The role of expectations and visions of the future in the development of target-based environmental policies: the case of the UK Air Quality Strategy

Vanessa McKean

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SPRU – Science and Technology Policy Research, University of Sussex

I hereby declare that this thesis has not been, and will not be, submitted in whole or in part to another University for the award of any other Degree.

Vanessa McKean

University of Sussex

Vanessa McKean, DPhil in Science and Technology Policy Studies

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Summary

Increasingly, policy-makers rely on forecasts to set targets for environmental and health protection. I examine the UK Air Quality Strategies (AQS) for particulate matter (1997-2007). Here policy-makers select and articulate visions for technological and policy developments in order to set targets and policies to achieve them. Despite growing evidence for adverse health effects of particulates, challenging targets in 1997 were followed by two revisions of Objectives without introducing measures for reducing pollution. In 2007 more challenging targets were resumed. This thesis is a study of the formation and evolution of a policy framework: of the interactions and contrasting roles of scientific expertise, wider political discourse, and the 'futures' presented by actors involved in the policy process. Sociology of Expectations has previously examined the roles of visions in innovation processes. I extended this framework to examine dynamics of visions in the policy-making process. My findings were based on analysis of visions and discourses identified in texts, model data, and interviews.

Whilst none of the explanatory factors alone accounted the developments in the AQS, together they provide an explanation of change which highlights the role of learning by policy-makers . Visions for technological development articulated in each version of the AQS were in line with the dominant visions articulated in central government, but over time policy-makers responsible for the Strategy used them to present options for taking action on pollution. Co-construction of the AQS and modelled forecasts enabled policy-makers responsible for the Strategy to articulate visions for technologies and policies to promote taking action to reduce pollutants, and this led to the more action-oriented Strategy in 2007.

This thesis proposes that visions can change more quickly than wider political discourses, and as such can provide opportunities for the introduction of new discourses.

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Dedication

For Rosemary Smith and Mary McKean, who made this possible.

And for Emily, who gave me purpose.

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List of Abbreviations

AEQ	Air and Environmental Quality: the division of Defra/ DETR/ DoE responsible for the Air Quality Strategy
APEG	Airborne Particles Expert Group
AQEG	Air Quality Expert Group
AQ Forum	Air Quality Forum
AQMA	Local air quality management area
AQS	Air Quality Strategy
CAFÉ	European Commission's Clean Air for Europe programme
CBI	Confederation of British Industry
CLRTAP	Convention on Long-Range Transboundary Air Pollution
COMEAP	Committee on the Medical Effects of Air Pollution
CNG	Compressed natural gas
DoE	Department of the Environment
DETR	Department of the Environment, Transport and the Regions
Defra	Department for the Environment, Food and Rural Affairs
DfT	Department for Transport
DPF	Diesel particulate filter
DTI	Department of Trade and Industry
DTLR	Department for Transport, Local Government and the Regions
EAHEAP	Ad-hoc group on the Economic Appraisal of the Health Effects of Air Pollution
EPAQS	Expert Panel on Air Quality Standards
ETSU	Energy Technology Support Unit
EU	European Union
HGV	Heavy goods vehicle
IGCB	Interdepartmental Group on Costs and Benefits
IPCC	Intergovernmental Panel on Climate Change

IPPC	Integrated Pollution Prevention and Control
LAQM	Local air quality management
LEZ	Low emission zone
LGV	Light goods vehicle
LPG	Liquid petroleum gas
MAFF	Ministry of Agriculture, Fisheries and Food
NAAQS	National Ambient Air Quality Standards
NAEI	National Atmospheric Emissions Inventory
NAO	National Audit Office
NAQS	National Air Quality Strategy
Netcen	National Environment Technology Centre, part of AEA Technology
NSCA	National Society for Clean Air
QUARG	Quality of Urban Air Review Group
RAINS model	Regional Air Pollutions and Simulation model
RCEP	Royal Commission on Environmental Pollution
RSPB	Royal Society for the Protection of Birds
SMMT	Society for Motor Manufacturers and Traders
TEOM	Tapered Element Oscillating Microbalance
UKPIA	UK Petroleum Industry Association
UNECE	United Nations Economic Commission for Europe
WHO	World Health Organisation
WSL	Warren Spring Laboratory

Chapter 1. Introduction

Policies for sustainable development seek to balance health, wellbeing and environmental protection with concerns for economic growth, technological innovation and a prosperous society. The UK Air Quality Strategy (AQS) sought to achieve this balance in its regulation of common air pollutants for the protection of public health. The Strategy set medium-term targets for reducing ambient pollutant concentrations, with the long-term aim of reaching concentrations where adverse health effects would not be experienced.

The AQS envisaged that all contributors to air pollution will work proportionately to reduce emissions, and so to achieve national target concentrations (Department of the Environment Transport and the Regions, 2000a). These contributors were a diverse group, including industrial combustion sources, road transport, construction, agriculture, and the general public – to name but a few. To succeed, the Strategy further required the cooperation of transport, environmental, and planning policy-makers at three levels of governance: local, national and European.

However, these stakeholders and policy groups were not simply the recipients of policy. Rather they were essential voices in the policy-making process of the AQS, and in related debates: about the existence and magnitude of health concerns, how targets should be set and achieved, the ability of actors to achieve them, and the perceived trade-offs between pollutant reduction and economic, technological and social development.

Since the AQS was first published in 1997 there have been two revisions of the Strategy and one Addendum. A significant proportion of pollution targets have yet to be reached. In January 2009 the EU began proceedings to prosecute the UK for failing to reach all air pollution targets or developing a plan for doing so (Vidal, 2009).

This study examines four versions of the AQS from 1997 to 2007. It focuses on the pollutant particulate matter (particles), in order to understand how targets were set, why they changed, and whether this resulted in changes in behaviour, technological innovation and adoption, and in policy. The AQS is oriented to the future. Decision makers set targets on the basis of a set of assumptions and forecasts about the future: about what emissions reductions were potentially achievable within the time frame, and about how these reduced emissions would affect ambient pollution levels.

The choice of targets also contained assumptions and preferences for technological innovation and adoptions, individual and societal behaviour, and the future industrial, economic and political climate. Such judgements, expectations and assumptions were made between competing conceptualisations of the future, made in conditions of uncertainty regarding the specific relationship between particulate matter and ill health.

This study examines how such expectations about the future – about future technologies, policies, behaviours and their impacts – competed and interacted in the processes of making and revising the AQS between 1997 and 2007.

1. Particulate matter and its properties

The sources, composition and effects of local air pollution in the UK are many and complex. This study focuses on regulation in the UK of airborne particulate matter (also called particles and particulates). During the period of time studied in this thesis, policy-makers and scientists examining the health effects of common air pollutants believed that particulate matter posed the greatest risk to health of all common air pollutants (e.g. Department of Environment Transport and the Regions (2000), Committee on the Medical Aspects of Air Pollution (2009)). Yet understanding of the mechanisms of these health effect was subject to great uncertainties, as this chapter will go on to explain. Scientific understanding of particulate matter and its effects changed significantly over the past twenty years, and the articulation of health effect has changed over the course of different iterations of the AQS.

"Particulate matter" is the generic name for airborne particles. Particles are physically and chemically diverse: they can be solid or liquid, organic or inorganic, natural or anthropogenic. They range in size from a few nanometres to about 100 micrometers (Air Quality Expert Group (AQEG) 2005a, p. 1). There is no standard particle against which others can be compared and for this reason, particulate matter is defined by how it is measured (EPAQS 1995 paragraph 3). Black smoke is a form of particulate matter measured by its visibility, and other common measurements include particle mass and particle number. PM_{10} and $PM_{2.5}$ are measurements of size: respectively, particles of diameter 10µm and smaller, and those with diameter 2.5µm and smaller in a specific unit of air (usually a cubic metre) (AQEG 2005b). Unlike most gaseous pollutants (which do have uniform chemical properties), there appears to be no safe "threshold" level for particulate matter below which health is not affected (EPAQS, 1995)

Particulate matter is detectable and measured only through monitoring technologies. Characterisation of the effects of particulates on health has been subject to uncertainties in

the mechanisms by which effects take place, and debates over the most harmful sources and sizes of particles.

By 2000 the majority of scientific experts believed that the $PM_{2.5}$ fraction had the strongest association with ill health outcomes (EPAQS, 2001). In the past few years *nanoparticles* (particles smaller than 50nm) and *ultrafines* (particles smaller than 100nm) have become of interest to scientists. Some have theorised that ultrafines, specific chemical composition, or particle number, rather than size, may be the main toxic fraction of airborne particles (see COMEAP (2009) for a review).

Particles are often categorised into three groups by size and by source: primary, secondary and coarse. These categories reflect the variety in size, properties and sources of particles and are described further in table 1.1.

Table 1.1. Characterisation and sources of particulate matter

Fraction	Description	Sources	Size
Primary	Emitted directly from source. Travel tens-hundreds of meters from source.	Combustion sources e.g. road transport emissions, domestic coal burning, industrial processes, power stations.	Smaller than 2.5µm.
Secondary	Formed in the atmosphere through chemical reactions of sulphur dioxide, nitrous oxides and ammonium and NMVOCs (usually through nucleation processes). Can travel hundreds of kilometres.	**Sulphate**: formed from SO_2 from power generation and industrial combustion processes. **Nitrate**: formed from NO_x from fossil fuel combustion (road transport and power generation). **Ammonium**: from agricultural sources and cars with catalytic converters. **NMVOCs**: road transport, solvents.	Generally smaller than 2.5µm (depending on humidity)
Coarse	What remains in the PM_{10} fraction when the primary and secondary particles are accounted for.	**Natural**: wind-blown soil, sea salt. **Anthropogenic**: Non-combustion processes e.g. quarrying, road dust. Generally formed by attrition and abrasion.	2.5-10 µm

Sources: AQEG (2005b), EPAQS (2001)

The chemical composition of airborne particles is dependent on the geographic and anthropogenic features of an area. Primary and coarse fractions tend to remain local to their

source (EPAQS 2001), but in some areas sea salt or desert sand can also travel large distances (AQEG 2005a, p. 3). Emissions from anthropogenic sources dominate the primary particulate fraction, and so vary with location.

In the UK the main sources of particulate matter are road transport (largely diesel combustion, but also brake and tyre wear), stationary combustion sources (e.g. electricity generation), and industrial processes (e.g. metal production) (AQEG 2005b, p. 17). Road transport and industrial sources are the most significant sources of primary PM_{10} in the UK, and in 2001 each contributed 27% of the national total (AQEG 2005b, p. 40). However, this does not reflect the composition of particles in urban areas, where people are more likely to be exposed to pollution from road transport. Thus human activities provided new sources and composition of particulates.

Some sources of particulate matter have been promoted as beneficial for other reasons. For example, diesel cars have less greenhouse gas emissions than petrol cars, so have been promoted as a cleaner form of transport. Other sources have inherent health benefits, including central heating, air conditioning and refrigeration (Green, Crouch, Ames, & Lash, 2002, p. 334). In management of particulates, decision-makers must make choices about the potential risks and benefits of these sources.

The composition of the secondary fraction is also affected by human activity. Although secondary particles form naturally in the atmosphere, many of their chemical precursors (including nitrogen dioxide, sulphur dioxide and ammonia) are outcomes of human activity, including power generation, industry, road transport and agriculture. Much of the secondary fraction measured in the UK comes from mainland Europe (King & Dorling, 1997; Stedman et al., 1998). This provides a significant international and transboundary contribution to local particulate concentrations and their management.

The diverse characteristics of particles are significant because of their effects on health. However, significant uncertainties and questions remain regarding how particulates affect health. These include uncertainty regarding the relative susceptibility of individuals: epidemiological studies show that populations overall are affected, but not which constituent parts. For example, the government advisory group the Committee on the Medical Effects of Air Pollution (COMEAP) estimated that there is a gain of 0.2-0.5 million life years for the populations of England and Wales for every 1$\mu g/m^3$ decrease over their lifetimes. However, because epidemiological studies cannot show which parts of the population are affected, this 0.2-0.5 million life years could in practice mean an average gain of 2.5 days per person

throughout the population of 52 million people, 5 days for 5 million people, or 4.5 months for 1 million people, or any mixture of these (COMEAP, 2001).

Moreover, understanding of the biological mechanisms by which health is affected is limited. Scientific knowledge has developed greatly over the past twenty years, but many questions remain unanswered.

Studies suggest that the effects of poor air quality disproportionately affect those of lower socio-economic status throughout Europe and the UK (Deguen & Zmirou-Navier, 2010; Pye, King, & Sturman, 2006) – although this is very much dependent on both the pollutant and the factors affecting its concentrations. Analysis by Pye et al. (2006) suggested that this relationship did hold for particulate matter in the UK, and that this may be because of correlation with major roads and urban areas, where more deprived communities tend to live. This may be because such groups are exposed to higher levels of air pollution, or because they are more susceptible to its effects or both.

This brief review demonstrates the complexity of particulate matter: its structures and properties are not uniform; its effects on health appear significant, but the mechanisms by which health is affected and who is affected are not well understood. The interactions of primary sources, meteorological conditions, secondary particles, and the resulting ambient concentrations have been understood in different ways over the course of the AQS, between 1997 and 2007. Developments in each of these forms of knowledge, together with changing political and social priorities, led to four different sets of targets for particulates and strategies to achieve them. The relevant targets for each Strategy are set out in table 1.2.

2. Characterisation of particulate matter as a modern pollution hazard

Despite falling concentrations of airborne particles since the industrial revolution (Maynard, 2004, p. 11), it was estimated that in 2002 short-term exposure to PM_{10} caused 6,500 deaths and 6,400 hospital admissions to be "brought forward" (AQEG 2005b, p. 29). COMEAP estimates that the effect of long-term exposure to anthropogenic $PM_{2.5}$ led to 340,000 life years lost in 2008 across the population of the UK and 29,000 deaths brought forward (COMEAP, 2010, pp. 1-2).

Particulate matter shares characteristics with other modern environmental hazards. Modern hazards have been explained as the unexpected effects of technologies designed for our benefit (e.g. Beck, 1992, p. 105; Grove-White, 1997, p. 54). Maarten Hajer (1995, p. 4) argued that the nature of environmental problems changed in the 1990s to become more complex -

yet more uncertain than what had gone before; defined and created through science, imperceptible without technology. Hajer's exemplars extended beyond national boundaries – climate change, acid rain and the diminishing ozone layer – nevertheless, risks from particulate matter and local air pollution share these properties.

3. The historical context of air pollution in the UK

In the UK, air quality is a sensitive political issue: the London Smog of 1952 was responsible for an estimated 4,000 deaths in five days (Maynard, 2001, p. 288). Subsequently, the Clean Air Acts of 1956 and 1968 sought to reduce the black smoke and sulphur dioxide which caused the smog problem. These pollutants largely resulted from burning coal for power and heating. "Black smoke" was airborne particulate matter measured as deposited soot (Smith & Jantunen, 2002, p. 867). Political action coincided with a gradual reduction in coal's importance as a power source and the switching by industry, commerce and households to gas and electric power during the period from the 1950s to the 1980s (Williams, 2004, p. 16).

Evidence of a continuing association between prevailing levels of urban air pollution and short-term ill health diminished, and by the early 1970s was barely discernible (Maynard, 2004, p. 9). As a result, the Medical Research Council closed its air pollution and health research centre in 1978 (Williams, 2004, p. 16) and the number of black smoke and sulphur dioxide monitoring stations reduced (Dunn & Kingham, 1996, p. 831; Harrison, 2004, p. 5). In 1980 the European Commission introduced ambient concentration standards for black smoke and sulphur dioxide for health protection purposes, with which the UK largely complied without extra effort (Loader, Mooney, & Lucas, 1999). During the 1980s policy-makers' attentions turned to global and international pollutant problems (Williams, 2004, p. 17). With these competing issues, including acidification and climate change, local air quality was no longer a high priority for attention by policy-makers. As a result, many policy-makers – for example, those responsible for the 1990 Environment White Paper – concluded that the problems of smog and air pollution were essentially eliminated.

Interviews conducted for this study indicated that by 1991 there were only two scientists investigating air quality and health in the UK, there was no government research unit, no funding, and very little air quality monitoring. Joel Schwartz, who first uncovered the association between fine particles and health in the USA, described the situation in the UK:

> *What happened in England was that the war was declared won and everyone went home.*
>
> (W. Brown, 1994)

However, air quality's complacent position in the policy backwaters was about to change.

3.1. New forms and sources of air pollution

As the traditional air pollutants diminished, new and unforeseen forms had grown. In the latter half of the twentieth century road transport became the largest source of air pollutants in urban areas of the UK (Chell & Hutchinson, 1993; Hutchinson, 1997). Airborne pollutants, including nitrogen dioxide, ozone, particulate matter and VOCs increased significantly as a result (Dunn & Kingham, 1996, p. 832; Maynard, 1993, p. 63). Evidence accrued to suggest that the most harmful of these new pollutants was particulate matter, measured initially as PM_{10} – airborne particles of diameter 10µm and smaller (Air Quality Expert Group, 2005b) – which were smaller than the particulates (including black smoke) that had previously been responsible for smog.

Whilst black smoke and smog were visible and odorous, this new pollution problem was imperceptible and invisible. The pollutants of concern were diverse and more numerous. Often pollutants were detectable only through automated monitors, as was the case with PM_{10}. Similarly, the study of the health effects of particulate matter was made possible only due to the advancement in computing techniques available to researchers (Maynard, 2004, p. 9). More sophisticated computer programmes enabled development of multiple linear regression models to analyse the relationship between a large number of variables, and account for the many possible confounding factors (for example, temperature, levels of other pollutants and disease epidemics). These enabled ordinary background variations in particulate concentrations to be assessed; a move away from the assessment of peak episodes only – such as the 1952 Smog (Parliamentary Office of Science and Technology, 1996, p. 1).

3.2. Epidemiological studies of particulate matter

Epidemiological studies carried out in the 1980s and early 1990s in the USA found associations between ambient PM_{10} and acute respiratory and cardiovascular problems at concentrations previously not considered harmful (Dockery et al., 1993; Schwartz, 1994). Moreover, studies also suggested that long-term exposure to particulates correlated with early mortality (Dockery et al., 1993; EPAQS, 1995). Such health effects were unforeseen, even by air quality scientists (Maynard, 2001).

Collectively, these studies caused alarm amongst the media, public, and policy-makers in the UK, because they indicated that particles affected health at very low concentrations – those previously not considered dangerous. When the results of these studies were applied to the UK by the advisory Committee on the Medical Effects of Air Pollution (COMEAP), these

suggested that levels of PM_{10} in the UK contributed to 8,100 premature deaths, and 10,500 extra hospital admissions (COMEAP, 1998). Moreover, there appeared to be no threshold below which particles were harmless (Quality of Urban Air Review Group, 1993b, p. 34). This meant that any target for reductions would be as much a political decision as a scientific one.

The publication of the American studies coincided with a series of episodes of poor air quality in the UK. In 1991 London experienced the highest levels of nitrogen dioxide on record (Maynard, 1993), and in summer 1994 there were widespread ozone smogs (Department of the Environment, 1997). It was not known then whether nitrogen dioxide affected health, but higher levels of ozone were associated with measured adverse health effects amongst asthmatics (Maynard, 1993). The coincidence of new research, UK smog episodes, and new evidence of an association between levels of childhood asthma and vehicle emissions led to increased media and public attention on this new pollution problem (Lane & Peto, 1995, p. 190).

The UK authorities were not prepared for this new evidence on air pollution and health (Maynard, 1999). Nevertheless, policy-makers acted quickly by taking advantage of the requirement for an air quality strategy in the Environment White Paper, to extend it to local air pollutants including particulate matter.

