TOWARDS A SYSTEM APPROACH FOR MATERIALS IN THE WHOLE VALUE CHAIN

Materials Ontology Workshop

29 June, 2018
Brussels, DG RTD, CDMA -SDR-1

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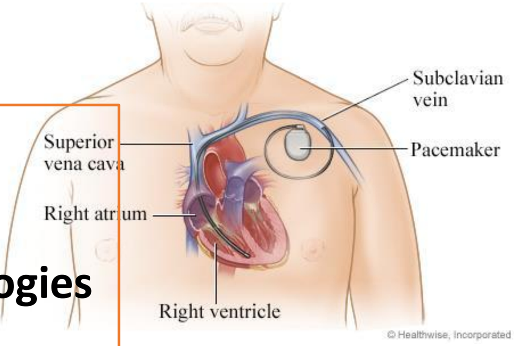
INNOVATIONS RELATED TO MATERIALS R&D



HEALTH

- Modern Health Technologies for Monitoring
- Imaging Techniques

TRANSPORT

- Airplane
- Automobile
- Spacecraft
- Highways

COMMUNICATION

- Radio and Television
- Internet and smart phones
- Electric and electronic devices like computers

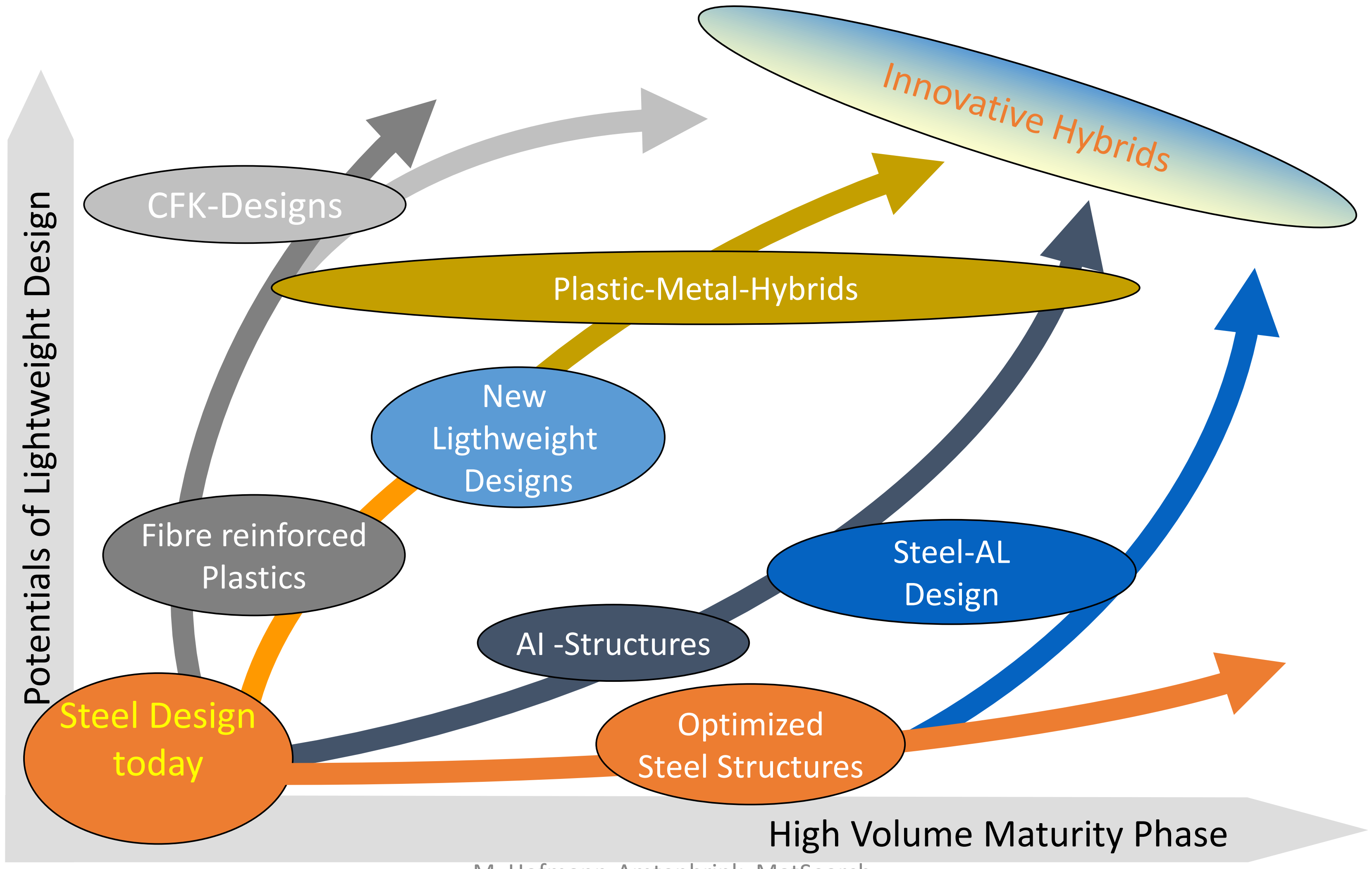
ENERGY

- Green Energy
- Petroleum and Petrochemical Technologies
- Nuclear Technologies

MATERIALS IMPORTANT ROLE IN INDUSTRIAL SECTORS OF THE FUTURE

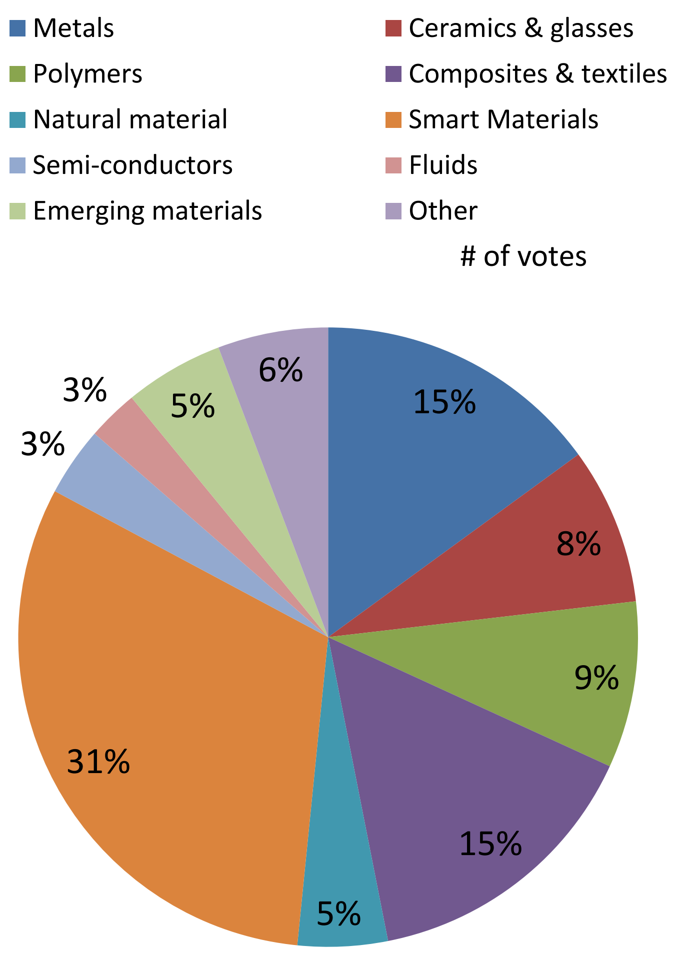
1. Secure Clean Energy
2. Health, Demographic Change and Well-being
3. Food and water security
4. Smart, Green and Integrated Transport and Energy related topics
5. Secure Society

