HOW LOW-COST AIR QUALITY MONITORING TOOLS CAN CONTRIBUTE TO COMPLY WITH EUROPEAN DIRECTIVES ON AMBIENT AIR QUALITY AND CLEANER AIR FOR EUROPE

Jorge Ferreira

Jorge.ferreira@qart.pt
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HOW AIR POLLUTION IS DESTROYING OUR HEALTH

KEY FACTS:

91%

of the world population in 2016 was living in places where the WHO air quality guidelines levels were not met

4.2

million premature deaths worldwide in 2016 were estimated to be caused by outdoor air pollution in both cities and rural areas

400.000

premature deaths every year in **Europe**.
Worse than for road traffic accidents, making it the number one environmental cause of premature death.

Fonte

World Health Organization

OF ALL DEATHS AND DISEASE, WORLDWIDE AMBIENT AIR POLLUTION ACCOUNTS FOR:

43%

CHRONIC OBSTRUCTIVE PULMONARY DISEASE

29%

LUNG CANCER

24%

STROKE

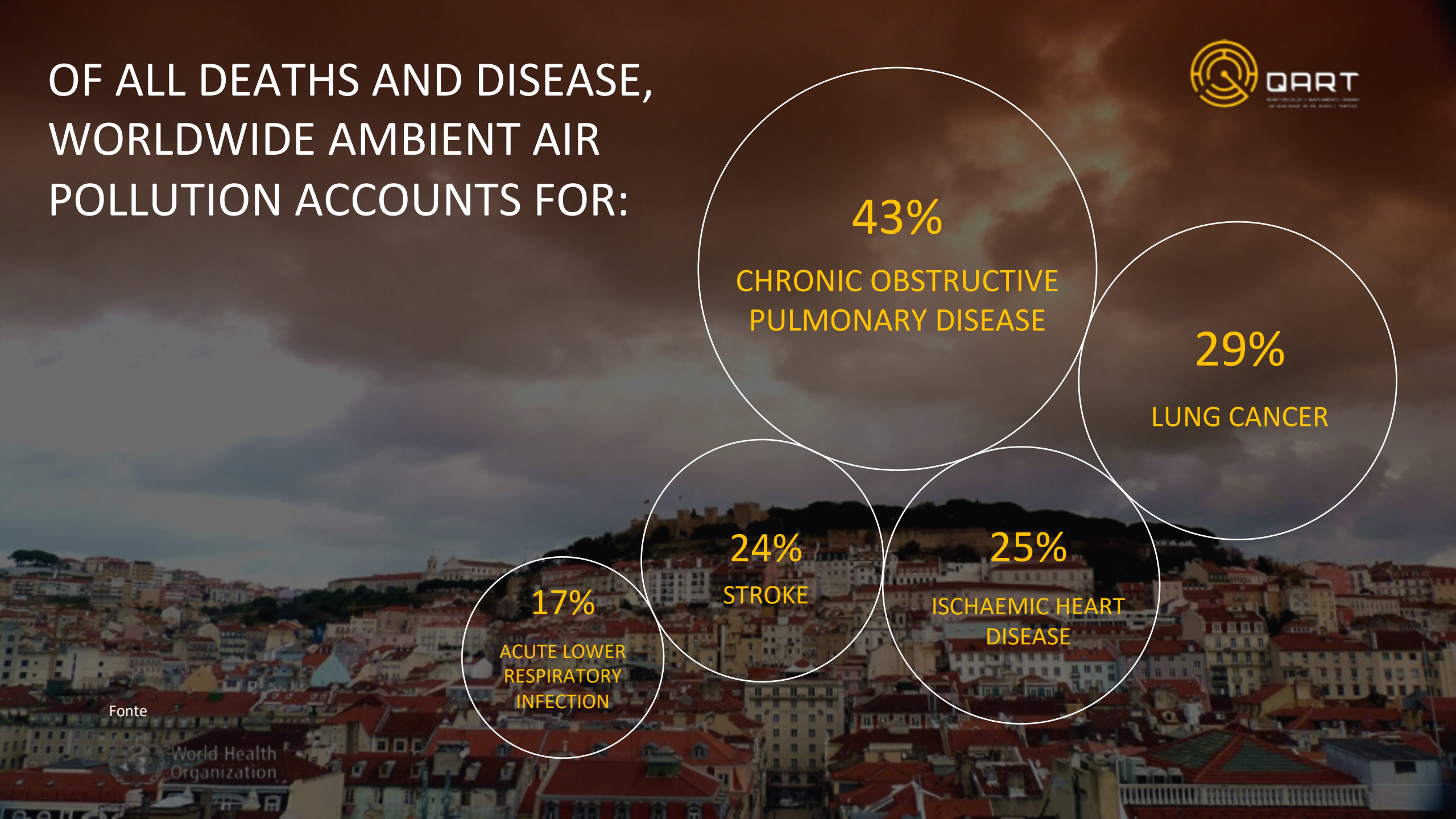
25%

ISCHAEMIC HEART DISEASE

17%

ACUTE LOWER RESPIRATORY INFECTION

Fonte

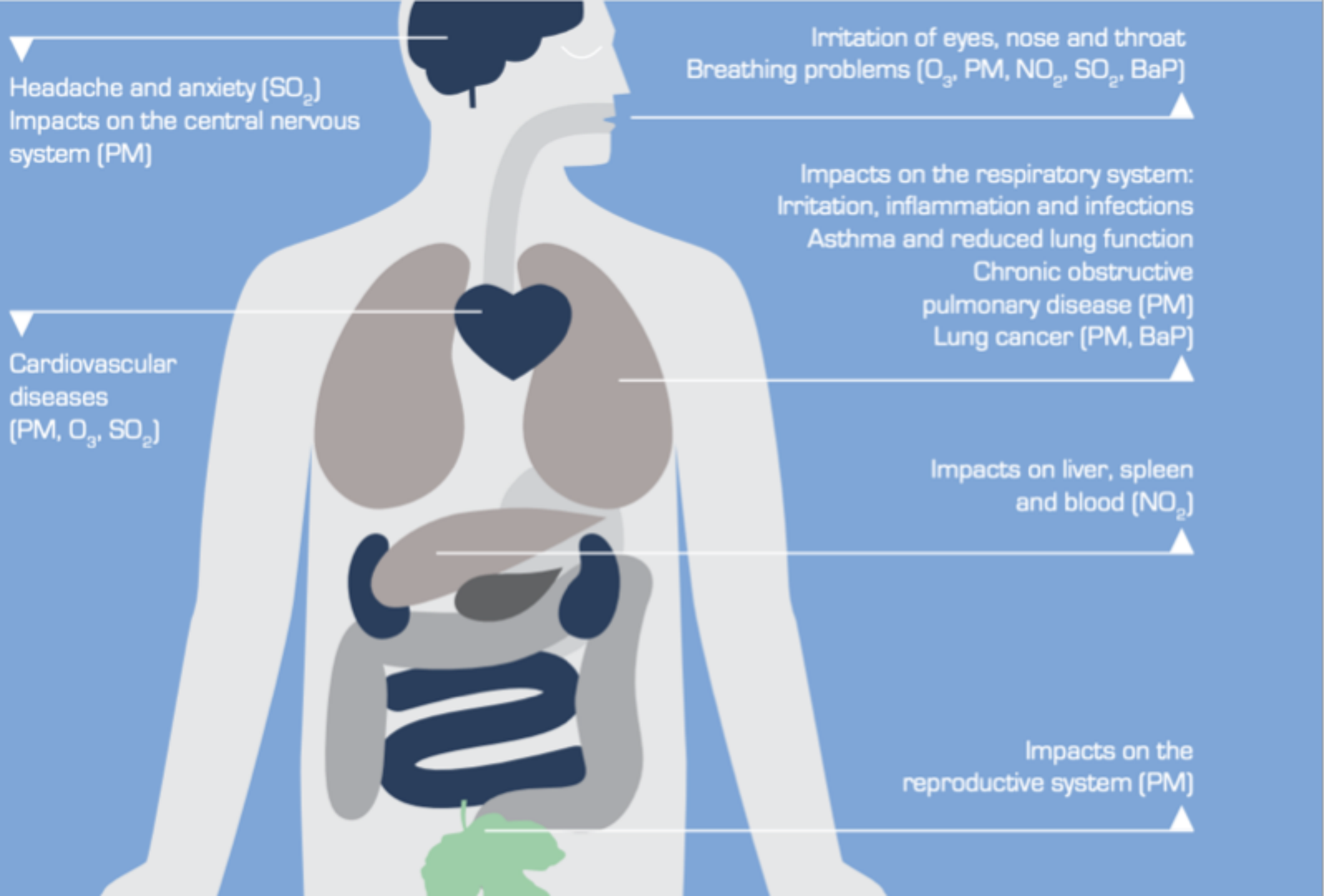


European Environment Agency

QART

