Concawe NOx/NO_2 Source Apportionment Viewer

Intro & Demonstration

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Concawe – Environmental Science for European Fuel Manufacturing

Concawe Membership

Concawe represents 38 Member Companies ≈ 95% of EU Refining

Concawe Mission

- To develop scientific research and technical studies on industry's products and operations, and their impact, often in association with external research institutes in order to:
  - Increase the understanding of the impact of our industry and use of our product through advanced scientific developments
  - Develop with scientific rigour technically feasible and cost-effective pathways to achieve the EU's health, environmental and climate goals
  - Contribute to an informed legislative decision and facilitate the industry's regulatory compliance
  - Evaluate, for future scenarios, the potential role and contribution of our industry and its evolution.

Concawe NOx/NO_2 Source Apportionment Viewer

Objective: Assess the impact of local and EU-wide traffic measures on NO_2 concentration

Developed in collaboration with VITO - EU-wide, high resolution (~ 100 m), main focus on road transport

Main Functionalities (currently available):

- Viewer on fleet composition per country in terms of vehicle category, fuel and Euro standard
- Source apportionment per 100x100 m cell: 10 sectors with traffic in higher detail (local vs. regional)
- Source apportionment at city-level (948 cities* available): urban and extra-urban contribution of 10 sectors with traffic in higher detail
- Local and EU-wide scenario functionalities to assess the impact of traffic measures:
  Urban Access regulation – e.g., "LEZ-like" scenarios
  Activity changes – e.g., modal shift, road pricing, Covid-19 lockdowns
  Introduction of a more stringent "new Euro standard"
  Excluding vehicle types from the local fleet (for 100x100m cells)
- Functionalities available for: 2015-2020-2025-2030

* Source: https://ec.europa.eu/eurostat/web/cities/spatial-units)

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Methodology

NO_2 source apportionment methodology

Methodology overview

1. Choice of cities.
2. Road network and vehicle flows: OpenTransportMap
3. Vehicle emissions on the EU28 road network for 42 vehicle types.
    - Provided by EMISIA (www.emisia.com): consultancy company collecting data about the vehicle fleet composition and emission factors (COPERT)
    - Euro 6d/VI vehicles build in 2027 or after were relabeled as Euro 7/VII for petrol Car and LDV, diesel Car and LDV, and diesel trucks.
4. Concentration calculation:
    - SHERPA (developed by JRC) source apportionment at low resolution (7x7 km) to determine how much NOX in the city comes from each sector (10 SNAP sectors) and from where (inside or outside the city).
    - QUARK (IFDM annual average kernels, developed by VITO) high resolution modelling of road traffic.
    - Combination of SHERPA and QUARK results into an NO2 map

Choice of cities

- Eurostat definition of Cities, Greater Cities, and Functional Urban Areas:
  - ***City***: Administrative unit with more than 50.000 inhabitants
  - ***Greater City***: consists of a city and its commuting zone
  - ***Functional Urban Area***: approximation of the urban center when this stretches far beyond the administrative city boundaries

Example: Dublin

- Cities and Greater Cities correspond roughly to current Low Emission Zones.
- Functional Urban Areas are much larger than typical low emission zones.

(Source: https://ec.europa.eu/eurostat/web/cities/spatial-units)

Vehicle fleet and emissions

Spatial transport emissions based on:

- Sybil by EMISIA: up-to-date vehicle fleet and activity data for road transport based on recent national statistical data and projections based on fleet turnover, 2nd hand imports,…
- COPERT by EMISIA: emission factors and emissions of the fleet
- FASTRACE by VITO: spatial distribution of road transport emissions over the OpenTransportMap network.

