Supporting Spain’s national emission projections with the EmiPro tool

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1. INTRODUCTION

- Emission projections have become an essential tool in supporting environmental policy design and decision making.

- Compulsory requirement for the Member States under the CAFE (Clean Air For Europe) program.
- Better national Emission Inventories:
  - Clear and detailed methodologies and standards for compilation and submission of National Emission Inventories

IPCC Guidelines for National Greenhouse Gas Inventories

EMEP/CORINAIR Emission Inventory Guidebook
These enhancements have somehow reached Emission Projections, but there are still many issues to address:

- Lack of reference procedures for National Emission Projections development
- Compatibility with National Emission Inventory
- Consistency and completeness
- Reliability and uncertainties
- Update methodologies
- Submission schedule
2. BACKGROUND

Spain’s National Emission Inventory

- It is based on the CORINAIR methodology.

- It relies on the SNAP nomenclature (Selected Nomenclature for Air Pollution), harmonized with the IPCC/OECD and EMEP/UNECE ones. This classification has a hierarchical structure based on the following three levels: Group (11) > Sub-group (76) > Activity (430)

Example (SNAP activity 010101)

Group = 01 (Combustion in energy and transformation industries)

Subgroup = 01 (Public Power)

Activity = 01 (Combustion Plants ≥ 300 MW (Boilers))
- Temporal resolution: yearly
- Spatial resolution: province (NUTS-3 level according to the European geographical administrative classification provide by EUROSTAT, the European Statistical Office)

Nomenclature des Unités Territoriales Statistiques

NUTS 0 - Countries
NUTS 2 - Autonomous Regions
NUTS 3 - Provinces
Legislative aspects

- There are two fundamental references that determine the conception of the SEP project and the design of EmiPro:

**Kyoto Protocol**

- Spain is legally bound to achieve its targets for greenhouse emissions according to the recently entered into force Protocol:

<table>
<thead>
<tr>
<th>Year</th>
<th>CH&lt;sub&gt;4&lt;/sub&gt;</th>
<th>CO&lt;sub&gt;2&lt;/sub&gt;</th>
<th>N&lt;sub&gt;2&lt;/sub&gt;O</th>
<th>HFC</th>
<th>PFC</th>
<th>SF&lt;sub&gt;6&lt;/sub&gt;</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>31982</td>
<td>224471</td>
<td>26465</td>
<td></td>
<td></td>
<td></td>
<td>282918</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td>4645</td>
<td>790</td>
<td>94</td>
<td></td>
<td></td>
<td>5529</td>
</tr>
<tr>
<td></td>
<td>Total Kyoto Protocol Base Year</td>
<td></td>
<td>Total Kyoto Protocol Base Year</td>
<td>288447</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spain’s Kyoto Protocol Target for the first period of compromise (assumed 2010)</td>
<td></td>
<td>Spain’s Kyoto Protocol Target for the first period of compromise (assumed 2010)</td>
<td>331715</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Kyoto Protocol base year GHG emissions and emission target for Spain. All figures are in kt of CO<sub>2</sub> equivalent.*
- All the GHG emissions released in the national territory are accounted for the Protocol

- The “flexibility mechanisms” are not taken into account in the SEP project, so that the +15% target is considered


- The Directive 2001/81/EC is intended to reduce the emission of acidifying, eutrophying and photochemical air pollutants precursors across Europe.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Emission (kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>746</td>
</tr>
<tr>
<td>NOₓ</td>
<td>847</td>
</tr>
<tr>
<td>NMVOC</td>
<td>662</td>
</tr>
<tr>
<td>NH₃</td>
<td>353</td>
</tr>
</tbody>
</table>

Spain’s National Emission Ceilings for 2010
- Only anthropogenic emissions are computed, so emissions from SNAP group 11 (nature) and the NMVOC from group 10 (agriculture) are not taken into account.

- The Directive is only applicable for the territories inside the EMEP grid ⇒ The Canary Islands are not affected by the NEC Directive.

EMEP 50x50 grid system
3. SPAIN’S EMISSION PROJECTION (SEP) PROJECT

- **Aim and scope**
  - This project tries to fill all the gaps regarding national emission projections for the Spanish case
  - The main aim of the SEP project is the development of useful information for policy decisions within the atmospheric pollutant emission field
  - Developed under contract with Spain’s Ministry of Environment
Basic objectives

- To obtain emission projections for the period 2001-2020.
- To determine possible future scenarios
- To estimate the efficiency of the adopted measures in each scenario
- To evaluate the fulfilment of the Directives and the Protocols
- To integrate prospective studies and official plans and forecasts available for all the sectors covered in the study in a consistent way
Coverage

- The considered activities are all those included in the most up-to-date version (SNAP 97) of the SNAP nomenclature. The 2000 National Emission Inventory edition accounts for 282 SNAP activities.

