PhD Proposal Brief

Is Local Air Quality Management a successful strategy in achieving selected EU Limit Values?

1. Introduction

This proposal brief is written in support of my PhD application and is part of the Research Associate post within the Air Quality Management Resource Centre (AQMRC) in the Faculty of Environment and Technology. The proposal has been developed over the last six months in discussion with Professor Jim Longhurst and the research proposed is intended to complement the Research Associateship and *inter alia*, align with the key strategic requirements of the AQMRC in their role as Review and Assessment advisors to local and central government.

2. Background

The UK Government has failed to meet 2005 EU air quality limit values for particulate matter (PM_{10}) and also looks set to breach 2010 limit values for nitrogen dioxide (Defra, 2009a). In addition to the implementation of national actions (e.g. incentivising cleaner fuels), one of the Government's main strategies for meeting the requirements of the EU Air Quality Framework Directive (1996/62/EC) (CEU, 1996) is through the implementation of Local Air Quality Management (LAQM) as laid out under Part IV of the Environment Act 1995 (HM Government, 1995). Under LAQM, local authorities are required to carry out regular "Reviews and Assessments" of air quality in their areas against standards and objectives as prescribed in the Air Quality (England) Regulations 2000, the Air Quality (England) (Amendment) Regulations 2002 (HM Government 2000; 2002) and the Air Quality Strategy (2007) (Appendix 1) (Defra, 2007). Where it is found that these objectives are unlikely to be met, local authorities must designate air quality management areas (AQMAs) via the publication of an AQMA Order, and also prepare remedial action plans to tackle the problem(s). These Air Quality Action Plans (AQAPs) are appraised by consultants and accepted or rejected by Defra or the Devolved Administrations (DAs) based on the consultants' recommendations.

Review and Assessment reporting operates on a three-year rolling programme beginning with an Updating and Screening Assessment (USA) to identify air quality issues in the local authority area and Detailed Assessments, using monitoring and modelling to investigate potential exceedences of the legislative objectives (Crabbe *et al.*, 1999). Annual Progress Reports are also required to provide a continual record of air quality within each local

authority's district. In addition to local authorities' regular Review and Assessment reporting, in the 12 months following declaration of an AQMA, local authorities are required to complete a Further Assessment to verify that the AQMA declaration remains valid, and within 12 to 18 months of declaration the AQAP must be submitted. Air Quality Action Plan Progress Reports (AQAP-PRs) are required annually thereafter, and AQAPs may also be subject to periodic review and revision (Defra, 2009b).

The first round of LAQM Review and Assessment reporting began in 1998 leading to the first AQAPs being published in 2001, primarily for exceedences of the objectives for traffic-related nitrogen dioxide and PM_{10} (Laxen *et al*., 2001). There have since been two subsequent Review and Assessment Rounds (Round 2: 2003-2006; Round 3: 2006-2009), during which further AQMAs have been declared and although both national and local government have become progressively more familiar with the causes and extent of air quality issues faced in many parts of the UK, there is little evidence on the effectiveness of implemented traffic management schemes (Crabbe and Elsom, 1998). The long period of implementation between the publication of the first Round AQAPs and the completion of the latest third Round AQAP-PRs provides an opportunity for reflection on this growing body of evidence to attempt to assess the effectiveness of AQAPs, and ultimately the whole LAQM process, both at a local level and, collectively, at a national level.

3. Aims and objectives

This research will draw on the extensive body of evidence provided by the Review and Assessment process between the completion of Rounds 1 and 3 to establish whether AQAPs have been effective in achieving their aims and in improving air quality at a local level. By evaluating the degree of success achieved through individual AQAPs and then building an aggregate picture of progress to achievement of their goals it will be possible to assess the effectiveness and efficiency of the LAQM regime as a national strategy to meet EU air quality legislative requirements.

The research hypothesis is as follows:

Air Quality Action Plans are successful in terms of reducing local concentrations of nitrogen dioxide and PM_{10} and therefore Local Air Quality Management will enable the UK Government to meet the relevant EU Limit Values in the future.

The research objectives are therefore to:

Objective 1: Determine whether there has been any change in the concentration of pollutants, in AQMAs declared in Round 1 of Review and Assessment

Objective 2: Evaluate whether the measures included in the Air Quality Action Plans produced following Round 1 are being achieved; and

Objective 3: Critically assess whether implementation of the Action Plans has resulted in the change in pollutant concentrations identified in Objective 1.

