

Dealing with complexity in developing new recycling technologies - the case of critical metals



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Umicore Precious Metals Refining
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Introduction to Umicore

- Global materials technology company
- Mission: “materials for a better life”
- Majority of growth comes from clean technologies:
technologies that are specifically designed to optimize the use of natural resources and to reduce environmental impact
- 2010: turnover €9.7 billion , 14,386 employees
- Listed on Euronext Brussels, market capitalization €4.5 billion
- Visit us at www.umicore.com

Key megatrends for Umicore



Leading manufacturer of Special Metals

	<p>Tellurium</p>	<p>Capacity: 150 t/y Quality: 2N5 Form: powder</p>
	<p>Indium</p>	<p>Capacity: 50 t/y Quality: 4N, 4N8 Forms: ingots, shots, shells</p>
	<p>Selenium</p>	<p>Capacity: 600 t/y Quality: 2N5, 3N, 4N5, 5N, 5N+ Forms: powder, shots</p>



Roadmap

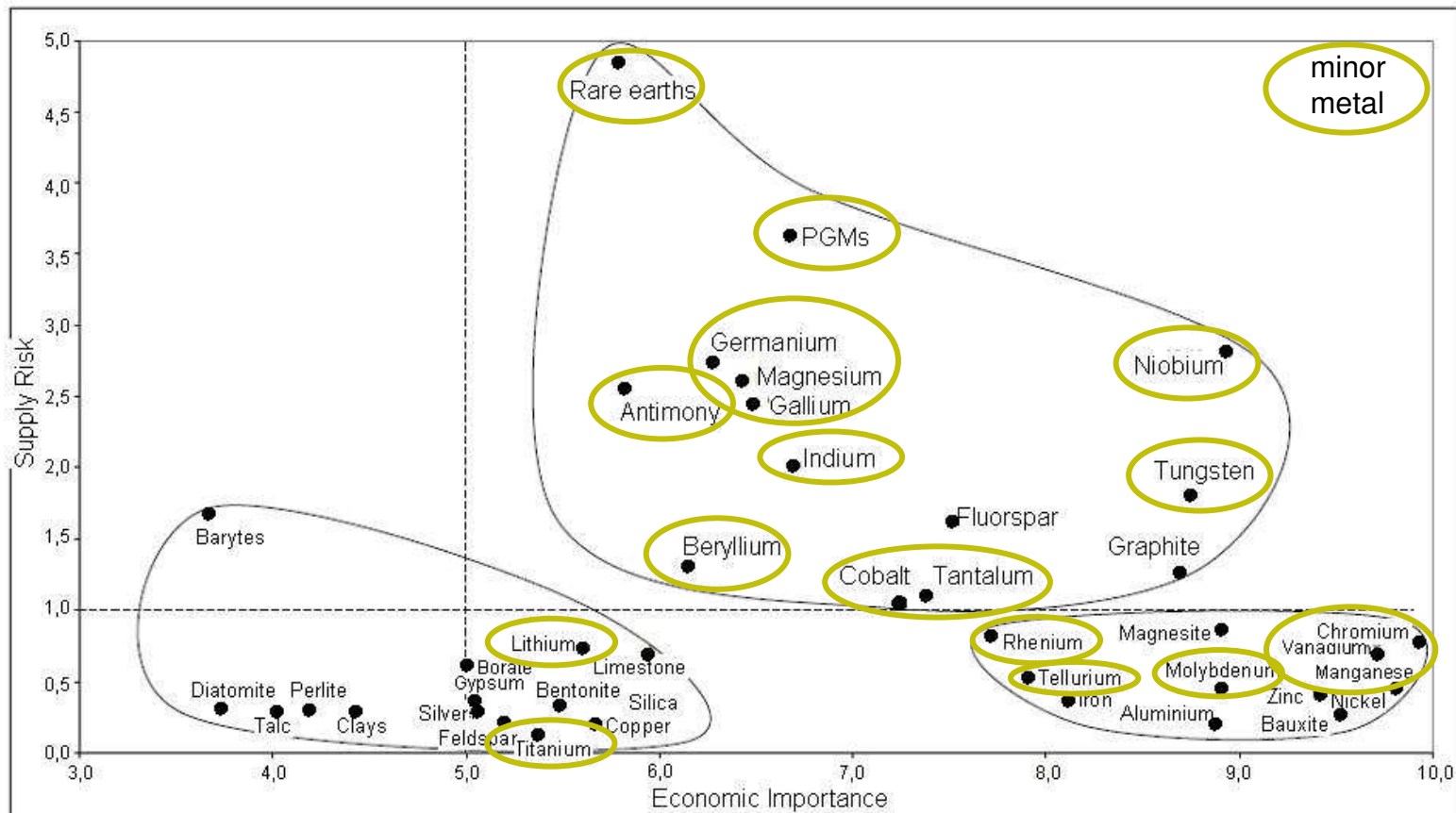
- **What are critical metals? Why recycling?**
- **Complexity in recycling**
 - **Economic**
 - **Technological**
 - **Commercial**
- **Case studies**
 - **ITO recycling**
 - **CIGS recycling**
 - **Battery recycling**
- **Closing remarks**



