# Knappheiten und Ressourcen von Rohstoffen

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Lehrstuhl für Ressourcenstrategie

# Materials critical to the energy industry. An introduction

Materials Resource Management

**Materials critical**
**to the energy industry**
An introduction

The world's energy systems rely on a wide range of materials with specific properties. A secure energy future depends on sustainable supplies of those materials.

A University of Augsburg publication, supported by BP, as part of the multi-partner Energy Sustainability Challenge, which explores the implications for the energy industry of competing demands for water, land and minerals.

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bp

**Materials critical to the energy industry** An introduction

**Materials critical**
**to the energy industry**
An introduction

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# Gliederung

Materials Resource Management

Verschiedene **Energiezeitalter** und deren Einfluss auf den Rohstoffbedarf

Die Rolle von: **Seltenen Erden** im Energiesektor.

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# Energiezeitalter

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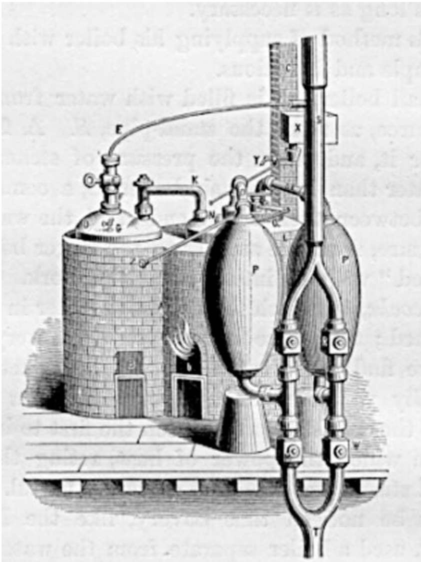
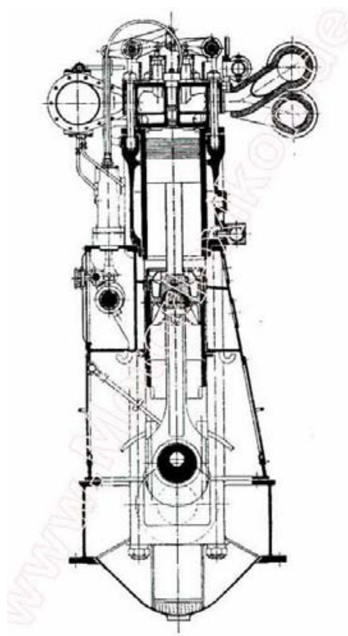
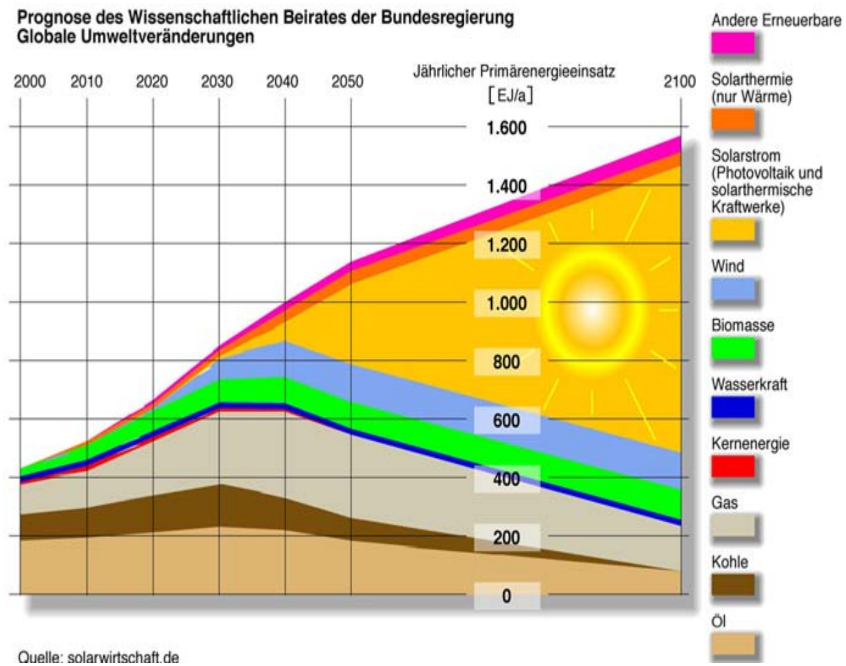


Fig. 13.—Savery's Engine, A. D. 1702.






Quelle: WBGU 2008

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# Intensiv genutzte Elemente im Energiesystem

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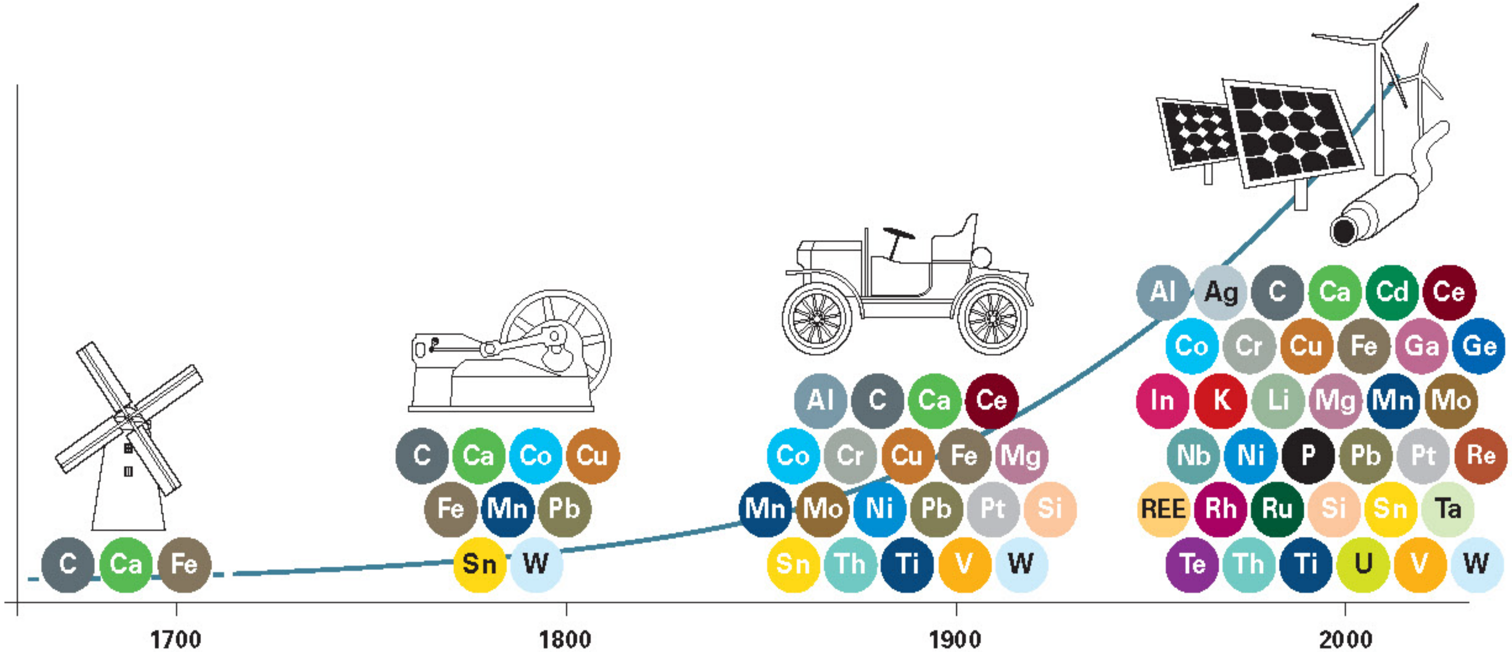


Elements widely used in Energy Pathways

Achzet B., Reller A., Zepf V., University of Augsburg, Rennie C., BP, Ashfield M. and Simmons J., ON Communication (2011): Materials critical to the energy industry. An introduction.