In 2013, the European Commission adopted a **Clean Air Policy Package** for Europe. This package of measures aims to achieve full compliance with existing air quality legislation by 2020 and further improve Europe's air quality by 2030 and thereafter.

European Commission



QART

EEA SIGNALS 2013

DIRECTIVE 2008/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2008 on ambient air quality and cleaner air for Europe

This Directive lays down measures aimed at the following:

1. defining and establishing **objectives for ambient air quality designed to avoid, prevent or reduce harmful effects on human health** and the environment as a whole;

2. **assessing the ambient air quality in Member States** on the basis of common methods and criteria;

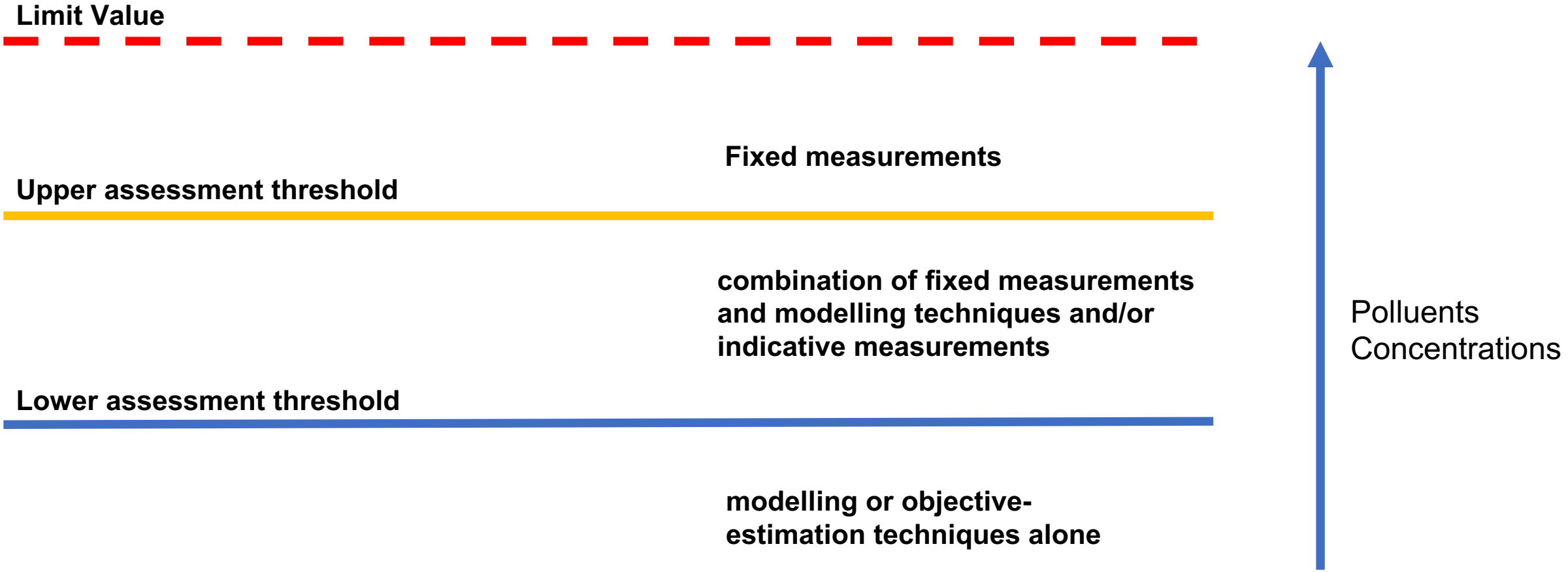
3. **obtaining information on ambient air quality** in order to help combat air pollution and nuisance and to **monitor long-term trends and improvements** resulting from national and Community measures;

4. **ensuring that such information on ambient air quality is made available to the public;**

