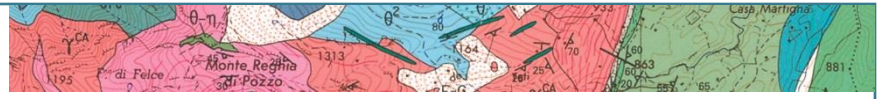

Mineral raw materials: sustainability issues for the XXIst century

European Geosciences Union
General Assembly 2015
GIFT Workshop

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Presentation outline

1. The modern metals and minerals boom
2. Demand drivers
3. The transition towards a circular economy
4. Conclusions

1 – THE MODERN METALS AND MINERALS BOOM

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Early XXth century: only a few elements were routinely used at industrial scale

H																He
Li	Be										B	C	N	O	F	Ne
Na	Mg										Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh		Uuo

Lanthanides	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Hm	Er	Tm	Yb	Lu
Actinides	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Routinely used elements

Rarely used elements

Compilation: P. Christmann, BRGM

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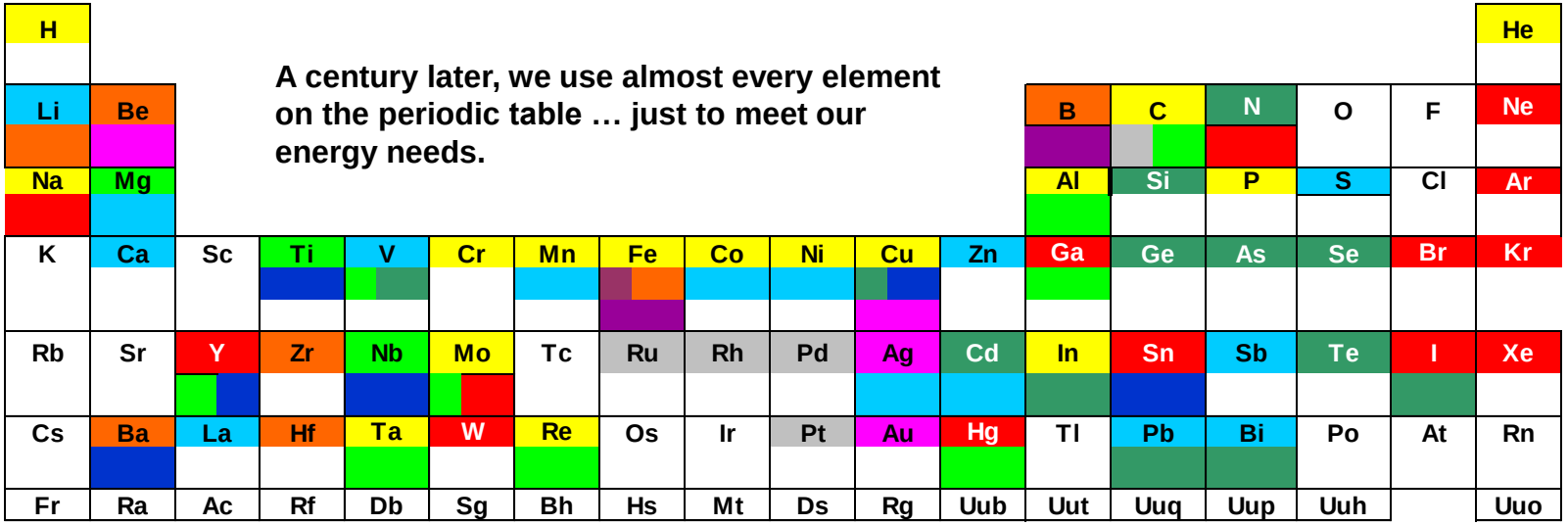
A century later, we use almost every element on the periodic table … just to meet our energy needs.



- Batteries
- Connectivity
- Energy saving
- Catalysis (fuel cells)
- Electricity generation and storage
- Elements specific to nuclear electricity generation
- Photovoltaics
- Permanent magnets for windmills and electrical/ hybrid cars
- Lighting
- Supraconductors

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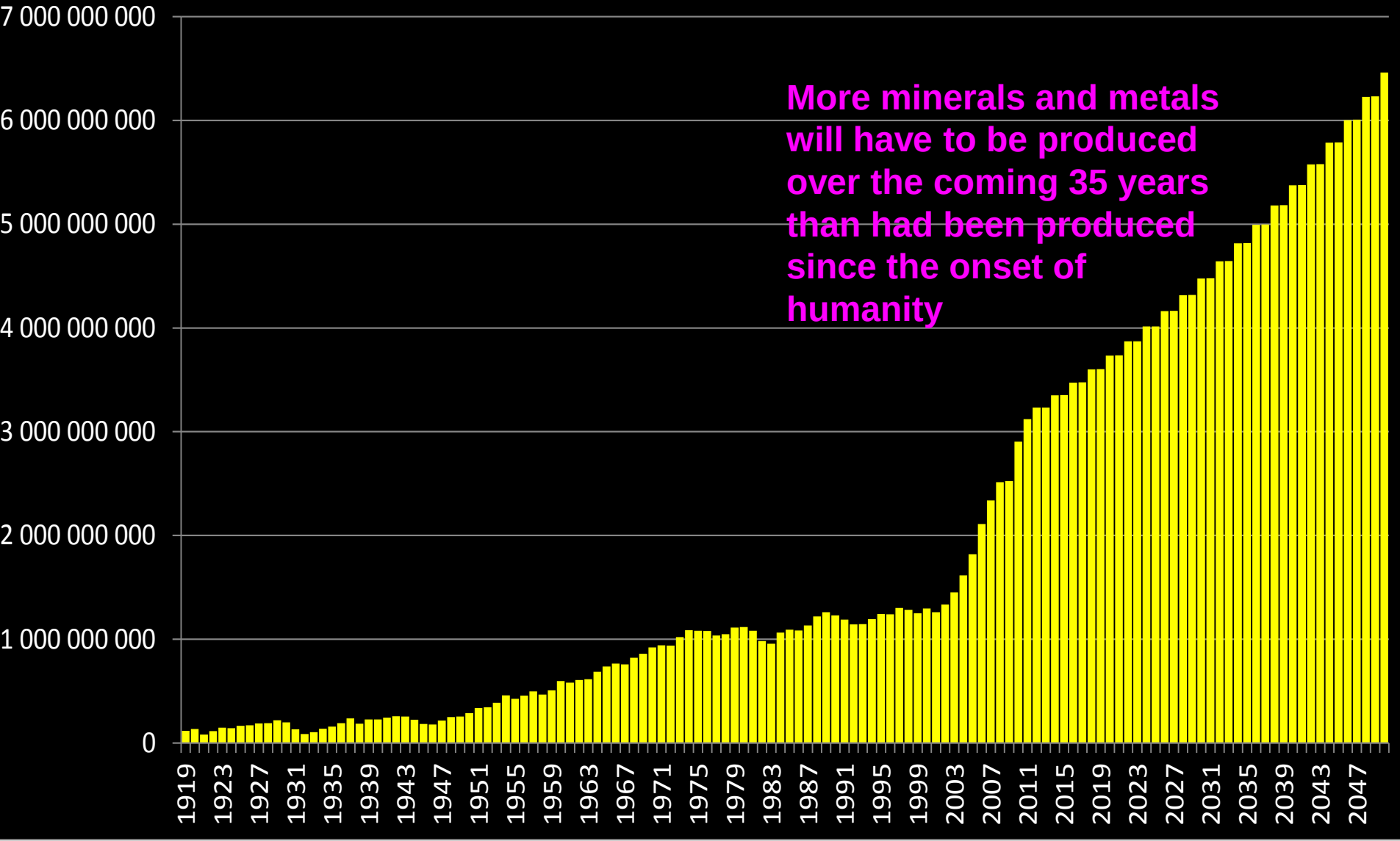
1919-2050 production, in metric tonnes, of 14 mineral raw materials (Al, Au,Ba, Co, Cr, Cu, iron ore, K2O, Mn, Ni, phosphate, Pb, Pt, Zn) - 1919-2010: real growth - 2010-2050: 3.2% CAGR based on the average growth 1981-2010



