Assessing the uncertainty of the Romanian Greenhouse Gas Inventory

Documentation of work

Consortium consisting of Umweltbundesamt, Vienna, and University of Graz

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Introduction

Romania is an Annex I party to the UNFCCC and submits annual reports of her Greenhouse Gas emissions. Uncertainty Assessment and Key Category Analysis are intrinsic elements of the inventory (IPCC, 2000). This paper documents the efforts taken to establish the uncertainty of the Romanian inventory. The calculation algorithm as such and the results are being reported elsewhere.

The procedures taken follow the method established and implemented successfully previously (Austria, Luxembourg, Bulgaria). In collaboration with the national inventory team and organizations providing information to the inventory, a one-week workshop was set up in Bucharest (September 3-7, 2012) to walk through the individual sectors and discuss with sector experts. Discussions had a two-fold meaning:

1) Sector experts have a good understanding of the processes for establishing data to be used in the inventory process. Valuating these processes with respect to comparable activities elsewhere, together with guided judgment by the experts, allows to derive available information (multiple measurements, literature data, or expert judgments) on the scale of uncertainty of a given data input to the inventory.
2) Sector experts become aware of the uncertainty issue, and will take a second look at uncertain parameters in their domain in the future, thus contributing to an implicit improvement program.

Expert interviews within the workshop were conducted in a form loosely structured by a guidance questionnaire (Appendix 1). The recurring line of each interview was to establish the procedure of emission assessment, requesting information specifically for Romania and discussing with them possible concepts to use.

The schedule of the work program is also attached (Appendix 2, includes names of participants to the respective discussions). All interviews were held in English language, in some cases translations by technical experts had to be provided. In order to make experts familiar with the concepts of considering uncertainty, a general presentation (see agenda) on the methods and the justification of approach preceded the interviews – slides from this session are shown in Appendix 3. According also to previous experience, it proved for some attendance difficult to comfortably discuss the weaknesses of their approach, while elsewhere they are required to confirm the results presented. The presentations however did lay out the path for successful collaboration.

Industrial processes

Leading expert/Romania: Mihaela Balanescu (University Politehnica of Bucharest)

Lead interviewer: Wilfried Winiwarter

Iron and steel industry is operating under ETS and EPRTR providing a transparent quality setting.

Romania features integrated flow steel production, with blast furnace and basic oxygen furnace. Coke as well as iron ore is imported. The large production site at Galati is situated at the Danube. There are a few smaller electric steel producers, even small induction furnaces for special steel production, but Arcelor Mittal Galati is main emitter (> 90%) of CO_2.

Galati operates under ETS, provides direct response to questionnaires with regard to NIR, and since last year also enters data electronically into ePRTR (first year of reporting, on paper: 2008).

The situation in the base year 1989 was quite different, both in terms of the emission situation and the data situation. In 1989, a coke plant operated in Galati, and two lines of open hearth steel production were active. Despite of significant changes in structures and organization, the iron and steel plants are still the same as the ones in 1989, so some continuity exists. Still assessing the 1989 situation is quite difficult.

Romanian Iron and Steel plants report to a national industry interest group and to WorldSteel, which confirms robustness of data.

Coke currently is imported exclusively for iron production so that activities can be taken from import statistics (independent from overall energy statistics). The carbon content in scrap and steel of electric furnaces is less than perfectly known, so there is some added uncertainty.

<u>Uncertainty factors used</u>:

Activities: final year, 1% (coke import statistics, independent); base year, correlated with energy/solid fuels

EF (emission factor): 10%, based on IPCC default uncertainty

Ferroalloys: There is now one operational unit, while many were operating in 1989. Activity data have been derived from the statistical agency (for 1989, ministry of economy), but the split is confidential. A default emission factor is used.

<u>Uncertainty factors used</u>:

Activities: final year, 5% (coke import statistics, independent); base year, 10%

EF: 30%, based on IPCC default uncertainty

Aluminum: Emissions of PFCs from plant specific online measurements in one plant, and they report to ETS. Prebaked anodes (CWPB but also SWPB) are used. A new owner (since 2002) changed technology, but also to some extent calculation principles. Possibly, in 1989 a second Al plant was operative.

Uncertainty factors used:

Overall emissions: final year, 5% (online measurements, information from operators); base year, 15%

Cement: Information on activity is derived by plant operator; emission calculations are being done by National Environmental Protection Agency (NEPA) based on these figures (via a questionnaire). All 7 cement plants are under ETS, so the procedure merely is for verification.

Uncertainty factors used:

Activities: 2% (direct operator reporting)

EF: 2%, based on stoichiometry and IPCC default uncertainty

Lime: Data from national institute of statistics, split between lime types according to IPCC GPG (no national information); data for 1989-1991 is missing, had to be extrapolated which adds to uncertainty. Limestone use is taken from iron/steel production, again using default factors.

Uncertainty factors used:

Activities: final year, 5% (via statistical processing); base year: 15% (extrapolation); limestone use, 3% (inferred from iron/steel production)

EF: 2%, based on stoichiometry and IPCC default uncertainty

Soda ash, glass: statistical data is being used (national institute of statistics), but as there are only few producers information is confidential. Split between container glass and flat glass is unavailable, estimated only. Statistics are per unit, so the split is needed to obtain glass weight estimates. An emission factor is derived from the Netherlands. Overall, the national inventory provides slightly smaller emissions than the one provided by the industry.

Uncertainty factors used (for both subsectors assumed to be correlated):

Activities: 5% (via statistical processing – note also the missing detailed differentiation of glass types)

EF: 20% (inferred from the Netherlands, possibly systematic error: too low)

Ammonia production: covered by ISPE – will be dealt with in detail in another interview

Nitric acid production: Activity numbers derive from production statistics (national institute of statistics). In regulatory terms, Romanian EPA is in charge. Both institutions work on a subsidiarity principle (34 local agencies, 8 regional to collect and then further feed to national agency). N_2O emissions however are being calculated centrally, using the upper limit emission factor presented in IPCC GPG.

