics

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Products	Rare earth/Components	Amount	Unit
Variable-frequency air conditioning	NdFeB	100-200	g/unit
		250	g/unit
DVD Player/DVD ROM/Driver	NdFeB	5	g/unit
E-Bike	NdFeB	500	g/unit
		300	g/unit
Hard disc drives (HDD)	NdFeB	15	g/unit
		22	g/unit
Loudspeaker	Magnet	153	g/unit
	NdFeB	50	g/unit
Mobil phone	Permanent magnet	5	g/unit
Mobil phone	light phosphors	0.006	g/unit
Laptop	light phosphors	0.05-0.6	g/unit
LCD TV	light phosphors	4.5-6	g/unit
Plasma TV	light phosphors	100-125	g/unit
LCD Display	light phosphors	1.5-2.5	g/unit
fluorescent lamp (market average)	Lanthanum	0.35	g/unit
	Cerium	0.46	g/unit
	Europium	0.20	g/unit
	Terbium	0.19	g/unit
	Yttrium	2.87	g/unit

Example: NdFeB: 15g/unit
HDD shipment in 2010: 651 million

9765t NdFeB≈3039t REO
→ 13% of global demand of rare earth for magnets

Global magnet production

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RE Mining & Concentration	97 % in China
Separation of Ores into Oxides	97 % in China
Refining of Oxides to Metals	almost 100% In China
Forming Metals into Magnet Alloy Powders	75 - 80% in China 20 - 25% in Japan
NdFeB Magnet Manufacturing	75 - 80% in China 17 - 25% in Japan 3 - 5% in Europe

Energy efficient lighting

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- Most new energy efficient lighting systems contain rare earths (compact fluorescent lamps, LED, plasma displays, LCD displays)

⬀ High growth rates due to the ban on classic incandescent bulbs, dissemination of LEDs and shift to plasma and LCD displays

- Substitutions are rare. ➲ R & D required for alternative phosphors with high efficiency and high light quality

