The EVA model: A high-resolution tool for Economic Valuation of Air pollution

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1. The true costs of air pollution

Clean air is essential for life and a cornerstone of wellbeing and good health. The revised EU Ambient Air Quality Directive[1], places **air quality at the forefront of the political agenda**. This highlights the urgent need for evidence-based interventions targeting key emission sources.

New research enables more precise estimates of health-related damage costs per kilogram of pollutant emitted, supporting targeted, cost-effective interventions.

By applying these unit damage costs in socio-economic impact assessments, **policymakers can prioritize actions in high-impact sectors** such as transport, agriculture, and residential heating, improving public health and equity outcomes across regions.

2. Air pollution: A major health and economic burden in Europe

Air pollution is currently the **leading environmental health risk** in Europe, contributing to more than 400,000 premature deaths annually.[2,3] More and more research shows that air pollution exposure is linked to a wide range of chronic diseases —such as cardiovascular and respiratory conditions— placing a **heavy toll on public health and a significant economic burden on society**. Previous studies have shown that the health costs of air pollution in Europe must be counted in billions of euros, but these studies often did not provide estimates for all sectors.

The health impacts and related economic costs of air pollution are **highly site-specific and not evenly distributed**: they vary depending on regional and local emission sources, atmospheric dispersion, and population exposure patterns. **Vulnerable groups**, including children, the elderly, and individuals with pre-existing health conditions, are particularly sensitive to air pollution, making air pollution not only a health challenge but also an equity issue.

To support evidence-based policymaking, health assessments that determine air pollution **from emissions to impact** can provide **site-specific damage cost estimates** per unit of emission. Such unit costs of air pollution refer to the monetary values assigned to the health damage caused by emitting one kilogram of a specific pollutant into the atmosphere.

They can be used directly in socio-economic impact assessments: comparing the costs of emission-reduction measures (e.g., cleaner technologies, regulations) with the benefits of avoided damage. These metrics are tailored for key sectors such as **transport** and **agriculture**, enabling policymakers to prioritize and select interventions that can be expected to deliver the greatest health and economic benefits.



3. Research approach: Quantifying health costs of air pollution

To improve how the societal health costs of air pollution are calculated, each step in the Impact Pathway[4] approach has been updated based on the most recent and consolidated evidence, as established by World Health Organization studies **(Figure 1)**.

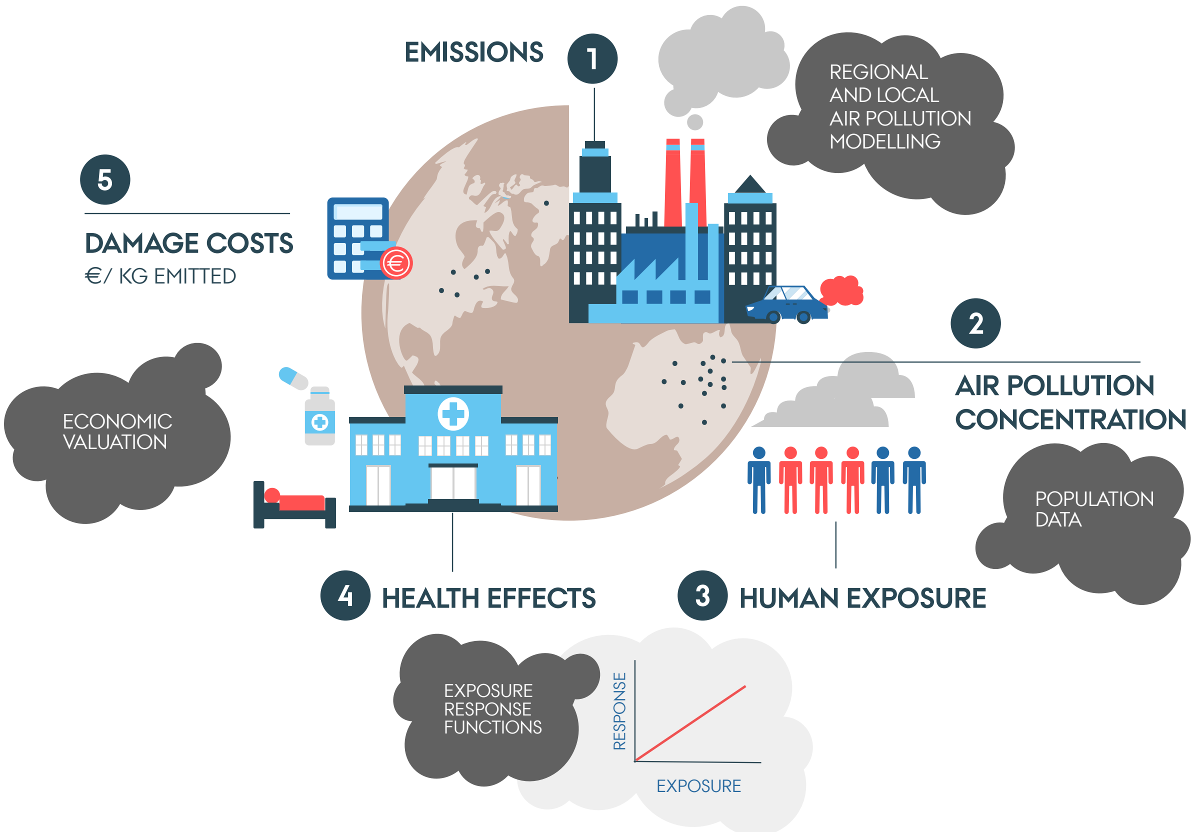
At the core of this effort is the **EVA model system (EVA standing for Economic Valuation of Air pollution).** EVA integrates **air pollution data** from atmospheric models —capturing atmospheric dispersion, and chemical transformation of the pollutants— with **population data** (density, age distribution) to estimate human exposures. After that, it uses formulas that link pollution exposure to health risks according to local health status, estimating the occurrence of early deaths and various chronic diseases to be expected statistically. These health impacts are then monetized using valuation methods according to recommendations from OECD for the Value of a Statistical Life and related concepts. The system covers both short- and long-term exposure to key air pollutants such as **fine particles ($PM_{2.5}$), nitrogen dioxide (NO_2), and ozone (O_3)**.

