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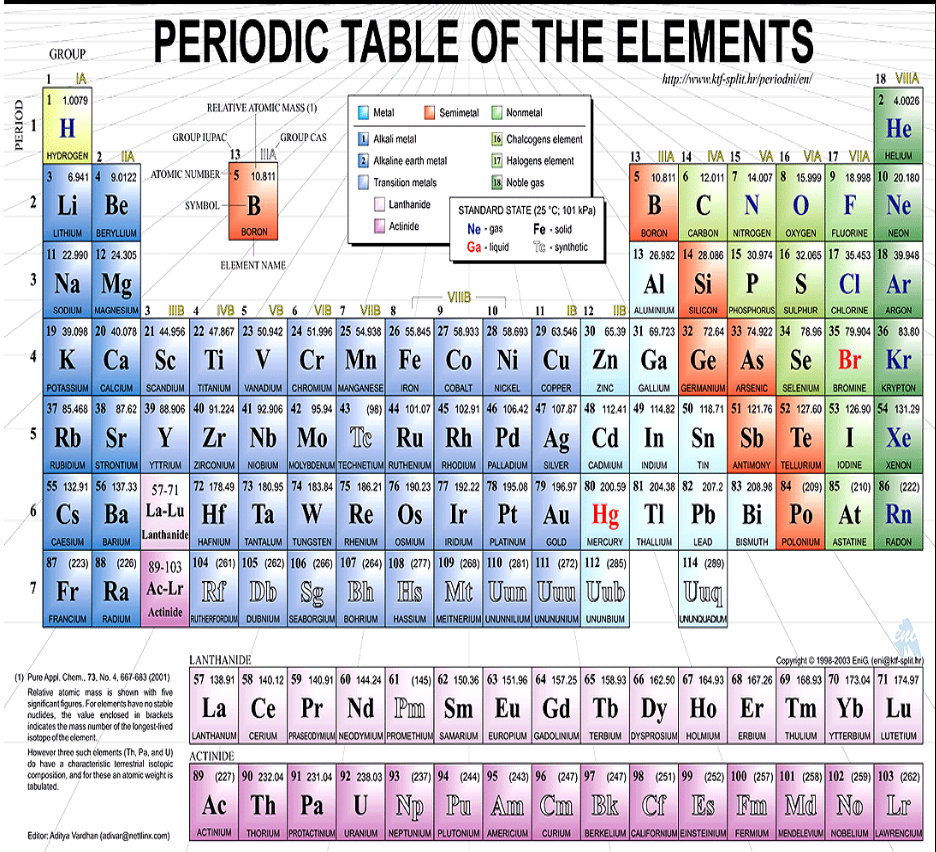
Critical Materials and Substitutes



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Agenda

- Introduction
- Application Requirements
  - Renewable Generation & Power Electronics
  - Lighting
- Discussion

Trans-Atlantic Workshop on Rare Earth Elements and
Other Critical Materials for a Clean Energy Future
Hosted by the MIT Energy Initiative
December 3, 2010

Introduction
Megatrends

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Megatrends for the Future

Siemens is the worldwide largest supplier of environmental friendly technologies.

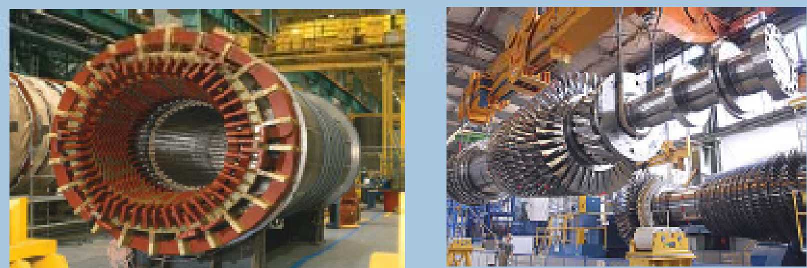
One third of the corporate turnover, being approx. 23 bn Euro is accomplished with green products and solutions (FY 2009)

Especially green products are dependent on the supply with special commodities !

The mix of raw materials for future production will change drastically in the future.

