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Supplement of

Speciation of anthropogenic emissions of non-methane volatile organic compounds: a global gridded data set for 1970–2012

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Supplementary material

S1 – NMVOC emissions comparison using EDGAR versions, HTAP_v2 and EEA inventories

Figure S1 shows the comparison of global NMVOC emissions by sector for different EDGAR versions v4.2 (refer to http://edgar.jrc.ec.europa.eu/overview.php?v=42), v4.3.1 (refer to http://edgar.jrc.ec.europa.eu/overview.php?v=431) and v4.3.2 (http://edgar.jrc.ec.europa.eu/overview.php?v=432) for the most recent year (2008) available for all datasets. Total emissions are slightly higher (ca 17%) in the current version of EDGAR compared to v4.3.1 mainly due to changes in the activity data and emission factors. At sector level, rather good agreement is observed between EDGARv4.3.2 and EDGARv4.3.1, although major differences are found for the application of solvents showing 15.6 times higher emissions for EDGARv4.3.2 due to revised activity data (to account for household products and other solvents use) and emission factors (especially for paints and pesticides), the residential and transformation industry sectors having ca 30% and 22% lower emissions. Finally, in EDGARv4.3.2 waste water treatment and glass production (from the year 1990) have been introduced.

Figures S2 and S3 show the comparison of NMVOC emissions of EDGARv4.3.2 and the best estimates provided by the HTAP_v2.2 inventory for the year 2010 by HTAP sector and country (refer to Janssens-Maenhout et al. (2015) and http://edgar.jrc.ec.europa.eu/htap_v2/index.php). Very good agreement for all sectors is found between EDGARv4.3.2 and HTAP_v2.2 for Asian countries and North America (refer to Fig. S2), as well as for Europe (refer to Fig. S3). Lower NMVOC emissions are reported by EDGARv4.3.2 for India and Indonesia for the residential and transport sectors compared to the HTAPv2 data (although the reported HTAP_v2.2 emissions appear to be very high compared for example with the Chinese ones). On the other hand, EDGARv4.3.2 provides larger NMVOC emissions for Germany for the residential sector, although the HTAP_v2.2 data appear to be too low compared for example with France residential emissions. In general, larger differences between the two inventories are observed for the power generation due to the low NMVOC emissions associated with this sector.

Focusing on European countries (see Fig. S4), detailed comparison by sector and country (defined with ISO codes) is also performed with officially reported EEA NMVOC emission inventories for the year 2010 (http://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-convention-on-long-range-transboundary-air-pollution-lrtap-convention-10). Total NMVOC emissions at European scale are 15% higher for EDGAR compared to EEA and HTAP_v2.2. However, insights on the origin of such differences can be retrieved looking at sectorial emissions. The power generation sector in EU represents less than 2% of total NMVOC emissions although it shows quite some discrepancies among inventories. As shown in Fig. S3 and Fig. S4, industrial, residential and ground transport NMVOC emissions are characterized by better agreement among the three inventories, with the exception of few countries. EDGAR estimates 30-50% lower emissions for ground transport emissions for France, Poland and Czech Republic compared to HTAP and EEA, while it generally overestimates residential emissions (e.g. in particular for Germany, France and UK, possibly due to an underestimation of the combustion of biomass in the household sector as reported by van der Gon et al. (2015)). Differences in the NMVOC emissions of the industrial sector among the inventories might be due to the underestimation by 50% of the EDGAR gas distribution subsector for Europe and by 15% at the global scale.