Against the background of increased public awareness of air pollution issues and developing scientific evidence, the first air quality Objectives were set in the National Air Quality Strategy (NAQS). In the first review of the Strategy, published in 2000, the PM_{10} Objective was reduced in stringency. Changes followed in 2003 and 2007 both in the fraction measured (PM_{10} and $PM_{2.5}$) and in the form the Objective took. These are set out in table 1.2.

4. History of the AQS

4.1. The National Air Quality Strategy (NAQS) and the structure of the Strategy

The stated aim of the NAQS was "… to render polluting emissions harmless" (Department of the Environment, 1997, p. 18). The NAQS was published in 1997, and regulated eight common air pollutants which affected health: benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide, ozone, PM_{10}, and sulphur dioxide. A PM_{10} target was set for the end of 2005.

The advisory committee EPAQS (the Expert Panel on Air Quality Standards) recommended a *Standard* for each pollutant, which was defined as the maximum ambient concentration at which health was not affected. There appeared to be no such safe threshold level for

particulate matter, but the particles Standard was established at a level where the majority of people would not suffer ill health effects (EPAQS 1995 paragraph 29).

The NAQS and subsequent Strategies set Objectives: medium-term targets for reduction towards the Standards, to be achieved within a particular time frame. Objectives were policy decisions, set with reference to evidence from experts in health effects, modelled forecasts, and chemistry, but also with regard to social, economic and technological feasibility. The Strategy set out how the Objectives would be achieved. The NAQS Objective for $PM_{2.5}$ was to be achieved by 2005. It was measured as a daily running mean, and each local authority was permitted to exceed this mean on only four days each year.

The NAQS was novel in its effects-based approach to air pollution control in the UK. Previous air quality controls had been developed sector-by-sector, dealing with emissions, rather than ambient air quality. Pollutants were regulated at source and different regulatory bodies controlled different sectors. The Strategy, partly in response to this situation, was an exercise in co-ordination and simplification: bringing together diverse policy domains under one framework, to manage the appropriate regulation of each in the pursuit of a common goal. These policy domains included local authorities, management of industrial sources, innovation policy, and the negotiation of European vehicle and fuel standards. The effects-based approach also meant that, in theory, no source would be disproportionately burdened with reducing emissions.

Implementation of the NAQS and subsequent Strategies covered three levels of governance: national, local and international. Cannibal and Lemon (2000) argued that this caused some over co-ordination of implementation efforts, both between these levels and within local government. Furthermore, each Strategy required the general public and businesses to take responsibility for reducing some air pollution, for example by shifting from private cars to public transport.

The Objectives provided a benchmark against which the air quality impact of plans and policies not in themselves designed for air quality purposes could be judged. The policy makers who wrote the NAQS believed that the effects-based approach would enable the development of more innovative policy measures in order to reach the Objectives (1994, p. 3). The NAQS established the local air quality management regime, by which local authorities were given responsibility for assessing air quality in their areas and developing plans to meet Objectives that they forecast could be exceeded. This institutional change promoted by the Strategy

aimed to ensure that air quality improvement was integral to policy domains beyond that of environmental protection.

However, the policy-makers in the then Department of the Environment, who were responsible for the development of the NAQS, were reliant on their influence to deliver the Strategy, as they had little power to regulate many of the source of pollution identified within it. Many of the policy instruments and decisions that could affect air quality were responsibilities of other departments or levels of governance. For example, vehicle and fuel emissions were set at a European level, fuel duty is set by the Treasury, and innovation policy was a matter for the then Department of Trade and Industry. The National Audit Office (2001a, p. 37) reported that the second version of the Strategy identified thirty-eight policy instruments affecting air quality, originating from institutions including the European Union, private sector self-regulation, local authorities, other government departments, cross-government initiatives, and the Department for Environment Transport and the Regions (DETR, the successor to the Department for the Environment).

4.2. The Revised Strategy (2000)

The NAQS was published in May 1997 and was immediately reviewed by the new Labour government. The new Revised AQS was published in 2000, and addressed many developments in expert knowledge of particulates which were set in train by the NAQS. Table 1.2 indicates that the revised Objective for particulates was less stringent than that of the NAQS, in that the number of days for which exceedences were permitted increased from four to thirty-five. This Strategy also set an annual mean concentration target. Each area of the UK was required to meet these Objectives by 2005.

From the Revised Strategy onwards, computer modelling provided forecasts of ambient air quality under different scenarios. Modelled forecasts of national concentrations of particulate matter developed to support the Revised Strategy indicated that the NAQS Objective was not achievable by 2005, but that a new European Union target would be largely achievable under a business-as- usual scenario. This European target was adopted as the new Objective. It was labelled a “staging post” in the Revised Strategy (DETR, 2000a, p. 52) and a further review was promised by policy-makers.

4.3. The Addendum (2003)

The 2003 Addendum to the Strategy also incorporated a European limit value, for attainment by 2010. It set three particles Objectives for 2010: for London, for Scotland, and for the rest of the UK. Scotland set an Objective which was more stringent than the requirements of the

European 'second stage' limit value for 2010, whilst the rest of the UK had to meet this. The Objective for London was purposely set at a less stringent concentration than the European requirement by policy-makers on the basis of modelled forecasts of achievable concentration reductions. This led to criticism that, as a result Londoners would experience lower quality of life than the rest of the UK population.

4.4. The 2007 Strategy

The Revised Strategy and the Addendum focused on setting and revising Objectives, rather than formulating new actions to achieve them. In 2006, a change of approach was announced. An "exposure reduction" target was set for $PM_{2.5}$. This required each urban area to reduce concentrations of $PM_{2.5}$ by 15% at background locations between 2010 and 2020. To meet these targets extra actions would have to be taken to reduce particulates in these urban areas, whether local, national or regional.

The choice to regulate $PM_{2.5}$ as well as PM_{10} in 2007 was political. The USA began regulating $PM_{2.5}$ in 1997. In the UK expert advisory committees including COMEAP (2001) and EPAQS (2001) recognised $PM_{2.5}$ as more strongly associated with ill health effects than PM_{10} as early as 2000. However, it was not regulated until 2007.

Both the Addendum and 2007 Strategy contained sets of 'illustrative measures': a range of measures concerning technological change, industry, transport, and policy, which could be developed into policies to improve air quality beyond the business-as-usual scenario. The impact of each illustrative measure on air pollutants was modelled, and then these data incorporated into cost-benefit analysis on these scenarios. Yet there was no mechanism by which these scenarios could become policies.

5. Presentation of assumptions and expectations about the future in the policy-making process of the Air Quality Strategy

5.1. 'The future' portrayed in each Air Quality Strategy

The AQS aimed to be a policy driver, yet revised its Objectives for particulate matter as expectations of feasibility changed. In each version of the Strategy, 'feasibility' was defined in different ways: the Revised Strategy did not require extra actions to achieve the Objectives for particulate matter, but other Strategies did, to differing extents. In the Revised Strategy feasibility was defined as what was attainable under a 'business-as-usual' scenario. The Addendum and the 2007 Strategy both set particulate Objectives which required further actions to reduce emissions to be met.

Each set of Objectives incorporated assumptions and expectations about the medium-term future in which actors would attempt to meet them. The modelled forecasts of future ambient particulate concentrations provided pictures of the future in a situation in which there were many different variables with complex interactions. Yet, these modelled forecasts also incorporated assumptions and preferences for policy change, technological change, and of the outcomes of implementing current policies and agreements. Even 'business-as-usual' modelled scenarios incorporated the assumed effects of future implementation of planned policies. The sets of illustrative measures presented in 2003 and 2007 Strategies contained specific preferences for future technological and policy developments.

5.2. Changes in conceptions of future technological change

Such expectations of feasible targets and of the means of reaching them changed over the course of the Strategy. For example, particulate filters for diesel vehicles have been variously presented in different Strategies as necessary, as inevitable, and as economically unviable. The first three Strategies contained increasingly specific expectations about the future uptake and use of natural gas vehicles, but these were absent entirely from the 2007 Strategy.

Expectations about the future embodied in the Strategy were choices or preferences, not certainties. As seen from examples above, the authors of each Strategy had different expectations of the feasibility of air quality improvement and how it could be achieved over the course of the Strategy. In selecting only one version of what could be achieved in the future, policy-makers had effectively rejected others.

5.3. 'The future': a contested concept in the development of the Air Quality Strategy

Stakeholders and other policy-making institutions also had preferred futures, which may or may not have included improved air quality. As a holistic policy Strategy, which brought together regulation of different sectors, the AQS inevitably was the subject of interest of many different stakeholders. These included:

- Clean air and health protection NGOs, including the National Society for Clean Air and Friends of the Earth;
- Local government,
- Manufacturing industries,
- The vehicle and fuel industries and their representatives,
- And 'clean' vehicle technology producers.

The government departments responsible for the regulation and interests of each of these sectors were also involved in policy development. Such actors would not necessarily hold air quality regulation as a high priority. Even within Defra and its predecessors, air quality is only one issue of many competing for attention and resources. Actors presented their preferences and constructs of preferred futures to policy-makers during the creation of each Strategy, through routes including consultation responses, the media, unofficial conversations, and the Air Quality Forum for stakeholders. Given the range of stakeholders involved in the Strategy, there were inevitably a wide range of preferences.

In formulating policy, policy-makers selected one articulation of the future and possibilities for technological, policy and behavioural change, in order to create the plans for fulfilment of each Objective.

6. Research questions

Starting with a challenging Objective for particulate matter, subsequent revisions of the Strategy led first to a situation where Objectives were based on expectations of a business-as-usual scenario, and subsequently to more ambitious Objectives accompanied by policies insufficient to achieve them. This study aims to explain how this situation came about, and assesses why there was a complete change of approach to the regulation of particles in 2007. The development of each AQS was based on expectations about the future (i.e. the compliance date of each Objective). Different actors have different visions of the future, and this study examines how policy-makers and stakeholders made use of these during the development of the Strategy.

This thesis examines the formation and evolution of a policy framework: of the interactions and contrasting roles of scientific expertise and the 'futures' presented by actors involved in the policy process. It asks the overall research question:

> ***How were the AQS Objectives for particulate matter set and policies to achieve them developed? Did this change over time – between 1997 and 2007 – and, if so, how and why?***

This thesis asks three initial research questions to facilitate analysis and to answer this overall question:

1. *What role did statements about the future play in each version of the AQS?*
2. *How did policy change in the light of new and often uncertain scientific understanding of particulates, their properties and behaviour, and their effects on health?*

3. *To what extent did modelled forecasts shape policy, and why?*

Chapter 4 develops a theoretical framework for answering these research questions. Two further research questions (4 and 5) are introduced in this chapter; designed to expand our knowledge of how and why statements of expectation act to shape actions in the present[1]. The theoretical discussion in chapter 4 then reframes research question 1, so that answering it contributes to both theoretical development and case study[2].

6.1. The scope of this thesis

Although the AQS aimed to be a holistic policy driver, the focus of implementation has largely fallen on reduction of emissions from road transport. This takes many forms: through UK negotiations in European vehicle and fuel emissions regulation; local air quality management policies; measures encouraging voluntary action by individuals and businesses; and fiscal incentives for innovation and adoption. In urban areas, where the Objectives are required to be met[3], road transport is the "major" source of particulates and other Strategy pollutants (DEFRA, 2007a, p. 12). Air quality Objectives have not required industrial sources to reduce Strategy pollutants beyond levels stipulated by pre-existing Industrial Pollution Prevention and Control (IPPC) regulations. For this reason this thesis largely focuses on the range of futures presented in the versions of the AQS in which road transport emissions are reduced: through policy, behavioural change, innovation, and adoption.

This thesis examines the formation and consequences of a policy aimed at health protection, and its impact on a wide range of actors. In implementing the AQS there were several ways in which emissions from road transport could be reduced: through changes in diesel vehicle and fuel technologies; alternative technologies, promoted for example by fiscal incentives; changes in behaviour (for example, modal shift from cars to public transport) and changes to the urban environment (for example, traffic management schemes). This is not just a study of innovation and adoption of emission-reducing technologies for road transport. Rather, the wide range of stakeholders involved in the AQS, and its distinct history enables this study to examine how expectations of future technologies, policies and behaviour interacted in the policy-making

[1] Research question 4 is introduced on page 74, and research question 5 on page 75.

[2] See page 69.

[3] Air quality Objectives must be met at "…locations which are situated outside buildings or other natural or man-made structures above or below ground and where members of the public are regularly present and might reasonably be expected to be exposed over the relevant averaging period" (DETR 2000, p.34).

process. The role of expectations in innovation and adoption of new technologies has been studied by others (e.g. Borup, Brown, Konrad, & Van Lente, 2006; Van Lente, 1993), but their role in policy-making and implementation has not.

Given the similarities between the European Air Quality Framework Directive and the Air Quality Strategy, and the incorporation of European limit values into the AQS, it could be argued that this study should examine European air quality policy instead. However, the UK Strategy was developed prior to the European Air Quality Directives. It also went beyond the European Directives in some measures (the Scottish PM_{10} Objective for 2010 for example), but did not attempt to meet it in others (the London 2010 PM_{10} Objective). The UK NAQS, and especially the UK policy-makers involved in European negotiations, had a strong impact on the format of the EU Framework Directive, and Elsom (1999, p. 112) stated that "… convergence of the two strategies is evident". The European Air Quality Framework has not superseded the AQS. Rather, as this study demonstrates, at different times the European and UK frameworks have both influenced and led the other.

6.2. Contributions to knowledge

This study aims to provide evidence on how the AQS was constructed, and how it has been incorporated into decision making in everyday behaviour, policy and innovation. Conclusions will be drawn about the extent of the success of this policy, which may be generalised to comment on other complex policies which draw on expertise from a range of scientific disciplines and other sources. The role of modelled forecasts as both articulators and recipients of visions of specific technological futures will be discussed, together with their roles in the construction of environmental problems and potential solutions.

The AQS is also one of a series of target-based policies, which proliferated under the Labour government between 1997 and 2003. The use and relevance of such target based policy-making and its effects on the Objectives set and range of policies to achieve them will be examined, and the utility of such policy styles in environmental management discussed.

This thesis contributes primarily to the Sociology of Expectations literature in its examination of the dynamics of expectations over time – how they interact, change, and influence actions in the present. These matters are discussed in the theory of Expectations (for example in Bakker, Van Lente, and Meeus (2011); Van Lente (1993), but have not been investigated empirically. Instead, studies have examined on how one group of actors articulate their aspirations and expectations to others. This study is unique in that it uses concepts from the Sociology of Expectations literature to examine policy development, as well as innovation.

Finally, this study attempts to show why some visions or expectations of the future are deemed more credible than others by a particular audience – another area of expectations dynamics that has not previously been investigated.

7. Thesis Outline

The second and third chapters of this thesis, the Context chapters, provides the reader with information about the case study and an assessment of previous studies of air pollution policies. The third chapter comments on academic studies of the AQS and similar policies.

The Theoretical Framework is the fourth chapter, and begins with a study of approaches to agenda setting in policy before turning to the Sociology of Expectations, which is the main theoretical perspective used in this thesis. The thesis is also positioned as a study of discourse. However, not all the theoretical literatures examined in this chapter are in the realm of the discursive, and study of institutions and actors provides evidence towards answering the research question. Drawing on theories on the use of expertise, and of models in policy development, a theoretical framework is developed for answering the research questions.

Chapter 5, the Methodology, discusses and explores the research design, the methodologies used to collect and analyse data, and their limitations. This chapter sets out the method by which the theoretical framework is used to study the developments in the Air Quality Strategy to answer the research questions.

Analysis is undertaken in chronological order in chapters 6, 7, 8 and 9. Chapter 6 examines the process of setting up the NAQS and development of the AQS framework. Chapter 7and 8 look at the Revised AQS and the Addendum, to understand the change in approach from the challenging NAQS to a situation where the focus of policy was on revising the Objectives. Chapter 9 examines the events leading up to the publication of the 2007 Strategy, to understand how and why a different approach to regulation of particles was adopted, and provides insight into how the Strategy as a whole impacted on behaviour, local and national policies, and innovation and adoption. The Conclusion draws the findings from the separate time periods together to answer the research questions. It makes recommendations to policy-makers, provides an assessment of the study's contributions to knowledge and makes proposals for further research.

Table 1.2. Objectives set for each AQS

Regulation	Fraction size	Applies	Objective	Permitted exceedences per year	Permitted exceedences as percentile of 24 hour mean	Frequency of measurement	Achievement date
1997 NAQS	PM_{10}	UK	50μg/m³	4	99th	24 hour running mean	01/01/2005
2000 Air Quality Strategy Review[1]	PM_{10}	UK	50μg/m³ 40 μg/m³	35	90th	24 hour mean Annual mean	31/12/2004
2003 Air Quality Strategy Addendum	PM_{10}	England ,Wales & N Ireland (except. London)	50μg/m^3 20 μg/m^3	7	n/a	24 hour mean Annual mean	31/12/2010
	PM_{10}	London	50μg/m^3 23 μg/m^3	10	n/a	24 hour mean Annual mean	31/12/2010
	PM_{10}	Scotland	50μg/m^3 18 μg/m^3	7	n/a	24 hour mean Annual mean	31/12/2010
2007 Air Quality Strategy	$PM_{2.5}$ Objective	UK (except Scotland)	25μg/m^3	0	n/a	Annual mean	2020
	$PM_{2.5}$ Objective	Scotland	12μg/m^3	0	n/a	Annual mean	2020
	$PM_{2.5}$ exposure reduction	UK urban areas	15% reduction in urban background concentrations	0	n/a	Annual mean	Between 2010 and 2020

[1] 1997 set as TEOM – all others set as gravimetric measurements.

Chapter 2. The Context of the Air Quality Strategy

The Objectives for particulate matter developed over four versions of the Air Quality Strategy to manage a problem defined by scientific evidence – from epidemiological studies, monitoring of concentrations, and modelled forecasts of their future effects. Over ten years, the scientific understanding in these areas grew and changed. These developments held implications for regulation. The policy-making processes of the AQS included deliberations over the fraction of particulates most appropriate to regulate for the protection of health. Choice of fraction determined the sources to be focused upon by regulation, and the forms that reduction policies should take. An overview of the developments in scientific understandings of the health effects of particulates and of their physical and chemical properties – and how these were incorporated into each version of the AQS – is given here in order to provide a background to the analysis in later chapters.

The Introduction indicated that regulation of ambient air pollution potentially involves the regulation of many different emitters of pollutants. This chapter takes one source – road transport – and sets out the technological and demand management options available to policy-makers over this time period for reducing emissions from this source. Such information provides context for the analysis chapters, and indicates the many options to policy-makers.

This thesis divides the development of the Strategy into four time periods, to aid analysis and for clarity in describing events. Each captures a period of review of the Strategy, and ends in the publication of a Strategy containing new particulate matter Objectives. These time periods are set out in table 2.1, together with the abbreviations used for each version of the Strategy.

Table 2.1. Division of the duration of the AQS 1994-2007

Time period	Dates	Strategy	Abbreviation	Particulate fraction regulated
Period 1	1994-1997	*The United Kingdom National Air Quality Strategy*	NAQS	PM_{10}
Period 2	1997-2000	*The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Working Together for Clean Air*	Revised Strategy	PM_{10}
Period 3	2000-2003	*The Air Quality Strategy for England, Scotland, Wales and Northern Ireland: Addendum*	Addendum	PM_{10}
Period 4	2003-2007	*The Air Quality Strategy for England, Wales, Scotland and Northern Ireland*	2007 Strategy	$PM_{2.5}$ PM_{10}

1. Defining and measuring particulate matter, and the implications for regulation

In the UK the requirements of policy have shaped original research into the sources and behaviours of particulates, and forecasts of future concentrations. Much of the development of scientific knowledge on particulate matter was the result of government research programmes and investment. Defra, the government department responsible for the Air Quality Strategy, owns the national monitoring network (e.g. Smith, 2003). Others are owned by local authorities. Thus Defra owns the research base necessary for any epidemiological studies. Defra funded the national forecasting models and the national emissions inventories (DEFRA, 2007a). Similarly, local models and emission inventories have been developed for local air quality management (for example, the London emission inventory (Chell & Hutchinson, 1993)).

