Informative note on the Emission inventory compiled by EDGAR using also EPRTR data for the INGOS project

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1. Intro

The 2000-2010 global time series for CH4 and N2O emissions are mainly based on the EDGAR emission inventory, version v4.2FT2010 (Olivier & Janssens-Maenhout, 2012). The default emission factors from the 2006 IPCC Guidelines (IPCC, 2006) were used (instead of the Revised 1996 IPCC Guidelines), except for road transport where technology-specific factors were used from the EMEP-EEA emission inventory guidebook (EEA, 2009). The EDGAR v4.2 FT2010 provides an extended time series for all sources by adding emissions for 2009 and 2010 to the EDGAR v4.2 version available at http://edgar.jrc.ec.europa.eu/overview.php?v=42 (EC-JRC/PBL, 2011).

The emissions of EDGARv4.2FT2010 are gridded with improved EDGAR proxy data, documented in the EDGAR gridding manual (Janssens-Maenhout et al, 2013)

For the INGOS project, an upgrade of the CH4 and N2O gridmaps with data of EPRTR, available at http://prtr.ec.europa.eu/FacilityLevels.aspx is undertaken. The upgrade consisted mainly in better spatial distribution with the facility location of EPRTR database, version v4.2. There are three different methods to upgrade with the info of EPRTR:

- method 1: use only EPRTR point source data (as reported, i.e. without any scaling) for the EPRTR countries
- method 2: use EPRTR point source data, but scale them to match the EDGARv4.2FT2010 total for that sector and country
- method 3: use EPRTR point source data (as reported, i.e. without any scaling) but add a diffusive source for the difference between EDGARv4.2FT2010 and the EPRTR point source with the EDGAR proxy distribution so that the country and sector-specific total matches the EDGARv4.2FT2010 total for that sector in that country.

2. CH4 emission gridmaps

Two sets of CH4 emission data are provided:

1. **Baseline 2000-2010 for CH4**: this is the complete anthropogenic emissions dataset with EDGARv4.2FT2010 time series, gridded with upgraded EDGAR proxy data, except for coal mining, oil and gas production, solid waste disposal and wastewater in which EPRTR point source data were applied.
2. **Option: CH4 official emission data of EPRTR 2007-2010**: this is a subset providing anthropogenic emissions for some sectors (coal mining, solid waste, wastewater, oil production and gas production) as reported to EPRTR. The sectors are only gapfilled with EDGARv4.2FT2010 for those countries where no data are reported, or for those (diffusive) subsectors that are not subject to EPRTR reporting.

2.1 Baseline 2000-2010 for CH4

2.1.1 The CH4 inventory compilation under EDGARv4.2FT2010

For the baseline emission gridmaps the 2000-2010 emissions equals in sector- and country-specific total the values of the EDGARv4.2FT2010 time series. The compilation of the EDGARv4.2FT2010 emission inventory applied a bottom up approach with the following data information sources:

- For the agricultural soils (AGS): The total area harvested for rice cultivation was obtained from FAO (2007d, 2010), which was split over different ecology types (rainfed, irrigated, deep water and upland) using IRRI (2007). The total harvested area of rice production in China was increased by 40%, due to recognition that official harvested rice area statistics of China are largely underestimating the actual area (Denier van der Gon, 1999; 2000). However, methane emission factors were not from IPCC (2006) but from a review of Neue (1997), and country-specific studies by Mitra et al. (2004), Gupta et al. (2002) and IIASA (2007).
- For the agricultural waste burning (AWB): The fractions of crop residues removed from and burned in the field were estimated using data of Yevich and Logan (2003) and UNFCCC (2008) for fractions burned in the field by Annex I countries.
- For the energy, manufacturing and transformation (EMT): IEA energy statistics for OECD and Non-OECD countries (completed with EIA energy data to disaggregate some IEA regions into countries) were applied to calculate the emissions from energy production, energy consumption (small scale and industrial scale) and from energy transformation, each subsector per country and per fuel type of coal, gas and oil. For charcoal production the emissions factors are from Andreae (2011).
- For the enteric fermentation (ENF): Livestock numbers were taken from FAO (2007b,c, 2010). For enteric fermentation for cattle, country-specific methane emission factors were calculated following the IPCC methodology (IPCC, 2006) using country-specific milk yield (dairy cattle) and carcass weight (other cattle) trends from FAO (2007c) to estimate the trends in the emission factors. For other animal types, regional emission factors from IPCC (2006) were used.
- For the fossil fuel fires: Data for long-lasting underground coal fires have been compiled for China, India, USA and Australia based on van Dijk et al (2010). Oil fires are the Kuwait oil fires in 1991 due to the first Gulf War.
- For the fugitive emissions form solid fossil fuel mining (FFS): hard coal and brown coal production data have been split into surface and underground mining based on various national reports. Emission factors for coal mining are based on average depths of coal production based on CIAB (1994), EURACOAL (2008), Kirchgessner et al. (1993) and include post mining emissions. Methane recovery from coal mining was included for twelve countries amounting to about 1.3 Tg in 1990 (of which about one-third was allocated to the United States and Germany). Recovery in 2005 was estimated at 2.8 Tg (of which 50% in China and 25% in the United States (UNFCCC, 2010; Thakur et al., 1994, 1996; EPA, 2008; Cheng et al., 2011).
- For the gas production and distribution (PRO_GAS): For gas transport and distribution, pipeline length was used as activity data. Pipeline length and material statistics are taken from reports on Europe by Eurogas and Marcogaz, national reports (e.g. the United States and Canada), UNFCCC (2008) and supplemental data

