EU emissions

Some insights and developments

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11 June 2024

Agenda

1. Who, what, where?
2. Comparisons between countries
3. The story of condensable PM
4. Link to European scale air quality modelling
5. Observations and temporal profiles

EU emission inventory submissions

All EU-27 countries should submit the following emission inventories:

Inventory	Species	Legislation	Frequency	Temp. Scope
NIR	GHGs	UNFCCC	Annually	1990 – T-2
IIR	APs	LRTAP Convention & EU NEC Directive	Annually	1990 – T-2
Large Point Sources	APs	LRTAP Convention	Every 4 years	T-2
Gridded emissions	APs	LRTAP Convention	Every 4 years	T-2
Emission projections	APs	LRTAP Convention	Every 4 years	2025, 2030, 2040, 2050

Guidance:

- EMEP/EEA Guidebook & IPCC Guidelines listing emission factors, but countries are encouraged to apply their own best knowledge

Access submissions:

NIR: https://unfccc.int/ghg-inventories-annex-i-parties/2023

IIR: https://www.ceip.at/status-of-reporting-and-review-results/2024-submission

Cooperation and exchange

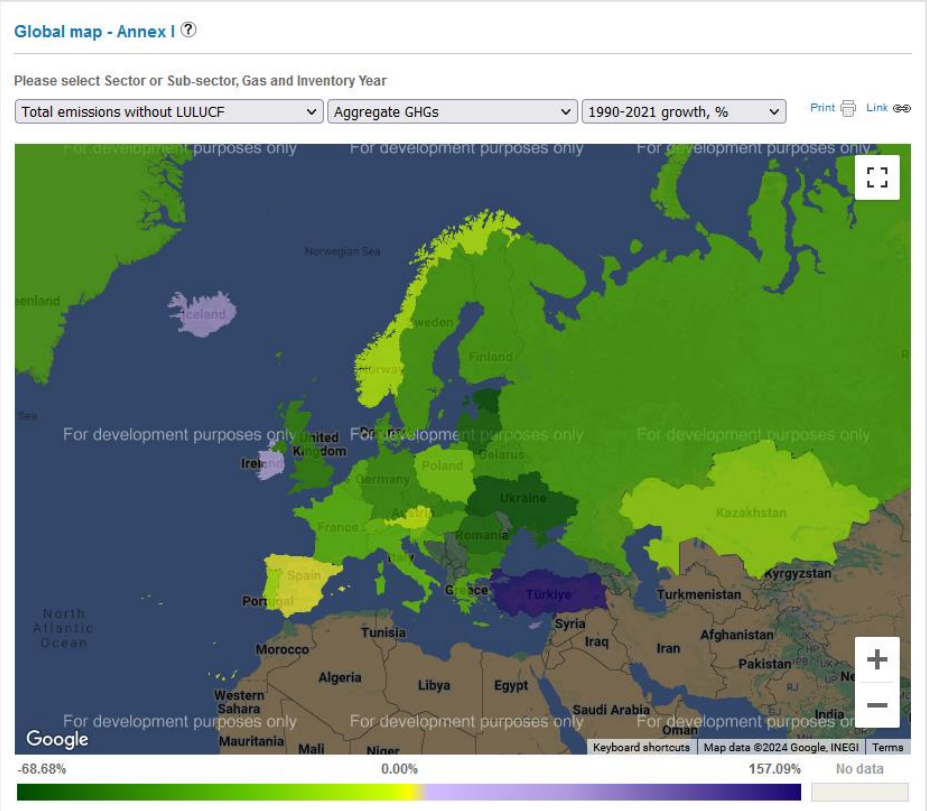
Several routes of cooperation and exchange, a.o. :

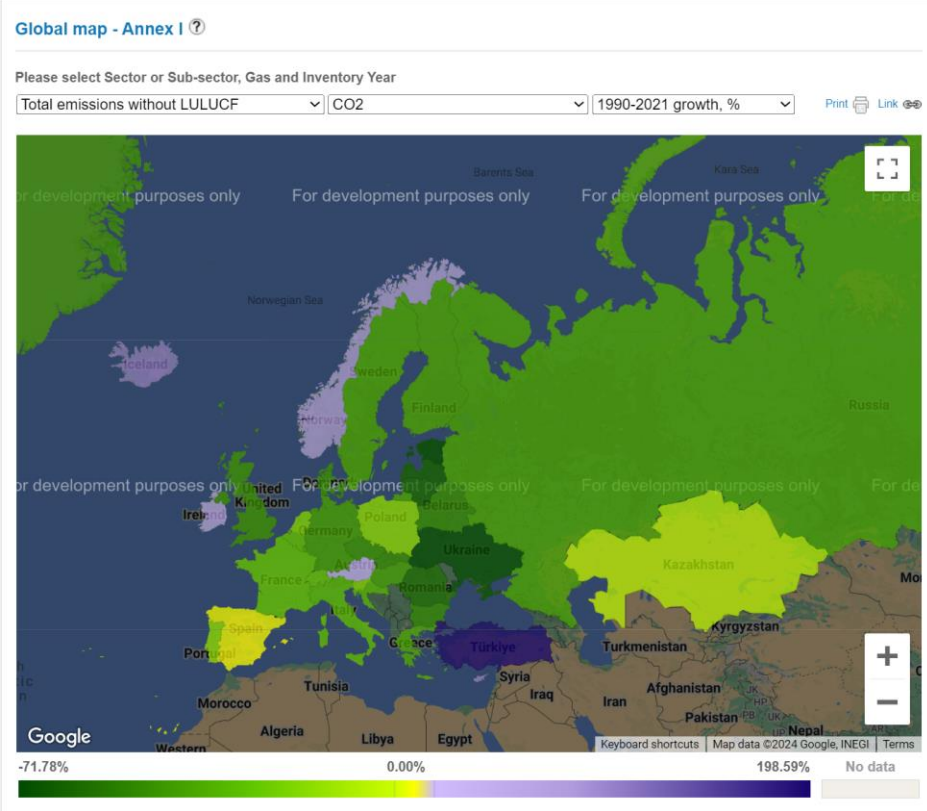
- UNECE TFEIP (Task Force Emission Inventories & Projections) develops guidance and guidelines for the development of emission inventories:
  - Regular meetings
  - Expert panels on various topics such as transport and waste.
  - Developing and updating the EMEP/EEA Guidebook

- Inventory reviews (UNFCCC, EU, NECD, LRTAP):
  - Experts from member countries (incl. ER members) review the submissions:
  - NECD review each round chooses a different focus (e.g. POPs and HM, gridded inventories etc.)
  - Yields insight in approaches of different countries, their data, difficulties and solutions.
  - Checking for and solving issues of **transparency, consistency, comparability, completeness** and **accuracy** (TACCC) of submitted inventory data

Data viewers for trends and comparisons

- EU and UNFCCC offer several data viewers for comparisons between countries and analysis of trends
- https://di.unfccc.int/global_map





Almost all EU countries have managed to reduce total GHG emissions AND CO2 since the base year (1990)

