HARMO'17

Improving Urban Air Quality using a Cost-Efficiency and Health Benefit Approach

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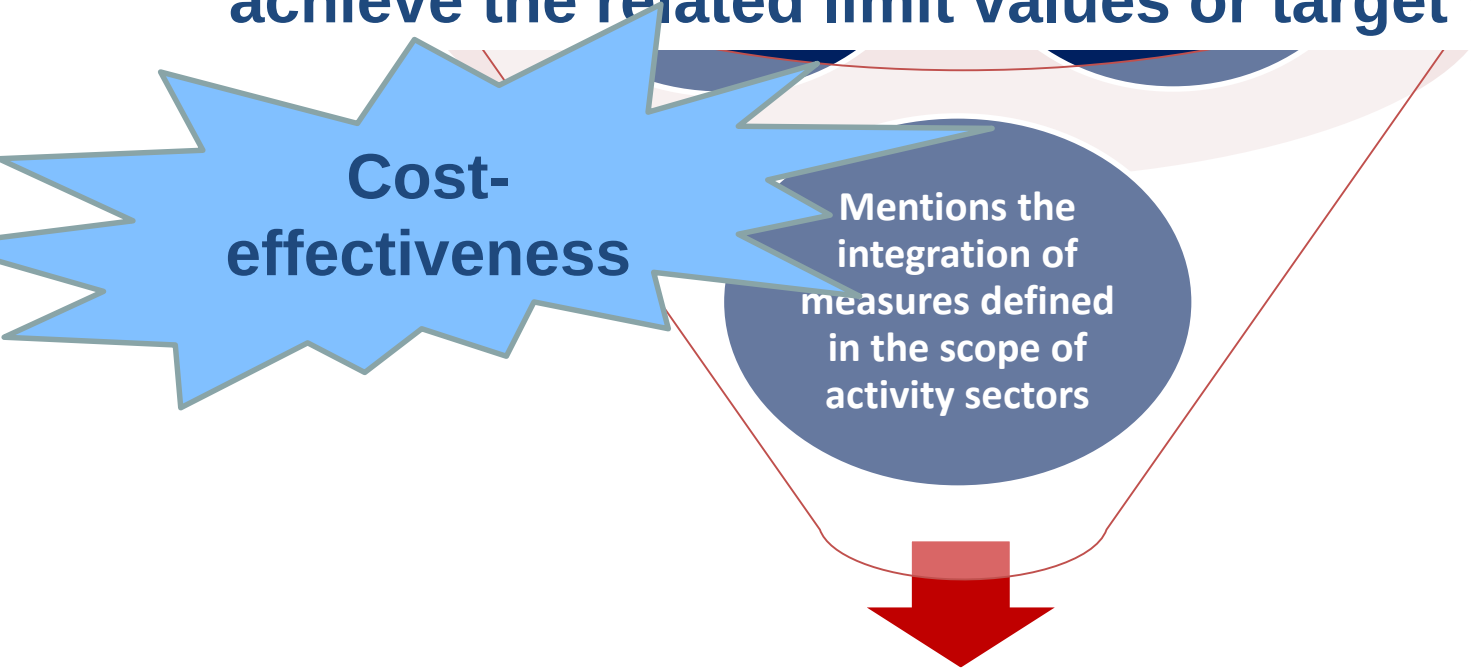
Motivation

