Air Quality Expert Group

$PM_{2.5}$ Modelling Result Workshop – Chair's summary

The Air Quality Expert Group considered the latest Defra-commissioned modelling of future $PM_{2.5}$ concentrations and exposure at its meeting on the 9th November 2021. AQEG used a workshop format with presentations from Defra, Imperial College and UKCEH, combined with extensive Q&A sessions to explore the modelling methodologies used, uncertainties and key sensitivities, and the appropriateness of conclusions drawn.

AQEG has already discussed $PM_{2.5}$ modelling, and related UK emission scenarios, to support Defra targeted-setting at previous meetings. It held a public Call for Evidence in November 2020 and a community workshop in January 2021 exploring the wider state of the science in $PM_{2.5}$ modelling and forecasts for the UK. See https://uk-air.defra.gov.uk/library/reports?report_id=1023

As set out in the previous AQEG report, $PM_{2.5}$ prediction is complex and inherently uncertain, but it remains nonetheless a key tool to support policy development and decision-makers. Previous reports have identified that large uncertainties in $PM_{2.5}$ modelling can arise from estimating emission factors and their future trajectories, the representation of non-linear chemistry (notably secondary inorganic and organic aerosols), the fine-scale representation of individual monitoring sites, and the impacts of meteorological variability and climate change.

Updated modelling following previous recommendations

AQEG was supportive of the additional work that had been commissioned by Defra following previous recommendations in areas relating to:

1) the potential scale of impact of year-to-year meteorological variability on forecasts of $PM_{2.5}$.
2) the sensitivity of modelling results to particular emission changes, including transboundary and shipping effects.
3) enhanced comparisons of modelling results against AURN measurements.
4) the inclusion of improved representation of secondary inorganic aerosols (SIA) to reduce model bias.

Imperial College and UKCEH presented new modelling data and interpretation related to these which were then discussed in detail by the group.

A comparison of the base case of 2018 against the 2003 meteorological year was very informative. The modelled impact of around a 1 ug m^{-3} increase in overall UK $PM_{2.5}$ in an 'adverse' meteorological year such as 2003 was considered critical contextual information to be presented to decision-makers. The inclusion of a correction factor for SIA contributed to an improvement in the agreement between the UKIAM model and current AURN measurement data, although it could not be

guaranteed that such a correction would hold true for future years. The lack of model : measurement bias was seen as positive, although this comparison highlighted that at individual monitoring sites considerable deviations from model predictions exist, up to nearly 2 ug m^{-3}. Models can provide a reasonable guide to future concentrations at the kilometre scale but cannot be relied upon to forecast whether individual monitoring locations will meet a particular limit value standard. This is a technical limitation that needs good visibility. The sensitivity studies examining effects such as transboundary changes, shipping emissions, or the responsiveness of models to changes in emissions from individual sectors/pollutants such as ammonia and NOx were useful additional information.

Emissions scenarios

AQEG discussed the emission scenarios that had been used in the modelling, which represented four levels of ambition/intervention: Baseline (representing policies already in train), Medium, High and Speculative. Updates were provided on how latest evidence in sectors such as shipping, road transport, domestic, industrial and international emissions had been reflected in these scenarios. In overall terms the scenarios were viewed as providing a representative spread of possible pathways for the future and included best available evidence on future emissions.

The Baseline scenario was not ideally named and could be mistaken for a scenario of fixed emissions. In practice it is a reduction scenario in its own right, one that assumes full attainment of anticipated benefits arising from existing commitments and policies, based on a 2018 starting point. Given the 2018 start point, it did not include a number of more recent additional air pollution emission reductions such as the more rapid adoption of EVs or new climate mitigation measures.

