Assessing critical materials demand in global energy transition scenarios based on the Dynamic Extraction and Recycling Input-Output framework (DYNERIO)

Topic: Energy Input-Output Modeling II (Chair: Lorenzo Rinaldi, Politecnico di Milano)
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The energy transition process calls for striving interventions at global level towards the switch to low-carbon and green technologies. Such technologies surely impact positively in the direction of reducing the greenhouse gases emissions; however, their massive deployment brings along intense raw materials exploitation. Some of these materials have already been classified as critical due to their scarce availability: their crucial geopolitical role is then becoming more and more relevant, resulting in several attempts of quantifying the materials impact of energy transition scenarios.

While the majority of the analysed studies adopts purely LCA-based methodologies, this article presents a novel hybrid approach to assess the impact of transition pathways on raw material extraction, which includes both LCA-based and energy modelling features. Such approach has been formalized in a modelling framework named Dynamic Extraction and Recycling Input-Output framework (DYNERIO) and it has been integrated in the open-source platform for input-output analyses handling, MARIO (Multi-functional Analysis of Regions through Input-Output), which the authors contributed to develop. DYNERIO is composed by two soft-linked modules: the first module is an environmentally-extended Multi-Regional Input-Output (MRIO) model, which allows for economic and environmental shock modelling and impact assessment; the second module consists of a linear programming optimization energy model, dedicated to the assessment of regional extraction and recycling of critical materials based on the results of the MRIO model.
Beside the standard environmental and economic impact indicators, such as GDP and CO2 emissions, DYNERIO returns the yearly operating and disposed capacities for energy technologies required to meet the production of exogenously defined final energy services, and the consequent raw materials extraction and recycling.

A simplified case study, based on the Exiobase hybrid-units database (version 3.3.18), is then proposed to demonstrate the framework capabilities. In such case-study, the 2050 energy transition strategy of European Union is analysed, by implementing a set of European announced policies as a technological perturbation in the MRIO module and evaluating their implications in terms of raw material dependence.