Emission-Free Transport

Mirrors / PV for Solar Energy



Electric and Electronic Products

Introduction
Classical Materials

Copper, steel and glass are so called classical raw materials - Examples

Copper

- Transformers

- E-motors

- Generators

Steel

- Industry

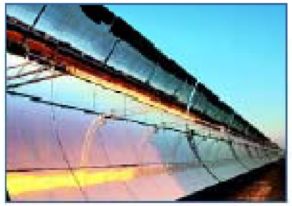
- Traffic

- Gears

Glass

- Phosphors

- Solar



- X-Ray tubes

Introduction
Special Materials

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Future Technologies dependent on special commodities - Examples

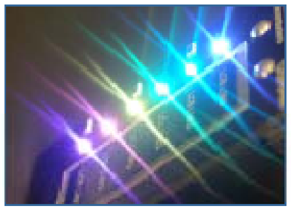
Rare Earths

- Magnets for gearless wind turbines

Rise in demand until 2030 to 19% of total demand of 2014. *)
(* higher than e-cars)

- Magnets for MRT

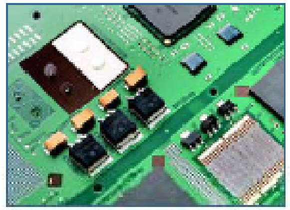
- Phosphors



Prerequisite for Energy Efficient Lighting

Silver

- Lead-free solder



- Solar heat (mirrors)

- Wastewater treatment

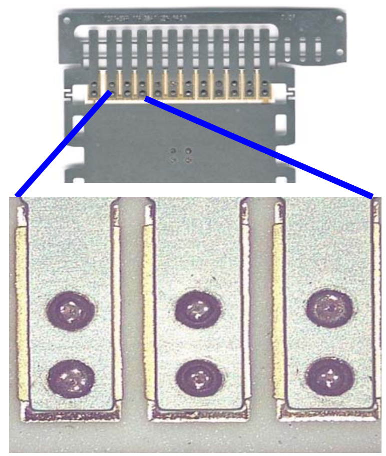
*) Studie der Oakdene Hollins Ltd., Cambridge

Application Requirements

Renewable Generation & Power Electronics

Siemens Wind Turbine: SWT-3.0-101

- Power Rating: 3 MW
- Classification: On-shore wind turbine
- Machine Type: Permanent magnet synchronous
- Drive Type: Direct drive, grid-connected
- Special: Rotor on the outside



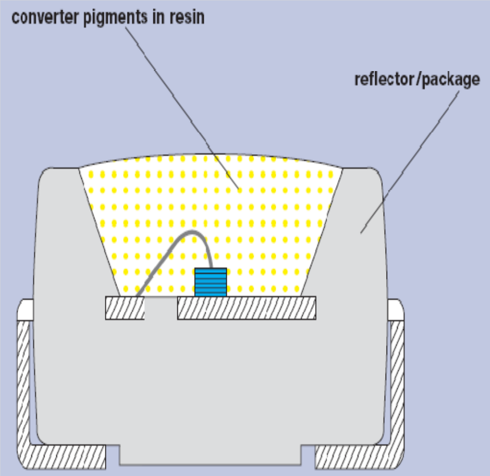
Power Electronics

- Materials: Substitution of Silver-containing solders for Laser Welding
- Example: Leadframes on Ceramic Substrate (DCB)
- Performance compared to conventional soldering: high temperature and mechanical stability, high speed processing

Application Requirements
Lighting

OSRAM Fluorescent Lighting (tubular, compact)

- Provides 2/3 of all electric light produced.
- Requires phosphors containing Rare Earth Elements (specifically La, Eu, Tb, Y, Ce)
- Rare Earth export out of China is restricted severely.
- Prices for RE, phosphors from China increase rapidly.
- OSRAM produces phosphors outside of China and has a JV with CRE (China) for phosphors.



OSRAM White LED

- Will dominate artificial lighting in ten years from now.
- Principle: blue-emitting LED + phosphor conversion.
- Requires rare earths Y, Ce, and Eu for phosphors.
- Requires In and Ga for Blue LED.
- Required quantities are small compared to fluorescent for the same amount of light, but as critical.