Some policy-makers were themselves air quality scientists, notably, Martin Williams, who wrote the NAQS and later headed AEQ. Prior to joining the Department of the Environment he had worked at the government laboratory, Warren Spring Laboratory (WSL), with John Stedman on pollution models. John Stedman and the modellers of Warren Spring later became part of the firm AEA Technology and designed and ran the national model of airborne particulates. In the Department of Health Robert Maynard and Heather Walton were experts on health effects of air quality.

1.1. Characterisation of particulate matter in the UK

Particulate matter does not have a uniform composition, but varies with sources, geographical location, and prevailing meteorological conditions, and particles in the atmosphere can change in chemical reactions with others (Wilson et al., 2002, p. 1011). Table 1.1. (p19) provides a common categorisation of particulate matter. Because of these characteristics, particles are defined by the choices made about how they are measured.

Over the course of the AQS the UK has set Objectives for both PM_{10} and $PM_{2.5}$, reflecting changes in both scientific and policy perspectives on the appropriate fraction of particulate matter to regulate. These fractions PM_{10} and $PM_{2.5}$ are based on evidence of the passage of particles into the lungs: particles 10µm and smaller into the airways, and those 2.5µm and smaller to the alveoli (Stanek, Brown, Stanek, Gift, & Costa, 2011, p. S12). There are other ways of measuring and defining particulates. Wilson et al. (2002, p. 1020) suggested that measurements of particles by number, surface area, size distribution, density, and other chemical properties may be of use to both policy-makers and researchers. Air quality regulation in the UK and Europe has only seriously considered mass.

This author previously argued that the decision in the UK to regulate the fraction PM_{10} in 1997 was predicated both by its associations with ill health and by the establishment of a national PM_{10} monitoring network (Smith, 2003). In 1992 the Department for the Environment established a network of 12 automatic PM_{10} monitors (Hester & Harrison, 1997), which expanded to 64 by 2007 (DEFRA, 2007a, p. 35).

The UK's increasing interest in $PM_{2.5}$ was demonstrated in the development of the $PM_{2.5}$ monitoring network. In 1997 only one monitor measured $PM_{2.5}$; in 2007 there were thirteen (DEFRA, 2007a, p. 35).

There are subtleties even within measurement of PM_{10} which means that policies which appear to regulate the same fraction do not always do so. The UK set the 1997 PM_{10} Objective to be measured by the monitors on its network, TEOMs (Tapered Element Oscillating Microbalance monitors). European Commission targets for PM_{10} are based on the gravimetric monitor, which measures a slightly different fraction of PM_{10} (the differences between the two measurements come from how each measures particle-bound water) (Wilson et al., 2002). The European target adopted in the Revised Strategy (DETR, 2000a) was in the gravimetric form, requiring the conversion of the TEOM measurements. This proved problematic, because there is no universal means of converting one measurement into another because of local variations in the chemical composition of $PM_{10.}$ This issue has had an impact on compliance

and regulation in the UK: the choice to reduce the stringency of the NAQS Objective in 2000 was due in part to the complexities of the different monitoring systems (Smith, 2003).

1.2. Modelled forecasts of particulate matter

Models are now established components of air pollution policy-making– from local air pollution (Smith, 2003) to global climate change (Tol, 2011) and transboundary air pollution (Maas, Amann, Apsimon, Hordijk, & Tuinstra, 2004). The strength of models lies in their ability to capture the complexity of modern environmental problems (Shackley, 1998, p. 81) and in their provision of forecasts. They are useful in situations where the options for action cannot be tested in the real world in advance, for example, the outcomes of a two-sided nuclear war (Oreskes & Conway, 2010) or of the future effects of climate change. Whilst models of air pollution have been used throughout modern air pollution policies, they necessarily simplify what they predict, and contain assumptions within them (Van der Sluijs, 2002).

Monitoring data are also of interest because of their role in modelling current and future PM_{10} concentrations. Models of future emissions and of future ambient concentrations were used in developing each version of the Strategy. A national-scale model was developed by the consultancy Netcen, to support policy-making from the Revised Strategy onwards (referred to here as the Netcen model).

The Netcen model used source apportionment, whereby measured ambient concentrations of a pollutant are assigned to specific sources. This necessitated a simplification of the origins of ambient particulate matter: in the model used in development of the Revised Strategy, particles were categorised as primary, secondary and 'other', which does not fully capture the variety of particle emitters. This characterisation enabled Netcen to forecast the effects of changes in each category and extrapolate this to the total ambient particulate concentrations. The model provided estimates for each site in the monitoring network. Netcen then extrapolated those site-specific data and the forecasts of the National Atmospheric Emissions Inventory (NAEI) to create national maps of future particulate concentrations.

Over the course of the four versions of the Strategy, the Netcen forecasts became more detailed, and were used in different ways. The Netcen model did not exist in Period 1, but the advisory committee QUARG (the Quality of Urban Air Review Group) made a study of concentrations and composition of particulate matter in the UK. Using the few models of pollution in UK cities, they found that the primary fraction (measured as traffic exhaust emissions) and secondary particles were dominant in the $PM_{2.5}$ fraction, which was the greatest component of PM_{10} (QUARG, 1996, p. i). The NAQS used QUARG's source

apportionment estimates, to determine which emissions sources needed reducing to reach the PM_{10} Objective (Department of the Environment, 1997, p. 153).

In 1997 a new advisory committee was formed to investigate UK particulate matter and carry out a source apportionment study, the Airborne Particles Expert Group (APEG). Netcen developed QUARG's receptor modelling methodology for APEG (Stedman et al., 1998). APEG found that up to 20% of primary and 50% of secondary particles were transported from mainland Europe – much more than previously estimated. The model tested whether the PM_{10} Objective from the NAQS and the European PM_{10} target could be met in 2005.

In Period 3 the Netcen model incorporated emissions data from a greater range emitters from the NAEI. It also provided considerations of uncertainties in the input data and some of the assumptions of the model. The Netcen model was used to demonstrate what emissions were possible under a business-as-usual baseline, and to forecast the impact of illustrative policy scenarios to how they would contribute towards meeting the proposed Objective.

Modelling undertaken for the 2007 Strategy contained further a sophisticated breakdown of the primary fraction, uncertainty analysis, and a range of scenarios to take into account several uncertainties within the model (DEFRA, 2007a). Both PM_{10} and $PM_{2.5}$ were modelled. DEFRA stated that the Netcen models were compared with results from three other (local) models to increase confidence in the forecasts (DEFRA, 2007a, p. 6). The treatment of illustrative measures was more sophisticated than that carried out for the Addendum. Each measure had its impact on emissions, air quality Objectives and ecosystems modelled (DEFRA, 2007a).

During Periods 3 and 4 the model provided data for cost-benefit analysis of the illustrative measures (Interdepartmental Group on Costs and Benefits, 2001, 2006).

2. The health effects of particulate matter

Despite the swift responses of UK policy-makers to the new evidence of the health effects of PM_{10} in the late 1990s, the four versions of the particulate targets developed against a backdrop of changing health evidence which was not taken up into policy with the same urgency. The majority of the health effects evidence came from American and European studies, which the advisory committee COMEAP used to quantify the health effects of particulate concentrations in the UK (COMEAP, 1998, 2001, 2006).

The developing scientific evidence on health effects is not neatly divisible into the different time periods of this study: all were part of the debate to a greater or lesser extent throughout. However, some issues were more important than others at different times; notably the shifts

in focus from acute health effects in Period 1 to chronic effects by Period 4; from respiratory to cardiovascular effects; and the increasing scientific interests in ever smaller fractions of particulate matter. Each of these had potential implications for regulatory policy.

2.1. Period 1: controversy over epidemiological studies

The decision by the Department of the Environment in the NAQS to regulate ambient PM_{10} for improvement of health was based on data from short-term epidemiological studies undertaken in the 1990s (for a review see Dockery (2009). These studies were consistent in their findings that a 10μg/m^3 rise in PM_{10} was associated with 1% increase in mortality (Parliamentary Office of Science and Technology, 1996, pp. 5-6).

The advisory committee EPAQS reported that this relationship between mortality and particulate concentrations were found to be consistent in studies from countries including the UK, the USA, Greece, Germany and China (EPAQS, 1995 paragraph 21). Although there was no evidence of a causal relationship at this point, EPAQS argued that the consistency in the findings "increase[d] the likelihood that the relationship is causal".

During Period 1 a vocal minority of scientists questioned whether particulate matter caused the effects on health indicated by the epidemiological studies. There were no toxicological data or proven mechanism by which such low concentrations of particulates were known to affect health (Dockery, 2009, p. 259). The use of time series methodologies used in the studies was new to epidemiology, enabled by improved computing power. It was criticised by some, including Gamble and Lewis (1996) as being only a 'statistical', rather than a causal, association.

Phalen (1998, pp. 264-265) argued that the results of epidemiological studies were problematic for several reasons: they did not account for people spending most of their time indoors; there was no proven causal mechanism for the health effects; that the cumulative effects of pollutants were not accounted for; that toxicological evidence did not support the studies; and that effects attributed to particulate matter may be the confounding effects of variation in season or weather. He concluded that:

> *…the magnitude of the associations, which are statistically significant, are weak in relation to the conventionally used criteria to establish causality…. Yet, when the small relative risks are multiplied by a potentially-exposed population of millions of US citizens, then tens of thousands of 'excess' deaths are projected.*
>
> (Phalen, 1998, p. 264)

Institutions including the World Health Organisation, the US Environmental Protection Agency, the European Commission, and the UK Committee on the Medical Effects of Air Pollution

(COMEAP) examined these issues (Parliamentary Office of Science and Technology, 1996, p. 7). All concluded that the statistical test used were sound and the effects were causal (Parliamentary Office of Science and Technology, 1996). By 2002 hundreds of studies from different countries replicated the results of the original studies (Dockery, 2009, p. 259). Nevertheless, the ability of the epidemiological studies only to provide evidence for health effects on populations rather than individuals remained problematic.

More recently two 'natural' epidemiological studies provided striking evidence that reducing ambient concentrations of pollutants can improve health outcomes. Clancy, Goodman, Sinclair, and Dockery (2002) examined the effects on mortality of implementing domestic coal burning regulations in Ireland. They concluded that regulation and its implementation led to an "immediate" reduction in deaths from cardiovascular and respiratory causes. Hedley et al. (2002) found that the mandatory use of low sulphur fuels in vehicles and power stations in Hong Kong was immediately associated with reductions in deaths from cardiovascular and respiratory causes.

2.2. The most appropriate fraction of particulate matter for regulation

Whilst early epidemiological studies examined the effects of PM_{10} or total suspended particles, scientists quickly moved on to studying smaller fraction sizes. However, influential meta-analyses of epidemiological studies, including that conducted by the Health Effects Institute (2000) converted the fractions used to PM_{10}, to provide a common metric for comparison. This provided a consistency of measurement in scientific evidence that was useful for policy-making purposes.

Evidence that the toxic fraction of PM_{10} lay in the fractions 2.5µm or smaller grew during Period 2 (for a review from this period see EPAQS (2001). Two earlier reports from advisory committees – EPAQS (1995) and QUARG (1996) - recommended that $PM_{2.5}$ should be considered for regulation in the UK. Whilst the UK and EU regulated ambient PM_{10} only, in 1997 the USA set air quality targets for $PM_{2.5}$.

In Period 2 EPAQS investigated the most appropriate fraction to use as the particulate Standard and concluded that there was insufficient evidence for a separate $PM_{2.5}$ Objective (DETR, 2000a, p. 52). In the UK $PM_{2.5}$ and PM_{10} are closely correlated, and it was difficult for EPAQS to separate the effects of the two (EPAQS, 2001). At this time were there were very few epidemiological studies of $PM_{2.5}$ in the UK, few monitoring sites, and no European directive on $PM_{2.5}$. Thus, during Period 2 UK advisory committees, scientific institutions, and

countries were divided on how to act on the growing evidence that $PM_{2.5}$ was the more harmful fraction.

In Period 4 the UK adopted a $PM_{2.5}$ Objective. The EPAQS recommendation did not change prior to this. However, the European Commission was considering the regulation of $PM_{2.5}$, and there was increased monitoring of $PM_{2.5}$ in the UK.

The significance of these choices about the appropriate fraction to regulate is that emissions sources contribute in varying proportions to different fractions. The smaller fractions - $PM_{2.5}$ and below - include relatively greater proportions of primary, anthropogenic and secondary particles, and fewer coarse particles. For example, in the UK in 2001, when the Addendum was being decided upon, diesel emissions contributed 15.2% of total PM_{10}, 24.1% of $PM_{2.5}$, 31.3% of PM_1 and 44.3% of $PM_{0.1}$ (AQEG 2005b, p. 80). For fractions $PM_{2.5}$ and smaller, diesel emissions are the single largest source (AQEG 2005b, p. 41). Choosing to regulate smaller fraction sizes changes the focus of regulation.

2.3. Long-term effects of particulate matter on health and mortality

Two studies were published in the 1990s which suggested significant associations between concentrations of particulates and long-term illness (including respiratory and heart diseases) and mortality rates (Dockery et al., 1993; Pope et al., 1995). During Period 1, COMEAP and other argued that these studies had considerable confounding factors (COMEAP, 1995). There were no clinical or toxicological data to support them, they had not been replicated, and the data used was not appropriate (Dockery, 2009, p. 260). Such concerns meant that, even though COMEAP viewed an association between PM_{10} exposure and mortality rates as "causal" (COMEAP, 2001, p. 1), they recommended that only the acute effects of particles be taken into account in setting the NAQS and Revised AQS.

In 2000 the American Health Effects Institute reanalysed the data of the longitudinal studies, and confirmed their results (Health Effects Institute, 2000). COMEAP was quick to react: in 2001 it published a quantitative estimate of the long-term effects of air pollution in the UK. Although different scenarios offered different figures, the majority of the committee believed that 0.2-0.5 million life years gained per 1µg/m³ reduction in ambient $PM_{2.5}$ was a useful estimate (COMEAP, 2001, p. 5)[4]. The AQS Addendum stated that "…the effects on life

[4] This statement is subject to uncertainties regarding the spread of health effects across the population. For example, this estimate could mean that reducing $PM_{2.5}$ by 1µg/m³ causes 2.5 days per person across the population of 52 million, or 5 days for 25 million, almost 2 months for 2.5 million people, etc. (COMEAP 2001 p4).

expectancy from long-term exposure to particles could be up to 10 times greater than the short-term effects" (DEFRA, 2003, p. 14). The long-term effects of exposure to particulates were considered in both policy and the modelling undertaken to support it.

In 2006 COMEAP advised that the long-term effects of air quality were more harmful than the short term (using a $PM_{2.5}$ metric). The 2007 Strategy claimed that as reducing particles had greater effects on long-term exposure than on acute effects, it "made sense to consider these as the major driver for the size of the exposure reduction Objective" (DEFRA, 2007b, p. 45).

2.4. Relative susceptibility and toxicological evidence for the effects of particulate matter

Studies of susceptibility had implications for regulation: if it were known that some individuals were more susceptible than others to ill health effects, then resources could be channelled into helping these people. However, epidemiological studies demonstrated associations between particulate matter exposure and morbidity and mortality in the general population of a specific area (Samet & Krewski, 2007, p. 231). These studies could not indicate whether some individuals were more susceptible than others. The toxicological and biological evidence for the effects of particulate matter lagged behind that of the epidemiological studies over the course of the Strategies, and only appeared to offer some explanatory power in Period 4.

From Period 1 onwards there was consensus in the scientific community that the impacts on health and mortality seen in epidemiological studies were not evenly spread among the general population, but rather those who suffered the adverse effects of particulates were already ill (e.g with heart or lung disease) or elderly (COMEAP, 1995, p. 105; EPAQS, 1995). There was however, no known biological mechanism to confirm this.

Toxicology studies provided support for those who were sceptical of the results of epidemiological studies during Period 1. This is because they tended to examine the impact of particulates on health in the workplace, where there were much greater concentrations of particulate than in normal urban areas and did not find the same results (EPAQS, 2001, p. 51). The toxicity of ambient particulates – the degree to which they cause harm – was believed to be quite low, which was also problematic because the common conception was that to be harmful they must be toxic (EPAQS, 2001, p. 51).

Toxicological studies have gradually provided data and biological theories to support the epidemiological findings (Stanek et al., 2011). Evidence indicates that some groups are more vulnerable than others, including children and older adults, those with pre-existing

cardiovascular and respiratory conditions, and those with specific genetic disorders (Sacks et al., 2011, p. 452). More recent studies suggest that those with obesity, diabetes and chronic obstructive pulmonary disease are also adversely affected (Sacks et al 2011 452). In Period 4, AQEG (Air Quality Expert Group) reported that susceptible groups were thought to be more likely to react to the inflammation in the lung which particulate matter is believed to induce.

3. Technologies and policies to reduce particulate emissions from road transport

In addition to the complex and disputed science of particulates and their effects, there are many different ways in which concentrations of ambient particulate matter could be reduced. Throughout the course of the AQS, road transport has been perceived as a major source of particulates and other pollutants. This source is significant, not only in the contribution it makes to total concentrations of particulates in the UK, but also in terms of the exposure of the general public. In 2001, in an analysis for the Addendum, private firm AEA Technology (2001, p. 25) claimed that road transport was the greatest source to which the UK population were exposed.

In 1995 QUARG (1996) claimed that road transport was the major source of PM_{10} in urban areas. Nationally it contributed about a third of total primary emissions; in London road transport contributed over 80% of the total (Quality of Urban Air Review Group, 1996). These figures were used for the NAQS. In the evidence used in setting the 2007 Strategy, AQEG reported that transport and industrial processes both contributed 27% of the total UK PM_{10} in 2001 (AQEG, 2005b, p. 40).

Emissions of particulates from road transport can be reduced in a number of ways. These fall into five categories: technological improvements to diesel engines, end-of-pipe emissions control technologies, changes in diesel fuel composition, alternative fuels and technologies, and traffic management schemes. At different times in course of developments of the Strategy different options were presented as preferred futures by stakeholders and policy-makers.

Such options were not available in the control of stationary sources – electricity producers and other combustion sources. These were controlled through the mechanisms of Integrated Pollution Prevention and Control (IPPC), set by the European Commission. Whilst there were some options for voluntary emissions reductions (the application of which will be discussed in the relevant analytical chapters of this thesis), there was not the same scope and choice in means to reduce particulates as there was for road transport.

3.1. Emissions from diesel engines

During the time period studied (1995-2007) diesel engines were more fuel efficient than petrol engines (e.g. in terms of miles per gallon), but emitted much greater quantities of particulates. For this reason they have been the focus of policies to reduce particles from road transport. For example, whilst diesel emissions of particulates are the subject of European vehicle standards, those from petrol vehicles are not (Arther D. Little, 2004). Diesel and petrol engines both produce ammonia and sulphur dioxide, precursor gases for secondary particles.

Diesel vehicles have been subject to legislation limiting their emissions through the European Union 'Euro' standards and fuel quality regulations. These set limits on exhaust emissions rather than requiring adoption of a specific technology (Friedrich, Tappe, & Wuzel, 2000). Euro I and Euro II set proportionately easier standards for diesel than for petrol engines, because it was comparatively harder to reduce diesel emissions (Arther D. Little, 2004, p. 63). The mandatory implementation dates for Euro II was 1996 for new models and 1997 for existing models.