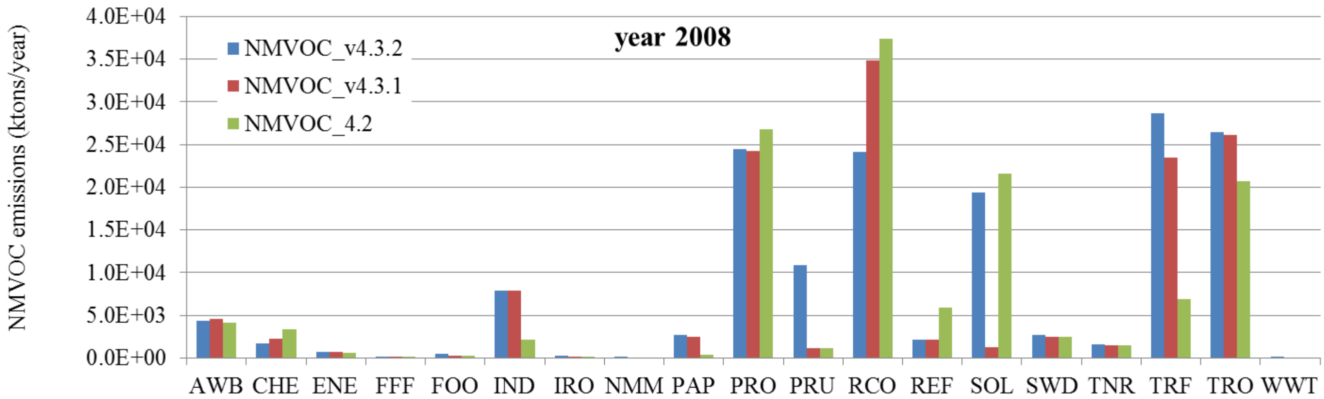

Figure S1. Comparison of 2008 EDGAR emissions by sector for different versions.

