For our environment

Umwelt Bundesamt

EUWOBOD 2

Using burden of disease estimates to support the update of the European Air Quality Directive

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Importance of air pollution for population health

- Around 4.9 Million deaths and 123.4 Million DALYs attributable to outdoor ambient particulate matter pollution globally (IHME, 2026)

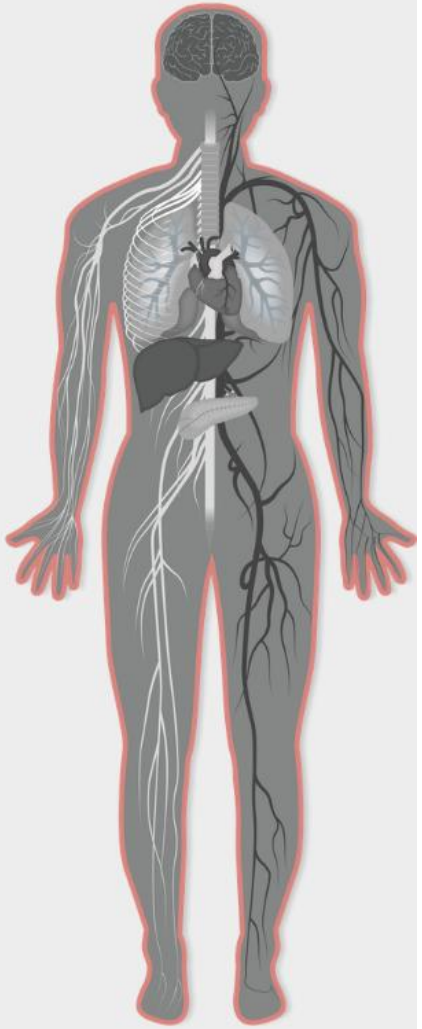
- According to the EEA 95.1 % of the urban population in Europe are exposed to levels of $PM_{2.5}$ higher than 5 µg/m³ - WHO's guideline value from the 2021 update (EEA, 2026)

- Evidence for systemic effects of air pollution is increasing

Importance of air pollution (example of $PM_{2.5}$) for population health

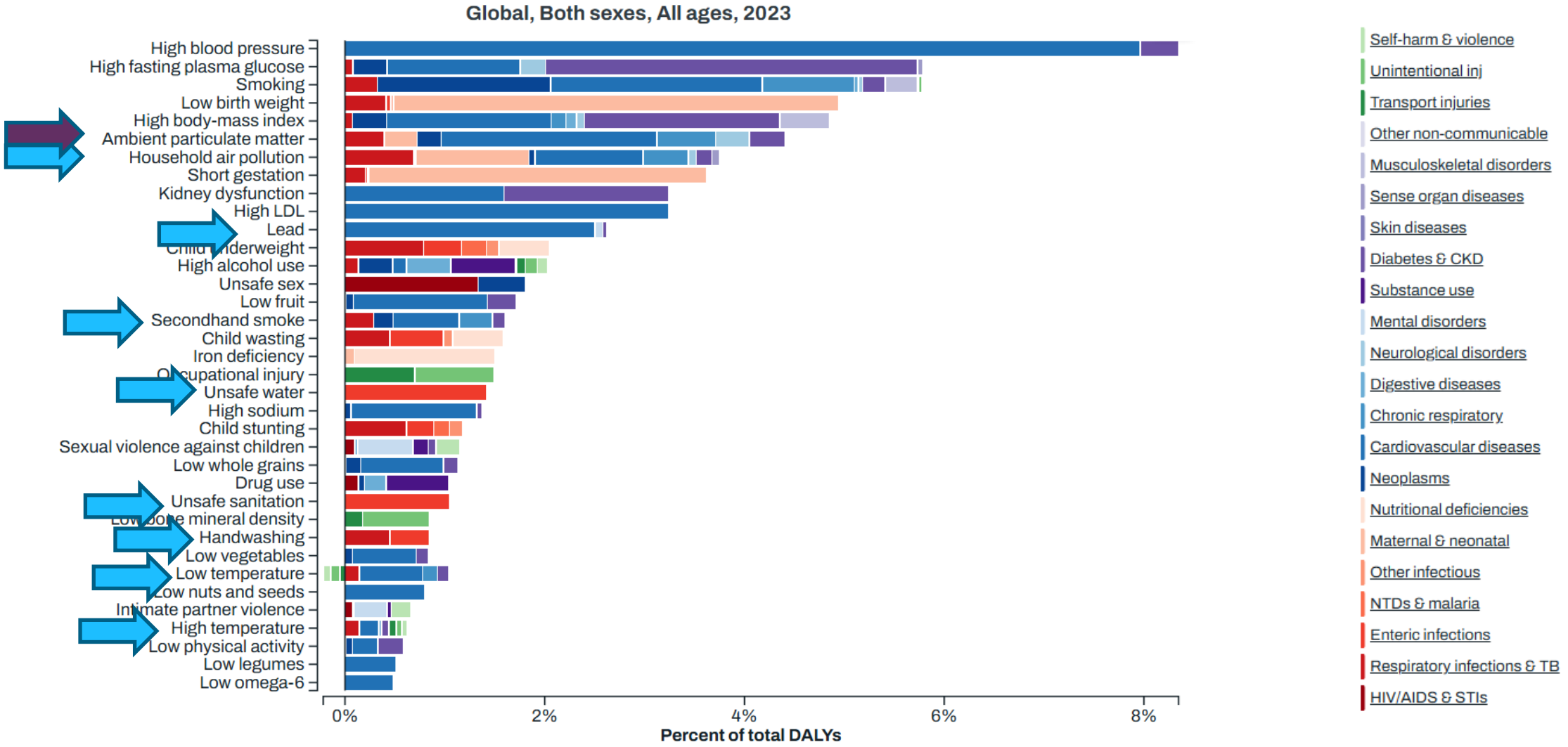
Respiratory system	
Asthma	◐
Respiratory/airway symptoms e.g. wheeze	◐
Exacerbation of the disease, increase in symptoms or medication in patients with asthma	◐
Impaired Lung growth	◐
Accelerated decline in lung function	◐
Bronchitis	◐
Airway/respiratory inflammation, inflammatory reaction	◐
Development of lung cancer	◐
Lung function decline	◐
Cardiovascular system	
Atherosclerosis	●
Hypertension	●
Arrhythmia	●
Blood coagulation	●
Nervous system	
Brain volume (white matter) decline	◐
Cognitive performance decline (dementia)	◐
Mortality	
Non-accidental mortality	●
Mortality due to cardiovascular disease	●
Mortality due to respiratory diseases	●
Mortality due to asthma	◐
Mortality due to COPD	◐
Mortality due to lung cancer	●
Mortality due to respiratory (tract) infection	◐