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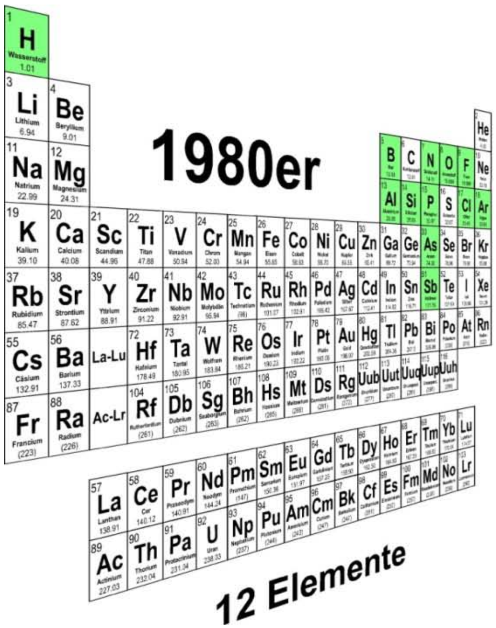
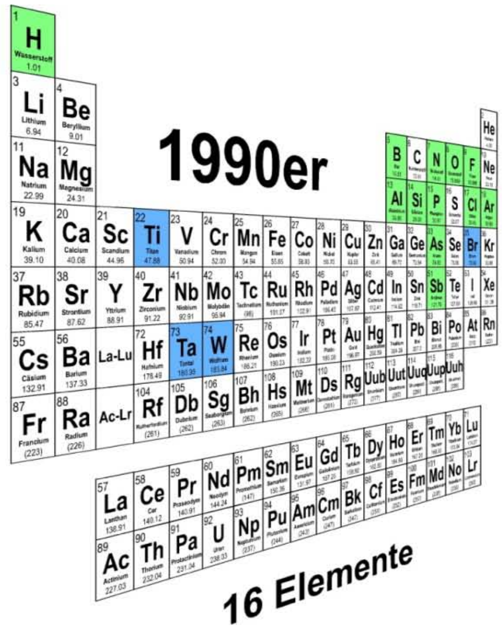
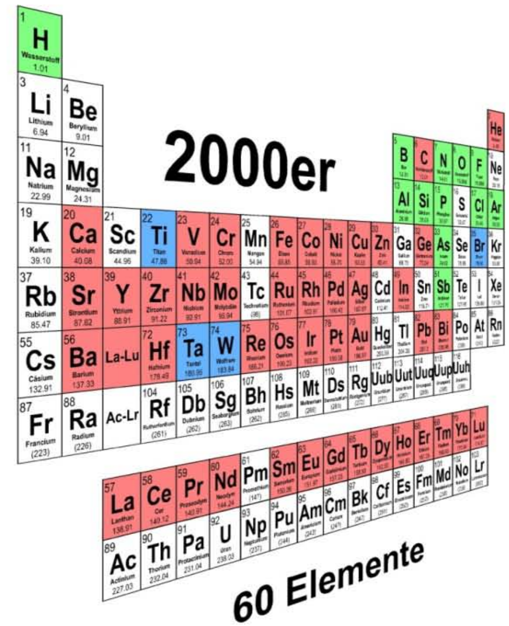
# Materialdiversität in der Mikroelektronik






# Vorgehensweise

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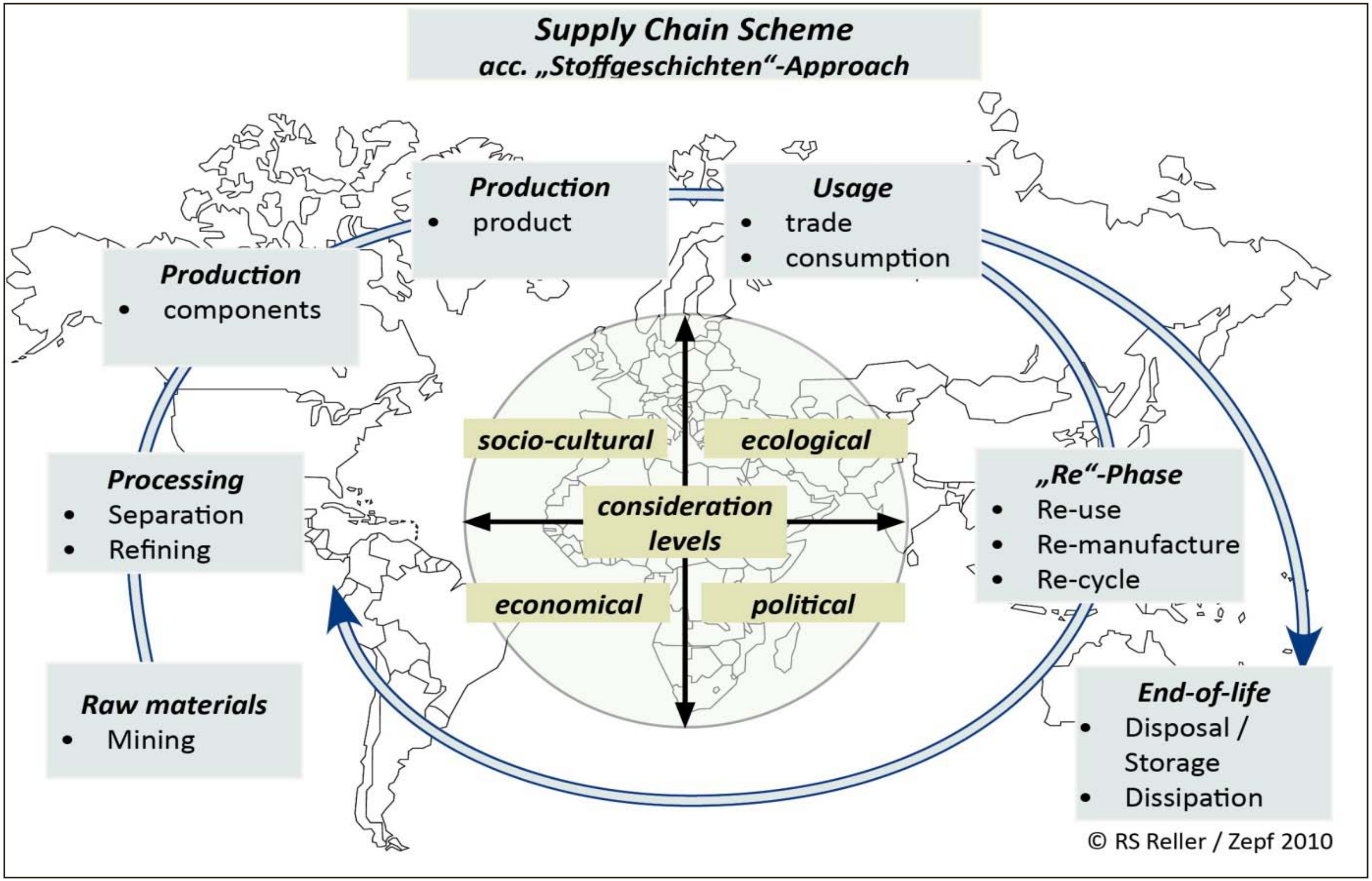
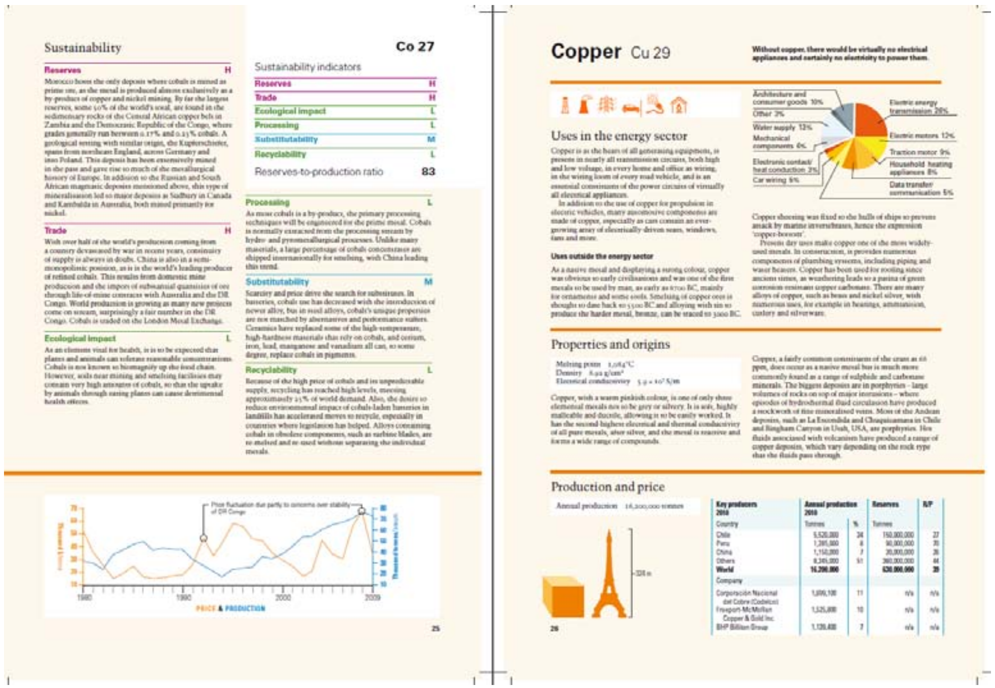