2 – XXIST CENTURY DEMAND DRIVERS

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An expanding world population means that more minerals and metals will be needed at least up to 2050…

Figure 6. Estimated world population: 1950-2000, and projections: 2000-2300

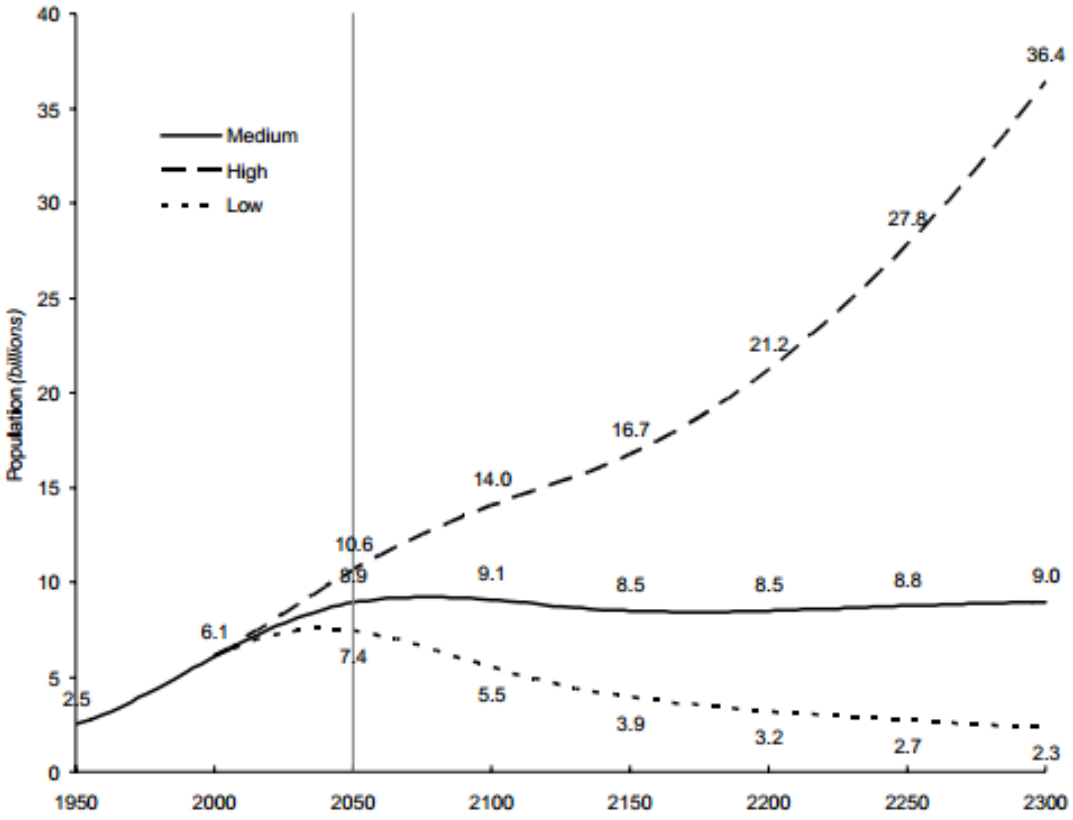

Figure 7. Change in world population over 50-year periods, estimates and three scenarios: 1950-2300