Uncertainty factors used:

Activities: 5% (via statistical processing)

EF: 40% (possibly systematic overestimation)

Adipic acid production: one plant operated until 2001, activity data was directly transmitted to the local agency. For 1989 limited information is available only. As an emission factor the IPCC default was chosen

<u>Uncertainty factors used</u>:

Activities: 15% (single installation, but little information available for 1989)

EF: 10% (IPCC default uncertainty for a default EF)

Energy - combustion

Leading expert/Romania: Gherghiţa Nicodim (NEPA)
together with National Institute for Statistics – energy balance and transport experts

Lead interviewer: Wilfried Winiwarter

The Romanian *energy balance* is established annually, based on several individual surveys:

- Resources and consumption – covers ~14000 enterprises. The selection of enterprises depends on their field of activity and number of employees. A full census is done for
    - Industry > 250 employees
    - Primary and secondary energy producers
    - Transport sector > 50 employees
    - Railways, aviation and naval companies
- A third of enterprises not in census are sampled

Data is collected by county statistical offices (40 counties) and compiled to regional totals before being sent to the national agency. Electronic checking procedures allow to eliminate errors in compiling the national total. Statistical procedures allow to match missing data. The response rate is above 90%, however. Supply (from census) and consumption (from survey) are being reconciled by checking the energy balance. Transformation factors allow to assess losses, again input vs. outputs are being checked. In reconciling, statistical errors are being corrected but company information is maintained.

Companies are expected to split their energy consumption according to the SNAP sectors they use it in (if a company is under different SNAP sector) but it is not clear how countries can do that. This way clear separation between e.g. transport and other activities in a company should become feasible.

A 3% sampling error at 95% confidence has been determined.

Also available are results on the total imports/exports, but these are not being used. These do not provide calorific values urgently needed to guess the detailed C content. A few companies who understand the data they deliver contribute 80-90 % of the total, so that any errors in assigning correct C content that could occur with less experienced companies will not effect results. In addition, fuel gasoline data is available from gas stations to yield road consumption. The Romanian energy balance always is a territorial balance, no residential balance.

The first year the energy balance is available is 2001, backcasting has been performed to 1992; estimating 1989 is “impossible” (exact quotation).

EUROSTAT data is available for stationary combustion (&fugitive emissions): solid/liquid fuels, natural gas, renewables, electricity (not used, as there is one nuclear power plant with two reactors). For some years, difference to the national energy balance of more than 2% is seen. A comparison with the EU-ETS is reported in the NIR of 2008. Differences in lignite still lack of complete explanation.

Uncertainty factors used:

Activities: 3% (statistical variation) for the last year, separately for solid/liquid/gas, which we assume to double (6%) and consider independent for the base year due to the very intransparent situation in 1989.

EF: 0.8% / 4% / 0.5% for liquid/solid/gaseous fuels (statistical analysis from ETS data – ISPE)

Transport: emissions are calculated using COPERT IV (COPERT III until 2012 submission, but updated for the whole time series starting 2005; transport before 2005 based on energy balance fuel consumption only). Mobility characteristics are established via a questionnaire-based sampling:

- Annual mileage per category
- shares urban/rural/highway
- daily mean trip length

average speeds (urban/rural/highway) are sampled in each county (41) using a "testimony vehicle"

COPERT is calibrated towards energy consumption from statistics.

Number of vehicles is available from the number of vehicle ID cards issued – validated with road counts differences in total mileage remain less than 10%, with a tendency to increase. A new approach is being developed as it seems not all scrapped vehicles are also removed from the vehicle ID card register.

For 1989, data of national statistical institute on fuel consumption are on a much coarser basis.

Most rail transport (at least high density lines) is on electric energy, thus direct contribution to GHG emissions are minor. Data are compiled from information submitted by the railway companies (1 big and 4 smaller companies, plus 20 specialized in goods transport). Solid fuel used in railways in the earlier part of the period derives from heating, but not from locomotive engines.

In aviation, register of aircrafts, hours flown and ton-km for Romanian carriers are available, likewise Landing-Takeoff cycles (by carrier and aircraft) on airports. There are 7-10 companies operating larger aircrafts. Since 2010/2011, fuel consumption and fuel sold to operators have been collected.

Consumption of fuels in shipping is reported by 65% of companies (authorized for naval transport) to the naval authorities, like harbour masters. Coast guard and Navy are missing from the statistics (also missing is the military aviation).

Off-road transport in industry (construction etc.) and agriculture (tractors) cannot be differentiated from stationary engines or heating. Thus a proper sectoral attribution is possible to a limited extent only.

Uncertainty factors used for road transport:

Activities: as of energy balance – COPERT is calibrated by total fuel (3% for latest year, 6% for base year)

EF: CO_2 as of energy, CH_4 and N_2O according to the methodology employed: for the latest year, COPERT IV has been employed and thus uncertainty as derived for COPERT IV (same as used for Bulgaria): +/- 48% and 108%, respectively; for the base year, energy statistics and default emission factor have been applied, thus EFs as derived for energy generally are used.

Off-road transport uses IPCC default factors and thus default uncertainties.

Fugitive emissions:

Leading expert/Romania: Gherghiţa Nicodim (NEPA)
together with the National Agency for Mineral Resources and TRANSGAZ S.A.

Lead interviewer: Wilfried Winiwarter

The transit gas network extends over 250 km length, along the Eastern part of the country (Ukraine to Bulgaria). According to the contracts, input equals output, there are no compressor stations on the Romanian territory. Two cleaning events per year cause losses, which have not yet been accounted for.