from CIA (2008). The CO2 emission factor excludes the indirect emissions through gas venting.

- For the oil production and distribution (PRO_OIL): For oil production, transport and distribution GHG emissions factors are from IPCC (2006), supplemented with data from UNFCCC (2008), except for the emission factor for CH4 from oil tanker transport which is from Rudd and Hill (2001). The CH4 emission factor for venting and flaring has been derived from country-specific data reported to UNFCCC (2010), with the average value used as global default, applied to all other countries. Total amounts of natural gas flared (sometimes including gas vented) for most countries for 1994 onwards are primarily based on amounts of gas flared determined from the satellite observations of the intensity of flaring lights (Elvidge et al., 2009), reported by NOAA (2011).
- For the industrial processes and product use (IPPU): Process emissions from iron& steel and from chemicals are based on UN Industrial Commodity Statistics (UN, 2006a), often supplemented for recent years by data from the US Geological Survey (USGS, 2007).
- For the manure management (MNM): The shares of different animal waste management systems were based on regional defaults provided in IPCC (2006) and regional trend estimates for diary and non-dairy cattle for the fractions stall-fed, extensive grazing and mixed systems from Bouwman et al. (2005). Methane emissions from manure management were estimated by applying default IPCC emission factors for each country and temperature zone. For the latter, the 1x1 degree grid map for non-dairy cattle from Lerner et al. (1988) was used and the annual average temperature per grid cell from New et al. (1999) to calculate the livestock fractions of the countries in 19 annual mean temperature zones for cattle, swine and buffalo and three climates zones for other animals (cold, temperate, warm).
- For the non-road transportation (TNR): IEA energy statistics and IPCC 2006 EF
- For the residential sector (RES): IEA energy statistics and IPCC 2006 EF
- For the road transportation (TRO): IEA energy statistics and IPCC 2006 EF
- For the solid waste disposal (SWD): For estimating the amount of organic solid waste in landfills three key parameters have to be determined: (a) Municipal Solid Waste (MSW) generated per year (kg/cap), (b) fraction of total solid waste that is landfilled, and (c) fraction of Degradable Organic Carbon (DOC) in the MSW (%). Total and urban population figures were taken from UN (2006b).The amounts of Municipal Solid Waste (MSW) generated are the primary statistics for emissions from landfills. The 2006 IPCC Guidelines provide country-specific data for 2000 of the amount of MSW generated per year per capita (urban capita in case of non-Annex I countries) and the fraction landfilled and incinerated. Based on regional defaults for the composition of MSW, IPCC (2006) provides regional defaults for the fraction Degradable Organic Carbon (DOC), which was adjusted with UNFCCC (2008) data for Annex I. For calculation of methane emissions from landfills using the First Order Decay (FOD) model of IPCC (2006), the Methane Conversion Factor (MCF), the k value and the Oxidation Factor (OX) are required. The MCF represents the type of landfill, managed aerobic or anaerobic, unmanaged deep or shallow. Apart from country-specific time series for 11 Annex I countries, two sets of MCF time series for Annex I and non-Annex I countries were determined based on assumptions for the fractions of the four landfill types over time. For the k-value, which is the methane generation rate (that is inversely proportional to the half-life value of the DOC), default regional MSW composition weighted k-values for four climate zones (tropical dry/wet and non-tropical dry/wet) are provided by IPCC