EU Air Quality Directive

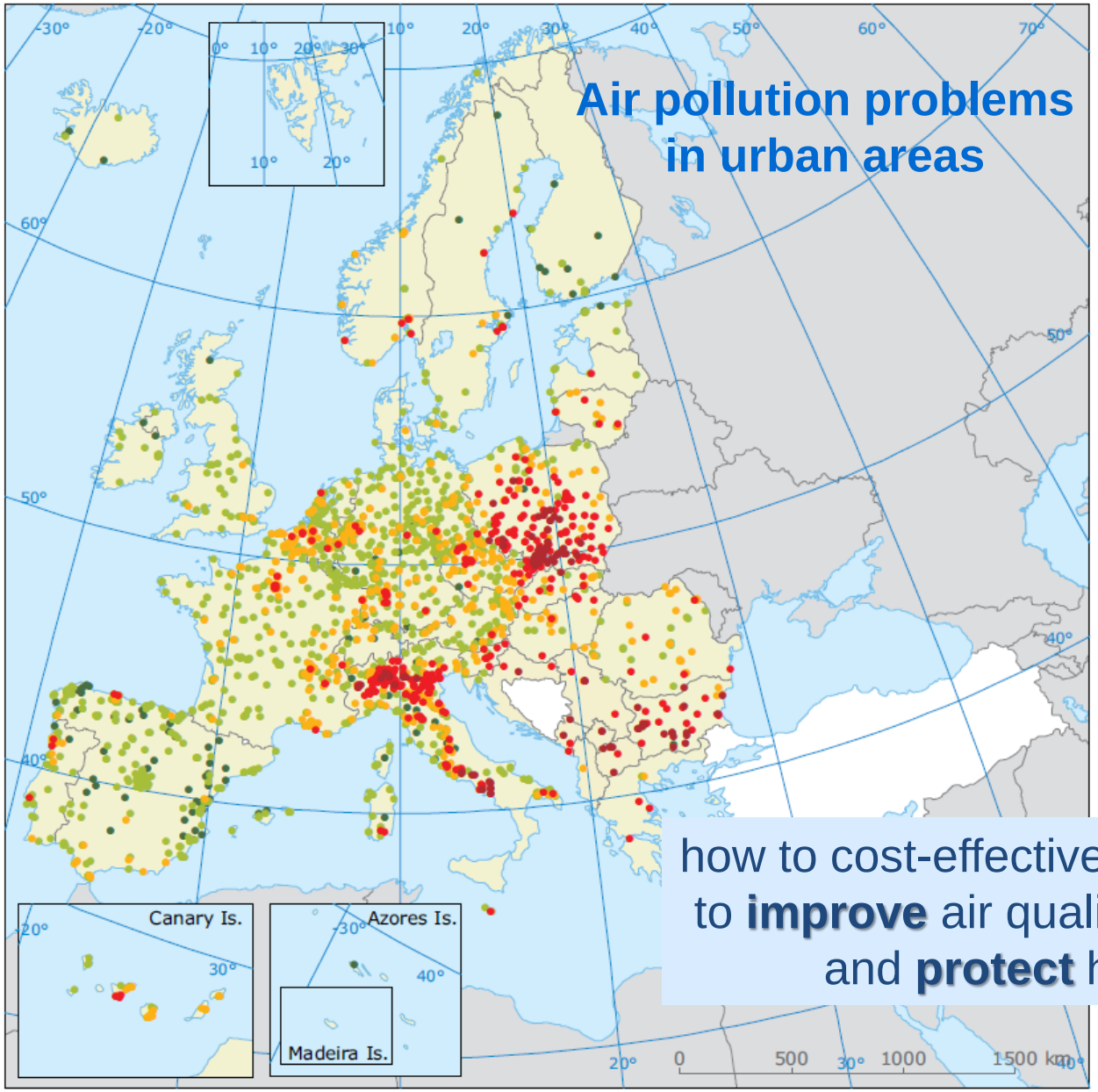
Where the levels of pollutants in ambient air exceed any limit value or target value, Member States shall ensure that air quality plans are established ... in order to achieve the related limit values or target values.



Air Quality improvement

Motivation

PM10 – exceedances in 2013



90.4 percentile of PM_{10} daily concentrations in 2013

µg/m³

- ≤ 20
- 20–40
- 40–50
- 50–75
- > 75

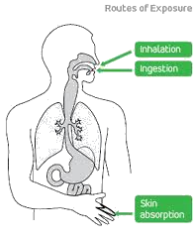
No data

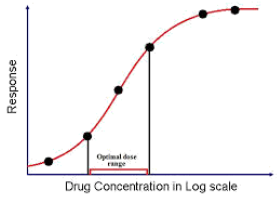
Countries/regions not included in the data exchange process

how to cost-effectively **reduce** emissions to **improve** air quality, reduce exposure and **protect** human health.

Motivation

How to select the best air quality improvement measures?





Abatement measures → Modelling the emissions and air concentrations → Exposure assessment → Impact assessment → Monetary valuation