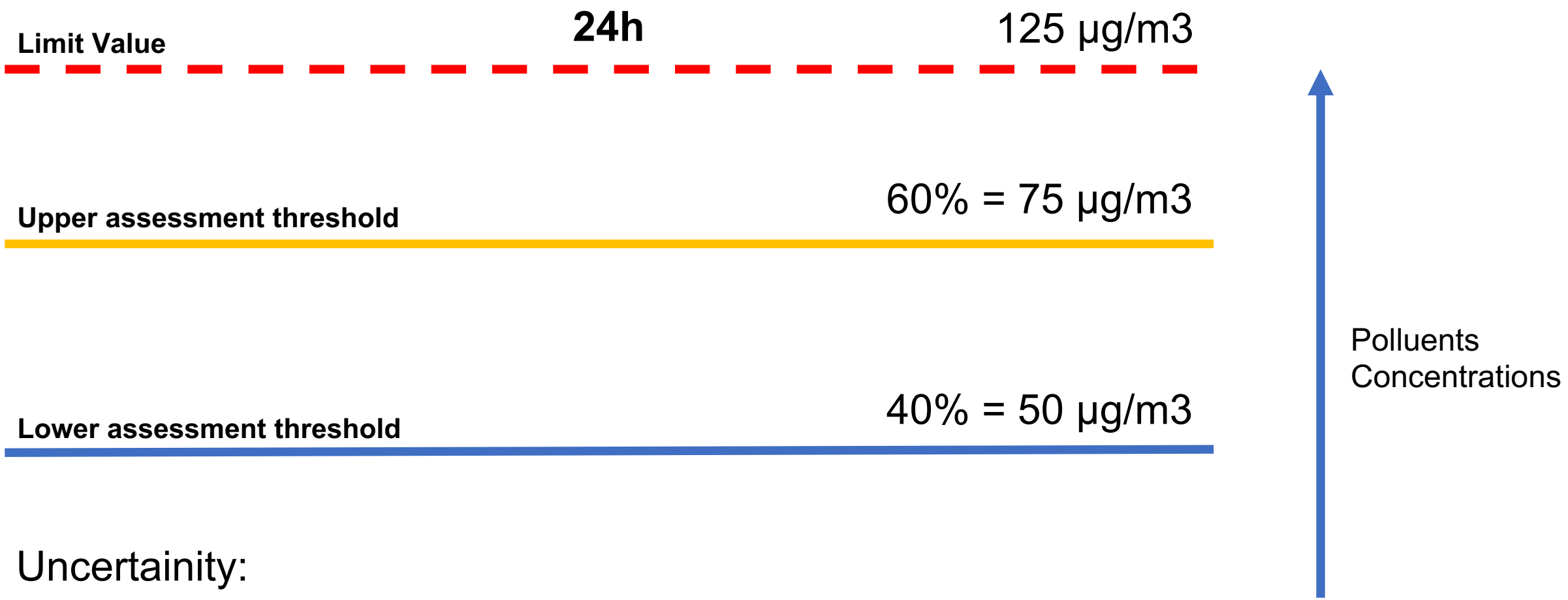
5. maintaining air quality where it is good and improving it in other cases;

6. promoting increased cooperation between the Member States in reducing air pollution.

DIRECTIVE 2008/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2008 on ambient air quality and cleaner air for Europe



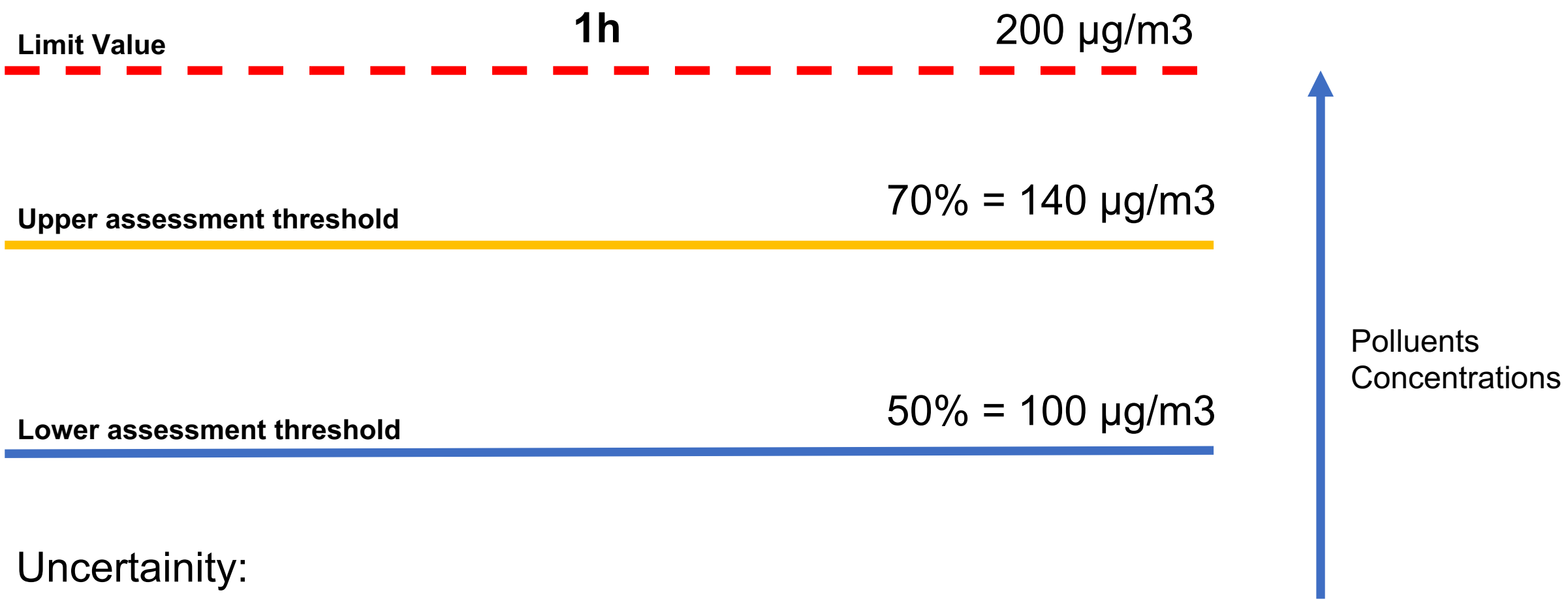
Sulphur Dioxide (SO2)



Uncertainity:

- Fixed measurements: 15%
- Indicative measurements: 25%

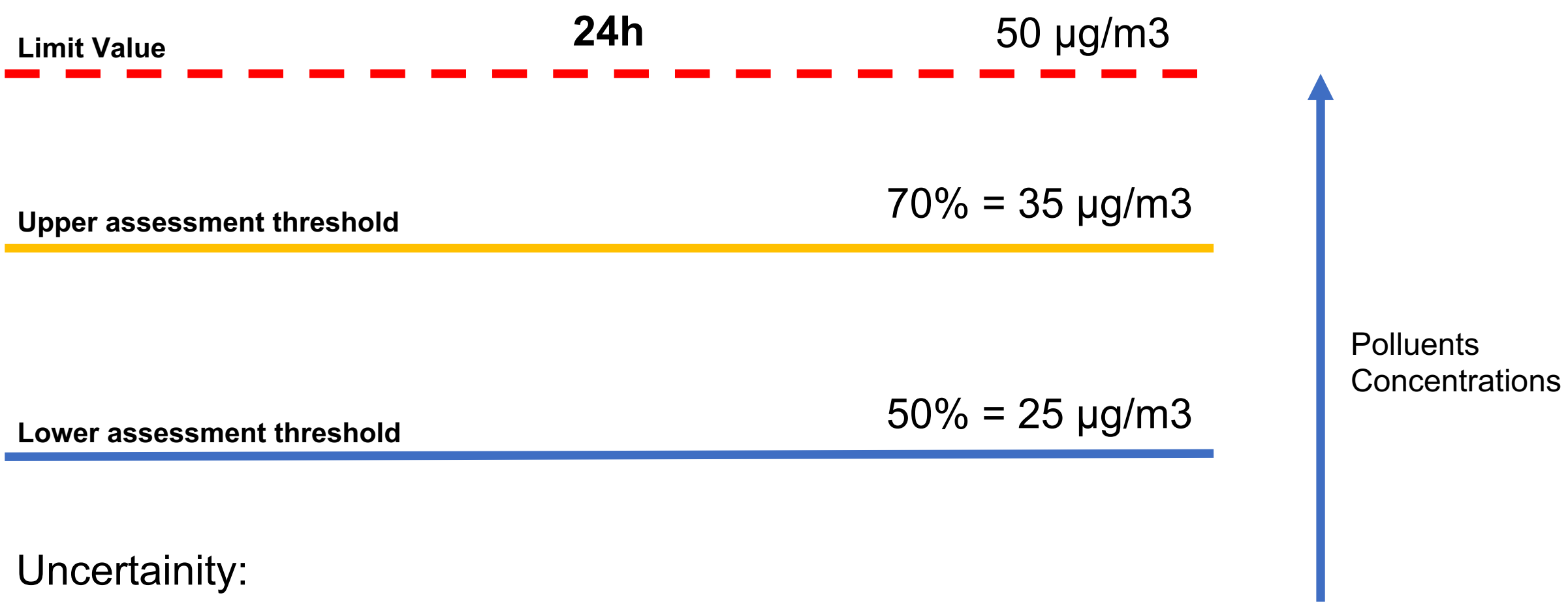
Nitrogen Dioxide (NO2)