National gas production and network: Romania produces a major share of her own consumption. There are 2 large producers and 2 small ones. Moreover, 40 local operators are responsible for distribution. The national gas network offers five major storage units and five compressor stations. The “own consumption” is described as 2.5%. There are about 12000 km high pressure lines (up to 40 bars) and 40000 km distribution network. Gas production started in 1908, in 1989 production was almost as high as today. Also the network has been extended, but replacement of old pipelines is performed very gradually. Pipelines’ lifetimes are expected near 50 years. Companies are privatized and owned in part by GdF, E.On.

Oil exploration: many exploration concessions, but one main producer, Petrom (owned by OMV).

For gas and oil industries, default EF are being used.

Coal mining: gas recovery is available on 2 mines which includes measurements. The recovered amount is subtracted from the emissions estimated from the default EF, with emissions totalling about 1000 t/a.

<u>Uncertainty factors used</u>:

Activities: same uncertainty assumed as in Bulgaria

EF: default IPCC uncertainty (as default uncertainty estimates are used)

ETS based national emission factors

Leading expert/Romania: Irene Samoila (Institute for Studies and Power Engineering, ISPE)
Lead interviewer: Wilfried Winiwarter

For some sectors, national emission factors can be derived directly from the ETS data. In those cases, variability between the installations investigated has been used to indicate the uncertainty of the factor.

Ammonia production: There are 7 ammonia production facilities in Romania, all operating under ETS. 5 also produce urea. Operators report ~5% higher production to ETS than to national statistical institute. Using ETS data and natural gas (CH_4) consumption, the emission factor varies by about 5-7%. There is no known difference in the quality of natural gas used.

Comparing emission factors based on methane consumptions with those based on ammonia production, there is good agreement (2%) for 2009 data, but the situation is worse for other years (13% difference in 1989, or 20% difference in 2008).

<u>Uncertainty factors used</u>:

Activities: uncertainty (fully correlated) from energy balance

EF: 10% (“7-10%” following ISPE study)

Agriculture

Leading experts/Romania: Dana Popa (animal husbandry; University of Agronomic Science and Veterinary Medicine – Bucharest, USAMV) / Vasilica Stan (soil emissions; USAMV))
Lead interviewer: Wilfried Winiwarter

Animal husbandry: Animal numbers derive from the national statistical institute. Emission calculation follows the procedures of IPCC (tier 2 approach) which mimics the animals' metabolism. Medium feed intake is assumed, differentiation in farming types is taken between "farms" and "households" (subsistence systems). Conversion rates describing the metabolism are taken from IPCC's default factors for developing countries (cattle & buffaloes).

Animal number is considered correct to +/-2%. Differences to veterinary statistics (used for calculating subsidies) are about twice as high. Nitrogen excretion, which may also be seen as an indicator of metabolic activity, is uncertain by 10-15% (reference to be provided).

<u>Uncertainty factors used</u>:

Activities: 10% (derived from the difficulties to fully explain data), correlated for all animal categories

Methane - EF: 20% (derived according to very limited national reflection of metabolic rates) for enteric fermentation, 30% for manure management (following Bulgarian data)

Nitrous oxide – EF: 50-200%, lognormal distribution (as used for Austria and other countries)

Soil emissions: Agricultural situations vary considerably between Romanian farms. Individual holdings may be as small as 1 ha, or as large as 50000 ha. Fertilizer consumption dropped from 74.8 kg/ha in 1990 to 23 kg/ha in 2000. Between 1990 and 2000, also a strong decrease in fertilizer production is apparent, the expert assumes that a majority of plants closed in that period. Detailed information is available on temperature condition as well as soil type.

Algorithm used to assess emissions may be classified as "IPCC Tier 1b", i.e. a little national information is added to the default IPCC factors. While IPCC default figures are used for crop residues, the amount of biological fixation (legume yields) is taken from data collected by the national statistical institute. Estimating manure amounts uses data from animal husbandry. Indirect emissions are considered to be known with a +/-30% uncertainty, here no specific information on volatilization is available.

Histosols are not used for agriculture in Romania.

<u>Uncertainty factors used</u>:

Activities: 20% (attributed in terms of total N input, not differentiating direct and indirect emissions)

EF: 30-300%, lognormal distribution (as used for Austria and other countries)

Rice fields: Rice production in Romania decreased until 1999, an increase (mostly due to foreign investors, e.g. from Italy who have experience with rice themselves) occurred since then. The further potential is quite limited. Cultivated area is taken from the statistical yearbook, but the extent of cropping can not always be determined from this data. IPCC default factors are used to assess emissions. In the NIR, uncertainties are presented at 5%, an assumption that has been inferred from the data reported by Hungary. EF uncertainty is reported at 40%. Methane emissions from rice are not a major source.

Uncertainty factors used:

Activities: 5% (see above – even if underestimated will be dominated by EF uncertainty anyway)

EF: 50% (IPCC default uncertainty for using default EF)

Carbon stock change (LULUCF)

Leading expert/Romania: Mihai Stoichitescu (Forest Research and Management Institute, ICAS)
Lead interviewer: Wilfried Winiwarter

The Romanian national statistical institute provides data on the area of land use. Moreover, the ministry of environment and forestry provides detailed information (in ha) on afforestation, deforestation and revegetation. Older data are available on reforestation only. Forest area and conversions are assumed to be highly accurate (<1%), and thus negligible in error propagation. No up-to-date forest inventory is available.

Romanian state-owned forests (3.26 Mha or about 50% of the total area) are operated by National Forest Administration-ROMSILVA (RNP), also about 1/3 of the private forest is managed by RNP. 11 forest inspectorates oversee the private forests. Data on all forests (private and state-owned) are collected twice a year, covering reforestation, regeneration, records of types and categories of forests. Expert judgment is used to assess changes.

