MICAT
Multiple Impacts Calculation Tool

Empirical Basis of Environmental Impacts Savings on material resources

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000132.

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The Material Footprint (MF) is an aggregated indicator of raw material savings from the extraction of fossil fuels, minerals, metal ores, biotic materials as well as the extraction of materials that are not put to an economic use (unused extraction). In MICAT, the MF represents the differences (usually savings) in removing material resources from nature before and after energy-efficiency measures take effect (pre- and post-action). In some cases, the scope of the indicator is not limited to direct effects from lower energy demand (use phase) but include effects from changes in technologies (production phase). Although the measures itself can take place on a small spatial scale (e.g., a city) the extractions (or savings thereof) take place on a global scale.

MF and its sub-indicators are expressed in form of intensities (gram of material per functional unit) that are derived from the input data (e.g., mix of energy carriers for electricity) and models (e.g., material demand for producing an electric vehicle). They can usually be multiplied with the marginal changes in the system (e.g., kg of hard coal for heat) and summed up.

The data required for material savings during the use-phase (energy demand pre- and post-action) are usually included in energy efficiency scenarios like PRIMES. By including or adding additional data on the key technologies (usually products) that are necessary to achieve the energy savings, the production phase can also be included in many cases. This requires at least data on changes in product stocks and basic assumptions or technical parameters for the technologies considered (e.g., the type and size of cars exchanged).

As MF is based on bottom-up modelling (similar to life cycle assessment (LCA)) its calculation reflects the status quo or ex-post calculations. If additional data is provided, ex-ante calculations are possible to the extent that databases for life-cycle-inventories allow for it. An example for that would be the integration of future electricity mixes into the use-phase.

For monetization, both direct (embodied) material costs and indirect (external) material costs are suitable approaches. However, they are limited to certain materials (usually metal commodities) and can overlap with investment costs or energy cost savings.

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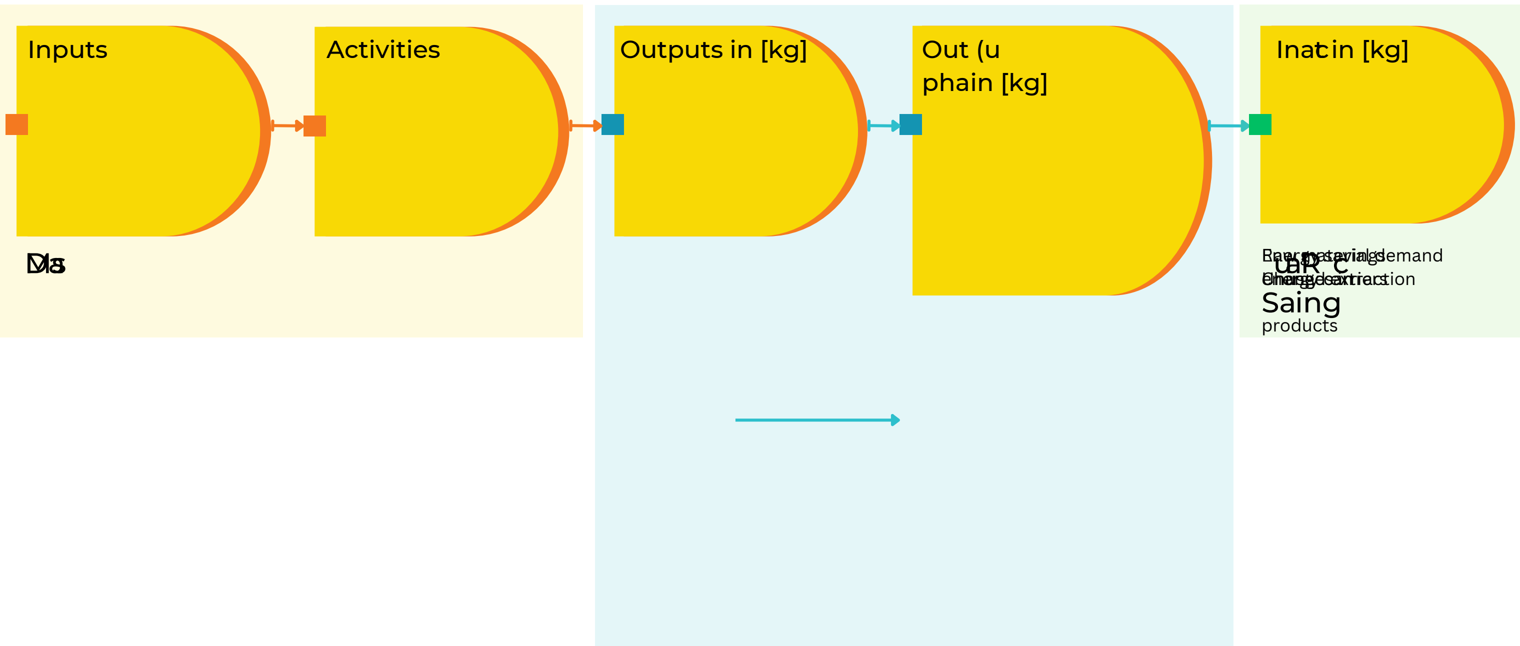

