Simone Schucht, Mike Holland | April 21th 2021 | TFIAM 50

Marginal damage costs for air pollutants and externalities from European industrial facilities

Updated assessment

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Costs of air pollution from European industrial facilities 2008–2017

- EIONET report - ETC/ATNI 04/2020, ISBN 978-82-93752-18-9
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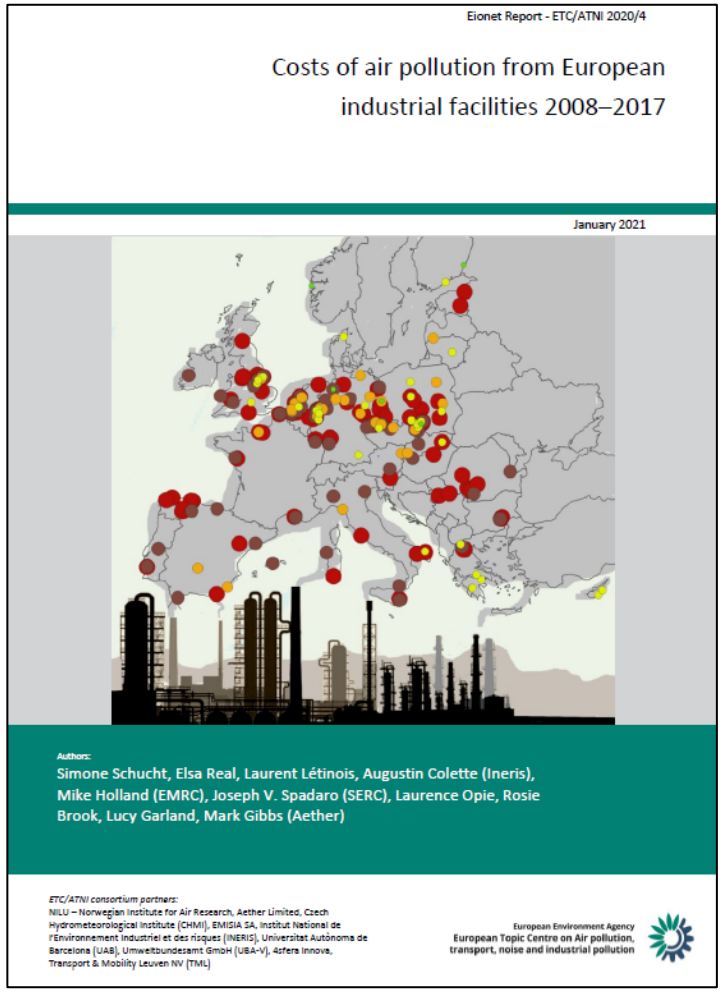
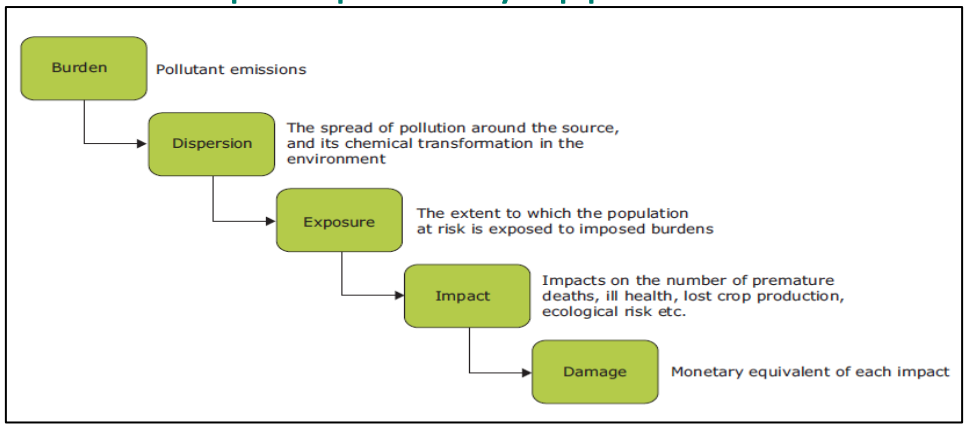
- Update of earlier EEA report
  - Costs of air pollution from European industrial facilities 2008–2012, an updated assessment, EEA Technical Report 20/2014



