MICAT
Multiple Impacts Calculation Tool

Empirical Basis of Environmental Impacts Reduction in Air Pollution Emissions

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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Executive summary

The reduction in air pollution emissions indicator describes the emissions of primary fine particles (PM2.5), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) saved as a result of energy efficiency measures. Nearly all combustion processes emit the precursor substances in varying amounts and relative importance.

The emissions and emission reductions of these pollutants can be viewed as a proxy for environmental problems caused by the chemical species, including fine particle and ozone pollution in ambient air, as well as resulting physical impacts, such as crop damages, impacts on human health and mortality. The latter two are actually covered in the empirical basis of social impacts. There the focus is on PM2.5 pollution, because the ozone chemistry is more complicated and the relationship between emission reductions and impact reductions is less certain than for PM2.5 and its precursors. Thus, in order to reduce uncertainties in the outcome, we do not include ozone related impacts. It also implies that the benefits of the empirical basis of social impacts tend to be underestimated.

Given that the health and mortality impacts of air pollutants are already covered in the empirical basis of social impacts, the benefits of reducing emissions of air pollutants are not monetized here, in order to avoid double counting.

The emission reductions of air pollutants as a result of implementing energy efficiency measures are calculated analogously to the emission reductions of CO_2. The only difference is that for the air pollutants from many sources, end-of-pipe control technologies and specific emission limits are in place. We use the GAINS model (which is used in the EU for planning new air pollution emission ceilings) for deriving source-specific emission reduction factors, because the GAINS model reflects all existing air pollution-related legislation and thus can realistically assess the actual emission reductions for specific measures.

The data required for this indicator include the effective emission factors by region, sector and carrier (and time) for each pollutant.

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Scope of MI indicator

Definition

Within MICAT, this indicator describes the reduced emissions of primary fine particles (PM2.5), sulfur dioxide (SO2), and nitrogen oxides (NOx) as a result of energy efficiency measures. Nearly all combustion processes emit the precursor substances in varying amounts and relative importance.

Relevance on EU, national and/or local level

Reducing the emissions of air pollutants is a key objective of air quality policies at all governance levels and their relevance is permeating all energy-related policies. However, reducing emissions of air pollutants is only a means to actually reduce the impacts of poor air quality and deposition. Thus, while emission reductions can be used as a proxy for environmental pollution, the actual health impact reductions are assessed in the empirical basis of social impacts. The illustrative impact pathway is given in Figure 1.

Impact pathway

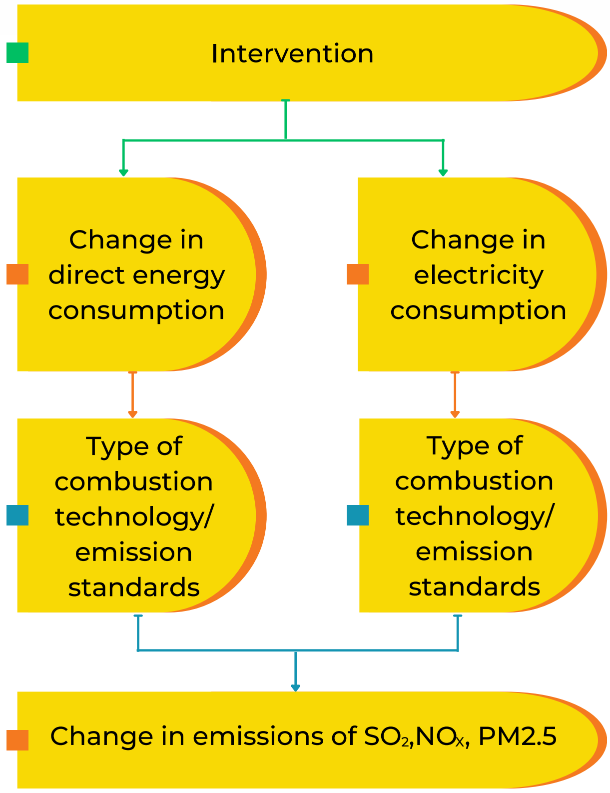

Figure 1 : Impact Pathway from energy savings to air pollution emissions

Overlaps with other MI indicators and potential risk of double-counting

Benefits would be double counted if emission reductions of air pollutants were to be monetized here and added to the health benefits calculated in the empirical basis of social impacts. Therefore no benefits associated with the emission reductions of SO2, NOx, and PM2.5 are quantified here.

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Quantification method

Description

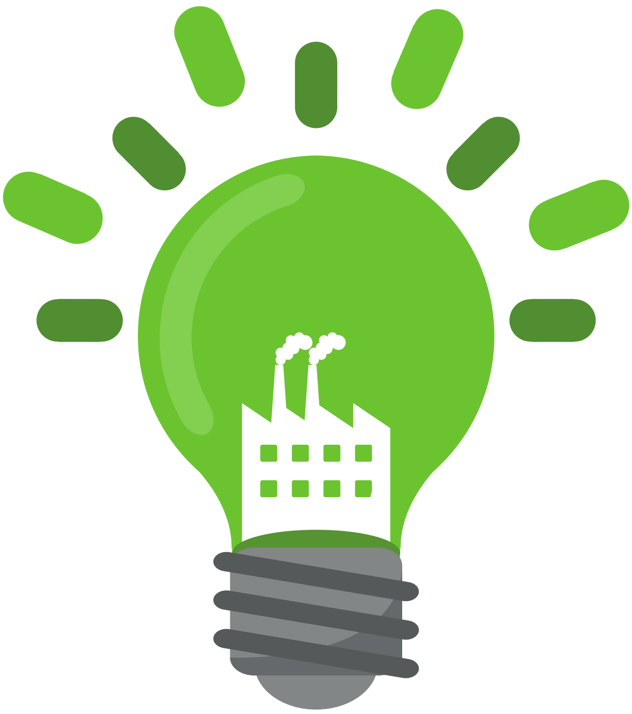
Energy efficiency measures affect air pollutant emissions through the channel described in Figure 1.

