Some personal thoughts on air pollution indicators

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1. **What is an “air pollution indicator” and what is its role?**

2. **Linking indicators to measurements and modelling and quantitative assessment**

3. **Examples illustrating strengths and limitations when used in driving policy**

4. **Some thoughts on setting indicators for $PM_{2.5}$ in relation to health**

Lichens were an early example of a biological indicator for SO_2

What is an air pollution indicator?

Something that can be used in evaluating an impact of air pollution.

e.g. emission of a pollutant, atmospheric concentration, exposure to pollution, exceedance of a critical threshold

What is the role?

Registering the current situation (and past) and future changes. Requires a combination of observation/measurements and modelling.

Policy applications and setting targets/legislation

But be careful how this may lead to distortion of the intent!

Pollutant emissions as indicators

Established procedures for calculating emissions

Widely used in regulation

National emission ceilings in Gothenburg protocols/NECD

Local emissions and source apportionment-> urban air quality abatement

But like all modelling gaps/missing sources; representation; uncertainties.

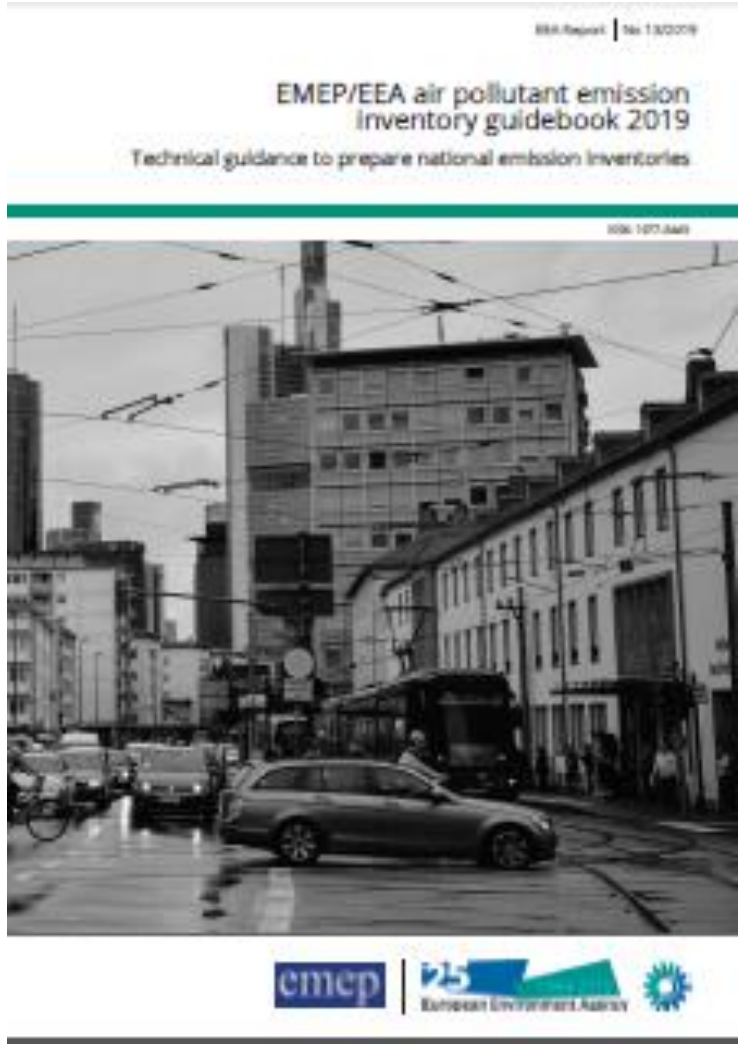
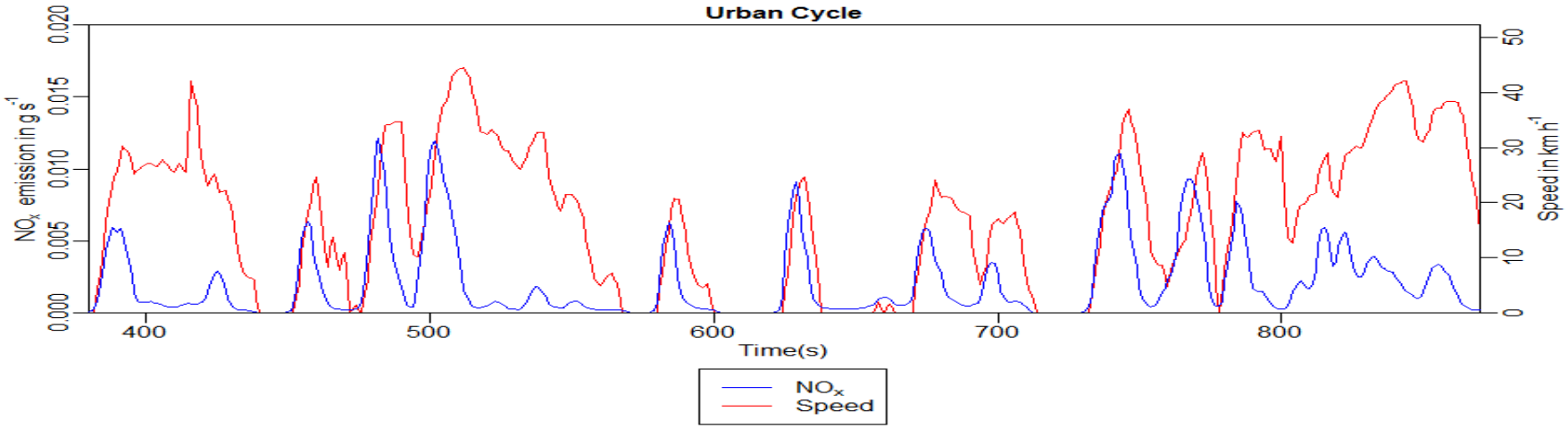