EXAMPLE AUTOMOTIVE - TREND TOWARDS MULTI-MATERIAL DESIGN

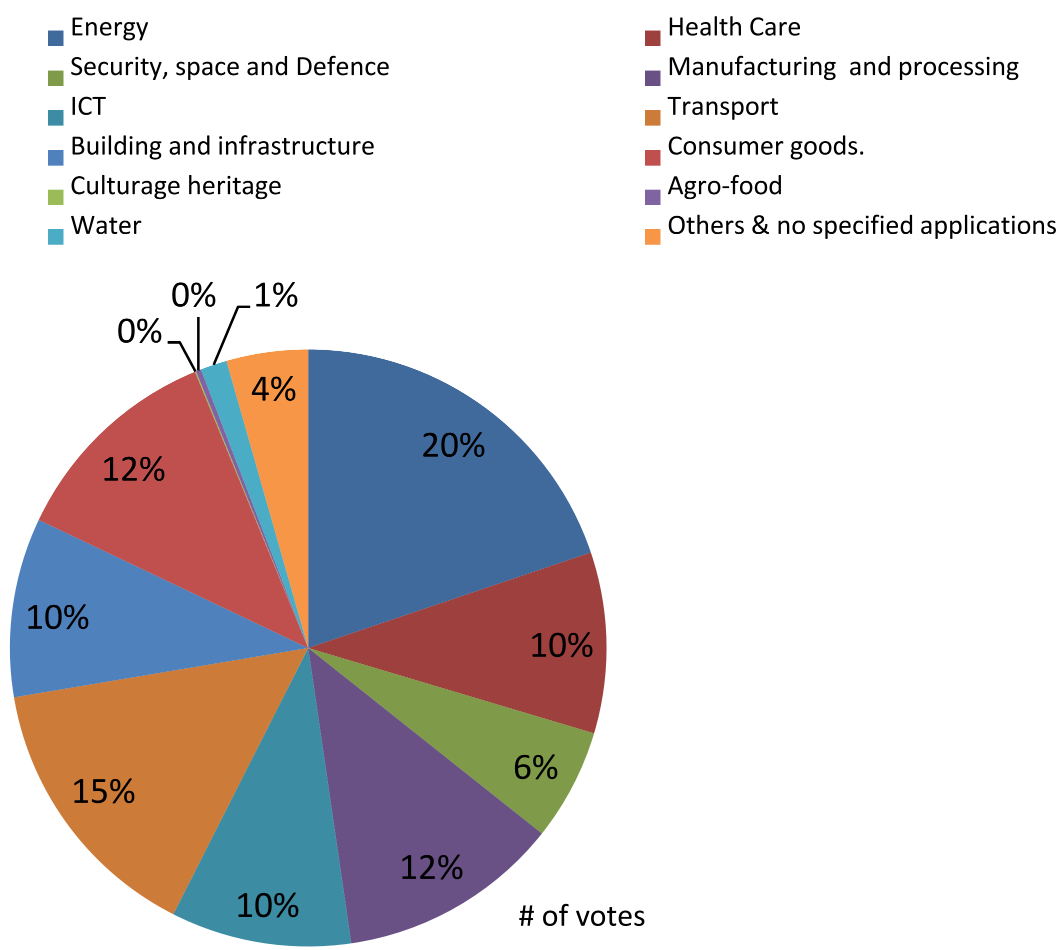


Source: M.Goede, VW Group Research, SLC

MATERIALS REQUEST FOR FUTURE APPLICATIONS

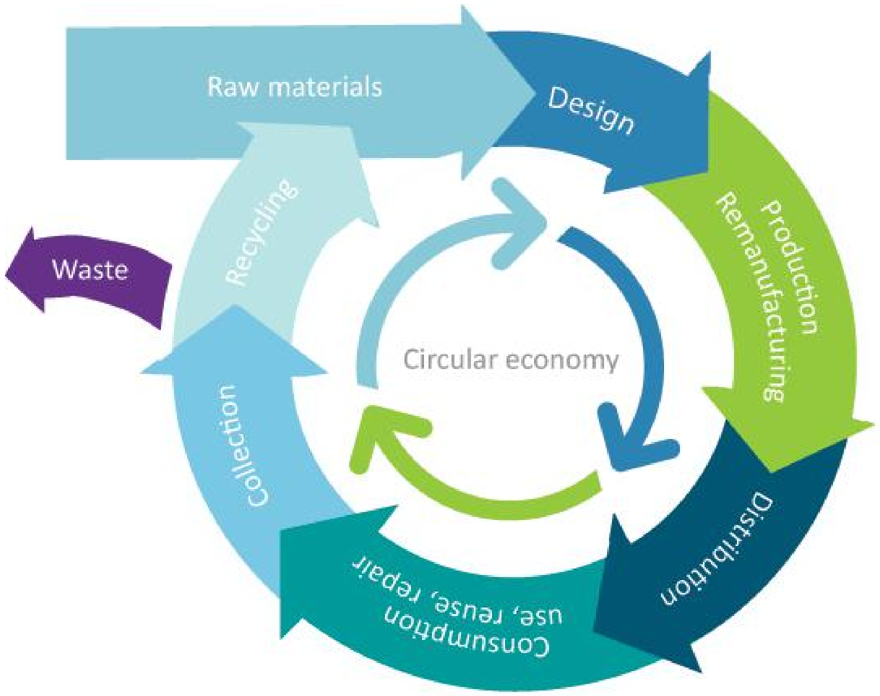


*Smart materials: including coatings & surface functionalization / structuration



Data from the EU Project MATCH/Partner CEA Liten

ADDRESS THE CHALLENGES FOR A CIRCULAR ECONOMY

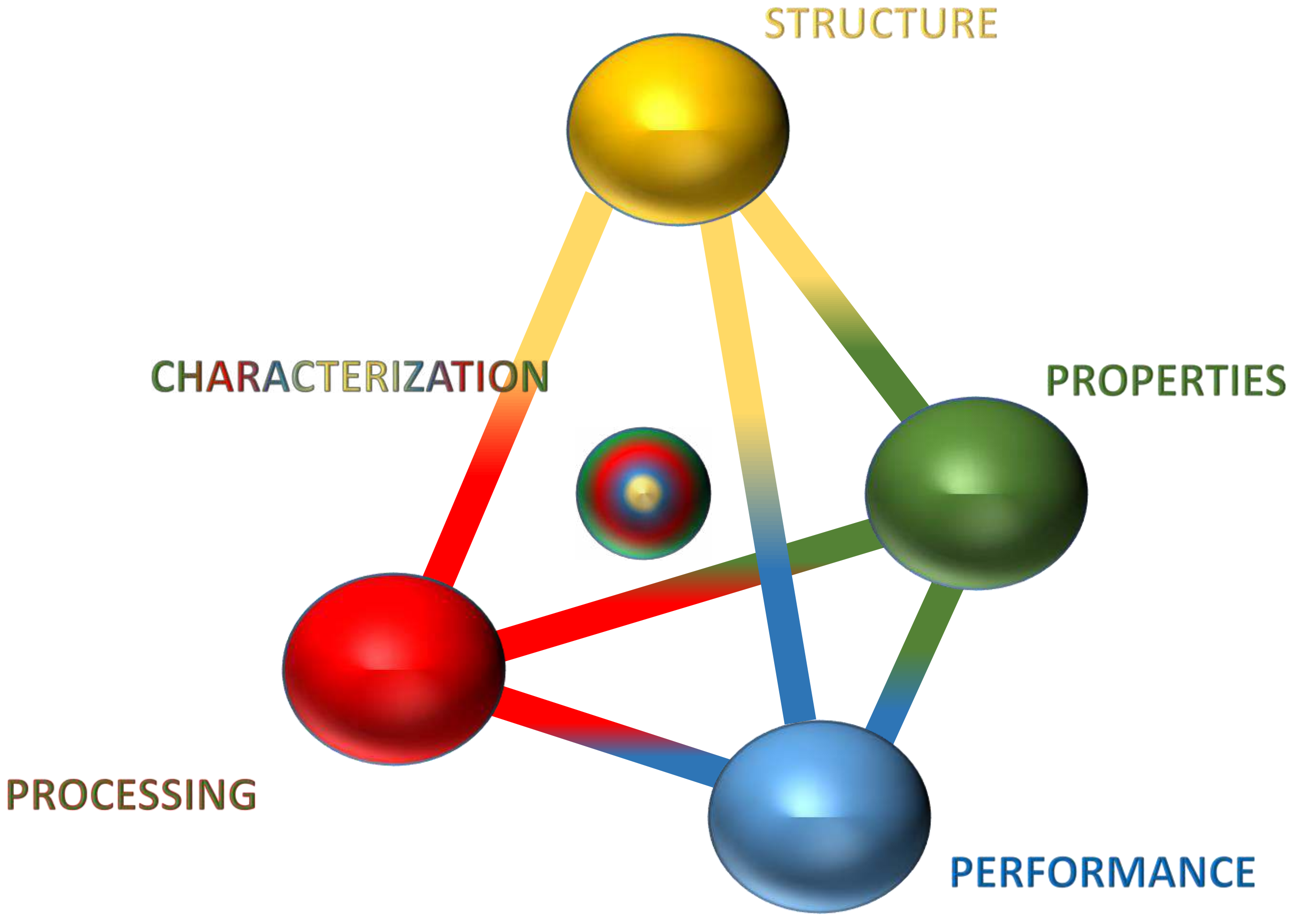


http://chemicalleasing-toolkit.org/node/64

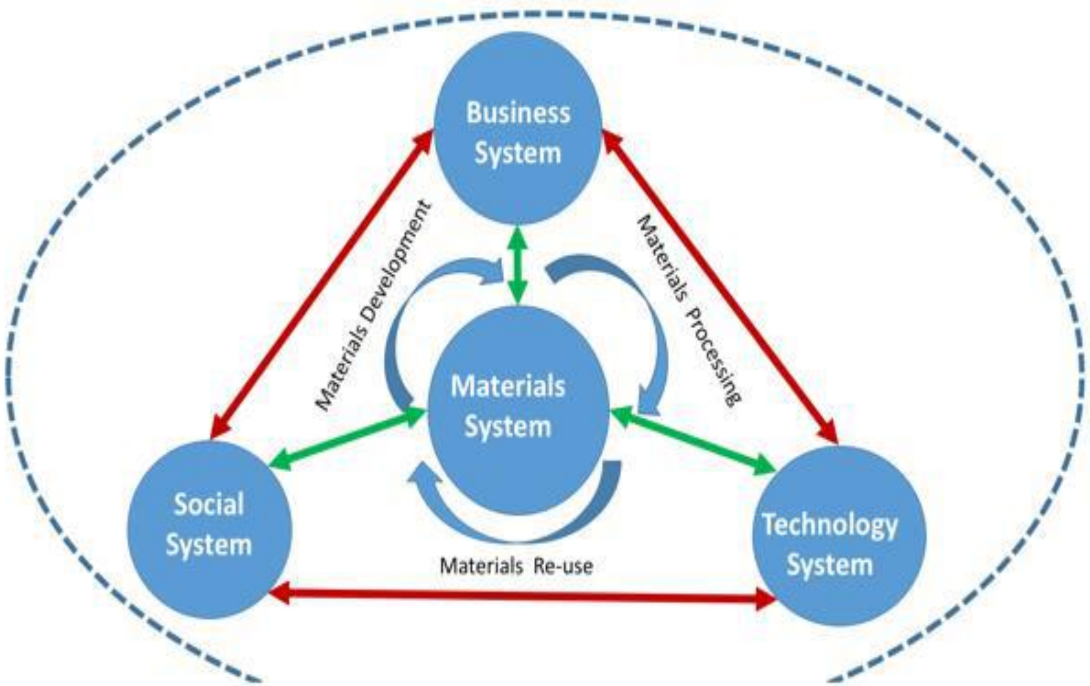
1. **Materials Selection and Characterisation:**
   - Existing or novel materials have to be optimised and adapted for the design and processing steps of the system.
   - Steps like materials design, -microstructure, -modelling and materials characterisation are crucial and need additionally standardised procedures, Standard Operating Procedure (SOP) or even ISO standards and regulations (REACH).
2. **Processing and Manufacturing:**
   - Optimisation and adaptation of a chosen process to fit the material to the desired function/properties – all kinds of processing/manufacturing methods and should be optimised by using methodologies like the life-cycle-assessment or similar tools