Source: http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf

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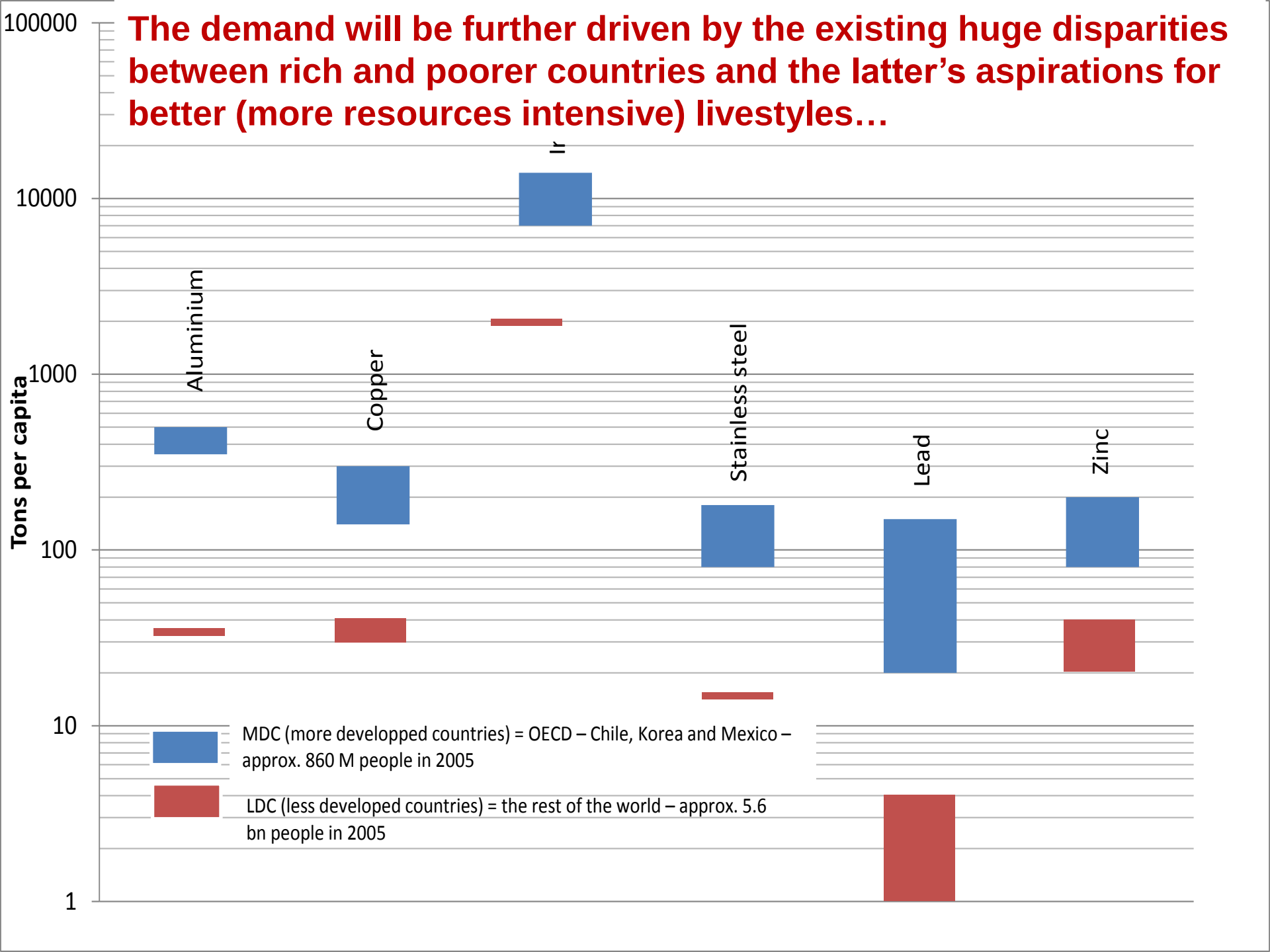
The demand will be further driven by the existing huge disparities between rich and poorer countries and the latter's aspirations for better (more resources intensive) livestyles…



5 billion cellphones, a rich metals resource

(2005 data, source: USGS)

	Per cellphone	Global stock (in t)	Share of the 2009 mine production
Copper	16 g	70 796	0,4 %
Silver	0,35 g	1 549	7,1 %
Gold	0,034 g	150	6,1 %
Palladium	0,015 g	66	34,6%
Platinum	0,00015 g	2	0,8 %

Cellphones also contain aluminium, arsenic, beryllium, bismuth, calcium, carbon, chrome, cobalt, tin, europium, indium, iron, gallium, indium, lithium, neodymium, silicium, tantalum, terbium, yttrium, zinc, …

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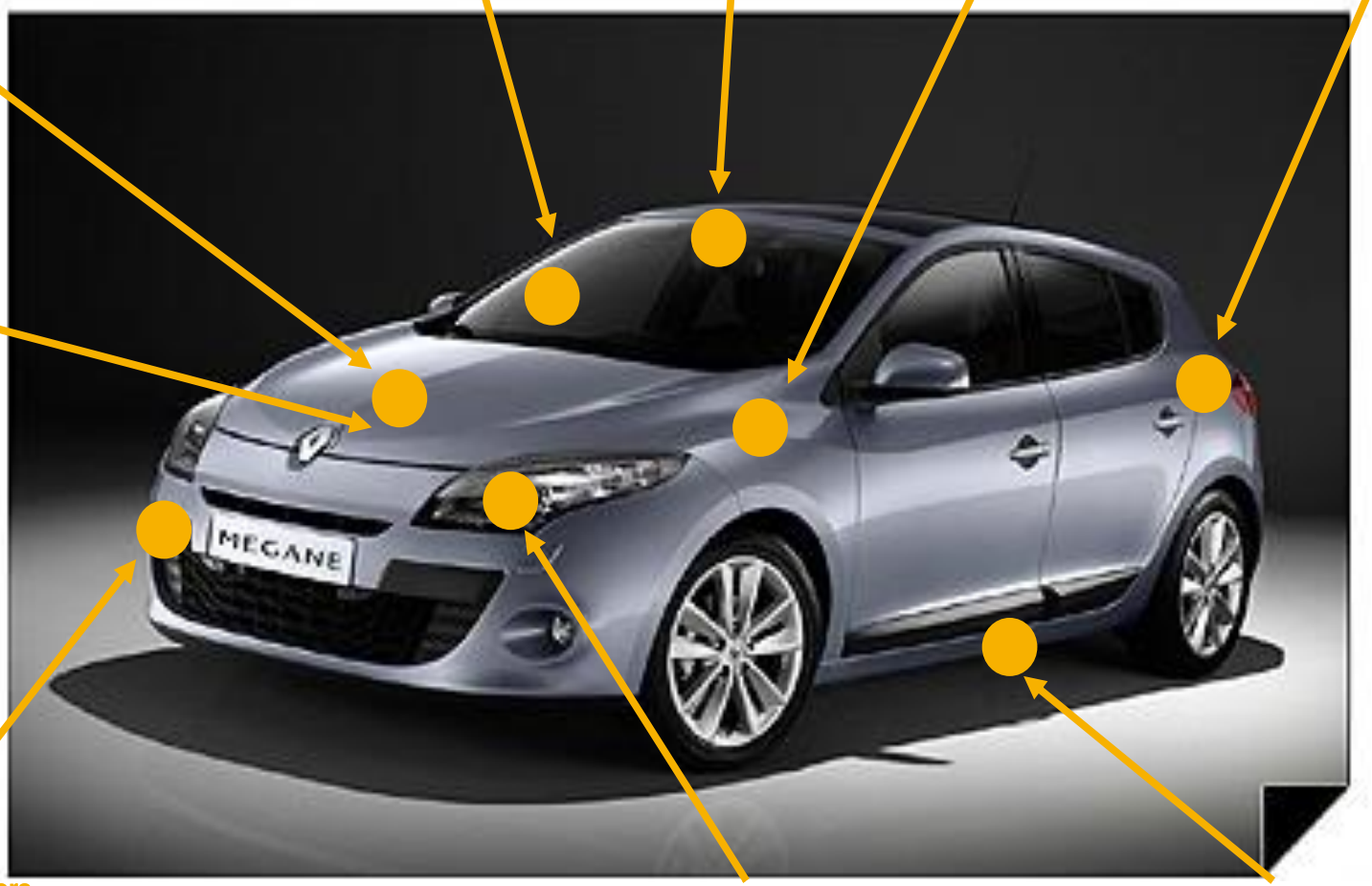
REE use in car manufacturing (By permission of Renault cars)