Critical raw materials (EU Commission)

materials for which a **threat to supply** could involve **harm to the national economy**,

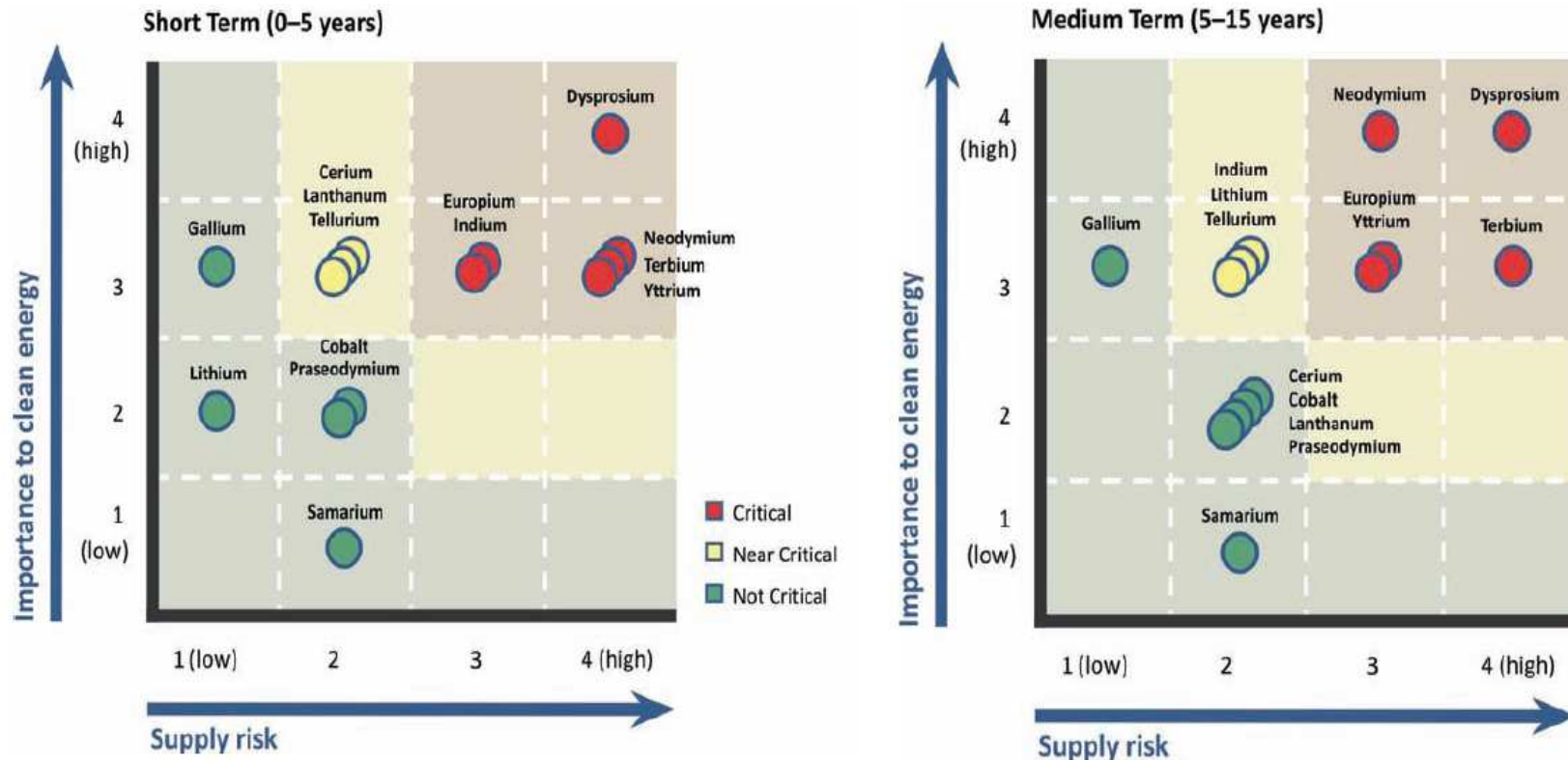
and for which the risk is higher than for most other raw materials **in the coming 10 years**