- NOx emissions decrease 69% and vehicle kilometers increase 19% from 2015 to 2030 in the EU28.

pollutant	NOX	
Row Labels	**Sum of vkm**	**Sum of emission**
2015	4.76E+12	3.76E+09
2020	5.09E+12	2.96E+09
2025	5.35E+12	1.95E+09
2030	5.68E+12	1.23E+09

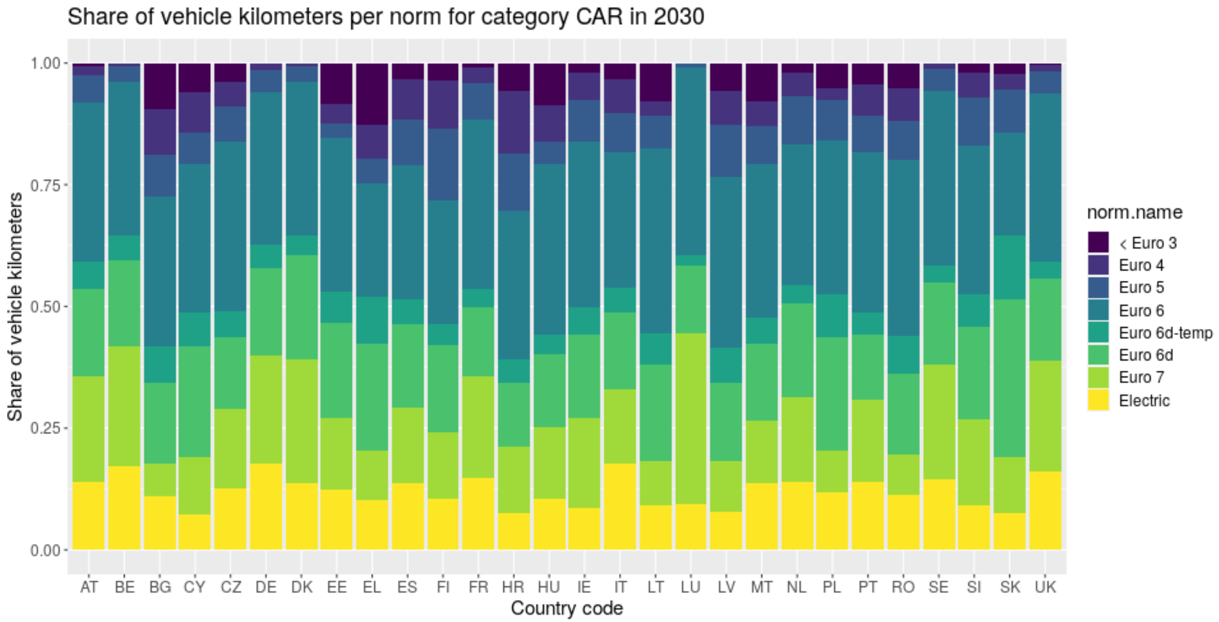
Passenger car fleet evolution

Decreasing vehicle km share of Euro5 Diesel cars:

- Spain: 23% in 2015 -> 7.4% in 2030
- Denmark: 27% in 2015 -> 1.8% in 2030

Increasing vehicle km share of EVs

- Germany: 0.8% in 2020 -> 17.6% in 2030
- Czechia: 0.4% in 2020 -> 12.5% in 2030



Concentration calculation

Challenges:

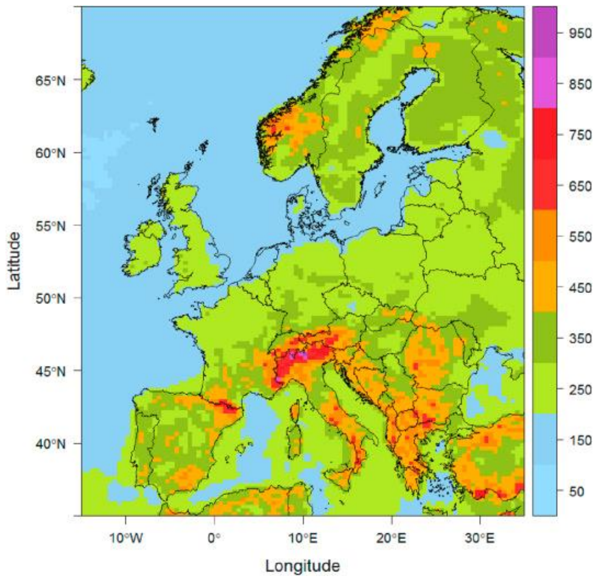
- Model **long-distance transport** at European scale (Euro 7/VII, traffic measures in big cities)
- **High resolution** in cities because NO_2 shows strong gradients close to roads