From Euro II onwards, standards were set through the European Auto Oil programme, established in 1993 as a means identifying cost-effective vehicle emissions reduction to improve ambient air quality levels by 2010 (Friedrich et al., 2000). The Auto Oil programme used models of future air quality to determine what levels of emissions reductions were needed to meet World Health Organisation standards (Friedrich et al., 2000, p. 598).

It is a simplification to say that the Euro standard drove innovation and adoption of emission-reducing technologies; however the period covered in this study was a time of comparatively rapid innovation of diesel technologies – and developments were hastened by up to seven years because of the need for compliance with the Euro standards (Arther D. Little, 2004). Later Euro standards – Euro 3, 4 and 5 for cars and light vehicles, and III, IV, and V for heavy goods vehicles – created the need to innovate in the diesel sector, leading to much wider use of oxidation catalysts, particulate traps and common rail fuel injection systems (Arther D. Little, 2004).

3.2. Reductions in the sulphur content of fuel

Sulphur content of diesel fuel reduced over the period of study. Sulphur in fuel is a pollutant in its own right, a precursor to secondary particulates, and causes inefficient combustion – so leading to more emitted particles. Removing sulphur from fuel enabled the use of exhaust after-treatment technologies (e.g. diesel particulate filters) (UK Petroleum Industry Association, 2003).

In 1995 the company Greenergy was the only supplier of ultra-low sulphur diesel (ULSD) – diesel with sulphur levels at 50ppm (parts per million). London Transport Buses carried out large-scale trials of particulate filters with Greenergy ULSD diesel between 1995 and 2000. They found that using the two together led to ninety per cent reduction in particle emissions (DTI & Anthony Collins Solicitors, 2006, p. 123). London Transport then encouraged all London fleet operators to switch to ULSD (DTI & Anthony Collins Solicitors, 2006, p. 124).

In 1997 the UK government set a duty differential of 1 pence between traditional diesel and ULSD, in favour of ULSD. In the March 1999 Budget, fuel duty on ordinary diesel was raised to three pence more than ULSD, to encourage its manufacture and use (DETR, 2000a, p. 68). It was for this reason that the larger fuel firms began to supply ULSD, and by 1999 almost the whole of the UK switched to ULSD (Ng, 2006, p. 9). The EU target date for their use was 2005 (UK Petroleum Industry Association, 2003). Sulphur free fuel – those with 10ppm or less sulphur - were planned to have reduced duty compared to others from September 2004, but this was not implemented.

3.3. End of pipe technologies: diesel particulate filters

Diesel particulate filters (DPFS) are end-of-pipe technologies, installed as part of the exhaust system of a diesel vehicle to trap particles before they are emitted. They can be installed on a new diesel vehicle, or retrofitted onto older vehicles. To work they require ULSD or lower sulphur content fuel. Public service vehicles, such as buses, have a lifespan of around twenty years, and are largely diesel-powered. DPFs were potentially a much cheaper means of reducing fleet emissions, compared to replacing older vehicles.

DPFs had been promoted as emissions-reducing technologies since the 1960s, but they were not commercially available until the 1990s (Zelenka, Cartellieri, & Herzog, 1996). There remained design problems with the DPF in the 1990s: especially in the ability of the trap to ‘regenerate’ itself, to burn off the trapped particulates so that it did not get blocked (Neeft, Makkee, & Moulijn, 1996).

In 1995 London Buses began a trial of Johnson Matthey self-regenerating DPFs, and by 2006 approximately 8,000 London buses used DPFs (Arther D. Little, 2004). Peugeot Citroën was the first vehicle manufacturer to install DPFs as standard in new cars, from 2000 (Jacob et al., 2005, p. 139).

In Period 4 it became apparent that DPFs cause an increase of emitted NOx . There was also controversy regarding whether they caught the larger particulates, whilst letting through a

greater mass of ultrafine particulates – those believed to do the most damage to health (Twigg, 2007). They were also not as fuel efficient as a diesel engine without a filter. There can also be problems if DPFs are unable to burn off particles and 'regenerate', especially in cars that work at lower temperatures than buses and lorries (Twigg, 2007).

3.4. Alternative technologies for reducing vehicle emissions

Alternative vehicle technologies as replacements for diesel vehicles considered by stakeholders or by policy-makers over the period of study are set out in Table 2.2. Some of these alternatives – CNG and LPG for example – were commercially available throughout the time period of this study. Others, such as hydrogen technologies, were considered to be future technologies and were not commercialised.

Table 2.2. Alternative vehicle technologies offering reduced PM emissions in comparison to diesel

Technology	Description	Significant actors promoting this technology in the UK	Advantages of this technology for air quality	Barriers to adoption experienced over the period of the AQS
Compressed Natural Gas (CNG)	Vehicle powered by compressed natural gas (methane). Retrofitted and new vehicles. Single fuel or hybrid vehicles.	Natural Gas Vehicle Association, British Gas, Mobile, Volvo, BMW.	Produces lower emissions of carbon dioxide and particulates compared to petrol and diesel cars, at least during Period 1.	• Lack of refuelling infrastructure • Problems in fuel storage (in and out of the vehicle) • High price of fuel • Advantage of emissions over diesel and petrol eroded by later Euro Standards.
Liquid Petroleum Gas (LPG)	Mixture of propane (93%) and butane (7%) in the UK (different ratios elsewhere in Europe). Retrofitted and new vehicles. Single fuel or hybrid vehicles.	Liquid Petroleum Gas Association, BP, Shell, Volvo, Vauxhall.	Produces lower emissions of carbon dioxide and particulates compared to petrol and diesel cars. Improved fuel economy over petrol and diesel vehicles during Period 1.	• Lack of refuelling infrastructure • No internationally agreed standard fuel mixture. • Less fuel efficiency than diesel vehicles. • Emissions advantages over diesel and petrol eroded by later Euro standards.

Table 2.2 (continued) Alternative vehicle technologies offering reduced PM emissions in comparison to diesel

Technology	Description	Significant actors promoting this technology in the UK	Advantages of this technology for air quality	Barriers to adoption experienced over the period of the AQS
Electric vehicles	Vehicles powered by a battery, charged by plugging it into mains electricity. Full electric vehicles, and hybrid, dual fuel and bi-fuel. Because of refuelling and limited battery life, this fuel is most appropriate to urban vehicles on relatively short journeys (about 50 miles).	Toyota and Honda both made hybrid electric vehicles. Axeon (largest lithium battery supplier in Europe).	Produce no emissions at point of use.	• Lack of refuelling infrastructure. • Length of refuelling time (up to 7 hours). • Achieving a battery life and capacity enabling driving comparable to conventional fuels. • Cost of the battery (Period 1)
Hydrogen	Vehicle uses a source of hydrogen for its power. Because of refuelling issues this fuel is more appropriate to buses and fleet vehicles with a central depot.	BMW – hydrogen ICE cars. GM, Ford, DaimlerChrysler, Toyota and Honda – hydrogen fuel cells. Buses: Transport For London, Fuel Cell Europe	No greenhouse gas emissions, no air pollution emissions at point of use – except NOx (for hydrogen internal combustion engine).	• High costs. • Hydrogen internal combustion engines are inefficient, and have high energy consumption in production. • Hydrogen fuel tank too big for normal cars (in Period 3 at least). • No hydrogen refuelling infrastructure and no agreement on designing one.

Sources: Energy Saving Trust (2002), Brevitt (2002), ETSU (1996)

Table 2.3. Cars registered by fuel type 1994-2007 (in thousands)

Year	Petrol	Diesel	Gas	Electric	Hybrid Electric
1994	19,620.9	1,576.2	1.8	0.1	0.0
1995	19,499.8	1,891.3	2.9	0.1	0.0
1996	20,051.6	2,181.6	4.1	0.1	0.0
1997	20,384.7	2,440.5	6.2	0.1	0.0
1998	20,590.5	2,692.9	9.6	0.2	0.0
1999	21,031.0	2,929.9	13.8	0.2	0.0
2000	21,232.6	3,152.7	20.0	0.2	0.0
2001	21,641.1	3,459.5	24.4	0.3	0.6
2002	21,839.5	3,912.4	28.8	0.3	0.9
2003	21,805.5	4,399.6	33.7	0.3	1.2
2004	21,976.6	5,010.6	37.6	0.4	2.8
2005	21,876.0	5,596.1	39.5	0.6	8.1
2006	21,465.8	6,083.3	42.4	0.8	16.6
2007	21,264.4	6,657.4	45.1	1.2	31.8

Source: DfT (2012b)

From table 2.3 it can be seen that although there were a range of alternative technology vehicles on the road, none challenged the dominance of petrol and diesel. The DfT combines CNG and LPG in its propulsion figures, but this table shows the steady growth in numbers of these vehicles.

The size of the electric vehicle fleet grew more slowly: there were fewer than one thousand electric cars on the road in 1997. This may reflect the barriers to their adoption in Period 1: short battery life, costs of the battery and low vehicle performance compared to others (ETSU, 1996, p. 100). By 2002, pure electric vehicles were largely run by local authorities (Brevitt, 2002, p. 65) or were trial vehicles (Energy Saving Trust, 2002, p. 18).

In Periods 2-4 attention turned to hybrid electric vehicles: those which used both electric power and an internal combustion engine, due to the limitations of electric vehicle batteries. The Toyota Prius, the most successful electric vehicle in the UK, was launched in Europe in 2001. This is a hybrid electric/ petrol vehicle, whereby electricity is generated by regenerative breaking and the engine (Society of Motor Manufacturers and Traders, 2011, p. 5). Table 2.3 demonstrates that numbers of these vehicles doubled each year between 2003 and 2006, demonstrating the relatively rapid success of this technology.

3.5. Local transport management policies

Throughout the life of the AQS local policies and projects have reduced emissions from road transport. These can involve incentives for use of cleaner technologies or removal of vehicles from the road. Significant examples include:

- The London Low Emission Zone (LEZ): plans were developed over the course of the time period of this study to introduce a low emission zone for Greater London. This sets minimum emission standards for lorries, buses, coaches, vans, caravans and specialist vehicles (e.g. snowploughs) in the area of Greater London.
- Bus quality partnerships/ freight quality partnerships: agreements between local authorities and fleet operators to improve bus services or freight delivery, and can include agreed emissions reductions.
- *Smarter choices*: a range of measures to encourage car drivers to use other forms of transport, and thus reduce cars on the road. Potential measures included car clubs, promoting cycling and walking, and improving information about public transport (Department for Transport, 2004b).

Over the time period studied the UK government used fiscal instruments to promote the uptake of some technologies over others. In addition to differential duty on ULSD, there were also preferential rates of duty on LNG and CNG compared to diesel. The government offered lower vehicle excise duty rates for heavy duty vehicles retrofitted with emissions reducing technologies (Brevitt, 2002, p. 37). The grant scheme PowerShift promoted the adoption of alternative technologies, including CNG, LPG and electric power systems by providing grants to assist purchase. It ran between 1996 and 2004. Another grant programme, CleanUp promoted retrofitting of cleaner diesel engines and alternative fuels systems between 2000 and 2004 (Brevitt, 2002; DEFRA, 2007a).

4. Summary: The contribution of science and technology developments in the history of the AQS

This chapter has outlined developments in how particles in the UK were measured and understood, and in how particles were known to affect health. Whilst developments in the science of measuring, characterising and forecasting particulates were driven by the requirements of the UK AQS; developments in comprehension of health effects were not driven by UK policy, but by the requirements of the WHO and others to understand the biological processes by which air pollution affects health.

Multiple forms of expertise contributed, including health scientists, monitoring and modelling specialists, and actors who have expertise in the various technologies, behavioural measures and policies for reducing emissions from sources. All these issues were considered in the creation of medium-term targets for reducing ambient pollutant concentrations. How they were assessed and used during different versions of the AQS by policy-makers is the subject of this study.

Chapter 3. Previous studies of the AQS and strategies for regulating ambient air quality

Three major themes are evident when reviewing studies of the policy-making process of the AQS:

- The co-construction of science and policy, and negotiation of the boundaries between science and policy;
- The problematic implementation of air pollution management across all levels of governance: local, national and international;
- Clashes between air pollution reduction strategies and the priorities of individuals, local and national government.

This literature has primarily focused on policy developments in the UK, USA and Europe, and this review reflects this.

1. Interaction of scientists and policy-makers in pollution management policy development

Much of the scholarly work on policy-making for air quality has focused on the relationships between scientists and policy-makers, and on the co-construction of science and policy. Zehr (1994, p. 56) claimed that analysis of the relationship between scientists and policy-makers and the factors shaping scientific knowledge are essential to understand environmental problems defined through monitoring technologies.

This is the case with the Air Quality Strategy (as shown above), and for the much-discussed case study of transboundary air pollution in Europe. Negotiations over the roles and tasks of science and policy in the Convention on Long-Range Transboundary Air Pollution (CLRTAP) have been widely studied (for example in Castells & Ravetz, 2001; Sundqvist, Letell, & Lidskog, 2002; Tuinstra, Hordijk, & Kroeze, 2006). Such studies have examined the delineation of the roles of science and policy, and the development of the CLRTAP agreements and RAINS (Regional Air Pollution and Simulation) model of transboundary air pollution.

Such studies have tended to take constructivist approaches to science/ policy relationships. That is, they presuppose that the demarcation of science and non-science are not set in stone, but that actors act strategically and tactically to position them, through social interaction (Sundqvist et al., 2002, p. 148).

1.1. Boundary work

Studies of boundary work have examined the negotiations over the identities and activities of science and policy, and the roles of "scientists" and "policy-makers" (Gieryn, 1999; Tuinstra et al., 2006, p. 350). Jasanoff (1987) claimed that such scientists and policy-makers are constantly in dispute over the boundaries between science and policy, with the aim of expanding and protecting their remits. Other scholars (e.g. Tuinstra et al., 2006) hold that boundaries can be the product of less adversarial negotiations.

Studies of boundary work between environmental modellers and policy-makers in the arenas of climate change and international transboundary pollution have characterised modellers as protective in the preservation of their 'scientific' territory (Maas et al., 2004; Van der Sluijs, 2002). Van der Sluijs (2002, p. 141) characterised this:

> *By drawing boundaries between science and policy, scientists post 'keep out' signs to prevent non-scientists from challenging or reinterpreting claims labelled as 'science'. The creation of such boundaries seems crucial to the political acceptability of expert advice.*

This appears to happen even in circumstances where modellers are aware of the political, economic and social factors incorporated into their models (Jasanoff1990). Such is the case with CLRTAP and the RAINS model. The RAINS model is an integrated assessment model: it does not only provide forecasts about air pollutants, but provides forecasts of the effects of scenarios throughout the socioeconomic and natural systems in which pollutants are emitted and have their effects (Maas et al., 2004).

Sundqvist et al. (2002, p. 153) argued that actors' desire to protect their individual spheres of knowledge is held simultaneously with their recognition of the interdependency of modelling and policy. Sundqvist and colleagues' analysis of boundary work between modellers of the RAINS model and policy-makers in the CLRTAP process indicated that the RAINS model was simultaneously a policy tool aimed to create fair and cost-effective abatement strategies, a scientific tool, and a tool for communication. Halffmann (2003) calls these functions the 'demarcation' and 'coordination' sides of boundary work.

Boundary work is not simply about establishing spheres of influence, but can be undertaken to increase perceptions of the credibility of both science and policy to a range of audiences. Tuinstra et al. (2006) found that in the case of CLRTAP, boundary work by policy-makers and modellers in the early stages of the policy process contributed to a range of audiences perceiving both model and political agreement as "credible, legitimate and relevant" (Tuinstra,

2007, p. 435). Tuinstra's comparison of boundary work between scientists and policy-makers in the CLRTAP and Clean Air For Europe (CAFÉ) processes argued that divisions of roles and responsibilities was different in each case (Tuinstra, 2007).

1.2. The co-construction of science and policy

Related to the construction of boundaries between science and policy is the concept of mutual or co-construction of science and policy, in which the development of each determines and constrains the other. Shackley and Wynne (1995a, p. 221) proposed that co-construction occurs when:

> *The dominant agendas, commitments and goals of particular policy communities may themselves act as closure mechanisms around particular scientific styles, practices and predispositions. Similarly, perhaps simultaneously – what are perceived amongst scientists as effectively incontestable scientific knowledge claims or methodological commitments may play a crucial, largely unrecognised, role in closing-off possible policy options, truncating debates and controversies, and inducing partial closure around specific policy approaches.*

Hunt and Shackley (1999, pp. 147-148) proposed that co-construction differs from boundary work, because it dissolves the boundaries between distinct science and policy, with the outcomes of both being negotiated collectively. These negotiations could include establishing or reinforcing the research objectives, practices, routines, methodologies, user groups, interpretations, and shared knowledge. They call this process "hybridisation".

The theoretical approach of co-construction proposes that closure around a specific style of policy or science can bring advantages to both scientists and policy-makers involved. Shackley and Wynne (1995b) claimed that the mutual construction interaction creates a "reality" which then re-orders other parts of society and policy. Alternative policy scenarios and scientific approaches may become excluded as a result (Keeley & Scoones, 2003, p. 21). In their example of global climate models and climate change policy in the 1990s, Shackley and Wynne (1995a) argued that the relationship had caused the exclusion from the policy process of other, possibly equally valid, scientific approaches, and determined the possible policy responses.

Sonja Boehmer-Christiansen (1995) questioned whether those policy-makers complicit in mutual construction of science and policy were those who could make decisions that could actually affect environmental change. In her experience of the UK she found that in general the Department for the Environment funded models of climate change, but could not make decisions about policies that would affect greenhouse gas emissions – those were made by

cabinet ministers and civil servants in other departments (for example, relating to industry and energy). In the case of UK climate change models used by Shackley and Wynne (1995a) she argued that even if mutual construction occurred between modellers and policy-makers in the Department for the Environment, this had little bearing on climate change policies. Boehmer-Christiansen raised an important consideration: what motivates the actors involved in mutual construction and other forms of boundary work ?

1.3. Knowledge monopolies

Tol (2011, p. 828) argues that single models can become "knowledge monopolies" in situations where there are high financial and resource costs to competition (in the forms of different models or different forms of knowledge). He used the example of the scenarios developed by the Interdepartmental Panel on Climate Change (IPCC), and claimed that these are more widely used than any other in the scientific fields of climatology, impact studies, and emissions reduction; that they have shaped both the direction of subsequent research and policy development. Tol (2011) concluded that the IPCC scenarios were used extensively both because they enabled results of studies to be compared, but also because the IPCC were more likely to cite papers which used their scenarios.

Cases of models as knowledge monopolies have generated concern that forecasts become accepted as truth rather than tools (Shackley, 1998). Whilst the resulting effect on the model's credibility could be positive or negative, this situation may favour one form of knowledge and preclude others.

1.4. Co-Construction of the AQS, the Netcen model, and the national monitoring networks

In a previous study I (Smith, 2003) examined the development of the UK's particulate matter monitoring network, modelled forecasts, and the setting of particulate Objectives and Standards between 1997 and 2003. I found that the network, models and policy were mutually constructed: "an interaction has taken place in which each has reinforced the others' validity and shaped their development" (Smith, 2003, p. 64). The PM_{10} Objectives for the AQS Review and the Addendum were determined by what the model and monitoring demonstrated feasible; but the models and monitoring data themselves "embodied the outcomes of predicted and actual policies determined by the policy-makers" (Smith, 2003, p. 64). This relationship of mutual construction precluded the use of alternative options for policy, models and monitoring strategies that were presented during the development of the AQS (Smith, 2003, p. 67).

I proposed that the mutual construction of policy and science was a product of "constraints placed upon the PM_{10} Objective by EC air quality policy, industry and transport – and the willingness or capability of policy-makers to regulate for further emissions reductions". Factors outside the mutually constructed monitoring network, models, and policy facilitated this relationship (Smith, 2003, pp. 72-73).