Causality: ● causal ◐ likely causal



https://www.swisstph.ch/en/projects/ludok/healtheffects

Global impact of air pollutants



http://vizhub.healthdata.org/gbd-compare/

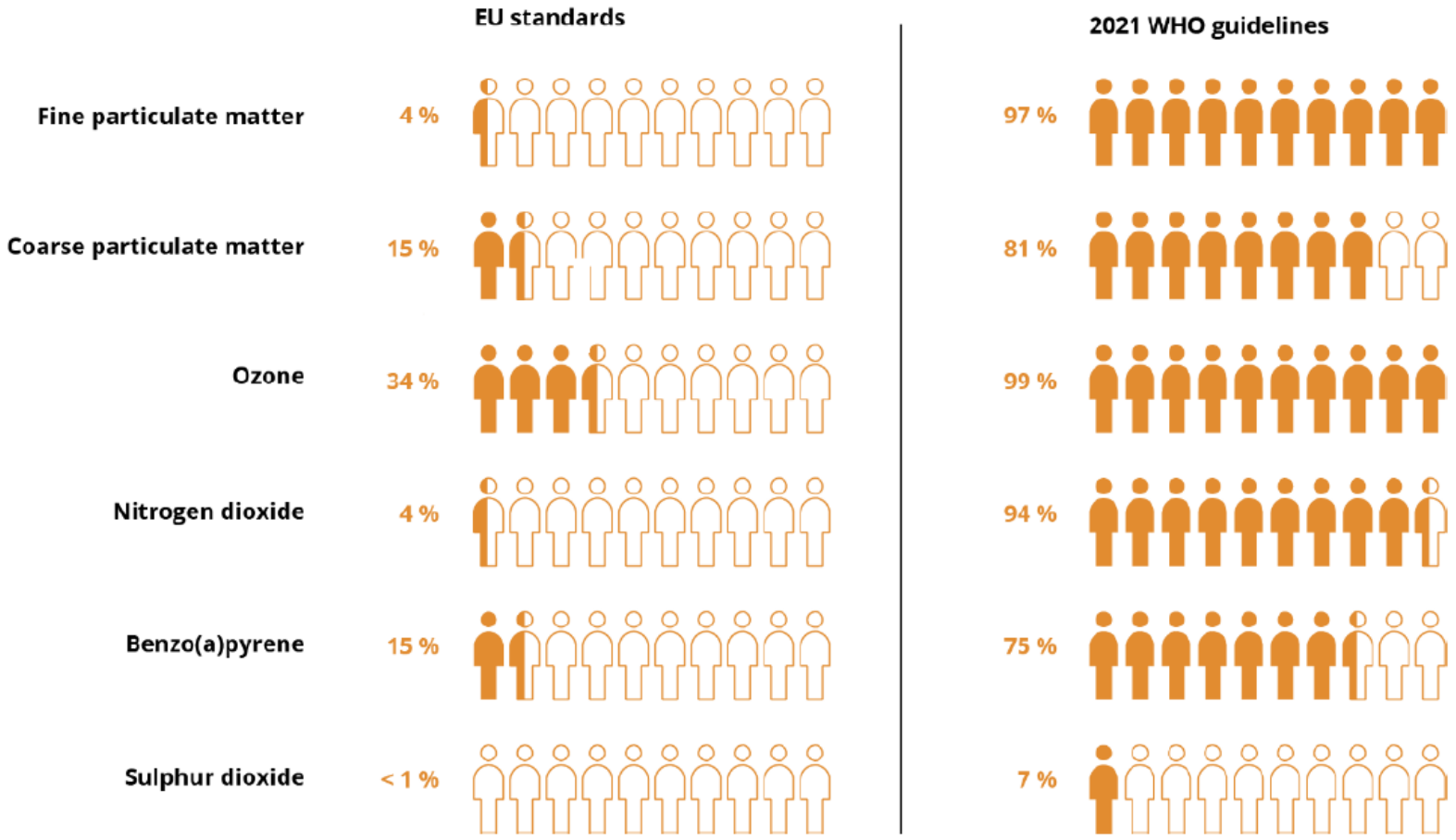
EU Ambient Air Quality Directive (AAQD) update process

- Previous directive enacted in 2008 and set legally binding limit values for a set of air pollutants: e.g. PM_{10}, $PM_{2.5}$, NO_2 (Directive 2008/50/EC)
- Update initiated after WHO published stricter recommendations for air pollutants based on newly available evidence (WHO 2021)
- Aim of the new directive: stronger align EU limits with WHO guidelines (According to EU's Zero Pollution Action Plan)

- EU tasked consortium led by "Trinomics" to produce additional estimates on:
  - Burden of disease
  - Economic impacts

  … covering different scenarios (potential measures)

WHO recommendation Vs. old EU AAQD



Source: (EEA, 2021)

