MICAT

Multiple Impacts Calculation Tool

Empirical Basis of Social Impacts

Human Health due to Reduced Air Pollution: Air Pollution-Related Mortality and Morbidity

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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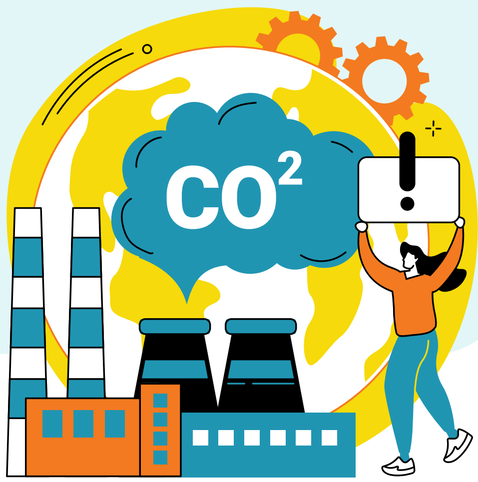
Executive Summary

- Air pollution-related mortality and morbidity
- This indicator measures the impact of energy efficiency measures on mortality and morbidity due to ambient PM2.5 pollution. It takes into account the relevant local air pollutants (SO2, NOx, primary PM2.5) that are typically emitted in energy-related combustion processes.
- For all sectors and subsectors (e.g. power plants, industrial boilers and furnaces, vehicles, etc) the emission factors used reflect all current EU and national policies that regulate emission sources. The impact factors used for the indicator reflect the atmospheric transport and chemical balance as simulated by the EMEP model, a standard chemical transport model used by the European Commission to assess air quality in its member states. The eventual impacts of PM2.5 concentrations on human health (mortality and morbidity) follows a standard methodology and para-metrization developed for the Global Burden of Diseases studies and the World Health Organization. Impacts can be aggregated from national level to EU level, or downscaled to the more local level, though the latter can lead to over- or underestimations.



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Scope of MI indicator

Definition

This indicator measures the impact of energy efficiency measures on mortality and morbidity due to ambient PM2.5 pollution. It takes into account the relevant local air pollutants (SO_2, NO_x, primary PM2.5) that are typically emitted in energy-related combustion processes. For all sectors and subsectors (e.g. power plants, industrial boilers and furnaces, vehicles, etc.) the emission factors used reflect all current EU and national policies that regulate emission sources. The impact factors used for the indicator reflect the atmospheric transport and chemical balance as simulated by the EMEP model, a standard chemical transport model used by the European Commission to assess air quality in its member states. The eventual impacts of PM2.5 concentrations on human health (mortality and morbidity) follows a standard methodology and parametrization developed for the Global Burden of Diseases studies and the World Health Organization.

Relevance on EU, national and/or local level

The benefits from reduced mortality and morbidity via improved air quality can be significant. The EU and its member states pursue various strategies to reduce these impacts. Individual member states benefit most from reducing their own national emissions, however, for some countries, especially smaller ones, transboundary fluxes and benefits from reducing the emissions in neighbouring countries are important and can even dominate the effects of national actions. In other words, while pollution can be highly localized, much of the pollution at a given location de-pends on the emissions of non-local sources. Thus, the negative impact of air pollution of say a single city typically can only be reduced by sets of measures that reduce the emissions at the national scale.

Impact pathway figure

The illustrative impact pathway is given in Figure 1.