To provide EVA with the necessary air pollution data, the DEHM model (Danish Eulerian Hemispheric Model)[5] has been used for **sector-specific simulations** for 37 European countries. That makes it possible to quantify the impacts from each emission sector in each country – both within the specific nation, but also beyond (as transboundary air pollution).

The final outcome of EVA is the **unit damage costs (€/kg pollutant)**, disaggregated by **sector** (e.g., transport, agriculture) and **location** (e.g., country or region). The unit damage costs include the health-related costs caused by emissions within the selected country and information on costs related to pollution flowing in and out of the country.

This approach provides policymakers with estimations of the true costs of air pollution, allowing for selection of interventions where they are likely to be most effective and where they deliver the greatest return. For example, the benefits of introducing **Low Emission Zones** (LEZ) can be estimated by comparing **avoided emissions and health savings** against the **direct implementation costs**.

FIGURE 1
EVA MODEL: HIGH RESOLUTION TOOL FOR ECONOMIC VALUATION OF AIR POLLUTION



Fact box:

Health impact assessments have typically been focused on mortality.

To get a more complete picture of the burden of air pollution, **morbidity should also be included**. Morbidity refers to the incidence of illness and disease, as opposed to mortality, which refers to death. In the context of air pollution, morbidity includes a wide range of health conditions caused or worsened by exposure to air pollution. The following impacts are included in EVA[6]:

THE FOLLOWING IMPACTS ARE INCLUDED IN EVA:

ACUTE MYOCARDIAL INFARCTION
STROKE
HYPERTENSION
CARDIOVASCULAR HOSPITAL ADMISSIONS

ACUTE LOWER RESPIRATORY INFECTIONS
ASTHMA (ADULT/CHILDHOOD)
CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)
LUNG CANCER