Data viewers for trends and comparisons

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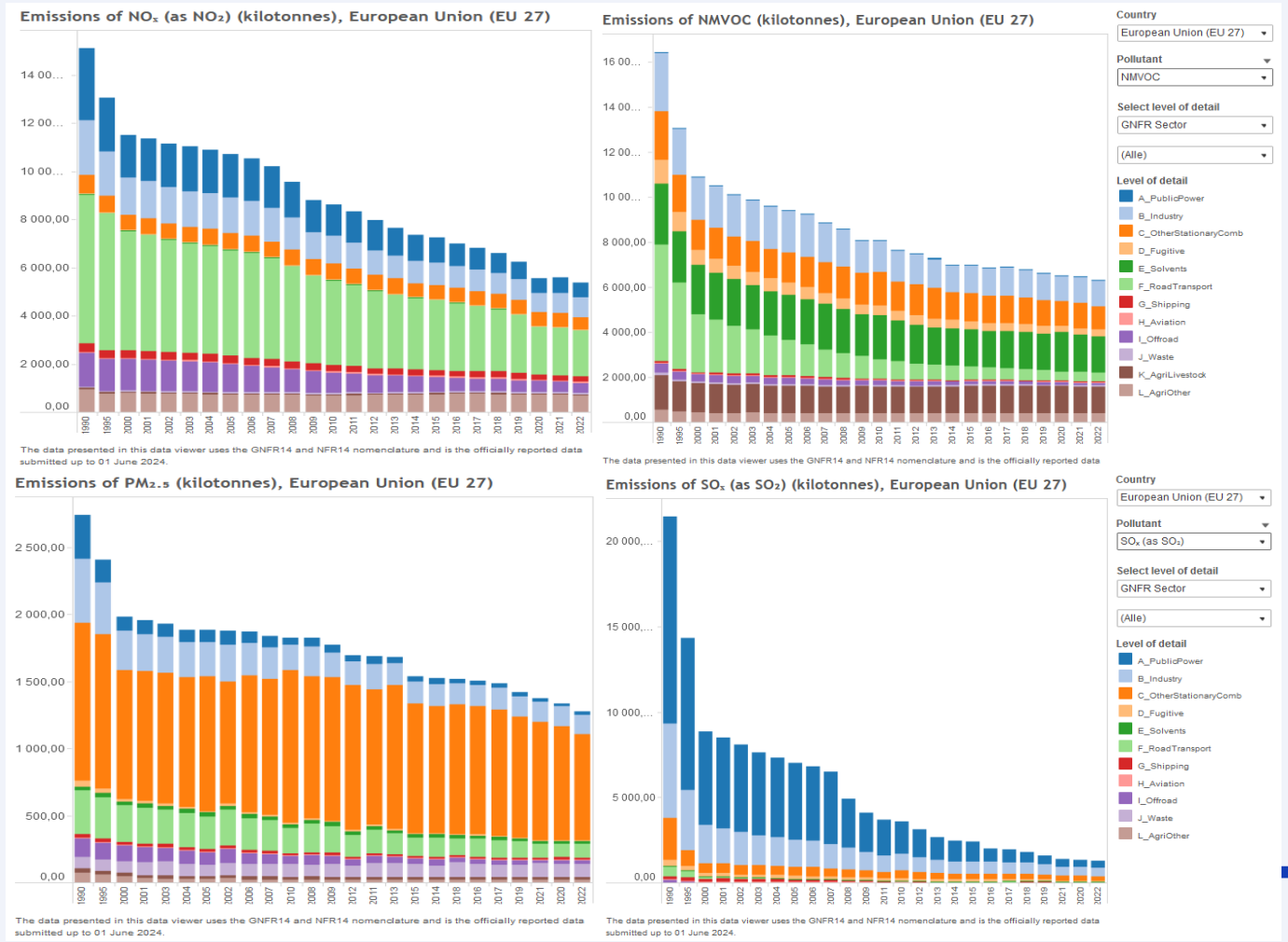
- https://www.ceip.at/data-viewer-2/officially-reported-emissions-data

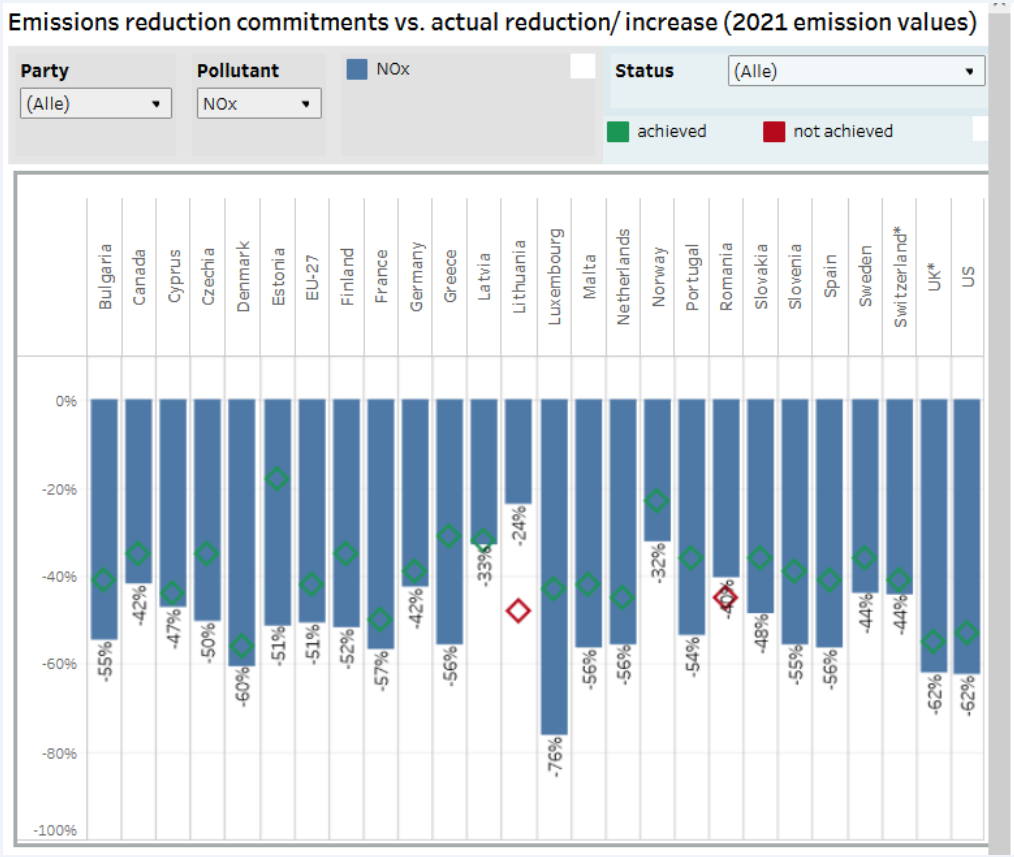


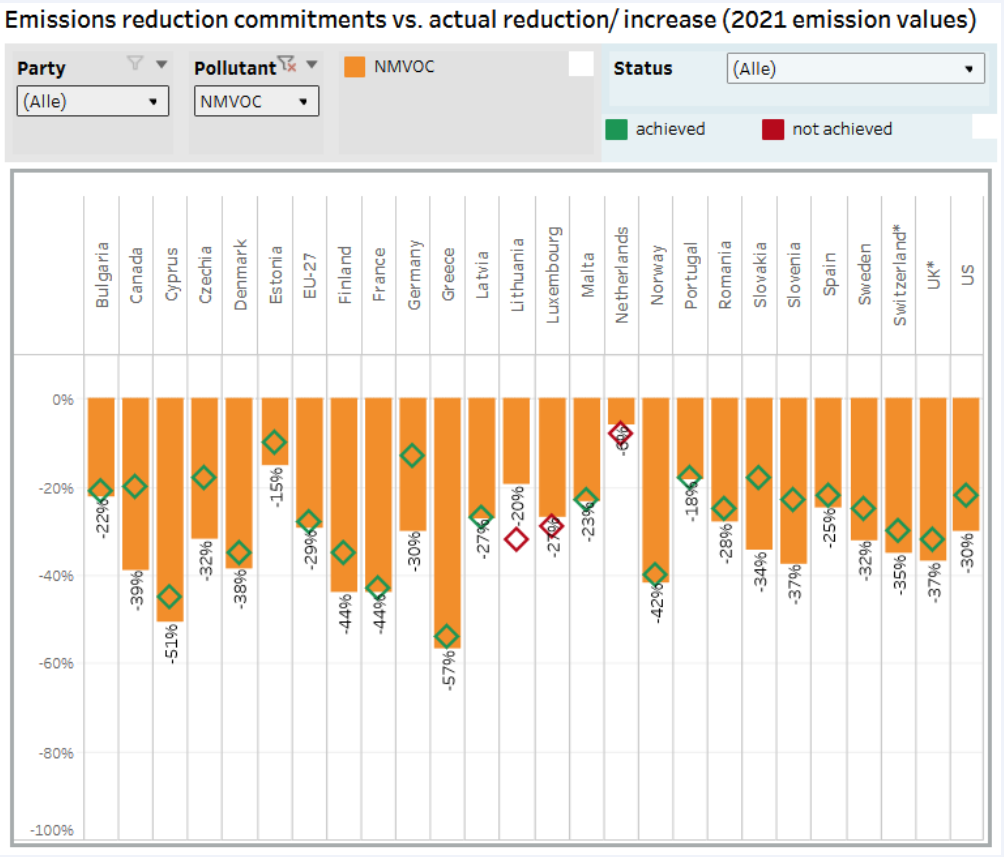
Substantial reduction in AP emissions across EU

But large differences between sectors

Data viewers for trends and comparisons

- EU and UNFCCC offer several data viewers for comparisons between countries and analysis of trends
- https://www.ceip.at/gothenburg-protocol/gp-targets-data-viewer-2