Scope of the report (1/2)

- Three distinct assessments
  - Marginal damage costs (MDCs) per tonne of pollutant and per country
  - Sectoral adjustment factors for main air pollutants
  - Externalities of industrial facilities using E-PRTR (*) emission data
- Pollutants
  - Main air pollutants: NH_3, NOx, SO_2, NMVOCs, PM_{10}, $PM_{2.5}$
  - Heavy metals: As, Cd, CrVI, Pb, Hg, Ni
  - Organic pollutants: 1,3 Butadiene, benzene, formaldehyde, PAH (as BaP equiv.), dioxins and furans
  - Greenhouse gases: CO_2, CH_4, N_2O
- Impacts
  - Health: main air pollutants ($PM_{2.5}$, O_3, NO_2), heavy metals, organic pollutants
  - Crops and forests: main air pollutants (O_3)
  - Building materials: main air pollutants (NOx, SO_2)
  - Ecosystems: main air pollutants (eutrophication)

Impact pathway approach



(*) E-PRTR: European Pollutant Release and Transfer Register

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Scope of the report (2/2)

- Countries
  - EEA38+UK wherever possible for MDCs
  - EU27 + Iceland, Norway, Serbia, Switzerland, UK for externalities
- Damage
  - Impact of emission per tonne of pollutant from a particular country wherever it occurs (≈ damage in EEA38+UK)
  - Impact occurring in the emitter country only
- Period
  - MDCs for 2017
  - Externalities for 2008-2017

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Updated marginal damage costs

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Main air pollutants – calculation of MDCs

- Dispersion & exposure modelling
  - EMEP Source-Receptor-Matrices (SRMs)
  - Calculation of higher resolution Source-Receptor-Relationships (SRRs) for NO_2 using SHERPA model (JRC)
- Calculation of sectoral adjustment factors for $PM_{2.5}$ and NO_2 precursors using SHERPA
  - Specific to each precursor, SNAP sector and country
  - Account for closeness of emission source to population and emission height
- Inclusion of health impacts from NO_2
  - Mortality and morbidity
  - Mortality response function without cutoff point
- Inclusion of impacts on forests => ECLAIRE approach (but AOT40)
- Inclusion of ecosystems impact
  - Exceedance of critical loads for eutrophication in Natura 2000 areas => ECLAIRE approach
- Mortality valuation updated as recommended by OECD (2012)
- Updated population and health data
- Response functions and valuation for health consistent with 2nd CAO (Amann et al., 2020)

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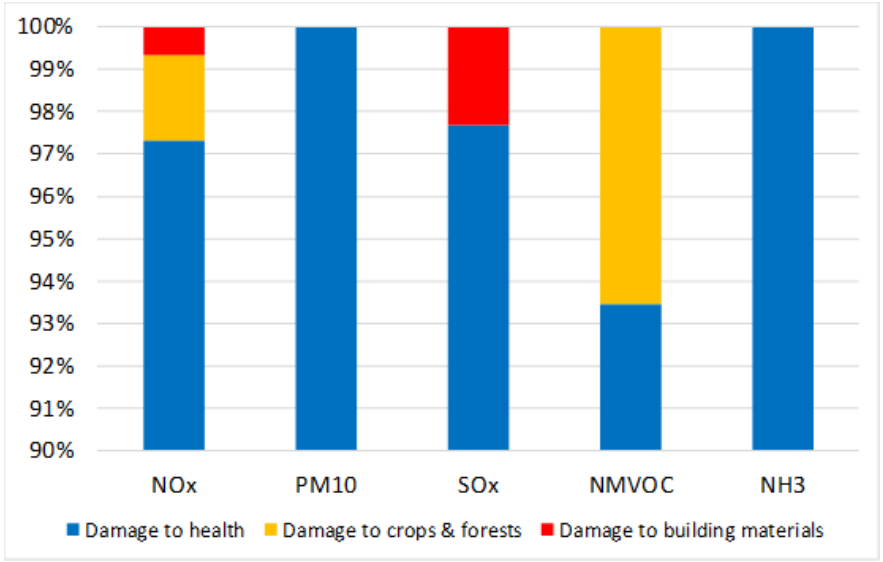
Main air pollutants – average European MDCs