DEMENTIA
AUTISM

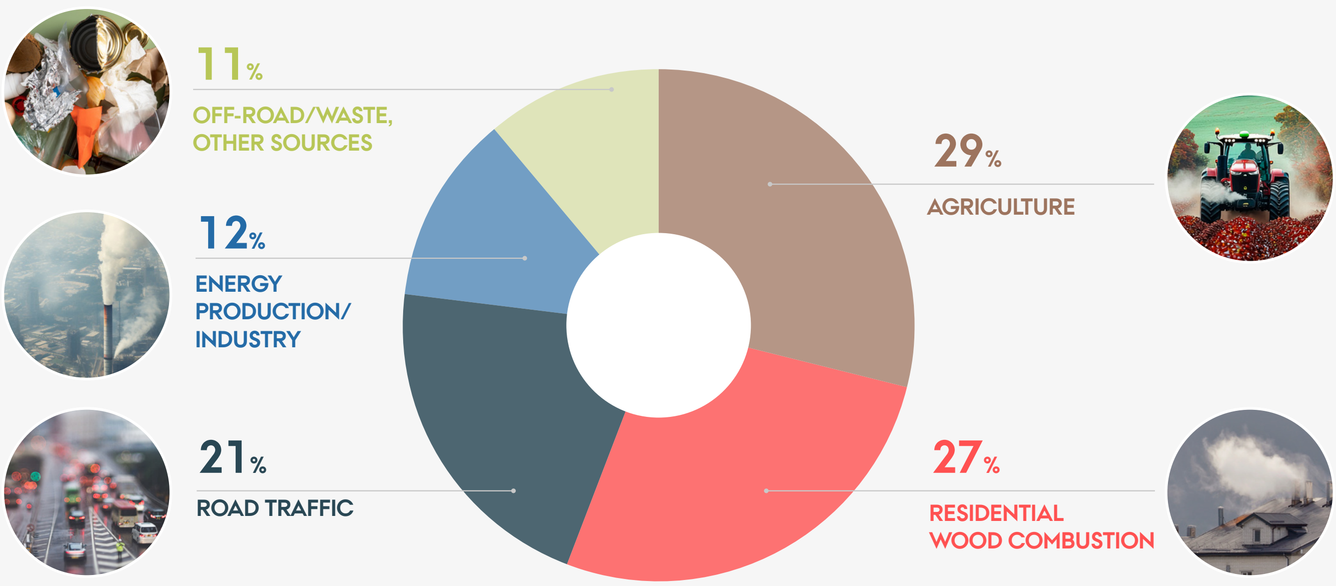
RESTRICTED ACTIVITY DAYS
WORK LOSS DAYS
DIABETES (TYPE 2)

4. Key findings: Main sources of air pollution – priorities for action

As part of the MARCHES project, the EVA model will provide unit damage costs for **37 European countries**, and with higher resolution for three distinct regions (incl. local-scale modelling), based on the most recent data available. Results for the case Greater Copenhagen Region are shown here for an illustration.

The output from EVA links the emissions in the area to the related health costs (both in Denmark/Sweden and in the surrounding countries). **Figure 2** shows the relative contribution of each main emission sector to the total health costs.

FIGURE 2
CONTRIBUTION FROM MAIN SOURCES IN THE GREATER COPENHAGEN REGION TO TOTAL HEALTH COSTS



The results show that air pollution associated with **emissions from three sectors** in Greater Copenhagen Region is contributing to about **75% of the total health costs** from local sources **(Table 1)**.

From this, it is clear that prioritizing emission reductions within **agriculture**, **residential wood combustion**, and **road traffic** have potential for the greatest health benefits.

To make specific estimates on the health cost to be avoided by implementing, e.g., stricter emission standards for wood-burning appliances, the unit damage costs can be used **(Table 2)**.

