Tools, method and case studies in emissions projections for regional and local air quality plans

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Topics

- National vs Regional & City Projections
- National Scenario definitions (GB)
- Regional Air quality planning
- E2Plan - Tool for regional/local AQP & CF
- Emissions projections methodology
- Regional Air Quality Plan case study
- ClairCity H2020 project city-level projections
- Conclusion
National vs Regional & City Projections

- **National projections**
  Used to assess progress towards targets (as for UNFCCC Paris Agreement and EU NECD Directive 2016/2284) and as an input to global and continental air quality models.

- **Regional projections**
  Used as an input to air quality models to evaluate future compliance of zone and agglomerate air quality standard (as for Directive 2008/50/EC); include national.

- **City level projections**
  Used as an input to air quality models to evaluate future hot spots compliance of air quality (as for Air Quality Directive 2008/50/EC); include national & regional.
National Scenario definitions (GB)

➢ **Without measures (WOM) or (BAU)**

excludes all policies and measures implemented, adopted or planned after the year chosen as the starting point for this projection (*Para 26 - UNFCCC, 2016*)

➢ **With existing measures (WEM)**

encompass currently implemented and adopted policies and measures (*Para 26 - UNFCCC, 2016*)

➢ **With additional measures (WAM)**

encompass planned policies and measures* (*Para 26 - UNFCCC, 2016*); where:

* options under discussion and having a realistic chance of being adopted and implemented in future (*Para 11, UNFCCC, 2016*)
National Projections Methodology

National projected emissions for a selected pollutant \((j)\) in a future year \((k)\) related to a specific activity\&fuel \&technology \((i)\) are estimated starting from the base year \((0)\) emissions and using specific projections factors \((\text{drivers})\) of activity level \((a_{ik})\) due to activity measures \(m\) and specific drivers for emission factors \((f_{ijk})\) due to emissions technology measures \(n\):

\[
E_{ijk} = E_{ij0} \Pi_m \Pi_n a_{ikm} f_{ijkn}
\]

(notation is equivalent to GB formulae)

The formula take into account:

- average national variations in activity levels (for example energy saving and/or fuel ban and/or fuels switch in domestic sector)
- average national variations in emission factors (for example new euro standard and/or exhaust filter control)
EU air quality directives

- in the last years European Union air quality directives have been introduced
- the Directives requires Member States to divide their territory into zones related to air quality standards
- the directives requires Member States to adopt plan and programs inside zones when air quality standards are not respected
- Italy legislation delegates air quality planning activities to the regions
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E²Plan - Tool for regional/local AQP & CF

E²Road

E²Port

E²Airport

E²Gov

Driving forces data

Energy balance

Emission Inventory

Global & Local Meteo Data

Land Cover Data

WRF Meteorological Model

Global Biogenic Emission (MEGANE)

Global models boundary conditions

CHIMERE

CALPUFF

Regional, municipal and gridded emissions

Regional, municipal and gridded scenario emissions and carbon footprint

Hourly gridded pollutants concentrations

AQ Directive Compliance

Carbon footprint

E²Projection

20th Joint EIONET & UNECE Task Force on Emission Inventories & Projections Meeting
Thessaloniki, 13th-15th May 2019
Regional and local emissions inventories

Sources:

- **Structure**, sources that is possible and useful geolocate and evaluated by direct census and emission factors:
  - **Point** - stationary sources whose emissions exceed fixed thresholds (i.e. 5 tons/year of NO$_x$ or PM$_{10}$, SO$_x$, NMVOC)
  - **Line** - the main roads, railways, seaways, canalways
  - **Area** - the main ports, airports, landfills, storage areas
- **Diffuse (statistic)** sources not included in the previous classes estimated at municipal or sub-municipal level by statistical or direct census data and emission factors

This level of detail is necessary to evaluate the effect of specific measures on air quality at a local dimension and to define air quality management plans with specific source oriented and spatially oriented measures.
Regional/local scenarios definition