- The pollutants projected are those included in:
  
  - the Geneva Convention: SO$_x$, NO$_x$, NH$_3$, NMVOC, CO, particulate matter (TSP, PM$_{10}$ and PM$_{2.5}$), Pb, Cd and Hg.
  
  - the Kyoto Protocol: CO$_2$, CH$_4$, N$_2$O, PFCs, HFCs and SF$_6$. 
Methodology

- Emission projections are fully-consistent with the Inventory. This usually means:
  
  - Same approach (bottom-up, top-down)
  
  - Same or compatible sources of information
  
  - Projection at SNAP-3 level (highest possible detail), or even at LPS (Large Point Source) level

Projections based on a wide range of particular methods and input information sources
- Reduction to a common basis (one of the two following simple algorithms):

\[
E_i = A_i \cdot FE_a \cdot \prod_{j=1}^{n} FC_j
\]

\[
E_i = G_{a-i} \cdot E_a \cdot \prod_{j=1}^{n} FC_j
\]

- Pollutant emission for year \( i \)
- Pollutant emission for year \( a \) (base year, 2000)
- Rate activity for year \( i \)
- Pollutant Emission Factor for the base year
- Emission Growth Factor between years \( a \) and \( i \)
- Control Factors \([0, 1]\) :

\[
FC_j = 1 - R_j \cdot p_j
\]

- Abatement per \( j \) measure
- Penetration of \( j \) measure
Scenarios

- A scenario is any combination of hypotheses regarding the values of each of the factors involved in the algorithms.

Considerations:
- Technological
- Socioeconomic
- Statistical
- Legislative

Hypothesis:
- Activity rate
- Emission factors
- Emission trends

= SCENARIO

- In order to standardize the procedure to define specific activity hypothesis and assure global consistency, three different types of scenarios have been identified to reflect three hypothetical situations that are interesting from the air quality management and decision making point of view.
- In accordance with the CAFE criteria, the scenarios are divided into three general groups or types:

- **Business As Usual (Tendencial):** reference scenario without any measure taking into account the past emission trends.

- **Baseline (Base):** the more likely future situation considering the enacted legislation and adopted plans, measures and policies.

- **Target (Objetivo):** the environmental objectives are reached through additional measures (e.g. good practices, technical improvements, further policies, etc.).
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- Specific methodology for the activity projection:

**Method for calculation**

\[
\begin{align*}
E_i &= A_i \cdot FE_i \cdot \prod_{j=1}^{n} FC_j \\
E_i &= G_{a-i} \cdot E_a \cdot \prod_{j=1}^{n} FC_j
\end{align*}
\]

**Basic information**
- Emission data (Inventory)
- Socioeconomic data
- Sectoral studies
- Legislation
- Technological aspects

**Hypothesis**
- Rate activity trend (A)
- Emission factor trend (FE)
- Emission trend (E)
- Control Factor (FC) and Growth Factor (G)

**SCENARIOS**
- BAU
  - Baseline

**Evaluation emissions**

**Results**

Yes
- Reached?

No
- Kyoto Protocol NEC

**CONCLUSIONS**

Definition of a Target scenario

14th International Emission Inventory Conference. Las Vegas. April 13, 2005
Databases

Generally, projections are made on national basis:

⇒ There is no need to keep NUTS-3 level information in the projections database

But, the setting of thresholds derived from NEC Directive’s commitments must be done taking into account only a subset of the total national emissions

Solution:

- Implementation of a parallel database system inside EmiPro corresponding to the two different geographic and pollutant scopes. None of them store NUTS-3 level information:
- Parallel projection scheme and information stored in each database

**BD CORINAIR 2004**

**SEP (1990-2000)**
- General
- TNE-Base

**EmiPro (1990-2020)**
- General
- TNE

**Results**

**General:**
- National scope
- All SEP’s project pollutants

**TNE-Base:**
- Only NMVOC, NH₃, NOₓ and SO₂
- SNAP 11 (nature) emissions are excluded
- NMVOC from SNAP 10 (agriculture) are excluded
- Emissions under the EMEP domain (Canary Islands are not included)
- Domestic cruise traffic (h > 1000 m) emissions are excluded
- International airport traffic (LTO cycles<1000m) emissions are included

Activity-rate historical datasets analysis and geographical disaggregation criteria
Integration criteria. Macroscenarios

- The emission projection methodology developed under the SEP project offers important advantages, but entails some disadvantages:
  
  - allows the formulation of very specific, high-detailed hypotheses for each activity
  
  - provides a useful framework to perform the assessment of the measures assumed under any scenario, both from the technical and the cost-efficiency points of view.
- Integration of prospective studies and official plans and forecasts available for all the sectors in a consistent way with the National Emission Inventory

- Consistency among individual projections calculated through different methods and based on different input data

- Activity rate is an exogenous variable to the model

- Basic socioeconomic inputs or drivers such us GNP, interest-rates, population projections, etc. behind activity rate forecasts often are unknown
Some kind of QA/QC process is needed in order to guarantee the consistency when merging individual projections.