Validation with measured data for a reference scenario

Exposure-response functions

Human health
Crops
Materials
Ecosystems

Total costs

AIR QUALITY ASSESSMENT

ECONOMIC EVALUATION

INTEGRATED ASSESSMENT

Objective

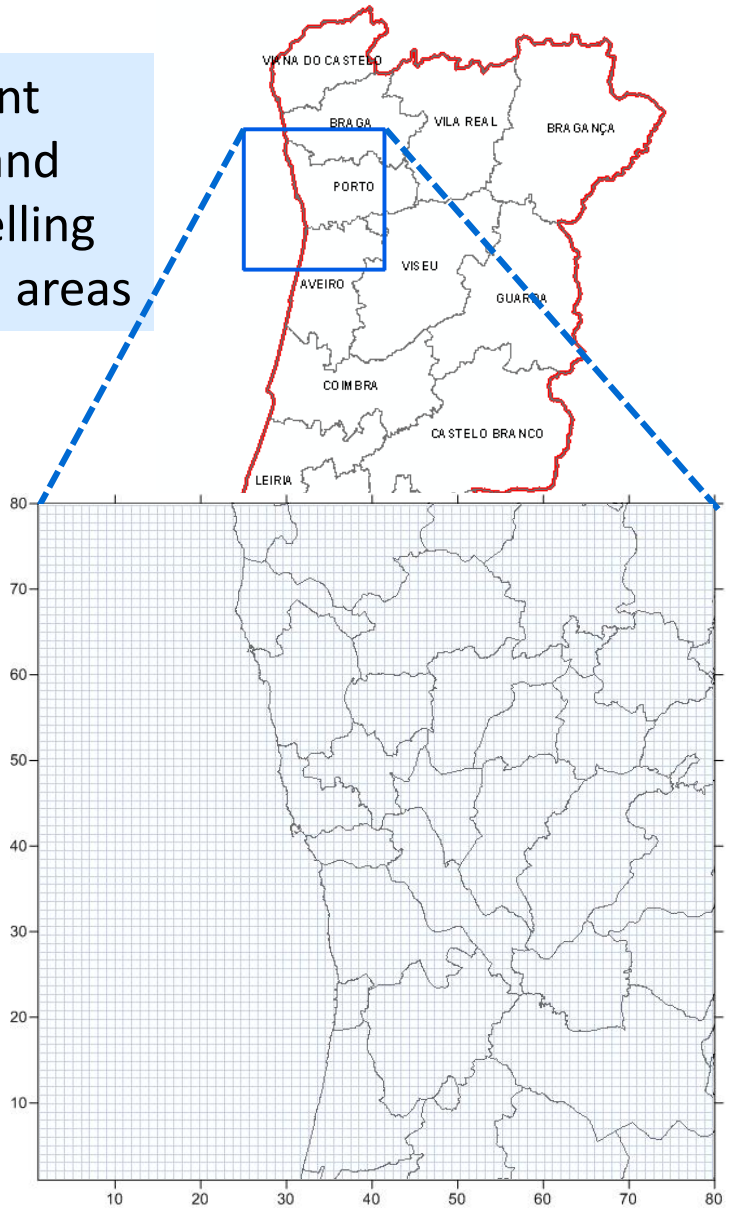
definition and assessment of emission abatement measures and their associated costs, air quality and health impacts and benefits using air quality modelling tools and cost-benefit analysis, specifically for urban areas

