



2011 World Materials Summit

Panel Discussion Report

Resource Assessment



Scope

- The panel determined 4 topics to be within the resource assessment scope
- Primary resources
 - Mines
 - Recycled materials
- Substitution as an alternative when there are shortages
- Analysis methods for resource production including materials, water, energy, land, greenhouse gases...



Current state of the technology (Bird's eye view)

- Mining: prospecting and extraction done by traditional methods, has become more efficient in recent years
- Recycling: break into small pieces and dissolve to recover metals, only certain metals can be recovered
- Substitution: done *ad hoc* in response to supply shortage
- Analysis: methodology to compare resource use for different technology solutions



Long-term vision or goal (toward 2030)

Having the raw materials needed for energy technologies when they are needed, provided sustainably, at an affordable price



Major research and technological needs and opportunities in support of vision

- Mining: challenges are sustainable, efficient mining methods, lack of understanding about ores containing rare elements, appropriate regulations
- Recycling and substitutions: lack of systematic knowledge about appropriate methods
- Analysis: lack of information on materials, resource needs and processes



The supply chain **imply** new « connected » research and information systems

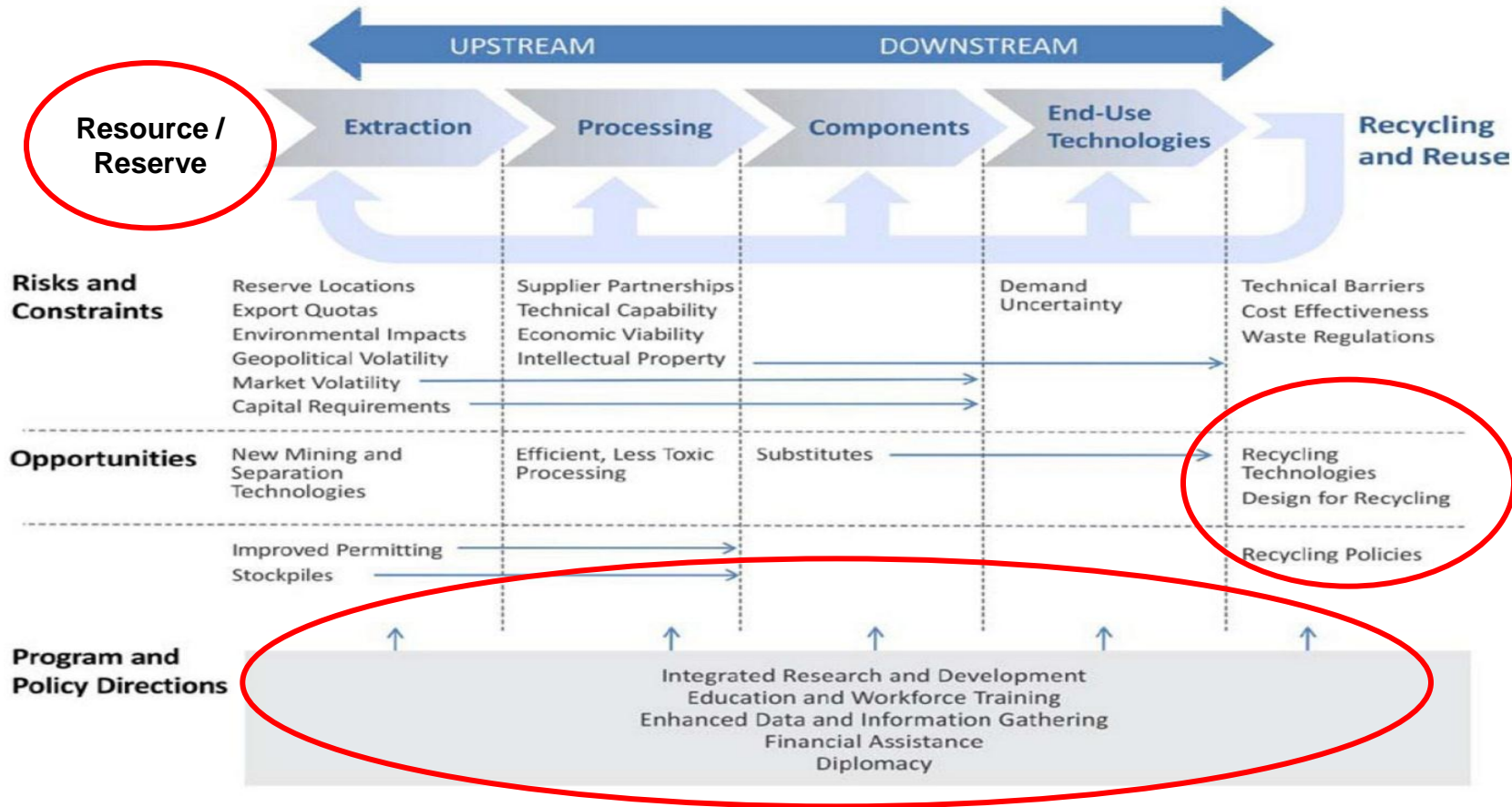


Figure ES-3. Program and policy directions and the critical material supply chain

References

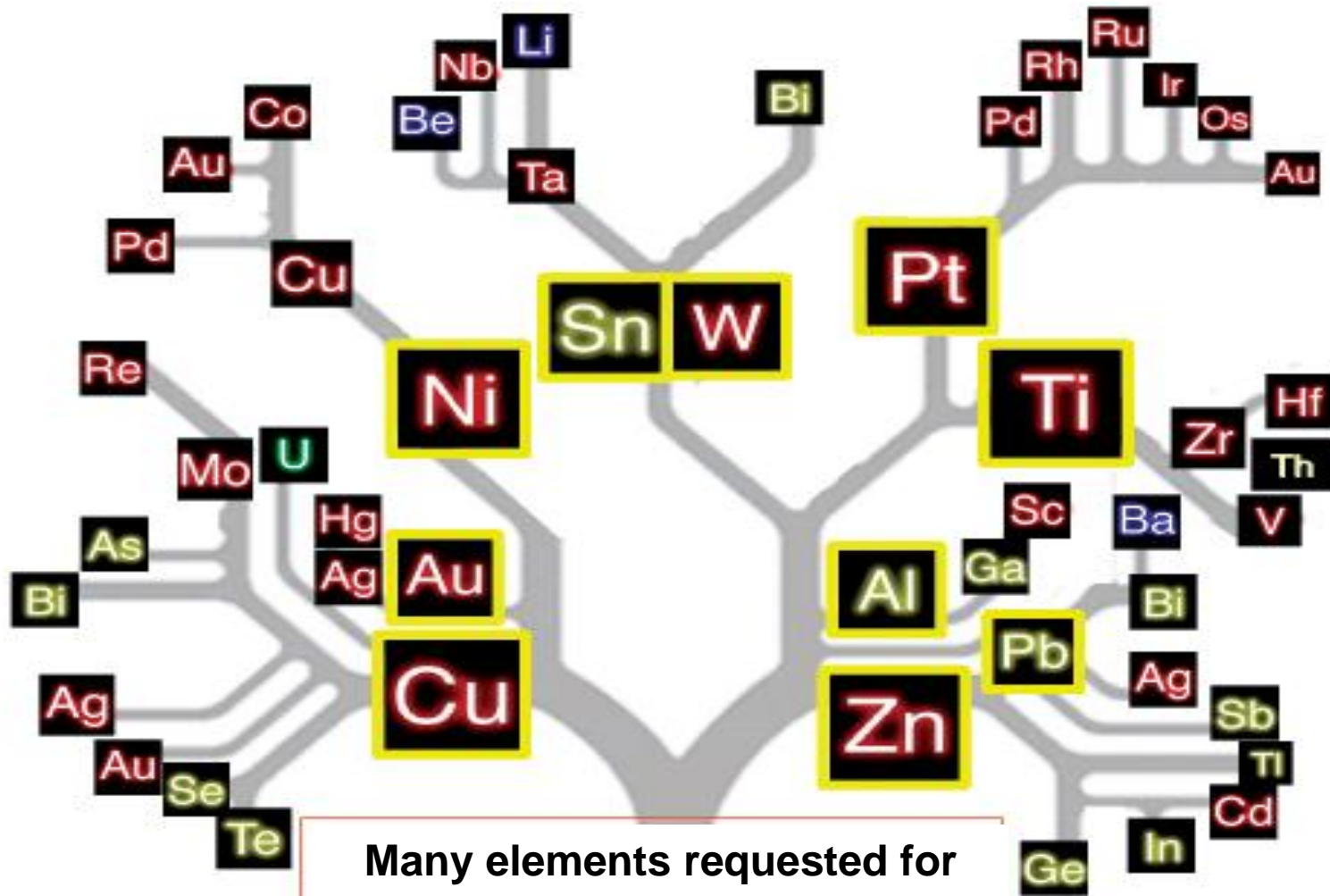
NAS (National Academy of the Sciences). 2008. Minerals, Critical Minerals and the U.S. Economy. Journal of the National Academy of Sciences