→ **update to most recent evidence base necessary**

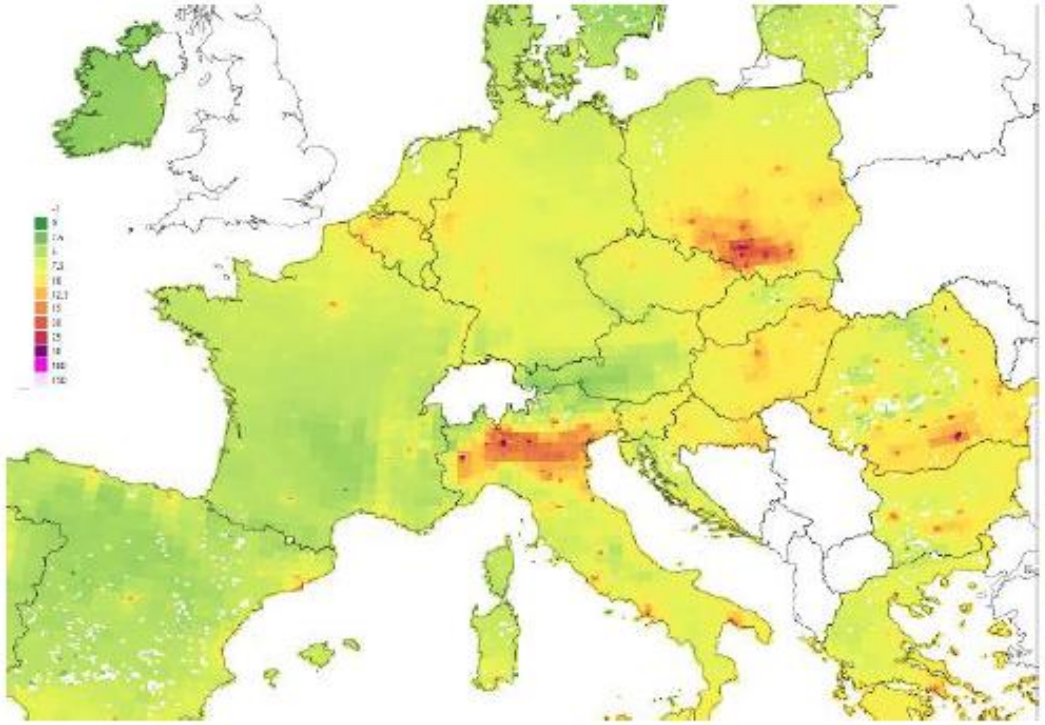
Air pollution impact assessment for the AAQD

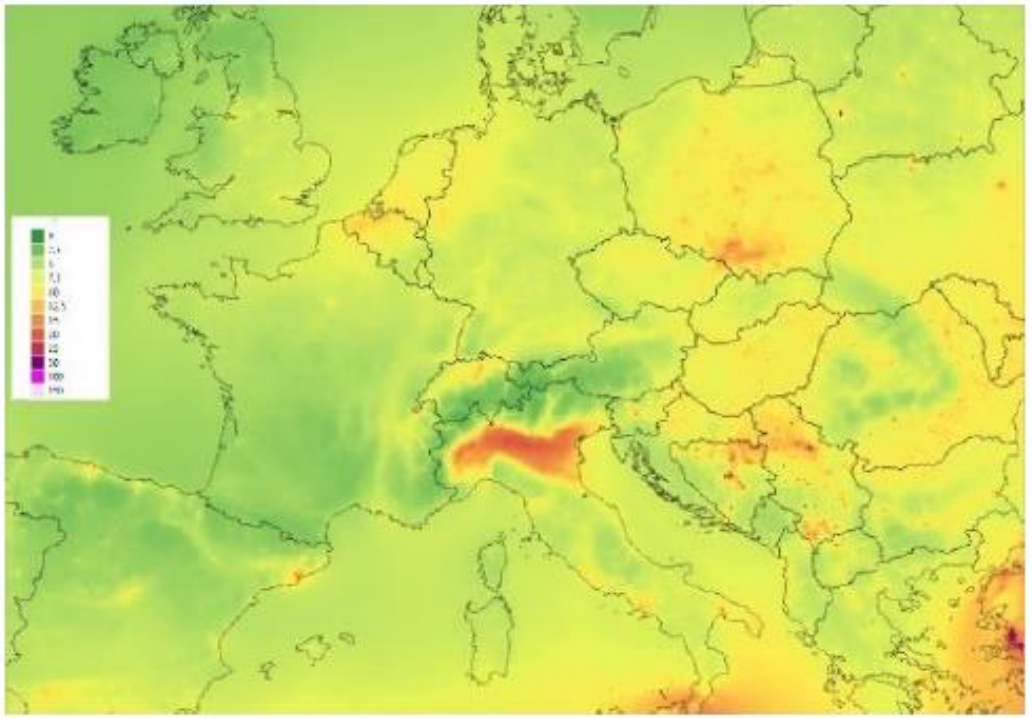
- Support EU COM revising the AAQD
- Quantify the impact of intended measures
- Defined 12 indicators
  - BoD
  - Costs
- Impact should be “quantifiable”
- Comparisons of potential scenarios with additional measures against “baseline scenario”