4. Method

This research aims to evaluate the effectiveness and efficiency and therefore the success of Air Quality Action Plans by using two approaches. One method is to identify the number of successfully implemented measures included in an Action Plan. The other measure of success will be observable as a reduction in concentrations of the pollutant on which the AQMA was declared. It is postulated that the former may not necessarily lead to the latter and it is recognised that a direct causal relationship will be compromised by local variations (Longhurst *et al*., 2009), but in seeking to quantify the effect of these external variables it may be possible to determine AQAP measures and strategies that have contributed to the reduction in pollutant concentrations.

The research will sample from the 407 British[1] local authorities those 119 Air Quality Action Plans that were accepted by Defra and the DAs following the first Round of Review and Assessment. This purposive sample will include AQMAs from England, London, Scotland and Wales, which reflect the differences in policy and practice between them, as well as the effects of any geographical effects on air quality (Woodfield *et al.*, 2003) e.g. meteorology. As the most prevalent cause of AQMA declarations (~95% of AQMAs) (Bureau Veritas and Transport Travel Research Ltd., 2007), the research will focus on AQAPs based on air quality objective exceedences of nitrogen dioxide and particulate matter (PM_{10}) from traffic sources. This will ensure the findings are widely relevant and transferable.

4.1 Objective 1: Determine changes in pollutant concentrations between Rounds 1 and 3

Having identified the traffic-related AQMAs resulting from Round 1 of the Review and Assessment process, AQMA Orders will be examined for each to confirm the pollutant on which the AQMA was declared, the objective breached, the geographical extent of the

[1] Northern Ireland authorities did not participate in Round 1 Review and Assessment.

AQMA and the date of declaration. AQMA Orders are held by the AQMRC at UWE and so are readily available.

Monitoring data from the first Round Stage 3 (Detailed Assessment) reports and the latest Round 3 Progress Report will be compared to identify monitoring sites that have remained in the same location within each AQMA. Grid references for monitoring sites will be recorded to enable sites to be plotted in a GIS to aid analysis and presentation of the resulting data. (If no original monitoring sites remain from Round 1 the closest available Round 3 site will be used and its distance from the original site recorded. Alternatively, where monitoring stations have been relocated between Rounds 1 and 3, it may be possible to use data from the nearest long-term national Automatic Urban and Rural Network (AURN) monitoring site (AEAT, 2009).) The capture year of each respective report's monitoring data will be noted, as will monitoring site types (i.e. roadside, kerbside, background), the urban/rural status of the monitoring site (Ing *et al.*, 2001) and the country/DA to allow pooled data analysis of these variables which may affect changes in pollutant concentrations. Any temporal variation between Defra and the DAs' acceptance of local authorities' Air Quality Action Plans and subsequent reporting dates will need to be taken into consideration in order to reduce the effects of annual variability in meteorological conditions and national trends in pollutant concentrations. Report authors will also be noted as contacts to assist in addressing the second Objective.

Monitoring data for all matched sites from both reporting periods will be checked for Gaussian distribution using the Anderson-Darling Normality test and, depending on the outcome, a Paired *t* test (parametric) or Wilcoxon test (non-parametric) will be used to statistically analyse whether any change in pollutant concentrations between the two reporting periods is due to chance using a 1% probability threshold ($P < 0.01$). Repeated measures ANOVA (parametric) or the Friedman test (non-parametric) will be used to determine any statistically significant change within and between the variables (country, urban/rural, site type) that may not be apparent, or may confound statistically significant change, in the whole sample.

4.2 Objective 2: Evaluate whether AQAP measures are being achieved

This objective will be dealt with in two parts: (a) a review of the measures within the AQAPs and the most recent AQAP-PRs/revised AQAPs resulting from Rounds 1 and 3 respectively, and (b) interviews/questionnaires with the local authorities/report authors.

4.2.1. Part A: Review of AQAP measures

Round 1 AQAPs and the latest Round 3 AQAP-PRs (or revised AQAPs where available) will be reviewed and the measures compared. These reports will be obtained from AEA Technology, who hold the Defra contract for appraisal of local authorities' AQAPs.

Round 1 AQAP measures will be categorised according to their potential to reduce pollutant concentrations within the available timescale, i.e. by the end of Round 3. Some AQAPs may have defined quantitatively the effect of the measures but in many cases these are likely to be crude estimates in such cases the professional, objective judgement of the researcher will be used to determine whether measures are likely to have direct/indirect effects on air quality, the strength of any potential air quality improvement and the timescale for implementation. A matrix scoring system for these categorisations will be devised to weight those measures that are most likely to have reduced pollutant concentrations within the available timescale.