(2006). For EDGAR 4.2 FT2010, country-specific values were calculated using the country-specific fractions of population (urban population for non-Annex I countries) in each climate zone. For the Oxidation Factor the IPCC default values were used (0.1 for Annex I and 0 for non-Annex I). Finally, the amounts of methane recovered (and used or flared), that is to be subtracted from the gross methane emissions, were used as reported by Annex I countries in UNFCCC (2010) and for 23 non-Annex I countries from CDM projects reported by the UNEP Risø Centre (2011). Total recovery in 2010 is estimated at 12.9 Tg CH4, half of which by the United States and almost one fifth by the United Kingdom; about 13% is recovered by non-Annex I countries.

- For the waste water treatment (WWT): For domestic wastewater, total organics in wastewater (BOD5) was estimated using regional default or country-specific default values for BOD5 generation per capita per day provided by IPCC (2006). For industrial wastewater, total organically degradable material in wastewater from industry was calculated per type of industry from WW generation per ton of product and COD values (chemical oxygen demand (industrial degradable organic component in wastewater) in kg/m3 WW, using defaults from IPCC (2006). Production statistics for industry types that produce most organics in wastewater are available from UN (2006a). Examples are meat and poultry, raw sugar, alcohol, pulp and organic chemicals. To estimate methane emissions from domestic wastewater, additional information is required on the WW treatment systems, such as sewer (to wastewater treatment plants (WWTP) or to raw discharge), latrines by type, open pits and septic tanks. Regional or country-specific default fractions for 2000 were from IPCC (2006). In addition, country-specific fractions of improved sanitation over time from Van Drecht et al. (2009) were used, based on the UN Water Supply and Sanitation (WSS) dataset and other national reports, and fractions reported by Doorn and Liles (1999). For industrial methane emissions, fractions on-site treatment in WWTP, sewer with and without city-WWTP, and raw discharge were based on regional values reported by Doorn et al. (1997). To calculate methane emissions from wastewater, default factors provided by IPCC (2006) per type of WW treatment were used, with default methane correction factors (MCF) per type of treatment. For Annex I countries, OECD or EIT average fractions of methane recovered in WWTPs (and either used as biogas or flared) were used, except for five countries for which country-specific values reported in UNFCCC (2008) were used.

2.1.2 The gridding of the CH4 emissions with EDGAR and EPRTR data

Baseline emissions 2000-2010 of EDGARv4.2FT2010 are gridded with upgraded EDGAR proxy data, except for coal mining, oil and gas production (refineries, the oil extraction and gas extraction), solid waste disposal (landfills and incineration) and wastewater (industrial). An overview of the gridmaps used for each of the sectors is given in Table 1. For more info on the EDGAR proxy data we refer to EDGAR gridding manual of Janssens-Maenhout et al (2013).

Table 1: For the CH4 main sectors: overview of the different gridmaps used for each of the human activities (with IPCC identification code). Special proxy data developed with the geospatial coordinates of the facilities in the EPRTR data start with "ingos_" to differentiate from the standard EDGAR proxy data