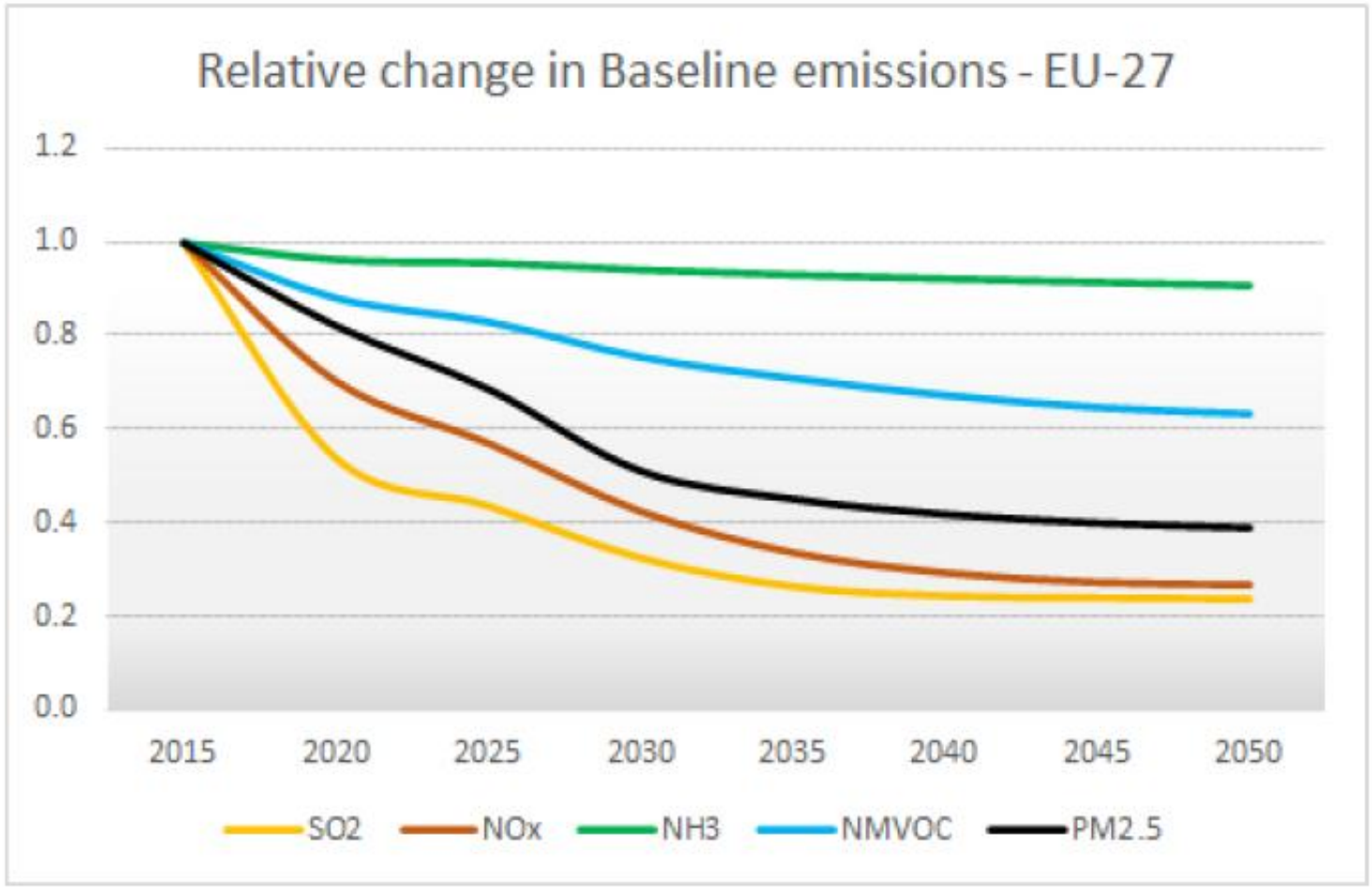
Exposure assessment

- Exposures were estimated using GAINS and EMEP CTM

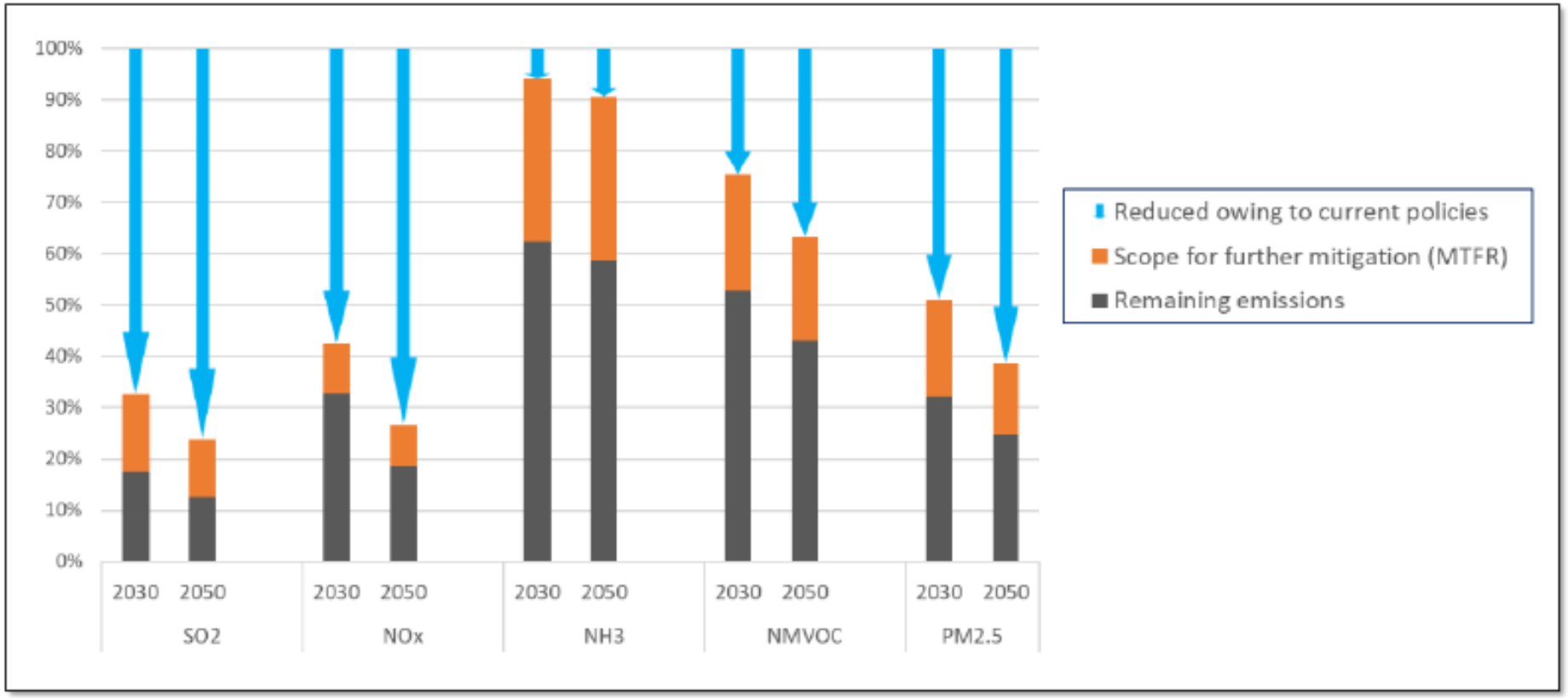




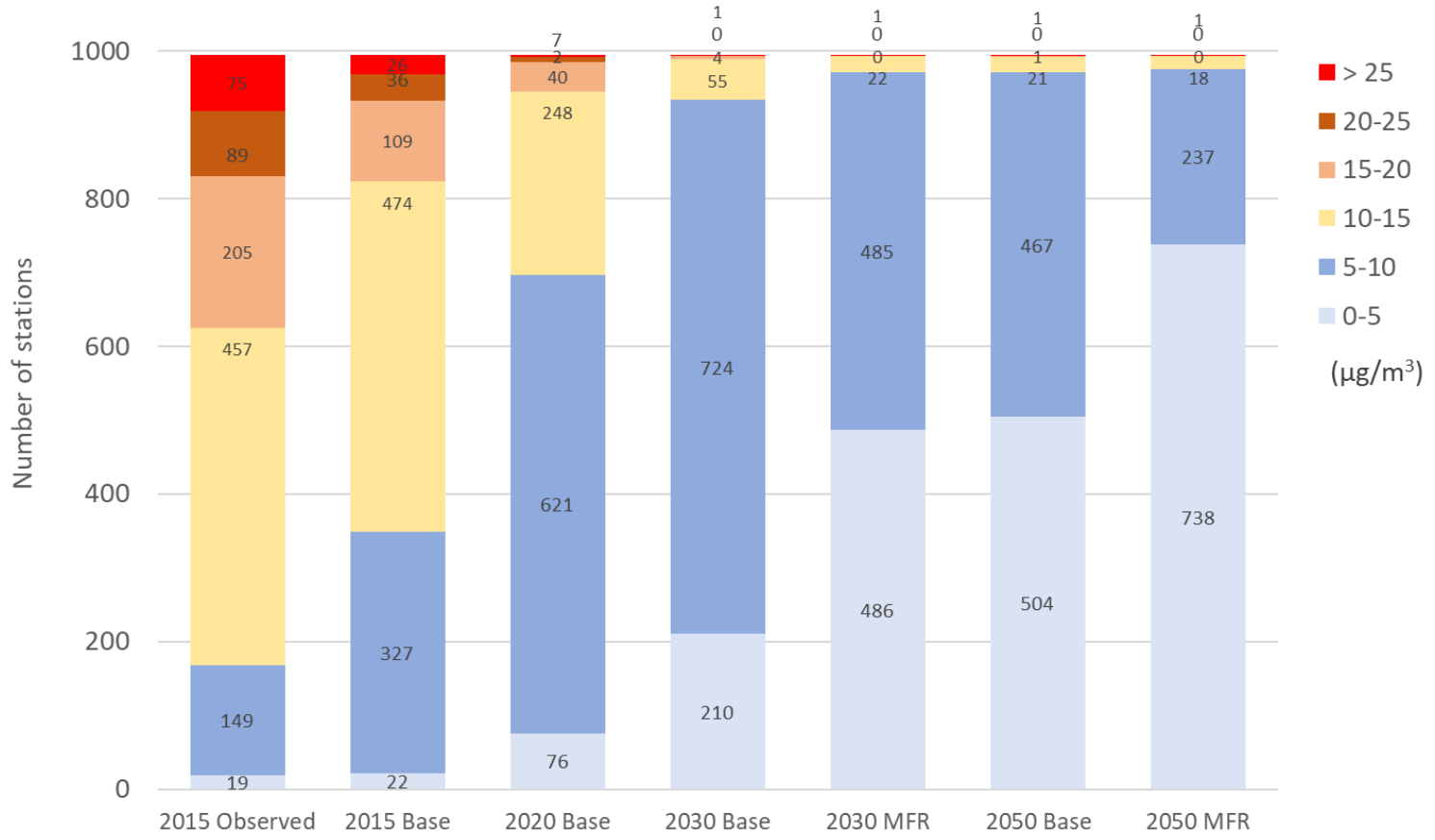