Source: Critical Raw Materials for the EU – European Commission Enterprise & Industry, July 2010

Critical raw materials (USA-DOE)

importance to the clean energy economy and risk of **supply disruption** on **short (0-5 years)** and **medium term (5-15 years)**



Source: U.S. Department of Energy – Critical materials strategy, December 2010

*“Within the next five years (short-term perspective), **Öko-Institut (DE)** estimates metals **tellurium, indium and gallium** to be regarded as most critical due to rapid demand growth as well as serious supply risks combined with moderate recycling restrictions.”*

Source: UNEP report, July 2009

Critical metals for future sustainable technologies and their recycling potential

Policies for secure access & materials efficiency

EU Commission:

- improve access to and extraction of primary resources
- level playing field in trade & investment
- **recycling**
- substitution
- materials efficiency

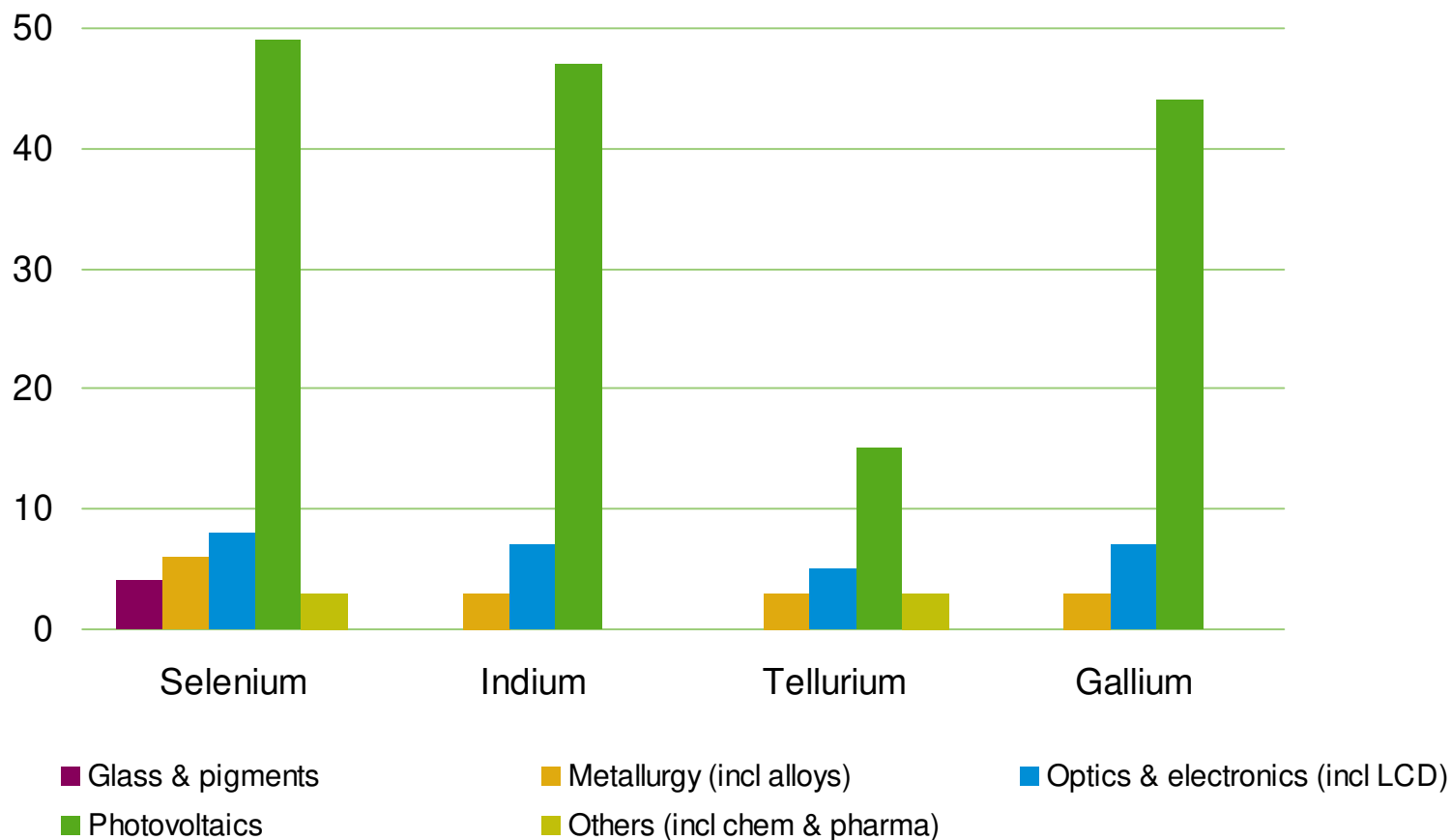
US – Department Of Energy:

- diversify global supply chains
- reuse
- **recycling**
- substitution
- materials efficiency

➔ **Criticality factors & need for recycling do not come out of the blue**

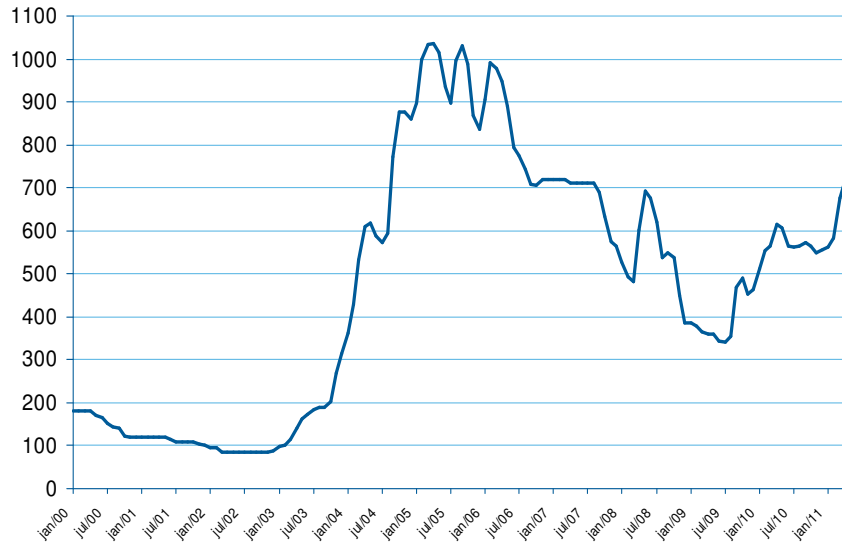
Clean tech applications: impact on demand

Compound Annual Growth Rate by 2015 [%]