According to the legal framework, any forest in Romania has to be managed. Thus specific information is available for all area that is legally assigned forest. Less well known is the wood density (previously estimated to be associated with a 40% uncertainty, according to ICAS) in the existing forests, or the potential of tree growth outside the designated forest areas.

Wind breakers, alleys etc. are designated as forest-like areas (about 7% of total forests). Harvest volume is available and includes illegal wood removal. Parameters like root/shoot ratio, basic wood density, and growth factors are available nationally (the latter from a forest inventory of 1985). A full forest inventory has been completed (~28000 sub-plots) but not fully evaluated. In 2013, teams will be sent to the same plots (about 7000) again to reevaluate.

Regrowth/regeneration is done according to forest management plans. These plans are issued centrally and are not influenced by the owners, on the level of production units (up to 9 production units exist per forestry district, 3-25 districts within each of the 41 Romanian counties). Conversion into forest is done by government decree, or via a “donation” in case of private land.

Forest regeneration is being checked and re-checked. If saplings would not grow, additional measures are being taken – appropriately fill-up planting or complete replanting is done according to the damage (which might be due to technical problems, criminal acts or natural reasons). The majority of re-planting is done by private firms (typically, SME’s).

Soil carbon: carbon stock measurements in Romanian forest soils follow a 16x16 km² grid for the whole country (to be changed to 8x8 km² grid in the near future). Out of all grid points, 850 are situated in forests and sampled. Carbon stock may vary considerably due to previous and current land use. In orchards, they are quite close to forests. Forest soils are assumed “not a source” currently.

Effectively, LULUCF emission / carbon sequestration in Romania are being assessed with support of JRC’s Institute for Environment and Sustainability (with the help of a Romanian delegate to JRC). Uncertainty assessment follows closely the procedures taken at least regarding the very large junks of removal/release of carbon.

Uncertainty factors used:

Sink activities: growth factor uncertainty 50%, root/shoot ratio 10%, overall 51%

Removal activity: 20% (expert estimate of 10% not plausible).

Overall uncertainty calculated as difference uncertainty, EF uncertainty for CO2 covered, for CH4 and N2O 100% uncertainty is used as for Bulgaria.

Uncertainty of other land use changes: 30% (as for Bulgaria)

Waste

Leading expert/Romania: Eugen Mitrita (ISPE) together with Brandusa Petroaica (NEPA)
Lead interviewer: Wilfried Winiwarter

Until a few years ago, 99% of all waste in Romania was landfilled. In the new system, sorting, treatment, recovering stages are included. Biodegradable compounds sometimes go to an "integrated waste management system". Incinerators exist only for hazardous waste. Combustion of some industrial and otherwise sorted waste (plastic, paper, textiles) in cement kilns just started. The 2010 inventory in fact uses 2009 data (as 2010 had not been completed).

Total waste has been traced back to 1953. Since 1995/1996, information on "complying landfills" is available – these are managed sites, "deep" sites more than 5 m and "shallow" sites less than 5 m deep.

NEPA's own information reaches back to 2003 (having been established in 2004). Information in the whole period from the 1950s to 2010 derives from studies by ISPE and the National Research and Development Institute for Environmental Protection (ICIM). With a deadline of 2009, illegal dump sites had to be removed and the waste was deposed of at regular landfills. Such illegal sites rather existed in the surroundings of cities as on the countryside a large deal of waste used to be reused anyway.

There are 30 complying landfills in Romania, 9 of which capture landfill gas (only about 10% of landfill gas generated is flared). These are run by private operators. 70 old landfills, non-complying, are operated by municipalities. LEPA, the local branches of NEPA (organized by counties) performs checks and collects data. Operators distinguish waste only by waste type, but the waste collectors also provide information on waste composition. It is not really clear how data for the whole time series have been derived. Annual data as compiled by ICIM definitely can be traced back to the early 1990s only, and waste composition of 2003 had to be extrapolated to the 1950s. Waste generation and composition default of IPCC have been checked with but have not been used. The split into waste types is used only to assess DOC (degradable organic carbon), not to estimate different decay times.

Romania will have to implement all EU directives by 2017.

Uncertainty factors used:

Activities: 20% uncertainty in final year, 30% in base year

EF: DOC (waste composition) 20%, decay times (not established) 30%, in total 36% (error propagation)

The uncertainty introduced by collecting and flaring part of the landfill gas is considered negligible.

F-gases

Leading expert/Romania: Mariana Mihalcea together with Brandusa Petroaica (NEPA)
Lead interviewer: Wilfried Winiwarter

Experts collect data from operators – this collection is done on the level of the local agencies. Operators are the technicians of air conditioning, heat pumps, and since 2011 also industrial refrigeration. F-gases included are as covered in EU directive 842 (2006). Information covers imports, exports, consumption. There is a difference of 35-40% between use quantities and consumption reports by big operators.

Insulation foam from refrigeration is not covered in inventory. No information is available, also not on dismantling – this does not necessarily mean it is not done. Assessment is incomplete, not all operators are covered.

SF_6 is used in some permitted occasions only. The users are known (e.g., one Mg foundry in Romania). NB Romania reports SF_6 from electrical equipment and from fire extinguishers only.

Uncertainty factors used:

Overall uncertainty: due to almost complete lack of knowledge an order of magnitude uncertainty range was assumed. (30%-300%, lognormal distribution) as independent for each entry. Base year and final year were assumed to be statistically dependent.

Health care waste management system

Leading expert/Romania: Ana Maria Bratu (National Institute for Public Health)
Lead interviewer: Wilfried Winiwarter

This topic covers waste produced in 347 sanitary units (hospitals etc.) of Romania. Reports are collected by the directorate of public health in each county and then compiled. In 2011, about 5000 tons waste were incinerated, and about 3000 tons underwent "stabilization" either by private companies or in the hospitals. Some unreported waste has to be added to arrive at totals near 9000 tons.