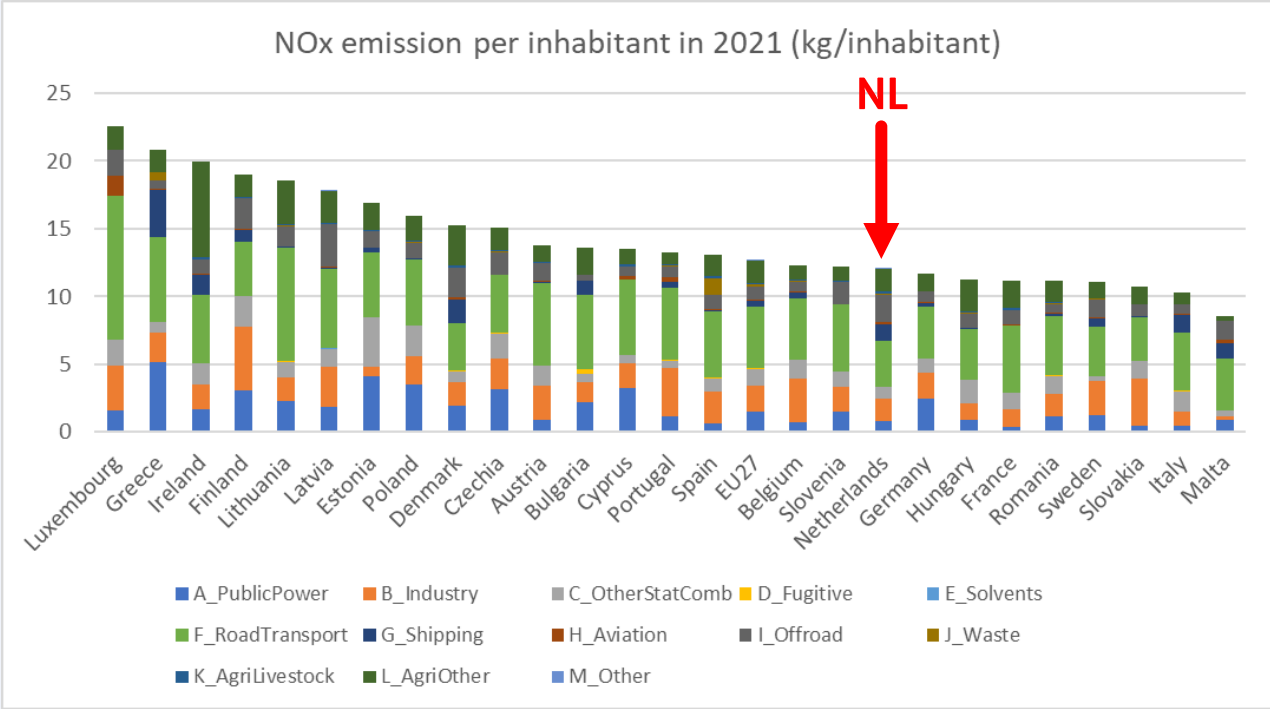


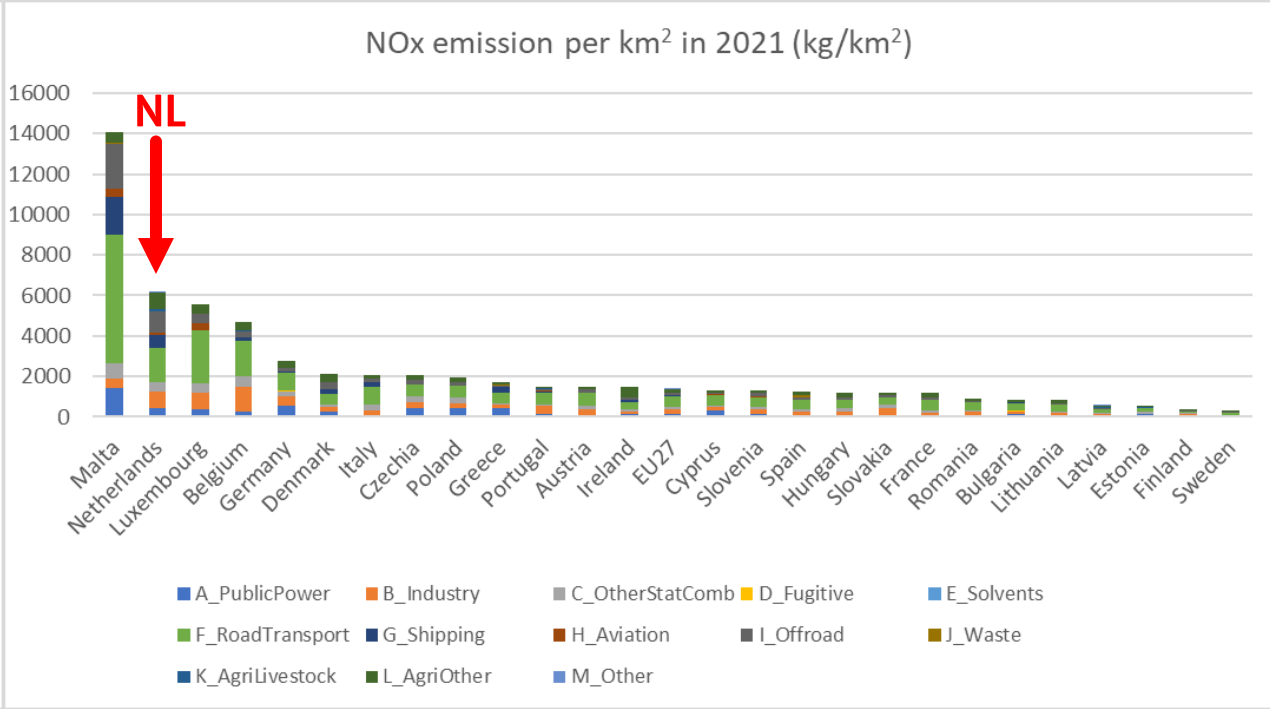


Many countries reaching their relative reduction commitments for national NOx and NMVOC ceilings, compared to 2005

NOx emissions per capita & per km²

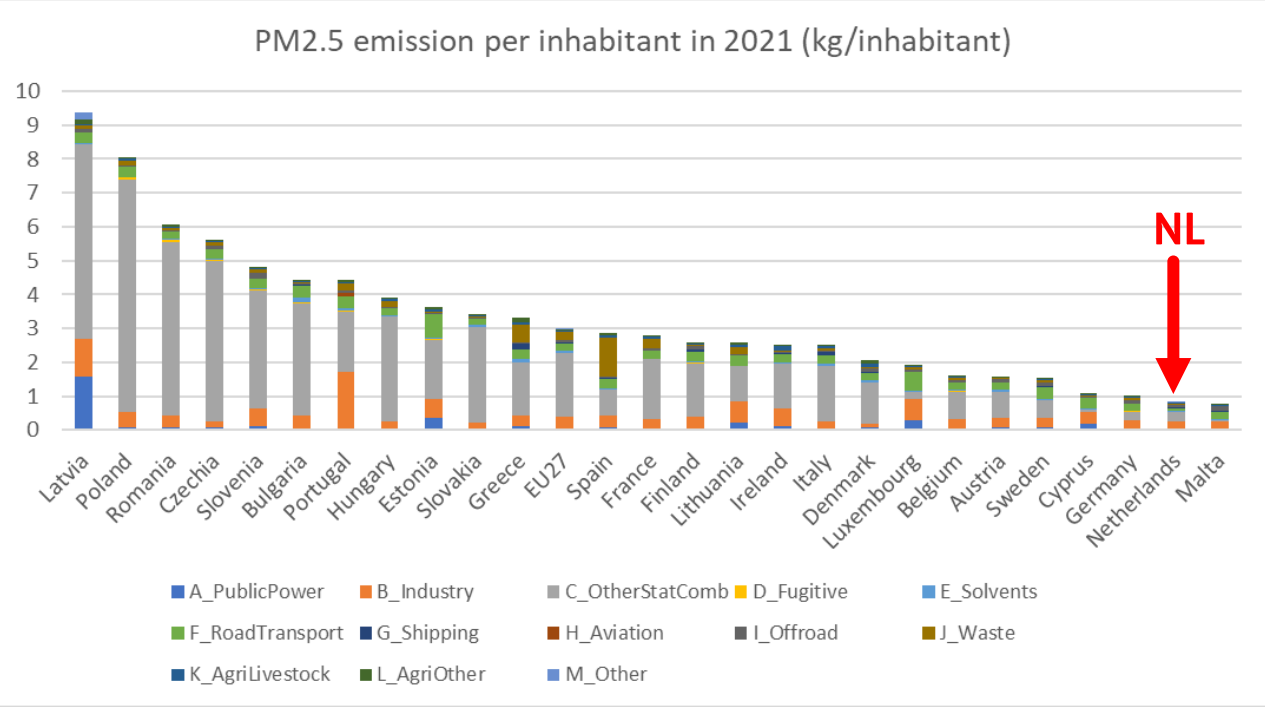
- Emissions mainly caused by transport, energy and industry
- Emissions per km² reflect the population density