Engine Sensors

-Yttrium (ceramics)

Ductile cast iron

Cerium,

Lanthanum

+25 Electric Motors Throughout vehicle

-Neodymium Magnets

-Dysprosium

UV cut Glass

-Cerium

Glass and Mirrors polishing powder

-Cerium

Car body primers and anti-corrosive coatings

-Yttrium

Rare Earth phosphors and filters are used in automotive headlights to reduce glare

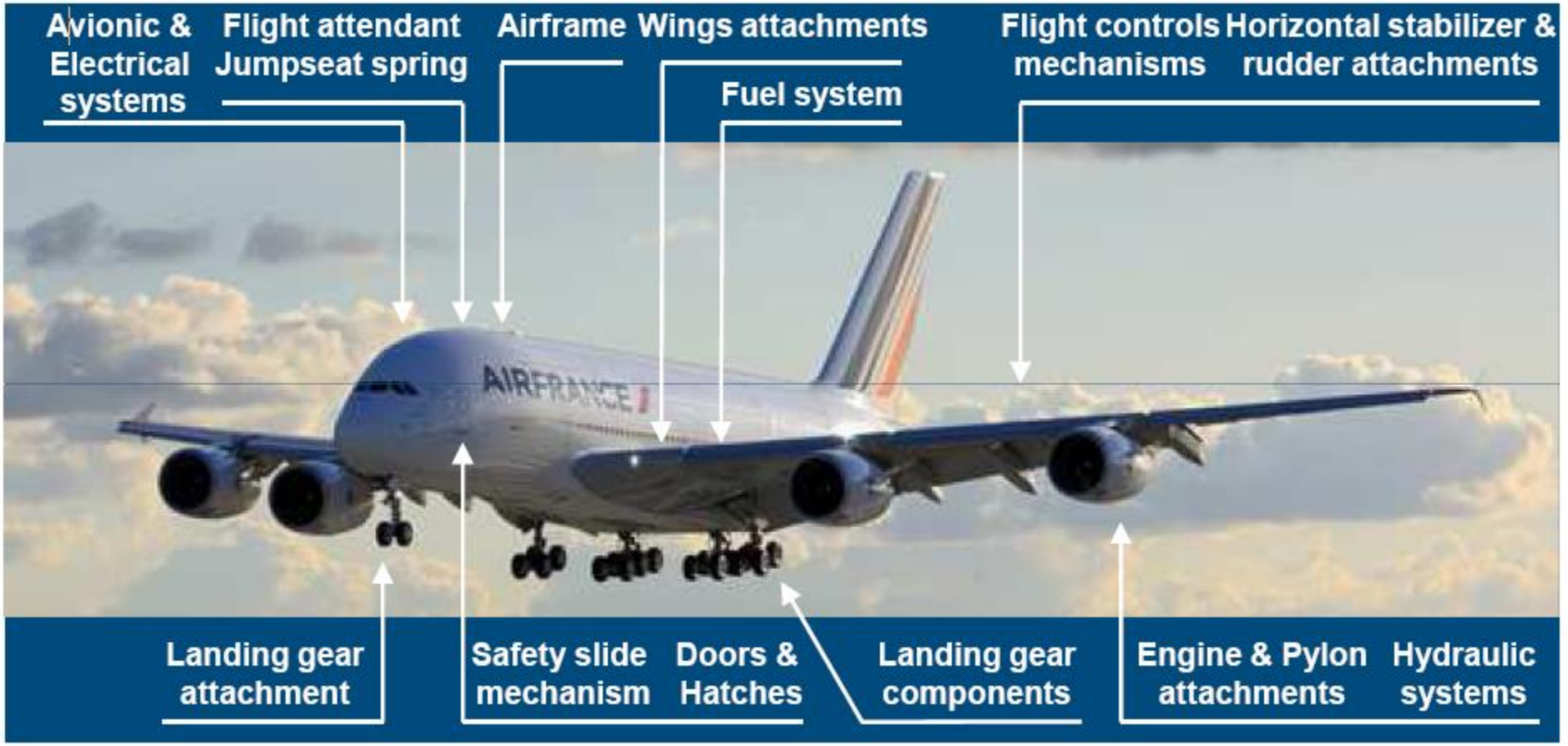
-Neodymium

Catalytic Converter

-Cerium

-Lanthanum

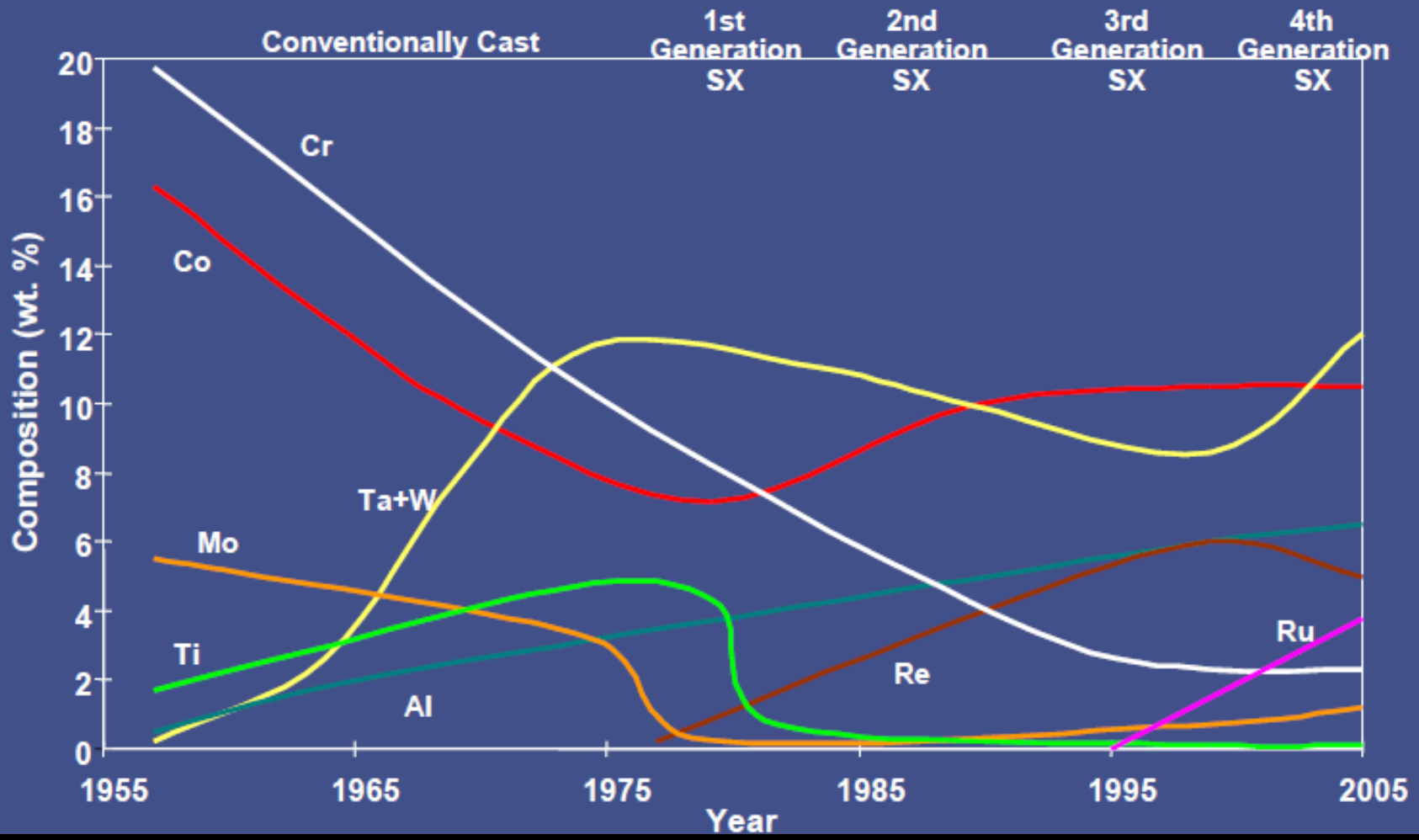
Beryllium uses in modern aircraft



An Airbus A380 uses 530 km of wiring; 40,300 connectors; 2.9 million terminals. Virtually all are made of Cu-Be alloy

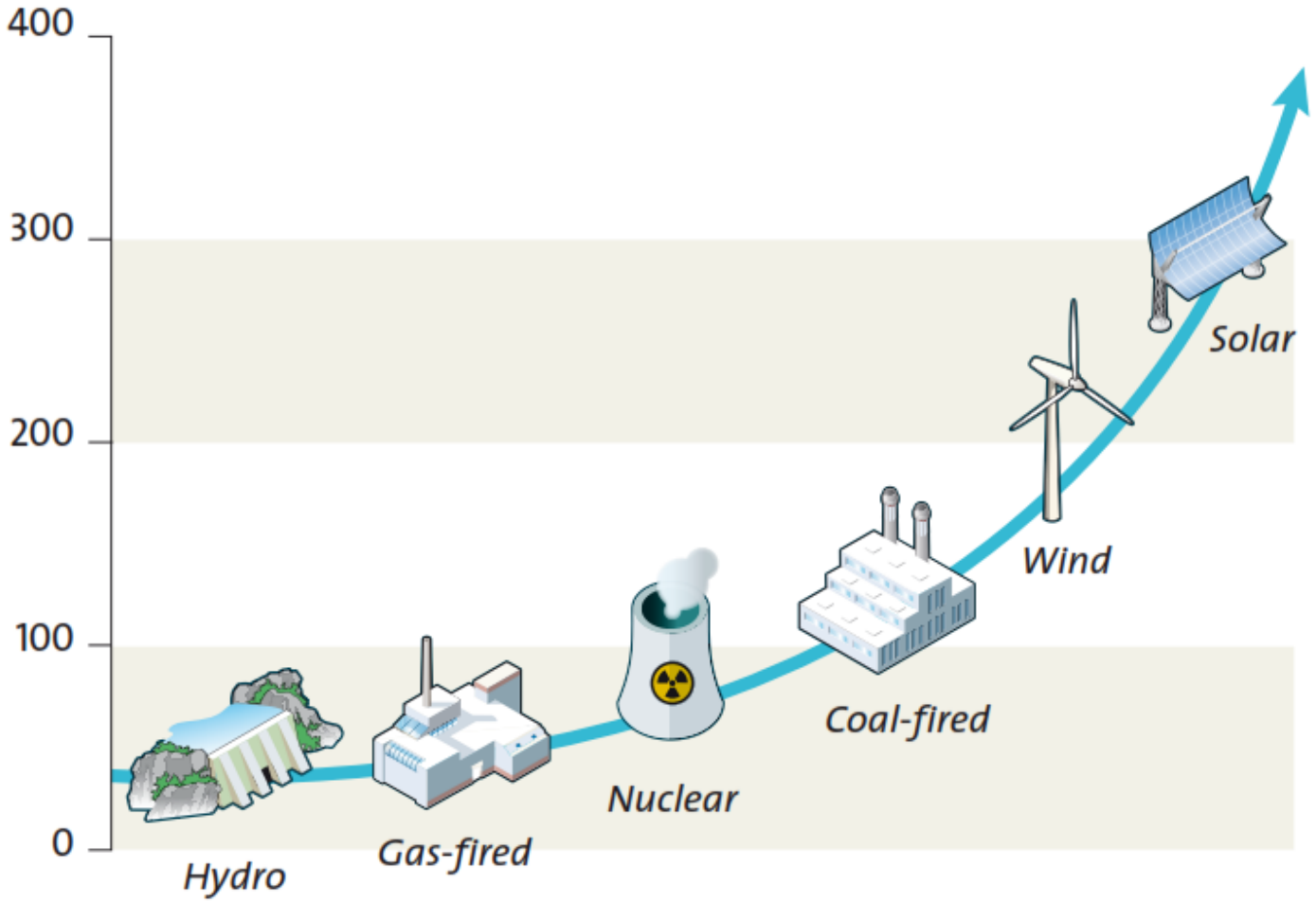
(Courtesy: Beryllium Science & Technology Association)