➢ activity scenarios defined associating to selected activities, specific activity drivers at national, regional, zone, line, area and units of point source level

➢ technology scenarios defined associating to selected activities and pollutants, specific technology drivers at national, regional, zone, line, area and units of point source level

➢ new sources scenarios defined introducing new specific source (new plant, new road, ...) or source category (for example new fuel)

➢ emissions scenarios obtained as combination of activity, technology and new sources scenarios
Regional/local Projections: diffuse sources

Projected emissions for a selected pollutant \((j)\) in a future year \((k)\) and in a single territorial unit (e. g. LSOA, Buurt, municipality, ...) \((u)\) related to a specific activity\&fuel\&technology \((i)\) are estimated starting from the base year \((0)\) emissions and using specific projections factors (drivers) of activity level \((a_{ikum})\) due to activity measures \(m\) and specific drivers for emission factors \((f_{ijkun})\) due to emissions technology measures \(n\):

\[
E_{dijk}^d = E_{dij0}^d \prod_m \prod_n a_{ikm} f_{ijkn} a_{dium} f_{dijn}
\]

The formula take into account:

- activities measures at national, regional and local (for example “gas free” or “wood ban” or “diesel ban” or “car ban”) level;
- measures about emission factors at national, regional and local (for example “Pre-Euro 4 car ban” in main urban areas)
Regional/local Projections: structures

Projected emissions for a selected pollutant \((j)\) in a future year \((k)\) and for a single structure (e.g. plant, road, port, ...) \((p)\) related to a specific activity&fuel &technology \((i)\) are estimated starting from the base year \((0)\) emissions and using specific projections factors (drivers) of activity level \((a_{(p)km})\) due to activity measures \(m\) and specific drivers for emission factors \((f_{ij(p)kn})\) due to emissions technology measures \(n\):

\[
E_{p_{ijp_k}} = E_{p_{ijp_0}} \Pi_m \Pi_n a_{ikm} f_{ijkn} a_{ipkm} f_{ipkn} + E_{p_{ijkp}}
\]

The formula take into account:

- specific regional and local measures about activities (for example “gas free” or “wood ban” or “diesel ban” or “car ban” and about emission factors (for example “Pre-Euro 4 car ban”
Scenario definition in regional/local plan

- **Baseline**: the current situation (i.e. 2016 data);
- **WEM**: future situation without any policy actions beyond what is already decided including:
  - national measures defined in the ‘with measures’ (adopted measures) NECD or energy/GHG strategies projection;
  - regional measures adopted in regional air quality plans;
  - all the other measures already adopted at city level by local planning actions;
- **Plan Scenarios**: added policy interventions to the WEM, same time horizon; including:
  - national or regional planned measures in the ‘with additional measures’ in NECD or regional plans, where available;
  - all the other planned measures defined at city level by local planning actions or during the project
  - eventual “hot spot” measures (single plant, road, port)
**Abruzzo Region air quality planning case study**

- Zone with higher anthropic pressure
- Zone with lower anthropic pressure
- Ozone concentrations above target values in large areas of the region
- NO\(_2\) exceeds annual limit
- \(\text{PM}_{10}\) exceeds daily limit
- Benzo(a)pyrene near limit
- Pescara Chieti agglomeration
- Ozone concentrations above target values in large areas of the region
Abruzzo Region Air quality Management planning activities

➢ multiyear emission inventory (by source for main sources and at municipal and 1km x 1km scale for other sources)
➢ specific road traffic, airport, port, vegetation emissions models
➢ emission projection model implemented with inventory base year and projections at 5, 10, 15 years in different scenario
➢ air quality models applications (CHIMERE & CALPUFF) in different scenario
BAU and plan scenario

- Reference or Business as Usual (BAU) Scenario has considered socio-economical and technology trends and all already planned and approved measures.