Uncertainity:

- Fixed measurements: 15%
- Indicative measurements: 25%

Particulate matter (PM10)

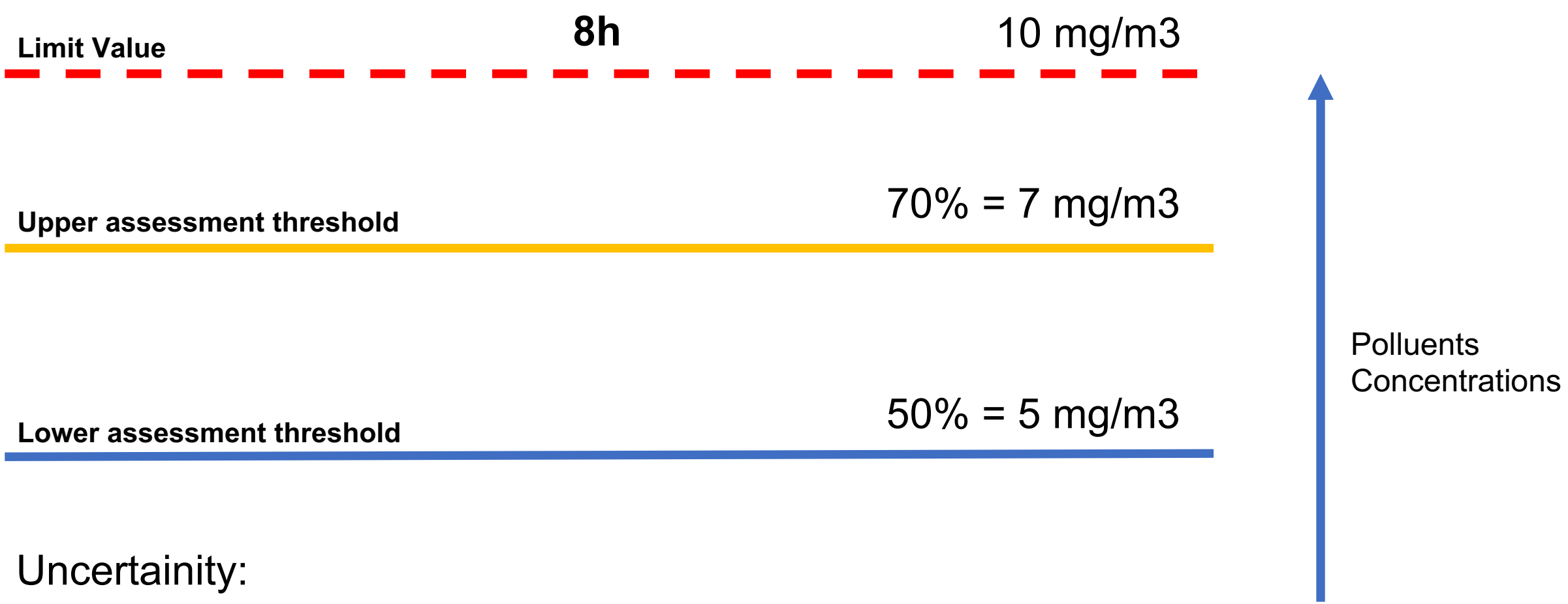


Uncertainity:

- Fixed measurements: 25%
- Indicative measurements: 50%

European Commission

Carbon Monoxide (CO)



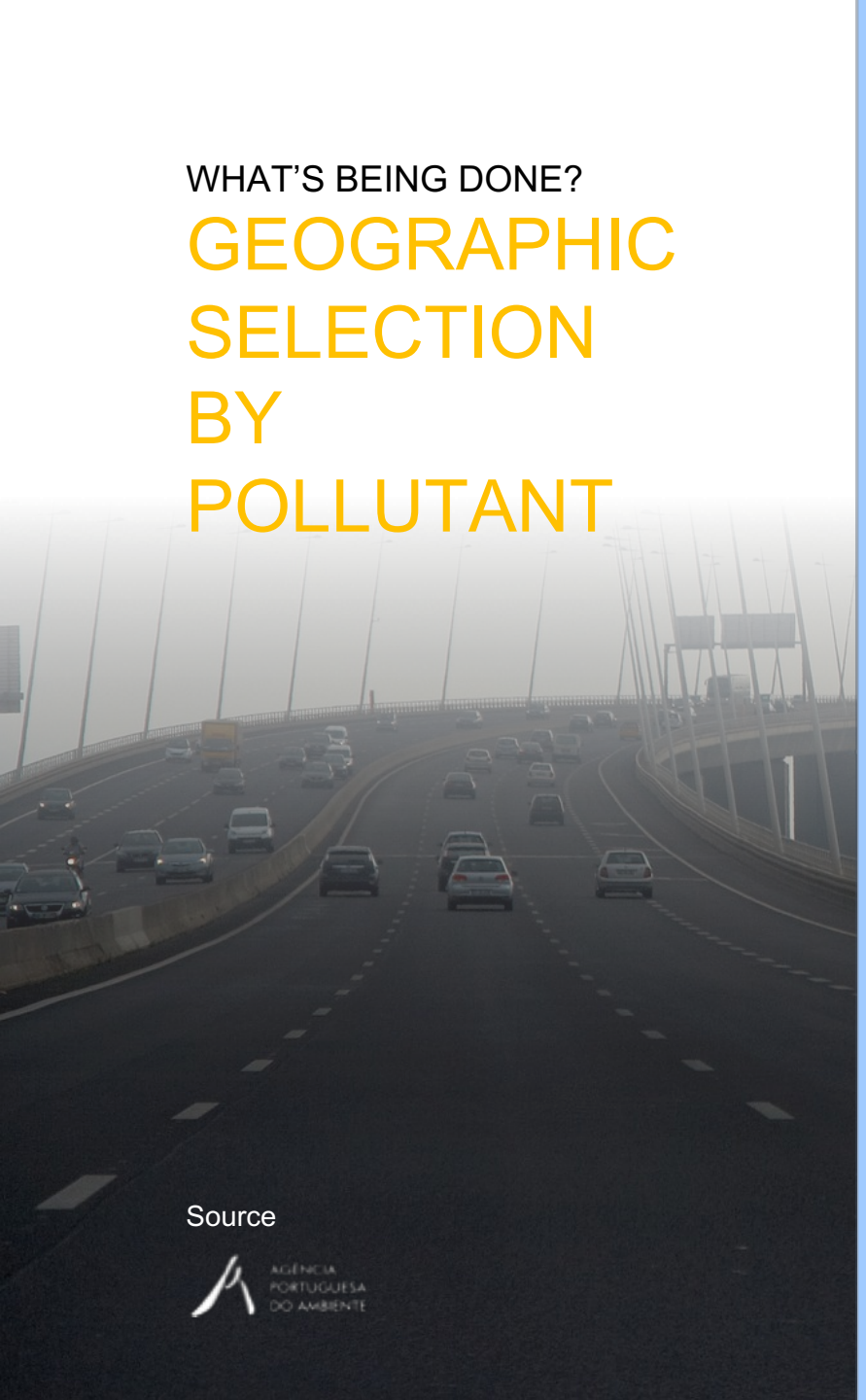
Uncertainity:

- Fixed measurements: 15%
- Indicative measurements: 25%

WHAT'S BEING DONE?

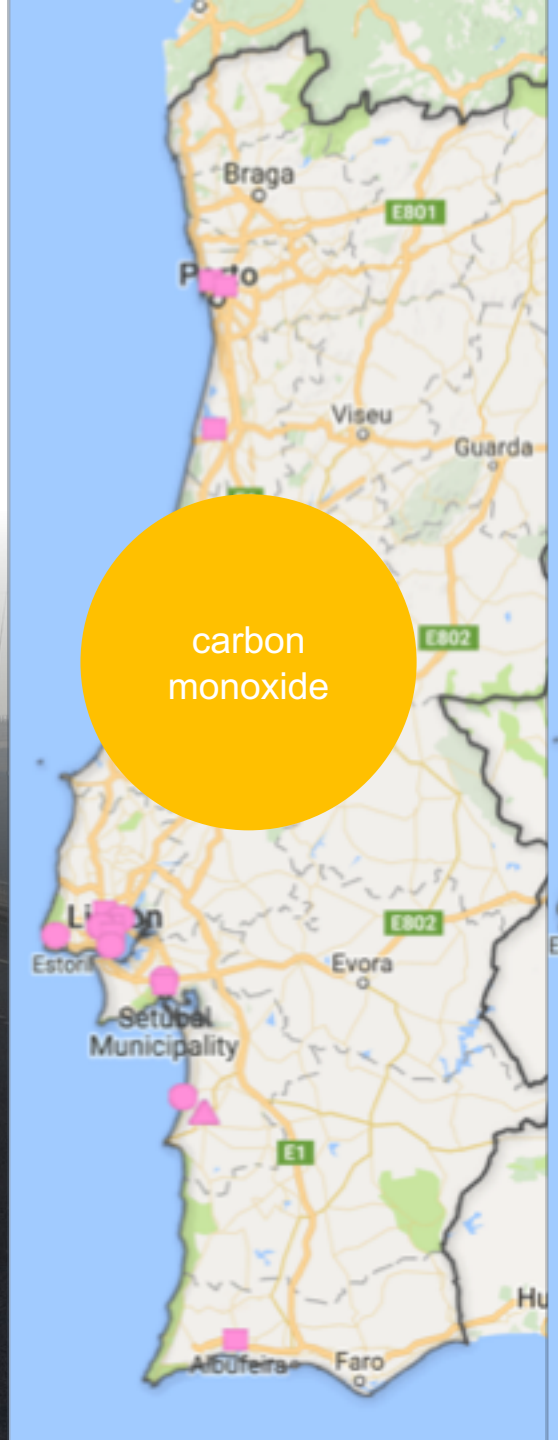
WHAT'S BEING DONE?

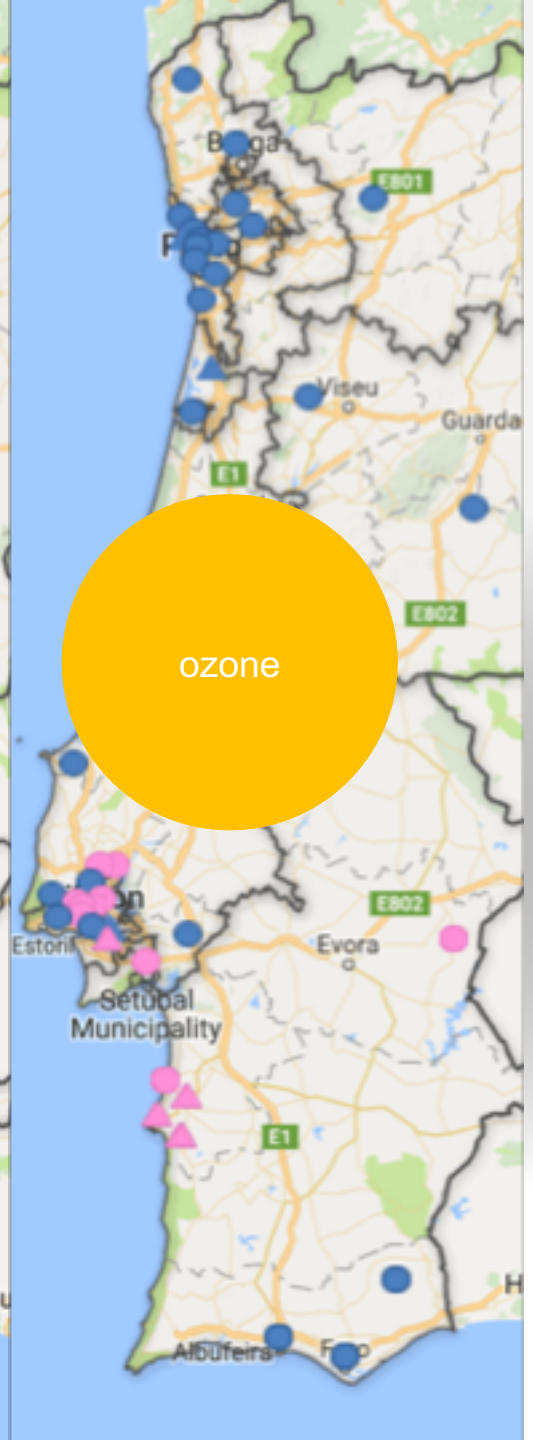
GEOGRAPHIC SELECTION BY POLLUTANT



Source

AGÊNCIA PORTUGUESA DO AMBIENTE





QART

- Few measurement locations
- Low density outside Lisbon and Porto
- Not all pollutant are being measured in all stations

STATIONS:
Influence / Type

	Fixed	Indicative
Traffic	■	■
Deep	●	●
Industrial	▲	▲

WHAT'S BEING DONE?