I also argued that further research was needed to determine the process by which factors outside the science-policy relationship constrained its form and progress. This study explores this further by examining not only the roles of scientists and policy-makers, but also those of stakeholders in the policy process of the AQS, and how their visions for the future may have shaped policy development.

This evidence suggests that modelled forecast hold a privileged position in policy development for air quality management and pollution control. The question raised by Smith (2003), of the wider reasons why this relationship develops has not yet been answered for the AQS.

2. Studies of the integration of ambient air quality policy into wider political and social concerns

A key purpose of the AQS was to bring together a wide range of actors and sectors in its plans to meet pollution targets (Longhurst et al., 2009). The UK and European air quality management strategies required coordination between and within institutions of government: both horizontal interactions (between departments and agencies at one level of governance) and vertical interactions (between local and national, national and international).

2.1. The extent of integration of the European Air Quality Framework and the Auto-Oil programme

Wettestad and Farmer (2006) examined the extent of integration between the EU Air Quality Framework Directive and the Auto-Oil programme (which planned vehicle and fuel emission standards), which were both developed in the 1990s. One purpose of the Auto Oil programme was to improve air quality throughout Europe, and the two programmes used the same WHO health protection guidelines as references points.

Wettestad and Farmer (2006) claimed that the Auto-Oil programme would have a greater impact on air quality than the European Air Quality Framework Directive. They argued that the two policies had not been well integrated during the planning stages. Vehicle emissions, a significant contributing factor to air quality was controlled by regulations set prior to the development of European pollution targets (although Wettstad and Farmer (2003, p21) were optimistic that there would be more coordination in the future). These authors argued that

the greatest interactions between the two policy areas would come during implementation, when the reduced road transport emission would impact on air quality targets.

2.2. Local and national integration of the UK Air Quality Strategies

Cannibal and Lemon (2000) studied implementation of the UK NAQS. They argued that whilst local authorities were held largely responsible for meeting the Objectives, there was confusion over how this should be done and where the power for implementation should be: in environmental health or planning or with another department. Guidance from different national government departments often contradicted that provided to support the NAQS. Bickerstaff and Walker (2003, p. 60) postulated that the powers of local authorities were "heavily circumscribed by central government prescription and resourcing". This they believed, led to approaches to implementation that were specifically about cleaning up pollution, rather than causing a cultural shift in attitudes towards air quality.

Studies from the Defra-funded Air Quality Management Resource Centre have shown that the problematic implementation of LAQM was not confined to Period 1. A recent longitudinal study of the integration of local authority air quality responsibilities into local transport plans between 1997 and 2007 found systemic problems in implementation. Olowoporoku, Hayes, Leksmono, Longhurst, and Parkhurst (2010, p. 385) concluded that "…improvements are often constrained by institutional complexities that create implementation gaps between national objectives and local decision-making outcomes".

At all levels of governance - local, national and international - the AQS is one of many different policies. Cannibal and Lemon (2000) postulated that all levels of government tended to prioritise the more traditional and better funded policy areas. In local transport policy, for example, safety, congestion and accessibility have been objects of policy for longer than air quality, and these are higher priorities for transport planning (Olowoporoku et al., 2010, p. 399). In national policy, Cannibal and Lemon (2000, p. 294) argued that air quality was not a priority because "… the older more established departments, as well as those whose interests are more in line with the philosophy of the ruling political party tend to dominate at the expense of others… a feature that can be seen in the dominance of the Treasury in all areas of policy-making over the last 20 years or so…". Far from being a holistic guiding policy, Cannibal and Lemon (2000, p. 289) concluded that the NAQS did little more than collect together existing policies under one umbrella.

The evidence provided by those studies suggests that the AQS has failed in its bid to be a holistic policy, affecting all aspects of pollution production. Areas traditionally separated from

each other by the institutions of policy (e.g. environment, health, transport, and land use planning) remain separate; and implementation of air quality policy has been problematic as a result. Integration of air quality policy into areas of policy including economic and transport policies has shown to be slow, or problematic, at national, local and international levels of governance.

2.3. Consideration of air quality concerns among the general public

Bickerstaff and Walker (2003) reviewed constructivist studies of public understanding of air pollution, focusing on studies of the UK. Their review demonstrated a lack of awareness of government-provided air quality information services, public scepticism regarding the implementation of measures to improve air quality, and a disconnect between the scientific representations of pollution of the AQS and common understanding of the issue. They pointed to the provision of information by government or government agencies and claim that

> *… the information provided bears little relationship to most people's encounters with, or cultural understandings of, air pollution, and in consequence is either dismissed as an irrelevance or at worst taken as (further) evidence of disingenuous government motivations in the provision of information.*
>
> (Bickerstaff & Walker, 2003, p. 52)

Lindley and Crabbe (2004, p. 309) agreed, claiming that:

> *This mismatch between the desire to represent the intricacies of air quality-related data and the need for clear and transparent information represents a fundamental conflict between researchers, policy makers and the wider public.*

Public disengagement with air pollution policy points to a mismatch between public understanding of air pollution and what is assumed by policy-makers in the UK (Lindley & Crabbe, 2004).

In addition, air pollution policy has been found to clash with public notions of private transport and car use. Bickerstaff and Walker (2003, p. 53) proposed that the general public regarded motor vehicles as the major source of air pollution. They claimed that there is a tendency to blame this pollution other road users – for example, parents on the school run or unpopular transport choices (buses and lorries). This, these authors claimed, was a means of distancing the individual from the problem.

Cannibal and Lemon (2000, p. 296) argued that in order to bring about changes in air quality there needs to be a "cognitive shift" amongst the general public regarding road transport use. They claim that the second AQS, the Revised Strategy, did recognise this; but that such a

change in attitudes was unlikely to be brought about by the financial measures included in the Revised Strategy or the NAQS.

3. Summary

Just as local authorities have struggled with the integration of air quality Objectives into policy silos, the general public have been reticent in their responses to information on the health effects of air pollution. As section 3 demonstrated, the sources of particulates (and other pollutants) often have social, economic, and personal benefits: the motor vehicle; industry and power generation. Moreover the benefits of these sources are visible: in the ease of transportation and the comforts of modern living; and in their contributions to economic growth.

Particulate pollution is invisible, its effects on health often unperceivable. It is mediated and understood through technologies, including models, monitors, and software to analyse its effects on health.

Reduction scenarios, too, are complex and contested: to develop the AQS Objectives policy-makers must weigh up the forecasts for future concentrations, and the possibilities for future reductions, through technological, policy or behavioural change.

Academic studies have neglected both the processes by which targets are set for air pollution reduction, and how these relate to strategies for their implementation. Instead studies have focused on the science/ policy interactions, and the processes of implementation. There has been little study of the other factors involved in policy development: the assumptions and expectations for future technological developments, policies and social behaviours.

There is a gap in this literature: how a target-based ambient pollution strategy is created, and develops. I argued that co-construction of science and policy occurred in the AQS in the face of external pressures (Smith, 2003). This thesis takes these findings and builds on them, to study how scientific expertise and knowledge was weighed against other forms

Chapter 4. Theoretical Framework

Chapters 1 and 2 characterised the AQS as an effects-based policy set in conditions of uncertainty and disputed science. Management of air quality through national policy requires integration of concerns for air quality into public and private decision-making, but previous studies have indicated that implementation and integration have been problematic (Cannibal & Lemon, 2000). This thesis investigates how targets for particulate matter were set and policies to attain them were formulated. The Introduction set out three preliminary research questions for doing so:

1. *What role did statements about the future play in each version of the AQS?*
2. *How did policy change in the light of new and often uncertain scientific understanding of particulates, their properties and behaviour, and their effects on health?*
3. *To what extent did modelled forecasts shape policy, and why?*

This chapter provides the theoretical framework through which these questions will be reframed and answered. It proposes here that the Sociology of Expectations (Borup et al., 2006; Van Lente, 1993) may be usefully applied to answering these research questions. Other scholars have primarily used this theoretical perspective to examine how statements of the future work as organising factors in science and innovation, and this thesis proposes to extend this framework by applying it to the policy process.

The Sociology of Expectations has not yet been used to examine the effects and interactions of multiple competing expectations, as I set out to do. However, discourse theorists have studied the interactions and impacts of multiple discourses on policy-making. To assist analysis, and to develop the Sociology of Expectations, the theory of Discourse Coalitions (Hajer, 1995) is introduced into this framework. (The scholarly debate about the nature of expectations and whether they are purely discursive is discussed in section 7 of this chapter.)

A discursive approach to analysis has several benefits and enables expansion of the Expectations theory: it illuminates the often unseen roles of different discourses in policy making, shows how political discourses can shape the definition of an environmental problem and thus direct both the political and scientific research agendas. A framework is developed in this chapter which uses these discursive analytical perspectives and theories of science in policy development to provide an approach to answering the research questions.

1. Positioning this study as an examination of the developments of a policy process

Keeley and Scoones (2003, p. 5) proposed that study of environmental policy processes asks whose interests are served, whose knowledge is included, and which actors are involved in policy development. They take the position that in environmental policy, science and knowledge are constructed and positions and power are contested.

Alternative theoretical positions have also been used to study policy development. For example, studies of agenda setting have examined the contiguous factors which have facilitated some issues becoming part of the policy agenda (Exworthy & Powell, 2004; Kingdon, 1993; Mucciaroni, 1992). Such studies have provided insights into the roles and functions of negotiations and dialogue between multiple actors in bringing issues to the policy agenda, and emphasises the role of individual protagonists in these processes (Lipson, 2007; Nowak, 2010). Whilst Kingdon's theory of agenda setting can explain non-incremental change well, this focus does not facilitate the examination of incremental or smaller-scale changes in policy once it is already on the agenda, because of its focus on the congruence of factors that allow issues come to the agenda in the first place, not how they change.

This thesis is not simply a study of agenda-setting, but of the institutionalisation of ideas: how environmental problems are defined and how solutions and policies for their management are constructed; and how the 'future' is constructed in the present.

2. Science and Policy

Following Keeley and Scoones (2003), and in the light of my previous study (Smith, 2003), this thesis makes the assumption that the Netcen model and air quality Objectives were mutually constructed. This thesis expands on these findings. In Smith (2003) I identified that further research was needed to determine the process by which factors outside the science-policy relationship constrained its form and progress: whose interests benefit from the construction, who commands the construction, and how factors outside the science/ policy nexus affected the development of both science and policy. Whether the same relationship of co-construction existed in the 2007 Strategy and accompanying modelling will be examined.

Whilst question 2 (*How did policy change in the light of new and often uncertain scientific understanding of particulates, their properties and behaviour, and their effects on health?*) may be viewed as naïve in view of the discussion here and in Chapter 3 regarding the social construction of air pollution science and the co-construction of the AQS and monitoring and modelling in the UK. However, when examined in conjunction with the other research

questions it may provide insight into factors contributing to policy development in the case of the AQS.

The Air Quality Strategy has been characterised as a linear process by the National Audit Office (National Audit Office, 2001a). That report claimed that the Revised Strategy had three distinct, linear components: in the first stage policy-makers collated and assessed health effects evidence; then in the second stage used this in conjunction with social, economic and political inputs to select the Objectives; and planning for implementation made up the third stage. This presents a *rational model* of science-policy relations in which scientific knowledge is objective and valid, and thus informs policy (Funtowicz & Strand, 2007). Question 2 address whether this is a useful and accurate characterisation of the policy framework and its development.

Question 2 amongst other things, tests whether the interpretation of the policy process by the NAO was correct: that the major causal factor in the developments in the AQS and the particles Objective was changes in scientific knowledge.

3. Management of future risks

While science and technology may have reduced the vulnerability of humanity to nature, so risks associated with technologies may have increased (Webster, 1999, p. 414). Giddens (1998) argued that, as a result, modern society is preoccupied with a future it does not feel it can control. Ulrich Beck's theory of Risk Society, too, presents risk management in the present as contributing to one of two futures: the first, the Risk Society, a continuation of current practices characterised by increasingly specialised sciences, distant from an alienated public, and managed by increasingly technocratic and undemocratic governance (Cohen, 1997, p. 108). The second path leads to a democratisation of science, societal learning, and the uptake of more benevolent technologies (Cohen, 1997, p. 108). Such societal-level theories of risk make assumptions and predictions of future societal behaviours, responses to risk and patterns of technological risk management, but do not examine how such behaviours and expectations act in the present.

4. The Sociology of Expectations

This study examines how statements about the future may change and spread in a policy community, and how this can impact policies made and actions taken by stakeholders. In recent years a growing body of literature has investigated the role of expectations of the future on sociotechnical change. This literature has become known as the Sociology of

Expectations (Borup et al., 2006). In their Introduction to the book *Contested Futures,* Brown, Rappert and Webster (2000, p. 4) proposed that this theoretical position can be used:

> *… to understand how it is that some futures come to prevail over others, why once seemingly certain futures happened to fail, how other futures are marginalised as a consequence of the dominant metaphors and motifs used in every day life, and the consequences of particular framings of the future.*

4.1. The Premises of the Sociology of Expectations

Sociology of Expectations has its roots in Science and Technology Studies (STS) perspectives (Borup et al., 2006, p. 287). STS is constructivist: it explores how technologies get their shape, taking as its premise that the development of technology is a social process, involving actors rooted in social, technical, economic and political processes (Hedgecoe & Martin, 2003, p. 330). Sociology of Expectations has adopted premises of STS including the socio-technical character of technology and knowledge production, the mutual construction of science and society, the focus on actors rather than structures, and on constructivism over rationalism and empiricism (Borup et al., 2006, p. 287). This approach argues that new technologies, knowledge and social relations occur simultaneously through mutual shaping (Hedgecoe & Martin, 2003, p. 329).

The central thesis of Sociology of Expectations is that the future is contested (Brown et al., 2000, p. 3) and indeterminate: technologies and scientific disciplines are not inevitable, but are first created in imagination, expectations, and promises (Van Lente, 1993). Each actor has a preferred vision of the future and will work to ensure that this becomes reality through "…rhetorical, organisational, and material action" (Brown et al., 2000, pp. 3-4), to the exclusion of the expectations of others'. Scholars also assume the existence of a negotiation space in which discourses about the future take place (Hedgecoe & Martin, 2003).

Scholars of expectations regard statements about the future as "….strategic resource[s] in political and technical agenda-setting processes" (Brown et al., 2000, p. 17). Borup et al. (2006) proposed that such statements create and establish the future, and as such are essential to technological development. Van Lente (1993, p. 187) described expectations as resources used by actors to "legitimate" their argument, "mobilize" funds and attention, and to "allow decision-making and *reduce the uncertainty* inherent in technological developments". Van Lente claimed that as a result of these factors, expectations can co-ordinate activities and shape agendas.

4.2. The sociotechnical nature of statements of expectation

Why do these scholars believe that statements of the future have those effects? Michael (2000) argued that it is because such statements are imperative and performative: they *require* action in the present. Borup et al. (2006, p. 289) proposed that they are also 'constitutive': they assign roles to actors in order to create the 'future' they describe. As a result, statements of the future under this perspective are both about technologies and actor roles (Konrad, 2006, p. 431).

4.3. Statements of expectations serve to reduce uncertainties

Frans Berkhout (2006, p. 305) proposed that expectations can also function to map the "possibility space" . The range of expectations articulated by actors may show the alternatives available for technologies, their sociotechnical functions, and means for achieving them. Brown et al. (2003, p. 3) argued that making a statement of expectation does not make the speaker accountable for their transition to reality, but does require the speaker to be able to justify the statement, and, implicitly or explicitly, to create a promise that the speaker will work towards attaining this future. As support for a future grows, more actors take on this shared agenda and act upon it (Borup et al., 2006, p. 289), and this expectation gains momentum. Expectations can be self-fulfilling as a result of this momentum, but this is not always the case.

In their review of Sociology of Expectations studies, Borup et al. (2006, p. 287) proposed that actors use expectations and promises in order to make decisions, even if it is unlikely that the promises will become reality. Statements of expectation thus function to broker relationships between groups, and provide common reference points for action (Borup et al., 2006).

4.4. The impact of expectations on the present

The Expectations framework has provided insights into how technologies and technological fields have developed (Van Lente, 1993), and how new scientific disciplines and associated technologies and values become established (Hedgecoe & Martin, 2003). Expectations have been shown to be important in the early stages of the innovation process for shaping technological development and providing early support for new ideas (Brown et al., 2003), and seem to shape technological development rather than simply being public relations tactics (Van Lente, 1993). Scholars have considered the dynamics of expectations in government policies such as Foresight, which directly aim to influence innovation (e.g. De Laat, 2000; Webster, 1999). Others have utilised aspects of Expectations theory in the concept of technological regime change (e.g. Geels & Raven, 2006; Smith, Stirling, & Berkhout, 2004). Scholars of expectations have found that in the early stages of technological developments

expectations are essential to gain interest, create actor roles, and make actors accountable for their fulfilment (Van Merkerk & Robinson, 2006, p. 412). Such studies have drawn attention to the contribution of expectations to path dependency in innovation and scientific fields (De Laat, 2000)[5].

5. Sociology of Expectations and policy processes

These studies together present statements of expectation as essential to the processes of bringing ideas for innovation to fruition in technologies (c.f.Geels & Smith, 2000). Such concepts are potentially useful for the study of policy development, for policies such as the AQS which are based on decisions about potential futures. In 1993, in the first systematic sociological study of expectations, Harro Van Lente (1993, p. 11) argued that "… with the increased importance of making 'strategic' decisions in policy circles as well as in industry, the importance of expectations and promises appears to be increasing." However, to date there has been no study of the dynamics of expectations in policy outside of innovation policy.

Whilst not primarily about innovation and adoption, each AQS relied on expectations of technological developments to set targets and formulate policies. Examining the changes in expectations for the future between each version of the Strategy potentially shows why some are taken up and others are curtailed. This theoretical position potentially provides insights into why one 'future' can gain attention and support, and then be replaced by another.

This thesis proposes that the Sociology of Expectations could be an appropriate theoretical position from which to examine the development of the Air Quality Strategy. However, to answer the research questions it is essential to examine *how* and *why* multiple expectations of the future change and interact over time. These processes by which expectations exert their influences as organising factors are known as the *dynamics* of expectations (Borup et al., 2006).

[5] Sociology of Expectations shares concepts with the study of *leitbilder* – shared, prescriptive guiding visions developed by collaborating actors (Quist, 2008). These provide a shared goal, against which actions and plans can be evaluated. The *leitbilder* perspective is more normative and focused on changing real-world practices than this study requires, Both l*eitbilder* and Expectations study the "continuous or stepwise institutionalisation of ideas" (Späth, 2008, p. 5), but whilst *leitbilder* studies aim to provide tools and advice, and the author is an active participant within the area studied, Expectations studies aim to provide a more general understanding of how the future is contested and the author is an observer. The two literatures are sometimes treated as interchangeable, but the focus of *leitbild* on the conscious collaboration to form a vision is different to the study of the past dynamics of one or several visions.

6. The Dynamics of Expectations

The Collins dictionary defined dynamics as "those forces that produce change in any field or system" ("Collins Concise English Dictionary," 2008, p. 509). Van Lente (1993, p. 35) defined dynamics of expectations as the mechanisms by which expectations are generated, recognised, supported, and how they become "requirements, arguments, hope and facts". A central contention of Expectation theory is that these dynamics significantly impact on the speed and the nature of technological change (Konrad, 2006, p. 429). The scope of analysis of Sociology of Expectations has been the activities in the present and the impact of the stated expectations of one actor on the expectations and actions of others.