- Damage costs accounting for impacts on health, crops & forests and building materials (€/t)

Pollutant	Average European damage cost (€$_{2019}$ per tonne) - impacts on health, crops, forests & materials	
	VOLY	VSL
NO_X	16 767	54 815
SO_2	19 203	48 809
PM_{10}	45 507	143 703
$PM_{2.5}$	70 081	221 303
NMVOC	1 877	5 400
NH_3	18 620	57 045

EEA 38 + UK: missing emitter countries: Iceland, Liechtenstein, Albania, Bosnia and Herzegovina, North Macedonia and Serbia and Kosovo

- Relative share of damage to health, crops & forests and building materials in the overall European average damage costs



Y-axis cut off at 90%!

- Country specific MDCs in the report
- Changes compared to EEA (2014) due to
  - Changes in source receptor matrices
  - Price increase (28%) between 2005 and 2019
  - Update of monetary unit values for mortality
  - Inclusion of health impacts from NO_2

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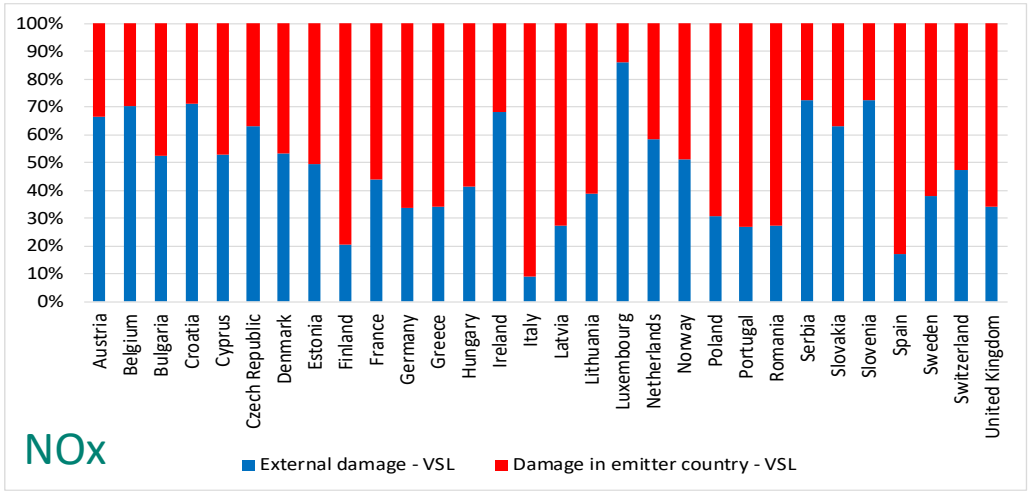
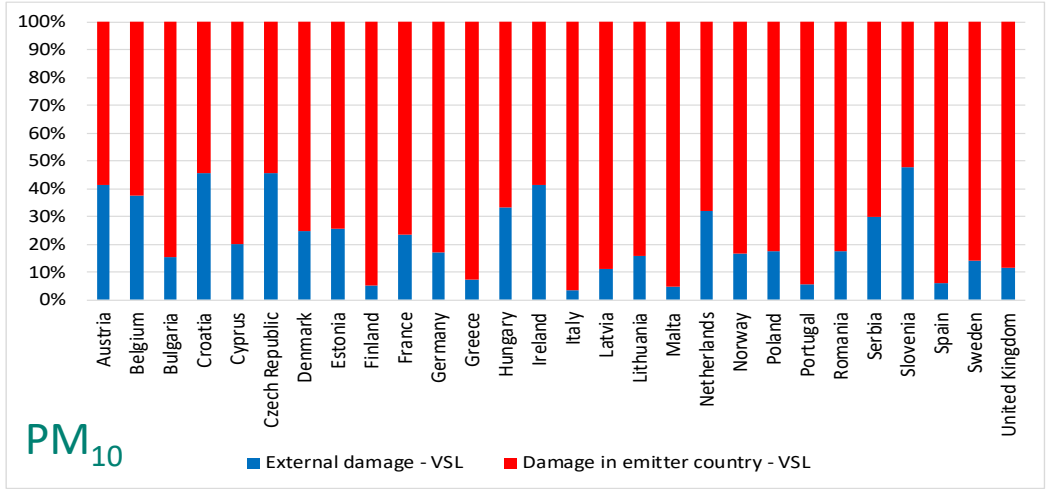
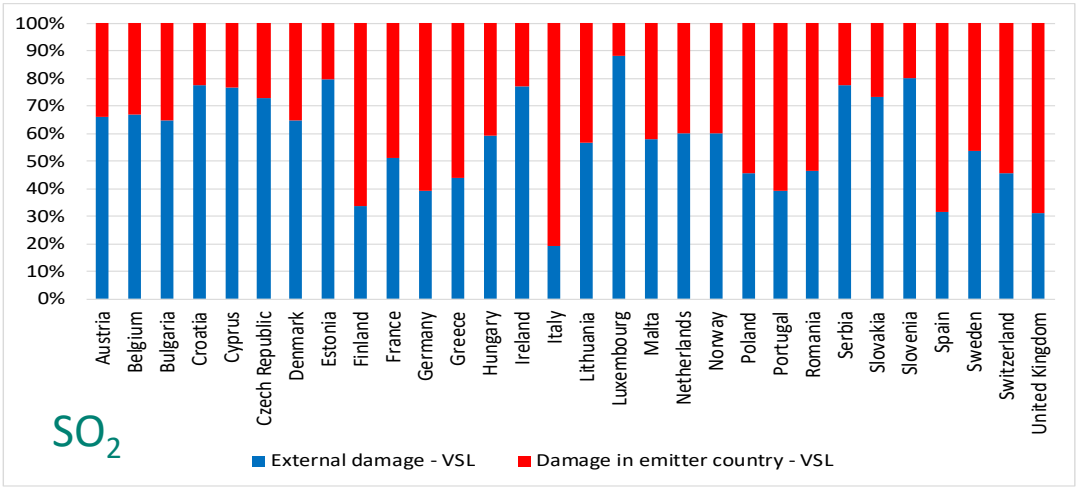
Neglecting transboundary impact ignores important share of damage