Illustration 1: Diesel car emissions of NOx (Euro class: age of car)

Measurement: in accordance with set test cycles now extended to RDE testing

Modelling: COPERT speed-dependent graphs based on real-world measurements

Simplified representation: emission from modern diesel in sharp peaks with acceleration & enhanced in congested conditions.

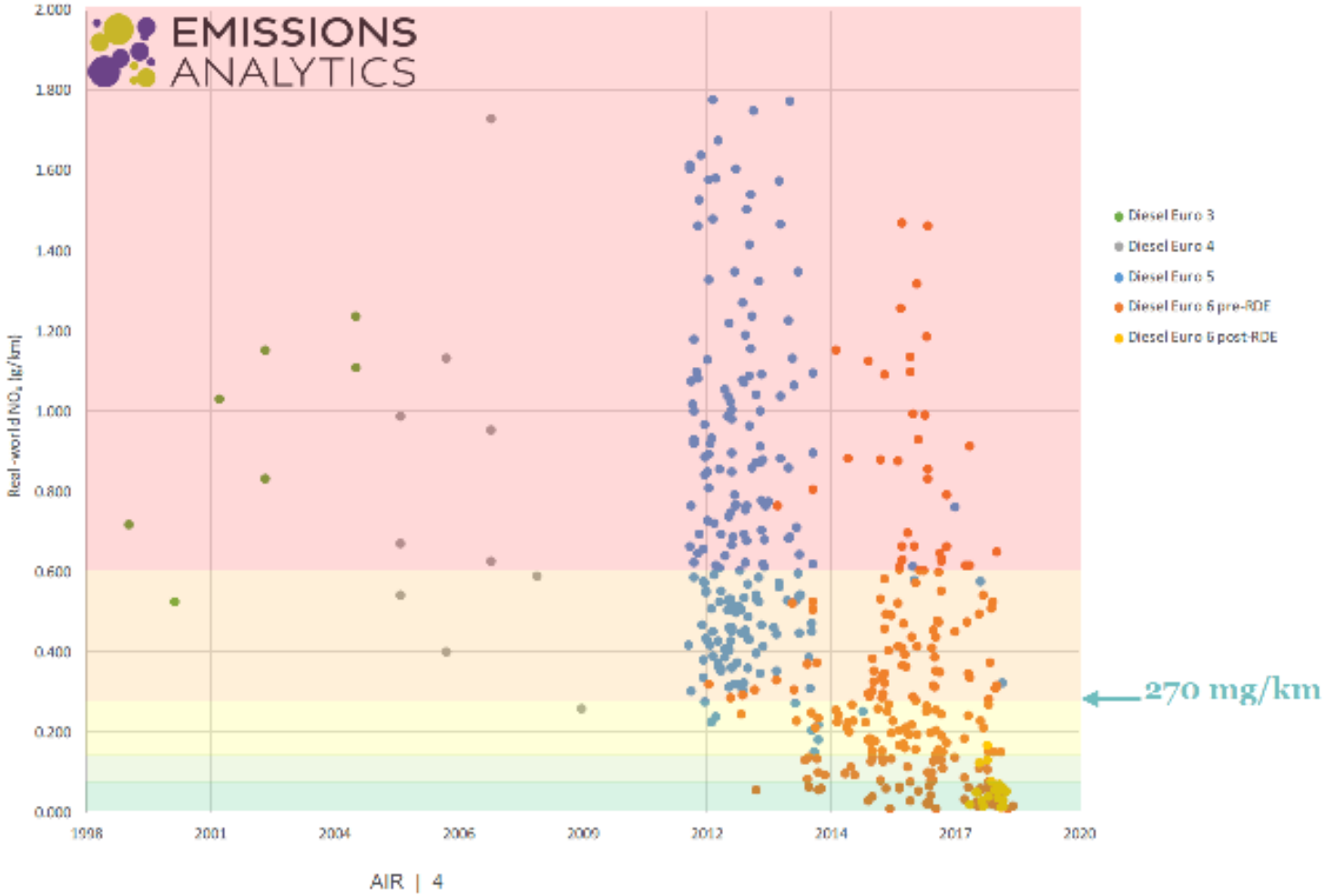


Euro class then used in regulation e.g. Low Emission Zones

Averages over variability between cars within the same Euro class

REAL-WORLD EMISSIONS PERFORMANCE

AIR
Allow Independent Road-testing



- Many Euro 6 diesels are dirtier than Euro 3/4
- Average Euro 5 emits 749 mg/km NO_x
- Average Euro 6 emits 382 mg/km NO_x
- Approximately 40 million over-emitting diesels on EU roads
- 270mg/km real-world limit proposed by German government for 14 cities
- Only 1 pre-Euro 5 diesel, 6 pre-Euro 6 diesels meets this
- 48% of Euro 6 fail to meet

Slide courtesy of Nick Molden , Emissions Analytics

Indicators for pollutant concentrations

Criteria for protection of human health

Maximum level of <u>individual</u> exposure->