Modelling long distance transport

- Typically done with Chemistry Transport Models (very slow)
- Alternative: annual average concentrations at low resolution (7x7km) from the **SHERPA source receptor** model ➔ impact of emissions outside the city and long-distance impact inside the city

High resolution close to roads

- Typically done with Gaussian dispersion model and hourly meteorology (slow)
- Alternative: annual average **concentrations kernels** of 4x4 km for typical meteorology all over Europe with the QUARK model.



Maximum concentrations ($\mu g/m^3$) of annual average dispersion kernels around a point sources of 1 kg/h

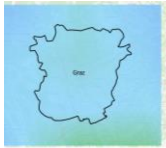
Concentration calculation

Constant non-traffic background

Long-distance low-res impact of urban and regional emissions

High-res impact of 42 vehicle types

$NOx \rightarrow NO_2$



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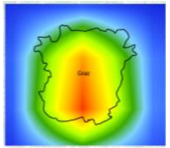

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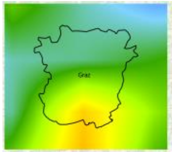

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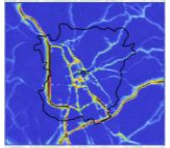
$$\sum_{vt=1}^{43} w_{vt} \times$$



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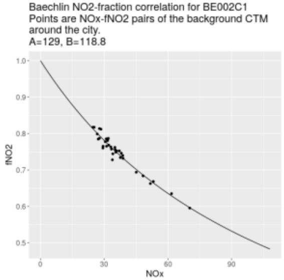

Final NO_2 concentration map

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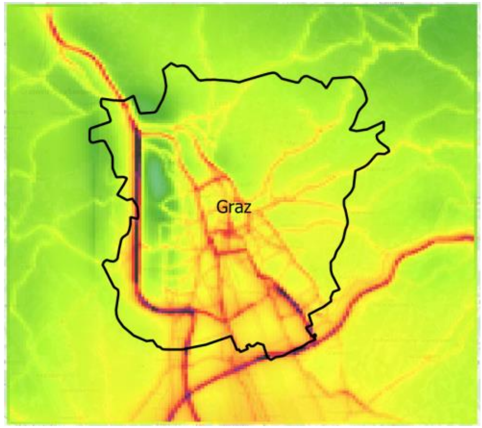

All these layers are precalculated so that scenarios can be calculated quickly in real time for 948 cities.

Summary and limitations

- A combination of SHERPA and QUARK allowed to calculate beforehand the data to explore a wide range of scenarios. This would take too long with a CTM and Gaussian model.
- The NO_2 Source Apportionment viewer provides for almost 1,000 European cities:
    - an overview of the urban and regional contribution of traffic and other sectors,
    - detailed information about the contribution of vehicle types and,
    - a realistic picture of both local (LEZ, modal shift) and Europe-wide (Euro7) traffic measures.
- Some limitations are:
    - The traffic dataset does not contain traffic counts on individual streets, but national totals spread out with *OpenTransportMap* as a proxy.
    - No street canyon effects are considered, hence concentrations might be higher in some streets
    - Non-traffic sectors are kept constant (next version might include scenarios for other sectors)
    - The NO_2 concentration due to non-traffic sources comes from the CAMS ensemble for 2017.