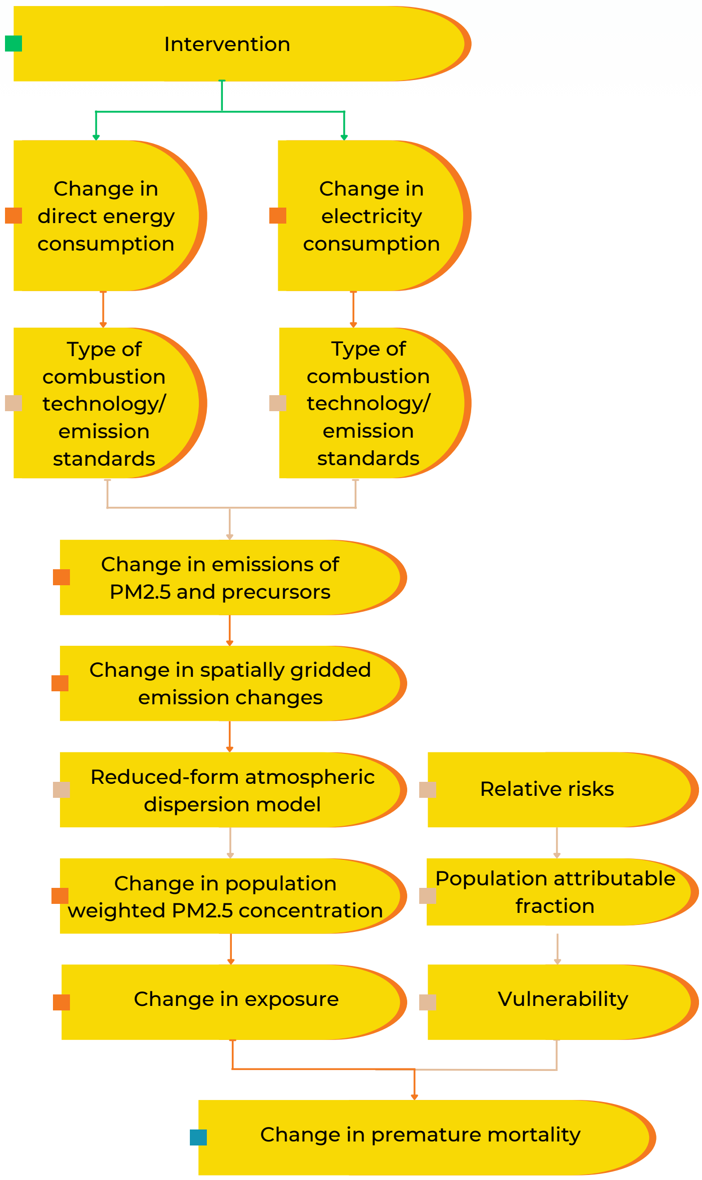

Figure 1: Impact pathway for air pollution-related mortality

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

No overlap has been identified.

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Quantification method

Definition

Energy efficiency measures affect the mortality from ambient air pollution from fine particulate matter (PM2.5) through the channel described in Figure 2, i.e. via an associated reduction in emissions of primary PM2.5 and relevant precursor substances (SO_2, NO_x, NH_3, VOCs). This bottom-up ex-ante assessment proceeds in six steps:

- **Step 1:** 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.
- **Step 2:** 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, 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 need 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 only one particular fuel (e.g., gas) being reduced, and again the vintage of the installation may be relevant.
- **Step 3:** Calculate the resulting changes in the emissions of primary PM2.5 and relevant precursor substances.