main sectors grouping the human activities	IPCC-code for activity	description	CH4_gridmap_baseline
energy_manufacturing_transformation	1.A1a.	power plants (not combusting biomass)	PP_CARMA_2007
energy_manufacturing_transformation	1.A1c.1	transformation coal - BKB	Urban_population
energy_manufacturing_transformation	1.A1c.2	other transformation of solid fuel and energy carriers	Urban_population
oil_production_refineries	1.A1r. (eprtr facilities)	refinery facilities of EPRTR	ingos_CH4_refineries
oil_production_refineries	1.A1r.	petroleum refining (other than EPRTR)	oil_refineries
energy_manufacturing_transformation	1.A2a.x	industrial combustion of biomass for iron&steel	steel
energy_manufacturing_transformation	1.A2a.	industrial combustion of fossil fuel for iron&steel	steel
energy_manufacturing_transformation	1.A2b.x	industrial combustion of biomass for nonferrous	nonferrous
energy_manufacturing_transformation	1.A2b.	industrial combustion of fossil fuel for nonferrous	nonferrous
energy_manufacturing_transformation	1.A2c.x	industrial combustion of biomass for chemical industry	chemical
energy_manufacturing_transformation	1.A2c.	industrial combustion of fossil fuel for chemical industry	chemical
energy_manufacturing_transformation	1.A2d.x	combustion of biomass for paper industry	Urban_population
energy_manufacturing_transformation	1.A2d.	combustion for paper industry	Urban_population
energy_manufacturing_transformation	1.A2e.x	combustion of biomass for food	Urban_population
energy_manufacturing_transformation	1.A2e.	combustion for food	Urban_population
energy_manufacturing_transformation	1.A2f.	combustion for other (incl. cement)	Urban_population
TNR_non-road_transportation	1.A3a.	domestic aviation	air_domestic
TRO_road_transportation	1.A3b.	road transport	Roads
TNR_non-road_transportation	1.A3c.	railway	railways
TNR_non-road_transportation	1.A3d.	inland waterway	fishing
TNR_non-road_transportation	1.A3e.	non-road other transport	Rural_population
RCO_residential	1.A4a.x	combustion of biomass for buildings of commercial and public services	Urban_population
RCO_residential	1.A4a.	combustion of fossil for buildings of commercial and public services	Urban_population
RCO_residential	1.A4b.x	combustion of biomass for buildings of residential sector	pop_01x01_LO
RCO_residential	1.A4b.	combustion of fossil for buildings of residential sector	pop_01x01_LO
RCO_residential	1.A4c.1x	combustion of biomass for buildings of agriculture or forestry sector	Rural_population
RCO_residential	1.A4c.1	combustion of fossil for buildings of agriculture or forestry sector	Rural_population
RCO_residential	1.A4c.2	combustion of fossil for off-road machinery in agri or forestry sector	Rural_population
RCO_residential	1.A4c.3	combustion for equipment & buildings in fisheries sector	Rural_population
RCO_residential	1.A4d.x	non-specified use of biomass for buildings, equipment, machinery	pop_01x01_LO
RCO_residential	1.A4d.	non-specified use of fossil for buildings, equipment, machinery	pop_01x01_LO
RCO_residential	1.A5b.1	Off-road machinery: mining (diesel)	Rural_population
energy_manufacturing_transformation	1.B1b.1	solid fuel transformation	Urban_population
energy_manufacturing_transformation	1.B1b.3x	charcoal production	pop_01x01_LO
fugitive_from_solid	1.B1r. (eprtr facilities)	coal mining sites of EPRTR	ingos_CH4_coal_mines
fugitive_from_solid	1.B1r.	coal mines (other than EPRTR)	ingos_CH4_coal_mines
gas_production_distribution	1.B2b.3	transmission of gas (pipelines from production to distributor)	pop_01x01_LO
gas_production_distribution	1.B2b.4	distribution of gas (to the citizen)	Urban_population
gas_production_distribution	1.B2b.	gas production	gas_production
oil_production_refineries	1.B2c.	venting and flaring at oil & gas production sites	oil_production
TNR_non-road_transportation	1.C1 .	international aviation	air_international
TNR_non-road_transportation	1.C2 .	international shipping	Ships_2007
IPPU_industrial_process_&_product_use	2.B .	process emissions of chemical industry	chemical
IPPU_industrial_process_&_product_use	2.C .	process emissions of iron & steel industry	steel
ENF_enteric_fermentation	4.A .	enteric fermentation of cattle	cattle_01x01_LO
MNM_manure_management	4.B .	manure management of cattle	cattle_01x01_LO
AGS_agricultural_soils	4.C .	rice cultivation	rice
AWB_agricultural_waste_burning	4.F .	field burning of agricultural residues	crop_01x01_LO
SWD_solid_waste_disposal	6.A . (eprtr facilities)	solid waste disposal in landfill facilities of EPRTR	ingos_ch4_swd_ldf
SWD_solid_waste_disposal	6.A .	solid waste disposal in landfill facilities (other than EPRTR)	ingos_ch4_swd_ldf
WWT_Waste_water	6.B1 . (eprtr facilities)	industrial waste water treatment facilities of EPRTR	waste_wwt
WWT_Waste_water	6.B1 .	industrial waste water treatmet facilities (other than EPRTR)	Urban_population
WWT_Waste_water	6.B2 .	domestic waste water treatment	pop_01x01_LO
SWD_solid_waste_disposal	6.C . (eprtr facilities)	waste incineration facilities of EPRTR	ingos_ch4_swd_inc
SWD_solid_waste_disposal	6.C .	waste incineration facilities (other than EPRTR)	waste_swd_inc
SWD_solid_waste_disposal	6.D .	other solid waste disposal (hazardous, compost)	waste_swd_inc
FFF_fossil_fuel_fires	7.A .	fossil fuel fires: coal (underground) and oil (Kuwait)	fossil_fuel_fires