# Vorgehensweise




**Reserve**

**Processing**

**Trade**

**Substitutability**

**Recycling**

**Ecological Impact**


Achzet B., Reller A., Zepf V., University of Augsburg, Rennie C., BP, Ashfield M. and Simmons J., ON Communication (2011): Materials critical to the energy industry. An introduction.

# 19 kritische Rohstoffe im Energiesystem

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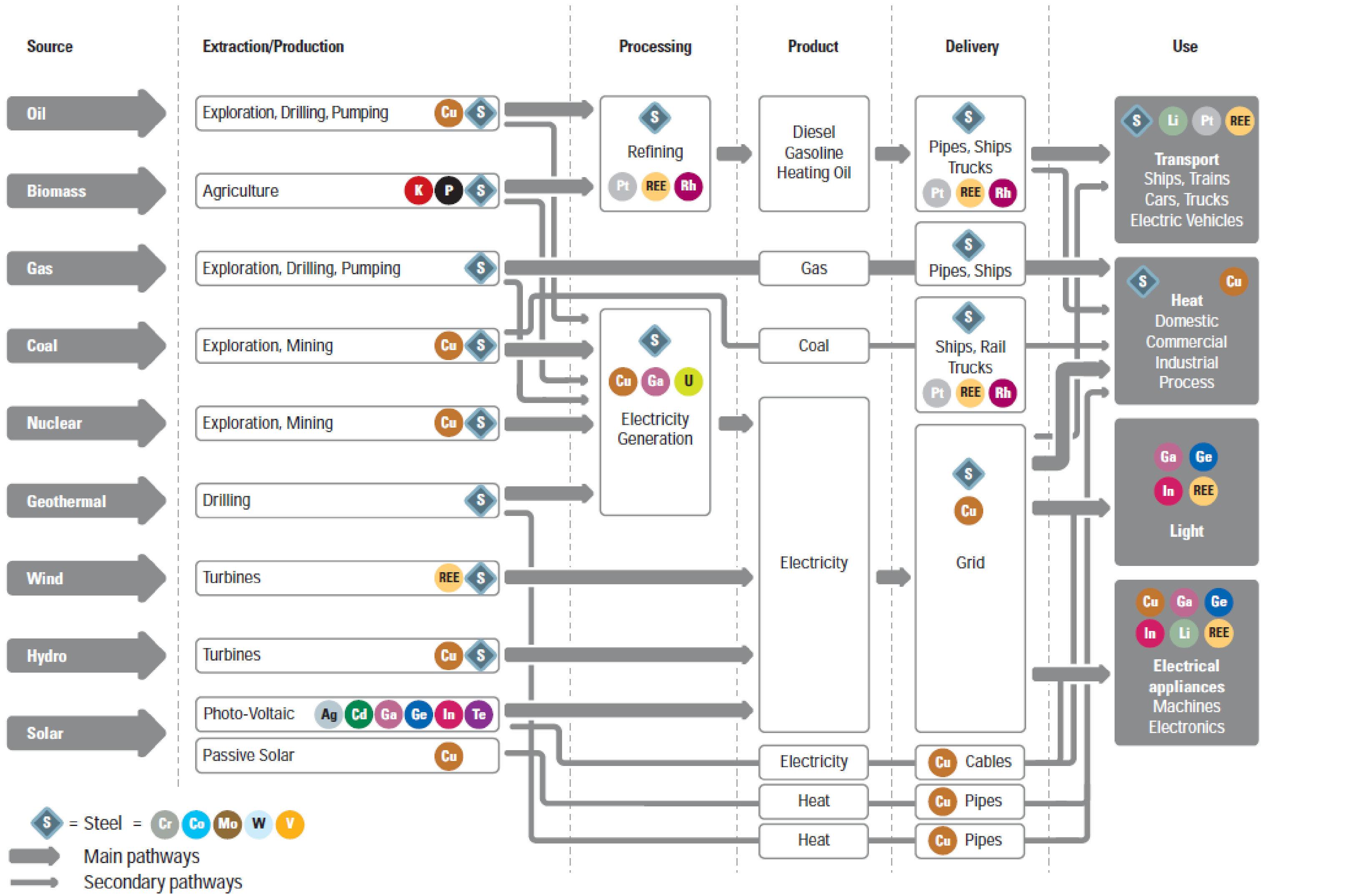


Achzet B., Reller A., Zepf V., University of Augsburg, Rennie C., BP, Ashfield M. and Simmons J., ON Communication (2011): Materials critical to the energy industry. An introduction.

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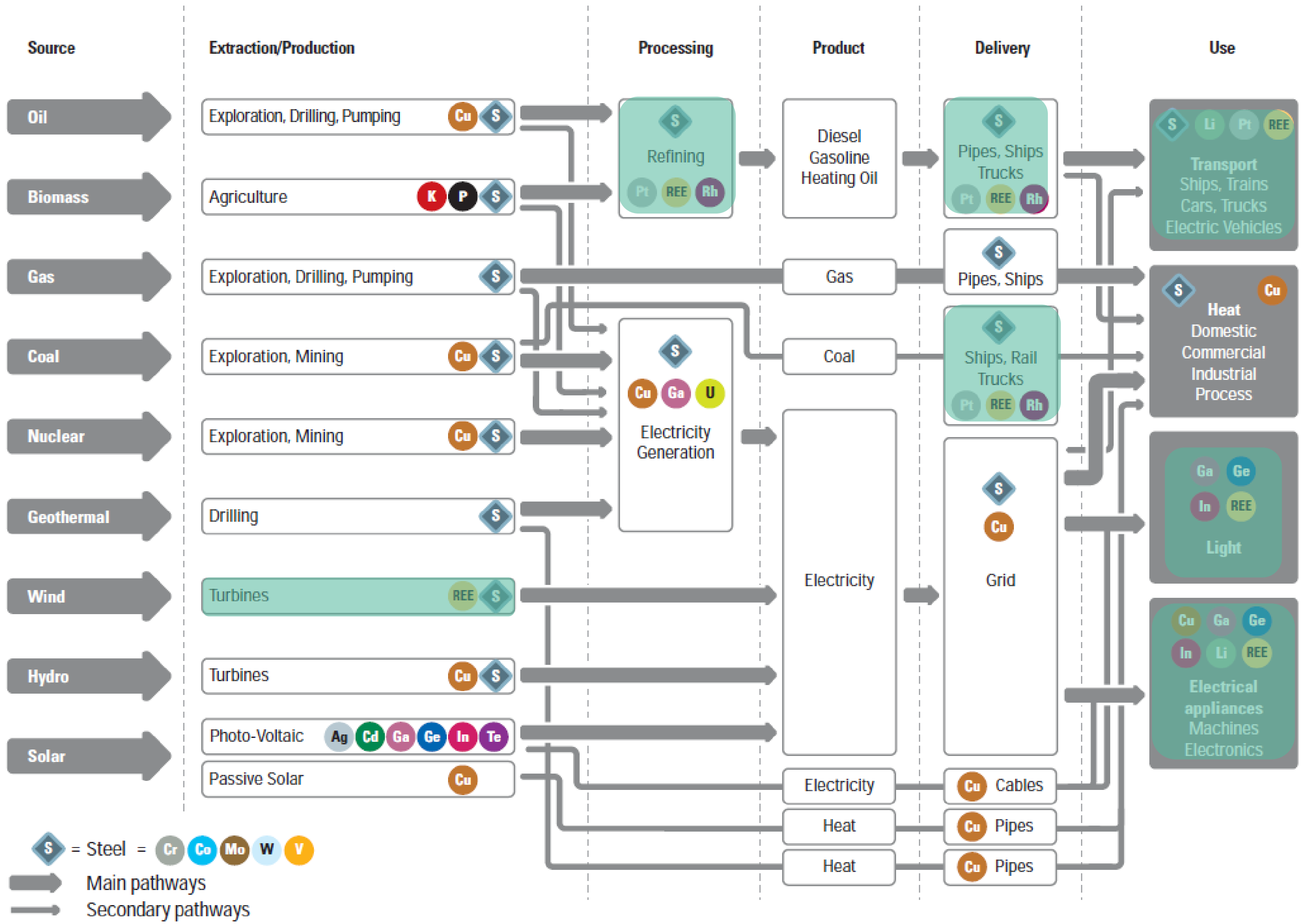
# Seltene Erden (REE) im Energiesektor