3. **Life Cycle Assessment, Recycling and Re-Use:**
   - Steps in 1. and 2. should be assessed by techniques to get the environmental impacts associated with raw material extraction through materials processing and manufacture to allow full recycling/re-use of materials or components (circular economy, Bill of Materials).
   - Life-cycle assessment allowing the monitoring of all development and manufacturing steps <u>needs exact materials data along the whole value chain.</u>

MATERIALS SCIENCE AND ENGINEERING PARADIGM

Materials Research and Development based on the a linear production-consumption model



SYSTEM APPROACH FOR MATERIALS RESEARCH & DEVELOPMENT & INNOVATION



System Approach for Materials R&D&I

WHY?

- Innovation and new system approaches are often driven by materials science / knowledge as materials are key factors for a large number of emerging technologies.
- Actors from other disciplines along the entire value chain must be integrated into the system to generate new knowledge.

The model includes a persistent and consistent "long-term" (> 4-5 years) R&D direction, that allows a systemic approach towards a "circular economy“, and involves the systematic assessment of the application, business potential and commercial implementation of the developed materials and technologies.

SYSTEM AND ITS INDIVIDUAL CHAINS

1. **Materials Research & Development**
   - Covers raw materials choice, materials processing and characterization in view of specific functionality, performance and pricing for a defined application. Does not cover re-use/recycling in most of the cases.
2. **Manufacturing**
   - Often seen in parallel to materials research and development and therefore other programmes/organisations are used for funding
   - Dependent often on industrial sector in view of pricing, number of pieces, legal and environmental issues (health and food sector)
3. **Standards and Legislation**
   - In the majority of cases existing standards to be used for measuring the targeted properties cannot be applied to new and complex materials (see nanomaterials). The full knowledge of health and environmental hazards of new materials is available only in about 30% of all cases.

