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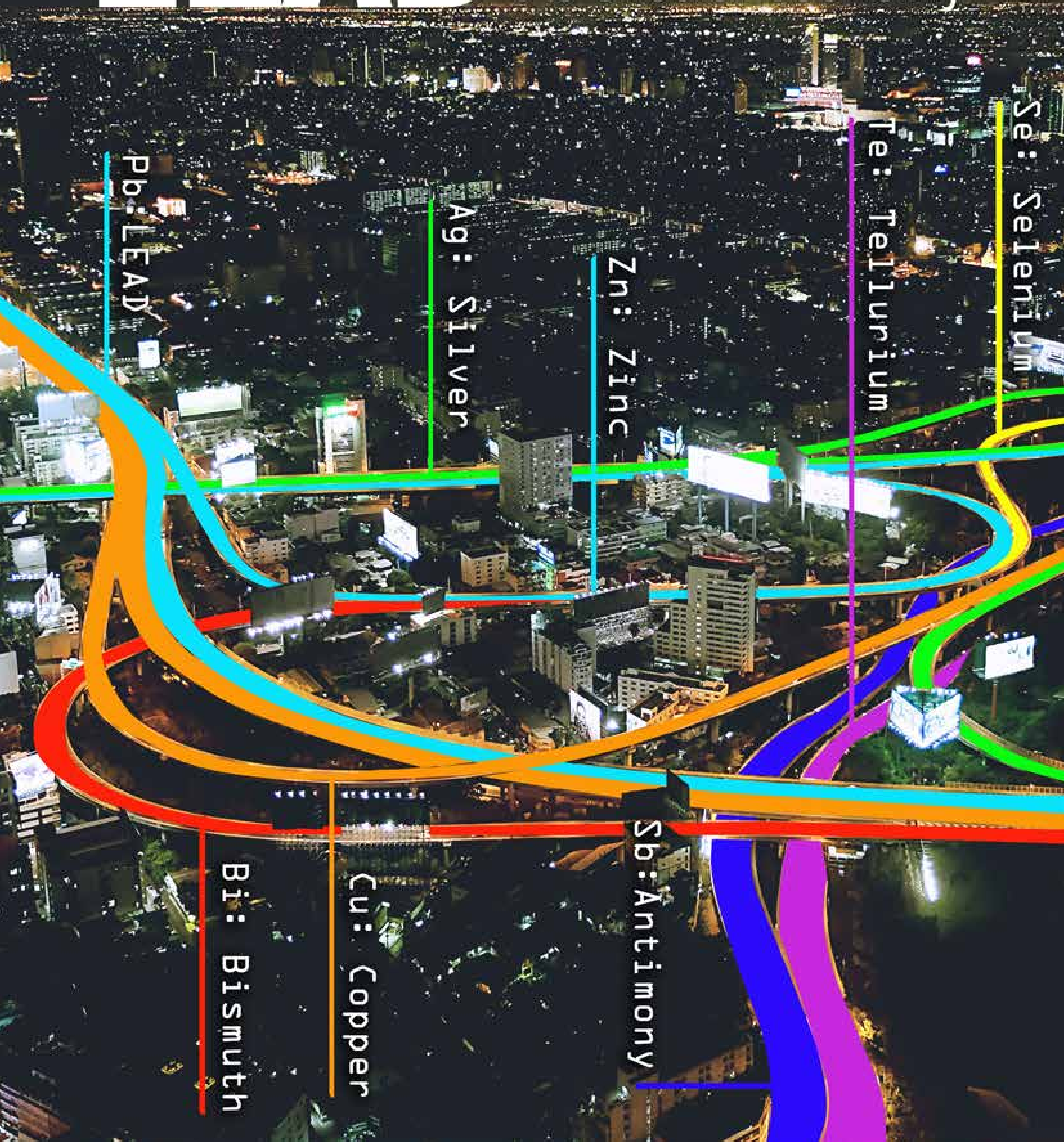
LEAD a key enabler of the circular economy



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Lead: a key enabler of the circular economy

Lead has unique properties that make it very valuable to our current as well as future society. It is integral to sustainability and the circular economy, particularly because of the key role it plays in the metallurgical separation and refining of numerous non-ferrous metals, its critical use in renewable energy storage and hybrid vehicles, and the ease of recycling of lead-based batteries. Lead metallurgy is a "critical infrastructure"; without it, the circular economy for many critical and valuable metals would be significantly diminished.