Comparison between internal and external damage in % – valuation for VSL







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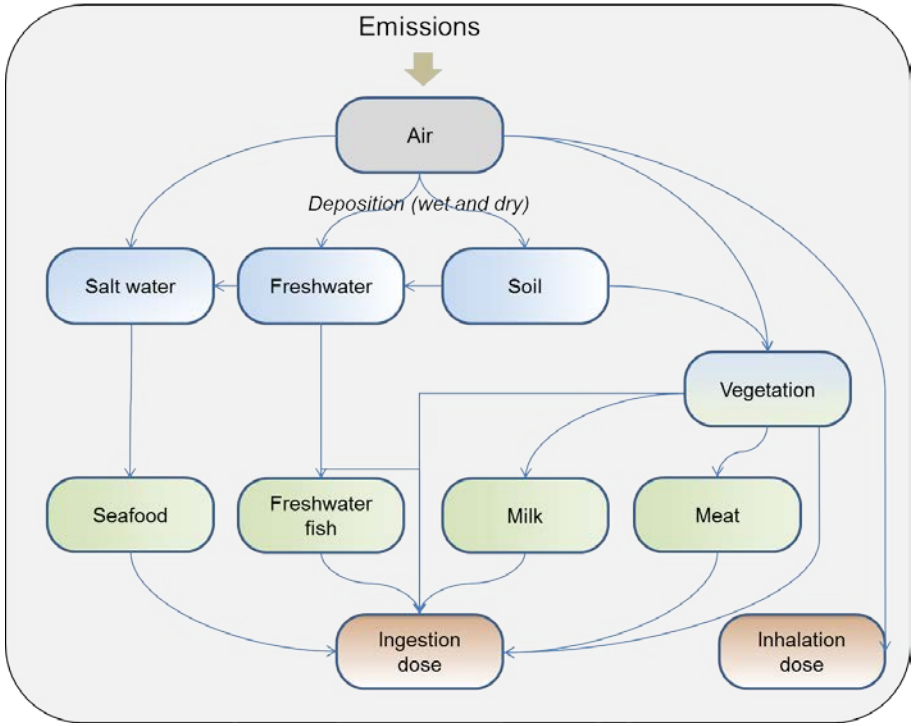
Heavy metals and organic pollutants – calculation of MDCs