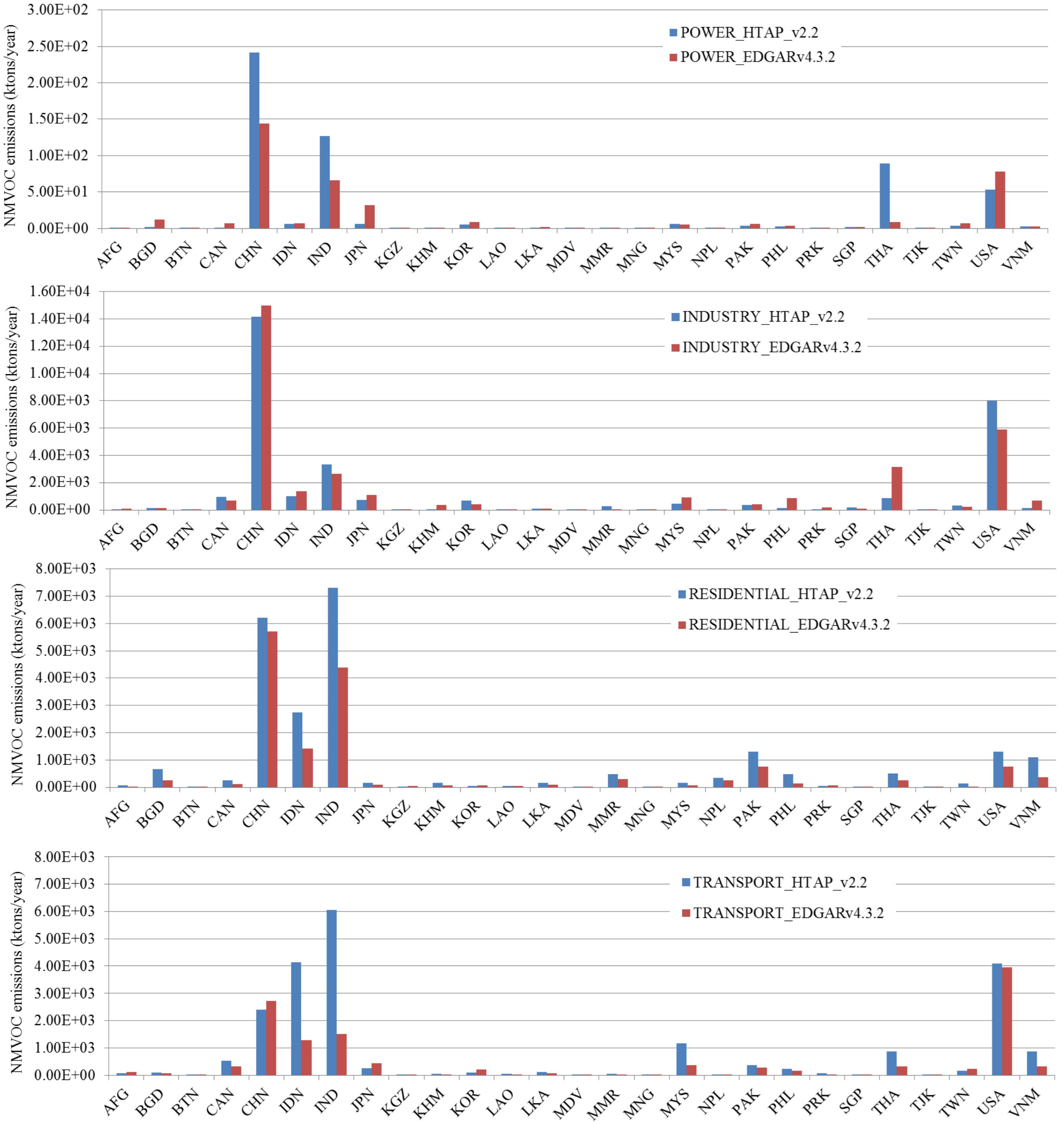

Figure S2. Comparison of 2010 NMVOC sectorial emissions estimated by EDGARv4.3.2 and HTAP_v2 for Asian countries and North America.