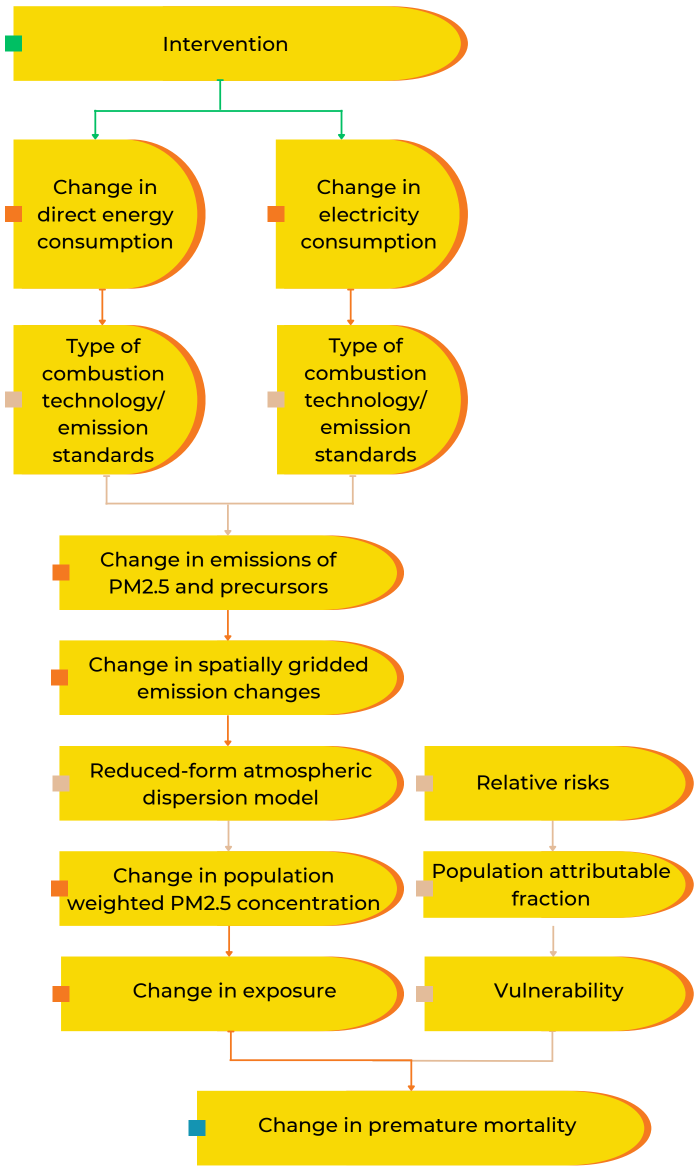

Figure 2: Impact pathway and calculation method for changes in premature mortality from air pollution from energy efficiency measures.

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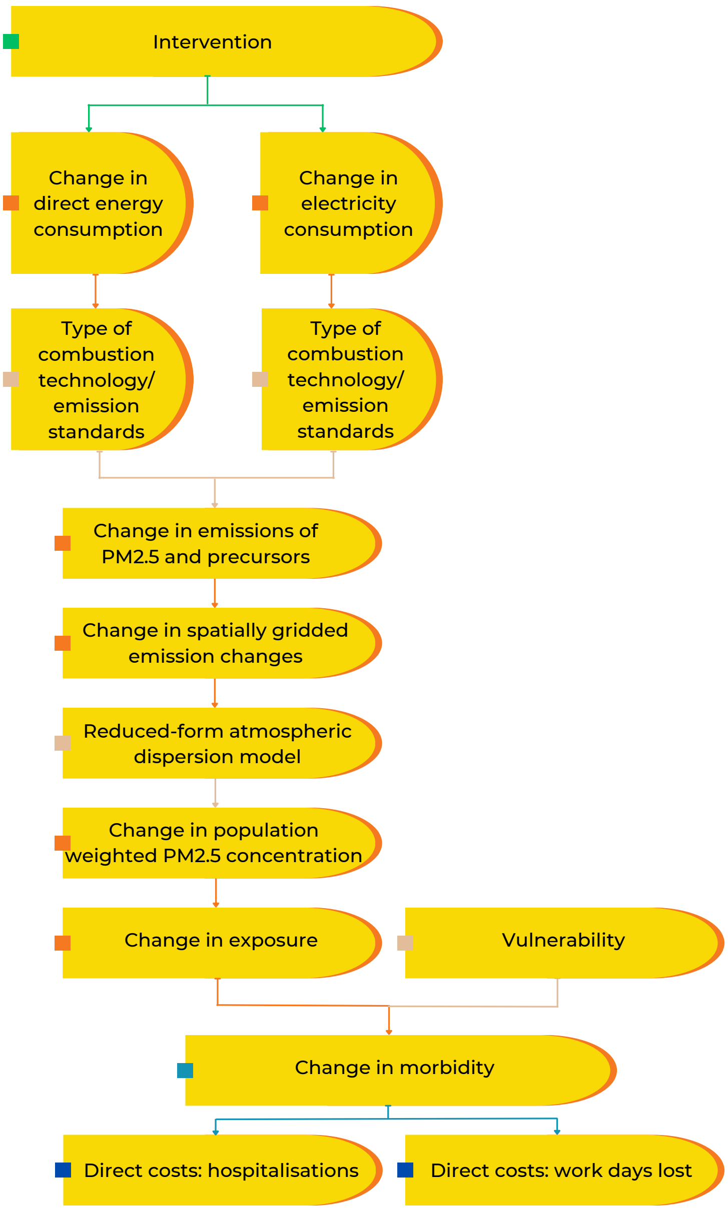
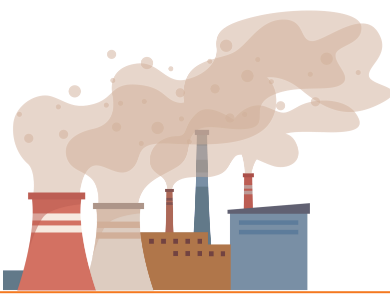