- Dispersion & exposure modelling
  - Uniform World methodology, environmental accumulation, transport in food & water, uptake via ingestion & inhalation
- Inclusion of additional health impacts for toxic metals (bold script)

POLLUTANT	CURRENT STUDY
Arsenic*	**All-cause, non-cancer mortality,** Cancer (fatal & non-fatal), **Chronic bronchitis, IQ loss and diabetes**
Cadmium*	**All-cause mortality,** Non-fatal cancers and **Osteoporosis (hip fractures)**
Chromium (hexavalent)†	Cancer (fatal & non-fatal)
Lead*	**All-cause mortality** and IQ loss
Mercury*	**Cardiovascular mortality**, IQ loss and **Anaemia**

Human exposure route: (*) Inhalation and Ingestion; (†) Inhalation only



- Impact calculation using RiskPoll
- Valuation of heavy metals following Nedellec and Rabl (2016a, b, c)
- Updated population and health incidence data

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Heavy metals and organic pollutants – average European MDCs

- Marginal damage costs of heavy metals and organics for European emissions (€$_{2019}$ per kg pollutant emitted to air)

Pollutant	Current study	EEA (2014)†
Arsenic (inorganic)	11 044	445
Cadmium	185 175	37‡
Chromium (hexavalent, VI)	3 129⁉	245‡
Lead	32 531	1 231§
Mercury	16 903	3 649§
Nickel	24⁉	4.8‡
1,3 Butadiene	1.3	0.64‡
Benzene	0.36⁉	0.10‡
Benzo(a)pyrene	6 806⁉	1 632‡
Dioxins/Furans (TCDD equiv.)	60.1 million	34.5 million
Formaldehyde	0.25⁉	0.28‡

† Costs adjusted for inflation to year 2019
‡ Considers inhalation dose only
§ Accounts for IQ loss only
⁉ An updated unit risk factor is used

The mercury estimate is global

- Differences compared to EEA (2014) due to
  - Inclusion of additional impacts, especially mortality
  - Chromium presented in hexavalent state instead of valence state 0
  - Update of incidence and population data

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Greenhouse gases – Marginal abatement costs (MACs)

- Extended scope of GHGs
  - CH_4, N_2O next to CO_2
- Marginal abatement costs as a proxy for carbon valuation
  - Valuation for CO_2 from DG MOVE Handbook on the External Costs of Transport (EC, 2019)
  - Conversion of methane and nitrous oxide through factors for temperature change after 20 years (IPCC, 2014)
- Climate change avoidance costs in €/tCO_2 equivalent (€2019)

	Low	Central	High
Short and medium term, to 2030	63	105	199
Longer term (2040 to 2060)	164	283	524

- GWP and GTP for CO_2, CH_4 and N_2O

	GWP		GTP	
Pollutant	**Cumulative forcing over 20 years**	**Cumulative forcing over 100 years**	**Temperature change after 20 years**	**Temperature change after 100 years**
CO_2	1	1	1	1
CH_4	84	28	67	4
N_2O	264	265	277	234