limit value for outdoor concentrations

But NB not a safe threshold for no effect.

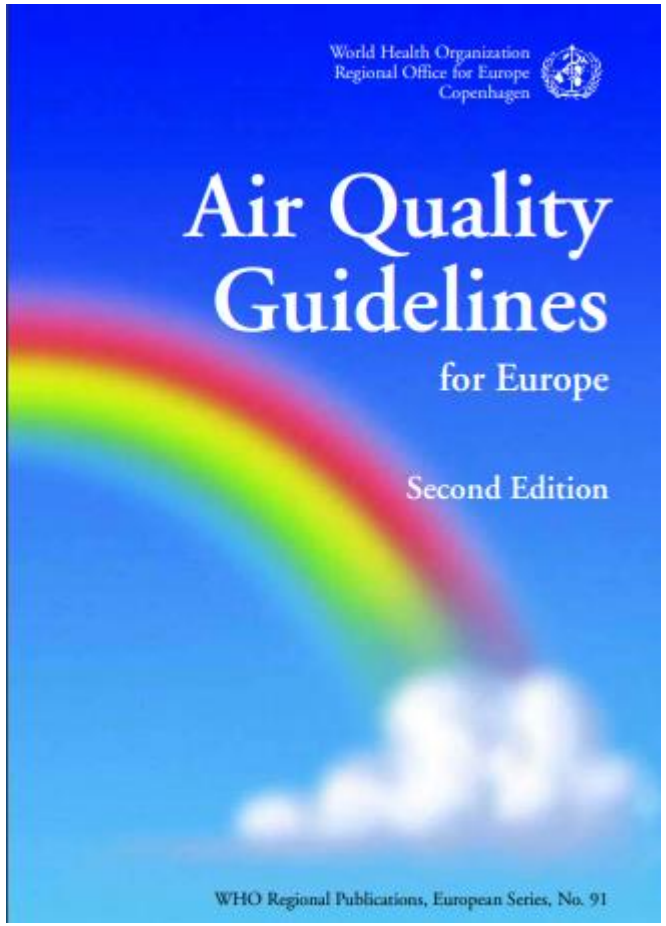


Illustration 2: Limit value for NO2 concentration (40ug/m3 annual average)

Indicator : exceedance of limit value across monitoring network; target=zero.

Measurements: extensive monitoring at network of background and road-side sites
Modelling: based on dispersion modelling down to street-scale and road-side concentrations

Has been very effective in driving big improvement. But now the focus on remaining few road-side sites with exceedance distorts regulation; also open to challenge as low-cost monitors show hot-spots not covered by network.

Indicator well linked to epidemiological evidence but use in legislation now not helping policy aim to maximise improvement in protection of human health.

? Additional indicators aimed at reducing overall human exposure and for critical groups (e.g.areas of higher concentration or round schools)

Some thoughts on indicators for PM2.5

Much more complex than NO2 :a cocktail of different primary and secondary pollutants