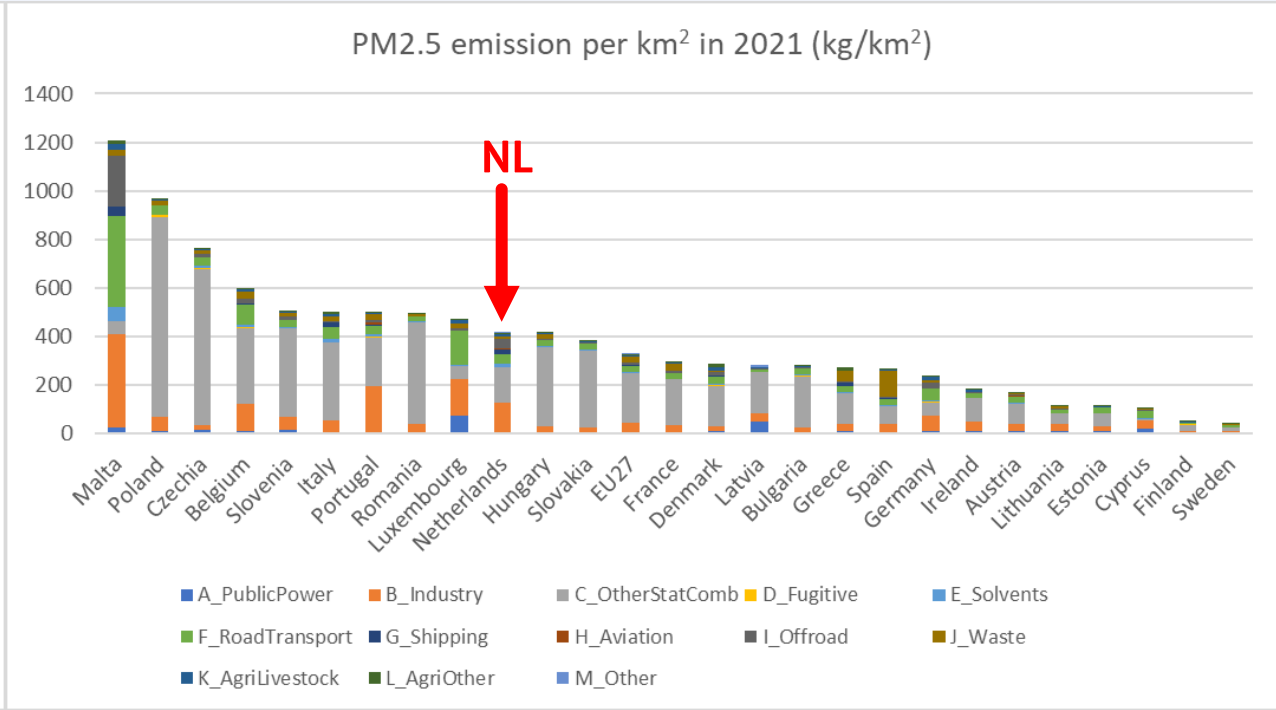




PM2.5 emissions per capita & per km²

- PM emissions mainly caused by small combustion (a.o. wood combustion).
- In the Netherlands: Industry is also a large source



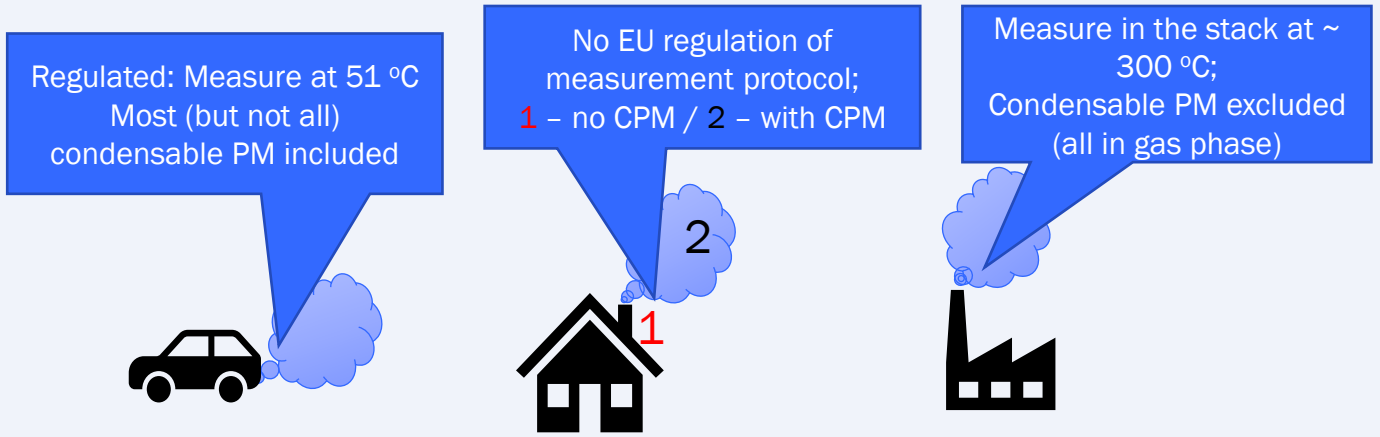


Condensable PM

- PM is partly formed shortly after emission in the atmosphere - relative importance of condensable PM varies by source
- Small combustion the most interesting:
  - Largest contribution to PM2.5 primary emissions in Europe (>50%!)
  - Different ways to measure PM emissions are being used in Europe => in different countries different PM emissions are quantified!

Filterable PM is directly emitted:
- Solid or liquid
- Captured on filter
- PM_{10} or $PM_{2.5}$

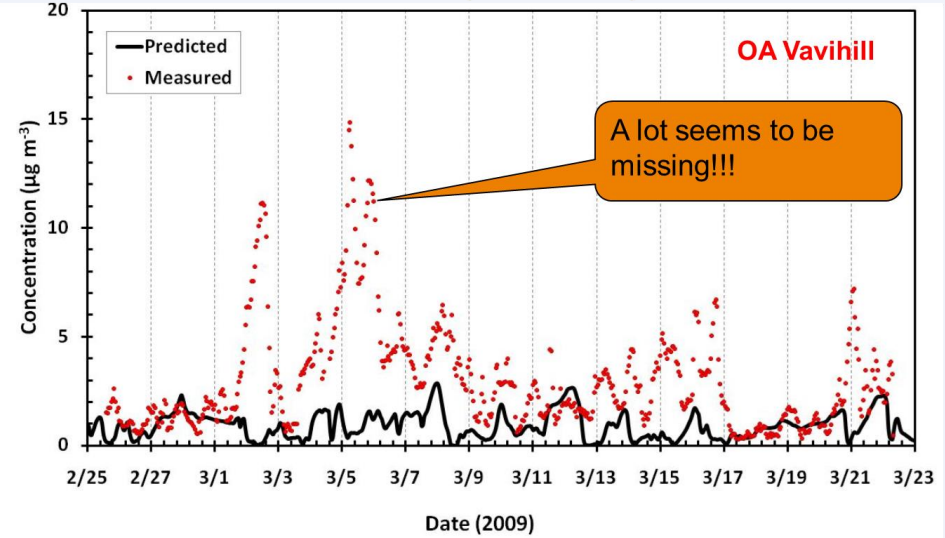
Condensable PM is in vapor:
- Reacts upon cooling and dilution
- Forms solid or liquid particle
- Always $PM_{2.5}$ or less



Impact on EU AQ policies: condensable PM

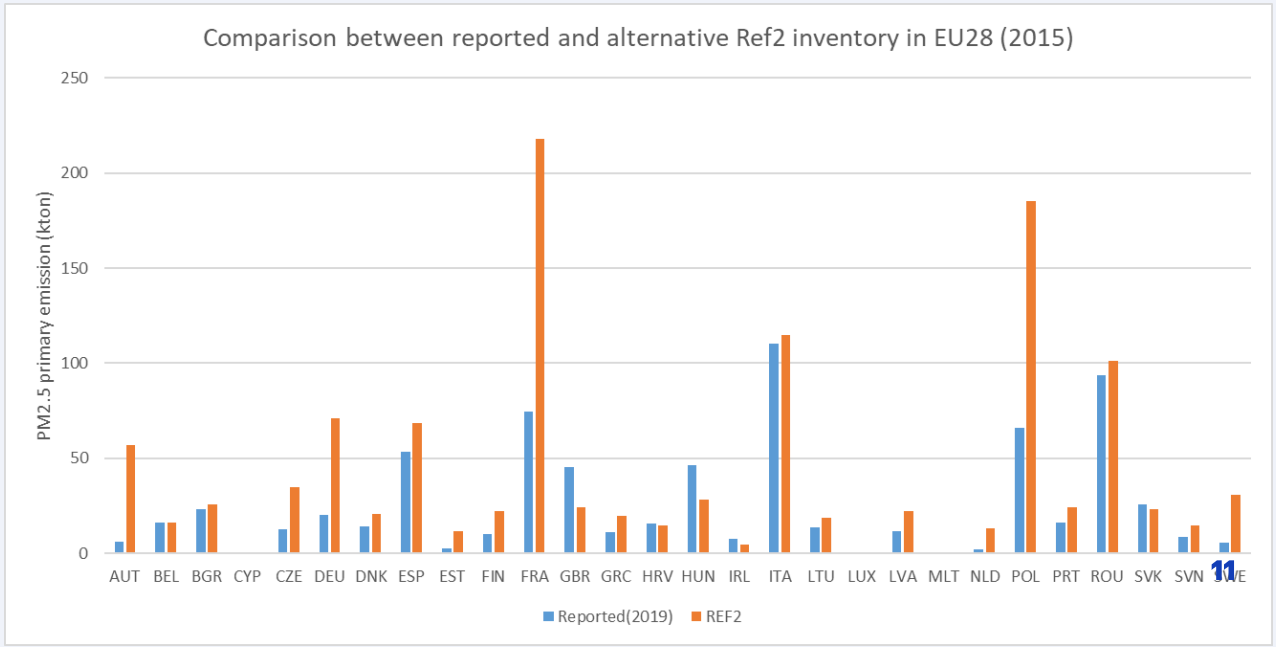
- **~2010**: FP7 research project EUCAARI
- **2011-14** Identification of missing "condensable" PM emissions in European data – Collaboration several groups (TNO, EMEP, etc.)
- 2015 Peer-reviewed Paper on alternative emission dataset for residential wood burning (RWC) → "**Ref2**": small combustion emissions increased by ~ 65% (EU28 total by ~ 35%)
- 2015-2017 Air quality models show significant improvement in forecasting PM using the new data
- 2017-2020 Progress published in EMEP reports
- Over time various workshops e.g. UNECE TFEIP; EEA; EIONET; EC; Nordic council workshop
- 2019 TNO updates the EMEP/EEA Guidebook
- **2018-2023 MS increasingly report adjusted emissions for RWC**; in EU only ~5 countries have not (yet) adopted); Increased awareness of importance for PM and health.