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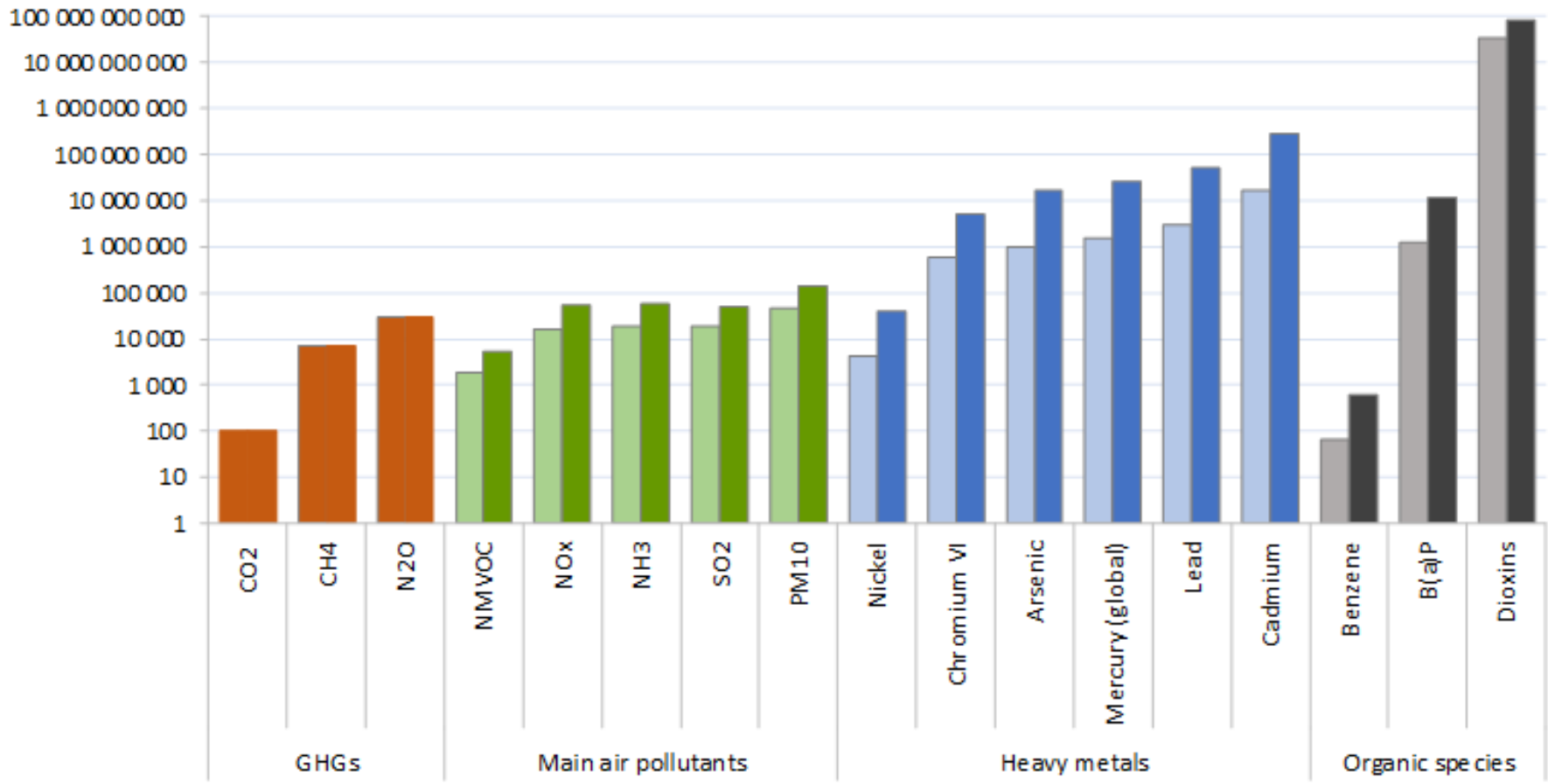
Average damage cost per tonne emitted, € ($€_{2019}$)

- All air pollutants considered



European averages, except for greenhouse gases and mercury, for which they are global

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Updated externalities – a few general results

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Only a limited share of emissions reported to E-PRTR

- Number of reporting facilities (all pollutant groups)

Number of facilities reporting the selected air pollutant emissions									
2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
11 137	11 040	11 077	11 208	11 137	11 375	11 561	11 764	11 768	11 893

- Emissions reported to E-PRTR and EMEP in 2017

	Emissions reported to E-PRTR (tonnes)	Aggregated national total emissions reported to EMEP (tonnes)	% E-PRTR emissions of national totals
NO_X	1 743 599	8 124 469	21%
SO_2	1 627 493	2 675 551	61%
PM_{10}	83 143	2 193 133	4%
NMVOC	429 143	7 673 940	6%
NH_3	234 447	4 236 339	6%
As	23	142	16%
Cd	9	67	14%
Cr	57	388	15%
Hg	26	55	47%
Ni	141	639	22%
Pb	287	1 482	19%
Dioxins + furans	0.0010	0.0020	50%
PAHs	48	1 256	4%

⇒ Externalities calculated in this study do not represent the total damage costs caused by air pollution across Europe