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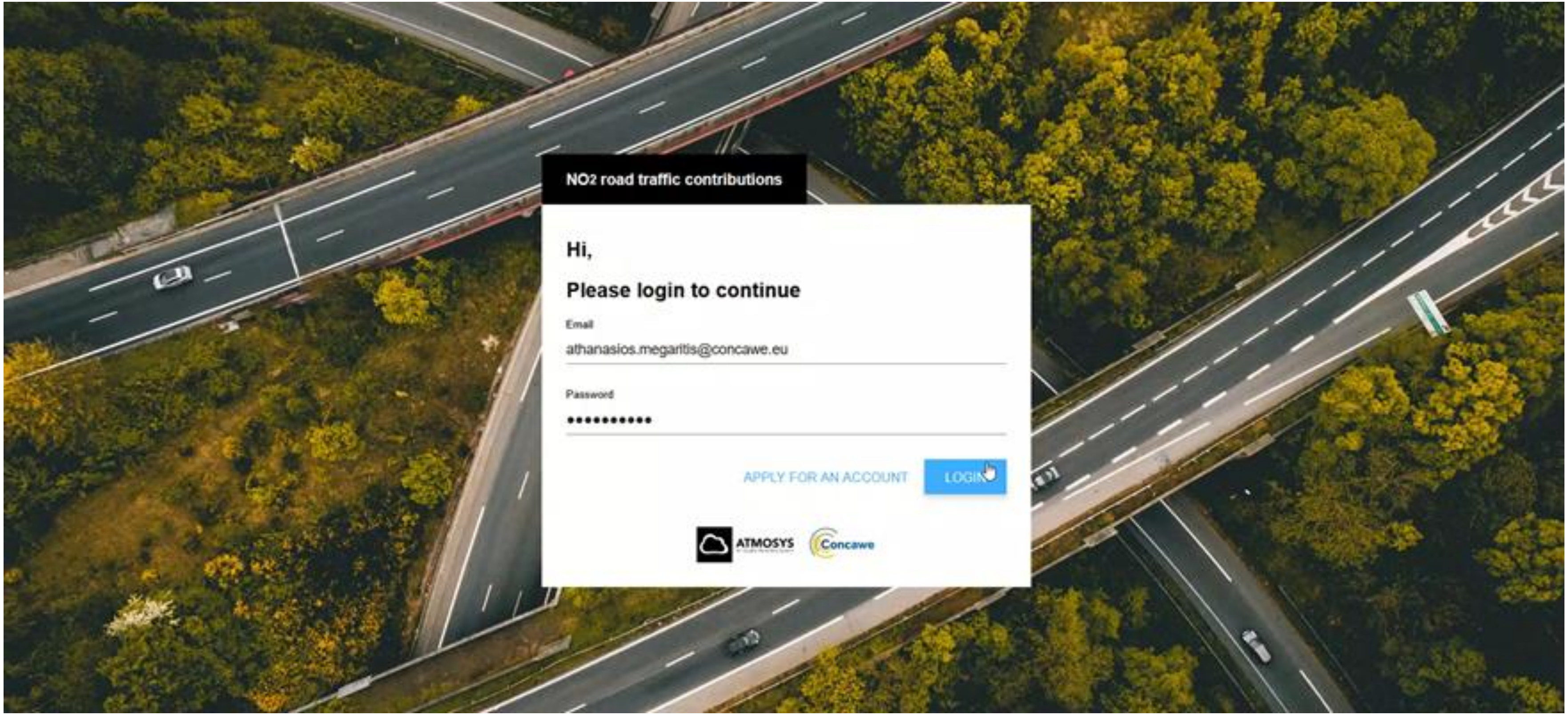
Concawe NOx/NO_2 SA Viewer