PMCAMX EVALUATION (WINTER)



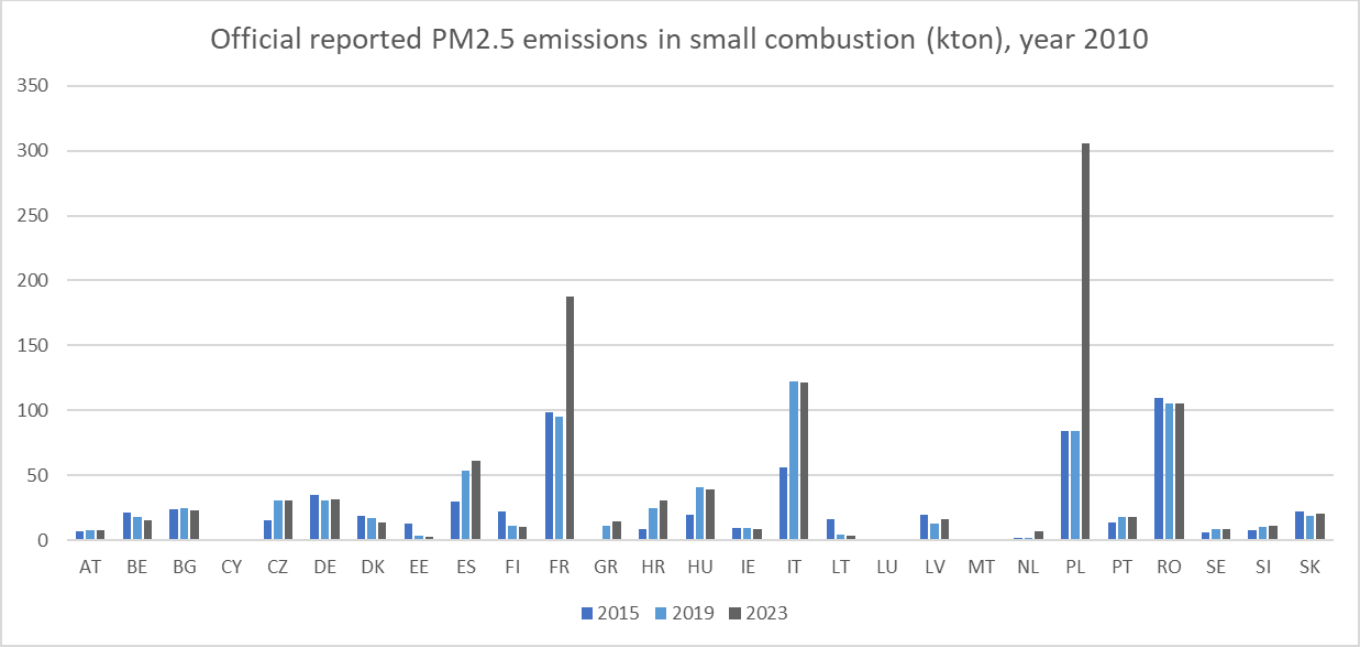
Similar performance in Payerne, Melpitz

[ACP - Particulate emissions from residential wood combustion in Europe – revised estimates and an evaluation (copernicus.org)]



Condensables

- In recent years, some major countries updated their inventories (Poland +200kton, France +100kton) which makes the difference between official reported and Ref2 much smaller
- In 2023 reporting, for EU as a whole slightly higher PM emissions in official reported than Ref2 (!)
- Emissieregistratie has started including condensable PM from wood combustion as of 2021



The use of emission inventories on a European scale

Monitoring emissions and emission trends, check compliance and distance to target

Table 3-2 Tier 1 emission factors for source category 1.A.1.a using hard coal

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	1.A.1.a	Public electricity and heat production			
Fuel	Hard Coal				
Not applicable					
Not estimated	NH3				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NOx	209	g/GJ	200	350	US EPA (1998), chapter 1.1
CO	8.7	g/GJ	6.16	15	US EPA (1998), chapter 1.1
NMVOC	1.0	g/GJ	0.6	2.4	US EPA (1998), chapter 1.1
SOx	820	g/GJ	330	5000	See Note
TSP	11.4	g/GJ	3	300	US EPA (1998), chapter 1.1
PM_{10}	7.7	g/GJ	2	200	US EPA (1998), chapter 1.1
$PM_{2.5}$	3.4	g/GJ	0.9	90	US EPA (1998), chapter 1.1

ANNEX 1: National sector emissions: Main pollutants, particulate matte

NFR 2019-1

COUNTRY:	XX	(as ISO2 code)
DATE:	05.02.2023	(as DD.MM.YYYY)
YEAR:	2005	(as YYYY, year of emissions and activity data)
Version:	v1.0	(as v1.0 for the initial submission)

XX: 05.02.2023: 2005	NFR sectors to be reported			Main Pollutants (from 1990)				Particulate Matter (from 2000)				Other (from 1990)	Priority Heavy Metals (from 1990)		
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg
NFR Aggregation for Gridding and LPS (GNFR)	NFR Code	Long name	Notes	kt	kt	kt	kt	kt	kt	kt	kt	kt	t	t	t
A_PublicPower	1A1a	Public electricity and heat production													
B_Industry	1A1b	Petroleum refining													
B_Industry	1A1c	Manufacture of solid fuels and other energy industries													
B_Industry	1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel													
B_Industry	1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals													
B_Industry	1A2c	Stationary combustion in manufacturing industries and construction: Chemicals													
B_Industry	1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print													
B_Industry	1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco													
B_Industry	1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals													

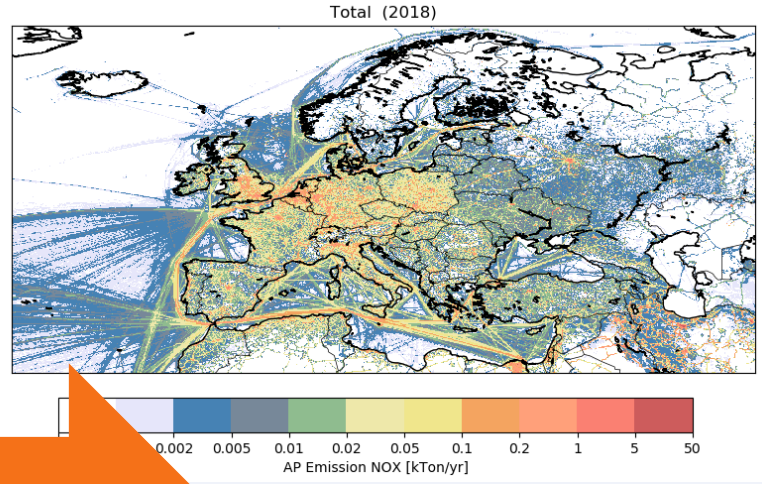
Emission inventories for policy purposes (compliance focus) require primarily:

- Emissions per substance, per year, per country, per sector

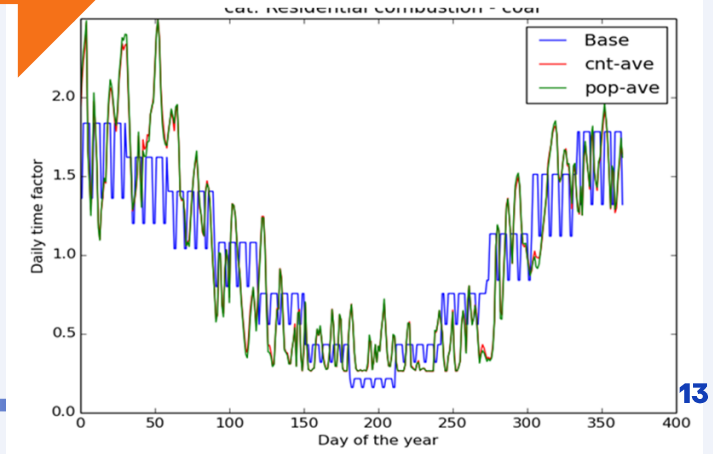
For use in air quality modelling studies, (additional) information is needed on:

- Location of each emission source
- Information on the temporal variability of emissions
- Speciation information for lumped species (e.g. PM, NMVOC)

Input to the assessment of air pollution and its impacts



Meteo dependent emission modelling



CAMS-REG in a nutshell

EU27+UK, NO,CH,IS with corrections

- Official reported GHG emissions (UNFCCC CRF)
- Official reported Air Pollutant emissions (EMEP CEIP)

Other Eur countries

- Other emission datasets (most notably, IIASA GAINS)

All countries

- TNO internal estimates (bottom-up)

Sectors harmonized
Missing years estimated
Fuels introduced for air pollutants
~ 250 subsectors in total
~ 50,000 records/year (>0)

TNO/CAMS emissions by subsector

Spatial proxies

- NMVOC from hand sanitizer
- Inland shipping
- Aviation for GHGs
- Agricultural waste burning
- Road transport fuel tourism
- International shipping
- And country-specific issues…

For each emission *E(s,c,y,p)* a specific proxy is assigned

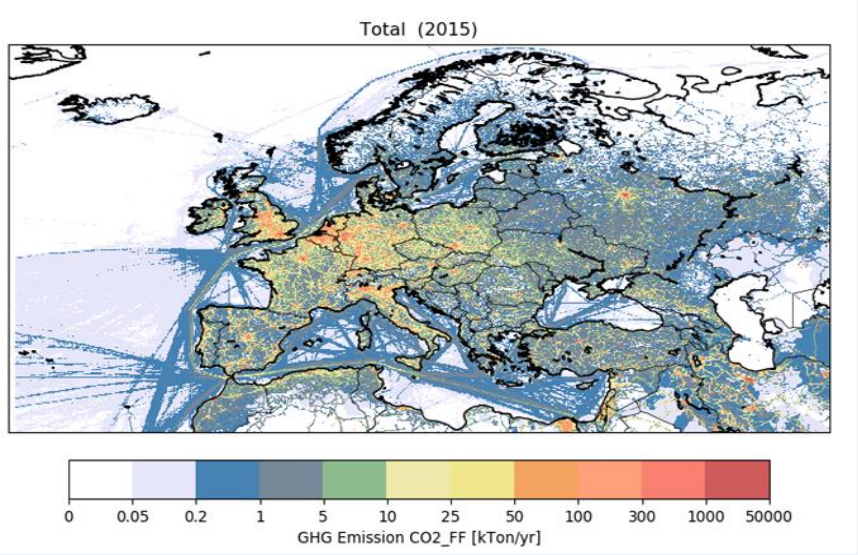
- Population
- Road transport
- Animal densities
- E-PRTR, etc. etc.

CAMS-REG grid for Europe

Shipping grids (STEAM / FMI)

Outside Europe (CAMS-GLOB)

Gridded European regional emission product (time series)



Annual emission grids accompanied by:

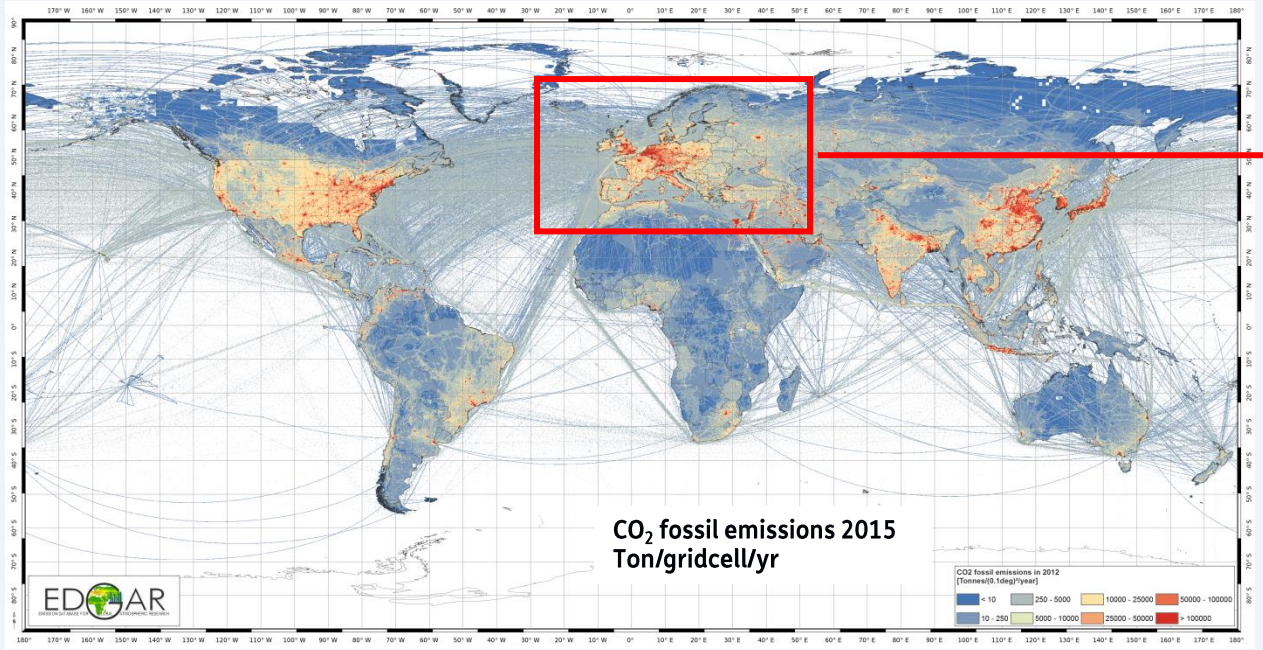
- Annual data broken down to hourly by using temporal profiles
- Speciation profiles for PM/NMVOC