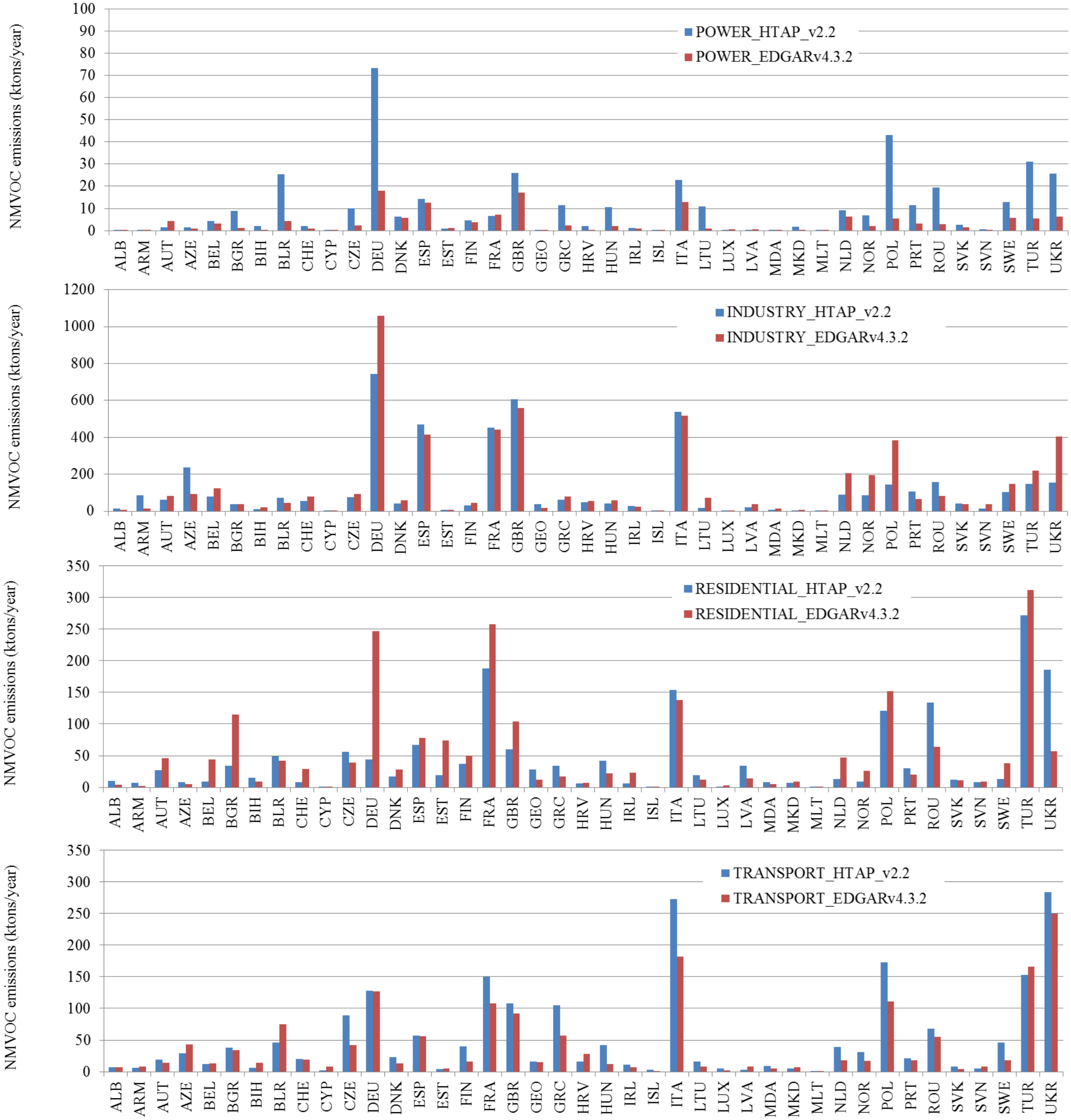

Figure S3. Comparison of 2010 NMVOC sectorial emissions estimated by EDGARv4.3.2 and HTAP_v2 for Europe.