Development of an

integrated assessment tool

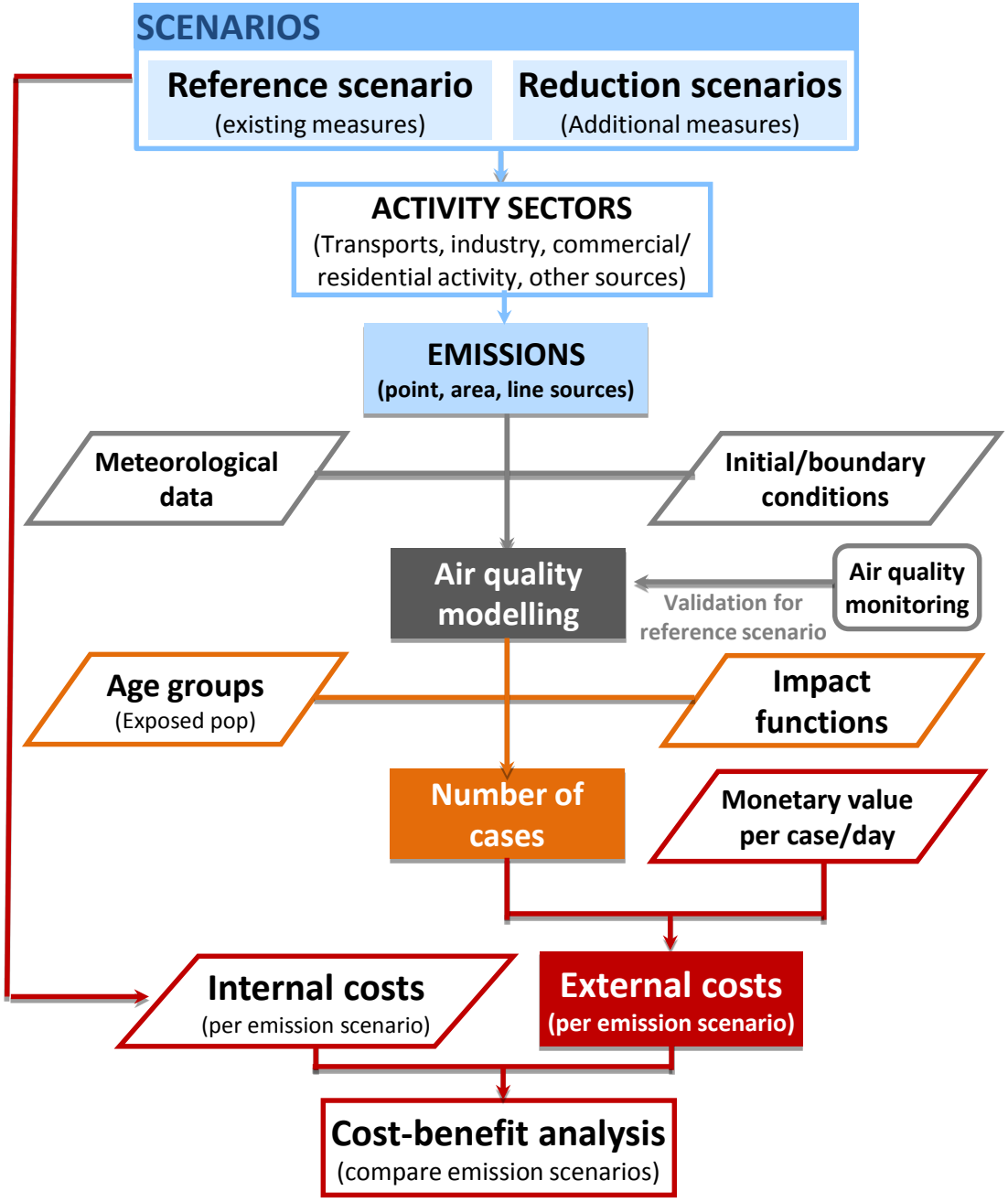
suitable for urban areas

Case study – Porto urban area



80 x 80 km²
1 km² resol

MAPLIA tool


SCENARIOS
Reference scenario
(existing measures)
Reduction scenarios
(Additional measures)
ACTIVITY SECTORS
(Transports, industry, commercial/ residential activity, other sources)
EMISSIONS
(point, area, line sources)
Meteorological data
Initial/boundary conditions
Air quality modelling
Air quality monitoring
Validation for reference scenario
Age groups
(Exposed pop)
Impact functions
Number of cases
Monetary value per case/day
Internal costs
(per emission scenario)
External costs
(per emission scenario)
Cost-benefit analysis
(compare emission scenarios)

MAPLIA tool

Health Benefit (external avoided cost)

Epidemiological data

Annual Incidence Rate

Relative risk

Population census 2011

Population exposed by age group

$$N_{cases,i,p} = IR_{base} \times RR_{i,p} \times \Delta C_{p} \times pop$$

i – health indicator
p - pollutant

Number of cases by health indicator

$\times$ $Cost_{case,i}$

Concentration difference between Ref Sc and Red Sc.