All details in Kuenen et al., ESSD, 2022

Anthropogenic CO_2 emissions – scales

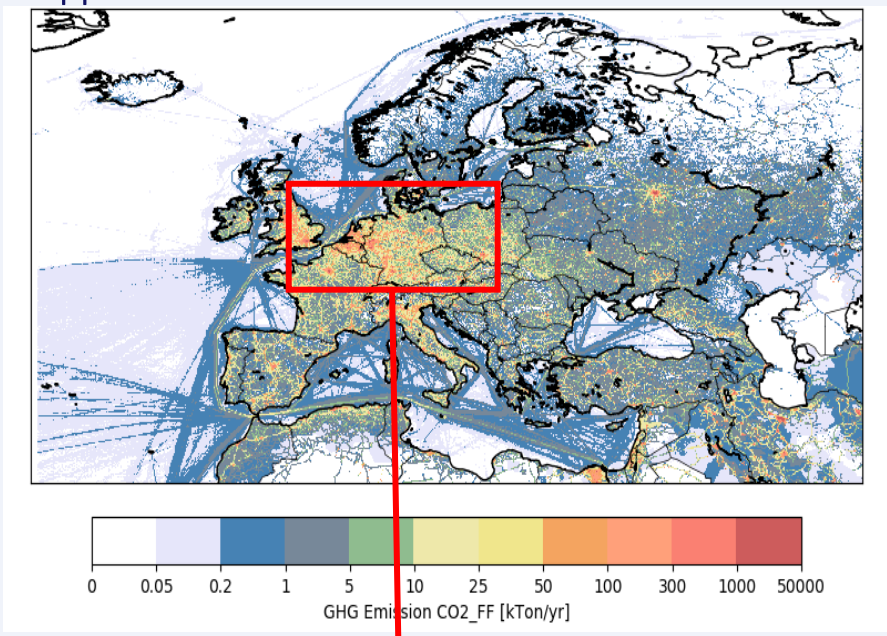
EDGARv4.3.2 Global

0.1° x 0.1°

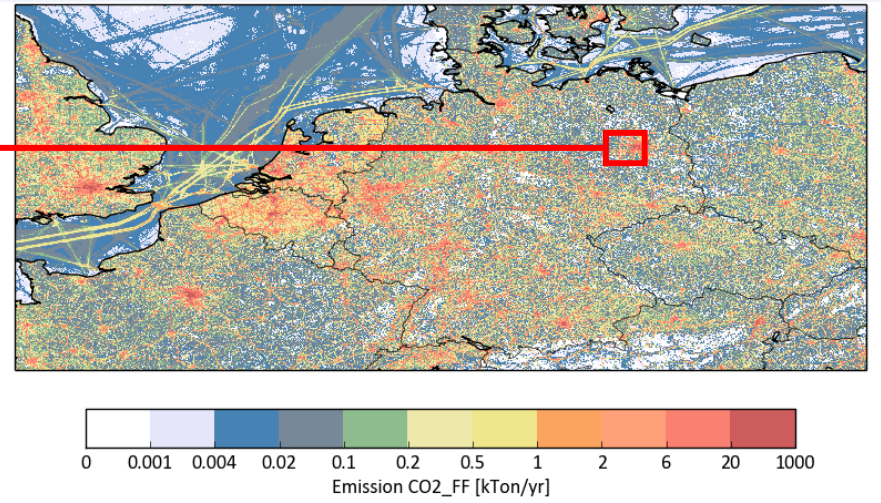


CAMS-REG / TNO-GHGco Europe

approx. 6 km x 6 km



TNO-GHGco zoom: approx. 1 km x 1 km

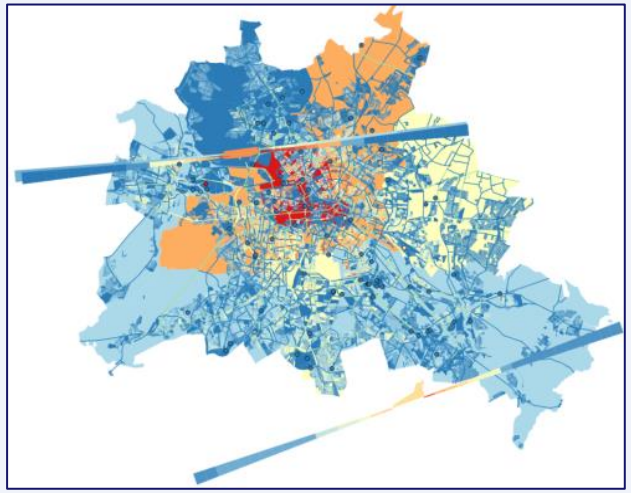


Senate of Berlin

point, area + line sources

Nested into TNO GHGco zoom

at 1 km x 1 km

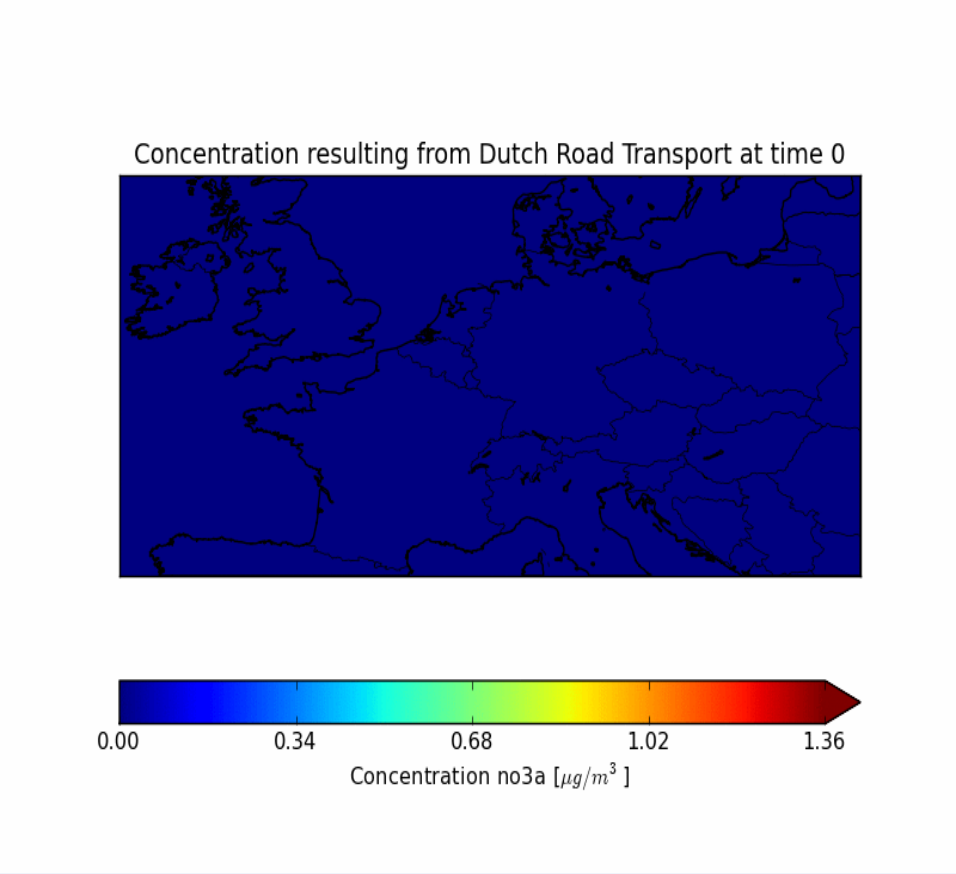


CO_2 Human Emissions

SPECIAL TOOLS: SOURCE ATTRIBUTION – TAGGING/LABELLING

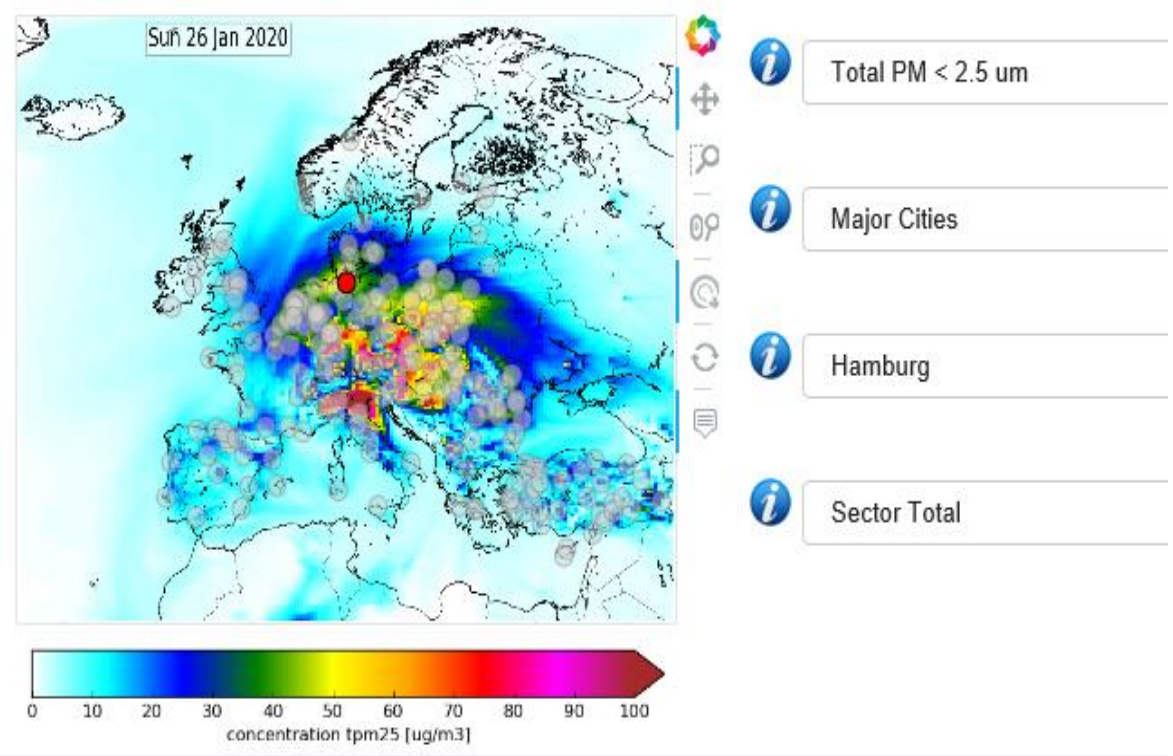
Which sources are responsible for the high levels of pollution?