Figure 3: Impact pathway and calculation method for changes in morbidity from air pollution from energy efficiency measures.

- **Step 4:** Calculate the associated changes in the concentration field of ambient PM2.5 and corresponding population-weighted averages. This calculation is per-formed with a reduced-form version of a chemical transport model, and is enhanced by a separate treatment of low-level combustion sources (households and transport sources) of primary PM2.5 that have a characteristic local effect.
- **Step 5:** Calculate population attributable fractions of mortality related to PM2.5 concentrations from relative risk factors and demographic life tables.
- **Step 6:** Combine exposure levels and vulnerability parameters from Steps 4 and 5 to calculate the changes in years of life lost and numbers of premature deaths as-sociated with PM2.5 pollution.

All calculations (e.g., energy saved, emissions, concentrations, mortality) are performed on an annual basis and at the level of individual member states of the EU. These results can easily be aggregated. The impact pathways are formulated as linear functions, so that once the characteristics of the interventions are specified, the changes in impact can be calculate using a simple impact factor. The morbidity calculation runs analogously, and identical through steps 1-4, with Steps 5 and 6 modified:

Here we use the method developed for the CaRBonH calculation tool (Spadaro et al., 2018), which relates the ambient concentration of PM2.5 to the number of hospitalizations and work days lost (WDL), which in turn can be translated into direct costs, using country-specific values for the unit costs.



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Methodological challenges

- The method to calculate premature mortality is well established and has been used by the European Commission in a number of assessments of potential air pollution control policies.
- The relationship between concentration and hazard is currently assumed to be line-ar, while in fact the relation is known to be non-linear and disease-specific. The method may be updated during the course of the project and would result the indicator to be represented as functional relationship rather than a simple impact factor.

Data requirements

- The analysis is performed with GAINS model (Amann et al., 2011) 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 reduced-form chemical transport model is based on the EMEP model and is readily available as part of the GAINS model. In MICAT, at the city level essentially only the values that are proportionally scaled from the national version can be offered.
- As described above, for each energy efficiency measure (intervention) to be analysed the specific impacts on the energy system needs to be given, both in terms of split into effects on electricity and other fuel uses, as well as emission characteristics of the marginal technologies involved. In particular, inputs such as a change in energy or carbon prices, the number of homes being insulated, or efficiency improvements for new vehicles need to be first translated into actual changes in the energy system.
- The health-related methods and data are based on standard and simplified methodologies including the Global Burden of Disease study (Cohen et al., 2017) and (Spadaro et al., 2018).

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Impact factor / functional relationship

- At this stage the change in mortality (number of premature deaths prevented) can be related to the change in energy consumption in the following way:

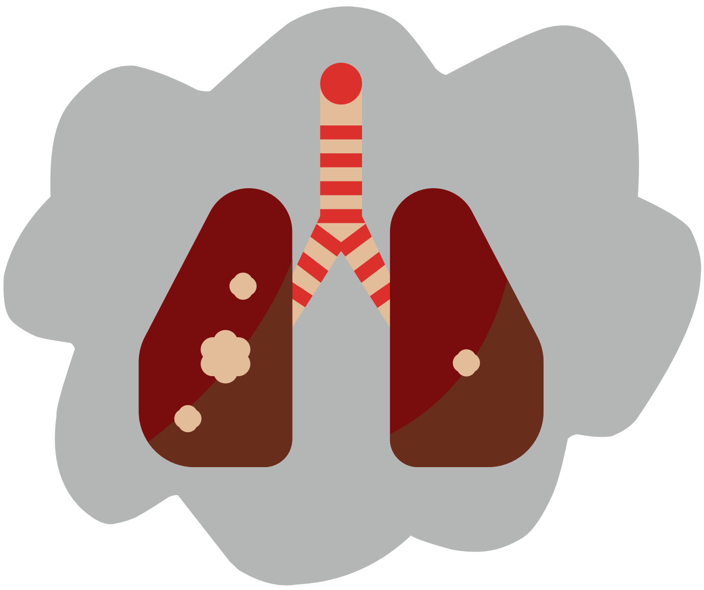
$$\Delta M_c = \sum_{c',s,u,t,e,p} \Phi_{c,c',p,s} \times \mathrm{EF}_{c',s,u,t,e,p} \times \Delta E^i_{c',s,u,t,e,p}$$