Pollutant Emission Trends (EU 27 – using GAINS model)



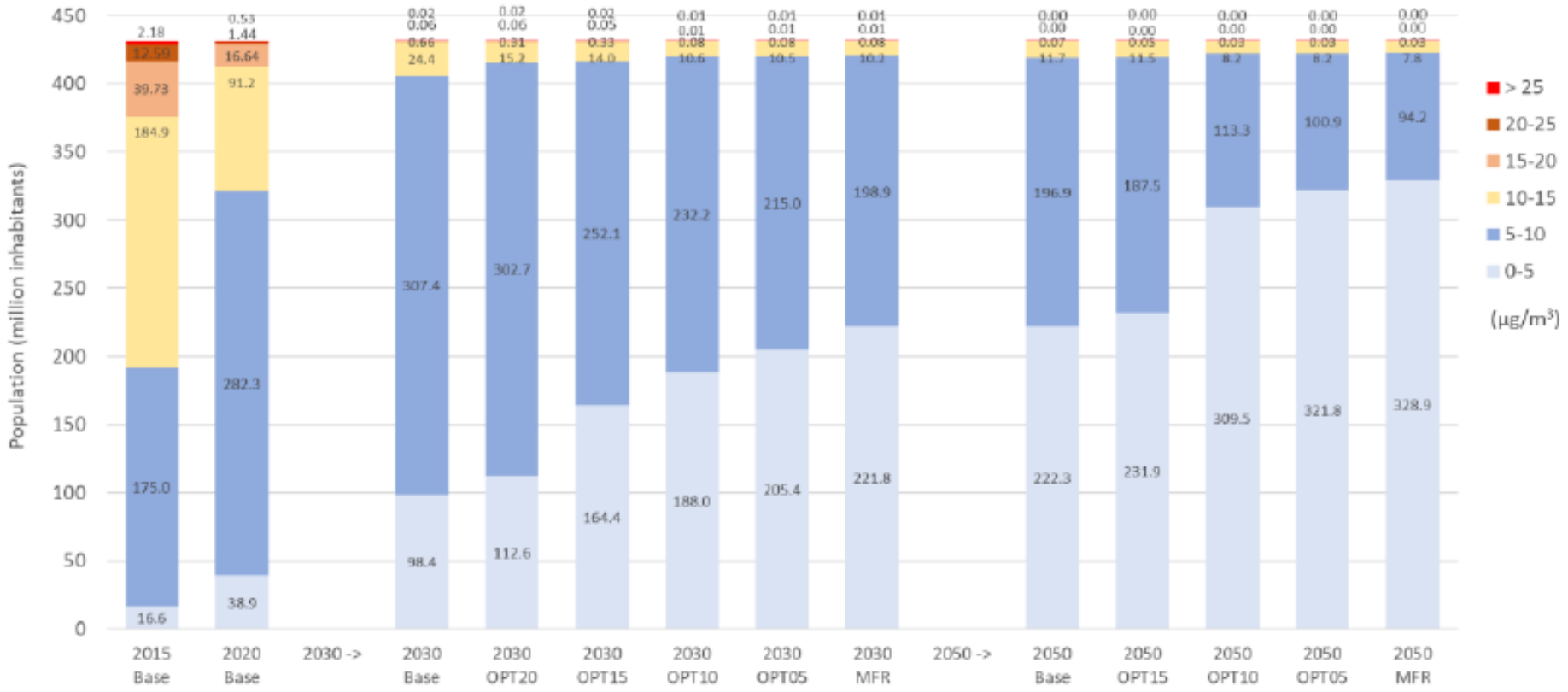
Impact of measures – projections of emission to 2030 and 2050