6.1. Linear dynamics of expectations in innovation

The role of expectations in innovation has often been portrayed as linear and sequential: for example, "…from promise to requirement" (Van Lente, 2000). A cycle of promise and requirement was proposed by Van Lente (1993) and extended by Geels and Smith (2000). This cycle traced the dissemination of a vision from a single actor to part of the collective agenda and its transformation into a 'requirement' – an imperative to act to fulfil it.

Konrad (2006, p. 432) criticised this cycle for diminishing the role of the *social* in sociotechnical expectations, through its portrayal of expectations dynamics as a unilateral process, rather than one of discussion and exchange. Such a cycle, potentially of use in the study of innovation in a situation in which there are no competing visions, cannot be applied to a contested dynamic policy-making process. It assumes that actors do not communicate with each other, except in prescribed points on the cycle, and gives the impression that expectations become requirement as a result of strength of numbers in support, rather than through negotiation. There is also no room for the vision to evolve and change.

Similarly, attempts to characterise the inflation and collapse of expectations in a 'hype-disappointment' cycle (e.g. the Gartner group, cited in Borup et al, 2006) focus only on one expectation, without interaction of others. Such cycles cannot provide insight into the mechanisms of multiple dynamics, or the contingencies of human interactions - both necessary for analysis of presentation and uptake of visions in a policy context.

6.2. The effects of dynamics of expectations

If the dynamics of expectations do not always resemble those of the promise/ requirement or hype/ disappointment cycle, what generalisations can be made about them?

Studies of the dynamics of expectations have focused on three organising effects of expectation dynamic (Borup et al., 2006, p. 286):

1. **To coordinate actors and groups:** Scholars have proposed that networks of actors are formed around shared expectations in early stages of product development (Brown, Rappert and Webster, 2000; Hedgecoe & Martin, 2003). Brown and Michael (2003) argued that in the case of innovation, new technologies emerge in established networks, but that in order to succeed, expectations work to destabilise old networks and establish new ones. Conversely, Brown, Rip and Van Lente (2003, p. 5) also proposed that when actor networks are relatively stable, expectations can be used to protect the current network and actor roles.

   This assumption is a potentially useful one for analysis of expectation dynamics because it provides insight into how expectations change the organisations and relationships of actors. This focuses analysis of expectation dynamics on the *social* aspects of sociotechnical change, and the power of expectations to organise actors, rather than simply on the nature of technological change they produce.

2. **To connect different scales of expectations:** Van Lente (1993) studied how expectations differ at the *micro* level (at the level of the firm or lab), *meso* (the competition between visions for different technologies at sector level), and *macro* (at the level of society) and how expectations interact between each scale.

3. **To explain changes in expectations over time:** Wyatt (2000) and Brown (2000) traced expectations in the form of metaphors for technologies or technological change, and their proliferation over time. Brown (2000) found that changes in social and political context over time, as well as the qualities of the metaphor were partially responsible for its growth in discourse.

These studies traced the impacts of only one expectation at a time. For example, whilst Brown (2000) studied the proliferation of two metaphors for technological change, they did not examine the potential for the growth of one to affect the other.

6.3. The dynamics of interacting, multiple expectations

Expectations theory does recognise the existence of multiple, competing visions. Borup et al. (2006, p. 289) claim that they "probably" exist at early stages of innovation. However, only one study, so far, has examined competing expectations for technological change: van Lente and Bakker (2010) examined the dynamics of competing visions for potential technological solutions to the problem of how to store hydrogen as fuel in hydrogen –powered vehicles.

They concluded that visions for future solutions were in competition with each other, and suggested adding an "…expectations phase…" as the first stage in models of innovation processes. Visions came from R&D, policy-making, the advocacy of non-governmental organisations, and from demonstration projects. These competed for both the market share of a technology, and the shorter-term gains of a place on the research agenda of organisations including governments and firms.

Apart from this single study, why have the dynamics of multiple visions and expectations not been investigated?

One reason could be that due to the necessarily retrospective nature of Expectations studies, it is difficult to trace actors' formerly-held unsuccessful expectations. Brown and Michael (2003, p. 7) argued that actors have a tendency to redefine past expectations in the light of present realities, and so studying retrospective expectations is difficult. van Lente and Bakker (2010) purposefully avoided this by examining visions for technological solutions which were still being developed.

No study has yet followed multiple visions and expectations over time to trace how one becomes successful over others; or how this relative prominence may change over time. This is a significant gap in the Expectations literature, and one of the means by which this study aims to contribute to the literature.

Studying the role of expectations dynamics in the policy process could help to solve some of the problematic issues of studying dynamics of multiple expectations in the innovation process. In the policy-making process actors may work to gain support for their visions, to gain legitimacy, resources and further support for their preferred future. They act within the policy space, and can be seen to have succeeded or failed on whether their visions and expectations are embodied in policies – both textually and practically. Their previously articulated visions and expectations are often on the record: in policy documents, in meeting minutes, in consultation responses and in government records, so any changes in expectations could potentially be investigated.

The research questions of this thesis take as their point of departure that, although one set of targets and policies developed for particulate matter in the AQS, there was the potential for different sets to have developed instead. Question 1 asked: what role did statements about the future have in each version of the AQS?

Reframing of research question 1 utilising the Sociology of Expectations asks;

1. How do expectations of future technologies, policies, and their impacts affect the creation of target-based policies for sustainable development? Do these policies subsequently shape expectations and if so, how? Can the changes in the AQS between 1997 and 2007 be explained by these dynamics of expectations?

This research question requires analysis of the contribution and dynamics of the expectations presented as part of the policy-making process at each stage of the AQS. The thesis proposes to extend the Sociology of Expectations in two ways: by its application to the policy process, and in the analysis of the dynamics of multiple expectations over time.

7. Discourse theories

The posited organising factors of expectations means that they shape actor roles, institutions, and resource allocations. In both their material outcomes and discursive shaping, the behaviour of statements about the future bears more than a little resemblance to that of discourses, as presented in studies examining the roles of discourses in policy formation.

Konrad (2006) argues that studies of Expectations can reveal how "taken-for-granted" knowledge shapes actors' understanding of the world – as theories of discourse also do. Both Expectations and Discourse Coalitions theories serve to explore the institutionalisation of ideas through language and their organisation of actors, in the areas of innovation and policy respectively. As the Sociology of Expectations perspective examines the institutionalisation of concepts about the future in language, roles and practices in the present, so Discourse Coalitions is about the institutionalisation of ideas in policy, language, institutions and practices. Such a theoretical perspective provides the scholar with tools to identify multiple discourses and to trace their usage over time. Perspectives on discourse have been used to examine the constructive and organising role of language in the definition and management of environmental problems (Keeley & Scoones, 2003): not simply the points at which language is used, but how discourses define institutions, actions, problems, and solutions.

Whilst there are many approaches to discourse analysis and theory (cf Phillips & Jorgesen, 2002), this thesis draws primarily on Hajer's (1995) work on discourse coalitions. Hajer and Versteeg's definition of discourse as "an ensemble of ideas, concepts and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of practices" (Hajer & Versteeg, 2005, p. 175). This definition is widely accepted by scholars of the interactions of discourses in the development of policy.

Studies of discourses in policy development rest on three assumptions:

1. **Environmental problems are socially constructed through "expert language and concepts, research practices and available technology**" (Feindt & Oels, 2005, p. 162). Hajer (1995, p. 61) characterises complex environmental problems as "inter-discursive", requiring different types of scientific knowledge, and other forms of specialist knowledge. For example, PM_{10} was not defined as a health problem until it could be measured, and the technologies were available to assess its effects on health. By taking a critical stance on widely-accepted knowledge (Sharp & Richardson, 2001, p. 194), discourse analysis enables the researcher to look beyond the accepted definitions of an environmental problem to see which definition came to dominate that particular area and why.

   Such assumptions of the construction of science and of the mutual construction of science and policy are not unique to discourse analysis. However, this discursive approach may be useful in integrating analysis of discourses about the future with that of the uses of scientific evidence in the policy-making processes of the AQS.

2. **This social construction of problems constrains possible solutions and actions.** Problem definition has consequences for policy, including determination of the requirements for regulation, and the limits of potential policies and activities (Van Roozendaal, 2002). For this reason, definitions of environmental problems are often contested (for example, in debates in the USA over the nature of climate change (Oreskes & Conway, 2010).

Hajer (1995, p. 62) termed this process by which discourses and associated storylines change institutions, practices and meanings through domination of a policy area "discursive closure". Under this theoretical perspective, the discursive context and problem definition that is dominant in a policy area would determine which expectations for the future could be seen as valid solutions or options.

3. **The concepts which make up the discourse have their basis in material and institutional practices, and themselves affect practices and institutions** (Feindt & Oels, 2005, p. 161). The Discourse Coalitions theory does not lose sight of the material world: discourses are manifested in the institutions and practices which manage an environmental problem. Hajer (1995, p. 52) argued that discourse creates and sustains functions, actions, roles, and the specific nature of institutions; the power of the institution is determined by the power of the discourse.

Hajer's discourse theory, following Foucault, maintains that discourses happen in a world of actors, institutions and practices (Feindt & Oels, 2005, p. 164). Discourses are enabled or constrained by their material context and in turn discourses change the roles, identities, practices, and institutions (Phillips & Jorgesen, 2002, p. 9). However, it remains a concern that taken to an extreme, discourse theory may invert the relationship between language and materiality, by putting more emphasis on the significance of language than on the properties of the physical world.

7.1. Competition between discourses

Hajer (1995) used this theoretical perspective to examine multiple discourses acting in one policy area, and asked why one may achieve discursive closure, and others are marginalised. Discussions about an environmental problem and its potential solutions can involve multiple discourses, which themselves can be more-or-less wide-ranging and coherent (Hajer, 1995, p. 45). Actors attempt to influence policy definition and the policy process through defining the dominant discourse (Hajer & Versteeg, 2005, p. 177). To analyse communication between discourses, Hajer presented the concept of 'discourse coalitions' and 'storylines'.

Hajer (1995, p. 65) defined 'Discourse Coalitions' as the actors who support a discourse at any specific time, the storyline(s) they ascribe to, and the practices in which the discursive activity takes place. However, this perspective argues that discourses are not authored by particular individuals, but emerge as "the cumulative effect of many practices" (Keeley & Scoones, 2003, p. 37). In the creation of environmental problems, discourse coalitions aim to attain support for their storyline and discourse, and to gain discursive hegemony in a policy area. Changes or continuation in actor roles and institutions are conceptualised as changes in the relative power and dominance of different competing discourses. Hajer (1995, p. 125) argued that "constant discursive reproduction" is required to maintain a discourse. Current discursive competition takes place in the historical context of past discursive struggles: current institutions and practices are the tangible outcome of past conflicts. This leads to the potentially problematic assumption of a simple, cause-and-effect relationship between the definition of a problem and the outcomes of policy in studies of discourse (Keeley & Scoones, 2003, p. 21).

7.2. The significance of storylines

The concept of storylines may assist in determining whether expectations are discourses in the sense used by Hajer, who proposed that discourse coalitions are formed and held together by actor's adhesion to shared storylines. Storylines are simplified narratives used to reduce complex issues, which enable actors to give meaning to artefacts and actions, and to make sense of areas of expertise and discourses beyond their own (Hajer, 1995, p. 63).

Often one part of a storyline can be used by actors to conjure up the whole. In policy-making, the complexity of the environmental problem is often simplified into 'emblematic issues'. For example, emblematic issues such as 'acid rain' or 'climate change' triggers the storylines an actor holds about that issue (Ockwell & Rydin, 2006, p. 383). 'Clean air' is an emblematic issue in the air quality debate: a metaphor that works as a simplification of complexity, and on which competition between storylines can focus. In storylines actors create their own understanding of complex problems, through simplification, over-simplification, reinterpretation of complex knowledge, and the creation of coherence from incomplete and uncertain knowledge. Storylines can be used to assign roles and responsibilities for actors.

Storylines are not necessarily well defined, and can be formed of only loosely connect concepts: Hajer (1995) states that they "suggest a common understanding" between actors, rather than actually providing one. Rather, interpretative flexibility is required for a storyline to appeal to a variety of actors, who can interpret its meanings differently (Hajer & Versteeg, 2005, p. 177). Smith and Kern (2007, p. 5) argued that successful storylines share overlapping concerns with other storylines, so increasing the range of actors and interests to whom the storyline can appeal. Thus, the simplifications provided by storylines attract a range of actors into discourse coalitions. The success of a storyline and discourse can be seen in the extent to which the previously adaptable storyline becomes intractable in institutionalisation (Smith and Kern, 2009, p. 81).

8. Expectations and discourses

Several researchers have drawn attention to the commonalities of Expectations and Discourse Coalitions theories (for example, Berkhout, 2006; Brown and Michael, 2003; Späth, 2008). However, the relationship between the two perspectives has not been critically examined. Whilst the Sociology of Expectations approach has the advantage of analysing expectations from a range of mediums (including modelled forecasts and speech), it does not comment on the formation of environmental problems.

Utilising assumptions from discourse coalitions theory in this theoretical framework may assist in two under-examined aspects of Sociology of Expectations: in explaining the dynamics of multiple expectations, and to test the similarities of the Expectations and Discourse frameworks.

Both Expectations and Discourse Coalitions theorists assume sociotechnical change is shaped through discourse. Sociology of Expectations studies have been criticised for focusing on the technological aspects of sociotechnical change, at the expense of the social (Brown and

Michael, 2003; Konrad, 2006). Brown and Michael (2003) argued that this is not purely a theoretical problem, but also the reason that many visions fail. Discourse Coalitions theory emphasises the social, cultural, and historical context of sociotechnical change, and for this reason may augment the Sociology of Expectations framework in this study.

8.1. Are expectations discourses about the future?

Brown, Rapper and Webster (2000, p. 5) argued that 'the future' is itself a discourse:

> *Like all discourses, 'the future' is constituted through an unstable field of language, practice and materiality in which various disciplines, capacities and actors compete for the right to represent near and far term developments.*

Following this conceptualisation of expectations, visions may be interpreted as discourses about the emblematic issue of 'the future'. Berkhout (2006, p. 308) argued that the success of a *vision* is determined by those interests who dominate a "discourse about alternative futures", and/ or the vision's attractiveness to a wide range of interests. Berkhout (2006, p. 305) uses much of the language of discourse coalitions; for example arguing that "storylines about visions and expectations are important for the enrolment of different actors into coalitions for or against change". However, this article is purely theoretical.

Späth and Rohracher (2010) equated *leitbilder* or guiding visions with discourses, and those who supported them with discourse coalitions. They examined the development of a guiding vision (*leitbild*) for an 'energy region' of Austria, including an assessment of how the guiding vision was institutionalised at different levels of regional governance, and how it impacted on wider socio-technical change. These authors identified storylines which accompanied the vision, and gave examples of how the discourse came to dominate the regional discursive space.

However *Leitbilder* are formulated and used intentionally to "….co-shape technical change in a multi-level, multi-actor process…" (Späth & Rohracher, 2010, p. 456). Unlike expectations and visions (as defined here), *leitbilder* are collaborative and deliberately constructed. Expectations, in part because they are analysed in retrospect, are not necessarily deliberately constructed, less collaborative, more haphazard and individualistic.

However studies of Expectation have also provided evidence that the development of visions and formation of coalitions around them happen simultaneously: Guice (1999, p. 82) argued that actors seeking to effect significant change in the direction of research and engineering act to

> "…form a coalition representing various elements of prospective technical order; and they use arguments as well as behaviour to reorient others' evaluations of the technical potential of the new approach."

From this perspective, building a supportive coalition and the development of visions are simultaneous. Hedgecoe and Martin (2003, p. 331) also argued that coalition formation can be an important element in the formation of visions: the one contributes to the other. They use the example of alliances formed between researchers in academia, drug companies and industry actors in the development of the field of pharmacogenetics.

8.2. Are expectations expressions of wider discourses?

An alternative perspective on the relationship between expectations and discourses is that expectations are articulations of wider political discourses. Expectations and visions are constituted and spread through discourse, but it is not certain that they always agree with wider discourses articulated in environmental policy processes.

A fourth research question is asked to test this relationship:

> 4. Are expectations and promises articulated by actors in the policy process of the AQS part of larger discourses about policy and technological change?

Visions and storylines

If visions are discourses, then they may have a storyline uniting actors into discourse coalitions for their support. There is some evidence that actors do use storylines to promote specific visions for sociotechnical change.

Two studies of Expectations have examined the means by which visions were communicated to other actors (the use of the term vision is specific here). Eames, McDowall, Hodson, and Marvin (2006, p. 362) examined the vision of "the hydrogen economy" and identified six narratives which supported this vision (ecotopia, hydrogen as technical fix, inevitability and technical progress and 'staying in the race). All narratives were characterised as competing with each other. Eames et al. (2006) showed that a shared "script" (with commensurate positioning, roles, and requirements for action) had developed from these narratives. Interpretative flexibility of the vision, they concluded, enabled a large variety of actors to join in support of one vision – from those who see hydrogen technology as maintaining the status quo of current power relations, to those who see it as the catalyst necessary for a paradigm shift to a decentralised, more democratic way of life. The interpretative flexibility of the vision

enabled different combinations of narratives to appeal and gain support. In this example[6], one simplified storyline does not dominate and guide the supporters, but multiple storylines (referred to as 'narratives') served to enrol others into the vision.

Bakker et al. (2011) also provide insight into the use of narratives in disseminating expectations. Their study examined the narratives used by the 'metal hydrides community' (those conducting research into metal hydrides as a potential solution to the quandary of hydrogen storage in vehicles powered by that source). The authors found two overall narratives: one used to present the vision to their peers, and one to those outside the community, for example potential sponsors and those working on policy roadmaps for hydrogen technologies. The narratives are articulated by different members of the metal hydride community. Large scale narratives which outlined the potential feasibility of metal hydrides as a hydrogen storage solution are presented to the wider groups of actors involved in shaping hydrogen technologies, and involve only those members of the community who act as its spokespeople. The second narrative consisted of "small scale expectations work" in research papers and proposals. These small scale promises were more guarded and provisional – as a means of avoiding disappointment (Bakker et al., 2011, p. 158).

Those two studies suggest that visions can be accompanied by narratives to justify, to explain and to promote them. Such visions and narratives serve to assign role and position other actors, as do storylines in Hajer's (1995) discourse theory. However, the narratives used in these studies of expectations are substantially different from Hajer's (1995) storylines. Whilst Hajer (1995) defines storylines as a "generative narrative" which provides a simplified version of complex issues, and allows actors who hold it to give meaning to artefacts and events, a 'narrative' provides support for the vision as it is presented to a specific group or actor, and is a means of gaining support and resources – of mobilising the future into the present. This narrative may simplify the complex, but its primary purpose is to communicate and spread the vision.

Positioning

In both Sociology of Expectations and Discourse Coalitions theories the discourse serves to position both the actor who articulates it and other actors. Hajer (1995) drew on positioning

[6] By identifying the hydrogen economy as a 'guiding vision' (leitbild), Eames and colleagues demonstrate the overlaps between the retrospective Sociology of Expectations and the prospective Leitbilder studies. For the purposes of this thesis, the retrospective nature of their work makes their work a study of expectations.

theory of interpersonal interactions for concepts of storylines and positioning. Storylines serve to position actors – to ascribe them roles, responsibilities and identities. Through positioning storylines create social and moral order (Ockwell & Rydin, 2006, p. 384) because they attribute responsibilities and blame, and define what is important. Ockwell and Rydin (2006, p. 384) conclude that storylines provide the relationships between expert knowledge and claims about morality and values.

Expectations and visions can also serve as tools for positioning actors implicitly and explicitly, by providing them with roles and identities for attaining the envisioned future (e.g. Geels & Raven, 2006; Van Lente, 1993). Positioning is viewed by these authors as an essential role of expectations in the development of a vision to a requirement.