- The procedure developed to solve this problem is based on the analysis of the relationships existing among SNAP groups, subgroups and activities.

- Any group of activities identified in having a clear connection through the activity rates involved in the emission estimation is called “Macroscenario”. This name is also applicable to the joint projection of these groups of activities.
The macroscenario concept and individual results merging process:

- Once the relationship mapping has been clearly identified, it is only a matter of introducing consistency conditions into the hypothesis made under each scenario for a particular activity rate.
4. THE EmiPro TOOL

Overview

- EmiPro (for Emission Projection) is a software tool specifically developed to handle all the data and procedures involved in the SEP project.

Last non-Beta version, currently v2.02

- Start screen -
- Its main functions are:

- Storage and recovery of past (history) emissions
-Generation of projections from history data and algorithm factors
- Storage and recovery of projected emissions
- Reports generation
Working procedures

Massive data input
- Massive data input is made from past emissions series, as provided by the Spanish Environmental Administration (CORINAIR-database) ⇒ “General” database.

- Pre-processed past emission series ⇒ “TNE” database.

- Usually, once a year (Inventory updates)

- Massive feeding cannot be done in user mode

- Once information is loaded, reports are available for it. Editions and corrections of the information are also possible.
**Projection parameters**

- Parameter hypotheses for a given activity according to the selected algorithm are fed into Emipro, which loads them and automatically proceeds with the projections for the given activity and time frame:

**Input requirements for single activity projection (for each scenario):**

- \( \text{MS}^{TM} \) \(Excel^{TM} \) file containing two worksheets with the parameters to be used for the projection

- \( \text{MS}^{TM} \) \(Word^{TM} \) file documenting the procedures and data used in the projection
Supporting Spain’s national emission projections with the EmiPro tool

THE EmiPro TOOL
- Scenario edition / projection dialog box -

Input box for scenario ID

Drop-down menu listing all valid SNAP IDs

Type of scenario

Descriptive document for the projection

Parameters spreadsheet

Load parameters and project button

(only available when all inputs properly supply)
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- Projection parameters input dialogue and browser-
Supporting Spain’s national emission projections with the EmiPro tool

- Parameters spreadsheet -

<table>
<thead>
<tr>
<th>Year</th>
<th>Pollutant</th>
<th>Values for $A_i$ or $G_{a-i}$</th>
<th>Values for $FE_a \cdot \prod_{j=1}^{n} FC_j$ or $\prod_{j=1}^{n} FC_j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Hg</td>
<td>2.838.076.402.628</td>
<td>0.000010</td>
</tr>
<tr>
<td>2001</td>
<td>CH4</td>
<td>2.884.813.000.000</td>
<td>0.000009</td>
</tr>
<tr>
<td>2002</td>
<td>CO</td>
<td>2.723.335.000.000</td>
<td>0.000005</td>
</tr>
<tr>
<td>2003</td>
<td>CO2</td>
<td>2.151.191.500.000</td>
<td>0.000002</td>
</tr>
<tr>
<td>2004</td>
<td>HFC122m</td>
<td>1.889.543.200.000</td>
<td>0.000001</td>
</tr>
<tr>
<td>2005</td>
<td>HFC125</td>
<td>1.393.060.300.000</td>
<td>0.000000</td>
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<tr>
<td>2006</td>
<td>HFC134m</td>
<td>3.875.314.900.000</td>
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<tr>
<td>2007</td>
<td>HFC135m</td>
<td>8.800.815.000.000</td>
<td>0.000000</td>
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<td>2008</td>
<td>HFC222m</td>
<td>9.121.615.000.000</td>
<td>0.000000</td>
</tr>
<tr>
<td>2009</td>
<td>HFC226m</td>
<td>7.177.935.000.000</td>
<td>0.000000</td>
</tr>
<tr>
<td>2010</td>
<td>HFC236m</td>
<td>5.655.135.000.000</td>
<td>0.000000</td>
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<tr>
<td>2011</td>
<td>HFC241m</td>
<td>3.318.790.000.000</td>
<td>0.000000</td>
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<tr>
<td>2012</td>
<td>HFC242m</td>
<td>3.460.972.000.000</td>
<td>0.000000</td>
</tr>
<tr>
<td>2013</td>
<td>NOx</td>
<td>3.154.630.000.000</td>
<td>0.000000</td>
</tr>
</tbody>
</table>
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- Parameters spreadsheet -