where p is the pollutant.
The independent variable $\Delta E^i_{c'}$ 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, Φ contains information about the source-receptor relation between emissions of p in country c' and concentration levels of PM2.5 in country c, as well as all relevant health vulnerability characteristics of country c. It also depends on the (aggregate) sector injection characteristic (high-level vs low-level source). Morbidity is directly monetized using the direct, country-specific cost factors of (Spadaro et al., 2018).

- Strictly speaking, the factors EF may depend on scenario assumptions, as they can reflect different air pollution control policies. The factor Φ is scenario-independent for the present purposes. The main scenario dependence actually lies in the independent variables $\Delta E^i_{c'}$, 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.

- As indicated above, Φ may be more appropriately represented as a function of the other two factors (EF, $\Delta E^i_{c'}$). However, at relatively moderate concentration levels in the baseline, and given that the indicator will only capture the marginal impact of each intervention i, the linear approach (and factorization above) is fully justified.

- In principle, transboundary effects from country c' to country c are included here. They can, however, be suppressed for national assessments, though they are relevant at the EU level.



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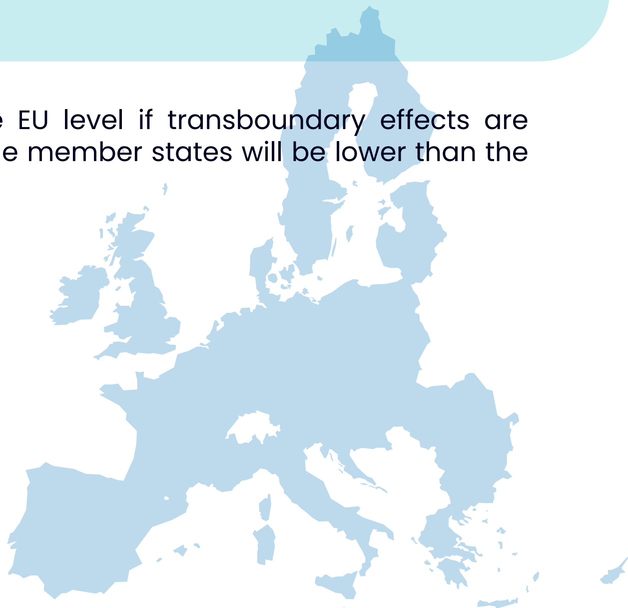
Monetization

- The GAINS model itself does not monetize mortality effects. This is because, while all other parts of the above impact assessment are based on a combination of methods that allow for an objective assessment, a monetization using the concept of the value of statistical life (VSL) introduces an element of value judgement that is fraught with methodological and conceptual difficulties. A choice of the VSL to be used (and possibly a different one in each country can bias an analysis in one way or another.
- However, since the VSL may/will be used for other indicators as well in this project, it is a parameter that the user of the tool will need to choose prior to the analysis.
- Alternatively, mortality (and morbidity) effects could be recorded without monetization and fed into a CGE analysis as reduced labour or foregone consumption. In this way the issues with the VSL could be circumvented.
- Direct morbidity costs (costs for hospitalizations and word days lost) are calculated using the data provided in the CaRBonH tool, as described above.

Aggregation

Member state data can strictly be aggregated to the EU level if transboundary effects are included as well. If not, the sum of the benefits across the member states will be lower than the benefits accrued at the EU level.



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www.micatool.eu

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