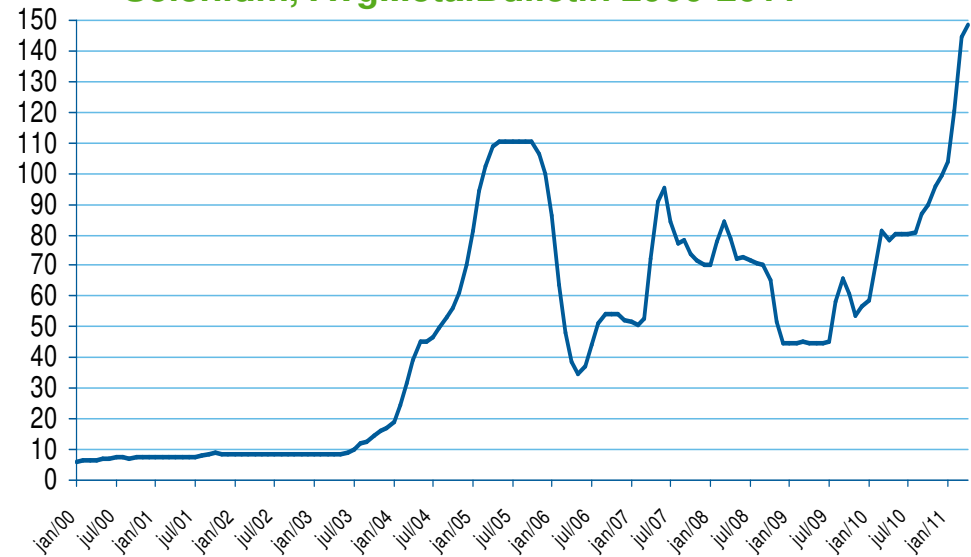


Source: Umicore scenario for PV: 80 GW/y in 2020, 35% share Thin Film PV

Indium, AvgMetalBulletin 2000-2011



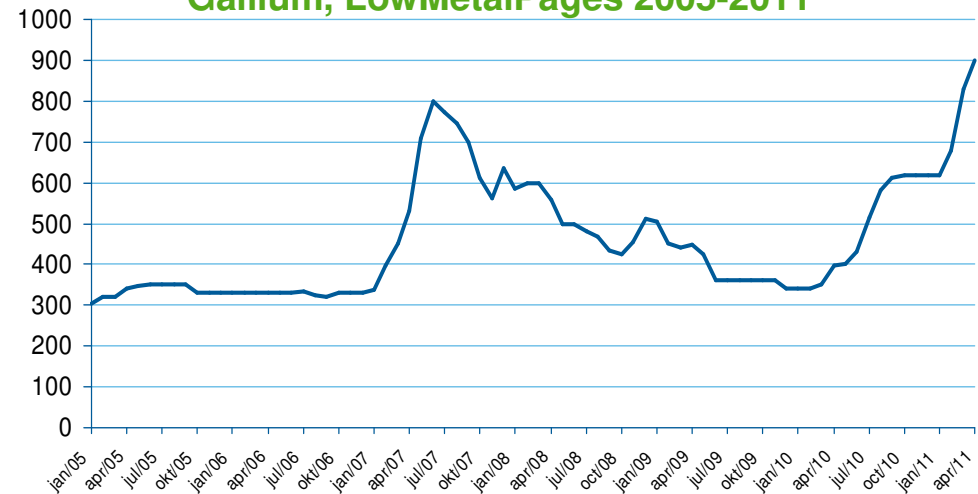
Selenium, AvgMetalBulletin 2000-2011



Tellurium, AvgMetalPrices 2004-2011



Gallium, LowMetalPages 2005-2011



Dealing with complexity in developing new recycling technologies

continuously increasing demand for a.o.

clean tech applications

&

government policies

&

consumer + producer policies



need for recycling

Recycling: clear benefits

- ✓ **De-coupling from primary production**
production scrap is a significant, readily available resource
- ✓ **Economically justifiable**
production scrap has an economic value
- ✓ **Lower environmental impact**
recycling needs less energy & has lower CO₂ emissions
- ✓ **Mitigate metal scarcity by resource conservation**
special metals are reused in products, instead of landfilled
- ✓ **Remove impact of metal price fluctuations**
the producer may remain owner of the metal in the scrap
- ✓ **Secure access to raw materials**
you know the location, the recycler and the owner



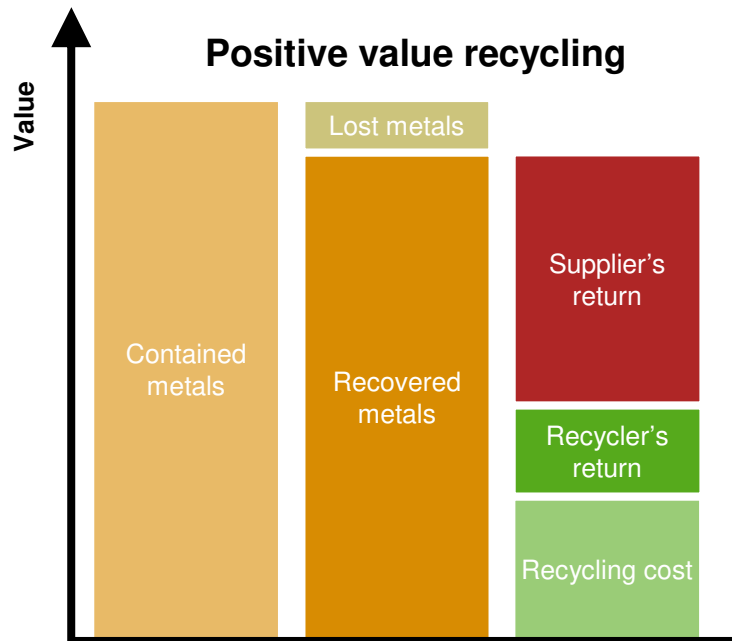
Roadmap

- ✓ *What are critical metals? Why recycling?*
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Economic complexity