Information on uncertainties is not available, moreover the sector is quite small and would not contribute specifically.

Waste water

Leading expert/Romania: Iulia Gheorghiu and Corina Boscornea ("Romanian Waters" National Administration) together with Virginia Elena Preda (ISPE)
Lead interviewer: Wilfried Winiwarter

Household wastewater treatment: very different systems exist – mechanical, biological as well as advanced systems. But a considerable part of the population (~45%) is not at all connected and emits directly, 5% operate an individual system (like septic tanks) about half release their wastewater to a centralized system. Even Bucharest covers only half of its population with a wastewater system – and there is little chance that the situation will be resolved by 2018 in accordance with EU legislation.

There are 22 large wastewater treatment plants (>150000 population units) the largest of which is in Bucharest prepared for 2,300,000 population equivalents. 20 plants are completed. 1500 small treatment plants are typically operated by municipalities, also details on operation types are available. Water discharge and default wastewater parameters are being monitored – after all, water consumed and waste released are parameters that at least theoretically the plant has to pay for. Information is collected by Romanian waters (structure: county branches, 11 main river basin authorities). Dual monitoring is pursued, more than 20% difference become unacceptable. This refers to the output from wastewater plants only, input monitoring (that could potentially be used to assess CH_4 and N_2O emissions) is not available.

Chemical industry, metal industry and fertilizer plants operate their own facilities, they are too different (also among each other) to be reasonably compared. Other industry operates installations more similar to household wastewater plants: beer, paper&pulp, refineries. These make up ~37% of total sewage (in 2003) and 25% of treatment.

Sewage sludge is left outdoors for aerobic drying, then treated with lime. As a maximum of 10% can legally be dumped on regulated landfills, currently sludge is being stored temporally on intermediate dump sites. Later on, sludge could either go into agriculture, used to fill closed mines etc.

For the inventory, country specific data on protein consumption (taken from FAO) is used, population numbers and the share of wastewater treatment.

<u>Uncertainty factors used</u>:

Activities: 30% (unclear share of population having access to tertiary treatment system)

EF: IPCC default uncertainties: CH_4 – 30%*30%, error propagation, is 42.5%; N_2O: 50%

APPENDIX 1: guidance questionnaire

Uncertainty of the Romanian Greenhouse gas inventory

[This sheet to be filled in together with the sector expert – please use several sheets for one sector if needed]

Source sector:
Emission generating process:
Units of statistical entities (activity):
Units of emission factor (usually mass per activity unit):

Please provide information on uncertainty: (Uncertainty: realistic margin of variation attached to each datapoint)

Statistical input used for emission assessment (activities) – if needed, differentiate between base year (1989) and current year

Relevant activities in Romania (all in t/yr or % of best estimate):	**Lower bound**	**Upper bound**	**Asymmetry*)**	**Reference, if available**

*) Please note if best estimate is known to be close to lower or upper bound, and try to provide additional information

Note on correlations, if any (i.e., common data assessment and retrospective split):

Parameters (Emission factors and other entities directly effecting emission calculations)

Note on correlations, if any:

Name of expert:

APPENDIX 2: Schedule for the Workshop on 'Key Category Analysis and Uncertainty Analysis for Romanian National GHG Inventory'

		Topic	Interviewee Group	TeamNet	NEPA	Umwelt-bundesamt
03.09. Monday	9:00-11:00	Introduction KCA & Uncertainties	Interested colleagues are welcome.	all	Inventory Team All	all
	11:00-13:00	Interviews Industrial Processes	NEPA ETS department NEPA LCP department NEPA ePRTR department NEPA IPCC / plant permits department Ministry of Environment and Forests (permit)	Responsible Person	IP Team	Wilfried Winiwarter Traute Köther Andreas Zechmeister
	Lunch					
	14:00 15:30	Interviews Industrial Processes	National Institute for Statistics (I.N.S) - Industrial process (Production statistics, import & export statistics)	Responsible Person	IP Team	Wilfried Winiwarter Traute Köther
	15:30-17:00	Interviews Industrial Processes	Ministry of Economy, Trade and Business Environment (M.E.C.M.A) people with overall industry overview, F-gas, F-gas-Ordinance	Responsible Person	IP Team	Wilfried Winiwarter Traute Köther
	14:00 17:00	KCA		Responsible Person	Responsible Person	Andreas Zechmeister
04.09. Tuesday	9-12	Interview Energy	National Institute for Statistics (I.N.S) - Energy Balance Ministry of Economy, Trade and Business Environment (M.E.C.M.A)	Responsible Person	IP Team	Wilfried Winiwarter Traute Köther Andreas Zechmeister
	lunch					
	13-15	Interview Energy - transport	National Institute for Statistics (I.N.S) – Transports data (navigation, aviation, road) Romanian Automobile Register (R.A.R) Romanian Civil Aviation Authority	Responsible Person	IP Team	Wilfried Winiwarter Andreas Zechmeister
	15-17	Interview Fugitive emission	National Agency for Mineral Resources (A.N.R.M) National Gas Transmission Company (TRANSGAZ S.A)	Responsible Person	Energy Team	Wilfried Winiwarter Traute Köther