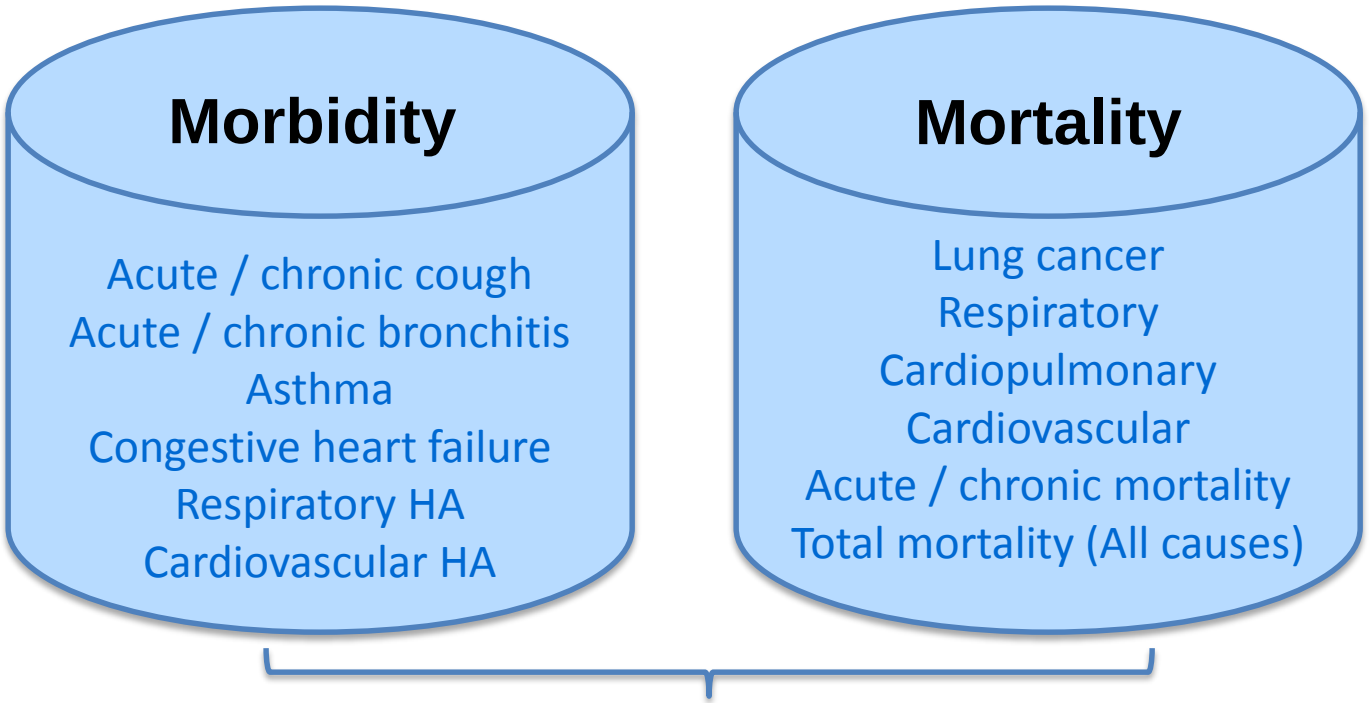
Air Quality Modelling

Benefit
(avoided costs)

MAPLIA tool

health impacts

Health Indicators:



Acute effects:
- Short-term exposure
- Explore time-series of hourly and daily changes in air pollution

Chronic effects:
- Long-term / cumulative exposure
- Design the overall effect of air pollution on life expectancy

MAPLIA tool

Health Indicators

Costs: year 2012

Short-Term

(PM10 - daily avg concentrations
NO_2 – daily max 1-h avg concentrations)

Asthma, 5-19 (PM10)
- IR: 17%; RR: 0,28 %
- Cost: 115 € per day

Heart failure, >65 (PM10)
- RR: 1,85E-05 (IR incl)
- Cost: 18 538 € per case

Respiratory HA, All ages (NO_2)
- IR: 0,05%; RR: 0,015 %
- Cost: 8 960 € per case (average duration 8 days)

Total mortality, All ages (NO_2)
- Mort. rate: 0,977%; RR: 0,027 %
- Cost: 1 844 € per YOLL

Long-Term

(Annual mean concentrations)

Chronic bronchitis (incidence), >18 (PM10)
- IR: 0,39%; RR: 1,17%
- Cost: 18 970 € per year

Chronic bronchitis (prevalence), 6-18 (PM10)
- Avg Prev: 18,6%; RR: 0,8%
- Cost: 18 970 € per year