Impact of measures – concentration of $PM_{2.5}$ at measuring stations



Impact of measures – Population exposure to $PM_{2.5}$



Health outcomes – tiered approach for the impact estimations
Tier 1 → all-cause mortality

Pollutant	Relative Risk with 95% uncertainty per 10 µg/m3	Population	Type of exposure	Underlying Metareview for the CRF
Particulate matter	1.08 (1.06; 1.09)	30-...	Long-term	(Huangfu & Atkinson, 2020)
Nitrogen dioxide	1.02 (1.01; 1.04)	30-...	Long-term	(Chen & Hoek, 2020)
Ozone	1.01 (1.00; 1.02)	All ages	Peak	(Chen & Hoek, 2020)

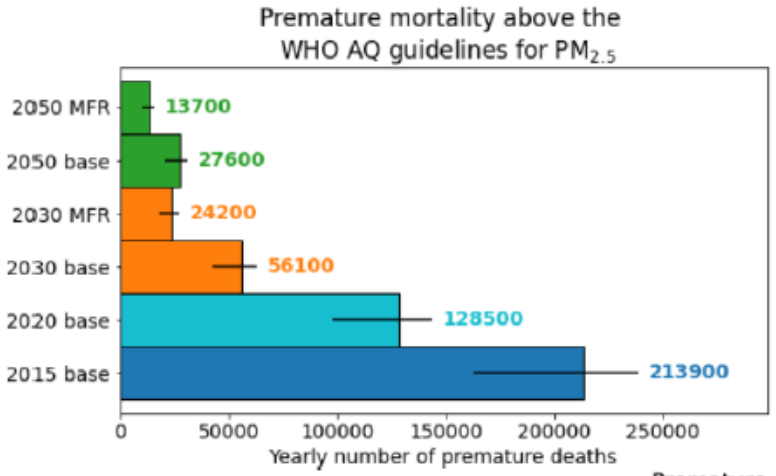
Health outcomes “Tier 2” – additional impacts focus on morbidity

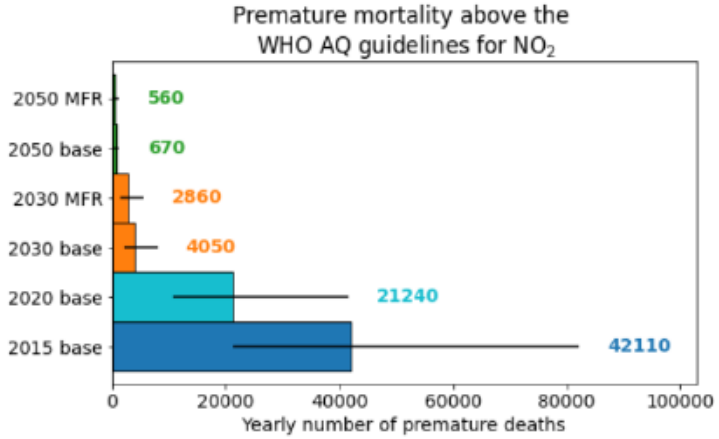
Health outcome	Relative Risk with 95% uncertainty per 10 µg/m³	Population	Type of exposure	Underlying Metareview for the CRF
Chronic bronchitis in adults	1.117 (1.040; 1.189)	18-...	Long-term	(Abbey et al., 1995) (Schindler et al., 2012)
Bronchitis symptoms in children	1.08 (0.98; 1.19)	6-12	Long-term	(Hoek et al., 2012)
Cardiovascular hospital admissions	1.0091 (1.0017; 1.0166)	All ages	Short-term	APED studies, 2000-2009
Respiratory hospital admissions	1.019 (0.9982; 1.0402)	All ages	Short-term	APED studies, 2000-2009
Restricted activity days	1.047 (1.042; 1.053)	All ages	Short-term	(Ostro, 1987)
Work-days lost	1.046 (1.039; 1.053)	20 - 65	Short-term	(Ostro, 1987)
Infant mortality	1.04 (1.02; 1.07)	1 month - 1 year	Long-term	(Woodruff et al., 1997)

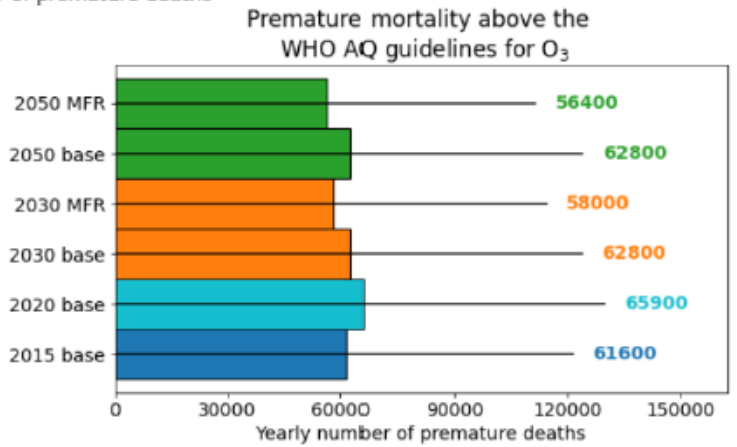
Health outcomes “Tier 3” – incident cases