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Description

All sub-indicators (biotic, fossil fuel, metal ore and mineral raw material savings) refer to the raw materials that are extracted or permanently removed from nature from cradle-to-grave (or for MICAT from cradle-to-gate). They are summed up over the entire life cycle and expressed as material intensity in grams of resources per gram of economically used material [g/g]. This includes e.g., the residues of extracted ores but not the overburden from mining which is only included in the so-called unused extraction (UU) and only added to the overall MF.

Although it is possible to quantify MFs with the help of Input-Output Tables (IOTs) (top-down) it usually requires a bottom-up perspective (e.g., material and energy flows in life-cycle inventories). By its nature, raw material demands are very difficult to quantify for the future which is why they can be considered to be results from an ex-post assessment. Certain changes in the surrounding systems can be integrated though that result in changes in the material intensity of services. The most likely use-case for MICAT is to account for the reduced demand of different energy carriers from electricity or heat production but also e.g., changes in the material composition of vehicles from batteries compared to internal combustion machines. The changes in direct energy use are incorporated via **use-phase models** while the changes in product types and product stocks are captured by **production-phase models**.

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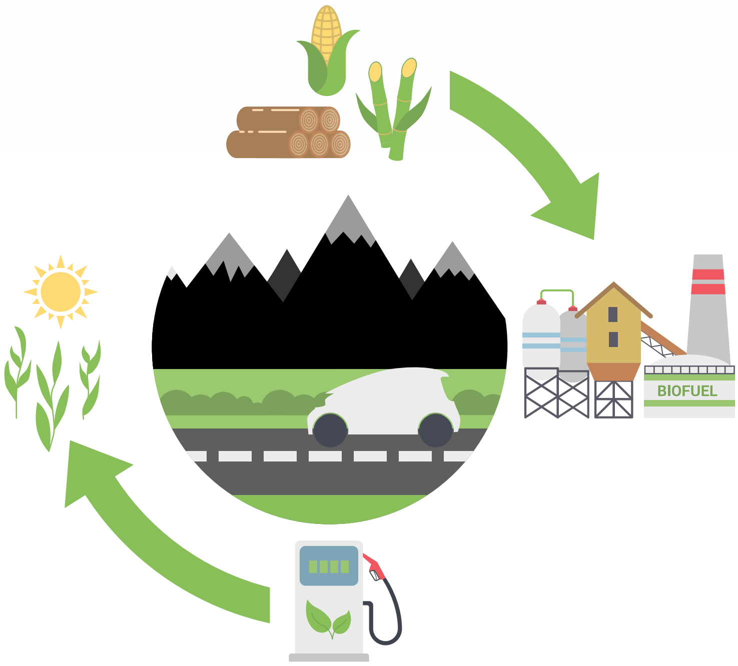
Methodological challenges

Using stock data for a variety of possible current and future products is limited to available life-cycle inventories and their potential matching to product classes in the input data. A number of assumptions are necessary to represent the best-available average, or rather, generic product type. This limitation not only affects the products and their use themselves, but especially the upstream material and energy flows for the provision of materials. For some materials like metals, although a global production is assumed, differences in the material intensity of raw material exporting countries and even between mines can be very high. For local applications in particular, this might not reflect the conditions in a specific case. The existing and further developed models will try to account for that fact by using secondary sources (e.g., EUROSTAT statistics) to identify the most appropriate level of aggregation.



Data requirements

The following data is needed to calculate the MF for the use-phase (resource savings from reduced energy demand) and the production-phase (savings and trade-offs for providing key technologies).

Table 1: Quantification of the indicator aggregated energy security (supply diversity)

All phases	Use phase	Production phase
electricity & heat demand	energy carriers for electricity pre-/post-action	definition of key technologies
changes to energy systems (e.g., new technologies)	energy carriers for heat pre-/post-action	stock of products in base-case/reference scenario
		stock of products post-action/energy efficiency scenario

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