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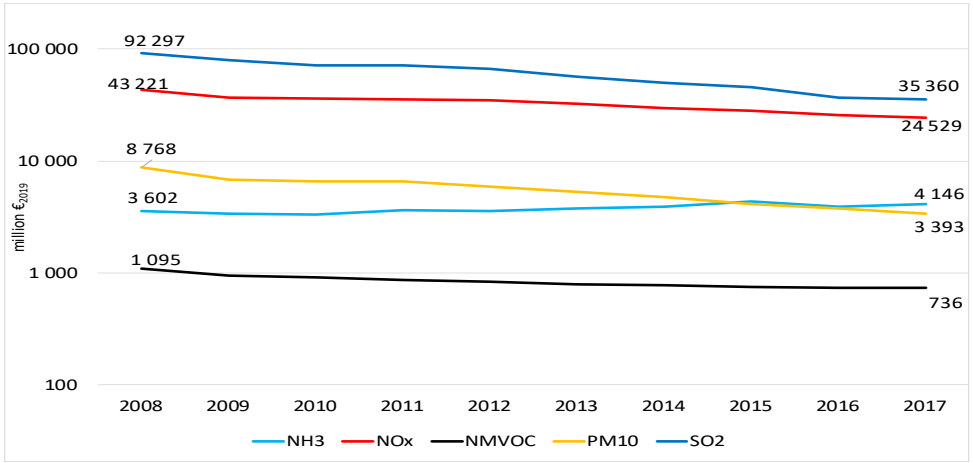
Aggregated damage cost declines over the period

- Aggregated damage costs by pollutant groups from 2008 to 2017 (million €$_{2019}$)

	Aggregated damage costs (million €$_{2019}$)									
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Main air pollutants (NH_3, NOx, PM_{10}, SO_2, NMVOCs)	148983-483692	127559-413532	118781-385673	117029-379726	111144-360979	98069-319434	88629-288937	82838-270272	70896-232313	68165-223350
Greenhouse gases (CO_2, CH_4, N_2O)	244 550	224 766	233 786	221 439	220 081	212 972	206 588	202 595	196 725	197 269
Heavy metals (As, Cd, Cr, Hg, Ni, Pb)	20 770	13 414	16 447	13 090	13 133	12 127	12 068	10 547	11 989	11 775
Organic pollutants (benzene, dioxins and furans, PAHs)	338.51	163.48	191.23	191.03	111.89	133.36	129.26	144.38	143.86	136.69
Sum	414641-749350	365904-651876	369205-636098	351750-614446	344469-594304	323302-544667	307415-507723	296125-483559	279753-441170	277346-432532

Main air pollutants: mortality valued by VOLY for low range and by VSL for high range

- Damage costs for main air pollutants from 2008 to 2017 (million €$_{2019}$) – indicator VOLY for mortality



Aggregated damage costs

- Dominated by costs from main air pollutants and greenhouse gases

Reduction in damage in 2017 relative to 2008

- Main air pollutants: 54%
- Greenhouse gases : 19%
- Heavy metals: 43%
- Organic pollutants: 60%

Main air pollutants

- Reduction most important for SO_2 and PM_{10}, followed by NO_X and NMVOCs
- Damage related to NH_3 increased