Achzet B., Reller A., Zepf V., University of Augsburg, Rennie C., BP, Ashfield M. and Simmons J., ON Communication (2011): Materials critical to the energy industry. An introduction.

# Definition “Seltene” und “Erden”

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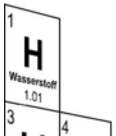
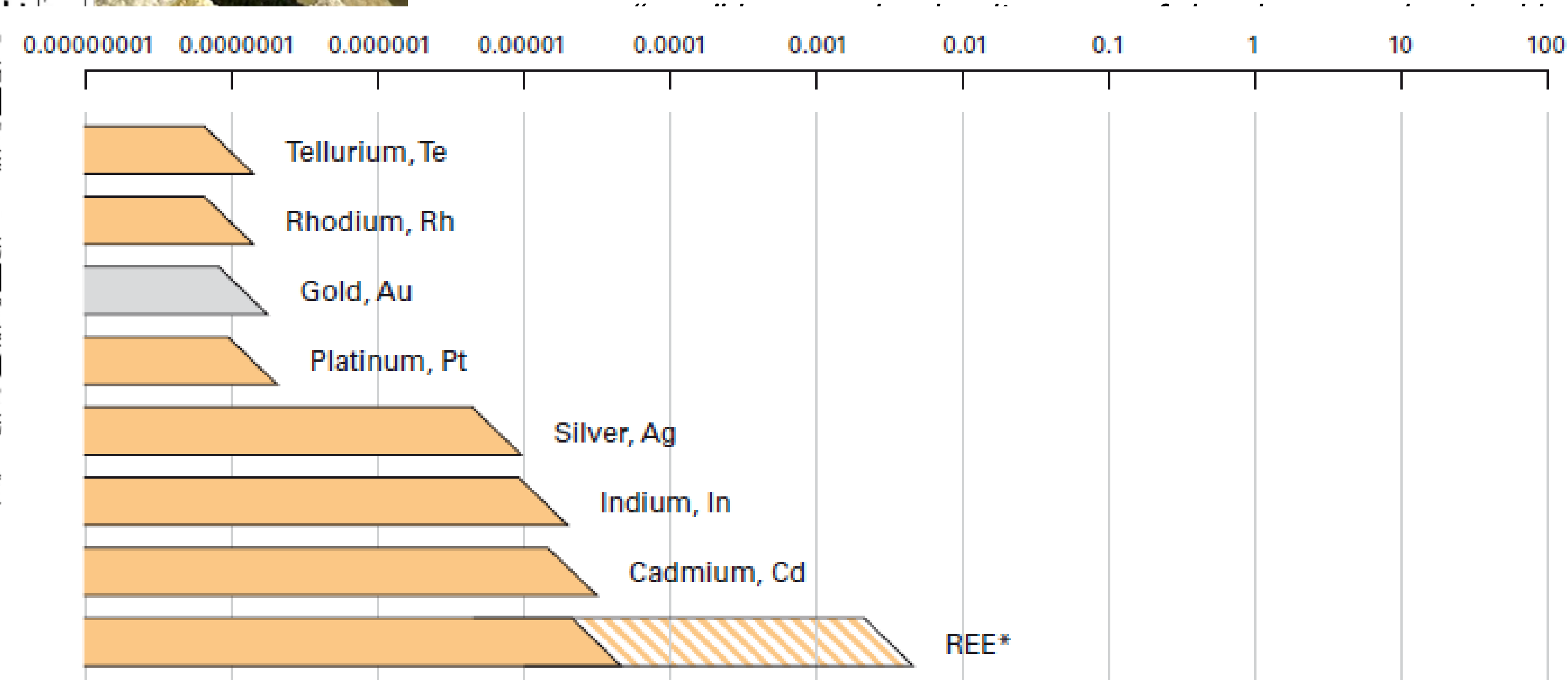
**Rare earth:**




•*17 elements (3 group of the perodic table and the lanthanoids)*




*…lant*

*…d-*

*use stocks*

# Anwendung von REE

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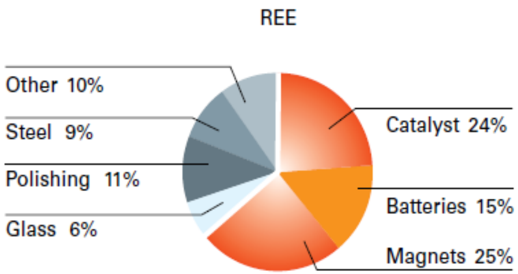


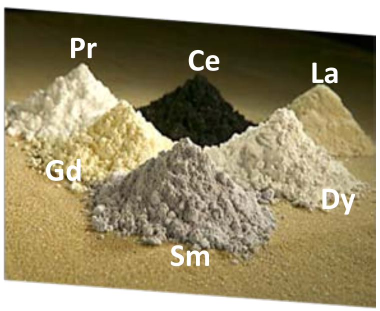


## Effizienter Einsatz von Energie

geringer Verbrauch

- Kompakt-Leuchtstoff-lampen
- Hybrid-Fahrzeuge
- Gewichtsreduktion im Automobilbau

## Umweltschutz

geringe Emissionen

- Windräder (Generatoren)
- Abgaskatalysatoren
- Diesel-Additive

## Digitaltechnologie

Kleiner, Leistungsfähiger

- Flat Panel Displays
- Digital Kameras
- Festplatten

Source: Powering the Future, Achzet, Reller, Zepf, 2011 (pre-publication)

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# Anwendung von REE

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## Medizintechnik

- Magnetic Resonance Imaging (MRI)
- Röntgenapparate
- Nuklearmedizin
- Additive für Medikamente
- Laser

## Militärische Anwendungen

- Permanentmagnete für Antriebssysteme, Sensoren und Lenkeinheiten
- Energiespeicher (Batterien)
- Elektromotoren (Kampfflugzeuge, Panzer, Schiffe)

## Weitere Anwendungen

- Laser-Schneidwerkzeuge (YAG-Laser)
- Glasfaser - Signalverstärker
- Superconductors
- Neutronenabsorber
- Anwendung in Siedewasserreaktoren
- Algenwachstums-kontrolle
- Wasseraufbereitung

Quellen: RWTH Aachen; USAF; Roskill 2007, Lynas 2010.