Positive vs negative value materials

Production scraps vs End-Of-Life materials



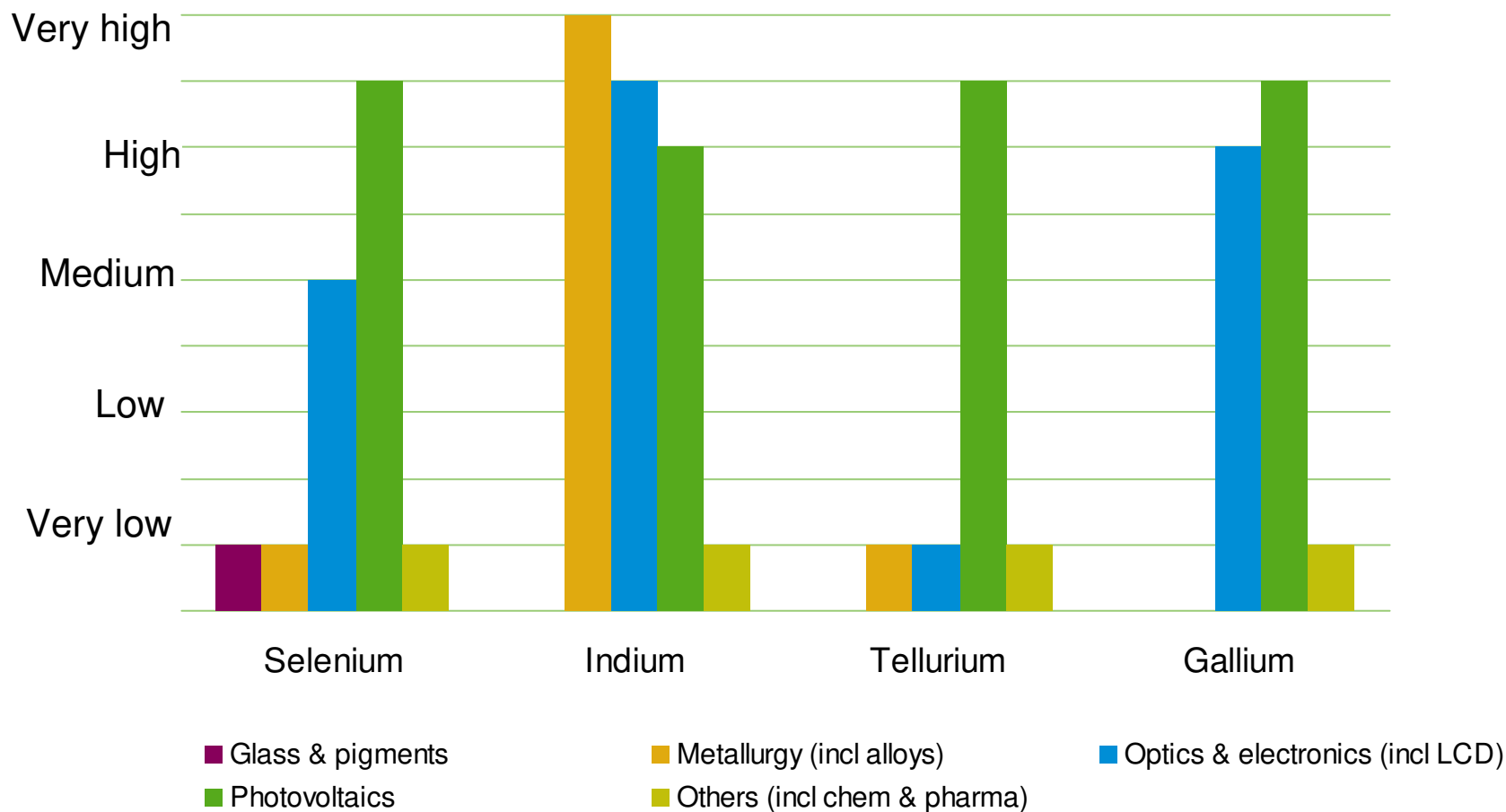
- e-scrap / printed circuit boards
- spent automotive catalysts
- spent industrial catalysts
- spent ITO targets
- CIGS production scraps

The value of the material is sufficient to cover
suppliers return + recyclers return + recycling cost