Some key themes that emerged from discussion of emissions were:

1) whether the level of ambition for NH_3 emission reduction in all scenarios was sufficiently high given the sensitivity of $PM_{2.5}$ in models to ammonia reductions. There were further uncertainties raised related to representation of future ammonia trajectories associated with sources such as anaerobic digestion, and possible wider impacts of a warmer climate in the medium term.
2) Representation of secondary organic aerosols (SOA) remains a challenge and whilst a constant ‘background’ value is now included in EMEP4UK, as a subcomponent of $PM_{2.5}$ this may still be underrepresented in the current modelling. Cooking also remains a potentially significant source in urban centres that is not represented in most formal emission inventories, with notable effects in central London presented as part of the IC modelling.
3) Balanced against possible missing PM sources, others such as biomass combustion may be possibly over-stated, with new evidence from Defra emerging on possibly lower emissions of primary PM from woodburning than are currently included in the NAEI. Future emissions from sources such as

aviation or temporary power supply were very difficult to predict with a range of outcomes, both positive and negative, being plausible. Whilst it is appropriate for Defra to be cautious and consider that PM may have other sources beyond those in the emissions scenarios, error compensation is also possible with some sectors ultimately emitting less than is anticipated.

Model forecasts under different emission scenarios

AQEG discussed the model-projected changes in $PM_{2.5}$ under four emission scenarios. Under all scenarios significant reductions in $PM_{2.5}$ were forecast, and the results were broadly in line with those reported from the earlier call for evidence. The steepest reductions in $PM_{2.5}$ occur in the first decade with more modest declines in the 2030s and 2040s. Assuming full attainment of currently planned emissions reductions, the 2018 Baseline scenario delivered substantial reductions in $PM_{2.5}$ concentrations by 2030, with other scenarios delivering further incremental improvements on that. As identified previously, the major area of challenge remains in London, where only the Speculative scenario was forecast to deliver all geographic areas under 10 ug m^{-3} by 2030 (if a 1 ug m^{-3} margin for error was included).

Given the extensive range of control measures that were included in the Speculative scenario, and that these may be unnecessarily restrictive if applied to cleaner areas of the UK, AQEG was supportive of Defra exploring hybrid scenarios. These would evaluate air quality outcomes should central London potentially follow a different emission pathway to all other regions.

Exploring how different emissions reduction scenarios impacted air quality inequality was strongly supported. All scenarios were forecast to lead to a reduction in the inequality in exposure to $PM_{2.5}$ based on deprivation indices. It is understood that quantification of the effects of reducing inequalities is being considered in the health impacts assessment work that Defra has commissioned.

Presentation of options

Using a traffic light matrix to summarise the potential attainment of different $PM_{2.5}$ limit values under different emission scenarios was found to be a helpful way to present options. Use of a single country-wide matrix is in practice a reflection of the forecast attainment of air quality in central London. This needs to be clear to decision-makers, and ideally separate matrices on options and attainment should be made available that exclude central London.

The way in which the IC and UKCEH model results have been integrated into the provisional Defra options matrix appeared defensible based on the totality of modelling data available. Inevitably expert judgements must be made regarding the extent to which different modelling uncertainties are represented in such a matrix. A recurrent theme in AQEG discussions was that Defra has taken a pessimistic view of likely attainment of different limit values under the different scenarios, building in ‘safety margins’ that could adsorb unfavourable meteorological conditions, model

under-representation of individual monitoring sites and only downside risks on emissions. It would be very likely however that some sectors would inevitably deliver lower emissions than anticipated as a degree of counterbalance. AQEG questioned whether smaller margins would be more appropriate along with a clear rationale for including margins of safety for extreme meteorological years, if they are to be included. In presentation of this matrix of options the inclusion of the various margins should be made clear.

AQEG recommended that Defra should also include a colour coding for the actual measured attainment of different $PM_{2.5}$ limit values for the year 2020, and provide colour-coding for London separately to the rest of England and Wales. Whilst 2020 was clearly a very unusual year for air pollution emissions due to the COVID-19 pandemic, an annual average $PM_{2.5}$ limit value of 10 ug m^{-3} or higher would have been achieved across the UK, including central London. This would be valuable contextual information for decision-makers when set alongside the assessments based on different future emission scenarios.

Prof. Alastair Lewis **18th November 2021**