Family of health outcome	Health outcome	Relative Risk with 95% uncertainty	Underlying reference for the CRF	Health metric	Source for health data	ICD10 code	Year for incidence data	Population	Type	Comparison: Alternative CRFs from recent meta-studies and reviews	Comparison: Results of ELAPSE (Brunekreef & et al., 2021)
Cardiovascular diseases	Stroke (CVA)	1.13 (1.11; 1.15) per 10 ug/m3	(Alexeeff et al., 2021)	Incidence of cases	EHN European Cardiovascular Disease Statistics	I60-69	2017	all ages	Primary analysis	Other meta-reviews have derived similar values for the central estimates, but with a somewhat larger uncertainty range (Scheers et al., 2015) RR: 1.13 (1.04;1.23) per 10 ug/m3 (Yuan et al., 2019) RR: 1.14 (1.10; 1.23) per 10 ug/m3	Higher impact in ELAPSE, HR: 1.21 (1.02 ; 1.46) per 10 ug/m3
	Myocardial infarction	1.08 (1.0; 1.18) per 10 ug/m3	(Alexeeff et al., 2021)	Incidence of cases	EHN European Cardiovascular Disease Statistics	I21	2017	all ages	Sensitivity study		Uncertainty intervals overlap HR: 1.04 (0.9 ; 1.21) per 10 ug/m3
Metabolic diseases	Diabetes Mellitus Type 2	1.10 (1.04,1.17) per 10 ug/m3	(Yang et al., 2020)	Incidence of cases	Global Burden of Disease	E11	2019	all ages	Sensitivity study	Other meta-reviews have derived similar CRFs (Eze et al., 2015) RR: 1.1 (1.02,1.18) per 10 ug/m3	
Cancer	Lung cancer	1.09 (1.04; 1.14) per 10 ug/m3	(Hamra et al., 2014)	Incidence of cases	European Cancer Information System (JRC)	C33-34	2020	20-...	Primary analysis	Other meta-reviews have derived similar CRFs (Huang et al., 2017) 1.08 (1.03; 1.12) per 10ug/m3	Higher impact in ELAPSE HR: 1.28 (1.10 ; 1.56) per 10 ug/m3
Respiratory diseases	Asthma (children)	1.03 (1.01; 1.05) per 1 ug/m3	(Khreis et al., 2017)	Incidence of cases	Global Burden of Disease	J45	2019	0-15	Primary analysis	Similar CRF from the ESCAPE cohort study (age group 7-15) (Jacquemin et al., 2015) RR: 1.04 (1.02 ; 1.07) per 1 ug/m3	
	COPD	1.18 (1.13; 1.23) per 10 ug/m3	(Park et al., 2021)	Incidence of cases	Global Burden of Disease	J41-J44	2019	20-...	Sensitivity study		Higher impact in ELAPSE HR: 1.36 (1.12; 1.66) per 10 µg/m3

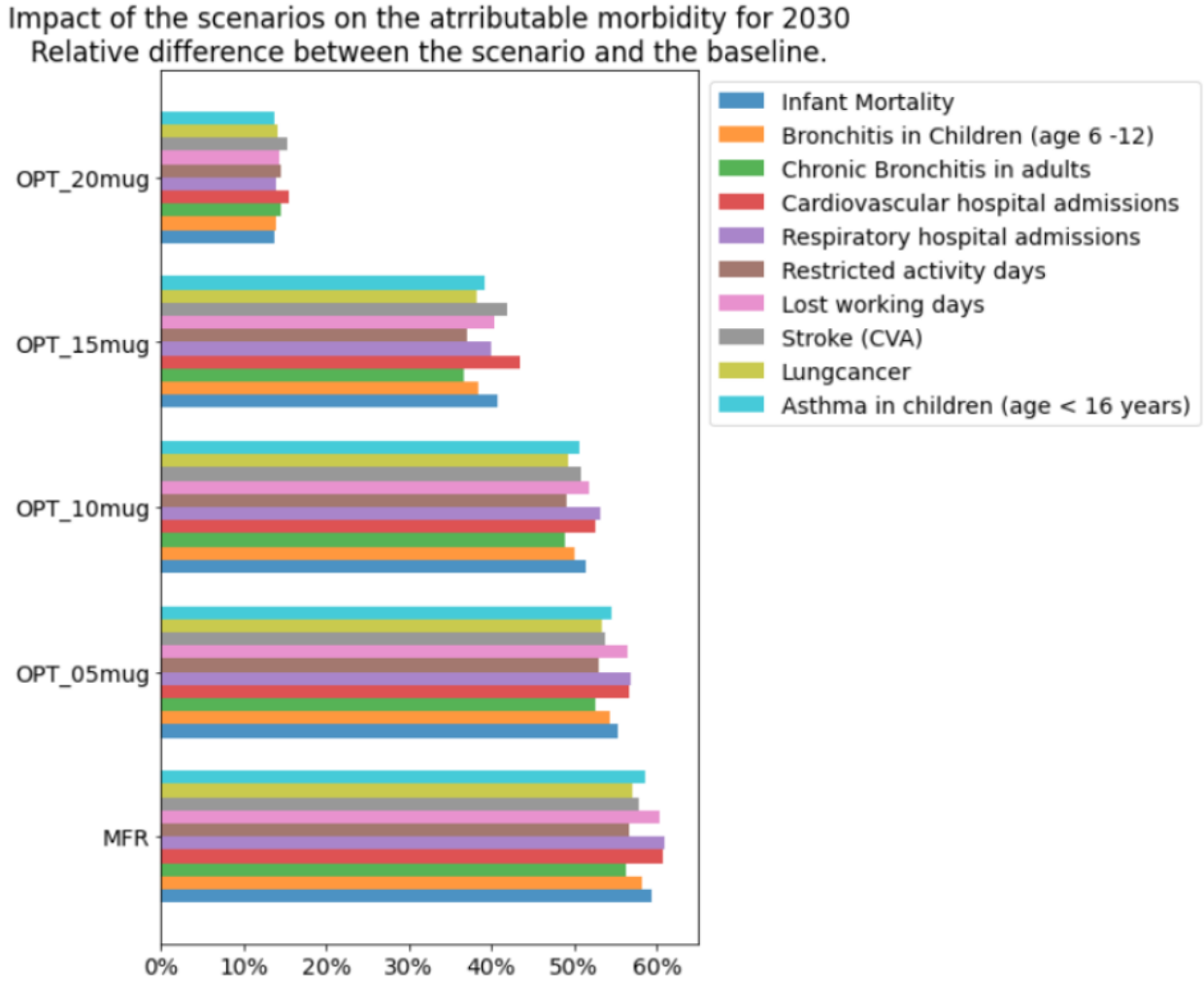
Health impacts – indicator: premature mortality for three pollutants