Research and Innovation opportunities

- Reduce risk by **knowledge of natural resources and information on materials needs of new technologies** – communication between suppliers, economists and technologists
- **Information on resources and reserves**, and on actual consumption for new energy technologies – reliable and timely to enable accurate projections of needs
- Geosciences – to better **identify good sources especially of scarce materials**. “surgical” mining rather than extracting a lot of rock for a little final product
- To establish a **systems methodology that will consider a process or product from the mine through to recycling to evaluate impacts**
- Better, more efficient and benign **extraction and refinement chemistry**
- **Recycling and separation processes** (chemical, biological, physical)
- Research on **properties of and processes using recycled metals**
- Learn efficient chemistries using **CO₂ as a raw material**
- **More efficient capture of CO₂** from process waste gases
- Research **linking discovery of material to prototype to scaleup to reliability**
- **Science for substitutions through materials discovery** (alloys, nanomaterials, components): composition, structure and morphology



Where are the new raw materials



Many elements requested for high technologies are by-products of common metals

Economic comparison of the main routes of *energy* storage from *CO₂*

- Sun...and.....bioalga..... 150 to 300\$/barrel
- **Coal- biomass-byproducts** 70\$/barrel
- Renewable energy and electrolysis 80\$/barrel
- **Decarbonated energy electrolysis** 55\$/barrel
- **Coal +CCS+HydrogenCH4 (US)** 40- 50\$/barrel

These data are the breakeven price for oil production

(oil cost Sept 2011 WTI (85\$/b)

- **These data depend of many parameters such as:**
capex and opex of the installations,
interest rate, commodities, insurance, risks, (coal, gas, oil) cost, electrical cost
- Market place: ETS of CO₂ and regulation decisions (EEC, EPA..)

CO₂: a recycled source for new fuels and other materials

What is being done today?

- New awareness of limits over past few years and **rebuilding of mining and extraction research**
- New programs in **recycling chemistry and biological recycling processes**
- New efforts to develop **cost models for full mine to product systems**, eg life cycle assessment, resource and environmental aspects
- **Basic research needs being codified** to identify grand challenges for energy including materials substitutions and discovery



Opportunities for international cooperation

- **Coordination** of research needs and programs (multilateral)
- Identify priority areas through **focused multi-society international workshops** (industry, government, chemistry, materials, physics, engineering, mining, geosciences, economics) (see D. Arent in backup section)
- Create **networks of information**, develop information systems
- Develop and validate **analysis methods** for resources, economics (“mineral intelligence”, end uses, costs etc)
- **Training of workforce** in countries with active mining (eg China) to accelerate rebuilding of workforce in the west
- **International agreements on exchange of funds and IP** in joint work - process not easy today. (See D. Arent in backup section)
- **Tools for materials discovery** (synthesis and characterization, modeling and computation, testing)
- **Funding of major research facilities** (microscopy, spectroscopy etc) specialized for minerals research and shared internationally



| | analysis | To scientists R&D | To policy makers |
|------------|--|---|--|
| resource | LCA, Systems methods for predictions, national/global resources inventories | Geosciences, Measurements to support LCA, separations science | Address national needs, need consistent support in the face of cyclic shortages, international cooperation, information collection |
| recycle | Resource use and needs | Design for recycle, separations science, new feedstocks such as CO ₂ | Regulations, incentives, standards |
| substitute | Resource use and needs, sustainability analysis | Materials discovery | Support long term pre-competitive research |

All materials used for a product (raw resource plus resources used to make the product)
Materials scientists should be aware of cost when working on performance



Panel Participants

- Jacques Amouroux (co-chair)
- Douglas Arent
- Pol Guennoc
- Frances Houle (chair)
- William Tumas
- Hongtao Wang



BACKUP COMMENTARY
AVAILABLE ON
REQUEST