New System Agenda I

1

Materials should be developed in a context that enables to choose optimal and sustainable solutions for the final product and re-use

2

Material-based key enabling technologies and new manufacturing technologies should be taken into account along the entire TLR (1-8)

3

The exchange of material-relevant information should come from the end product to the researcher and vice versa and be available/useful at all steps in the system chain

New System Agenda II

Define materials for the system in terms of functions, interplay of manufacturing parameters, market accessibility, price, legal issues, and disassembly and reuse as a secondary raw material or as system as well

Observe the material along the system and pinpoint where improvements are appropriate or necessary. Discuss with the respective specialists and give information back into the system chain.

Make sure a) that customer requests and feedback (e.g., dissatisfaction) flow back into the product cycle and improve the system and that b) the information is incorporated as data and can be used directly.

NEED FOR A MATERIALS ONTOLOGY

- Materials engineering is an important part in the value chain in a circular economy, starting from the raw materials followed by design and processing steps to recycling and reuse.
- None of these steps is independent but each has impact on the final product, the economy, the environment and the society.
- Materials should already be described and catalogued in research and development: Opportunities for industrial use are increased (standardization is mandatory there) and, it makes it easier to track information about material composition and manufacturing processes.
- A system approach between research - social, technical and business systems urgently needs a common language.

THANK YOU

Acknowledgement and Contacts for Experts

- MATCH: www.match-a4m.eu
- Federation of European Materials Societies – FEMS www.fems.org
- European Technology Platform for Advanced Engineering Materials and Technologies - EuMAT: www.eumat.eu
- European Institute of Innovation & Technology (EIT)- EIT Raw Materials: www.eitrawmaterials.eu
- European Technology Platform on Sustainable Mineral Resources - ETP SMR: www.etpsmr.org
- European Technology Platform for Sustainable Chemistry SusChem http://www.suschem.org
- Towards a World Forum on Raw Materials – FORAM: www.foramproject.net
- Entwicklungsfonds Seltene Metalle – ESM: www.esmfoundation.org

I like to thank my colleagues Heinrich Hofmann, EPFL, Switzerland, Rudy Koopmans, Competence Centre Plastics Innovation , Switzerland, Erik Schuring, Energy Research Centre of the Netherlands, Part of TNO, The Netherlands, Jan Meneve, Vito NV, Begium, and Roland Gauss, EIT Raw Materials GmbH, Germany for discussing the "System Approach" and preparing a common publication on this topic.

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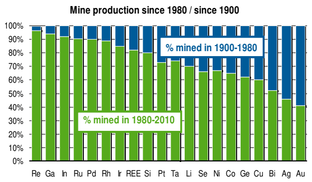
EXCHANGED SLIDES

“CRITICAL” MATERIALS IN INNOVATIVE PRODUCTS

- <u>Electric & electronic equipment (EEE)</u>
  Over 40% of world mine production of copper, tin, antimony, indium, ruthenium & rare earths are annually used in EEE

- <u>Mobile phones & computer</u>
  account for 4% world mine production of gold and silver and for 20% of palladium & cobalt.

- <u>Cars</u>
  > 60% of PGM mine production goes into autocatalysts,
  increasing significance for electronics (“computer on wheels“) and light metals



- In the last 30 years we extracted > 80% of the REE, PGM, Ga, In, … that have ever been mined

- <u>Clean energy technologies & other high tech applications</u> will further accelerate demand for technology metals
  (precious metals, semiconductors, rare earths, refractory metals, …)

Source: Christian Hagelüken, Umicore, Presentation at WRF 2013

CRITICAL ASSESSMENT OF SUSTAINABLE ENGINEERING

- During materials development
  - ✓ to assist in the choice of sustainable materials
- During design
  - ✓ to assist in the choice of procedures which help to re-use elements, materials and/or components.
- During fabrication
  - ✓ to assess process technologies in view of a balanced use of materials, and energy, if possible low negative impact on environment and optimized for a global market
- During and after operation
  - ✓ to assess issues like impact of the component/product on the consumer's wealth, on the society's well being and the environmental compatibility

INDUSTRIAL INNOVATION BEYOND 2020

The European Union will support Innovation in so called "MISSIONS" and "PUBLIC PRIVATE PARTNERSHIPS" driven by the request of industry at different levels of the value chain.

Materials R&D will be supported through individual and independent programmes and projects

- for different materials groups
- at different readiness levels and
- in different industrial sectors
- under different standards and legislative boundary conditions

This may increase the fragmentation of materials research and development, potentially reducing knowledge and communication across the value chain, and increasing understanding issues