Evolution of the superalloy used in the hot part of aircraft turbines – From « MATERIALS CHALLENGES FOR THE AEROSPACE SECTOR" - UK Aerospace, Defence, Security & Space Industries Trade Organisation



Steel intensity of different power generation technologies

Derived from: http://www.riotinto.com/documents/111128_RIo_Tinto_Investor_Seminar_slides.pdf



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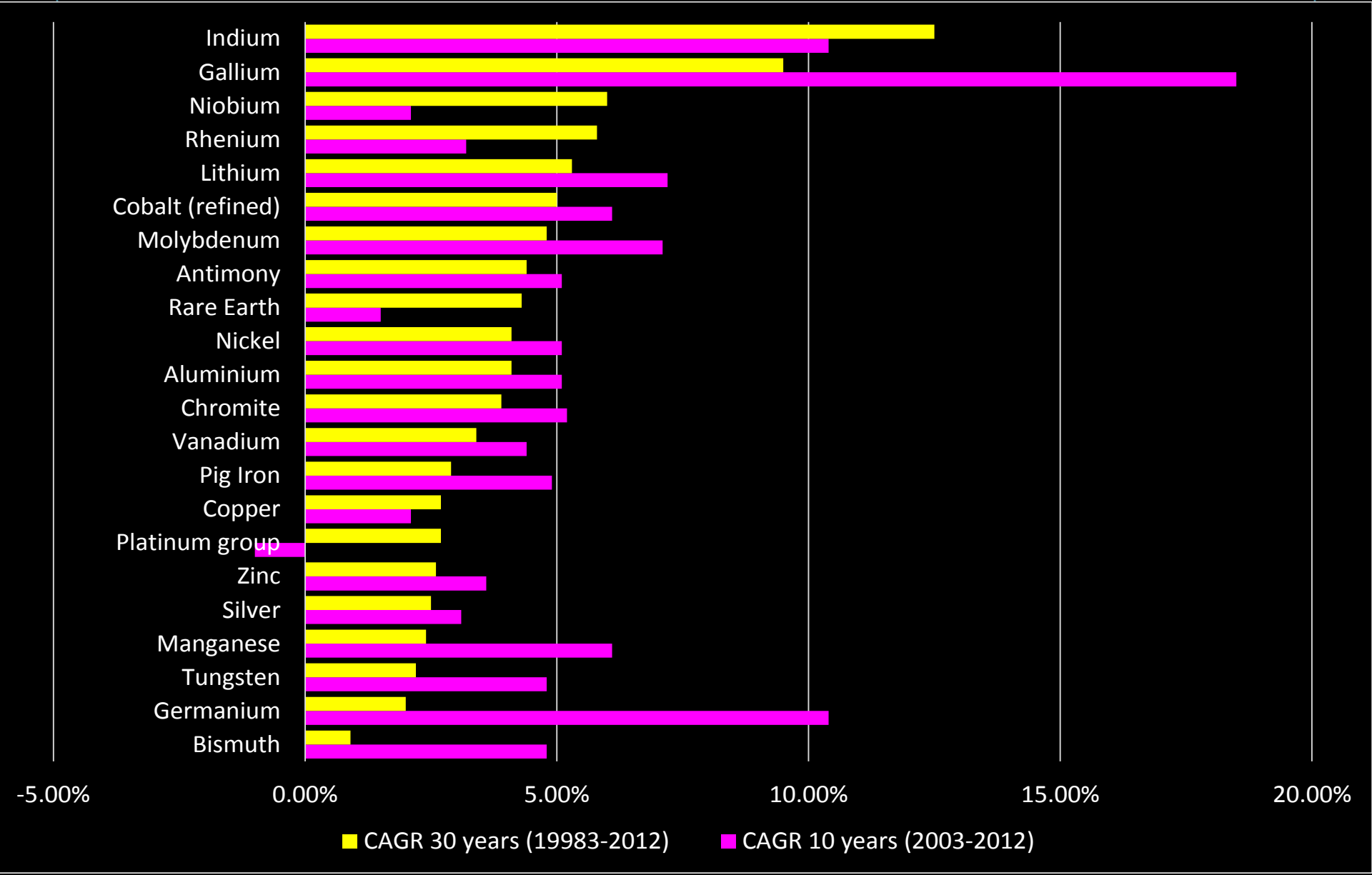
The rapid deployment of many new metals intensive technologies, including « green » or « dematerialised » technologies meant to save energy resources, leads to a very high metals demand compound annual growth rate. There are no signs for a rapid change of these trends.



3 – THE TRANSITION TOWARDS A CIRCULAR ECONOMY

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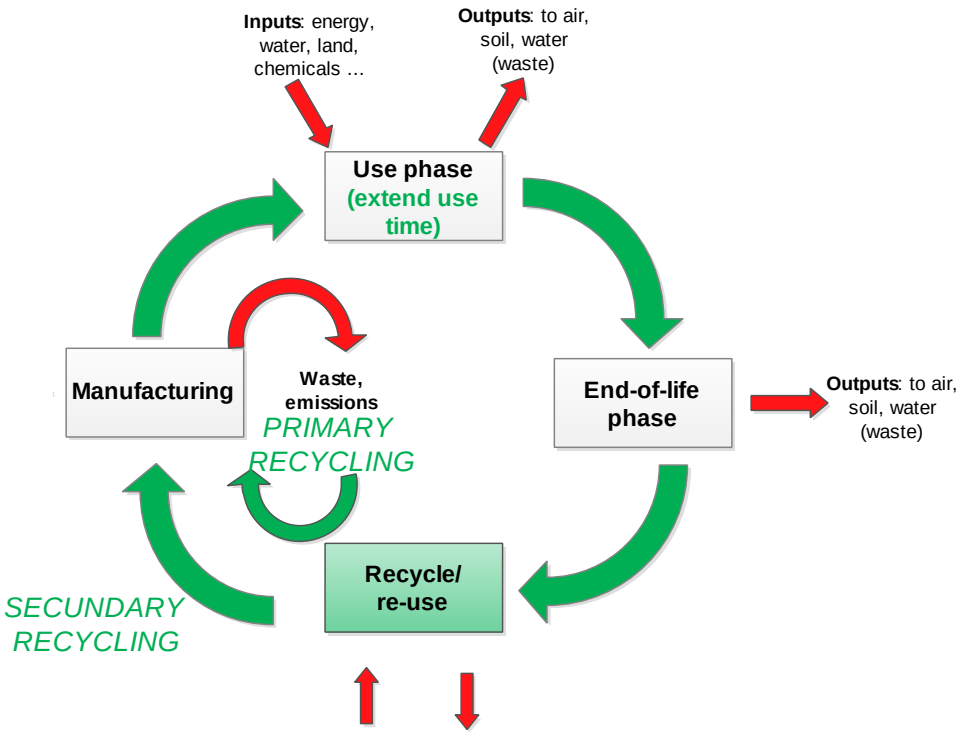
That is the circular economy as we dream about: almost no primary resources needs, limited emissions.