# LED technology and REE

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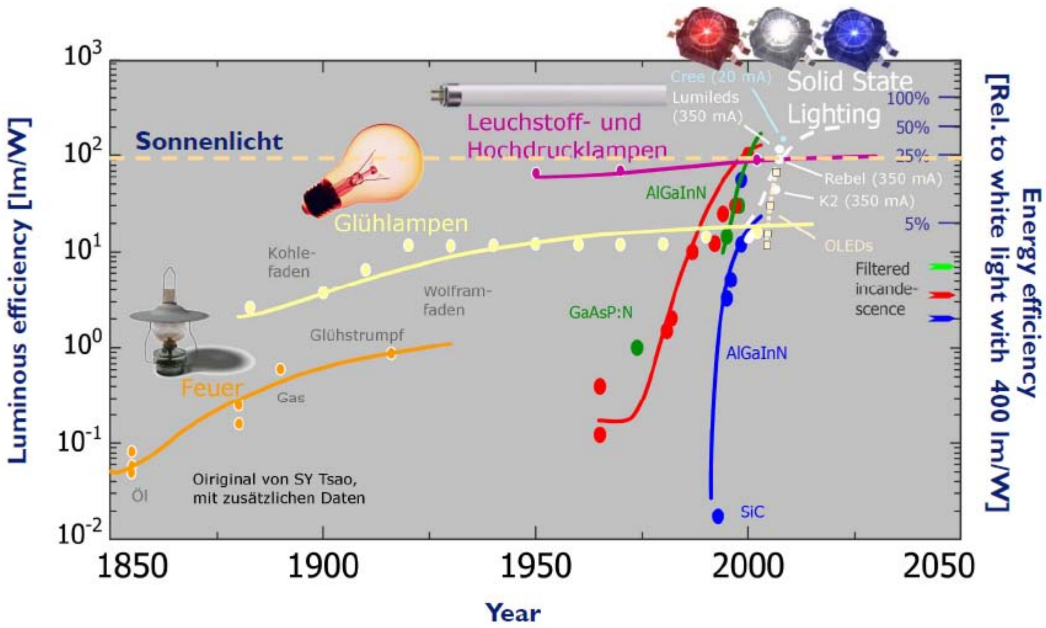


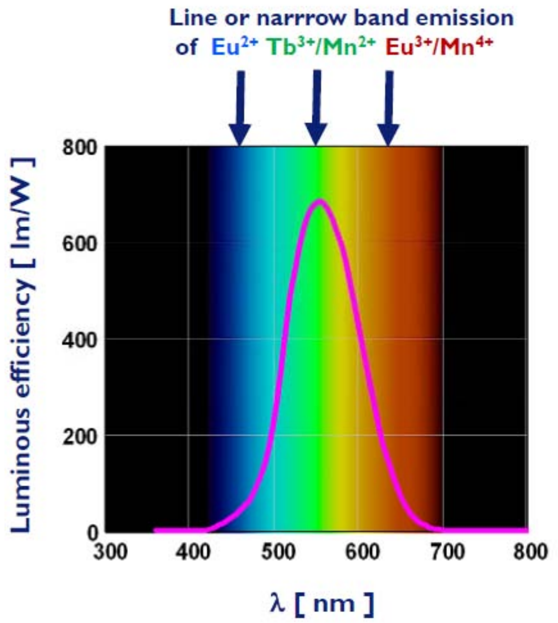


**Rare Earth elements are the “vitamine” for efficient lighting and clean lamp technologies**

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# REE – Trends in End-Use Sectors

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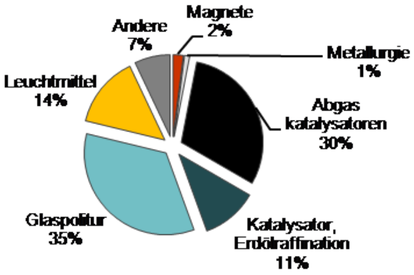
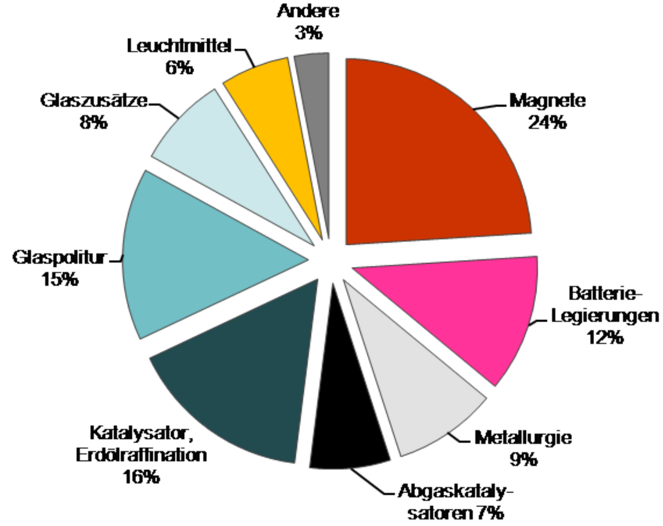
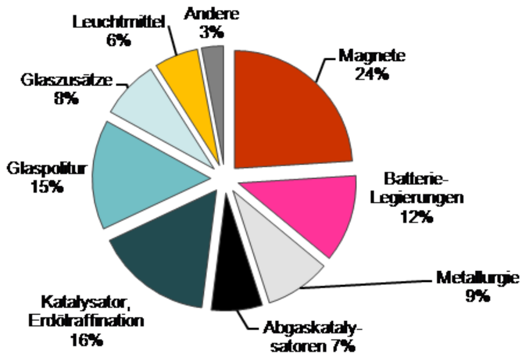
**2007**
**124.000 t**




**2014**
**182.000 t**




**2010**
**134.000 t**




Quellen: USGS 2010, Lynas 2010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# REE – World Production

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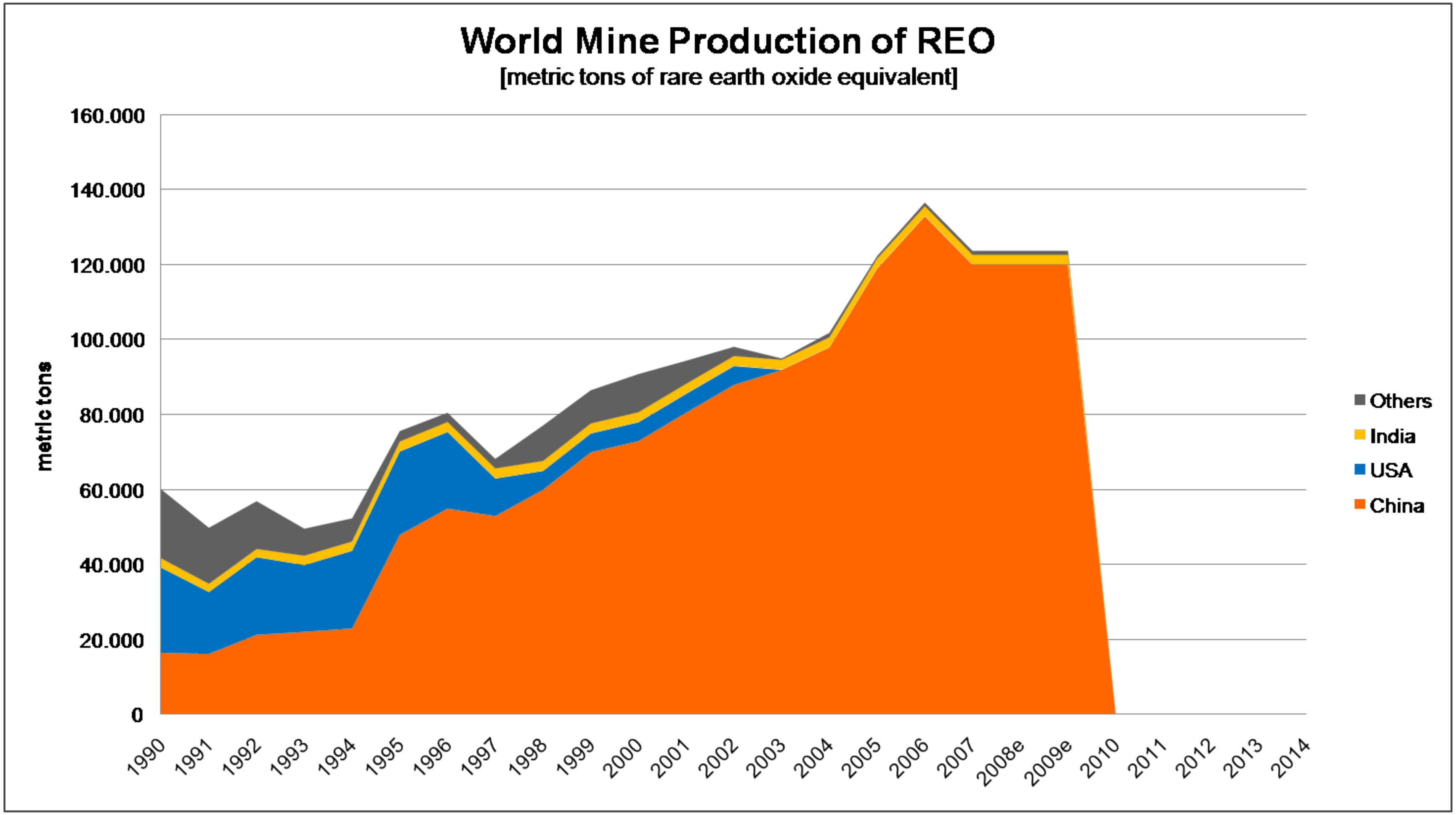