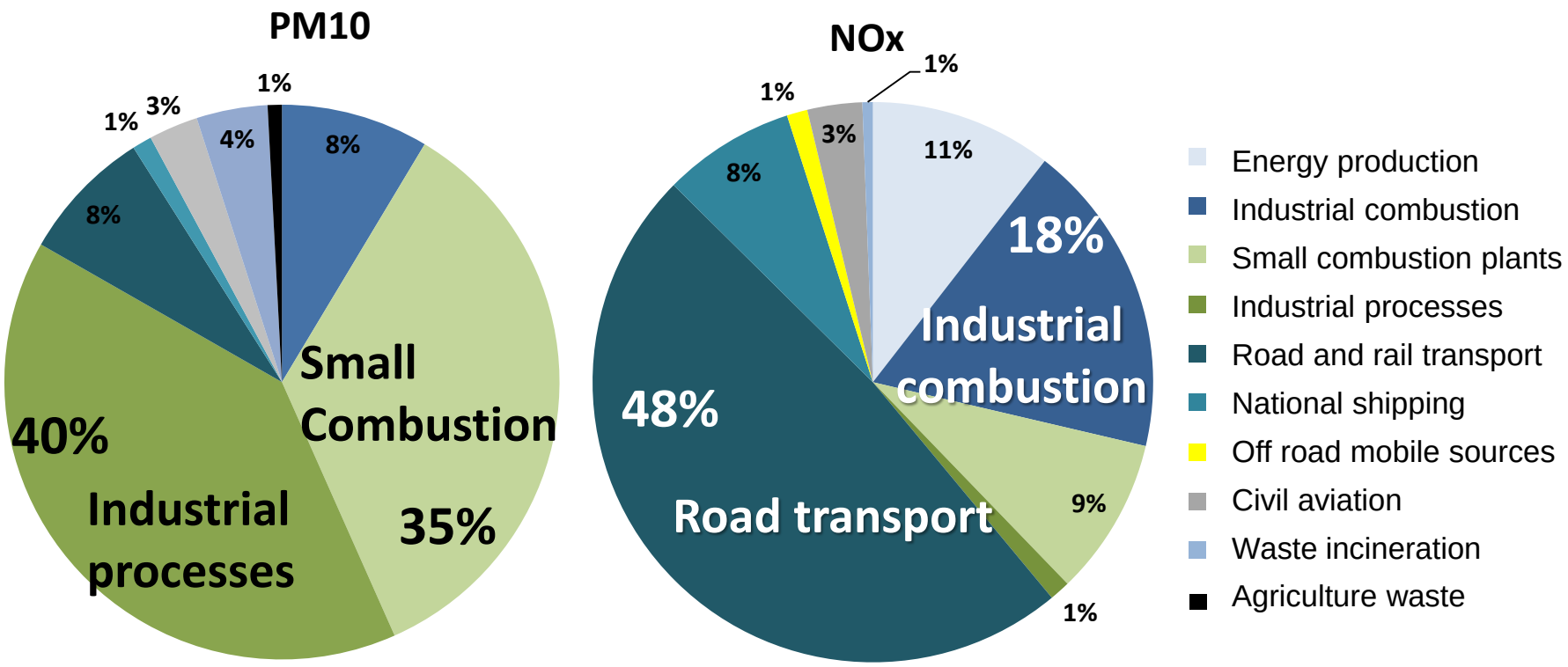
Total mortality, < 1 yr (PM10)
- Mort rate: 0,163%; RR: 0,4%
- Cost: 1 844 € per YOLL

Total mortality, All ages (NO_2)
- Mort. rate: 0,977%; RR: 0,55 %
- Cost: 1 844 € per YOLL

MAPLIA application

Definition of emission reduction measures

PM10 and NOx emissions in Grande Porto



MAPLIA system application

Selected measures for AQ improvement (NO_2 and PM10)

- Introducing a Low Emissions Zone where the circulation of vehicles below Euro 3 is banned **(LEZ)**
- Replacing 10% of passenger cars below Euro 3 by hybrid vehicles **(Hybrids)**
- Replacing/reconverting 50% of fireplaces in Grande Porto municipalities **(Fireplaces)**
- Applying technologies that allow to reduce 10% of PM emissions from industrial combustion and production processes **(Industry)**

MAPLIA system application

Assessment of selected measures

… from emissions to air quality levels

Application of the air quality model **TAPM** (1 year)

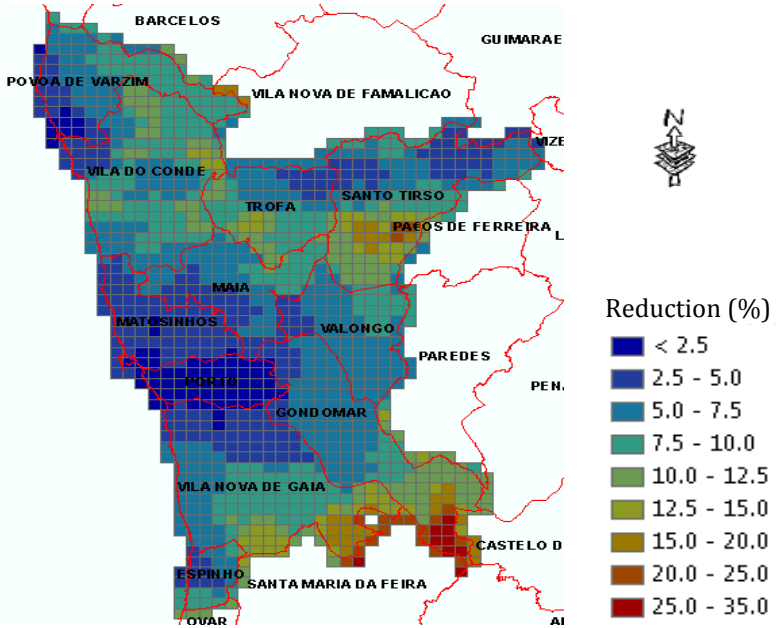
Reference Scenario

Reduction Scenarios
(15, as a combination of measures)