The Viewer



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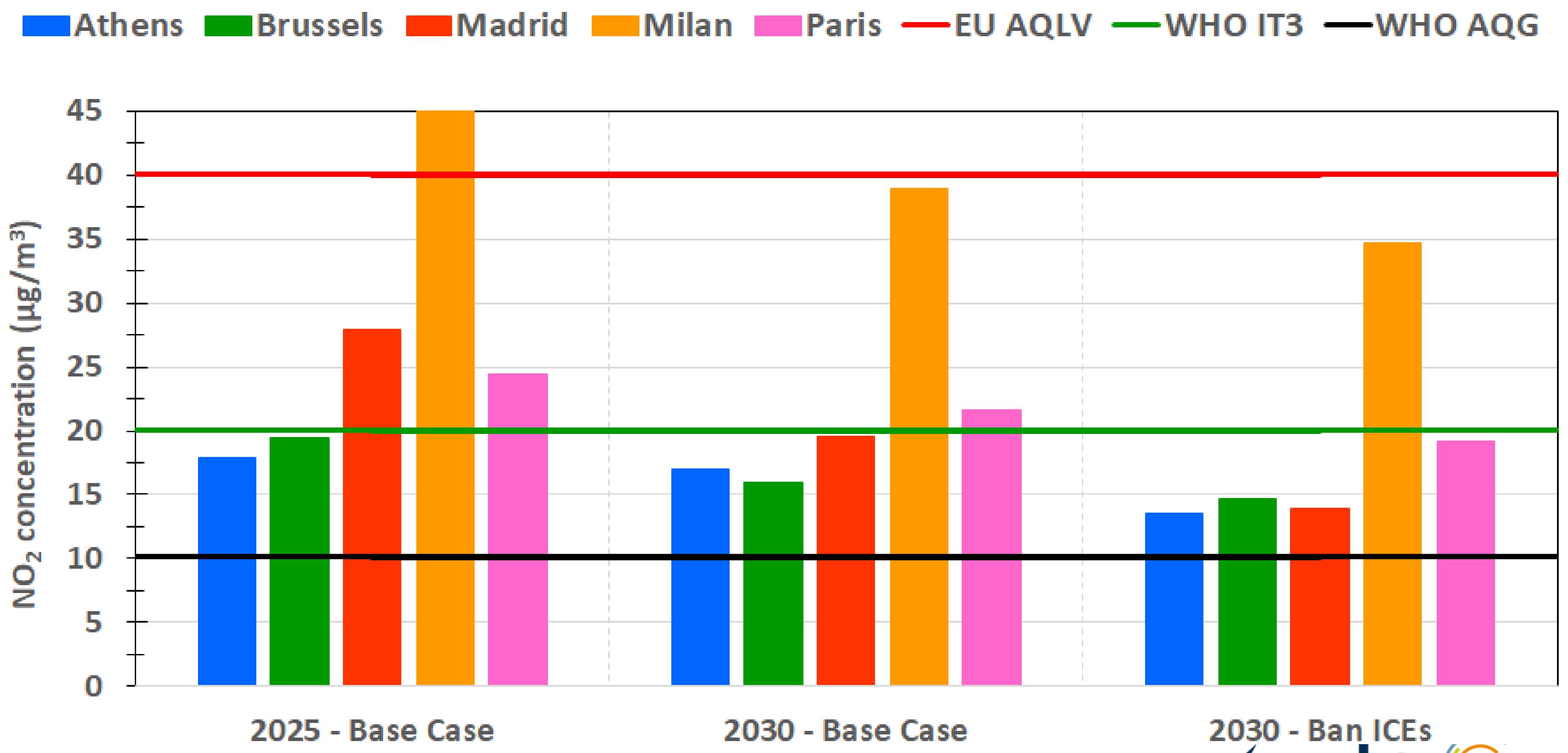
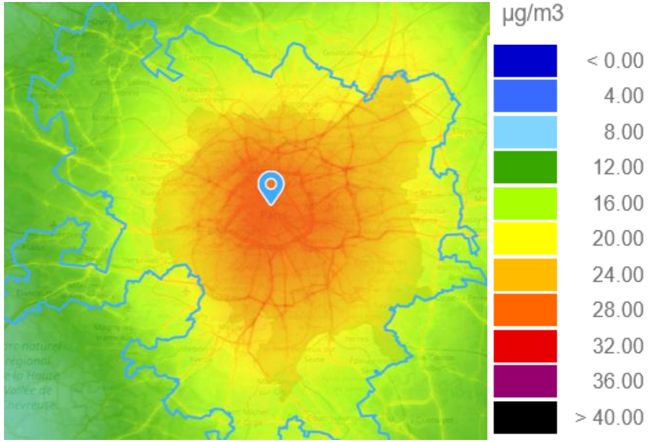
CASE 1 – Ban OF ICEs as of 2025 in EU