⇒ no direct need for regulation or incentives

Recycling potential

From production wastes - TODAY

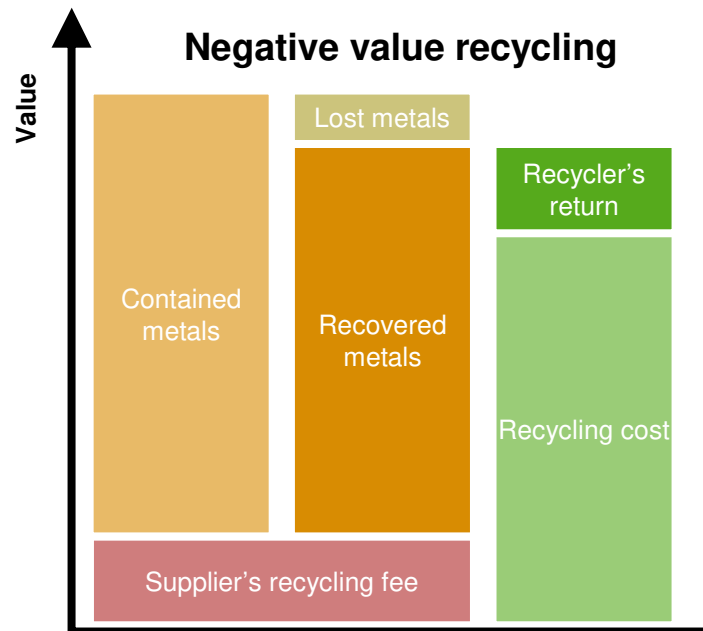


Source: Umicore

Economic complexity (2)

Positive vs negative value materials

Production scraps vs End-Of-Life materials



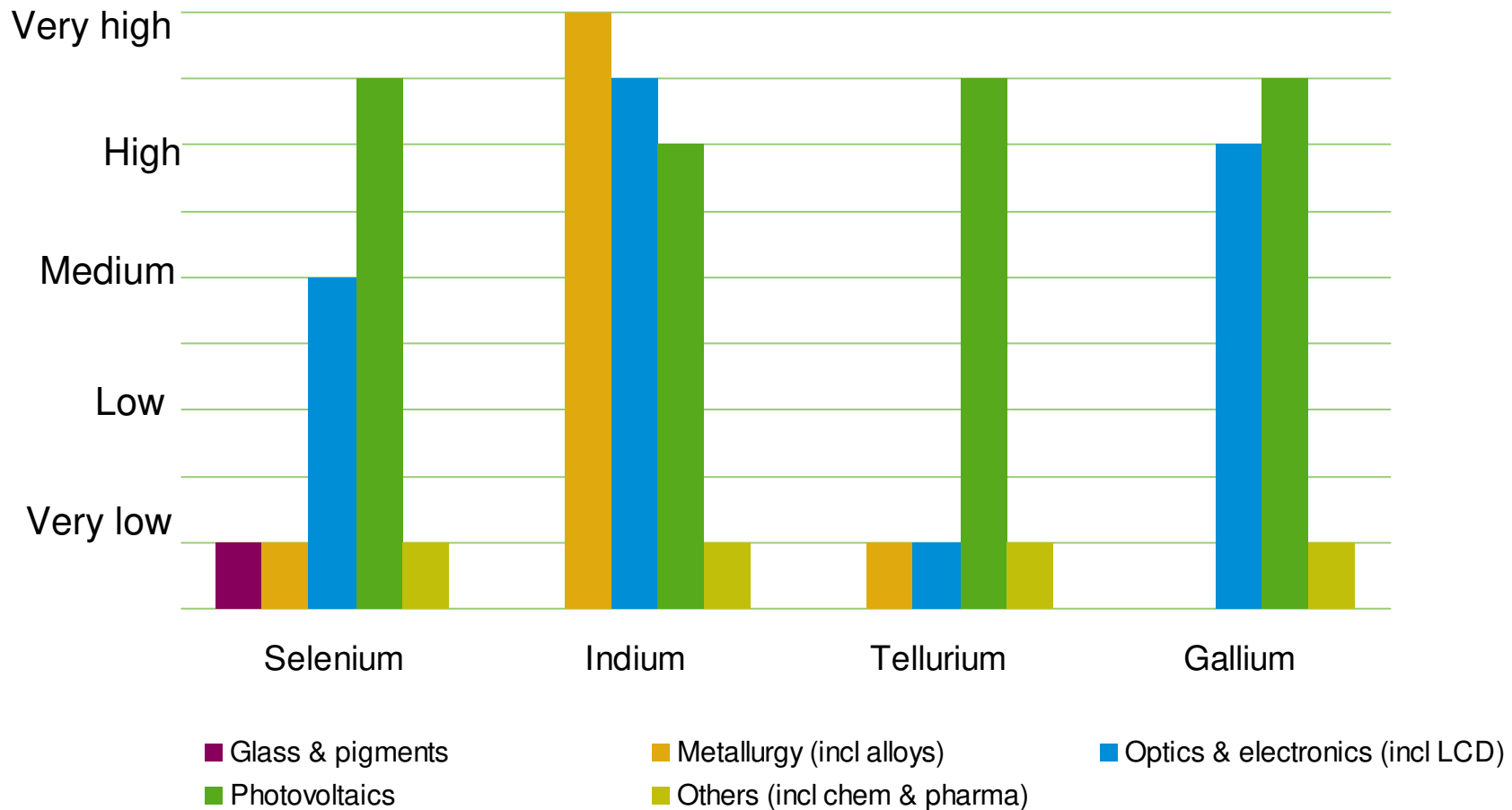
- rechargeable batteries
- LCD displays
- PhotoVoltaic (end-of-life) modules