From scenarios… to cost-benefit analysis

Results

Measure “reconverting fireplaces”



Reduction of PM10 emissions
from domestic combustion sector (in %)
compared to the reference scenario

Reconversion of 50% fireplaces → **17543 fireplaces** in Grande Porto municipalities

Measure “hybrid vehicles”

10% of fuel and diesel light vehicles → **30740 vehicles in** Grande Porto

Reduction of:

15% of PM10 emissions

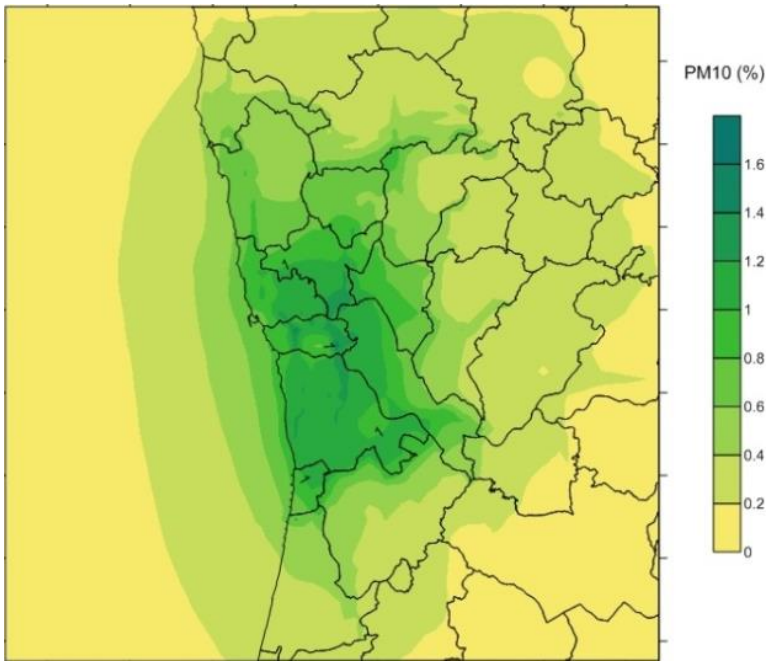
5% of NOx emissions

Relative to road traffic

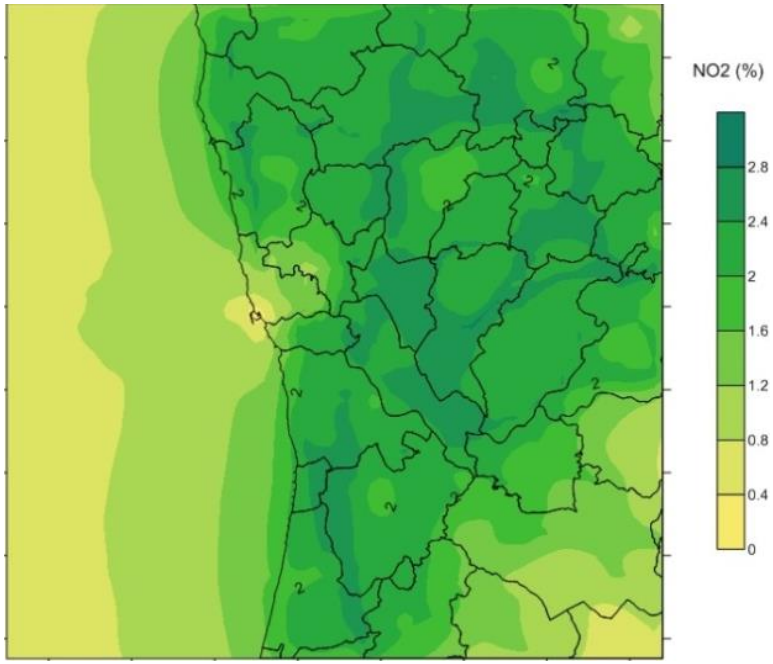
Results

… from emissions to air quality

PM10



NO_2

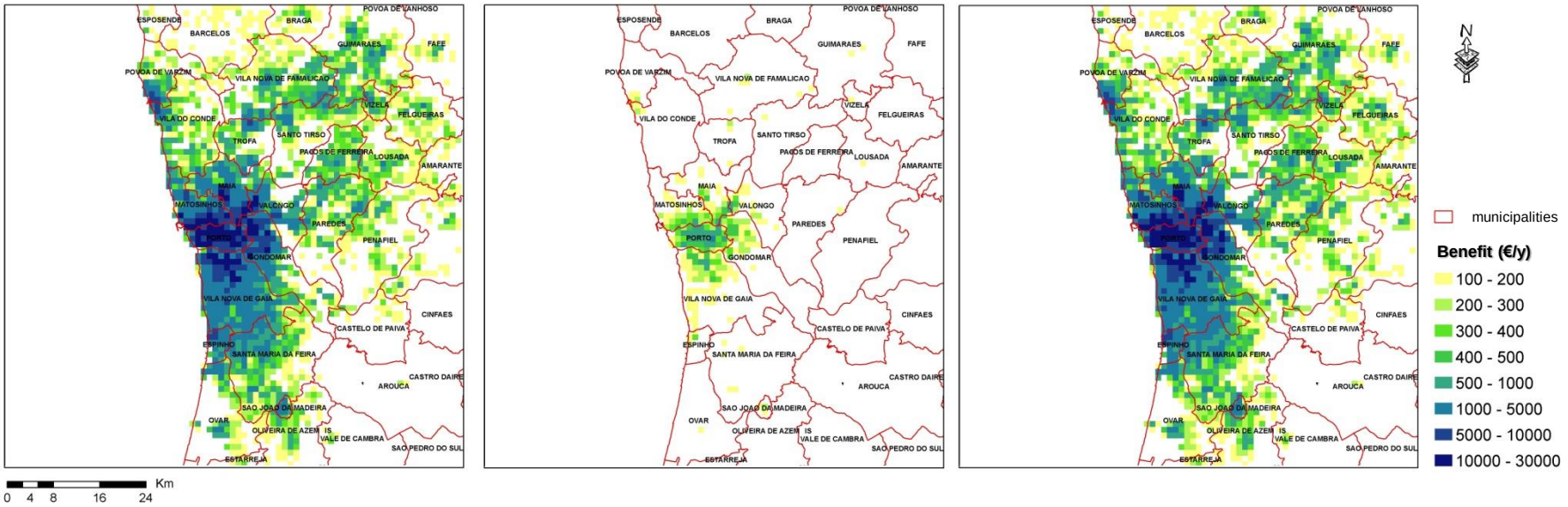


% Improvement of air pollutants concentration with the aplication of the reduction scenario **hybrids + fireplaces**

Results

from air quality to benefits (avoided costs)

PM10 **NO_2** **Total**



Long-term Health Benefit (€/year) applying the reduction scenario **hybrids + fireplaces**

- **Total benefit of 3,1 M €/year.**
- Higher contribution from the improvement of PM10 levels in the Grande Porto municipalities

Results

… from benefits (avoided costs) to the cost-benefit analysis

Total net benefit (annual average) = 0,3 M€/year

Ratio Benefit-Cost (RBC) of 1,11

reduction scenario **hybrids + fireplaces**

Annual average cost of **2,8 M€** for the implementation of the measures

Health benefits derived from the long-term exposure of **3,1 M€/year**

Internal Costs