Data Sources: USGS 1994 – 2010, Lynas 2010



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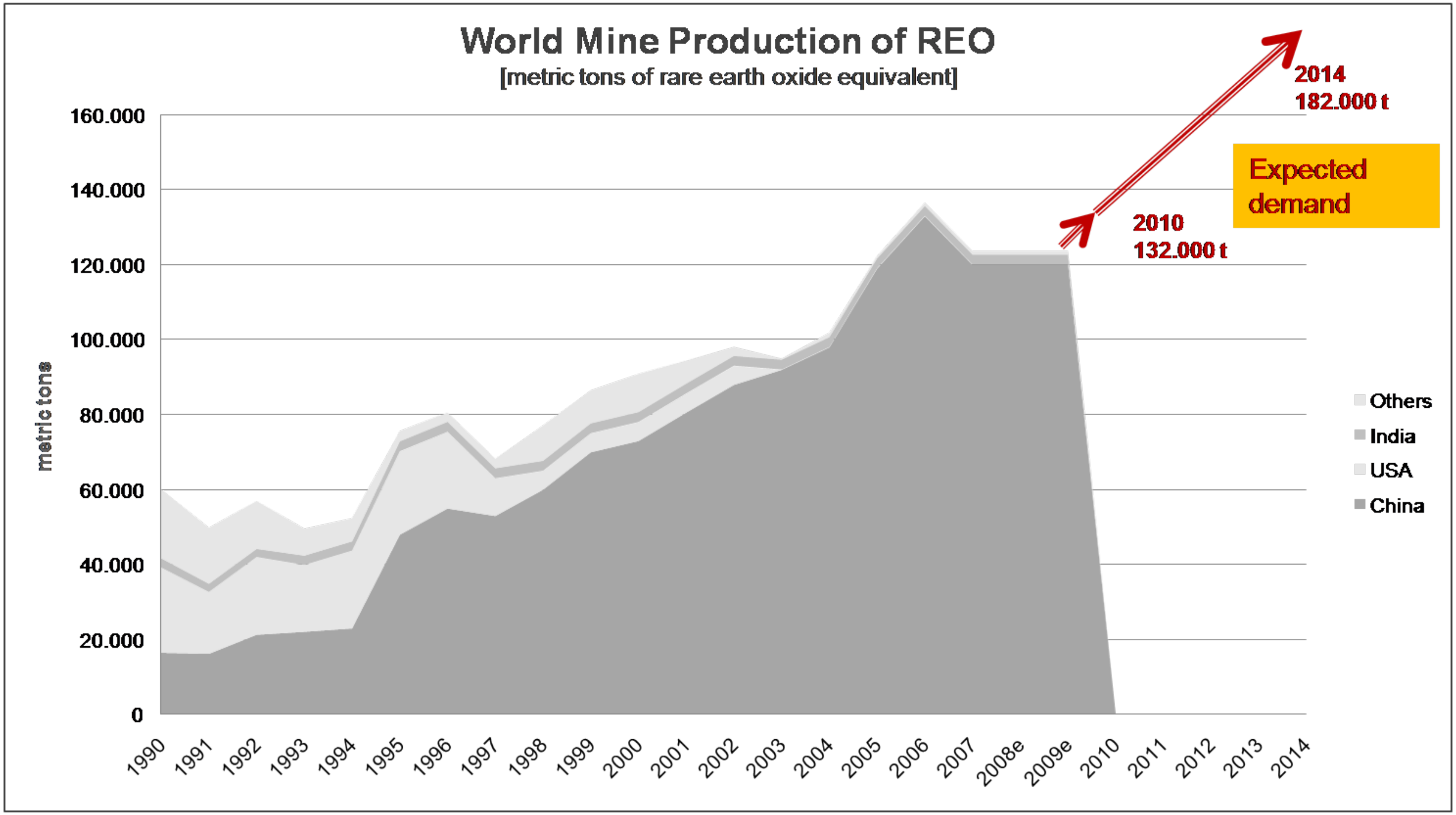
# REE – Production Trends

Materials Resource Management




Data Sources: USGS 1994 – 2010, Lynas 2010
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# REE production capacitity

