Integrated assessment of direct and indirect impacts on health of active mobility measures

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Introduction and context
Particulate matter (PM), is still a major problem in some European areas, where high concentration levels represent a continuing threat to human health. In these areas, behavioral measures could be a viable option to abate PM precursor emissions beyond levels reachable with end-of-pipe measures application. Integrated Assessment Modelling (IAM) is a methodology that allows to evaluate the socio-economic and health impacts of Air Quality policies. This work presents the MAQ model, an Integrated Assessment Model, designed to select efficient Air Quality policies. The model has been applied to assess fuel savings, greenhouse gases emission reduction, direct and indirect health impacts of active mobility (AM) measures (i.e. cycling or walking).

Materials and approaches

MATERIAL-DIMENSIONAL AIR QUALITY MODEL
The MAQ model [1] is based on a multi-objective approach. It aims at minimizing, in a given domain, one or more Air Quality Indicators (AQIs), representing the impacts on air quality of a policy, namely a set of measures (decision variables) and its implementation cost (IC), while satisfying a set of constraints. The problem can be formalized as follows:

\[ \min \left[ A(Q(\theta), IC(\theta)) \right] \]

subject to

\[ \zeta(\theta) \leq 0 \]

\[ \eta(\theta) = 0 \]

where:

\[ \theta \] is the set of decision variables, including end-of-pipe and technical measures i.e. the feasible emission reduction measures;

\[ A(Q) \] is the Air Quality Index, it is linked to the decision variables affecting the precursor emissions E(\theta) through a non-linear relation;

\[ \zeta \] is a function constrained to non-linear functions constraining the decision variables.

HEALTH IMPACT ASSESSMENT
DIRECT HEALTH IMPACTS of PM exposure, in terms of Years of Life Lost (mortality) and morbidity impacts, is calculated following the External methodology [2].

The abatement policies are applied, not only to road transports, but throughout different activity macro-sectors to maximize efficiency. The table below shows the measures implementation costs for a selection of CORINAR macro-sectors.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Activity</th>
<th>MS1</th>
<th>MS2</th>
<th>MS3</th>
<th>MS4</th>
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<tbody>
<tr>
<td>Policy A - End of pipe</td>
<td>44.70</td>
<td>6.03</td>
<td>0.72</td>
<td>536.52</td>
<td>6.06</td>
<td>6.33</td>
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<td>Policy A - Energy</td>
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<td>258.44</td>
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The methodology is applied to Lombardy, a region in Northern Italy. The efficient emission reduction policies are described by the Pareto Curve, on the horizontal axis the internal costs are displayed in millions of euros per year, while on the vertical axis the AQI estimated is shown (see Figure below). Policy B is an extreme scenario where all the commuters decide to adopt AM measures at a very low social cost, the cost of an information campaign (0.02 MIEP). Two additional scenarios closer to reality can be developed starting from Policy A (not considering active mobility measures) and:

- assuming only a third of the commuters adopt AM measures at a cost equal to the communication campaign (Scenario 1);
- two thirds of the commuters may choose to adopt AM measures if paid for the increased time spent travelling (14.16hr [4]). (Scenario 2).

The costs and savings for the different scenarios with respect to road transport sector are summarized in the following table. The table also reports the overall CO2eq emission reductions.

The following table lists the direct and indirect health impacts of the Scenario.

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Transferability
This approach can be applied to different areas throughout the globe, from the regional to the metropolitan scale in order to assess user defined sets of end-of-pipe, energy and behavioral abatement measures. This flexibility allows the system to be applied by a range of different actors ranging from regional/municipal decision makers to industry, where the approach can be applied to assess the cost effectiveness of innovations in terms of air quality indicators.

References


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