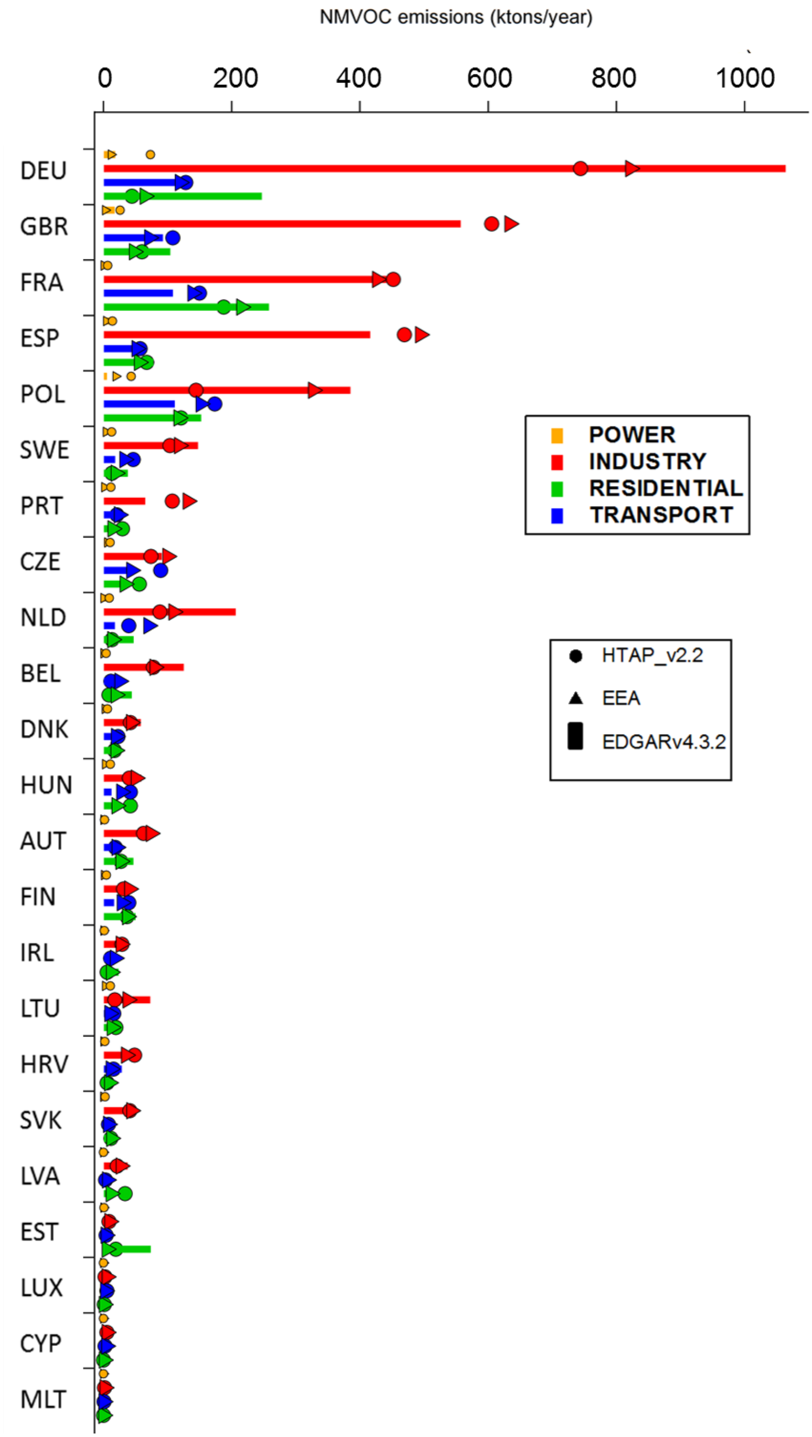

Figure S4. Comparison of 2010 NMVOC emissions from the power generation, industry, residential and combustion sectors of the HTAP_v2.2, EDGARv4.3.2 and EEA inventories.

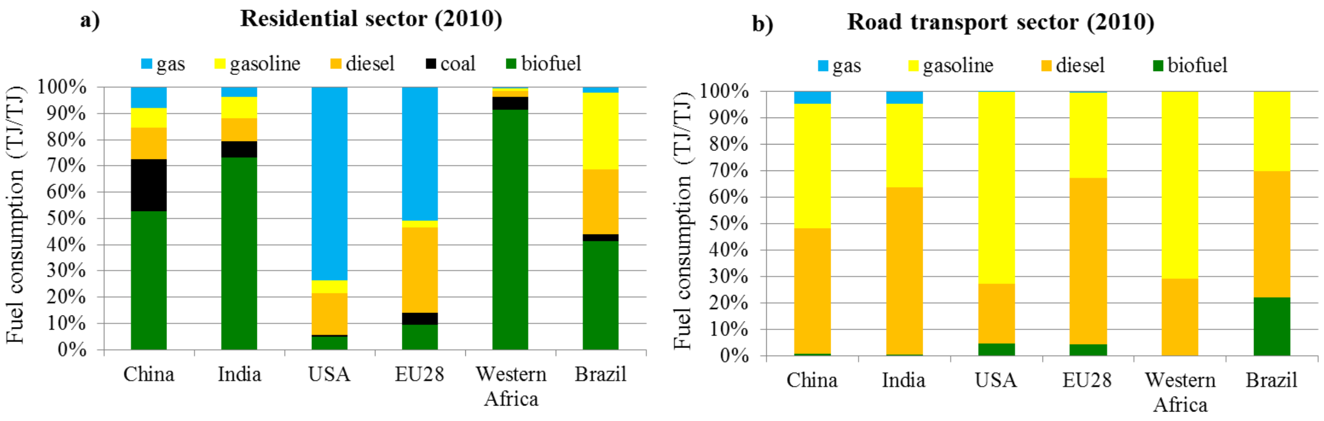

Figure S5. Share of different fuels consumed in the residential (a) and road transport (b) sectors in 2010 for major world regions.

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S2 – Mapping NMVOC profiles to EDGAR processes

Table S1. First step in mapping profiles to EDGAR process codes.

Source code	Source description	Tech code	EOP code	Profile name	Mapping quality
CHE.BLK.CPS	CHa-Polystyrene (total)	NSF	NOC	Plastics Production - Polystyrene	1
CHE.BLK.CPT	CHa-Phthalic anhydride	NSF	NOC	Phthalic Anhydride - O-Xylene Oxidation - Main Process Stream	1
CHE.BLK.CPV	CHa-Poly Vinyl Chloride (PVC)	NSF	020	Plastics Production - Polyvinyl Chlorides and Copolymers	1
CHE.BLK.CPV	CHa-Poly Vinyl Chloride (PVC)	NSF	NOC	Plastics Production - Polyvinyl Chlorides and Copolymers	1
CHE.BLK.CRU	CHa-Rubber, total (SBR + synthetic)	NSF	NOC	Consumer Products: Rubber and Vinyl Protectants - Aerosols	1
CHE.BLK.CST	CHa-Styrene	NSF	NOC	Methyl Styrene	1
CHE.BLK.CVC	CHa-Vinyl chloride	NSF	NOC	Plastics Production - Polyvinyl Chlorides and Copolymers	1
CHE.BLK.CXY	CHa-Xylenes	NSF	NOC	m-Xylene	1

Table S2. Example of mapping profiles with a quality code of 2.