External costs

Costs associated to the implementation of the measures/reduction scenarios

Results

Cost Benefit analysis

Avoided External Cost (short+long term)

Reduction scenario	Implementation Costs ($M€.y^{-1}$)	Health Benefit ($M€.y^{-1}$)	Net Benefit (impact) ($M€.y^{-1}$)	Benefit-Cost ratio RBC
HYB	2.0	1.5	-0.5	0.75
FIR	0.8	1.8	1.0	2.25
LEZ	3.8E-2	3.9E-2	1.0E-3	1,03
IND	5.8	5.6	-0.2	0.97
HYB + FIR	2.8	3.3	0.5	1.18
FIR + IND	6.5	7.4	0.9	1.14
HYB+FIR+LEZ+IND	8.6	8.9	0.3	1.03

Balance = Benefit - Cost

Final remarks

- The comparison between the reference and the reduction scenarios, including the balance between costs and benefits, allows to quantify the efficiency of the strategies.
- The cost-benefit analysis performed to all studied scenarios highlights the fireplaces measure as the most efficient.
- The implementation of the 4 measures has an annual net average impact of 0.3 M€
- This cost-benefit analysis did not consider all air pollution related health impacts and associated benefits. Also, environmental impacts and benefits were not taken into account.
- The MAPLIA system is a useful tool for policy decision support for air quality improvement strategies, since it covers both air quality and health impacts and costs, and could be applied to other urban areas where AQP need to be implemented and monitored.

Thanks for your attention

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