A comparison of the Round 1 AQAP and subsequent Round 3 revisions/AQAP-PRs will identify measures that have been completed. The success of the Round 1 AQAP may then be scored according to the weightings of the completed measures.

4.2.2. Part B: Interviews/questionnaires

Interviews with local authorities AQAP authors (or succeeding air quality officers), either face-to-face or remotely by telephone or postal/e-mail questionnaire using the recommendations of the UWE Research Observatory (2009), will be carried out to clarify any uncertainties identified in Part A (review of AQAPs). The interviews will seek to identify:

- The status of implemented AQAP measures,
- Why any remaining measures have not been implemented/completed,
- Whether any prioritisation of measures identified in the original AQAP has been adhered to in practice,
- Whether the agreed deadlines are being met,
- Any confounding issues, and
- Any unexpected 'wins', i.e. changes with the potential to improve air quality that were not included in the original Round 1 AQAP.

The purpose of the interviews is to provide a more personal interpretation of the success of AQAP measures to assist in the evaluation process and to inform subsequent discussions on why AQAPs are/are not a successful strategy.

4.3 Objective 3: Assess whether AQAPs have led to improvements in air quality

Having identified any statistically significant changes in pollutant concentrations between Rounds 1 and 3 (Objective 1) and attributed scores of success to Round 1 AQAPs (Objective 2), the research will assess whether there is any statistical association between successful AQAPs and improvements in air quality. The datasets will be tested for Gaussian distribution and, depending on the outcome, Pearson's correlation coefficient (parametric) or Spearman's correlation (non-parametric) will be used to calculate the *r*-value (*rs*-value for Spearman's correlation). Pooled data analysis of the other variables, i.e. country, urban/rural, and site type, will also be used to determine whether correlation exists within these categorisations that may not be apparent in the larger dataset.

5. Conclusions

As a critical evaluation of Local Air Quality Management, this research will rigorously assess whether Air Quality Action Plan measures are being achieved and, using the appropriate forms of statistical testing, determine whether this approach is leading to improvements in air quality both locally and nationally. A strong positive correlation would indicate that AQAPs are achieving their objectives to reduce pollutant concentrations, whereas no significant improvement in air quality associated with very few implemented AQAP measures would suggest that the Action Planning process is inefficient and ineffective. Implemented AQAP measures that are not associated with a corresponding decrease in pollutant concentrations indicate that the Action Planning element of the LAQM process is ineffective in improving air quality or that there are confounding factors. Additionally, a significant reduction in pollutant concentration independent of any AQAP measures would suggest that Action Planning is unnecessary and that other factors are likely to have a greater effect on local air quality.

These conclusions will assist Defra and the DAs assess the suitability of the LAQM mechanism within the Air Quality Strategy in contributing towards the fulfilment of UK and EU air quality legislation for nitrogen dioxide and PM_{10}. A thorough examination of both successful and unsuccessful measures and the identification of problems experienced in implementing Air Quality Action Plans will help to inform all local authorities in the preparation and execution of their own Action Plans and will be developed as a 'good practice' strategy paper. This research thus will have valuable implications both for air quality policy research and enhancement of practice.

Recommendations for further research will follow from these findings.

6. Timeframe

COMPLETION: 2013

YEAR	ACTION
1	Preparation ▪ literature review (primary research, current/historical legislative guidance); ▪ selection criteria (Round 1 AQAPs for traffic-related AQMAs); ▪ feasibility study (data accessibility, time availability, interview/questionnaire technique); ▪ data sourcing.(AQMA Orders [AQMRC], R1 Stage 3 assessments, R1 AQAPs, R3 AQAP revisions/AQAP-PRs, R3 PRs) [AEAT/BV]; Internal presentation: research methodology.
1-2	Objective 1: Determine changes in pollutant concentrations ▪ Review of AQMA Orders (date of declaration, pollutant, objective, boundary); ▪ Review of R1 Stage 3 assessments & R3 PRs (recurring monitoring sites, grid references, pollutant concentrations, site type, urban/rural status, Devolved Administration, reporting year, report author); ▪ Statistical analysis: Paired *t* test/Wilcoxon, ANOVA/Friedman. Regional/national presentation/1st peer-reviewed journal paper: evaluation of Objective 1 analysis.
2-3	Objective 2: Evaluate achievement of AQAP measures ▪ A) Review of R1 AQAPs & R3 AQAP-PR/revised AQAP (categorisation/scoring of completed measures, scoring of R1 AQAPs) ▪ B) Interviews/questionnaires (completed/outstanding measures, timescales, confounding/beneficial issues) National/international presentation/2nd peer-reviewed journal paper: evaluation of Objective 2 analysis.
3-4	Objective 3: Assess whether AQAPs have led to changes in pollutant concentrations ▪ Statistical analysis of results from Objectives 1 and 2 (Pearson's correlation coefficient/Spearman's correlation). National/international presentation/3rd peer-reviewed journal paper: evaluation of Objective 3 analysis.
4	Write-up National/international presentation, 4th peer-reviewed journal paper: results and recommendations; good practice Action Planning paper.