		Topic	Interviewee Group	TeamNet	NEPA	Umwelt-bundesamt
05.09. Wednesday	9-11	Interviews Energy	ISPE – Authors of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors **Energy**, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods“	Responsible Person	Energy Team ETS Team LCP Team	Wilfried Winiwarter Traute Köther Andreas Zechmeister
	11-13	Interview Industry	ISPE – Authors of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, **Industrial Process**, Agriculture and Waste, to allow for the higher tier calculation methods“	Responsible Person	IP Team ETS Team LCP Team	Wilfried Winiwarter Traute Köther
	lunch					
	13-15	Interview Agriculture	National Institute for Statistics (I.N.S) - Agriculture Ministry of Agriculture, Forests and Rural Development (MADR) – husbandry Ministry of Agriculture, Forests and Rural Development (MADR) – cultivation	Responsible Person	Agriculture Team	Wilfried Winiwarter Traute Köther Andreas Zechmeister
	15-17	Interview Agriculture	National Research and Development Institute for Soil Science Agro-Chemistry and Environment (I.C.P.A)	Responsible Person	Agriculture Team	Wilfried Winiwarter Traute Köther
06.09.Thursday	9-11	Interview Agriculture	ISPE - Authors of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, **Agriculture** and Waste, to allow for the higher tier calculation methods“	Responsible Person	Agriculture Team	Wilfried Winiwarter Traute Köther
	11-13	Interview LULUCF	National Forest Administration (RNP)	Responsible Person	LULUCF Team	Wilfried Winiwarter Traute Köther
	lunch					
	13-15	Interview LULUCF	Forest Research and Management Institute (ICAS)	Responsible Person	LULUCF Team	Wilfried Winiwarter Traute Köther
	15-17	Interview LULUCF	National Research and Development Institute for Soil Science Agro-Chemistry and Environment (I.C.P.A)	Responsible Person	LULUCF Team	Wilfried Winiwarter Traute Köther
07.09.Friday	9-11	Interview Waste	National Institute for Statistics - Waste National Environmental Protection Agency (NEPA) – Waste and hazardous chemical substances, soil and subsoil Directorate	Responsible Person	Waste Team	Wilfried Winiwarter Andreas Zechmeister
	11-12	Interview Waste Water	National Administration “Romanian Waters”	Responsible Person	Waste Team	Wilfried Winiwarter Andreas Zechmeister
	12-13	Interview Waste	ISPE - Authors of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and **Waste**, to allow for the higher tier calculation methods“	Responsible Person	Waste Team	Wilfried Winiwarter Traute Köther Andreas Zechmeister
	lunch					
	13-15	Software @Risk	Interested colleagues are welcome.	Responsible Person	Responsible Person	Andreas Zechmeister Wilfried Winiwarter
	15-16	Final Discussion	Interested colleagues are welcome.	all	all	All

Sector	Data sources	Interview group						
CRF 1 Energy	• National Institute for Statistics (I.N.S) - Energy Balance	A						
	• National Institute for Statistics (I.N.S) – Transports data (navigation, aviation, road)		B					
	• Ministry of Economy, Trade and Business Environment (M.E.C.M.A)	A						
	• National Gas Transmission Company (TRANSGAZ S.A)			C				
	• National Agency for Mineral Resources (A.N.R.M)			C				
	• Ministry of Transportation and Infrastructure (M.T.I)		B					
	• Romanian Automobile Register (R.A.R)		B					
	• Romanian Civil Aviation Authority		B					
	• ISPE – Authors of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors **Energy**, Industrial Process, Agriculture and Waste, to allow for the higher tier calculation methods“				D			
	• NEPA – ETS department	A	B	C	D			
	• NEPA –LCP department	A	B	C	D			
	• Inventory Team Energy (and Industry)	A	B	C	D			
	Group A	3 - 4 hours						
	Group B	2 hours						
	Group C	2 hours						
	Group D	2 hours						

Sector	Data sources	Interview group						
CRF 2 Industrial Processes & CRF 3 Solvent & other product use	• National Institute for Statistics (I.N.S) - Industrial process-Production of cement and lime (here especially people who deal with Prodcom & CN8 data)	H						
	• ISPE – Authors of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, **Industrial Process**, Agriculture and Waste, to allow for the higher tier calculation methods“		I					
	• Ministry of Economy, Trade and Business Environment (M.E.C.M.A) people with overall industry overview, F-gas, ...							
	• People who deal with F-gas and F-gas ordinance			J				
	• NEPA – ETS department (together with Energy)		I		K			
	• NEPA –LCP department	H			K			
	• NEPA or Romanian Ministry of Environment and Forests – IPCC / plant permits				K			
	• NEPA – ePRTR department	H			K			
	• Inventory Team Industry (and Energy)	H	I	J	K			
	Group H	2 hours						
	Group I	2 hours						
	Group J	2 hours						
	Group K	2 hours						

Sector	Data sources	Interview group						
CRF 4 Agriculture	• National Institute for Statistics (I.N.S) - Agriculture	L						
	• Ministry of Agriculture, Forests and Rural Development (MADR) – *husbandry*	L						
	• Ministry of Agriculture, Forests and Rural Development (MADR) – *cultivation*	L						
	• National Research and Development Institute for Soil Science Agro-Chemistry and Environment (I.C.P.A)		M					
	• Other not yet identified data provider for ⇨ Fertiliser ↑ ⇨ Milk production ↑ ⇨ AWMS ↑ ⇨ Feeding system ↑							
	• ISPE - Authors of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, **Agriculture** and Waste, to allow for the higher tier calculation methods“			N				
	• Inventory Team Agriculture	L	M	N				
	Group L (maybe split if useful)	2 – 3 hours						
	Group M (maybe together with N if useful)	2 hours						
	Group N (maybe together with M if useful)	2 hours						

Sector	Data sources	Interview group						
CRF 5 LULUCF	• Ministry of Environment and Forests-Forests General Directorate (2009-2010)							
	• National Forest Administration (RNP)	S						
	• Forest Research and Management Institute (ICAS)		T					
	• National Research and Development Institute for Soil Science Agro-Chemistry and Environment (I.C.P.A)			U				
	• Other not yet identified data provider Where do the Land Use data come from?							
	• Inventory Team LULUCF	S	T	U				
	Group S (maybe together with T and/or U if useful)	2 hours						
	Group T (maybe together with S and/or U if useful)	2 hours						
	Group U (maybe together with S and/or T if useful)	2 hours						