REFERENCE STATIONS

- Large size stations
- High initial investment
- High maintenance
- Offline data
- Landscape impact
- Not very discreet (attracts attention and vandalism)
- The Portuguese territory has a total area of 92090 km2:
  - 80 Air Quality Stations,
  - 1 station at each 1200 km2,
  - Most located at Oporto/Lisbon,
  - Most territory is not covered (low level of time and space representability),
  - Data provided in the covered part of territory is not reliable,
  - A part of the working stations do not measure all parameters
- Ineffective in the communication and information of citizens, municipalities and companies.

WHAT'S BEING DONE?

LOW-COST SENSORS

- Measure saturations (and not concentrations)
- Frequent measurement errors
- Don't take into account the specific air quality regulation (e.g. EU directives)
- high or unkown uncertainty

- Don't produce comparable data
- Don't replace the reference stations (do not meet the objectives of data quality)

IT'S NOT THE SOLUTION

COMMON PROBLEMS

LOW-COST SENSORS

- Measures in ppm (not in ppb)
- Low resolution (ex: Arduino is 10bit)
- Noise (ex: Raspberry Pi clock frequency 1.2Ghz, power supply)
- Designed for high concentrations detection
- Ignore cross-sensitivity

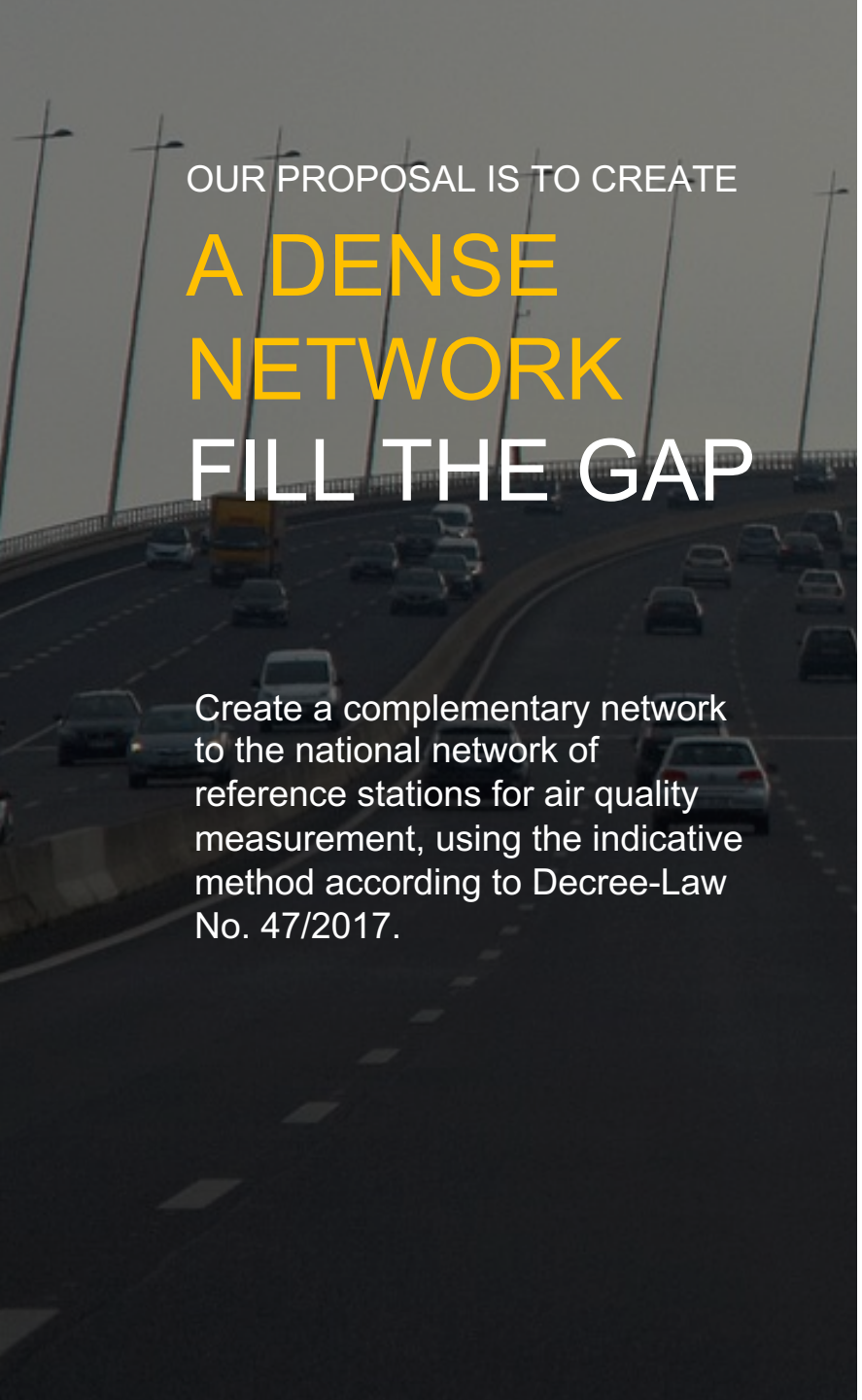
The conversion assumes an ambient pressure of 1 atmosphere and a temperature of 25 degrees Celsius.

• SO2	1 ppb = 2.62 µg/m3
• NO2	1 ppb = 1.88 µg/m3
• NO	1 ppb = 1.25 µg/m3
• O3	1 ppb = 2.00 µg/m3
• CO	1 ppb = 1.145 µg/m3
• Benzene	1 ppb = 3.19 µg/m3

0.1 ppm of SO2 = 262 µg/m3
(limit value is 125 µg/m3)

The general equation is
µg/m3 = (ppb)*(12.187)*(M) / (273.15 + °C)
where M is the molecular weight of the gaseous pollutant.
An atmospheric pressure of 1 atmosphere is assumed.

HOW CAN WE USE LOW-COST SENSORS ?



OUR PROPOSAL IS TO CREATE

A DENSE NETWORK FILL THE GAP

Create a complementary network to the national network of reference stations for air quality measurement, using the indicative method according to Decree-Law No. 47/2017.

MEASURES AT LEAST:

- CO
- NO
- NO_2
- O_3
- SO_2
- PM10
- PM2.5
- PM1
- Noise
- Temperature
- Humidity
- Atmospheric pressure

With:
CE Certification
Calibration of sensors using reference stations

KNOW THE UNCERTAINTY

FIELDWORK

- Sensor validation (DL 47/2017)
- Laboratory tests
- Fieldwork
- Comparison with reference methods

OBJECTIVES:

- Evaluate the adequacy of the gas sensors expected for QART in accordance with DL N.º 47/2017 as indicative method.
- Determine the uncertainty of the abovementioned QART sensors.

Meet the data quality objectives defined in annex II of DL 47/2017, July 7

Guide to the Demonstration of Equivalence of Ambient Air Quality Methods – EC working Group.