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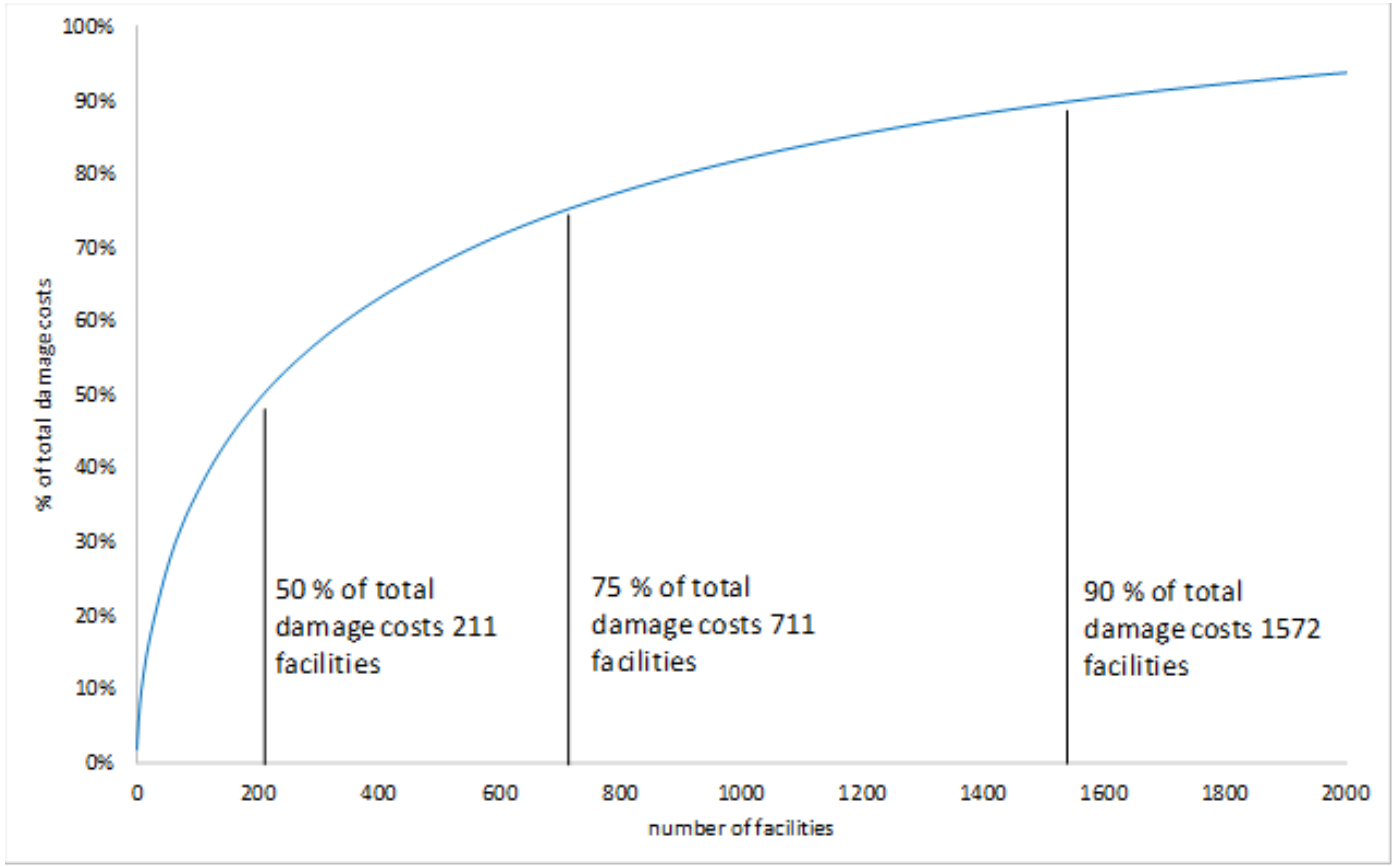
A small number of plant account for 50% of damage

- Cumulative distribution of the estimated damage costs from main air pollutants and greenhouse gases, 2017 – mortality valued using the VOLY indicator



Number of facilities accounting for 50% of damage in 2017:

- Main APs and GHGs: 211 (1.8%)
- Heavy metals: 9
- Organic pollutants: 6

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Conclusions and outlook

- Updated assessment of MDCs implies increase in numbers compared to 2014 assessment
  - Broad magnitude of numbers, performance of facilities relative to one another, and trends in terms of % reduction in damage over time, are relatively stable
- Full consistency with Second Clean Air Outlook in the use of exposure-response functions and monetisation of health impacts from main air pollutants
- Calculation of a comprehensive set of sectoral adjustment factors for all sectors and countries
- Importance of accounting for transboundary impacts
- Priorities for further updates could be
  - Updating health response functions (response-coefficients, range of effects)
  - Valuation of new health endpoints
  - Further increase spatial resolution (beyond 7km for NO_2)
  - Extending the assessment of ecosystems impacts beyond the Natura 2000 sites
  - Use ozone flux indicator for crop & forest assessment (availability of POD SRMs?)

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Thank you for your attention!

The report ETC/ATNI 04/2020 is available here:

https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etc-atni-report-04-2020-costs-of-air-pollution-from-european-industrial-facilities-200820132017

The review report ETC/ATNI 18/2019 is available here:

https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etc-atni-report-18-2019-development-of-a-refined-methodology-for-the-eea-externalities-assessment-1

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