The EPRTR data, version v4.2, was used applying method 2 for the coal mines emitting CH4 (5 EU countries[1]), waste incineration (5 EU countries), refineries (10 EU countries + 1 nonEU), oil extraction (3 EU countries+ 1nonEU), gas extraction (4 EU countries + 1 nonEU) and applying method 3 for the landfills (24 EU countries + Iceland) and the industrial wastewater emissions (13 EU countries).

The proxy datasets based on EPRTR are yearly datasets, 2007, 2008, 2009 and 2010 (with for coal mining considerable variation in number of facilities over the 4 years). For the years 2000-2006 the same proxy data as for 2007 are used. The scaling - a relative weighting within the country- of the emissions was based on the CH4 emitted by the facilities, with exception for the waste incineration. For the incineration the CO2 emissions are less uncertain and more representative for the level of the activity and therefore selected for the scaling instead of the CH4 emissions.

2.2 Option: CH4 official emission data of EPRTR 2007-2010

The CH4 dataset reported for the facilities under EPRTR has been compared to the EDGAR estimates. The EPRTR data for coal mining show lower estimates for the 9 countries than the EDGARv4.2FT2010, as shown in Table 2 and Fig. 1. The EPRTR are in the same range as reported for UNFCCC and can indicate that the uncertain emission factor estimate following the general IPCC guidelines lead to overestimation.

Table2: Comparison of the coal mining data reported in EPRTR (v4.2) and the EDGAR (v4.2) data

	EPRTR					EDGAR				
Country	2007	2008	2009	2010	#points	2007	2008	2009	2010	#points
Germany	173.702	176.926	110.641	121.763	17	355.114	313.027	289.269	276.635	10u + 9s
spain	2.404	2.429	0	0	4	68.134	56.4217	52.0544	46.8912	8u + 4s.
Poland	466.69	404.707	465.736	456.351	18	1615.96	1546.1	1563.74	1536.76	14u + 3s
Roumania	16.04	15.3	12.308	12.515	4	48.5291	48.6321	46.066	42.1885	1u
UK	30.91	70.28	69.18	56.75	7	72.405	85.066	74.2823	80.3492	31u
										with u=underground, s=surface

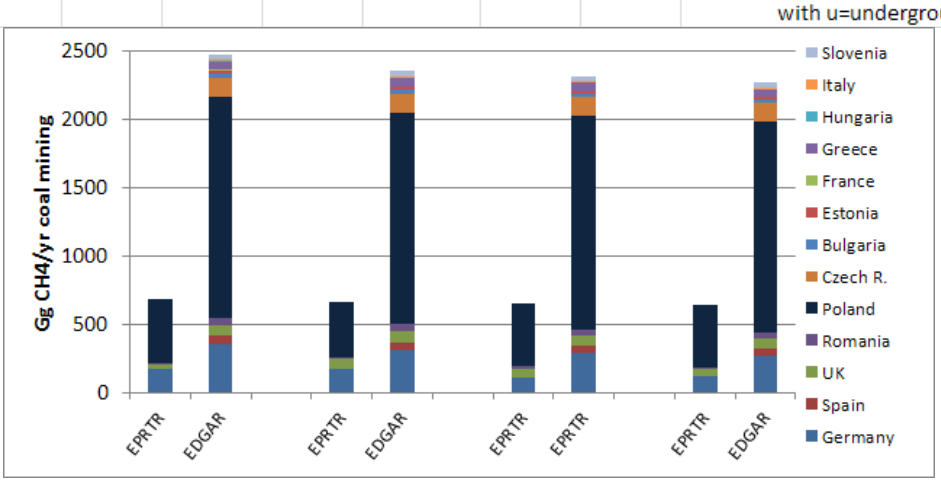

Fig.1: coal mining in EDGAR for EU-27 (13 countries) and in EPRTR reported for the 5 countries

[1]The underground coal gasification reported for some countries, do not emit CH4 and are not taken up here.