The value of the material is **not sufficient** to cover suppliers return + recyclers return + recycling cost

➔ financing models, government incentives or legislation is needed

Recycling potential

From End-of-Life wastes – FUTURE



Source: Umicore

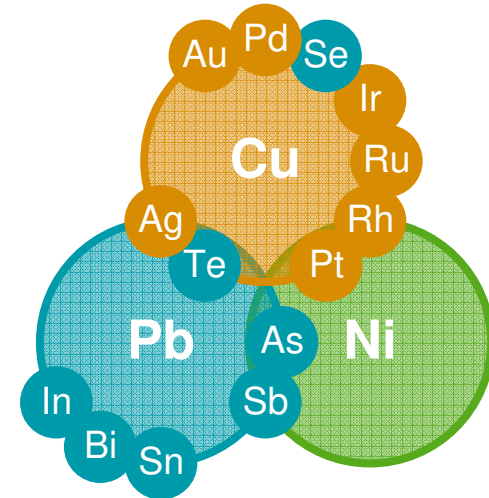
Technological complexity

Multi-metal (complex) materials require:

- State-of-the-art technology;
 - combination pyro-& hydrometallurgy
- Knowledge management (knowhow, IP)
- R&D support;
 - continuous improvement
 - break-through ideas

- Sampling & assaying essential to determine return distribution

- Environmental management excellence;
 - resource efficiency (materials and energy)
 - eco-efficiency



Commercial complexity

- Market intelligence;
 - supply market
 - metals market
 - worldwide sales network in order to secure access to scraps
 - ethical supply
- Credit worthiness important in business where high (metal) values are in the loop
- Control the costs
- Offer a no-worries service (pick-up, customs formalities, metal account)
- EHS support: MSDS, CLP, REACh-compliant
- Auditing



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ITO target recycling

Closed loop recycling of indium in Providence (US)

- Spent ITO targets have a high value, which drives recycling
- Umicore combines production of indium and ITO targets with recycling of spent targets, all in-house
- Old target can easily be swapped for new target via regional centers in US, Taiwan and Liechtenstein
- Indium (as ITO target) quickly enters the life cycle again

➔ Efficient material usage and a closed material loop

CIGS production scrap recycling

New process in Hoboken (BE) [capacity 50 t/y]

- Umicore has closed the cycle for production wastes from sputtering and evaporation chambers
- Convert hazardous waste into valuable materials
- Cu, In, Ga and Se are recovered for use in the PV or other industries
- Business model:
 - Customer pays a treatment charge for the recycling service
 - Metals return is based on sampling and assaying of the production scrap
 - The customer may remain owner of the metals, so no impact of price fluctuations
 - Assistance with waste shipments etc. can be provided



Battery Recycling

New process in Hoboken (BE) [capacity 7,000 t/y]



First ever developed process with a specific focus on the need for rechargeable battery recycling

➔ Li-ion & NiMh

- Unique recycling process with a maximum valorisation of **valuable metals Co & Ni**
- Clean process with minimum energy use, CO₂ and waste generation
- Safe and full service from battery transport to recycling, all complying with the strictest regulations

First industrial pilot plant under construction, to be commissioned mid 2011

- Future volume of this business is driven by the merging electrification of transport



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Closing remarks

- Present and expected future growth of the clean tech & high tech industry will place strong demand on specific “critical” materials that leads to a debate on their respective future availability
- Recycling of production scraps (today) and End-of-Life modules (future) can make significant contributions to ensuring a secure metals supply
- This recycling potential is found in currently minor applications, with high CAGR creating future material resources
- Umicore operates appropriate technologies for efficient and environmentally sound recycling of production scraps
- Effective recycling goes beyond technology aspects.



Thank you

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