Lead is an important carrier metal in the non-ferrous metals industry

Lead is associated with many critical and valuable non-ferrous metals in natural orebodies because of its thermodynamic properties. These natural properties also make lead an important carrier metal, meaning that lead can attract, dissolve, and therefore separate these elements from other elements (i.e. impurities). This lead-based separation can occur both in molten metal (pyrometallurgy) or aqueous solution (hydrometallurgy) [Reuter 2015]. For example, "molten lead is an excellent solvent for a variety of metals and compounds including copper, … zinc … arsenic, tin, antimony, bismuth, silver, gold, PGMs, and occasionally nickel, cobalt, tellurium" [Sutherland 2005]. Indium and germanium, which originate from zinc ores, can also be recovered from secondary sources though lead pyrometallurgy.

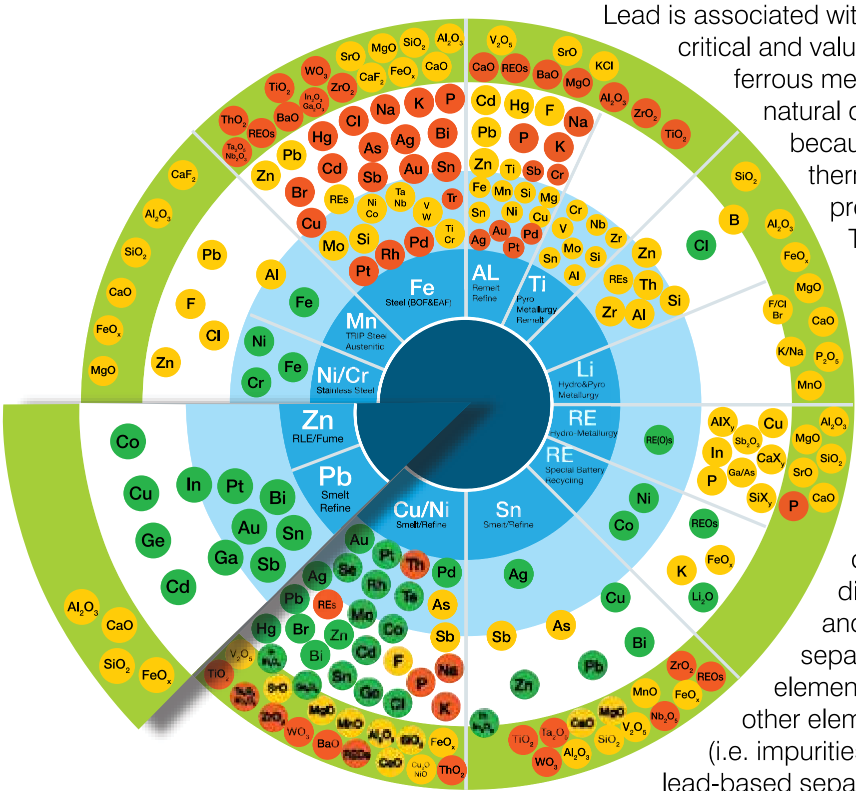

Figure 1: Metal wheel illustrating carrier function of base metals. The base metals are shown in the dark blue ring, and the metals for which they can act as carrier metal (chemical symbols in green circles) are mentioned in the corresponding pie slice (segment). The light blue band contains elements that dissolve in the carrier metal when in metallic form, and white band denotes compounds of the metal *(Figure taken from UNEP (2013) Metal Recycling: Opportunities, Limits, Infrastructure).*

The "Metal Wheel" (UNEP 2013), based on primary metallurgy but equally valid for metals recycling, reflects the destination of different elements in base-carrier metal minerals as a function of interlinked metallurgical process technology.

The use of lead as a carrier metal enables high-tech recycling in the EU

The increasing complexity of consumer products require an industrial network of metallurgical production to maximize recovery of all elements in end-of-life products. The carrier metal properties of lead make the use of lead metallurgy an efficient and effective way to recycle a broad range of non-ferrous metals. For this reason, many of the large-scale complex metallurgical plants in the EU and elsewhere employ lead metallurgy to at least some extent. These plants serve as the end of the recycling chain for complex metal-based materials such as circuit boards, ELV / WEEE mixed metal scrap, catalysts, incineration bottom ashes, various industrial residues/ intermediates and more. For them, lead metallurgy is a key facilitator in converting complex secondary raw materials into refined metals for a new life cycle. The loss of lead metallurgy in the EU would result in a less efficient and less competitive recycling industry for these complex materials, with the very real threat that these materials would then be landfilled or exported for recycling. Not only could this have an overall negative environmental impact, but it could also harm the EU's position as a global leader in recycling.