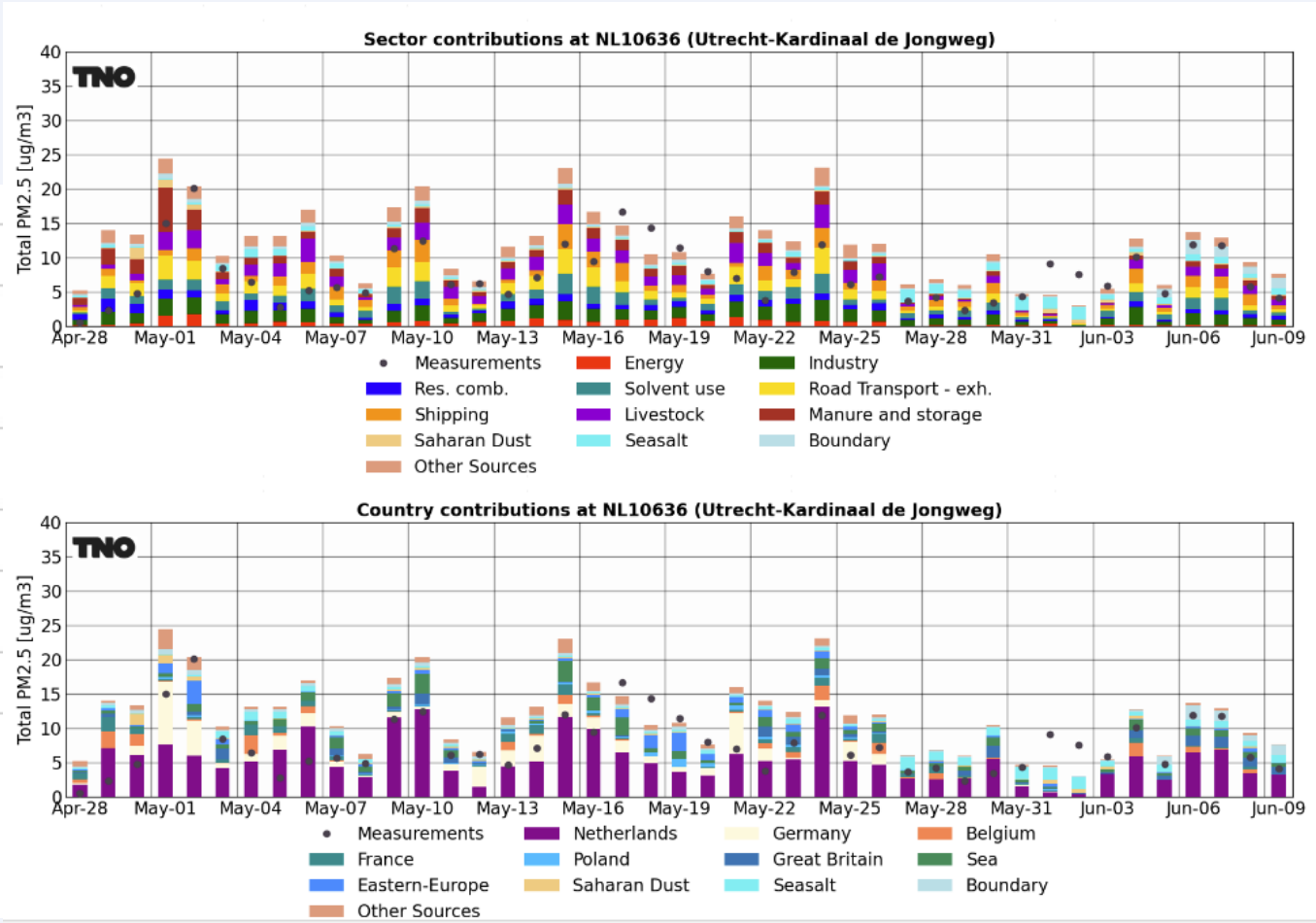
- Emitted pollutants can be tracked by accounting conserved atoms (such as N, S, and passive tracers) through the model, including chemical conversions (e.g. formation of sulphate, nitrate) according to their source **sector** and **geographical origin**
- Can increase policy relevance of air quality modelling



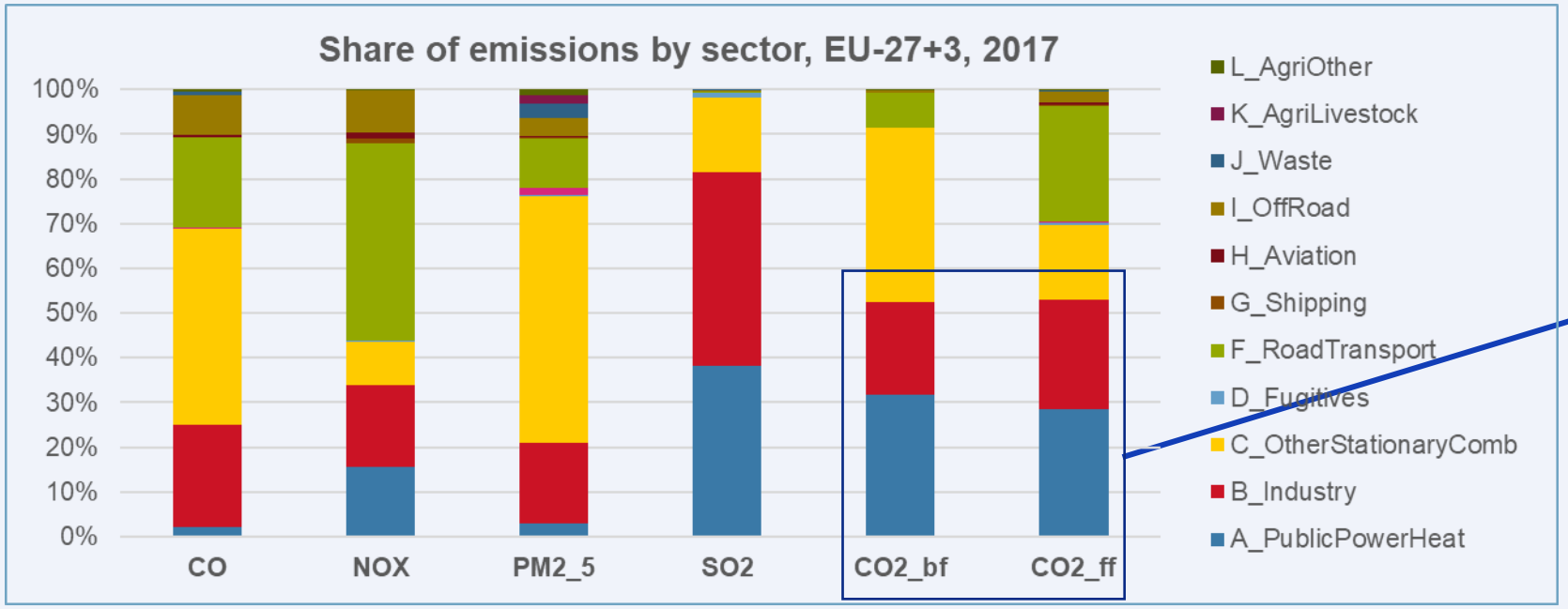
TNO Operational source attribution service (TOPAS)

- http://topas.tno.nl/
- Currently available for PM, NO2, SO2 and CH4
- Much better results with condensables included!





Emission inventory: point sources 50% of CO2



Industry + Powerplants = 50% for CO2 from fossil & bio fuels (all point sources)

- **Public power and heat (PPH)** sector total contribution to emissions is significant:
- Datasets: European Pollutant Release and Transfer Register (E-PRTR) & Large Combustion Plants (LCP)

S. Dellaert, H. Denier van der Gon, A. Visschedijk, J. Kuenen, Ingrid Super, *Compiling a more complete inventory of public power and heat plant point source emissions in the EU*, presented @ ICOS science conference 2020

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TANGO satellites

- TANGO = Twin Anthropogenic Greenhouse gas Observers.
- Working with ISISpace, SRON and KNMI, TNO has played an essential role in designing a twin satellite system that can measure emissions at individual industrial facilities at a spatial resolution of around **300 m x 300 m.**
- The TANGO mission will use two Spectrolite instruments to measure:
  - **Carbon dioxide (CO_2)** emissions with a threshold of ≥ 5 Mt/yr and goal of ≥ 2.5 Mt/yr, representing respectively about 44% and 66% of the annual global total CO2 emission of the power sector,
  - **Methane (CH_4)** emissions with a threshold of ≥ 10kt/yr and goal of ≥ 5 kt/yr, representing respectively about 68% and 75% of the annual global total emissions of major industrial emitters including the oil & gas sector, coal mines, and landfills and,
  - **NO_x emissions**, which will improve the detection of CO_2 plumes, deriving historic CO_2 emission trends based on readily available global NOx measurements, and to detangle the possible CO_2 contribution in mixed CH_4 - CO_2
- Well established policy needs (Paris Agreement – Global Stocktake, EU Methane Strategy, Methane pledge, OGMP, IMEO)

› Status: On-going multi-million EUR technology development with ESA, and scientifically approved by ESA

Summary and outlook

- National emission inventories are compiled to check whether countries comply with emission reduction goals
- European collaboration is important to ensure high quality and consistent emission reporting
- Particulate matter and its components receive increasing attention (health impacts!) → success story on cooperation on condensable PM
- High quality emission inventories are also a key input for air quality modelling
  - EmissieRegistratie provides high resolution emission data for the Netherlands, while CAMS-REG is the main (annually updated) emission inventory for European scale for main pollutants
  - Bridging the gap between policy-relevant inventories and inputs needed by air quality modellers across Europe → Improved spatial & temporal disaggregation ⇄ Source attribution can increase policy relevance
  - Spatial emission inventories are important inputs when comparing with observations, such as satellites

Thank you !