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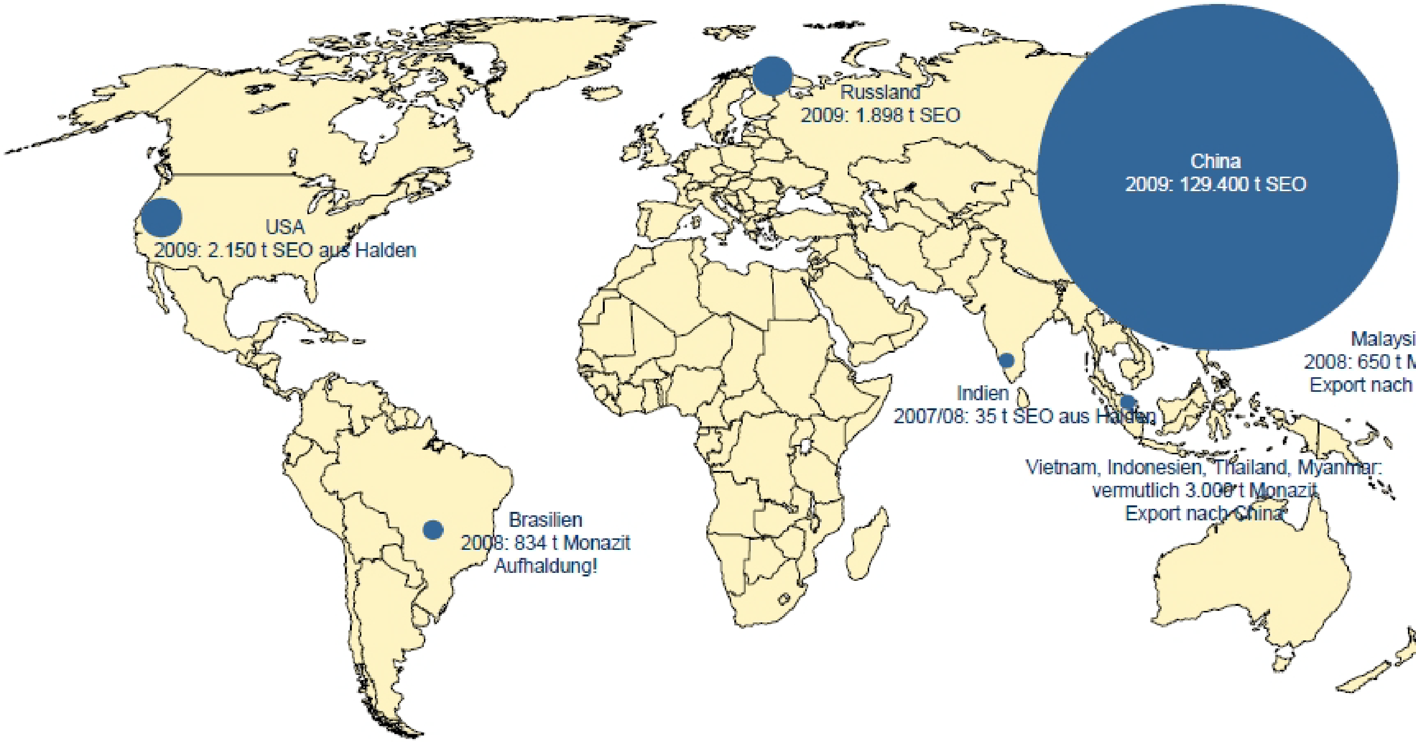
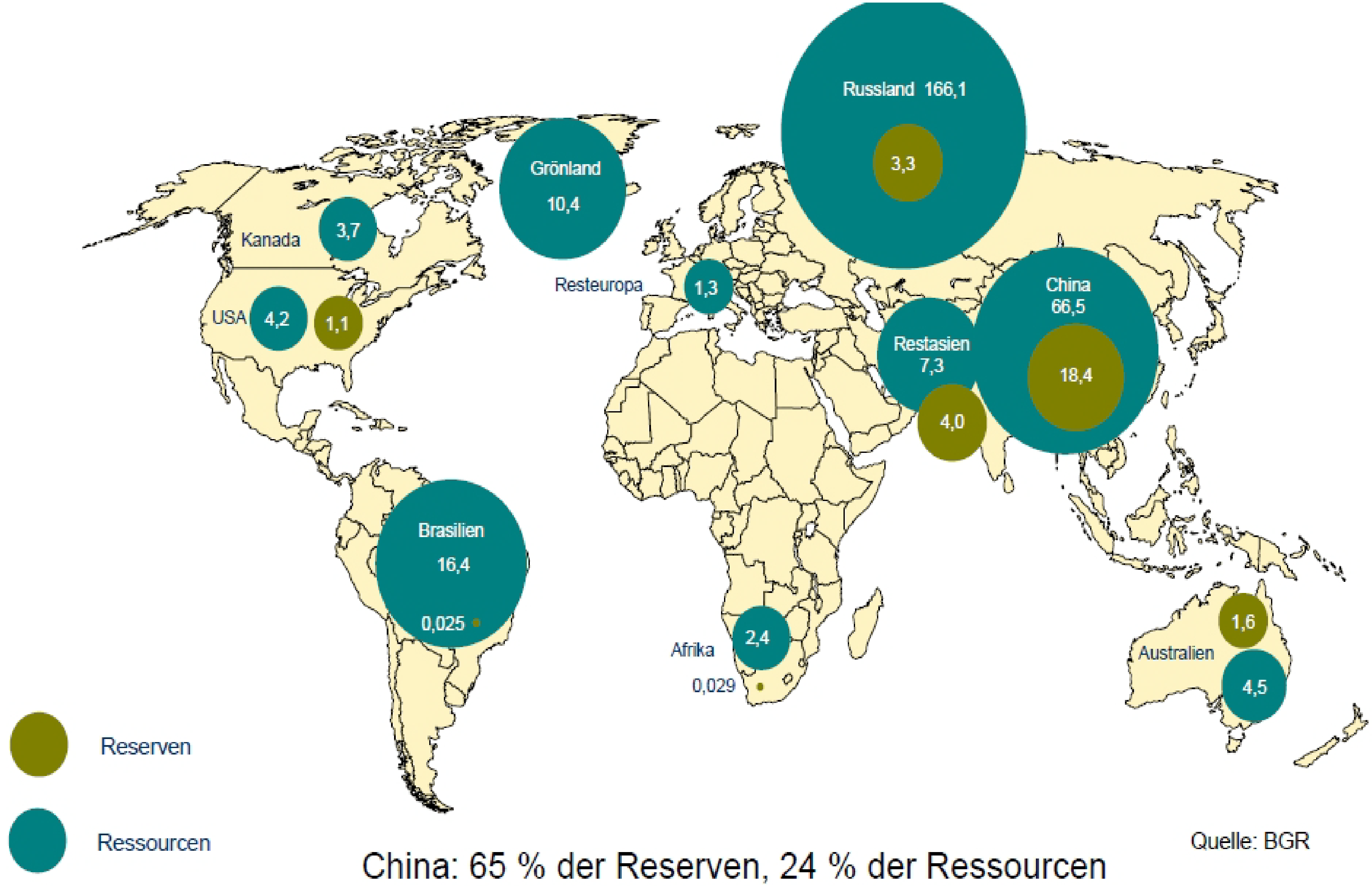



Produktion 2009: ca. 133.500 t SEO
China: 97,0 %, USA: 1,6 %, Russland: 1,4 %, Indien: <0,1 %

Quelle: BGR

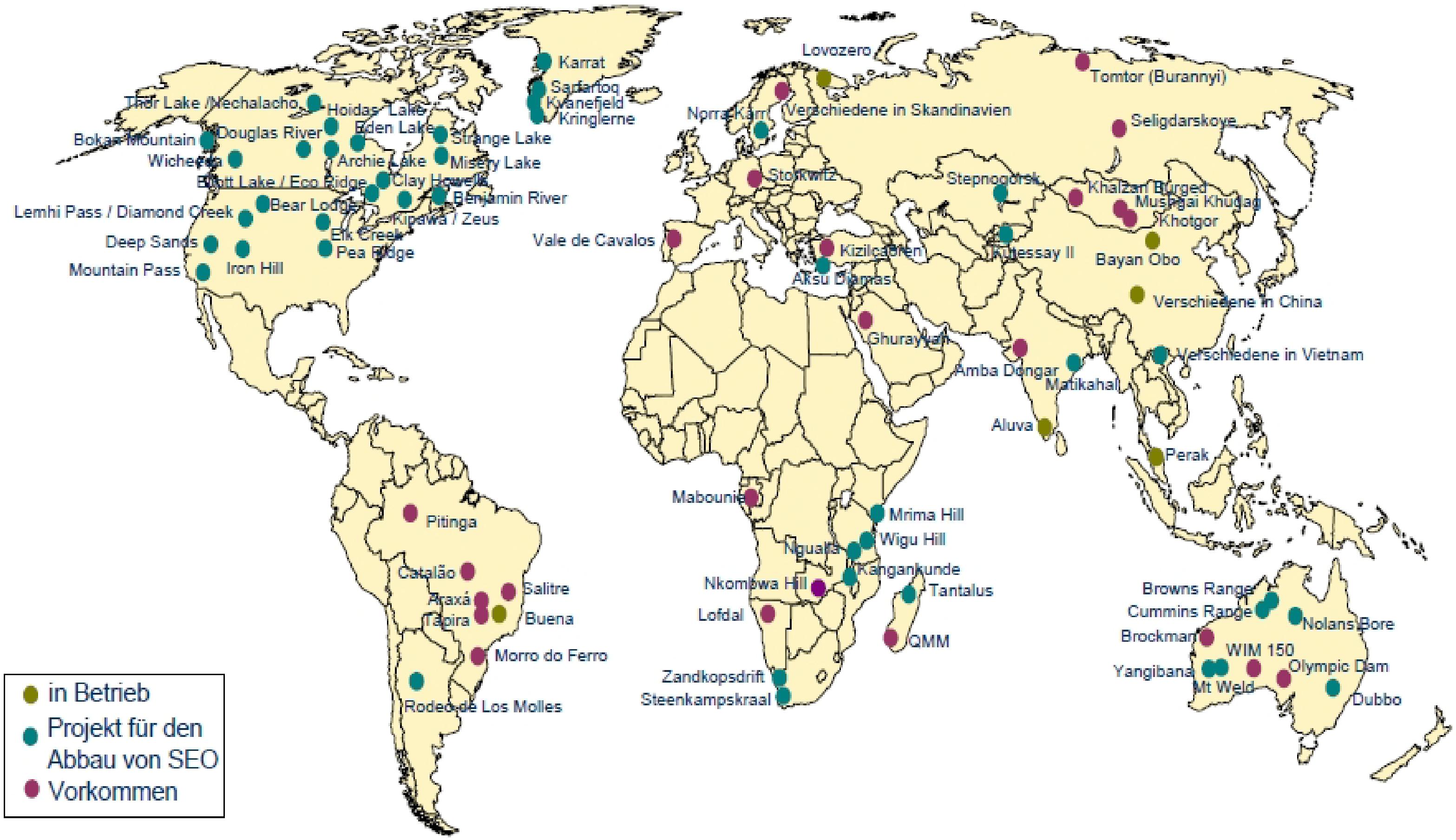
# REEE reserve and resource distribution




