Applications of EDGAR. Including a Description of EDGAR V3.0: Reference Database with Trend Data for 1970-1995

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EDGAR Version 2.0 provides global annual emissions of greenhouse gases, both per region and on a 1^{o}x1^{o} grid. The overall aim for Version 3.0 was to update the inventories from 1990 to 1995, and for direct greenhouse gases also to 1970, to include new greenhouse gases. After consultation of the users, the objectives have been somewhat changed and extended. Thus, specific aims were: (a) update/extension from 1990 to 1995; (b) extend time series for direct greenhouse gases to 1970-1995; (c) include new greenhouse gases HFCs, PFCs, SF_6; (d) greenhouse gases also on per country basis using IPCC source categories; (e) include PM_x; (f) improve/include uncertainty and time profiles. Also during the project, we have tried to identify the most urgent wishes of current and potential users and checked whether we could include these in the update programme. In addition the work is linked into and part of the *Global Emissions Inventory Activity (GEIA*) of IGBP/IGAC.

Compounds
For updating and extended time series different priorities were given for four group of gases:
- direct greenhouse gases CO_2, CH_4, N_2O and new gases HFCs, PFCs, SF_6: 1970-1995
- ozone precursors CO, NO_x, NMVOC as well as SO_2 and NH_3: update 90 and 95
- add PM_x based on TNO study results for Europe
- extend CFCs, halons, HCFCs to 1900-1995.

Special attention was given to the compilation of a reference dataset for new F-gases as none was available.

Approach
For the update of the current Version 2.0, we followed the following principle:

- *Activity data*: update by including relevant statistics for the period 1970-1995, after checking for possible changes of source categories; this implies the inclusion of the 'new' countries, e.g. for the former USSR
- *Emission factors*: only to be changed for 1990 if validation showed major discrepancies; only to be changed for 1995 compared to 1990 if there are concrete indications that there major changes have occurred that cannot be neglected; the same holds for factors for 1970, in particular for direct greenhouse gases.
- *Grid maps*: only to be updated if maps available of better quality or better applicability.

Validation
In order to judge whether update of methods or emission factors for 1990 is needed, a validation of V2.0 data for 1990 was performed: for greenhouse gases with National Communications submitted under the UN Climate Convention and for other gases with data from CORINAIR, GEIA and others. In addition, inventories in National Communications were checked for the use of different emission factors for 1990 and 1995 in order to select sources and gases for which specific emission factors for 1995 in EDGAR V3.0 need to be determined.

This has been done for the purpose of the update, but also as application of Version 2.0 as reference dataset for comparing with official national greenhouse gas inventories to flag possible inconsistencies in source allocation, incompleteness of sources, and areas of incomparability. In addition, for CO_2, NO_x and SO_2 a comparison was made with the present GEIA inventories, both on grid and per country, from which interesting conclusions could be drawn regarding the apparent uncertainty in international statistics, on emission factors, missing sources and on apparent strong emission trends in specific regions/sources.

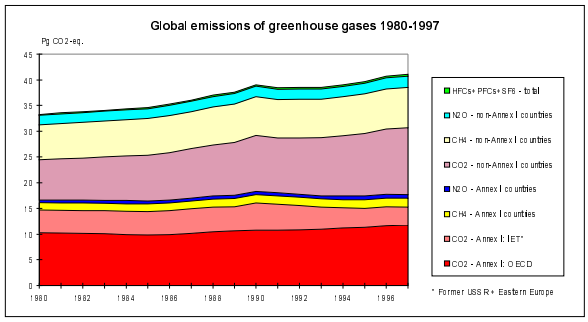

Fig. 1 Trend in greenhouse gas emissions 1980-1997 of the six 'Kyoto' gases in Annex I countries and other regions (in CO_2-eq.)
Sources: EDGAR/RIM+, 1996 (CO_2, HFCs); BP, 1998 (CO_2); World Bank, 1998; FAO, 1998 (CH_4, N_2O); IMAGE 2.0, 1994 (CH_4, N_2O); own estimates (1997 CH_4, N_2O, HFCs, PFCs, SF_6).

Activity data
Next, data were collected for the period 1970-1990. A major part could be drawn from IEA (energy), UN (supplementary energy, industrial production) and FAO (agriculture) databases. But for some source like biofuels and specific industrial production of commodities like adipic acid, nitric acid and fluorinated carbons country statistics are not readily available. For each of these latter compounds additional data sources were found and used. For biofuels we use the previous V2.0 dataset for less developed countries and FAO fuelwood plus IEA data for OECD countries. In addition, for

the IPCC sources 'Land-use change and forestry' (LUCF) and 'Waste' there is no readily available data in time-series per country. Here, in line with the approach taken for the compilation of the GEIA NH_3 inventory, biomass burning data (vegetation fires) for LUCF were based on FAO reports providing 10 year averaged estimates, supplemented with an estimate for agricultural waste burning essentially based on the methodology used for NH_3. For waste, the activity data per country are based on a fit with of international waste generation figures per capita - as recently published by IPCC and references mentioned therein - with per capita income per country.