For the landfill emissions the total sum of reported CH4 from the 1359 landfill facilities in EPRTR mounts at much lower estimates for the 25 European countries than the estimates of EDGAR, as shown in Fig. 2. Given the threshold for reporting, set by the EPRTR directive for landfills with either a capacity of more than 10 tons/day or a total capacity of more than 25000 tons in total have to report pollutant releases. They report those pollutants that are above the given threshold, which is for CH4 100ton/yr. Many small landfills which do not release 100 tons/yr might be missing out. For the solid waste incineration, the reported amount of CH4 incinerated is in the same order as estimated by EDGAR, as shown in Fig. 3, but the number of countries reporting in EPRTR is very small.

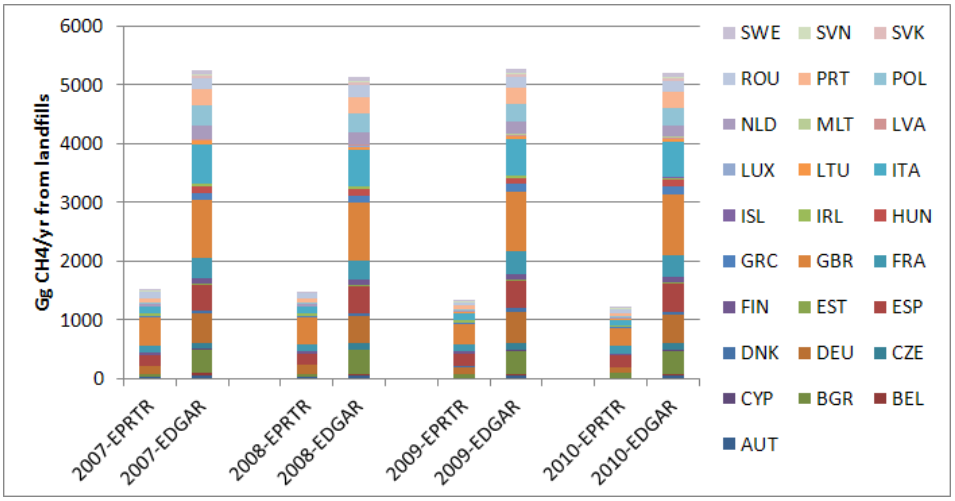

Fig.2: landfill emissions in EDGAR for EU-27 + Iceland and in EPRTR reported for the 25 countries

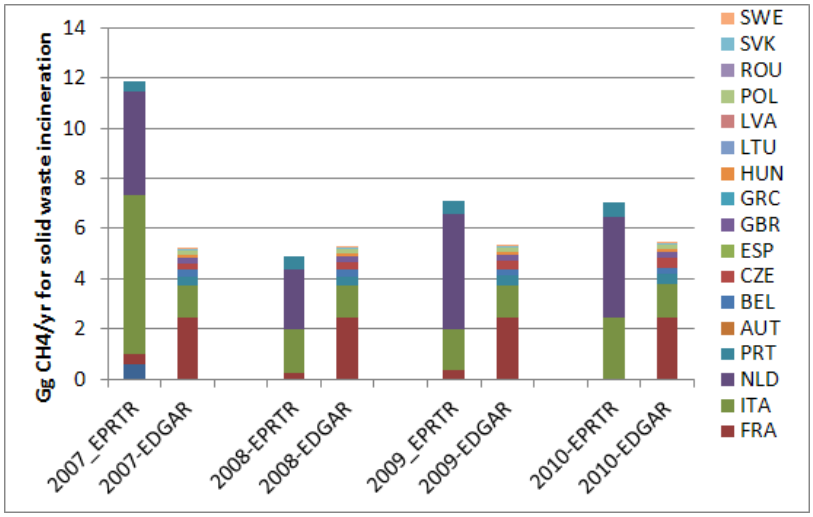

Fig.3: Solid waste incineration emissions of CH4 in EDGAR (18 out of 27 EU countries) and in EPRTR (5 out of 27 EU countries)

For the industrial wastewater even lower emissions are reported. Fig. 4 compares the industrial facilities estimated in EDGAR with those reported in EPRTR. The domestic wastewater is left out in this comparison because it is not subject to EPRTR-reporting.