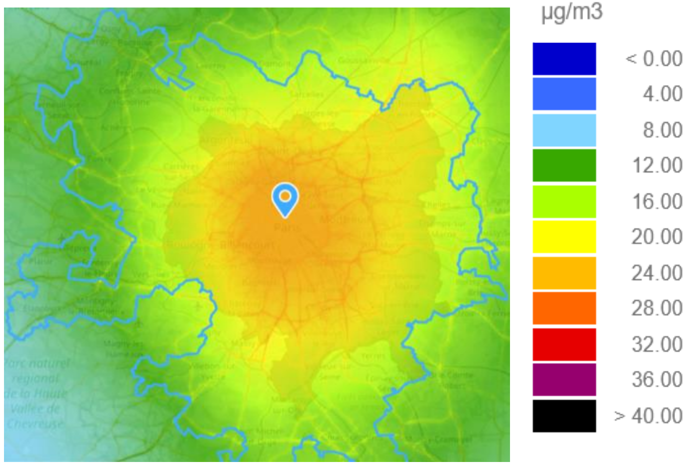


CASE 2 - Paris plans to phase out diesel cars

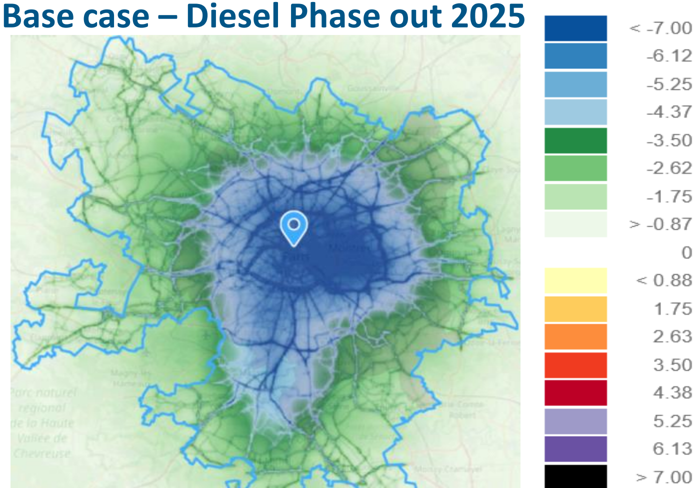
Paris - 2025



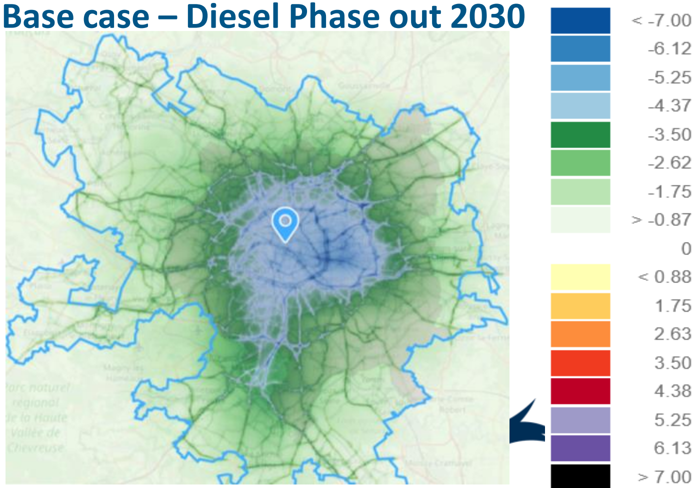
Paris - 2030