Development of prices

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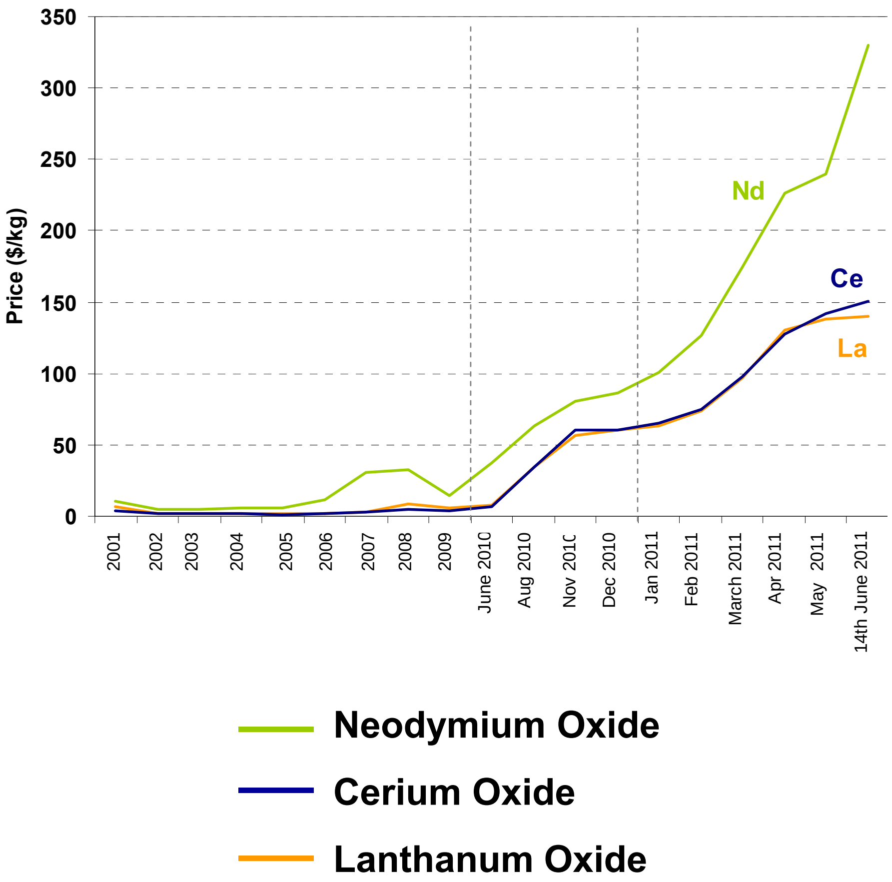
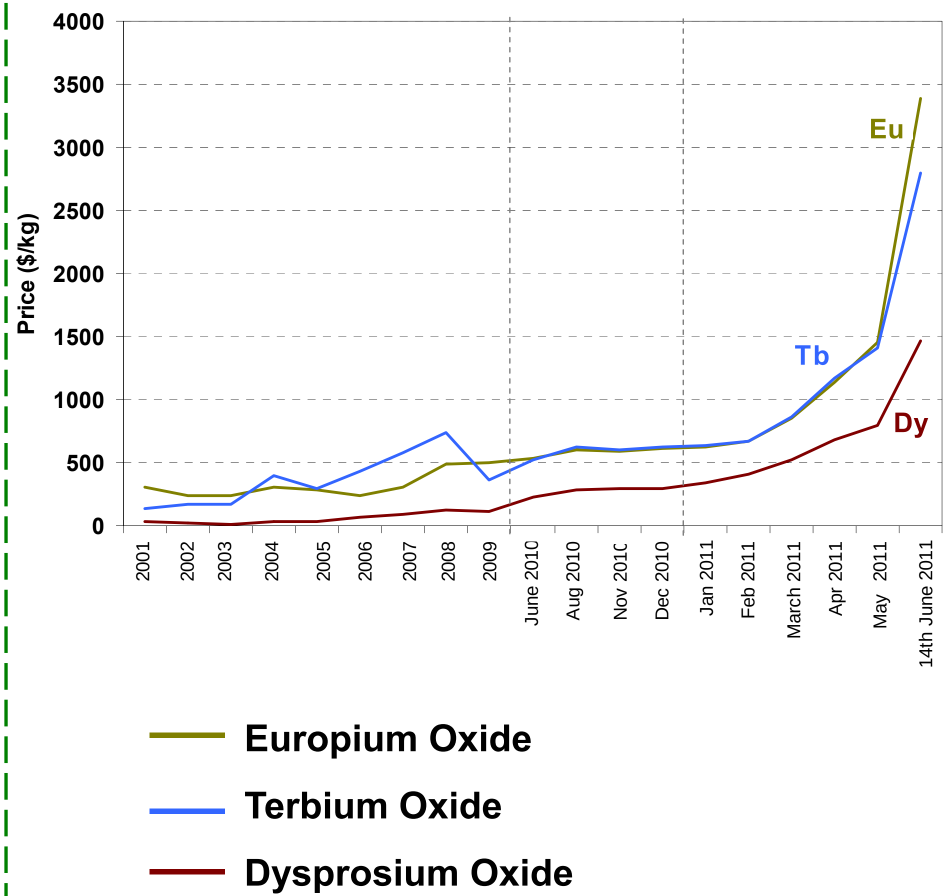
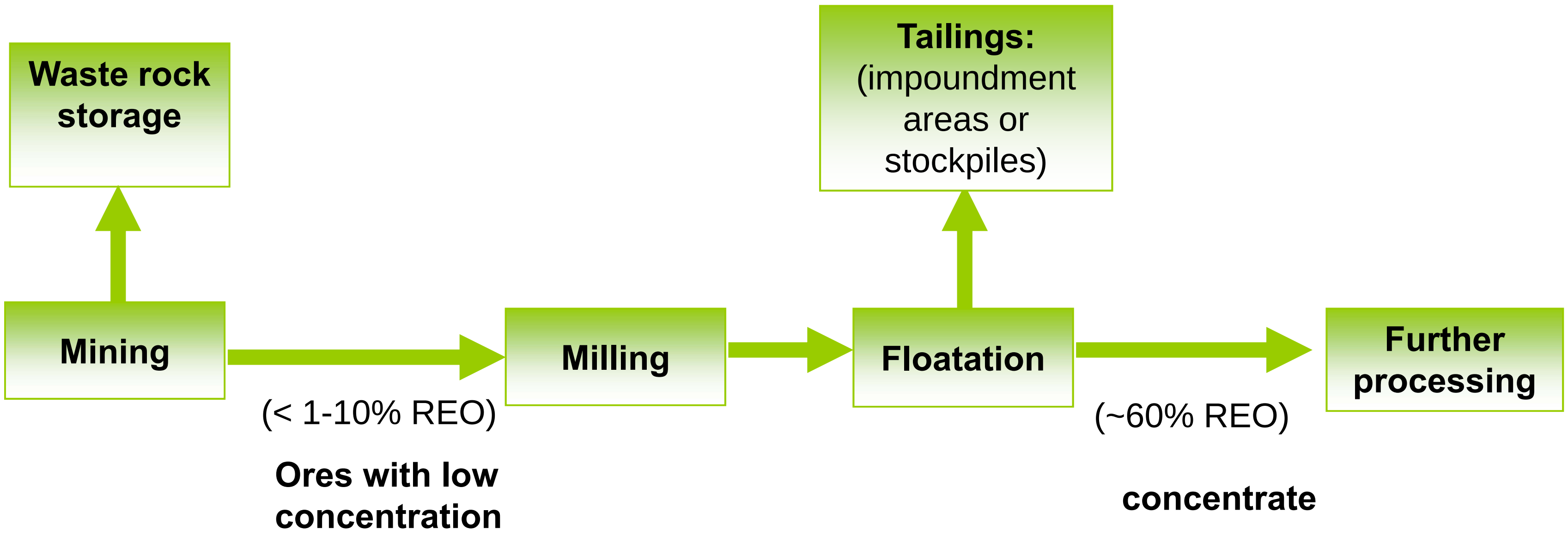
Light rare earth elements