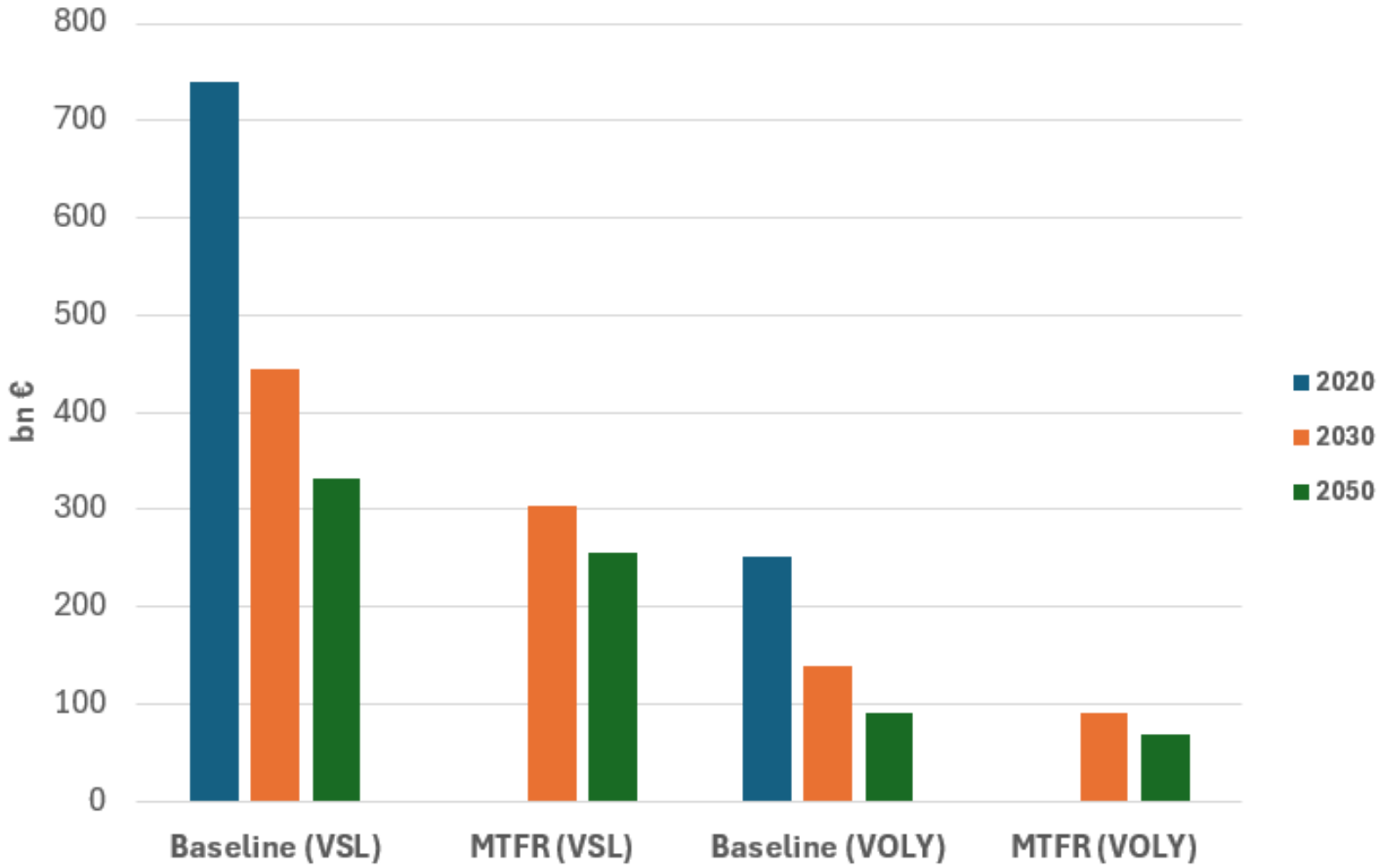




Health impacts – indicator: morbidity



Monetized health impact



Impact Evaluation

+++	Very significant direct positive impact (e.g. Indicator 1 – Air Quality: full alignment WHO AQG for $PM_{2.5}$)
++	Significant direct positive impact
+	Small direct positive impact
(+)	Indirect positive impact
+/-	Both direct positive and negative impacts, and balance depends on how implemented
0	No impact or only very indirect impacts
(-)	Indirect negative impact
-	Small direct negative impact
- -	Significant direct negative impact
- - -	Very significant direct negative impact (e.g. Indicator 6 – Mitigation Costs: costs of maximum feasible technical potential (MTFR) and more)

Impact Evaluation

		Focus on EU air quality standards	BCR	35	C3	Revise short-term action plans & air quality plans	M
1	O1	Revise standards for annual $PM_{2.5}$	H	36	C4	Introduce additional short-term action plans	M
2	O2	Introduce standards for daily $PM_{2.5}$	H	37	C5	Introduce requirement to update air quality plans	M
3	O3	Revise average exposure standards for $PM_{2.5}$	L-H	38	D1	Revise requirements to involve stakeholders	H
4	P1	Revise standards for annual PM_{10}	H	39	D2	Introduce a 'one zone, one plan' requirement	L
5	P2	Revise standards for daily PM_{10}	L	40	M1	Introduce methodology to assess transboundary	H
6	P3	Introduce average exposure standards for PM_{10}	L-H	41	M2	Revise obligations for transboundary cooperation	M
7	Q1	Revise standards for annual NO_2	H	42	E1	Introduce minimum levels for financial penalties	M/H
8	Q2	Revise/introduce standards for hourly/daily NO_2	H	43	E2	Introduce right to health damage compensation	M
9	Q3	Introduce average exposure standards for NO_2	L	44	E3	Introduce a fund to be fed by penalties paid	L
10	R1	Introduce standards for peak-season O_3	L/M	45	E4	Introduce an explicit 'access to justice' clause	H

Final decision on limit values in the updated AAQD

→New AAQD enacted in October 2024

Pollutant	Averaging period	Old Directive 2008/50/EC	New Directive 2024/2881	New value applies / target
NO_2	Annual mean	**40 µg/m³**	**20 µg/m³**	From **2030**
NO_2	1-hour mean	**200 µg/m³**, max. 18 exceedances/ year	**200 µg/m³**, max. **3** exceedances/ year	From **2030**
NO_2	24-hour mean	—	**50 µg/m³**, max. **18** exceedances/ year	From **2030**
$PM_{2.5}$	Annual mean	**25 µg/m³**	**10 µg/m³**	From **2030**
$PM_{2.5}$	24-hour mean	—	**25 µg/m³**, max. **18** exceedances/ year	From **2030**
O_3 (ozone)	Maximum daily 8-hour mean	**120 µg/m³**, max. 25 days/year averaged over 3 years	**120 µg/m³**, max. **18 days/year** averaged over 3 years	From **2030**
O_3 (ozone)	Long-term objective	**120 µg/m³**	**100 µg/m³**	Long-term objective, **2050**

Learnings and conclusions

- Burden of disease estimates can be used as additional indicators to emphasize population health impacts
- Scenarios showing different outcomes of implemented measures with different policy options as guidance
- Monetized health impacts for cost-benefit analyses

Thank you for your kind attention!

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