Base case – Diesel Phase out 2025



Base case – Diesel Phase out 2030



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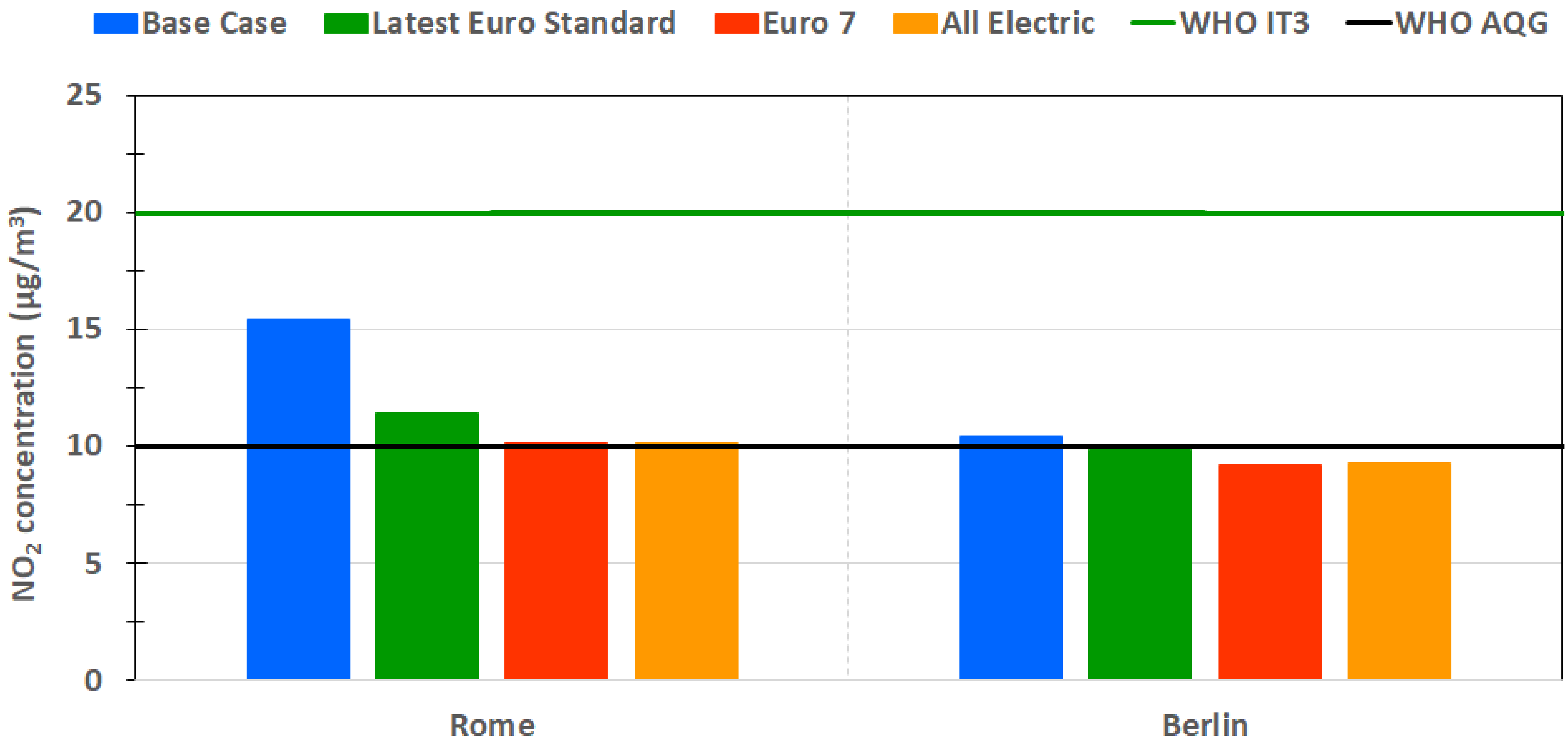
CASE 3 - New Euro Standard