Sector	Data sources	Interview group						
CRF 6 Waste	• National Institute for Statistics - Waste							
	• National Environmental Protection Agency (NEPA) – Waste and hazardous chemical substances, soil and subsoil Directorate	V						
	• National Administration “Romanian Waters”		W					
	• ISPE - Authors of the study „Elaboration of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Process, Agriculture and **Waste**, to allow for the higher tier calculation methods“			X				
	• Other not yet identified data provider							
	• Inventory Team Waste	V	W	X				
	Group V	2 hours						
	Group W	1 hours						
	Group X	1 hours						

APPENDIX 3: General presentation of methodology

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Uncertainty in national GHG inventories

General principles

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Objectives

- General principles of uncertainty analysis
- use for national inventories
- "good practice" considerations

- Method to assess / understand uncertainties
- Methods of error propagation and their application

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Why uncertainty analysis?

… if all is well known anyway!

Sources of uncertainty (examples):
- Imprecise measurement data
- Limited applicability of surrogate information / proxies
- Models used reflect a real situation only partly

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Benefits of information on uncertainty

- Identification of reliable areas in inventories
- Identification of areas that are subject to improvement

→ inventory improvement program

- Inform users on robustness
- Assess limitation of applicability
- Establish confidence and trust in inventory use

→ quality indicator

Regulatory requirements (UNFCCC)

- Uncertainty assessment embedded in QA/QC program
- Methodological inventory development routinely coupled with uncertainty analysis
- Inventory improvement (also) based on a-priori uncertainty information:
  priorities set to assess more uncertain parameters
- Inventory uncertainty is ***not*** used to qualify inventory data (no posterior use)

Method

- Emission inventory is made up from input data (statistical quantities, emission factors)
- Task: assess uncertainties of input parameters
  - Familiarize with situation in country
  - Interview source sector experts
  - Obtain specific national information on magnitude of uncertainty, OR
  - Derive information from appropriate literature
- Combine input uncertainty:
  - Error propagation (uncertainty propagation)
  - Monte-Carlo method

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Uncertainty propagation …

- Error propagation works for uncorrelated (independent) variables:

$$s_{AB} = \sqrt{s_A^{\,2} + s_B^{\,2}} \qquad \text{(Additive terms: AB = A + B)}$$

$$RSD_{AB} = \sqrt{RSD_A^{\,2} + RSD_B^{\,2}} \qquad \text{(Multiplicative terms: AB = A x B)}$$

s … Standard Deviation, RSD … Relative Standard Deviation s/x

- Some boundary condition exist for application, most important of which refers to dependency!

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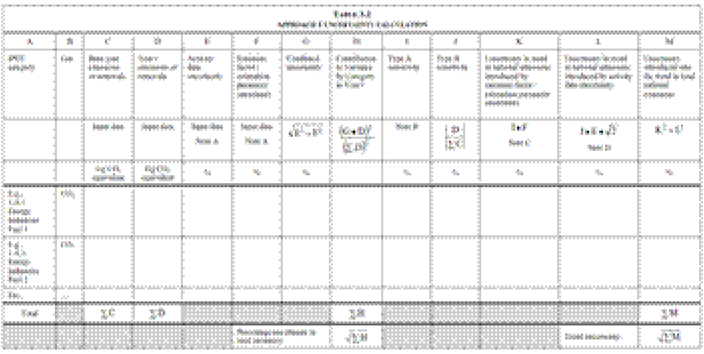
IPCC Approach 1 error propagation sheet (2006 IPCC GL)



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Monte-Carlo simulations

- Random variation of input & multiple calculations

- Correlation of inputs, unusual distributions of input parameters
  … all can be considered

- In practice important: correlated input parameters

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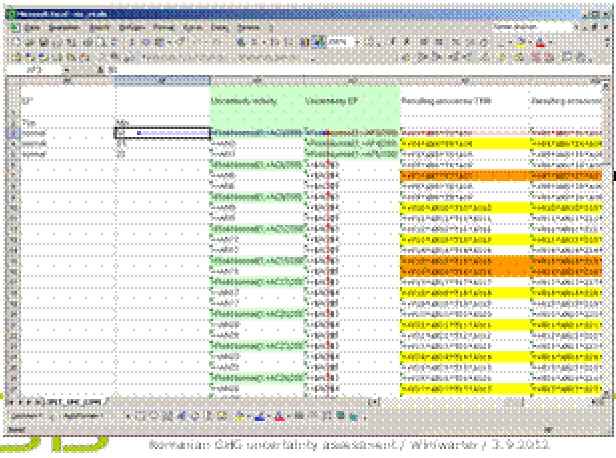
Monte-Carlo simulations



Uncertainty propagation …

- Error propagation algorithms work as well as Monte-Carlo methods do …

… as long as correlation is addressed adequately.