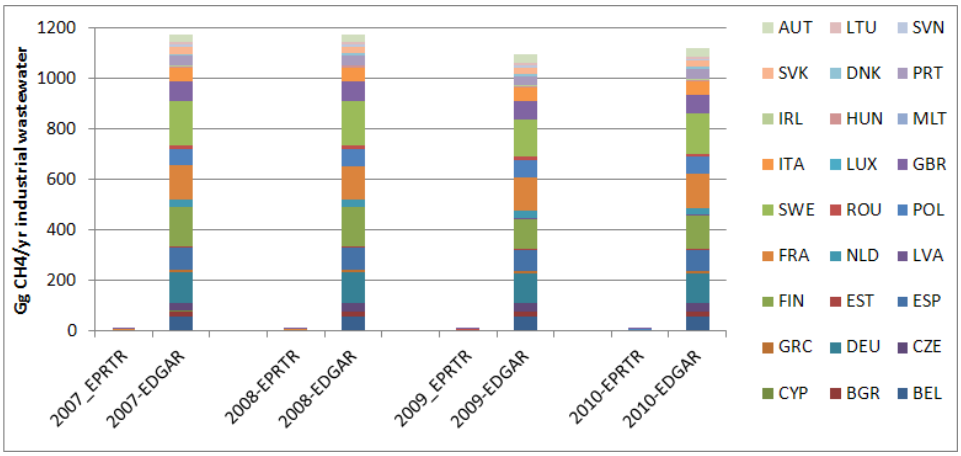

Fig.4: Industrial wastewater emissions in EDGAR for EU-27 and in EPRTR reported for the 13 countries

For the oil and gas production, the EPRTR v4.2 database reports the CH4 emissions from oil refineries, which are higher than in EDGARv4.2FT2010, as shown in Fig. 5 as well as the CH4 emissions from oil extraction sites in Table3 and gas extraction sites in Fig.6. The number of reporting countries remains smaller than estimated in EDGAR with the energy statistics of IEA, but the reported values are expected to have a lower uncertainty. Fig. 6 for the total gas production and distribution sector shows that EDGARv4.2 provides the dominant transmission and distribution leakages.

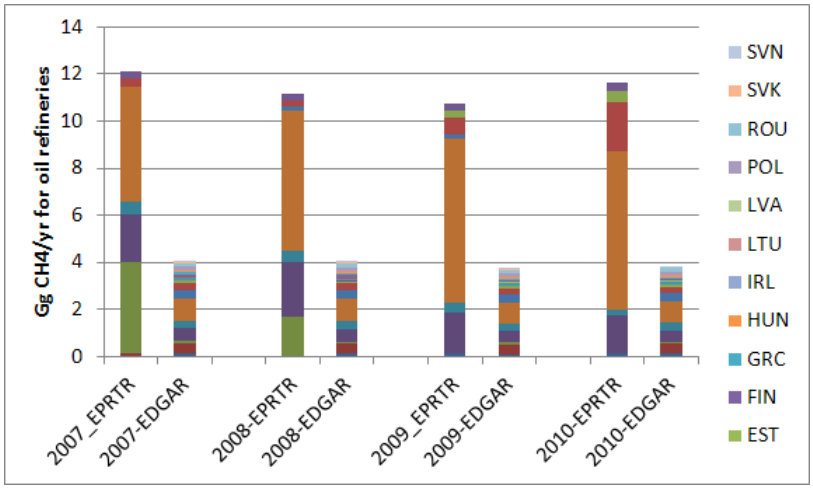

Fig.5: CH4 emissions from oil refineries in EDGAR (25 country-specific emissions estimated) and in EPRTR (10 reporting countries) for EU-27

Table 2: oil extraction from EPRTR and EDGAR in comparison

	EPRTR				EDGAR			
Country	2007	2008	2009	2010	2007	2008	2009	2010
Norway	245.70	253.55	254.12	254.09	20.12	21.84	21.37	18.94
Poland		13.00	6.94	6.87	8.40	8.60	8.70	8.90
Roumania		1.19	0.88	0.85	1.20	1.20	1.20	1.20
UK	0.48				1.60	1.60	1.60	1.60