Lead provides a critical source of metals that are sustainability-enabling but have low recycling rates

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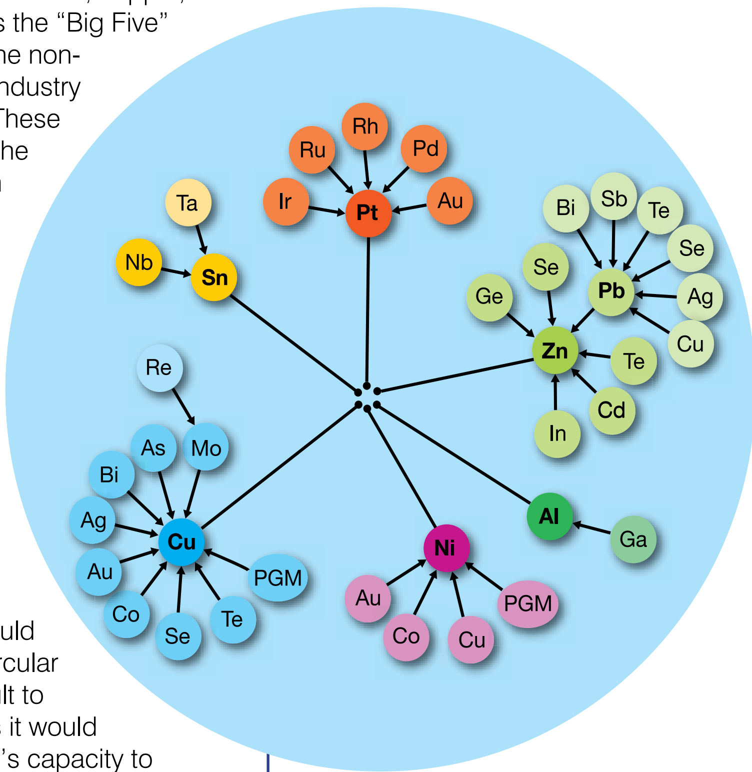
The growth in technological innovation that has occurred over the past decades has, in part, been possible because an increasing number of metals of the periodic table are used to perform specialized functions. However, many of these metals are recovered only as by-products during the production of one or more carrier (host metals) as they are contained in ore bodies or complex end-of-life products as accompanying elements of the carrier metals, usually at low concentrations (Nassar, Graedel 2015).

Not all metals are created equal in terms of recyclability. Some metals are used largely in dispersive applications (e.g. bismuth in pigments and pharmaceuticals), while others are used in far too low concentrations to be economical for recycling (e.g. indium in LCD screens). In these situations, a reliable source of primary metals is required to supply a high-tech, modern economy. Many of these recycling-challenged metals are key functional materials in sustainability-enabling applications such as renewable energy, electric vehicles, energy-efficient electronics and more. As many of these metals are associated with lead in natural orebodies, they are only available in significant quantities through lead primary raw materials. Bismuth is a particularly stark example, in that there are no dedicated bismuth mines and nearly all bismuth mined outside of China comes from lead-based ores [Willis 2012]. As seen in the diagram below, the key metals associated with lead primary production are zinc, bismuth, antimony, tellurium, selenium, silver and copper, plus cadmium, indium and germanium via zinc ores. Decrease of lead mining and production over time has the potential to imperil supplies of antimony and bismuth, for which lead is the main host (Nassar, Graedel 2015). The loss of lead metallurgy in the EU would have a significant impact on the EU supply and production of sustainability-enabling metals which are rare or have limited dedicated production infrastructure and yet are vital for the progress of our society and the competitiveness of our economy.

Lead is part of the critical metallurgical infrastructure of the EU economy

Elements never occur alone in nature nor in products, and thermodynamic interactions during their processing are complicated. Policy should thus pay particular attention to the complete infrastructure. The consideration of lead (or other metals) in isolation by policymakers can lead to erroneous conclusions and significant unintended consequences. The role of lead as both carrier metal and key supplier of critical and valuable metals warrant the inclusion of lead metallurgy as a "critical infrastructure" of the EU circular economy. In fact, lead should be seen alongside zinc, copper, nickel and tin as the "Big Five" at the heart of the non-ferrous metals industry [Reuter 2015]. These five metals are the carrier metals in both primary production and recycling for many of the critical and valuable metals needed for today's sustainable technologies. The loss of any of these metallurgies would make the EU circular economy difficult to realize in full, as it would diminish the EU's capacity to recycle complex materials as well as supply metals to its industry using its own sources. A healthy circular economy for the EU is built upon the foundation of an advanced metallurgical infrastructure, of which lead metallurgy is a critical component.



Based on a diagram in the Strüngmann Forum Report, Linkages of Sustainability (2010)

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