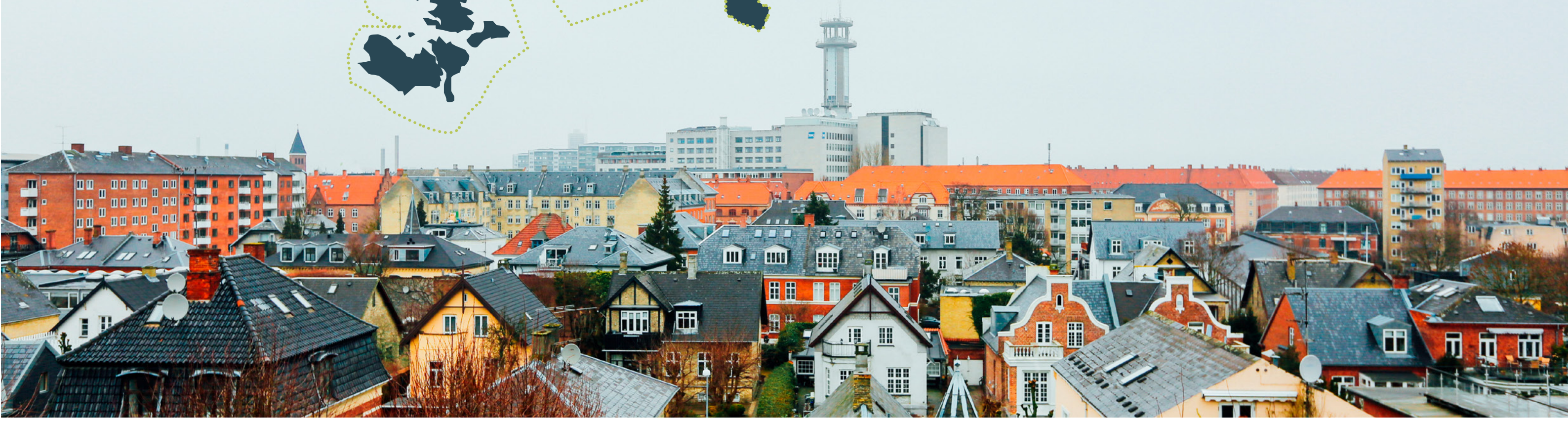
TABLE 1
TOTAL DAMAGE COSTS OF EMISSIONS
IN THE GREATER COPENHAGEN REGION

TOTAL DAMAGE COSTS FOR ALL EMISSIONS ACROSS KEY SECTORS (MILLION EURO)					
SECTORS	**POLLUTANTS CAUSING HEALTH EFFECTS**				
	SO_2/SO_4	$O_3/NO_2/NO_3$	NH_4	TOTAL DUST/ASH/ EC/POA/SOA	TOTAL
Agriculture	290	1,310	350	160	2,110
Residential wood combustion	30	80	30	1,860	2,000
Road traffic	100	810	120	520	1,550
Energy poduction/industry	150	320	90	310	870
Off-road/Waste, other sources	60	280	50	430	820
TOTAL	**630**	**2,800**	**640**	**3,280**	**7,350**

The Greater Copenhagen Region is a transnational metropolitan region, centred around the Øresund strait, and the two cities which lie on either side, Copenhagen in Denmark and Malmö in Sweden.

Table 1 shows sectoral damage costs (million €) broken down into the relevant pollutants burdening public health.

Acronyms:
Dust/Ash, Mineral dust; **EC**, Elemental Carbon; **NH_4 (NH_4+)**, Ammonium; **NO_2**, Nitrogen dioxide; **NO_3 (NO_3-)**, Nitrate; **O_3**, Ozone; **POA**; Primary Organic Aerosols; **$PM_{2.5}$**, Particulate Matter < 2.5 µm, **$PPM_{2.5}$**, Primary $PM_{2.5}$; **SOA**, Secondary Organic Aerosols; **SO_2**, Sulphur dioxide; **SO_4 ($SO_4$²-)**, Sulphate.



These figures reflect the societal costs of air pollution from fine primary particulate matter ($PPM_{2.5}$), nitrogen oxides (NO_x), sulfur oxides (SO_x), and ammonia (NH_3), based on their contribution to harmful secondary pollutants and their estimated health effects.

TABLE 2

UNIT DAMAGE COSTS FOR AIR POLLUTANTS EMITTED IN THE GREATER COPENHAGEN REGION

UNIT DAMAGE COSTS PER KILOGRAM OF POLLUTANT EMITTED ACROSS KEY SECTORS (MILLION EURO)					
SECTORS	**EMISSIONS**	SO_x	NO_x	NH_3	PRIMARY $PM_{2.5}$ ($PPM_{2.5}$)
	POLLUTANTS CAUSING HEALTH EFFECTS	SO_2/SO_4	$O_3/NO_2/NO_3$	NH_4	TOTAL DUST/ASH/ EC/POA/SOA
Agriculture			180	10	
Residential wood combustion		70	30	30	310
Road traffic			40	130	390
Energy poduction/industry		50	30		240
Off-road/Waste, other sources		200	40	60	260
ALL SECTORS		**180**	**60**	**20**	**300**

Table 2 shows unit damage costs (€/kg) of pollutants emitted (SO_x; NO_x; NH_3 and Total $PPM_{2.5}$; corresponding to SO_2 and SO_4; O_3, NO_2 and NO_3; NH_4; and dust/ash, EC, POA and SOA, respectively).

Note:
Unit costs are not reported for sectors with negligible emissions of the displayed pollutants.

Acronyms:
Dust/Ash, Mineral dust; **EC**, Elemental Carbon; **NH_3**, Ammonia; **NH_4 (NH_4+)**, Ammonium; **NO_2**, Nitrogen dioxide; **NO_3 (NO_3-)**, Nitrate; **NO_x**, Nitrogen oxides; **O_3**, Ozone; **POA**, Primary Organic Aerosols; **$PM_{2.5}$**, Particulate Matter < 2.5 µm, **$PPM_{2.5}$**, Primary $PM_{2.5}$; **SOA**, Secondary Organic Aerosols; **SO_2**, Sulphur dioxide; **SO_4 (SO_4^{2-})**, Sulphate; **SO_x**, Sulphur dioxides.