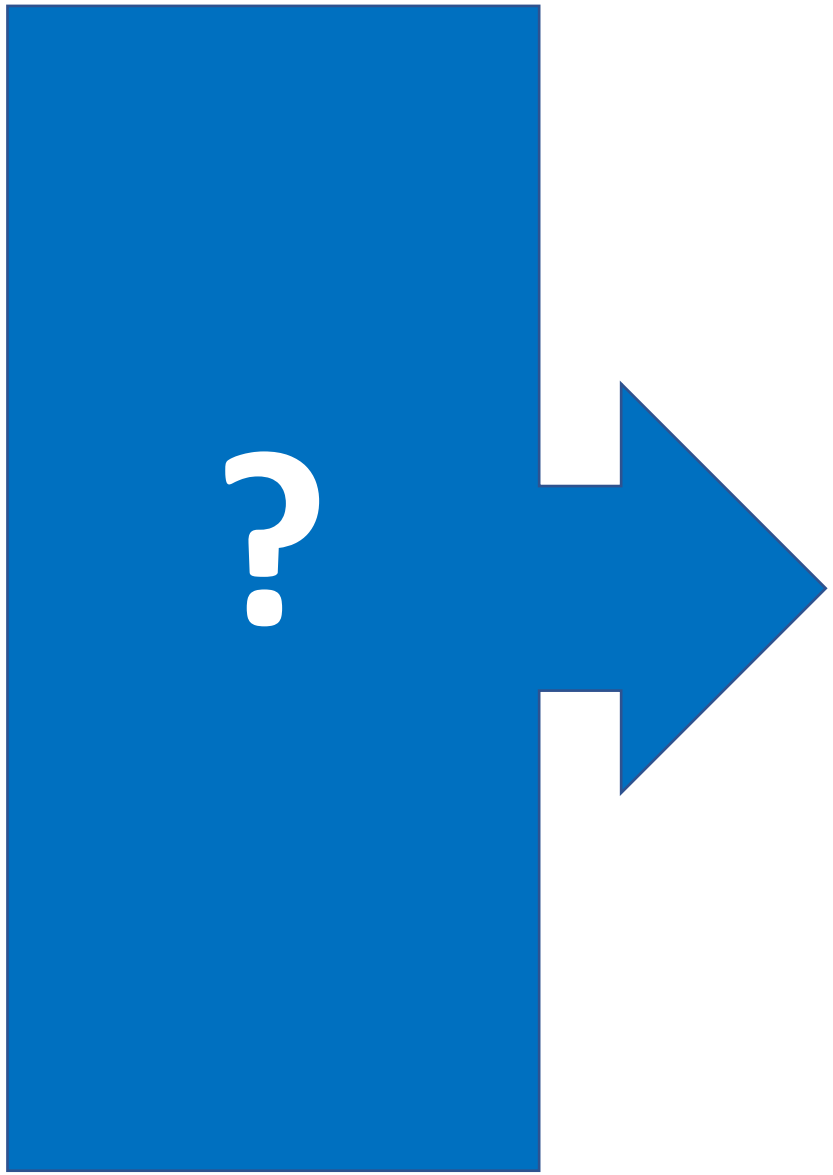
WHO guideline of 10 ug/m3 applies to total mass. Relative toxicity components?

Contributions from continental to very local scale

Big uncertainties in emissions of primary PM2.5 and other components e.g. IVOCs, SOA: plus natural/non-anthropogenic contributions

Far more limited monitoring than for NO2

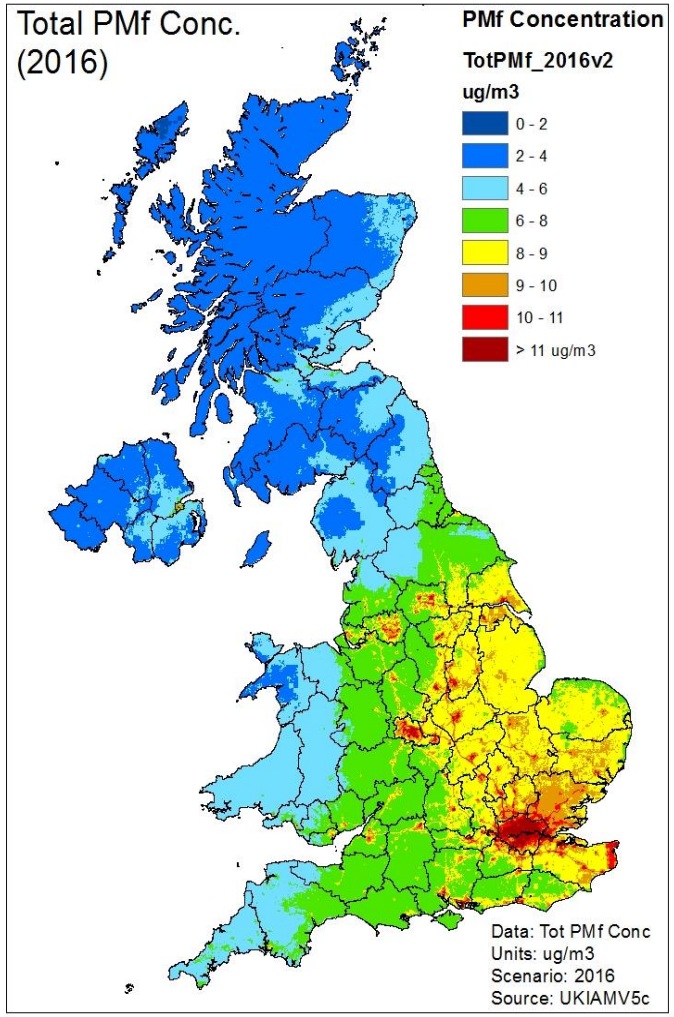
illustrations alternative ideas from work in the UK using UKIAM