Emission factors

The emission factors for direct greenhouse gases CO_2, CH_4 and N_2O will be brought more in line with the defaults recommended in the *Revised IPCC Guidelines for Greenhouse Gas Inventories* and for reference purposes any departures from them will be clearly identified. For CO2 from fossil fuel use, emission factors per detailed fuel type will be used (in V2.0: one aggregated factor for coal, oil and gas). This also means that the agricultural emissions will be affected considerably by the inclusion of some 'indirect' emissions. Other examples of areas where emission factors will be updated are NO_x from international shipping and CH_4 from rice and landfills.

Updated emission factors, or another mix of sub-activities, for 1995 will be required for sources such as coal mining, gasoline cars, shifting type of rice cultivation, landfills with gas recovery, but also for power plants and some industries in countries where additional control technology e.g. for SO_2 and NO_x has been installed. For extension to emission factors for 1970 similar considerations have been made.

Uncertainty

It has been acknowledged, that providing improved uncertainty estimates is an urgent need for models and policy applications, but also that it is hard to achieve on the short term other than through collective expert judgement. Within the IPCC Inventory Programme a special activity has recently been started aiming at providing default values and a better framework for estimating and reporting of uncertainties. A similar activity will start within GEIA, aiming at the same results at country level as well as on grid level, but for a more extended group of compounds and in a more scientific setting. Comparisons of different datasets, e.g. as done with the EDGAR data, may be an input to this process.

Therefore, it was decided by the EDGAR team that it was at present not feasible to go beyond the uncertainty table compiled for Version 2.0, except for the apparent conclusions on uncertainty that could be drawn from the comparison of V2.0 with other datasets as part of the validation and check for urgent adaptations.

Results

As an example of the capability of the new version some preliminary results are shown here of the historical trend in global emissions of the new greenhouse gases and of the 'six gases included in the Kyoto Protocol on the reduction of greenhouse gas emissions in the period 2008-2012 by so-called Annex I countries (OECD and Economies In Transition). These emissions are either based on global total activity data and subsequently allocated to individual countries or based on activity data per country (e.g. aluminium production). Fig. 2 shows trends in HFCs, PFCs and SF_6, per application, whereas Fig. 1 presents the trend in global CO_2-eq. emissions, by gas and by group of countries. As one of the final products from Version 3.0 we intend to publish the trend in emissions of all these gases 1990-1995 for all individual countries. Another product of the database are the so-called EDGAR-HYDE V1.0 inventories, which provides gridded and regional emissions of the direct and indirect greenhouse gases included in EDGAR V2.0 for 1990, but now for the whole period 1890-1990 with time steps of 10 year.

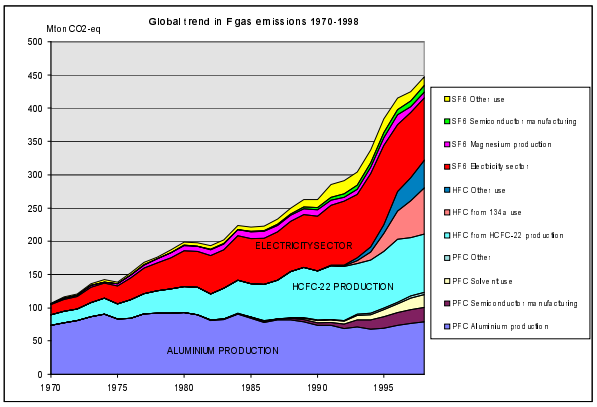

Fig. 2 Global emissions of HFCs, PFCs and SF_6 1970-1995 (in CO_2-eq.)

Applications of Version 2.0 to date

Version 2.0 has been used for comparison of inventories provided in the first National Communications of Annex I countries and available inventories resulting from country studies for other countries. This has shown to be a useful tool to check the submitted inventories for their comparability. Other use of the inventories is by modelers, who can download the gridded inventories and tabular data for regions from the FTP site.

The trend features of the new EDGAR 3.0 inventories will be used for the annual Environmental Balance of RIVM as well to calibrate new versions of the emission scenario modules of the IMAGE model. We anticipate that the new EDGAR/GEIA inventories on direct greenhouse gases will be used as scientific reference data sets for comparison of official country data. In addition, the EDGAR software is capable of converting official emission figures per country into gridded emissions which can then be tested or even verified by atmospheric model calculations, provided that there are sufficient atmospheric concentration measurements to compare with. Here too, knowledge of the time profiles of sources is relevant aspect that needs to be considered. Also, EDGAR data may be used as defaults for more spatially detailed GEIA inventories

The Future?

Possible future directions for the EDGAR system could be that, in cooperation with other international and regional organisations, the database on direct greenhouse gases is maintained for the purpose of reference EDGAR/GEIA dataset to the official country submissions as well linking official country data with atmospheric models through the conversion to the grid as part of the interaction between bottom-up and top-down evaluation of annual budgets as well as the trend in them based on bottom-up emission inventories and top-down calculations using concentration measurements. For the other gases the system could play a similar role.