Source code	Source description	Tech code	EOP code	Profile name	Mapping quality
ENE.CHP.OGS	Public cogeneration: Coke Oven Gas	BO0	223	External Combustion Boiler - Coke Oven Gas	2
ENE.CHP.OGS	Public cogeneration: Coke Oven Gas	BO0	300	External Combustion Boiler - Coke Oven Gas	2
ENE.CHP.OGS	Public cogeneration: Coke Oven Gas	BO0	423	External Combustion Boiler - Coke Oven Gas	2
ENE.CHP.RGS	Public cogeneration: Refinery Gas	BO0	000	External Combustion Boiler - Refinery Gas	2
ENE.CHP.OGS	Public cogeneration: Refinery Gas	BO0	002	External Combustion Boiler - Refinery Gas	2
ENE.CHP.OGS	Public cogeneration: Refinery Gas	BO0	003	External Combustion Boiler - Refinery Gas	2

Notes: BO0 = combustion: boiler for gas/ liquid of any size

Table S3. Example of mapping profiles with a quality code of 3.

Source code	Source description	Tech code	EOP code	Profile name	Mapping quality
TRO.ROA.BDS	Biodiesel in Road transport	BS0	NOC	Biodiesel Exhaust - Light Duty Truck operated at 0 ^{o}C; Cold Start	3
TRO.ROA.BDS	Biodiesel in Road transport	BS0	PEU	Biodiesel Exhaust - Light Duty Truck operated at 0 ^{o}C; Cold Start	3
TRO.ROA.BDS	Biodiesel in Road transport	BS0	EU1	Biodiesel Exhaust - Light Duty Truck operated at 0 ^{o}C; Cold Start	3
TRO.ROA.BDS	Biodiesel in Road transport	HD0	NOC	Biodiesel Exhaust - Light Duty Truck operated at 0 ^{o}C; Cold Start	3
TRO.ROA.BDS	Biodiesel in Road transport	HD0	PEU	Biodiesel Exhaust - Light Duty Truck operated at 0 ^{o}C; Cold Start	3
TRO.ROA.BDS	Biodiesel in Road transport	HD0	EU1	Biodiesel Exhaust - Light Duty Truck operated at 0 ^{o}C; Cold Start	3

Notes: BS0 = busses, HD0 = heavy duty vehicles

Table S4. Example of matching profiles with a quality code of 4, 5 and 6.

Source code	Source description	Tech code	EOP code	Profile name	Mapping quality
ENE.AEL.BFG	Auto produced electricity: Blast Furnace Gas	BO0	000	Coke Oven Blast Furnace Gas	4
ENE.AEL.BFG	Auto produced electricity: Blast Furnace Gas	BO0	002	Coke Oven Blast Furnace Gas	4
ENE.AEL.BFG	Auto produced electricity: Blast Furnace Gas	BO0	003	Coke Oven Blast Furnace Gas	4
ENE.AEL.CRU	Auto produced electricity: Crude Oil	BO0	000	Other Electric Power Generation	5
ENE.AEL.CRU	Auto produced electricity: Crude Oil	GT0	000	Other Electric Power Generation	5
ENE.AEL.CRU	Auto produced electricity: Crude Oil	IC0	000	Other Electric Power Generation	5
TNR.SEA.HFO	Residual Fuel Oil in International marine bunkers	BSP	NOC	Residual Oil-Fired Power Plant	6
TNR.SEA.HFO	Residual Fuel Oil in International marine bunkers	BSS	NOC	Residual Oil-Fired Power Plant	6
TNR.SEA.HFO	Residual Fuel Oil in International marine bunkers	CSP	NOC	Residual Oil-Fired Power Plant	6

S3 – Aggregation of the 25 NMVOC species

Table S5. Aggregation of the 25 NMVOC species into 8 main groups.

In this work we have developed the NMVOC split into 25 species. However, in order to show and discuss the results, they have been grouped into 8 major categories as reported in Table S5.