- Plan scenario include general national and regional measures and the following specific measures for the agglomeration Pescara – Chieti:
  - Reduction of urban and suburban traffic (-4% by 2020 and 10% by 2025)
  - Support for replacing existing stoves and fireplaces with advanced stoves and fireplaces or pellet stoves (target of 10% of installations replaced by 2025)
  - Reduction of the emissions of nitrogen oxides of selected industrial combustion plants in the area.
NO\textsubscript{x} agglomerate scenarios emissions (Mg)
Future air quality modeling results

**BAU scenario 2025**
NO₂ Annual mean (µg/m³)

**Plan scenario 2025**
NO₂ Annual mean (µg/m³)
ClairCity Horizon 2020 Ongoing Project

➢ ClairCity is aimed at creating a major shift in public understanding towards the causes of poor air quality, inviting citizens to give their opinions on air pollution and carbon reduction to shape the cities of the future.

➢ ClairCity will apportion air pollution emissions and concentrations, carbon footprints and health outcomes by city citizens’ behaviour and day-to-day activities in order to make these challenges relevant to how people chose to live, behave and interact within their city environment.

➢ ClairCity uses six pilot cities/regions: Amsterdam, Aveiro, Bristol, Genoa, Ljubljiana, Sosnowiec.
Amsterdam Claircity case study
spatial domain and LSOA subdivision
**Amsterdam industrial, residential and commercial (IRC) sector BAU scenario**

Amsterdam: Socio-economic drivers used to project emissions in industrial, residential and commercial sector

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<tr>
<th>Code</th>
<th>Name</th>
<th>Domain</th>
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<tr>
<td>AMS_BAS_CFF</td>
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<tr>
<td>AMS_BAS_RFF</td>
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<td>AMS_BAU_CFF</td>
<td>Amsterdam NEC: Residential &amp; Commercial - Fossil fuels</td>
<td>All MSOAs</td>
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<tr>
<td>AMS_HOUSE</td>
<td>Amsterdam Private Households Growth</td>
<td>All MSOAs</td>
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Amsterdam: Technological drivers used to project emissions in industrial, residential and commercial sector

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<td>All Buurts</td>
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Amsterdam: point sources drivers used to project emissions for point sources

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<tr>
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<td>AMS Coal ban</td>
<td>Nuon Hemweg Coal unit</td>
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Amsterdam residential and commercial (RC) sector BAU scenario
## Amsterdam RC Policy scenario

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<th>Code</th>
<th>Description</th>
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<tr>
<td>AMS_LblBC</td>
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<tr>
<td>AMS_Wood</td>
<td>Amsterdam ban wood stoves and fireplaces</td>
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<tr>
<td>AMS_SunMand</td>
<td>Amsterdam Solar Panel mandatory</td>
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<td>AMS_GFMand40</td>
<td>Amsterdam Gas free mandatory in 2040</td>
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<td>Amsterdam Gas Free Mandatory in 2040 Natgas</td>
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<td>AMS_GFM40Bg</td>
<td>Amsterdam Gas free mandatory 2040 Biogas</td>
</tr>
<tr>
<td>AMS_GFM40Gg</td>
<td>Amsterdam Gas free mandatory 2040 Greengas</td>
</tr>
</tbody>
</table>
Amsterdam RC sector Policy Scenario

- Commercial & Institutional - Gasoil
- Commercial & Institutional - Natural gas
- Commercial & Institutional - Wood
- Commercial & Institutional - LPG
- Commercial & Institutional - Biogas
- Commercial & Institutional - Green gas
- Residential - Gasoil
- Residential - Natural gas
- Residential - Wood
- Residential - LPG
- Residential - Biogas
- Residential - Green gas
Conclusions

➢ Different levels of planning require an integrated model for projections

➢ Air quality planning need the integration of national, regional, city level and hot spot modelling

➢ A specific integrated tool $E^2$Plan is presented to manage emission inventory on different territorial domains and to model projections

➢ Integrated air quality models (such as Chimere or Calpuff) give the instrument to evaluate the effect of measures on air quality
THANK YOU FOR THE ATTENTION

QUESTIONS?