Quelle: BGR

China: 65 % der Reserven, 24 % der Ressourcen

# The current rush on REE




Anfang 2011: 270 Projekte durch 176 Firmen in 28 Ländern

Quelle: BGR

# REE – A “No Go” for the wind energy?

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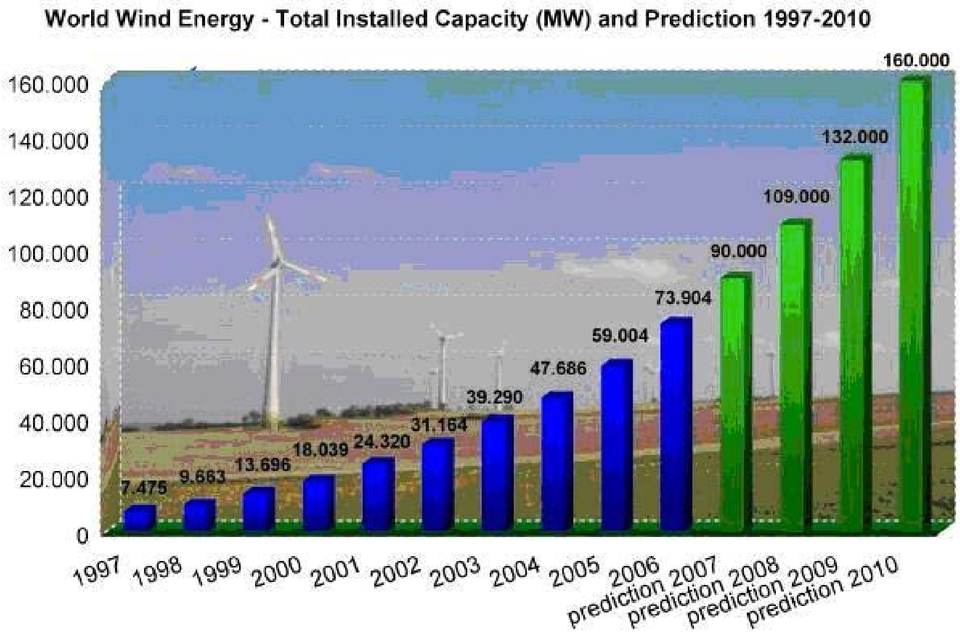



•0,5 tons/MW of NdFeB magnet ( or 0,2 tons/MW Nd) are need to build a permanent magnet direct drive wind turbine

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# REE – A "No Go" for the wind energy?

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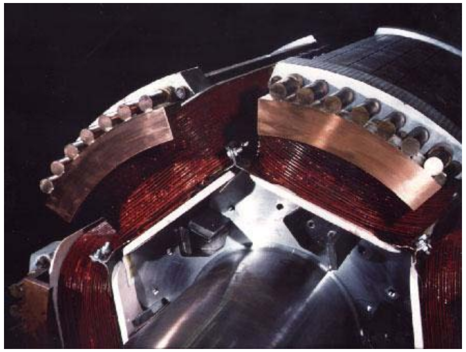
- **It is possible to build wind turbines without permanent magnets!**

  (wound field generator and permanent magnet generators)



- Only around 14% to 20% of all wind turbines do have a permanent magnet

# REE – Ein “No Go” für die Windenergie?

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- Fiktive CAGR von 20% für Windenergie Nachfrage von 100% magnet angetriebenen Windturbinen

➡ Nachfrage von **7000 Tonen/Jahr** Neodym.

- Die heutige Nd-Produktion liegt bei **11000 t/a** (Öko Institut) **, 24400 t/a** (Lyans Corp.)

- est. **30000 t/a in 2014**

# Zusammenfassung

Materials Resource Management

- Das fossile Energiezeitalter basierte auf ausreichend Metallen für Stahl bzw. Stahlveredler. Das post-fossile Energiesystem breite Basis von Edelmetallen, Halbmetallen und Selten Erdmetallen.
- Rohstoff Daten sind intransparent und basieren meist auf wenigen Quellen
- Eu, Tb, Dy sind wie die meisten kritischen Metalle multifunktional und besitzen eine geringe Nachfrageelastizität.

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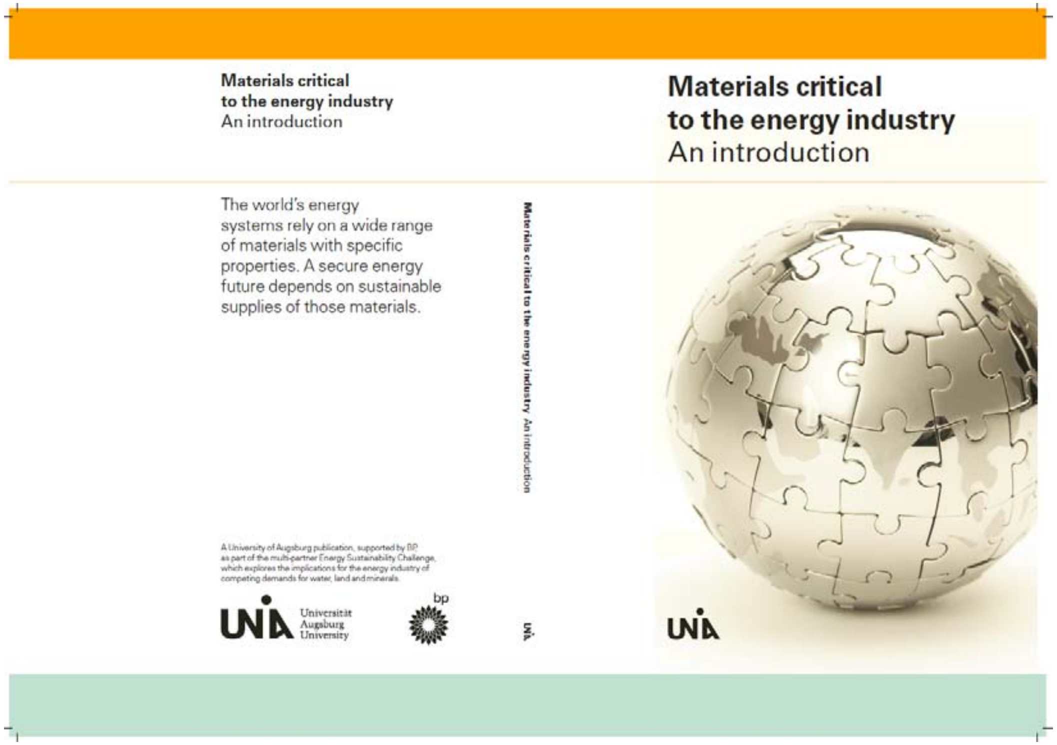


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