Way Forward - Thoughts for the Audience

A new version of the SA viewer is under development:

- Considering future projections towards 2050
- Emissions projections and scenarios in line with the EC’s Clean Air Outlook
- Implementing scenario functionalities for all sectors
- Implementing functionality for compliance check in the European NO_2 monitoring network

Aim to release the new version in second half of 2023.

Could the developed methodology be considered under current and future CT1 activities?

How the tool could be of support for air quality management practices?

Would FAIRMODE members be interested in further using it?

Environmental Science for European Refining

www.concawe.eu

Thank you for your attention

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Validation

Extension of the LEZ of the City of Ghent: Compare web-application with detailed LEZ study

- Current LEZ: no pre-Euro5 diesel and no pre-Euro2 petrol cars ➔ Extension for 2025: no pre-Euro6 diesel and no pre-Euro3 petrol cars
- Impact of the extended LEZ calculated
  - with RIO+IFDM ➔ avg. reduction of 0.36 µg/m3
  - NO2 SA-website ➔ avg. reduction of 0.28 µg/m3

Bias at stations

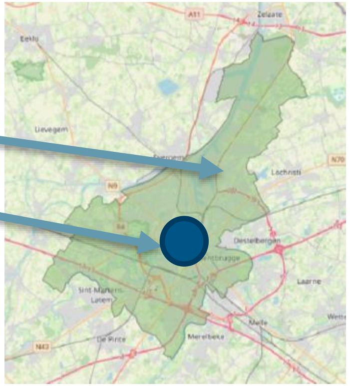
		CAMS 2017 ensemble			CAMS + SHERPA + QUARK			
AQ Station Area	**AQ Station Type**	**Bias [µg/m³]**	**RMSE [µg/m3]**	**R^2**	**Bias [µg/m3]**	**RMSE [µg/m3]**	**R^2**	**n**
All	All	-10.9	15.0	0.62	-8.7	12.8	0.69	3283
Rural	Background	-0.3	3.1	0.83	0.4	3.0	0.84	449
Rural	Industrial	-3.9	6.0	0.78	-3.2	5.4	0.80	104
Rural	Traffic	-22.1	24.7	0.39	-16.2	19.5	0.47	16
Suburban	Background	-5.7	7.8	0.68	-4.0	6.6	0.71	457
Suburban	Industrial	-7.0	8.8	0.72	-5.2	6.9	0.82	177
Suburban	Traffic	-17.5	19.6	0.53	-12.8	15.5	0.58	91
Urban	Background	-8.7	10.4	0.71	-6.8	8.8	0.76	911
Urban	Industrial	-9.9	12.2	0.48	-8.6	10.9	0.57	146
Urban	Traffic	-21.6	23.7	0.63	-17.8	20.3	0.63	932

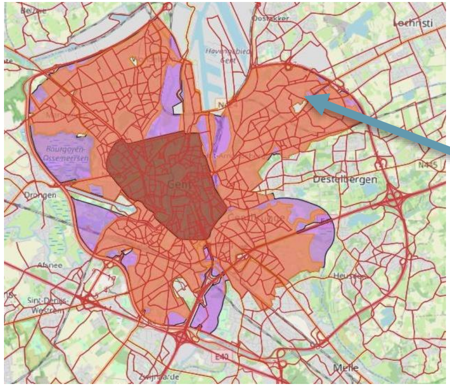
1. Choice of cities (example)

Comparison between LEZ and (greater) city for Ghent (BE) and Milan (IT)

Ghent, City

Ghent, current LEZ





Ghent, maximal extension (not adopted)

Milan, Greater City

Milan, City