<table>
<thead>
<tr>
<th>Year</th>
<th>Pollutant</th>
<th>Values for</th>
<th>Parameters for the “TNE-Base” database</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td>( FE_a \cdot \prod_{j=1}^{n} FC_j ) or ( \prod_{j=1}^{n} FC_j )</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td>( A_i ) or ( G_{a-1} )</td>
</tr>
</tbody>
</table>

**Equations:**

\[ \prod_{j=1}^{n} FC_j \]

**Legend:**
- **Year:** Year column
- **Pollutant:** Values for pollutants
- **Values for:** Parameters for the “TNE-Base” database
- **Parameters for the “TNE-Base” database:** \( FE_a \cdot \prod_{j=1}^{n} FC_j \) or \( \prod_{j=1}^{n} FC_j \)
- After clicking the “Load parameters and project” button, reports on projections are available. Once all activities are projected, global reports –both graphical and numerical – may be generated.
Macroscenarios

- Firstly, they must be defined by the user:
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- Macroscenario definition screen -

Macroscenario brief description

Macroscenario ID
Macroscenario edition screen

- Once a macroscenario has been defined, it can be edited (which activities it includes)

<table>
<thead>
<tr>
<th>Macroscenario ID</th>
<th>Type of scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description

SNAP description (automatically loaded)

Drop-down menu for activity selection (by SNAP ID)

-Macroscenario edition screen -
- The macroescenario concept is developed mainly to perform the QA/QC regarding hypotheses consistency

- However, it is useful also for other purposes:

  - Projection results aggregation (e.g. SNAP group or national total)

  - Translation of the results to report under other nomenclatures categories (e.g. Nomenclature for Reporting (NFR) of UNECE CLRTAP)
- Regarding the calculation of macroscenarios results, EmiPro uses an aggregation rule, depending on the type of scenario:

- If the scenario is “Baseline” or “Target”, Emipro will look for the corresponding scenario at activity level. In case it doesn’t exist, the results for the “BAU” or “Baseline” scenario will be retrieved in the query and added to the computation.

- Beside from the results (either in tabular or graphic format), EmiPro will generate a report informing the type of scenarios included for each activity.
- Results and reports main menu -

Results at macroscenario level:
- “General”
- “TNE-Base”

Checks and analysis

Report of the activities included in a given macroscenario
- **Macroscenario ID and type selection dialogue box** -

Drop-down menus for macroscenario and type of scenario selection

Calculate and visualize results
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Macroscenario calculation report: projections included

Switch between graphical - tabular views

Pollutant selection

Time frame selection

Emission projection at macroscenario level

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Export to MS Excel utility

Dynamic table view
**Helper functions**

- The tool has some helper functions to make the tracking of tasks easier, as indicating the list of activities not yet projected for each scenario:
- Activity-level activity rate path hypotheses plot -

Activities to be included in the comparison

Type of scenario

Macroscenario

Time frame selection
Technology

- EmiPro is a MS Access built-on PC tool specifically designed to support the SEP project

- It is intended to be used in a local area network under any MS Windows-NT based operating system.
- EmiPro is made up of two components:
  - **EmiPro.mdb**
  - User interface to be installed in every client PC. Must be linked to the proper EmiProBase.mdb
EmiProBase.mdb

- Includes the kernel of the system and all the databases
- Resides in the PC acting as server
- It cannot be edited directly. The users are not allowed to access the raw data, so they must use the interface
5. CONCLUSIONS

- The volume of managed data in the SEP project, both for the algorithm factors of the projections and the results of projections themselves revealed the need of a software tool to handle them.

- EmiPro is a key element to guarantee the consistency and quality of the national projections.

- Although this piece of software must be considered as a work in progress, it has shown to be very useful at data management, synthesis and analysis of the results inside the SEP project.
This tool can serve as a basis for the updating and revision of national emission projections.

Therefore, EmiPro could give support to the annual revision and publication of national emission projections, in coordination with the National Emission Inventory. This would help Spain’s Environmental Administration to fulfill the information requirements at the scheduled time.
6. NEXT STEPS

- Continuous revision and improvement of the performance, reliability and functionalities of the tool

- Basis for a tool capable of working as an interface with the RAINS model, which provides a bridge between national emission inventory and projections and the CAFE program

- Enhancement of its exporting capabilities in order to provide a consistent way to generate SMOKE-ready IDA ASCII format files, useful for modeling purposes
THE END

THANK YOU FOR YOUR ATTENTION

Any questions?

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