Discussion
Influencing Factors

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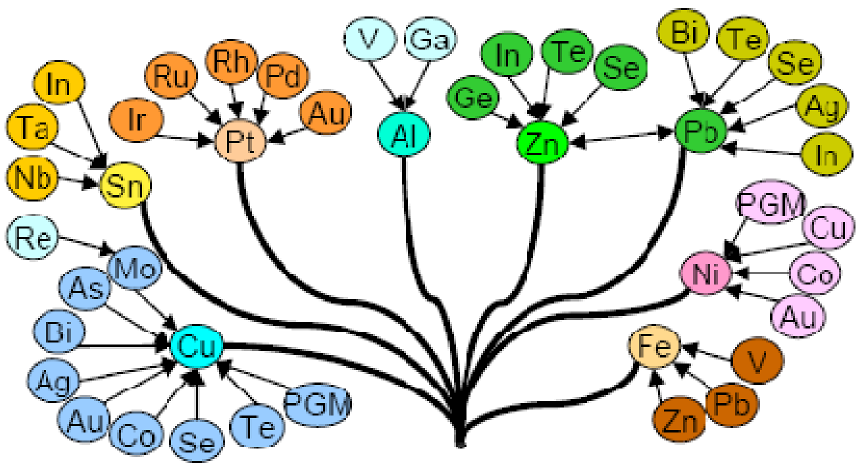
Geological Conditions



Production of critical materials coupled to major commodities.
These important by-products are thus price inelastic and restricted.

Demand >> Supply

Megatrends call for new technologies.

⇓

These technologies demand a different material mix in product manufacturing in the future.

⇓

Imbalance between demand for „base materials“ and „by-products“

Discussion

Measures for Mitigation

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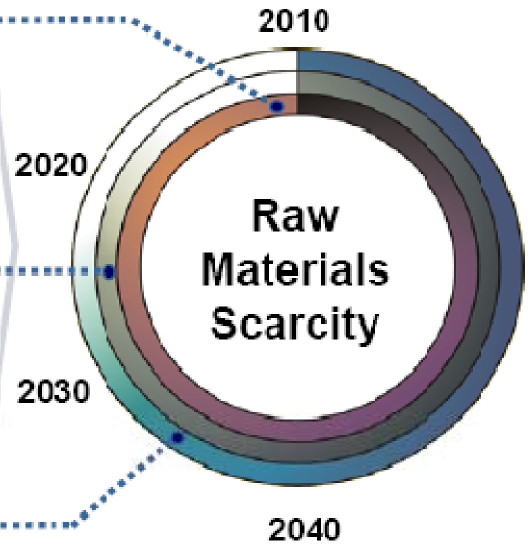
Factors

1. **Political Risks**
   e.g. Export quotas, taxes;
2. **Geological Scarcity**
   No static system !
3. **Demand >> Supply**
   due to
   - Future technologies
   - higher demand from emerging nations



Measures

1. **Substitution**
2. **Efficient Use**
3. **Recycling**
4. **Supply chain mgmt, cooperations**
   to ensure supply chain and of calculable prices