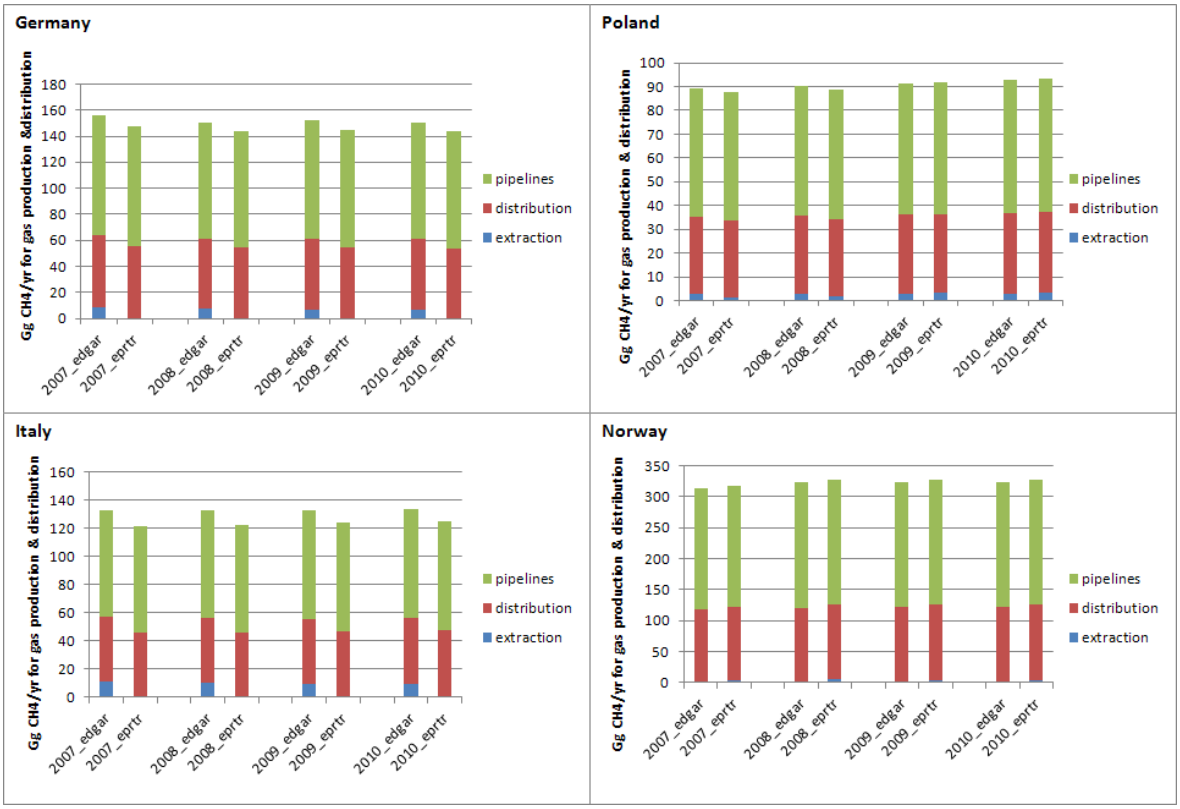

Fig.6: comparison of the complete gas production and distribution sector, under EDGAR and under EPRTR in which EPRTR data are only reported for the extraction.

A variant for each of the sectors where EPRTR data are reported have been calculated applying method 1 and using solely the EPRTR official emissions for the years reported (2007-2010) for those countries where reporting is done. All missing countries were gapfilled with EDGAR data. These subsets of data ares made available under the "Option" CH4 emission gridmaps for 2007-2010.

For the coal mining the emission gridmap contains only EPRTRv4.2 CH4 emissions for the reporting countries. For the solid waste disposal, the emission gridmap contains only EPRTRv4.2 CH4 emissions for the landfills and the incinerators in the reporting countries. For the oil production and refineries sector, both the refineries data and the oil production data are from EPRTRv4.2 for the reporting countries. For the waste water sector, the emission gridmaps are containing EPRTRv4.2 emissions for the industrial waste but in addition are including also the domestic wastewater from EDGAR to represent the sector complete. Idem for the gas production and distribution sector, the gas extraction data are from EPRTRv4.2 for the reporting countries but the CH4 leakages of the transmission by pipelines and of the distribution network in cities are taken from EDGAR for all countries and included to complete the sector.

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