Heavy rare earth elements



Risks of REE mining without Environmental Protection Systems



Advantages of recycling

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- Secondary REE potential in Europe.
- Lower dependency on foreign material supply.
- Build-up of know-how on rare earth processing.
- No radioactive waste in processing.
- Environmental benefits regarding air emissions. groundwater protection, acidification, eutrophication and climate protection.

Developing a recycling scheme

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Basic research

Identification of stakeholders

European Competence Network on Rare Earth

European Material Flow Analysis

Identification of initial products to be recycled

Development of Pre-treatment & Collection Schemes

Installation of Pilot Plants for Recycling / R&D

Promotion of re-use

Financial support

Improvement of legal framework in EU

Implementation of large scale collection and recycling for initial products

Green technologies call for "green metals"

- There are manifold initiatives for sustainable mining.
- Among them are certification schemes addressing different problems:
  - Environmental, small-scale mining, safety issues, human rights.
- Increasing interest in politics and industry on certified minerals
- Today's mining companies could be interested in certification schemes or similar co-operations in order to highlight their environmental efforts.
- The Analytical Fingerprint is a control instrument if other control mechanism fail.

Conclusions

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- Identification of REE with high relevance: Dysprosium; Terbium; Yttrium; Lanthanum; Neodymium; Europium; Praseodymium
    - potential shortages in the short-term
    - important role in Green Technologies
- Rare Earth Mining and Processing shows high environmental risks → sustainable mining initiatives like certification schemes should be integrated into an environmentally sound strategy.
- R & D needed for <u>all applications</u> concerning
    - avoidance / substitution
    - higher material efficiency
    - recycling

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Thank you for your attention!

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More detailed information can be found on the following websites:
www.oeko.de
www.resourcefever.org