Expectations can be treated as a form of discourse, yet whether they are small aspects of larger discourses regarding specific aspects of sociotechnical change, after Hajer (1995), or simply discourses around the future is an open question. After reviewing key points of agreement and disagreement it is suggested here that whilst expectations and discourses share the common point of positioning other actors, they differ in their narratives and storylines, and in the ways in which actors can choose to use them. However, these points may not be true for every expectation or discourse in every situation.

9. The Credibility of Expectations about the future

A weakness of the Sociology of Expectations theory is that it has not yet been able to characterise or explain why some expectations are taken up and thrive, whilst other perish. This is because Expectations research focuses on the interactions between actors and processes by which one set of expectations achieve their success, rather than on the qualities of competing expectations.

These gaps in explanatory power have not gone unnoticed: Brown, Rip and Van Lente (2003) and Berkhout (2006) pointed out that both the qualities of expectations and their selection environment are seldom considered in the Expectations literature.

This thesis calls characteristics which influence the uptake of expectations the *credibility* of the expectation: *the quality of being believed or trusted* ("Collins Concise English Dictionary," 2008, p. 389)[7]. To answer research question 3, a fifth research question is introduced:

[7] 'Credibility' has been used to signify different qualities by some authors discussed in this chapter (e.g. {Tuinstra, 1996 @351@author-year) defines it as "scientific and technical believability").

5. Why were some expectations and visions regarded as more credible than others by policy-makers?

To answer question 5 it is necessary to examine the perceived relative credibility of the visions and expectations which were presented to decision-makers involved in the policy process of the AQS, and to find out the reasons why some were accepted and others were not. Examination of how policy-makers decided between multiple expectations about the future may also provide evidence to answer Research Question 3 (*to what extent did modelling determine policy, and why?*), through the comparison of perceived credibility of those and other sources, and whether it changed over time.

9.1. Credibility in the Expectations literature

Berkhout (2006, p. 306) identified three broad factors which he believed contribute towards a vision's credibility: the influence and power of actors who support the vision, the content of the vision itself and its appeal, and the cultural and political context in which expectations are made and received.

Whilst Berkhout's discussion was purely theoretical, scholars of Expectations have examined contributing factors to in studies. Issues which have been found to contribute to relative credibility include:

- The timescale of the vision: visions looking further into the future are scrutinised less closely than those for the shorter term (Pollock & Williams, 2010, p. 528);
- Greater interpretative flexibility provides credibility for a vision to a greater range of actors (Eames et al., 2006),
- Actors can work to discredit those with competing visions (van Lente & Bakker, 2010).

In situations where actors have unequal knowledge, promises and expectations can be hyperbolic (Brown and Michael, 2003). Indeed, such hype has been shown to be important at the early stages of innovation (Brown, 2003) and in the presentation of the future promises of scientific research (Brown and Michael, 2003). In contrast however, Guice (1999, p. 95) found that visions more obviously promoting the speakers' interest may not gain as much support from an audience compared with those that are more understated.

The almost-inevitable disappointment after an expectation has been hyped, and subsequent readjustment of expectations suggests that credibility of expectations can be both lost and renegotiated. Loss of credibility caused by failure of an expectation's content can be significantly damaging: Brown (2003) demonstrated that cumulative disappointments in

biotechnology, nanotechnology and stem cell treatments have caused long-term damage to the credibility of those who articulated expectations about them. However, this is not always the case (Pollock & Williams, 2010).

Brown, Rappert and Webster (2000) claimed that Expectations literature generally assumes that visions supported by relatively powerful actors (e.g. governments or large firms) will have greater chances for success than those held by less powerful actors. Findings from environmental psychology suggest that it is not necessarily always the more powerful that are most trusted (for example, Trumbo and McComas (2003) found that environmental NGOs are perceived as more credible than state and federal government institutions). Credibility may vary with the circumstances of each case, and depend as much on audience as speaker.

Bakker et al. (2011, p. 157) suggested that a community built around a technology can anticipate its future selection environment: "It has an understanding of what its selectors desire and thus what its message should be". In their study the community adapted their articulated expectations about the technology to the characteristics of the selection environment, including the current dominant expectations, visions and discourses.

This brief review demonstrates that studies have identified aspects of expectations which may contribute to their credibility, but it is not yet clear whether any of these factors can be generalised. This thesis studies how and why policy-makers took up one set of expectations and rejected others in the process of policy development: it is the *relative* credibility of the vision that is significant in this case.

9.2. Credibility and the medium of communication

Research question 4 asks *to what extent did modelling determine policy – and why?* A straightforward answer to this question would be that the Netcen model provided the best scientific advice to policy-makers on what levels of pollution reduction could be achieved and how (see Reid, Misra, Amman, and Hales (2007) who claim this for atmospheric modelling more generally). However, Chapter 2 indicated that the Netcen model used in AQ policy development made predictions for issues which were themselves not science: for example, the state of the economy, assumptions about human behaviour and for potential technological and policy changes. This thesis proposes to examine the Netcen model in terms of the relative credibility of the expectations presented through its forecasts, to policy-makers in AEQ and from other relevant institutions.

Brown, Rappert and Webster (2000, p. 12) argued that models are "… used as aids to think through possible futures which might then be actively pursued", and posed the question of whether those who are modelled actively construct the modelled future, or whether they were co-opted into a specific "text". Michael (2000) proposed that the medium in which expectation are communicated affects the portrayal of the expectation, a concept he calls "textualisation". In examining credibility, and to answer research question four, this thesis suggests that it will be productive to examine how expectations were embodied in computer models for policy development and whether this affected their relative credibility.

Shackley and Wynne (1995b, p. 221) propose that co-construction and policy serves to lend credibility to both (and this finding has been replicated by Tuinstra et al. (2006)). They proposed that the trustworthiness of models emerges from "institutional interactions and commitments and in particular from certain large unstated policy assumptions and 'styles'" (Shackley & Wynne, 1995a, p. 219). This draws on Gieryn's (1999) premise that the construction of science that is accepted as reality generally advances the position of those who formulate it. However Shackley and Wynne also suggest that any recognition by third parties of the co-construction of science and policy may lead them to question the credibility of model.

Under this formulation, examining the relative credibility of any expectations presented in the Netcen model to policy-makers, compared with other statements, may provide evidence toward research questions 3 and 5.

9.3. Discourse coalitions and credibility

A discourse's credibility is essential for it to gain support, acceptability and trust (Hajer, 1995, p. 59). Sharp and Richardson (2001, p. 198) described this competition between discourses, as "… a view of social change as shaped by power, conceptualised as a competition between differing systems of meaning". That is, under Hajer's construction of discourse (and generally in Foucaultian perspectives on discourse (Litfin, 1994, p. 20)) power relations and knowledge are inseparable. This links the credibility of a discourse to the power it embodies. A discourse embodied in institutions, practices and routines determines what can be assumed credible by speakers and their audiences.

Practically, for an actor to accept a positioning by a discourse, Hajer (1995, p. 59) argues the discourse must be credible to them. For an actor to be seen as credible by others, Hajer (1995, pp. 60-61) argued that they must use the language, concepts, and categories of a dominant discourse in a domain (referred to as the "condition of discourse structuration"). Power of a

discourse lies also in how it performs when in conflict with others – in how actors use it, and use it to construct new meanings (Hajer & Versteeg, 2005, p. 182). Thus what is considered credible can change as a result of interaction and conflict between discourses.

Once more, this Discourse Coalitions theory could provide insight into the relative credibility of expectations. Under this theory, existing institutional structures and dominant discourses would determine which expectations could be considered as credible, and which would be immediately curtailed.

The Expectations perspective allows only a limited role for the audience to whom expectations are made: it is assumed that they accept or reject expectations, but few studies have examined the role of the audience in this process. Berkhout (2006, p. 306) argues that audiences "… align themselves to visions of the future that are aligned with their interests and which they believe they have the resources to achieve (or which they believe they can convince other powerful actors to achieve with them)." It is intuitively plausible that audiences would adopt the visions which fitted with their interests. Yet Konrad (2006) draws attention to the phenomenon of 'collective expectations' – those which have become taken-for-granted by a group or society, whether or not they work in an actor's favour. Collective expectations indicate that actors can attribute credibility to expectations, even when they do not agree with the content.

9.4. Testing relative credibility

This review of the literature suggests that a wide range of factors may have an impact on how policy-makers perceive an expectation's credibility. This study examines why certain expectations may become part of the policy process, and why others do not. It assumes that the content of an expectation cannot be the only contributing factor to its acceptance and success.

The dynamics of expectations in both policy and technology developments cannot be fully understood without asking the question of *why* some expectations proliferate, and others are curtailed. However, it is not possible within the scope of this DPhil to investigate all the issues raised in the literature review which could impact on credibility.

By examining the significance of the means of communication of the expectation, and in identification of which expectations were taken up and discarded by policy-makers over the course of the AQS, it may be possible to add to the growing evidence on relative credibility.

10. The Theoretical Framework

This chapter has articulated three strands of theoretical framework which will be used to answer the research questions identified in this chapter and in the Introduction. The reframed research questions are as follows:

1. How do expectations and promises of future technologies, policies, and their impacts affect the creation of target-based policies for sustainable development? How do these policies subsequently shape expectations? Can the changes in the AQS between 1997 and 2007 be explained by these dynamics of expectations?

2. How did policy change in the light of new and often uncertain scientific understanding of particulates, their properties and behaviour, and their effects on health?

3. To what extent did modelled forecasts shape policy, and why?

4. Are expectations and promises articulated by actors in the process of forming the AQS part of larger discourses about policy and technological change?

5. What made some expectations more credible than others to policy-makers?

The Theoretical Framework outlined in this chapter will aim to answer these research questions. In developing this framework, this thesis has become a comparative study of the role of three potentially complementary explanatory factors for the developments in the Air Quality Strategy:

- The role of expectations and visions as organising factors
- the role of larger discourses,
- And to a lesser extent, the role of science in policy-making, compared to other factors.

11. Contributions to knowledge

This thesis expands the Sociology of Expectations by applying it to the policy process, and examining the dynamics of multiple dynamics in that setting. It proposed that policy-making process of the AQS may be appropriate for study of the interaction of multiple expectations because of the many actors involved.

Secondly, this thesis seeks to gain understanding into the relationship between expectations and discourse coalitions. It is not clear whether expectations are part of wider discourses, or whether they can be articulated separately.

Third, this thesis attempts to put the science-policy relationship in context by examining these features. It is hoped that combining these factors in one framework will then provide insights into how credibility in the eyes of policy-makers can be gained by expectations about the future.

Chapter 5. Methodology

This chapter sets out the means by which this study set out to answer the research and the research design utilised in this thesis. It provides an outline of the methodologies used to collect and analyse data, and assesses the potential weaknesses in this design.

The Theoretical Framework transformed the research questions identified in the Introduction into a set of questions which test not only the policy process of the AQS, but also the utility of three explanatory factors in the study of the AQS. These factors are:

- The role of expectations about the future
- The role of wider discourses
- The role of science in policy decisions – including both scientific discoveries about the health effects of particles, and the use of modelled forecasts for policy-making.

Such comparative studies have been used by scholars to test the reasons and assumptions underlying policy-makes choices and developments in policy, and to provide a more rounded account than can be made using only one framework (Allison, 1971).

1. The methodological approach

Studies of expectations dynamics and of discourses typically take a constructivist approach. That is, they assume that knowledge is not neutral and objective, but created and shaped by interested groups and individuals (Keeley & Scoones, 2003). The Expectations framework requires the retrospective examination of statements of expectations from a variety of sources, with a focus on language used. The discursive approach also demands analysis of stability and change in language and discourse.

Research Questions 2 and 3[8] examine the impact of changing scientific knowledge on developments in the AQS. The Theoretical Framework chapter described Question 2 as a 'control' question: asked in order to ascertain whether previous assessments of the policy-making process of the AQS as linear science-policy relationship (e.g. National Audit Office, 2001) were correct; and also to provide a context for the study of expectations and discourses on a strategy aimed ultimately to protect human health. My previous study of the AQS (Smith,

[8] Question 2: How did policy change in the light of new and often uncertain scientific understanding of particulates, their properties and behaviour, and their effects on health? Question 3: To what extent did modelled forecasts shape policy, and why?

2003) characterised the relationship between AQS and modelled forecasts as one of co-construction. This analysis also takes a constructivist approach to scientific knowledge.

2. Methodological issues in the examination of Expectations and Visions

2.1. Analytical distinction of Expectations and Visions

There is no established definition of an 'expectation' in the Expectations literature. Examples of definitions of the related concepts of *expectation*, *vision*, and *promises* are set out in table 5.1. From this table it can be seen that there are a number of different definitions in the literature. Definitions have become more sophisticated since Van Lente's first characterisation of expectations as statements made about the future.

Definitions of the concepts listed in the second column of Table 5.1 can be themed by distinguishing firstly those who consider visions or expectations as the future goal towards which gives guidance to actions in the present (e.g. Geels and Raven, 2006); secondly those who consider expectations/ visions as a tool intended to gain resources or support for the speaker (e.g. Berkhout, 2006); and thirdly those for whom the key feature of expectations/ visions is that they are shared by multiple actors (e.g. Konrad, 2006). Those positions are not mutually exclusive, and the definitions may be partially determined by the focus of the study.

For those scholars who use 'expectations' and 'visions' interchangeably in table 5.1 (Berkhout, 2006; Geels & Raven, 2006), both are strategic resources, used to gain support and other resources. Geels and Smith (2000) definition of a 'promise' is similar: a 'resource in niche creation'. The use of 'promise' emphasises the use of statements about the future to attract resources and to create accountability from the speaker, and appears to be a distinct class of expectation statements.

Table 5.1. Examples of definitions of common concepts in Sociology of Expectations

Authors	Concept	Definition	Theme of definition
Van Lente (1993)	Expectations	Statements made about the future.	Speakers' statement
	Promises	Expectations made about the expected outcomes of research to attract resources and funding.	Speaker aims to attract resources and support
Geels and Smit (2000, p.880)	Promises	*…diffuse scenarios about the potential of future technologies… Resources in niche creation*.	Guidance for actions to achieve goal
Brown et al., (2003)	Promises	An expectation for which the speaker is accountable (at least in their justification for making, if not fulfilling, the promise).	Accountability of speaker
Hedgecoe and Martin (2003, p. 330)	Visions	*… a particular class of expectation which both project and anticipate how the future might emerge, and provide a strategic framework for actors as they attempt to construct particular socio-technical networks.*	Guidance for actions to achieve goal
Berkhout (2006)	Expectations & visions	"bids" about potential futures. Resources used to gain material support for an actor's position.	Speaker aims to attract resources and support
Borup et al. (2006, p. 288 & 286)	Technological expectations	*…real time representations of future technological situations and capabilities. …wishful enactments of a desired future*	Speakers' statement
	Visions and promises	Definition overlaps with expectations, but with more emphasis on the normative character and their power to induce action.	Speaker aims to attract resources and support
Eames et al. (2006, pp. 361-362)	Expectations	*…less formalised often fragmented and partial, beliefs about the future*.	Speakers' statement
	Visions	*…internally coherent pictures of alternative future worlds… explicitly intended to guide long-term actions.*	Guidance for actions to achieve goal
Geels and Raven (2006, p. 375)	Expectations & visions	*…a special set of cognitive rules that are oriented towards the future and related to action, in the sense that they give direction to search and development of activities.*	Guidance for actions to achieve goal
Van Merkerk and Robinson (2006, p. 416)	Vision	An expectation shared by multiple actors.	Focus is on actors holding expectation
Konrad (2006)	Collective expectations	normalised and taken-for-granted expectations which are shared within a community	Focus is on actors holding expectation
	Specific expectations	Held by individuals or groups. There is likely to be a range of competing positions within a community	Focus is on actors holding expectation

Some studies portray 'visions' and 'expectations' as different concepts. In the three definitions of *expectations* alone in Table 5.1, they are more general than *visions:* "…less formalised often fragmented and partial…" (Eames et al., 2006, pp. 361-362), or "…wishful enactments of a desired future" (Borup et al., 2006, p. 286). 'Visions' were defined more specifically, as expectations made with the aim of attracting resources, or to give guidance for actions in the present and planning for the future (Eames et al., 2006; Hedgecoe & Martin, 2003).

2.2. Definition of 'expectation' and 'vision' used in this study

This thesis separates the concepts of 'expectations' and 'visions', following Eames et al. (2006, pp. 361-362) and Hedgecoe and Martin (2003). An 'expectation' is defined as any statement about the future, either positive or negative. 'Vision' is defined as a subsection of expectations: a coherent, positive, and consistent vision of a specific future, made to guide action in the present. 'Expectations' is used here as a general term for statements about the future, and includes visions and promises, unless otherwise stated.

Such definitions enable the distinction to be made between an actor's preferred vision of the future and that same actor's expectations, both positive and negative, about what is likely to happen. This is done to distinguish statements made by actors in the policy process about their preferred future (visions) from more generalised statements about what the future will hold (expectations).

2.3. Distinguishing public and private expectations

A potential problem for the study of expectations is that of determining whether actors believe their own spoken expectations, and the difference between privately held expectations, and expectations spoken to other actors. Of course individuals do hold private expectations, but it is the expectations made in public which are significant for the Sociology of Expectations research, because of its focus on the impact of one actor's expectations on the expectations and actions of others.

To address this issue Van Lente (1993, p. 39) argued that what matters to the researcher is that actors are motivated to make a statement of expectation, not whether they believe what they are saying. Studies of expectations examine the ways in which expectations facilitate relationships between actors and the institutionalisation of ideas, and these are social acts

rather than private thought. Such definitions enable examination of expectations without concern for the actors' cognitive states.[9]

This thesis examines only written statements of expectations made publically to other actors, as tools used in the agenda-setting process, which may not necessarily reflect the beliefs of those who made them. Interviews were conducted with policy-makers and stakeholders, but these were largely concerned with understanding the reasons for articulation and acceptance of these public statements. There is, of course, some overlap between the private beliefs held by actors and institutions, and those articulated in public settings. However, this thesis is concerned with how expectations made *in public* in the context of *air quality policy making* contributed to changing expectations/visions in the Air Quality Strategy.

2.4. Identifying Expectations and Visions

Researchers have identified rhetorical statements of expectations using a variety of means including written statements or those made in public (Van Lente, 1993), metaphors (Wyatt, 2000), construction of narratives (Deuten & Rip, 2000), and ideographs (higher order concepts with flexible definitions which include implicit commitment to a normative goal and action – e.g. 'freedom' or 'privacy') (Van Lente, 2000).

Brown, Rip and van Lente (2003, p. 8) argued that it is easier to provide examples of expectations in speech and language than in material objects, but that this has led to a focus in analysis on these linguistic sources of evidence on expectations and away from materially embedded expectations (for example, those embodied in scientific experiments, artefacts such as immortal stem cell lines, and computational processes).

This study assumes that expectations and visions can be embodied and visible in artefacts: in technologies, models for policy-making, demonstration projects and in actions. This study identified expectations and visions in text and in evidence about material objects. These material objects were technologies developed, or promoted, as means to reduce particulate air pollution. Two examples of such technologies are diesel particulate filters - developed purely to reduce particulate emissions from road vehicles – and LPG fuel. -

[9]However, the distinction between private, cognitive expectations and publically articulated expectations is not shared by all scholars. In table 5.1. it can be seen that Geels and Raven (2006 p375) described expectations as a "special set of cognitive rules", and argue that they "… cannot be checked independently but only through actions that make them come true" (ibid. p377).

The Netcen computer forecasts and alternative models are neither strictly linguistic nor material. Analysis of their content came from the detailed technical documentation supplied with each version of the AQS, which contain breakdowns of the assumptions and scenarios modelled in each time period.