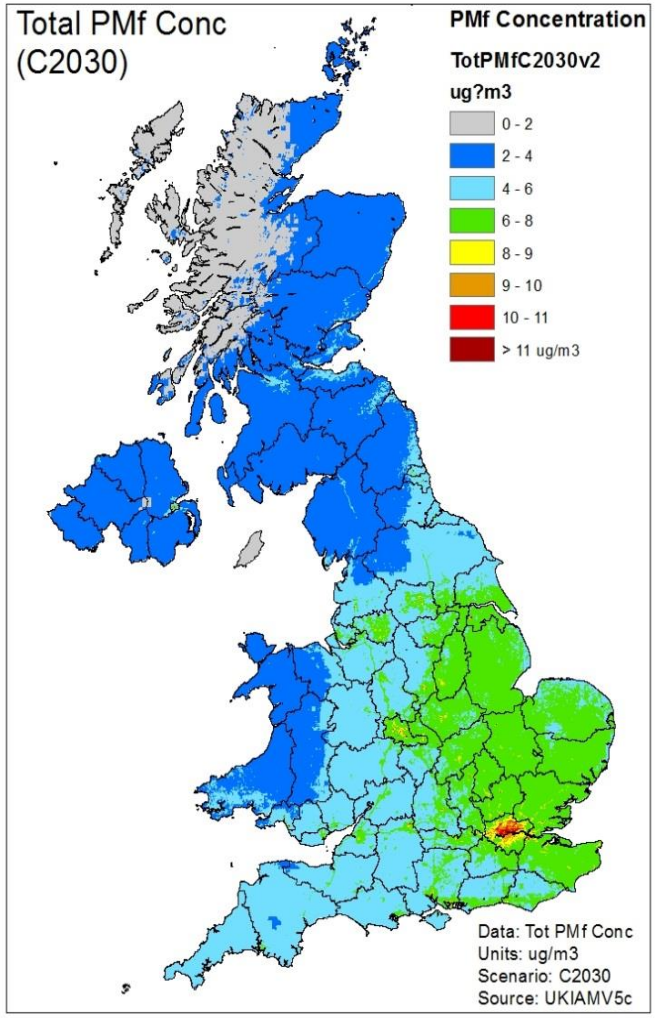
UK Government committed to setting target for annual mean PM2.5 (Env Bill). How should this relate to WHO AQ guidelines?

NGOs are calling for target to be WHO guideline- but what does this mean in practice?

How can we avoid the same problems as limit values for NO2, focusing on hot-spots/roadside sites rather than reducing overall exposure and health effects?



2016



Central 2030 scenario

Modelled PM2.5 using UKIAM taken from report : "PM2.5 exposure and reduction towards achievement of WHO standards"
ApSimon et al… *www.gov.uk/government/publications/air-quality-assessing-progress-towards-who-guideline-levels-of-pm25-in-the-uk*

Modelling with UKIAM

POSITIVE MESSAGE:-

clear improvement by 2030

reflects reduction in imported contribution as well as in UK emissions in Central 2030 scenario meeting NECD ceilings

BUT:

still exceedance of WHO guideline of 10 ug/m3 in major towns and cities with local sources primary PM superimposed on background

Indicator 1) Number of people exceeding the WHO guideline of 10 ug/m3

e.g. UK commitment to halve population exceeding 10ug/m3 by 2025

Will be safely met, but not a good indicator as very sensitive to modelling uncertainties: small difference in concentration in populated areas close to 10ug/m3 can make a big difference.

Baseline 2016: central estimate 14.8 million people above 10ug/m3

Model +1ug/m3 -> 27.2 million

Model -1ug/m3 -> 8.6 million

Also implies little improvement in London where concentrations are highest relative to rest of country

Alternative : Aim to reduce population exposure (as in CLRTAP and GAINS)

Indicator 2: Population weighted mean concentration, PWMC

(population exposure without complication of population growth)