The problem is that while it is highly desirable from a resources conservation perspective, a strictly circular economy just can't exist,



With a growing demography and a shift to ever more resources intensive lifestyles, mineral resources will continue to be needed, and in vast amounts.

HOWEVER THIS LEAVES ROOM FOR MANY POLICY AND TECHNOLOGY DRIVEN ACTIONS TOWARDS A MORE CIRCULAR ECONOMY. THE GOLDEN RULE TO GUIDE THINKING AND ACTION IS: NO MORE WASTE, THINK OF WASTE AS A VALUABLE RESOURCE

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RECYCLING RATES FROM END-OF-LIFE PRODUCTS OF MOST OF THE RARE/ MINOR METALS ARE IN THE RANGE OF 1% AND LESS. ALTHOUGH CURRENT R&D ALLOWS MUCH HOPE FOR PROGRESS THIS COULD BE UNDERMINED BY LOW METALS PRICES

Source: UNEP International Resource Panel (UNEP - 2011 - Recycling rates of metals - A Status report. A Report of the Working Group on the Global Metal Flows to the UNEP International Resource Panel - Graedel T.E., Allwood J., Birat J.-P., Reck B.K., Sibley S.F., Sonnemann G., Buchert M., Hagelüken C. - UNEP (Nairobi, Kenya) - http://www.unep.org/resourcepanel/Portals/24102/PDFs/Metals_Recycling_Rates_110412-1.pdf

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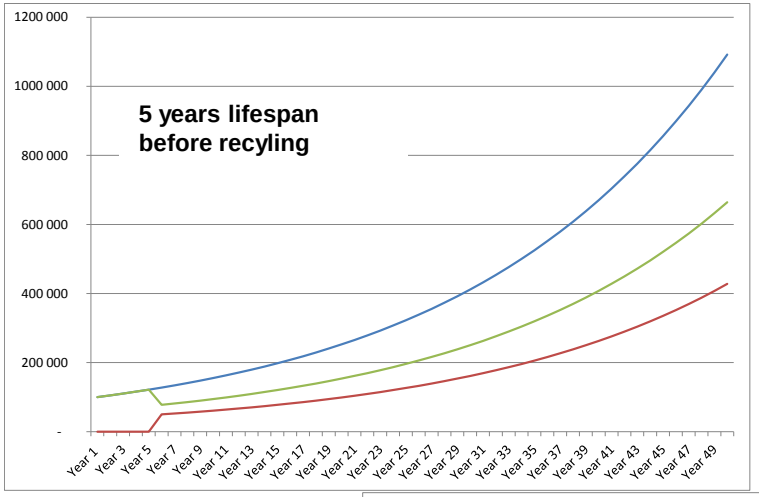
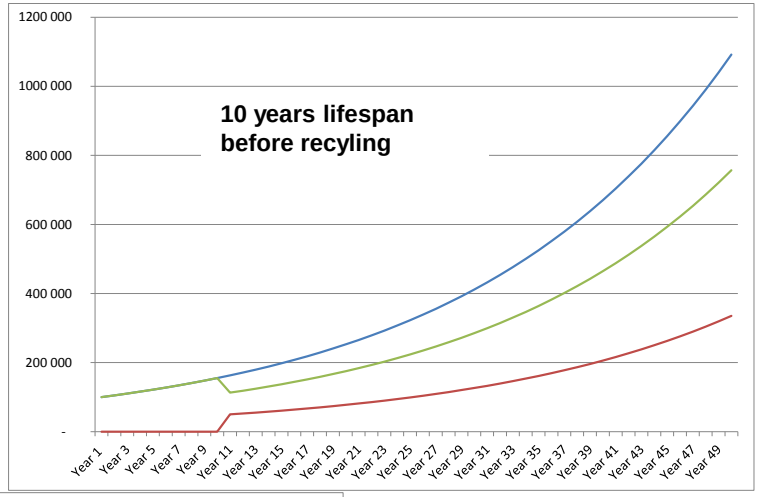
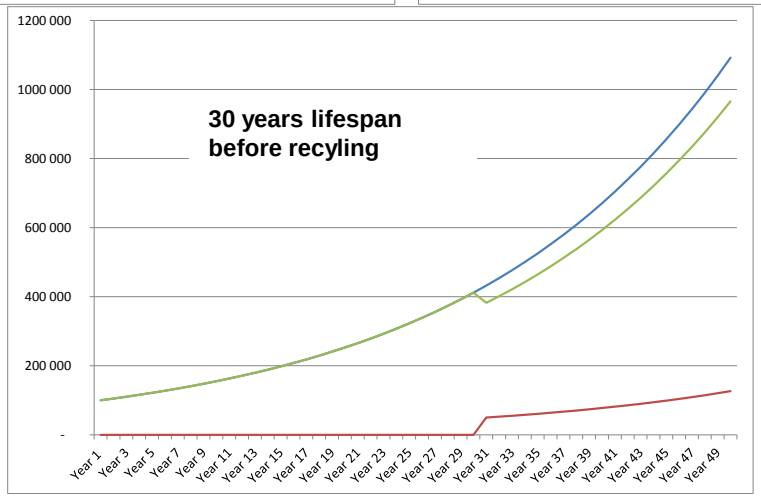
WHILE RECYCLING PROVIDES IMPORTANT SUSTAINABILITY BENEFITS, IT HAS LITTLE IMPACT ON THE FUTURE MINERAL RESOURCES DEMAND AS SHOWN BY EXAMPLES OF RECYCLING, AT A 50% RECYCLING RATE, ON THE DEMAND FOR PRIMARY METAL, COMPUTED FOR 3 DIFFERENT PRODUCT LIFESPANS (5,10, 30 YEARS LIFESPAN)