7. References

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Appendix 1

Table 1: National air quality objectives and EU limit values (Defra, 2007).

National air quality objectives and European Directive limit and target values for the protection of human health							
Pollutant	**Applies**	**Objective**	**Concentration measured as[10]**	**Date to be achieved by and maintained thereafter**	**European obligations**	**Date to be achieved by and maintained thereafter**	**New or existing**
Particles (PM_{10})	UK	50µg.m^{-3} not to be exceeded more than 35 times a year	24 hour mean	31 December 2004	50µg.m^{-3} not to be exceeded more than 35 times a year	1 January 2005	Retain existing
	UK	40µg.m^{-3}	annual mean	31 December 2004	40µg.m^{-3}	1 January 2005	
	Indicative 2010 objectives for PM_{10} (from the 2000 Strategy and 2003 Addendum) have been replaced by an exposure reduction approach for $PM_{2.5}$ (except in Scotland – see below)						
	Scotland	50µg.m^{-3} not to be exceeded more than 7 times a year	24 hour mean	31 December 2010			Retain existing
	Scotland	18µg.m^{-3}	annual mean	31 December 2010			
Particles ($PM_{2.5}$) Exposure Reduction	UK (except Scotland)	25µg.m^{-3}	annual mean	2020	Target value 25µg.m^{-3} [12]	2010	New (European obligations still under negotiation)
	Scotland	12µg.m^{-3}		2020	Limit value 25µg.m^{-3}	2015	
	UK urban areas	Target of 15% reduction in concentrations at urban background[11]		Between 2010 and 2020	Target of 20% reduction in concentrations at urban background	Between 2010 and 2020	
Nitrogen dioxide	UK	200µg.m^{-3} not to be exceeded more than 18 times a year	1 hour mean	31 December 2005	200µg.m^{-3} not to be exceeded more than 18 times a year	1 January 2010	Retain existing
	UK	40µg.m^{-3}	annual mean	31 December 2005	40µg.m^{-3}	1 January 2010	
Ozone	UK	100µg.m^{-3} not to be exceeded more than 10 times a year	8 hour mean	31 December 2005	Target of 120µg.m^{-3} not to be exceeded more than 25 times a year averaged over 3 years	31 December 2010	Retain existing

National air quality objectives and European Directive limit and target values for the protection of human health							
Pollutant	**Applies**	**Objective**	**Concentration measured as**	**Date to be achieved by and maintained thereafter**	**European obligations**	**Date to be achieved by and maintained thereafter**	**New or existing**
Sulphur dioxide	UK	266µg.m^{-3} not to be exceeded more than 35 times a year	15 minute mean	31 December 2005			Retain existing
	UK	350µg.m^{-3} not to be exceeded more than 24 times a year	1 hour mean	31 December 2004	350µg.m^{-3} not to be exceeded more than 24 times a year	1 January 2005	
	UK	125µg.m^{-3} not to be exceeded more than 3 times a year	24 hour mean	31 December 2004	125µg.m^{-3} not to be exceeded more than 3 times a year	1 January 2005	
Polycyclic aromatic hydrocarbons	UK	0.25ng.m^{-3} B[a]P	as annual average	31 December 2010	Target of 1ng.m^{-3}	31 December 2012	Retain existing
Benzene	UK	16.25µg.m^{-3}	running annual mean	31 December 2003			Retain existing
	England and Wales	5µg.m^{-3}	annual average	31 December 2010	5µg.m^{-3}	1 January 2010	
	Scotland, Northern Ireland	3.25µg.m^{-3}	running annual mean	31 December 2010			
1,3- butadiene	UK	2.25µg.m^{-3}	running annual mean	31 December 2003			Retain existing
Carbon monoxide	UK	10mg.m^{-3}	maximum daily running 8 hour mean/in Scotland as running 8 hour mean	31 December 2003	10mg.m^{-3}	1 January 2005	Retain existing
Lead	UK	0.5µg.m^{-3}	annual mean	31 December 2004	0.5µg.m^{-3}	1 January 2005	Retain existing
		0.25µg.m^{-3}	annual mean	31 December 2008			