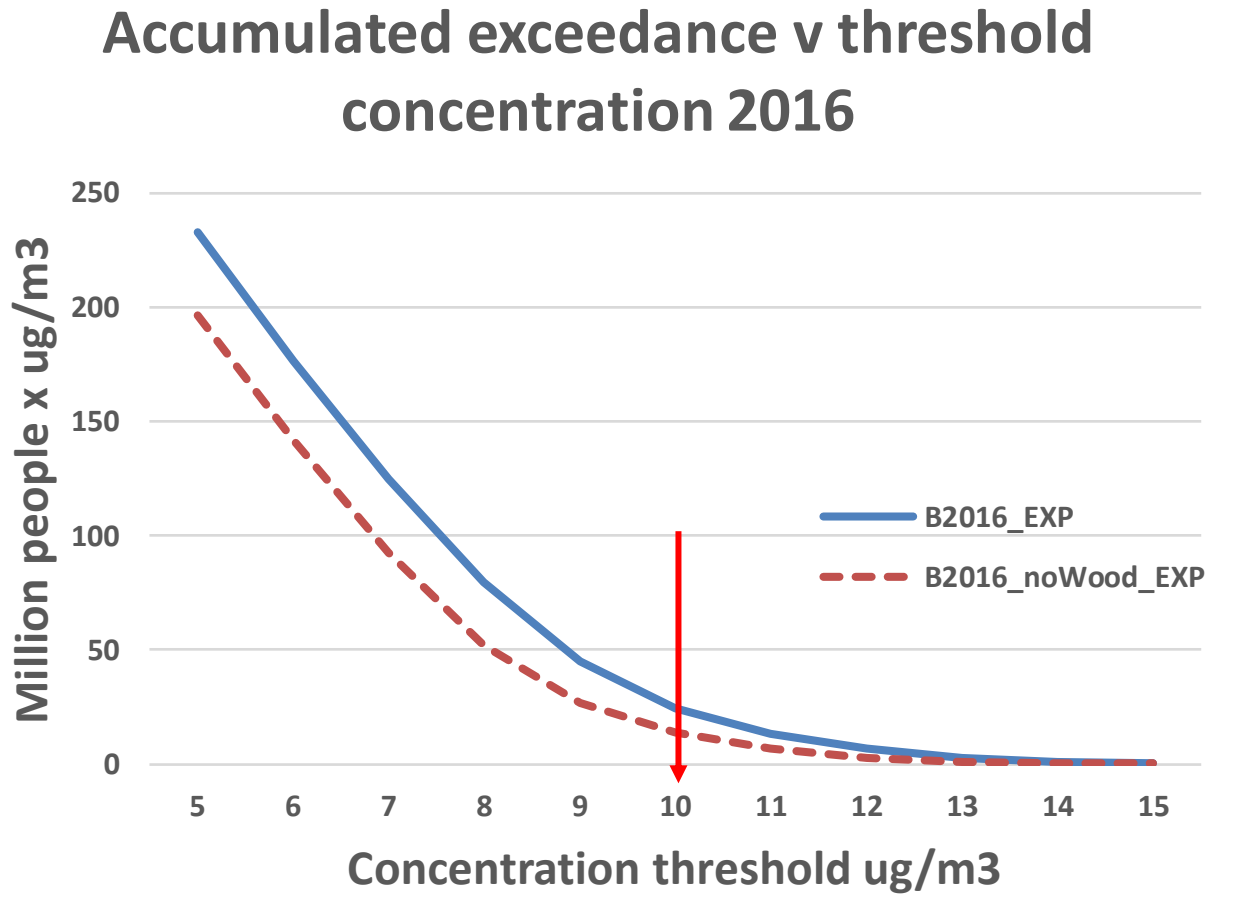
-> Direct assessment of health impacts based on total mass and driving down concentrations everywhere including below WHO guideline.

Consistent with no threshold, but no emphasis on higher exposure e.g.> current WHO guideline

PWMC	National	Rural	Urban	London
2016	7.706	6.479	8.060	10.56
2030C	5.668	4.834	5.909	7.84

Indicator 3: Population weighted mean exceedance, PWME

= (Accumulated exceedance >threshold) /population



Far more robust than no of people above threshold

Reflects whole community but emphasis on most exposed

% improvement 2030 Central from 2016

National 94.6 % (89.9 to 96.4)

London 95.2 % (85.5 to 98.8)

Although modelling & indicators helpful, a legally binding target needs a robust protocol to assess progress and compliance. How should measurements and models be used in this, and what is the role of indicators?

