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## Raw materials (CRM/SRM) supply from waste recycling and landfill mining: interdisciplinary approach to exploit resources from extractive waste facilities

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The acceleration in deployment of the key low carbon technologies in the wind, solar, and energy storage areas has real implications for the commodities market, not only rare earths, such as indium and neodymium. Aluminum, copper, silver, bauxite, iron, lead, and others all stand to potentially benefit from a strong shift to low carbon technologies. It would be reasonable to expect that all low carbon energy systems are more likely than not to be more metal intensive than high-carbon systems. All literature examining material and metals implications for supplying clean technologies agree that building these technologies will result in considerably more material-intensive demand than would traditional fossil fuel mechanisms. At present the minerals/materials considered “critical” (Critical Raw Materials – CRM) for EU economy are mainly constituted by rare earth metals, base and precious metals. The supply of CRM is highly connected to international politics and global market conditions; most of them are exploited in countries other than EU ones, causing high economic dependence from non-EU countries.

RM and CRM are principally extracted from natural resources, urban and industrial landfill sites, and extractive waste facilities. To evaluate the potentially exploitable quantity and typologies of RM/CRM and secondary raw materials (SRM), standardized protocols, including waste characterization and waste volume potentially exploitable are needed. Further to this, and together with environmental and human health aspects, the economic and societal aspects need to be integrated and therefore common cost benefit analysis (CBA) and life cycle assessment (LCA) methodologies should be also used. A more sustainable and integrated approach in the management of extractive industry at large, also thanks to proper Guidelines, is needed to boost the waste recycling. Some tools, as the sustainable finance, can be applied to encourage industries to be more responsible.

Fundamental is the interaction within Research Centers, Academies, Industries and Public Administrations in researching innovative and newer solutions for waste recycling (in terms of new technologies and products) and in guaranteeing the application at a wider scale of the products, objects of patents and already tested, not already present in the global market. In many cases, the possibility to re-use SRM from mining waste is invalidate from landscape constraints or bans on

protected areas; to move these limits, it's necessary working harmonically with Public Administrations and Mining Companies in order to show them the results of materials recovered in terms of LCA, if compared to mining. The typical objection from "stakeholders" is to consider the removing operations too much invasive on territory, but this belief could be debunked with a correct, agreed approach of the project; good solutions of environmental recovery should be found after exploitation, also to solve safety and pollution problems and return the site in better condition. For these reasons, we consider to give priority to the case-histories which represent a real or potential risk (for production, of stability, hydrogeological, chemical, etc.), but in perspective mostly a precious resource.

The present research investigates the chance to guarantee a more sustainable mining in selected Italian case studies.