1

In a first step, quantify the amount of energy (direct combustion and electricity) saved by an intervention. Such an intervention can affect the direct consumption of fuel as well as the consumption of electricity. For example, heat pumps replace direct combustion, but consume electricity.

2

Secondly, determine the corresponding supply-side changes in the use of technologies. For example, saving electricity would result in less electricity being produced. An assumption needs to be made about what kind of source of electricity is being reduced, whether the most carbon-intensive (coal-based electricity), or an average (country) fuel mix, or else. Moreover, for the emission characteristics further assumptions would need to be made whether, in the case of thermal power plants, whether the cleanest, the dirtiest, or the average device (in terms of air pollutants) are assumed to be reduced. Finally, if the energy efficiency measure reduces direct combustion of fuel, the emission characteristics of that reduction needs to be specified. For example, increasing the energy efficiency of a particular process in the chemical industry may result in all direct fuel uses being reduced proportionally, or may result in only one particular fuel (e.g., gas) being reduced, and again the vintage of the installation may be relevant. The allocation of saved fuels is done using default values representing the average energy mix of the selected improvement action in the relevant subsector or user-defined values.



3

Lastly, calculate the resulting changes in the emissions of air pollutants and precursors by taking into the effective emission factors that are consistent with the respective emission standards and air pollution legislation.

All calculations (e.g., energy saved, emissions) are performed on an annual basis and at the level of individual member states of the EU. These results can easily be aggregated.

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Methodological challenges

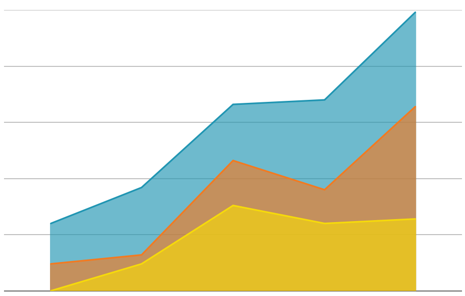
Representative emission factors can be very source-specific. However, the sectoral and energy carrier structure of the MICAT tool is limited. The corresponding resolution is much higher in the GAINS model. In reality, the spectrum of emission factors in a source category are broader.

Specifically, e.g., biomass combustion in the household sector can be associated with very different emission factors, depending on whether the biomass is burned in a fire place, a stove or a pellet boiler. Thus, at the higher aggregation of the MICAT tool, the emission reductions resulting from a concrete intervention can be higher or lower than the average calculated by MICAT.

Data requirements

The analysis is performed with GAINS model [1] which typically uses, for Europe, PRIMES energy system data for analysis of alternative scenarios, though for the assessment of interventions the link to PRIMES is actually not required.

The representative emission factors are available in the GAINS online model and reflect all existing and relevant legislation on emission controls and ambient air quality standards. They cover around 1,000 different emission source categories in each EU member state. From these the representative emission factors for the MICAT tool are aggregated.



Impact factor / functional relationship

The emission reductions of pollutant *p* are calculated as follows:

$$\Delta EM_{i,p,c} = \sum_{s,u,t,e}^{r} EF_{i,s,u,t,e,p} \times \Delta E^{i}_{c,s,u,t,e}$$

The independent variable ΔE^{i}_{c} describes how an intervention *i* in country *c* affects the energy consumption of carrier *e* using technology *t* for end-use in sector *s*. The factor *EF* describes the emission factor relevant for the change in energy consumption *ΔE*.

Strictly speaking, the factors *EF* may depend on scenario assumptions, as they can reflect different fuel mixes, though the calculation can of course be performed fuel by fuel. The main scenario dependence lies in the independent variables ΔE^{i}_{c}, i.e., in the narrative and specification of how an energy saving intervention *i* actually affects the consumption of different fuel uses in different sectors etc.

[1] Amann M, Bertok I, Borken-Kleefeld J, Cofala J, Heyes C, Höglund-Isaksson L, et al. (2011). Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications. Environ Model Softw 2011;26:1489–501. https://doi.org/10.1016/j.envsoft.2011.07.012.

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Monetisation

In order to avoid potential double counting and in the absence of meaningful average impact values for the air pollutants, no monetization is carried out.

Aggregation

Member state data can be aggregated to the EU level and also downscaled to the city level.

Conclusion

This indicator describes the emission reductions of the important air pollutants precursors SO2, NOx, and PM2.5 as a result of energy efficiency measures. The emission reductions serve an indicative proxy for environmental benefits. This indicator however, is not monetized as the actual impacts of air pollutants on human health are quantified already under the empirical basis of social impacts.