Key insights for policy making:

Primary $PM_{2.5}$ emissions carry the highest health-related costs across all sectors, especially from road traffic (€390/kg) and residential wood combustion (€310/kg).

The damage cost of ammonia emitted in the agricultural sector is relativity low in this example (10 € per kg), but the total emissions are high. In contrast, nitrogen oxides (NO_x) have a much higher damage cost of €180 per kilogram.

However, the two pollutants are connected, since they require both emissions of nitrogen oxides and ammonia to form the particles (ammonium nitrate) in the atmosphere.

This highlights the urgent need for targeted measures to reduce emissions in the agricultural sector.

Although off-road vehicles (such as construction machinery) and waste management produce smaller amounts of emissions overall, they are responsible for high health unit damage costs from sulphur oxides (SO_x) at €200 per kilogram and ammonia (NH_x) at €60 per kilogram.

This indicates that even modest reductions in emissions from these sectors could lead to significant health benefits.

These figures, representing the benefits, need to be seen in combination with estimations of the costs per kilogram abatement associated with actual emission reductions, e.g., the costs of adding filters to construction machinery or of injection of slurry into the soil to limit ammonia evaporation.

5. Turning evidence into action

Overall recommendations:

- **Incorporate health impact assessments** into air quality management, using detailed integrated assessment tools like the EVA system to quantify exposure, health outcomes, and societal costs from air pollution.
- At region and city level, use systematic health impact assessments to **identify the emission sectors** that contribute the most to health-related damage costs, based on site-specific data.
- Identify site- and sector-specific **unit damage costs** (€/kg pollutant) with the appropriate tools to support evidence-based decisions and make interventions where the benefits for health and reductions in societal costs are largest.
- Introduce socio-economic impact assessments and unit damage costs systematically in national policy evaluations, **comparing the costs** of emission-reduction measures **with the benefits** of avoided health damage.
- **Support transboundary cooperation on clean air**, acknowledging that emissions in one country can cause significant health impacts in neighboring countries.
- By linking **air quality measures** to **quantified health outcomes** —reductions in diseases and premature mortality — authorities can ensure compliance with the requirements of **Directive (EU) 2024/2881** and support alignment with **WHO recommendations**.

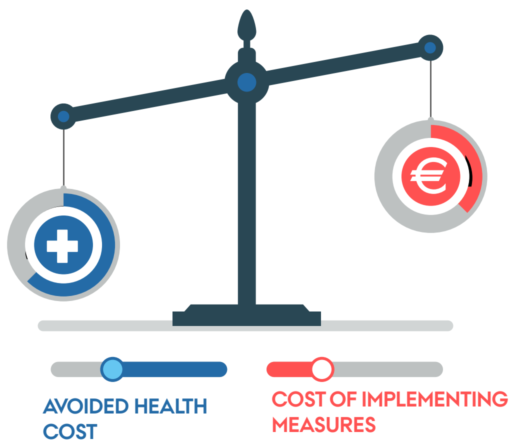
Sector specific recommendations:

- Promote cleaner technologies and **stricter emission standards**, especially for sources of **fine particulate matter ($PM_{2.5}$)**, which carry the highest health-related unit damage costs (wood combustion, traffic, industry, and off road machinery).
- Implement policies to regulate ammonia (NH_3) emissions in **agriculture** and NO_x and SO_x emissions from **combustion** processes, recognizing their role in secondary particle formation and long-range pollution transport.

IMPLEMENTATION COSTS

Comparing the implementation costs of emission-reduction measures with health cost savings from avoided damage.

The cost of implementing one measure can be very little while it would saved a great cost from health effects.



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MARCHES Project

The Horizon Europe MARCHES (Methodologies for Assessing the Real Cost to Health of Environmental Stressors) project aims to advance methodological rigor and consistency in accounting for the welfare economic health costs of pollution, based on systematic reviews of health effects.

It aims to calculate the impact of nitrates in drinking water and of air pollutants (which include ammonia from fertilizers) on public health and to quantify the economic benefits of reducing emissions and exposures.

Establishing updated exposure-response functions is essential for accurately estimating the societal costs of pollution and highlighting the societal value of implementing mitigation measures.

This will be demonstrated in case studies where MARCHES partners with public authorities in six countries (Czechia, Denmark, Estonia, Kosovo, Spain, and Sweden). Learn more about the research and activities of the MARCHES project here: https://projects.au.dk/MARCHES

The project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no.101095430.

Readers will be able to access the full details of all publications via the MARCHES website. https://projects.au.dk/marches/policy-briefs/policy-briefs.

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