25 NMVOC species codes	25 NMVOC species	8 aggregated NMVOC species
voc1	Alkanols (alcohols)	Alkanols
voc2	Ethane	Alkanes (C2 - C5)
voc3	Propane	Alkanes (C2 - C5)
voc4	Butanes	Alkanes (C2 - C5)
voc5	Pentanes	Alkanes (C2 - C5)
voc6	Hexanes and higher alkanes	Alkanes (C6+)
voc7	Ethene (ethylene)	Alkenes
voc8	Propene	Alkenes
voc9	Ethyne (acetylene)	Alk(adi)enes/alkynes
voc10	Isoprenes	Other
voc11	Monoterpenes	Other
voc12	Other alk(adi)enes/alkynes (olefines)	Alk(adi)enes/alkynes
voc13	Benzene (benzol)	Aromatics
voc14	Methylbenzene (toluene)	Aromatics
voc15	Dimethylbenzenes (xylenes)	Aromatics
voc16	Trimethylbenzenes	Aromatics
voc17	Other aromatics	Aromatics
voc18	Esters	Other
voc19	Ethers (alkoxy alkanes)	Other
voc20	Chlorinated hydrocarbons	Other
voc21	Methanal (formaldehyde)	Alkanals
voc22	Other alkanals (aldehyedes)	Alkanals
voc23	Alkanones (ketones)	Other
voc24	Acids (alkanoic)	Other
voc25	Other NMVOC (HCFCs, nitriles, etc.)	Other

S4- Details on the EDGAR v4.3.2 methodology

Total NMVOC emissions from a given sector i in a country C accumulated during a year t are estimated with the following formula in the EDGAR database:

$$EM_i(C,t) = \sum_{j,k}\left[AD_i(C,t) * TECH_{i,j}(C,t) * EOP_{i,j,k}(C,t) * EF_{i,j}(C,t) * \left(1 - RED_{i,j,k}(C,t)\right)\right]$$

EDGAR emission estimates are based on country-specific activity data (AD) for each anthropogenic emission sector i, on which a mix of j technologies (TECH) and a mix of k end-of-pipe measures (EOP) are installed; uncontrolled emission factors (EF) for each sector i and technology j with relative reduction (RED) by abatement measure k are also used in the calculation. The technology mix, (uncontrolled) emission factors and end-of-pipe measures are defined at country-specific, regional, country group (e.g. Annex I/ Non-Annex I), or global level. In particular, NMVOC emission factors are consistent with the EMEP/EEA 2013 Guidebook (EEA, 2013) for Europe and scientific literature has been taken into account to introduce country- and region- specific information, while abatement measures are implemented mainly for the road transport sector (consistent with the Euro standards), for the production of chemicals (CHa-formaldehyde (methanal), total polyethylene, CHa-propylene glycol, total polystyrene), for power generation (auto produced electricity and public electricity production from natural gas) and for landfills. Further details on the EDGAR methodology can be found in Section S4 of the Supplementary material of Crippa et al. (2016a).

Table S6 reports the Euro standards implementation over time as reported by regulations. Country- and region- specific time series with the penetration of the Euro standards are applied in the EDGAR database as reported in Crippa et al. (2016b).

Table S6 - Euro standards implementation over time (1990-2012). Note that mopeds Pre-Euro standards are defined as PEU for Europe and are also assumed to take place from 1970 till 1992.

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Passenger car	PEU	PEU	EU1	EU1	EU1	EU1	EU2	EU2	EU2	EU2	EU3	EU3	EU3	EU3	EU3	EU4	EU4	EU4	EU4	EU5	EU5	EU5	EU5
Light duty vehicle	PEU	PEU	EU1	EU1	EU1	EU1	EU2	EU2	EU2	EU2	EU3	EU3	EU3	EU3	EU3	EU4	EU4	EU4	EU4	EU5	EU5	EU5	EU5
Heavy duty vehicle and bus	PEU	PEU	EU1	EU1	EU1	EU1	EU2	EU2	EU2	EU3	EU3	EU3	EU3	EU3	EU3	EU4	EU4	EU4	EU4	EU5	EU5	EU5	EU5
Motorcycle/Moped	PEU	PEU	PEU	PEU	PEU	PEU	PEU	PEU	PEU	EU1	EU1	EU1	EU2	EU2	EU2	EU2	EU3	EU3	EU3	EU3	EU3	EU3	EU3