METHODOLOGY

SENSOR CALIBRATION

Explore different methods of calibrating sensors against reference measurements motivated by the known presence of complex nonlinear and cross-sensitive behavior of sensors.

Field normalization techniques that attempt to address these complex behaviors include:

- multi-linear regressions,
- non-linear multi-variate models,
- machine learning

SONDAR.LAB

Certificado de acreditação para calibrações nº M0103 emitido em 2014-05-06 pelo IPAC).
Certificado de acreditação para ensaios nº L0353 emitido em 2005-09-02 pelo IPAC)

METHODOLOGY

TEST REPORT: RM_QUALAR_201709_QART

- Response time evaluation
- Sensor calibration and linearity deviation evaluation
- Calculation of quantification limit

INTERCOMPARATION DATA EVALUATION METHODOLOGY

A value pair evaluation procedure was used to verify compliance with the data quality objectives obtained by the sensors.

According to the directive, the relative expanded uncertainties allowed are 50% for PM10, 30% for O3 and 25% for CO, NO and NO2, in all cases in the respective limit value zone.

DEVIATION

Nothing to report.

Certificado de acreditação para calibrações nº M0103 emitido em 2014-05-06 pelo IPAC).
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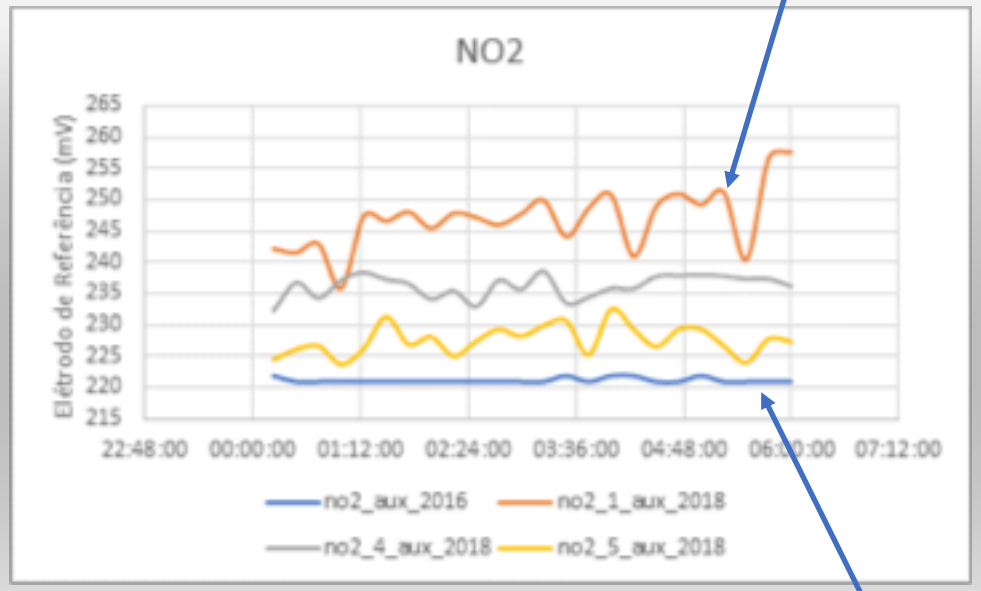
METHODOLOGY

NOISE EFECT

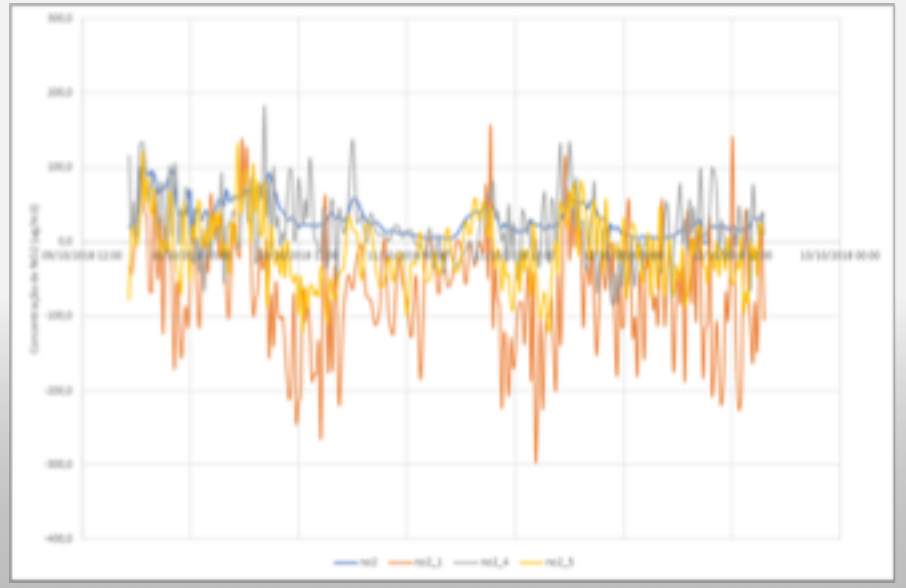
Uncertainty 60% - 70%

Hight noise



Low noise

Uncertainty ~18%
(< 25%)



KNOW THE UNCERTAINTY

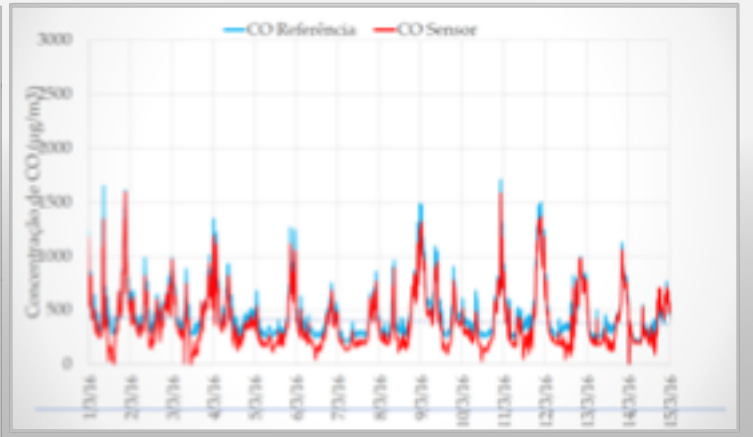
TESTS AND VALIDATIONS

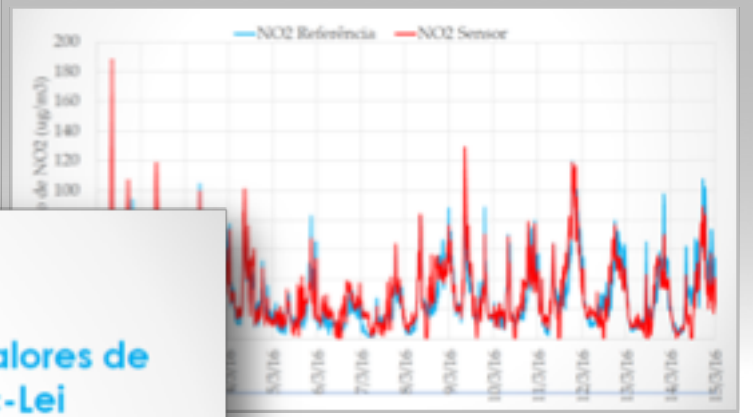
SONDARLAB

RESUMO DA VALIDAÇÃO DOS SENSORES DE QUALIDADE DO AR PROJETO QART

Metodologia

- Realização de Testes Laboratoriais
- Comparação dos sensores com o método de referência de acordo com o documento: GUIDE TO THE DEMONSTRATION OF EQUIVALENCE OF AMBIENT AIR MONITORING METHODS. Report by an EC Working Group on Guidance for the Demonstration of Equivalence.
- Realização de medições durante cerca de 3 meses (Viseu, Matosinhos e Maia)





Conclusões Gerais

- Todos os sensores deram, na zona do valor limite, valores de incerteza expandida inferiores ao definido pelo Dec-Lei 102/2010 para medições indicativas.