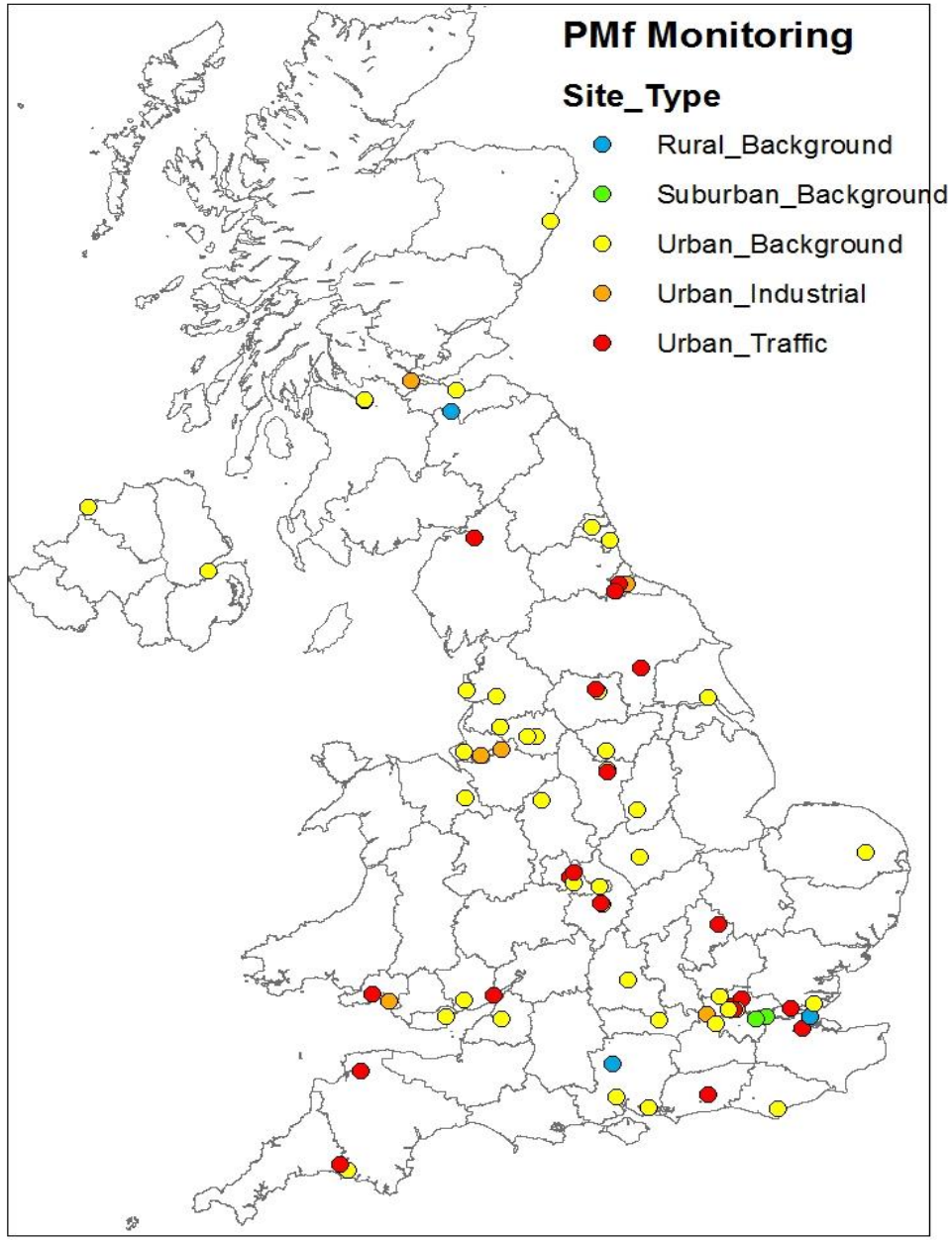
NB ***large model uncertainties; different models->different results?***

Legislation places reliance on measurements, but these also have their limitations.

Measurements in agglomerations are used as basis of current EU legislation on PM2.5.

Trends in "average exposure index" -> ~correspondence with PWMC.

PWME and mapping of exceedance ->areas where extra measurements needed to show improvement for those at highest risk .