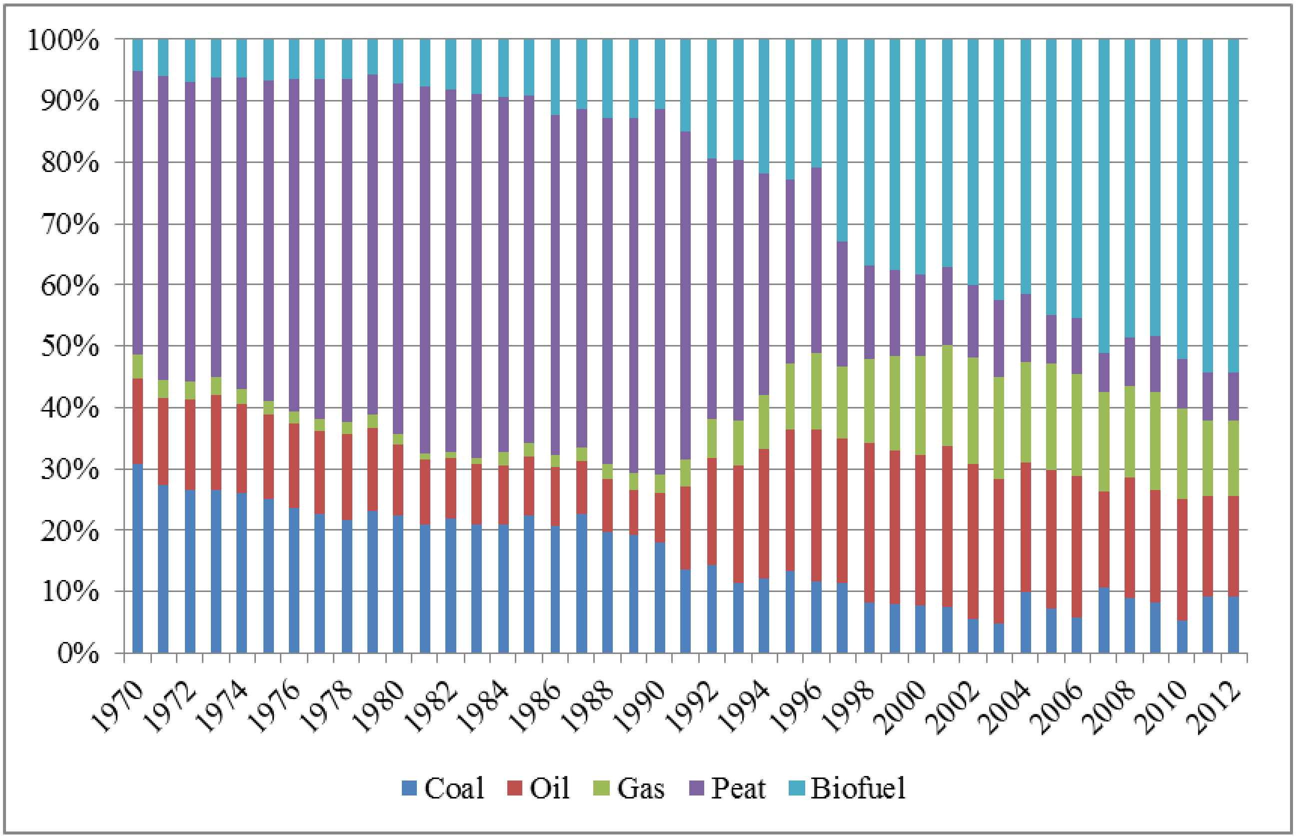

Figure S6. Relative share of different fuels to NMVOC emissions of residential sector in Germany during 1970-2012.

Table S7. Matching of RETRO sectors and EDGAR sources.

RETRO sector	RETRO sector description	EDGAR source mapped
Agr	Agriculture and Land use change	AWB
Exf	Extraction and distribution of fossil fuels	PRO, REF
Inc	Industrial combustion	IND, TRF
Pow	Power generation	ENE
Res	Residential, commercial and other Combustion	RCO
Sol	Solvent use	SOL
Tra	Road transport	TRO
Was	Waste treatment and disposal	SWD

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