Error propagation works for uncorrelated (independent) variables:

$E = EF_1 * A_1 + EF_2 * A_2 + EF_3 * A_3 + \ldots$

Note: additive terms allow for overall <u>decrease</u> of relative uncertainty

MESSAGE 1: error propagation also works for correlated input

Transformation required to remove correlated parameters from calculation:

$E = EF_1 * A_1 + EF_2 * A_2 + EF_2 * A_3 + \ldots$

$\rightarrow E = EF_1 * A_1 + EF_2 \ (A_2 + A_3) + \ldots$

Note: Uncertainty decrease diminishes (especially if – in the above example – the major uncertainty is with EF)

Correlated parameters in practice

- Example 1: Energy balance

  Sum = $A_1 + A_2 + A_3 + \ldots$

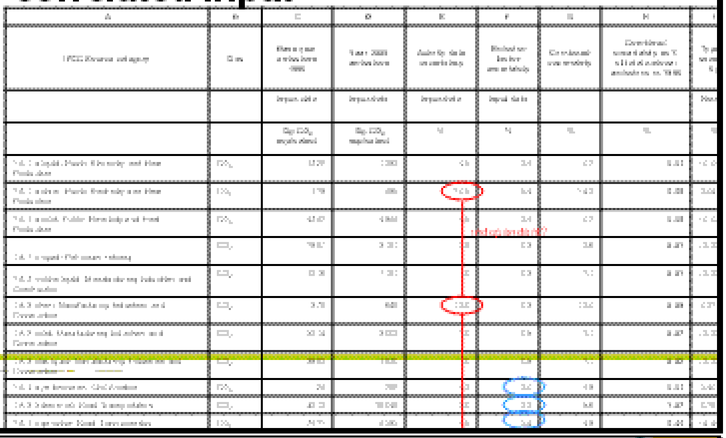
  (with Sum at much lower absolute uncertainty than any of the elements)
- Example 2: Methane emissions from combustion

  $E = g_1 * EF_1 * A_1 + g_1 * EF_2 * A_2 + g_1 * EF_3 * A_3 + \ldots$

  $\rightarrow$ $E = g_1 * (EF_1 * A_1 + EF_2 * A_2 + EF_3 * A_3 + \ldots)$

  Note: Despite of apparently different EF's, the largest share of uncertainty (g_1 as fraction of HC measured considered methane) is maintained due to correlation

MESSAGE 2: Tier 1 calculation won't work with correlated input



Consequence for Austria

- Tier 1 approach (error propagation sheet)

Level uncertainty 2005: 3.66 %

Trend uncertainty 1990-2005: 2.84 %-points

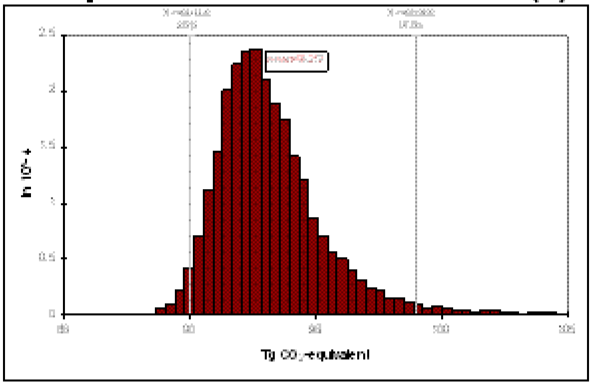
- Tier 2 approach (Monte-Carlo)
  – attempts to exclude occurrence of correlated inputs

Level uncertainty 2005: 5.14 %

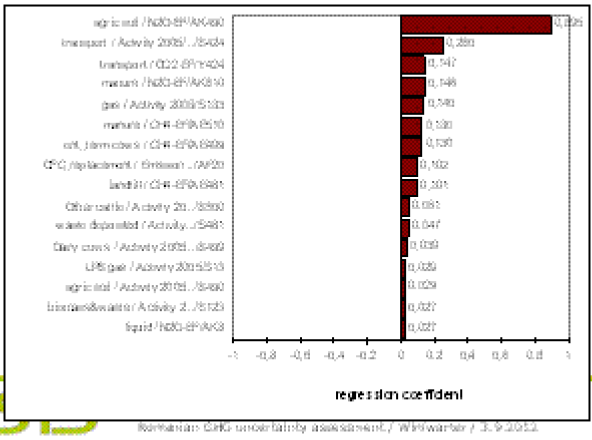
Trend uncertainty 1990-2005: 2.69 %-points

Additional effort leads to higher uncertainty ??

Examples from Austria: result (1)



Examples from Austria: result (2)



MESSAGE 3:
it all depends on soil N_2O …

- Direct and indirect N_2O EF's should be considered correlated → main difference between results using Tier 1 and 2
- Skewness of PDF fully reflects lognorm distrubution of N_2O EF uncertainty
- Compared to an earlier uncertainty estimate for Austria, the present IPCC uncertainty range seems more credible (factor 10 instead of previously 100), thus could not be easily dismissed → overall uncertainty becomes higher
- Arbitrary assumptions on soil N_2O determine final results on uncertainty:
  observed variability ≠ uncertainty

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Good Practice to assess input uncertainties

- Systematic way to obtain information
- Expert interviews (questionnaire as guidance)
  - Measurement data
  - Literature references
  - Expert judgement
  - Transfer from other countries

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Uncertainty of the Romanian Greenhouse gas inventory

[This sheet to be filled in together with the sector expert – please use several sheets for one sector if needed]

Source sector:
Emission generating process:
Units of statistical entities (activity):
Units of emission factor (usually mass per activity unit):

Please provide information on uncertainty: (Uncertainty: validity/margin of variation attached to each datapoint)

Statistical input used for emission assessment (activities) – if needed, differentiate between base year (1989) and current year

Relevant activities in Romania (all in t/yr or % of best estimate):	Lower bound	Upper bound	Asymmetry*)	Reference, if available

*) Please note if best estimate is known to be close to lower or upper bound, and try to provide additional information

Note on correlations, if any (i.e., common data assessment and retrospective split):

Parameters: (Emission factors and other entities directly affecting emission calculations)

Note on correlations, if any:

Name of expert:

....

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Specifications for good practice data collection

- Principles of transparency, consistency, comparability, completeness, and accuracy – "TACCC" (IPCC 2006 GL, QA/QC)
- Full documentation of assumptions
- Making best use of available resources ("key sector" analysis strives to avoid unnecessary work)
- Consider (lack of) effect when going into details, focus on where improvements can be expected