Discussion
Commercial Case

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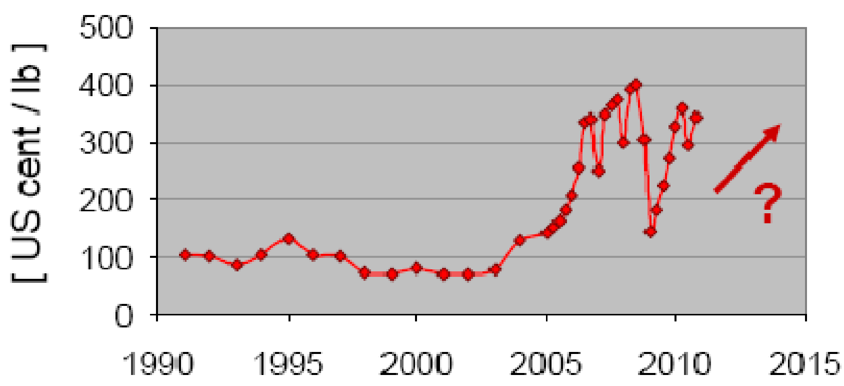
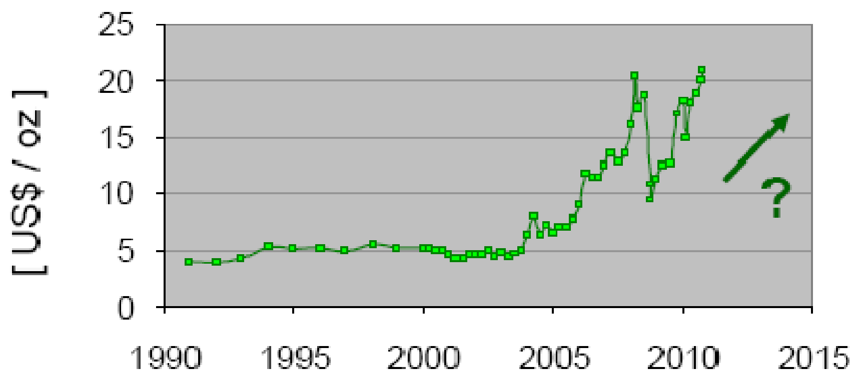
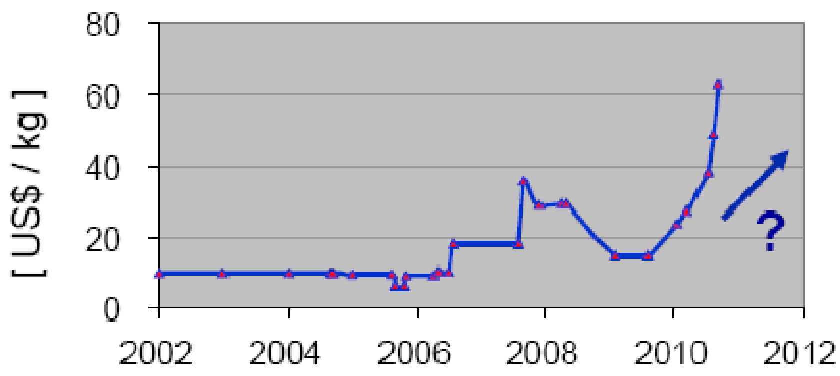
Copper



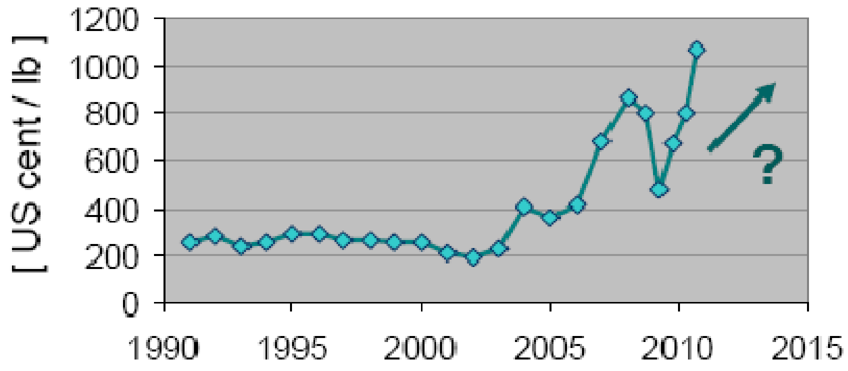
Silver



Neodymium-oxide



Tin



Conclusion
The time factor is generally underestimated

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Boundary Conditions	Consequence
▪ Economical lifetime of manufacturing sites ▪ Product families based on similar technologies.	▪ **Today** material and energy use in production and manufacturing is **determined** for the period **2020 to 2030**
▪ Substitution of materials, if possible almost always lead to extensive changes in - the design of product and - the manufacturing. ▪ Unscheduled changes on product design are expensive.	▪ **Short-term reactions** on materials scarcity or rising prices are not possible

Long-term strategies required !

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