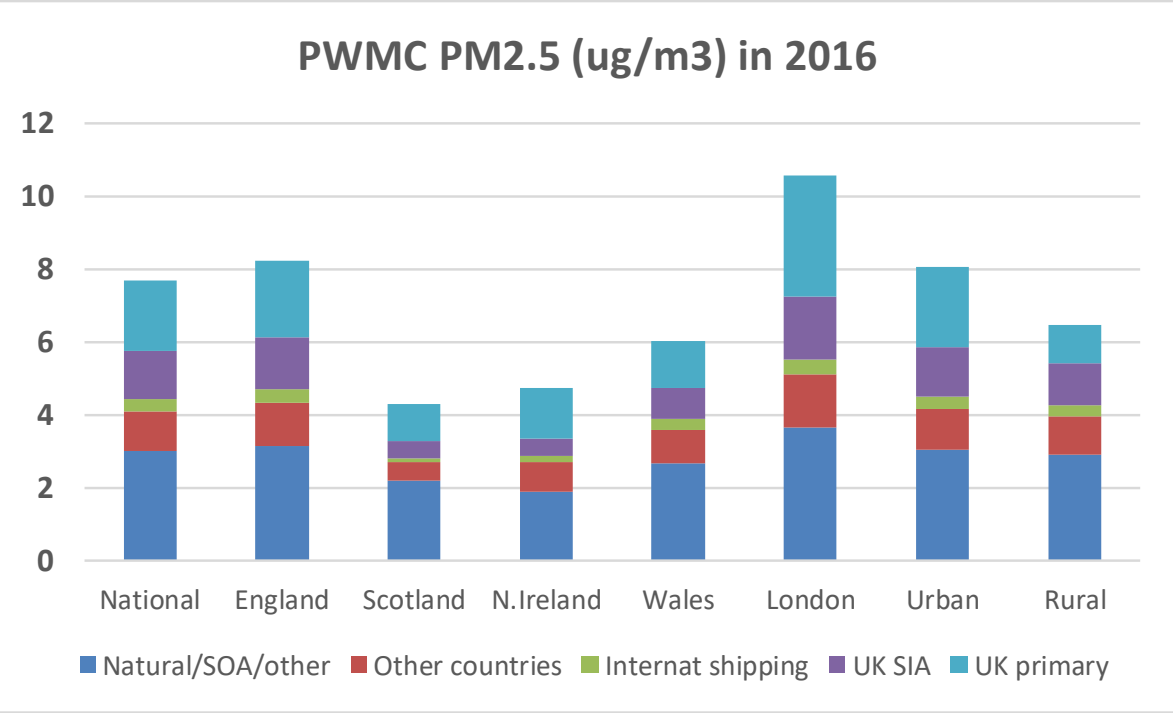


Use of indicators in developing strategies for improvement

Maximise reduction of PWMC re exposure and human health

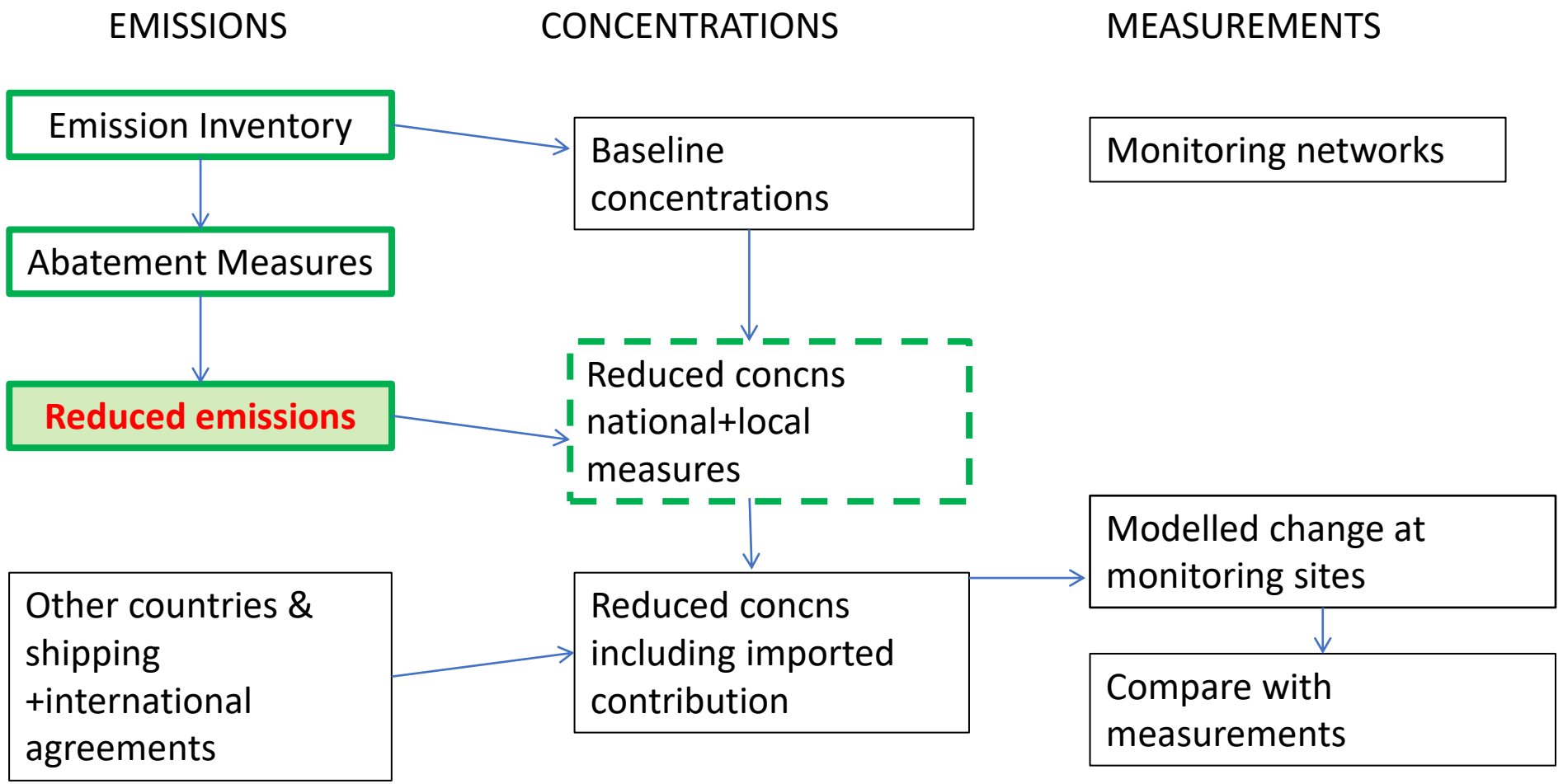
Reduction of PWME-> improvement for popn at highest risk

Source apportionment different regions



Focus on contribution from primary sources causing local peaks in densely populated areas. (May include more toxic components too.)

e.g. wood burning, cooking, non-exhaust emissions in city areas (unfortunately all with large uncertainties to address!)



Reduced emissions SO2,NOx, NH3,PPM2.5..
Supplementary : PPM2.5 in cities

PWMC-> health

PWME-> guideline

Exposure Index
?population weighted

Important to choose the right indicators

and to use them wisely(case studies)

Have proposed multiple indicators to apply for PM2.5 including PWMC & PWME

Thank you for listening.