Demand

Primary production needed

Recycled metal flow

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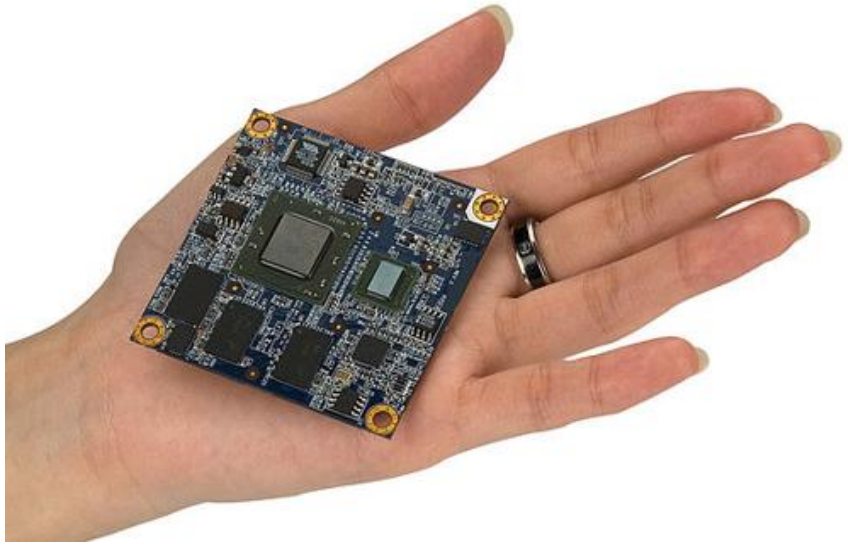
THE COMPLEXITIES OF MAN-MADE PRODUCTS IS FREQUENTLY MUCH HIGHER THAN THE COMPLEXITY OF NATURAL ORES, SETTING ECONOMIC AND TECHNICAL LIMITS TO RECYCLING



A natural ore has relatively simple mineral assemblages, with 1 to 3 minerals of economic importance, comprising 1 to 5+ metals

An electronic motherboard has very complex assemblages with a wide, and very variable range of metallic and organic components, comprising 30+ metals and metalloids, some in very minute amounts.

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4 – CONCLUSIONS

- **Science-based education in natural resources related issues, sustainable use and management from the youngest age is a key towards a sustainable future**
- **Research and innovation all along mineral resources dependent supply chains are equally important**
- **Knowledge-based natural resources governance has to be developed at the broad global level, based on transparency and accountability**

4 – SOME INFORMATION AND KNOWLEDGE SOURCES

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- **Visit the European Commission's webpages on the EU Raw Materials Initiative, it links to many documents, such as the 2nd edition of the report on Raw Materials Critical to the EU (2014) nd many EU research projects findings**

- **Visit the UNEP International Resource Panel website with its ever growing range of top level international science based, policy relevant assessments: unep.org/resourcepanel**

- **Watch the movie: « Planet Re:think », released at RIO+20, winner of several international awards: http://planetrethink.com**

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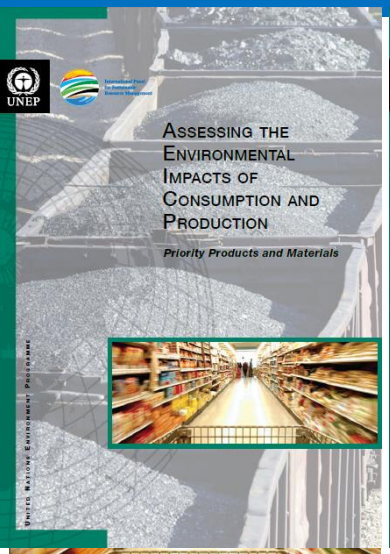
Metals related reports published by the International Resource Panel

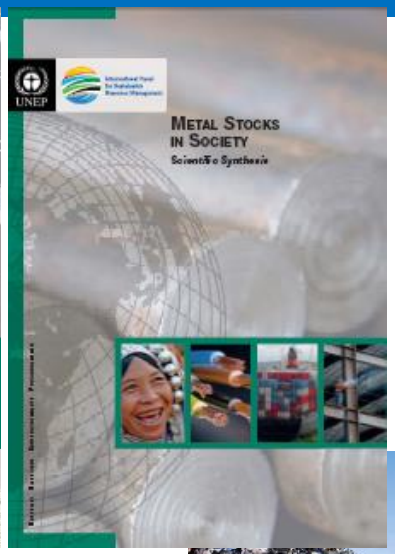
www.unep.org/resourcepanel

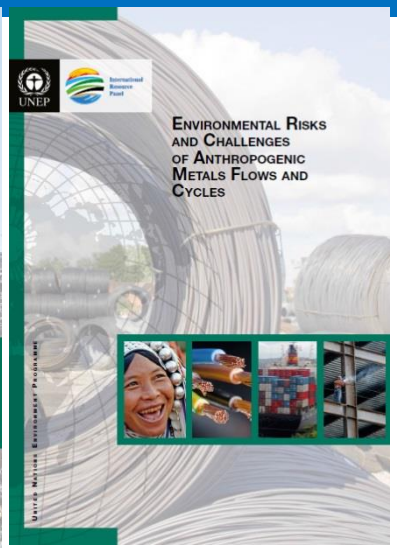
International Panel for Sustainable Resource Management

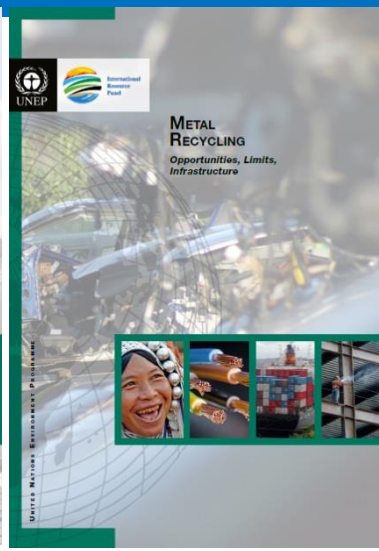
UNEP

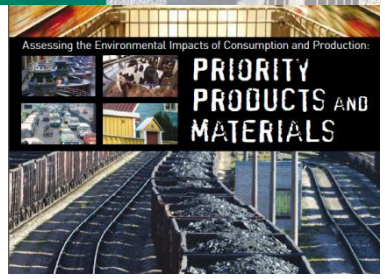
PRIORITY PRODUCTS AND MATERIALS	*METAL STOCKS IN SOCIETY*	*RECYCLING RATES OF METALS*	*ENVIRONMENTAL RISKS OF METALS*	*METALS RECYCLING OPTIONS, LIMITS & INFRASTRUCTURE*











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