PRODUCT AND SERVICE PROVIDED

QART BOX

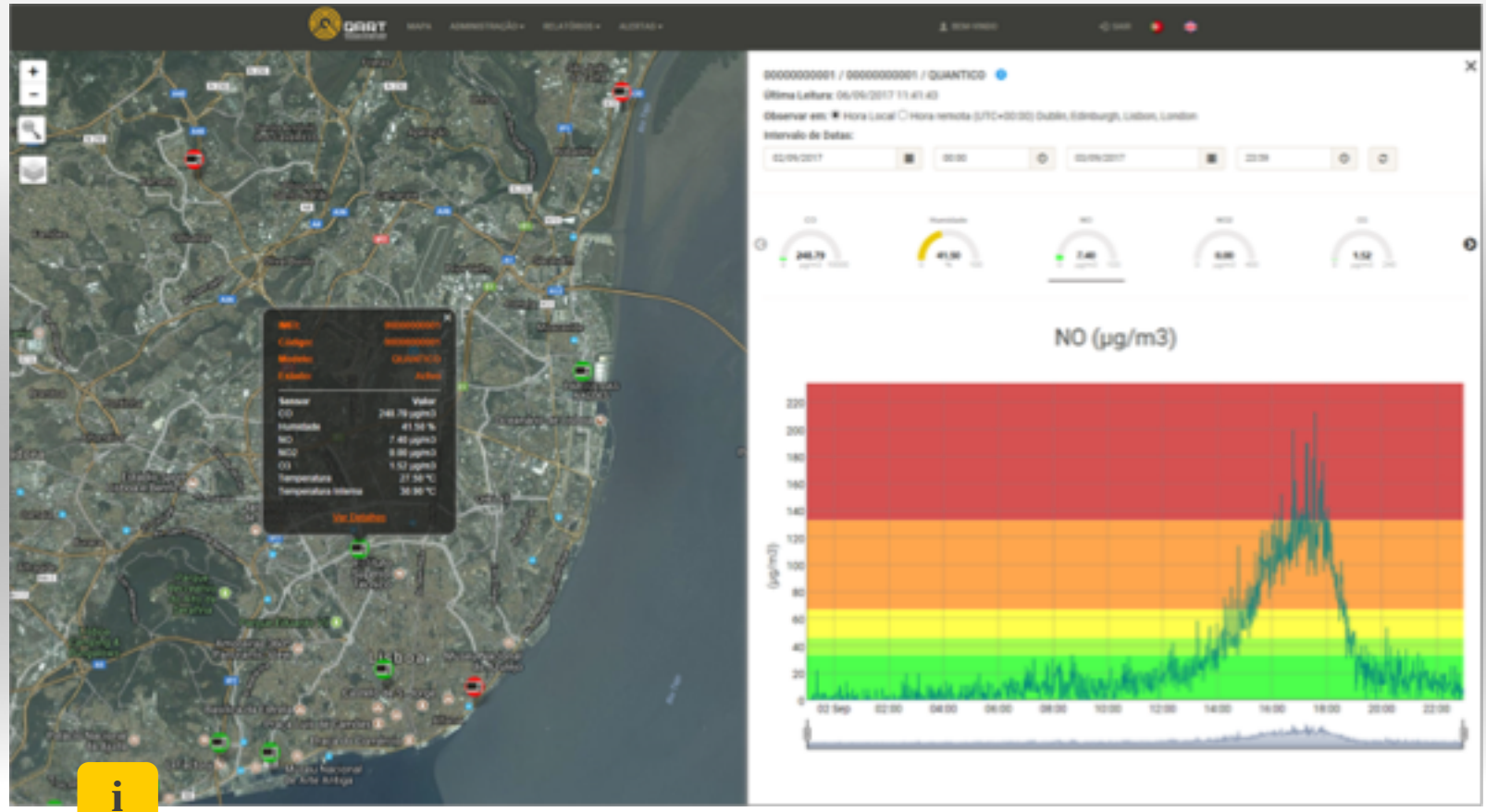
QART BOX is a miniaturized air quality and noise monitoring instrument, with a custom made built-in multiple CPU board, QART BOX internal board is always making a self-diagnostic to ensure that the accuracy of the sensor data that will be collected is accurate and reliable.

Sensors:

- CO (0.5 to 100 ppm)
- O_3 (10 to 200 ppb)
- NO_2 (5 to 500 ppb)
- SO_2 (5 to 500 ppb)
- O_2 (0 to 100%)
- H_2S (0 to 10000 ppb)
- Air pressure sensor (300 – 1500 mbar)
- External temperature sensor (-60 to 60 ºC)
- Internal temperature sensor (-60 to 60 ºC)
- External humidity sensor (5 to 100%)
- Internal humidity sensor (5 to 100%)
- Noise sensor (-30 to 120 dB)
- Optical particulate sensor:
  - PM0.5
  - PM0.7
  - PM1.0
  - PM2.5
  - PM10

TECNOLOGY

QART PLATFORM



SIMPLE AND INTUITIVE INFORMATION
INDIVIDUAL POINT'S MANAGEMENT
ALERT CONFIGURATIONS

SMARTCITIES

TURISM

REAL ESTATE

INDUSTRY

EVALUATION OF ENVIRONMENTAL IMPACT

AIR QUALITY MONITORING

The use of emerging technologies associated with indicative measurements, which are being subject to standardization (**Working Group 42 of CEN Technical Committee 264, "Air quality — Performance evaluation of sensors for the determination of concentrations of gaseous pollutants and particulate matter in ambient air"**) will complement the fixed measurements with data that are also continuous and that, despite being less accurate, increase the temporal and spatial representativeness of the monitoring.

QART

MONITORIZAÇÃO E MAPEAMENTO URBANO DA QUALIDADE DO AR, RUIDO E TRAFEGO

Avenida da República 25
1050-186 LISBOA
PORTUGAL
+351 212 888 989

www.qart.pt

Jorge Ferreira

Jorge.ferreira@qart.pt
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