2.5. Categorisation of Expectations and Visions

Studies of Expectations have examined expectations for sociotechnical change. However, in the examination of the Air Quality Strategy – a policy framework for improving air quality from all sources – it was necessary to search for expectations beyond those only for sociotechnical change. To assist in analysis, statements of expectation were assigned to one or more categories:

- expectations for technologies (for example, which specific technologies would be a commercial, less polluting alternative to diesel; the balance of technologies in the UK vehicle fleet; the future capabilities of specific technologies)
- expectations for behaviours (for example, how industry could voluntarily improve levels of polluting emissions, or how the general public would use their cars and/or public transport)
- expectations for policy (for example, visions for the outcomes of the Strategy itself – e.g. strategy as a policy driver – or of other policies related to air quality management)
- expectations about the feasibility of achieving Objectives (both those integrated into law and proposed Objectives).

The categorisation of expectations in this way is unique to this study, and served several purposes. It enabled expectations articulated by different groups to be compared (to contribute to answering research question 1), and to be compared with articulated expectations by the same group at different points in time. It also structured the organisation and coding of statements of expectation.

3. Identification and analysis of visions, expectations and their dynamics in the development of air quality policy

The Theoretical Framework identified three organising effects which had been examined by previous studies of expectations:

- the coordination of actors and groups

- coordination between "levels of expectation" (Van Lente, 1993): examination of how the expectations articulated in firms coordinated with those of sectors, and those with sectors with general societal level expectations.
- How and why a particular expectation or vision spread over time (temporal dynamics of expectations)

This study focused on two of these: the temporal dynamics and the use of expectations to co-ordinate actors and groups. The 'levels of expectation' was not considered because the study examines made in one 'level' – that of expectations and visions articulated within the air quality policy-making process.

Chapter 2 identified the four time periods of study, each relating to the period of development of one Air Quality Strategy (summarised in table 5.2 below). This temporal separation enabled comparison of expectations and visions articulated by an actor at different times. By splitting analysis into four parts, the changes in expectations articulated by one actor could be clearly identified. This facilitated an examination of changes in the expectations and visions articulated by stakeholders after the launch of a new Strategy.

Table 5.2. Division of the duration of the AQS 1994-2007

Time Period	Dates	Strategy published at the end of the time period	Abbreviation used
Period 1	1994-1997	*The United Kingdom National Air Quality Strategy*	NAQS
Period 2	1997-2000	*The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Working together for clean air*	Revised Strategy
Period 3	2000-2003	The Air Quality Strategy for England, Scotland, Wales and Northern Ireland: Addendum	Addendum
Period 4	2003-2007	The Air Quality Strategy for England, wales, Scotland and Northern Ireland	2007 Strategy

This methodology was appropriate to this case because between 1997 and 2007 the Air Quality Strategy was actively being reviewed by policy-makers for the majority of the time studied (with the exception of a few months in 1997, as will be explained in Chapter 6 and 7). This study recognises that policies are not always in such a state of review, and that UK air quality policy may be an unusual case in this respect.

3.1. Identification of Expectations and Visions in AQS Strategy documents

To answer research question 1[10], and to develop judgements on the relative impacts of statements about the future compared to evidence on health effects of air pollution and wider political discourses, it was first necessary to collect and organise statements of expectations and visions made during the policy-making process of the Air Quality Strategy between 1995 and 2007.

First, articulated expectations of the UK's ability and likelihood of achieving each set of Objectives before their deadline were sought from official policy documents, retrospectively in interviews with actors, and in modelled forecasts. Next, the visions articulated in each version of the Air Quality Strategy for future technologies, policies, and public behaviours were identified and coded according to whether they were about Objectives, technologies, policies or behaviour. At this stage the sources of these visions were identified and included in the categorisation. Tables of the visions articulated in each Strategy, their sources, and their categorisation by expectation type are included and discussed in each of the analysis chapters.

The following questions were asked of the data for each of the four Strategy documents, to provide an assessment of how expectations and visions in the Strategies changed over time:

- Were the Objectives in the Strategy categorised by the Strategy document as feasible or aspirational?
- The types of visions: did the majority of visions fall into one category (technology, policy or behaviour) and how did this differ between Strategies?
- The sources of the visions: did the Strategy rely on a few sources or one source in its visions? Were these consistent over the versions of the Strategy?
- Which visions were more or less prominent in the Strategy, and did this change over time?

[10] Question 1: How do expectations and promises of future technologies, policies, and their impacts affect the creation of target-based policies for sustainable development? How do these policies subsequently shape expectations? Can the changes in the AQS between 1997 and 2007 be explained by these dynamics of expectations?

3.2. Collecting and categorising visions from actors in the policy-making process: documentary evidence

The public written expectations and visions of actors involved in the policy-making process of the Air Quality Strategy were then examined in a similar manner to the policy documents, with the purpose of identifying whose expectations and visions were taken up in policy documents, and how multiple expectations and visions interacted. Articulations about the future were collected for actors involved in the policy-making process (including scientists, modellers, civil servants, environmental protection groups, industrial and road transport groups) these are explained in more detail in section 6 of this chapter.

Given the scale of industries and sectors potentially affected by the AQS, there was potentially a very wide field of interested actors in this policy community. Analysis was limited to those actors who were active in the air quality policy-making process: those on the Air Quality Forum and other advisory bodies, those who contributed to analyses and reports made to support policy development, those who responded to consultations on aspects of air quality and those who made public statements in the media. Given the scope of the potential impact of the AQS, there may have been more interested parties, making statements of expectation. However, this study limited collation of statements about the future to those made publically, and which were likely to reach policy-makers working on the Strategy.

Each source's visions and expectations were categorised by author, into the time period they were articulated in, and then by the category of expectation. An example template of categorisation is given in figure 5.3. This structure enabled comparison of an actor's expectations over time, and comparison between actors.

The expectations and visions of each actor were categorised by the time periods, then statements according to the expectation category they best fitted, or noted when the covered two categories – for example, a statement about how to develop a preferred future technology may be inseparable from visions for how government policy could assist in development and bringing the technology to market. Notes were made on whether the document articulated either of the wider political discourses (see section 5) and any references to the credibility of the vision (for example, if commenting on visions which originated with another actor) or lack of credibility of another actor's vision statements. This method allowed tracing of the variations in expectations over time. Visions for technologies were also sourced from demonstration projects funded during the period of the Strategy, and public statements made about their uptake.

Figure 5.1 Categorisation matrix for an actor's statements of expectations

Actor name:				
	Period 1	**Period 2**	**Period 3**	**Period 4**
Expectations/ visions for **technology**	*Source (audience where appropriate); quotation/ summary of expectation/ vision.*			
Expectations & visions for **policy**				
Expectations & visions for **behaviour**				
Cross-category expectations and visions (and others without categorisation)				
Comments on expectations/ visions of others				
Notes on perceptions of credibility				
Evidence of discourses				

This analysis treats scientific advisory committees (e.g. the Committee on the Medical Aspects of Air Pollution, COMEAP), and civil servants in AEQ and the Department of Health as actors and generators of expectations and visions. In the case of civil servants, position papers and journal articles written from a personal perspective were used to identify expectations and visions separate from those in policy documents.

Interviews with actors involved in the policy-making process of the AQS served several purposes in identifying and assessing the significance of the dynamics of expectations. These were, firstly, to ensure that statements of expectations and visions articulated had been interpreted correctly. Secondly, to gain insight into the reasons why some expectations and visions were accepted into each version of the AQS, and why others were not, and to test whether the 'dynamics of expectations' could explain all changes in the Strategies.

3.3. Identifying the dynamics of expectations / visions and its significance in setting the agenda for air quality policy

Analysis was undertaken for each of the four time periods and resulting strategies separately (thus, the analysis is divided into four chapters, each corresponding with one time period).

The origins of the visions and expectations incorporated into each version of the Strategy were sought, to ascertain how they appeared onto the policy agenda. Beginning with sources referenced in the Strategy published at the end of the time period, the origins of the visions

and expectations in the Strategy were traced. Networks of support for the vision/expectation within the policy community were identified. Expectations and visions held by actors which were not incorporated into the version of the AQS were identified along with their and networks of support.

The visions articulated in each AQS – distinct from its expectations – were collated and examined to gain insight into the extent of their role as organising and coordinating factors in the period immediately following publication. Interviewees were asked their reasons for articulating such visions and whether the changes to the AQS were responsible for any changes in visions, and also why other actors articulated specific visions, to understand the reasons for the patterns that were found. The use of visions to position and assign roles other actors in the policy-making process (e.g. to identify groups to bear the weight of reaching air quality Objectives) was examined.

Examining expectations' dynamics in this systematic way enabled comparison across the ten-year duration of the study, and enabled analysis of the credibility of visions and actors. This also enabled identification of hype, and potentially disruption and disappointment, in articulation of visions for particular futures.

4. Assessing perceptions of credibility

Research question 5 asks which factors made some expectations more credible than others to policy-makers . Interviews elicited information on the type of expectations and visions policy-makers in AEQ, the Department for Health and other relevant government departments found credible. Asking actors about other actors' perceptions of credibility provided further insight.

This study assumed that if a vision or expectation was expressed in the Air Quality Strategies and its source could be traced, then this source or the content of the vision was more credible than others to those developing the specific version of the AQS. Visions and expectations articulated by other actors in the air quality policy-making process that were not taken up were assumed to have been deemed less credible. The categorisation of expectations and visions by actor and by time period provided the basis for this assignment of credibility.

Questions in the interviews with policy-makers aimed to find more evidence on the relative credibility of expectations to policy-makers. Where the documentary analysis indicated that one vision or set of visions was accepted by policy-makers over others (or that this preference had changed over time), then interviewees (both policy-makers and stakeholders) were asked why this happened.

This study tried as far as possible to separate publically articulated and privately held expectations and visions. In investigating the relative credibility of specific statements of expectations and looking at specific instances where expectations failed, it was inevitable that interviewees articulated their personal reasons for accepting certain expectations over others.

5. Identification and testing discourses

Examination of discourses and discourse coalitions enabled understanding of how wider discourses acted on developments in the Air Quality Strategy, and to identify interactions between expectations, visions and wider discourses. Maarten Hajer states that a discourse can be identified in the following way:

> *There is a simple two-step procedure for measuring the influence of a discourse: if many people use it to conceptualize the world (discourse structuration) and if it solidifies into institutions and organizational practices (discourse institutionalization). If both criteria are fulfilled we argue that a particular discourse is dominant.*[11]

Two perspectives on how Objectives should be set, and on target setting in policy-making were identified by interviews conducted for my previous study of the AQS (Smith, 2003). These two perspectives were taken as the starting point for identification of discourses in this assessment of how and why policy developed over a longer time frame, and in assessment of the relationship between discourses and expectations for the future. This previous work served as a first reading of events; an initial identification of discourses and points of clash and disagreement, which was then, tested in this more comprehensive analysis.

This study began its identification and examination of discourses at the second AQS (the Revised Strategy) rather than at the first (the NAQS). Instead the NAQS was used as a background, against which to identify discourses in subsequent Strategies and trace their impact over time. There were several reasons for this: the NAQS was the first Strategy, its Objectives were set in a different manner to subsequent Objectives: they were aspirational, they were set without modelled forecasts, and policy-makers did not know whether they could be achieved. The tensions in subsequent air quality strategies and in statements by stakeholders about how targets *should* be set started in Period 2, after the publication of the NAQS. The existence of competing discourses was made apparent because of the differences between the NAQS and subsequent Strategies. Identification of discourses requires the scholar to see differences between the discourse and other discourses: using the NAQS as a

[11] www.maartenhajer.nl/?page_id=14

background against which to compare subsequent target-setting, problem definitions, storylines and discourses enabled this.

As established in the Theoretical Framework, discourses are characterised by distinctive storylines, language used, and in their effects on institutions and practices. To test whether differences in perspectives around target-setting were discourses the following were looked for in documentary analysis and interviews:

- A storyline: the simplified narrative used to reduce a complex issue (in this case air quality management, especially management of particulates); and emblematic issues which act as metaphors for the whole complex issue
- a unique conceptualisation of the air quality 'problem' and how this affected which scientific evidence was considered in the policy-making process
- how the problem definition shaped the possibilities for its solution
- common language of the discourse: common statements and metaphors used by those articulating the discourse.
- Points of clash between discursive positions
- Changes in institutions and practices resulting from uptake of the discourse.

Once potential discourses were identified, the air quality literature was reviewed to assess their presence and effects, starting with the three later Strategy documents, supporting literature and the Netcen model documentation. As noted in figure 5.1 (above), each document was examined for evidence of expression of the two discursive positions.

To understand whether these discourses were local to the air quality policy field or were representative of wider discourses affecting policy-making and target-setting in the UK government, key government policy statements on how policy targets should be set and measured were examined (for example statements by the Cabinet Office, the Treasury and the National Audit Office). The prevalence of these discourses in policy was supported by a literature review of academic articles on target setting in the UK during the time period studied. Internet searches were conducted using key phrases from the discourses in order to understand whether the discourses were limited to UK policy-making or part of a wider discursive shift.

Interviews with actors in the policy-making process were used to address and confirm the findings of the literature review, and to understand the reasons for actors adopting and changing discursive positions. They sought to elicit actors' interpretation of events, how shifts

in dominant discourses came about, and whether they recognised and assigned value to discourses other than their own. For actors who appeared to have articulated more than one discourse, their interpretations of events and their understandings of their own discursive shifts were examined.

When examining the dynamics of visions and expectations, the correspondence between holding a set of visions and articulating a specific discourse was noted, with the aim of understanding the relationship between visions, expectations and wider discourses. Where actors had changed expectations or visions, a corresponding shift in discourse was looked for, and vice versa.

6. Data collection and analysis

The main methodologies employed in this study were document content analysis and interviews with stakeholders actively involved in the development of the Air Quality Strategy.

6.1. Document sources and analysis

Document analysis of policy documents, models, and stakeholder publications associated with the air quality strategies served several purposes:

1. It served to identify actors, the timeline and key events, and key points where expectations, visions and discourses clashed;
2. Identification of expectations and visions
3. Identification of distinct discourses
4. Identification of points of interaction between expectations, visions and discourses.

All documents were assigned to a specific time period, so that variation in an actor's stated expectations and visions could be traced over time.

The following documents and sources were analysed:

- Strategy documents: the first analysis of visions and expectations was conducted on each of the four Air Quality Strategy documents, written by policy-makers in AEQ.
- Related documents by policy-makers in AEQ: including consultation drafts of each strategy, discussion documents published by AEQ
- Related documents published by Defra, the Department for Transport (DfT) and others, including guidance and consultation on local air quality management, the London Air Quality Strategy, and national transport plans.

The evidence based used to develop each version of the Air Quality Strategy:

- COMEAP archives (http://webarchive.nationalarchives.gov.uk/+/www.dh.gov.uk/ab/COMEAP/DH_108448) provided reviews undertaken for each time period on the health effects of particulates. Although analysed for expectations and visions, these were taken as an indicator of the contemporary scientific knowledge on particulates at each time period and of what was not understood during each time period.
- Expert advisory committee reports, for example, from EPAQS, QUARG and the Airborne Particles Expert Group (APEG).
- Economic cost-benefit analysis of air quality objectives undertaken by the Interdepartmental Group on Costs and Benefits (IGCB).

Documents published between 1997 and 2007 were available on Defra's online archive (uk-air.defra.gov.uk; accessed 1/12/2012). This was a comprehensive source of advisory committee papers, meeting minutes for committees including the Air Quality Forum, and the monitoring and modelling archive. Interviewees from AEQ and the Department of Health gave the author copies of pre-1997 documents, including discussion documents on the appropriate form of the air quality strategy, briefing to local authorities on air quality management, and the first QUARG report (QUARG, 1993a).

Sources of evidence on stakeholders' expectations, visions and discourses included:

- Stakeholders' responses to consultations on the air quality strategies and minutes from Defra's Air Quality Forum.
- Stakeholders' responses to House of Commons select committee reports, and statements in Hansard.
- Trade journals were key sources of the statements made by stakeholders to policy-makers and publically about the Air Quality Strategy and futures for technology, policy and behaviour. These also provided the timelines of key events and publications and significant points of debate and disagreement around each Strategy.
    - The Environmental Data Service *ENDS Report,* in which air quality was one subject of many affecting UK environmental policy.
    - The monthly *Air Health Strategy* and its successor, *Air Quality Management*, with an audience of national policy-makers, air quality stakeholders, and local authority environmental health professionals. Newspaper archives and academic journal articles also provided statements made publically about the Air Quality Strategy by stakeholders.

- Trade journals for vehicles, fuel and alternative technologies, including *Professional Engineering* and *Truck*. These provided information on technologies, demonstration projects, and expected uptake.
- Statements in the national media (searches of LexisNexis database for all years 1994-2007)
- Public statements and literature from actors' websites.

6.2. Computer Models

From Period 2 onwards, the AQS was supported by a series of forecasts for air quality developed through the Netcen model. Documents from Netcen were available on Defra's air quality archive (uk-air.defra.gov.uk). These summarise the inputs, assumptions, methodologies and forecasts for scenarios modelled for each version of the Strategy. The expectations and visions, together with their sources, were identified in each model and categorised in the same way as statements about the future from documents.

6.3. Interviews

Interviews with key stakeholders and policy-makers tested and added to the findings of the document analysis Interviews were conducted with key stakeholders and policy-makers for four purposes:

1. To test the conclusions drawn from the document analysis.
2. To gather articulated expectations and visions: their own for Period 4, their own for events in the past, and others' for all time period.
3. To provide evidence to support the identification and prevalence of specific discourses in the policy arena.
4. And to understand the process of creating each Air Quality Strategy from the point of view of those involved.

In identifying suitable interviewees I aimed to include actors from each time period, covering all types of stakeholder, including:

- Civil servants representing the main government departments involved in the AQS: Defra (the Department for the Environment, Farming and Rural Affairs) and predecessors, the Department of Health, the Department for Transport, and the Department of Trade and Industry;
- Scientists specialising in health effects of particulates, atmospheric chemistry and modelling who advised policy-makers through a range of government advisory committees throughout all time periods

- Environmental and health protection advocacy groups (e.g. the National Society for Clean Air)
- Representatives of business, industry and the transport sector who were actively involved in the AQS (for example, the Society of Motor Manufacturers and Traders, Johnson Matthey –particulate trap manufacturers, and Volvo)
- Representatives of local authorities and the Greater London Assembly and others involved in local air quality management. (for example the Environment Agency and Local Government Association)

Interviewees were identified by their roles in the policy-making process (ascertained in the documentary analysis), from their prominence in the documentary evidence, positions on scientific advisory bodies, and presence in the Air Quality Forum. Where possible, at least one representative was interviewed in each category of source (outlined above) for all four time periods. In comparison to other regulatory areas, the actors, groups and institutions involved in air quality policy-making were relatively stable over the time period studied, and so many interviewees were involved in one or more roles throughout the period studied.

I observed an Air Quality Forum meeting in November 2006, and this provided an opportunity to meet actors and watch them interact. A snowball approach to interviewing was taken by which actors were asked to identify suitable interviewees. The process ended when the names given were those already known; and when potential interviewees were not willing or able to be interviewed.

Interviews were conducted with 29 actors and took place between March 2006 and March 2007, before and after publication of the 2006 consultation on the 2007 Strategy, but before publication of the Strategy. Period 4 was thus the only part of the study where expectations and visions were collated and analysed concurrent with events, rather than retrospectively.

Due to the sensitivity of some of issues discussed - including but not limited to, interdepartmental relationships in government, the development of future policy, and technological development and competition - these interviewees are anonymous. In text they are referred to by a number. When an interviewee wished to speak off the record even within these terms, they are identified only by institutional affiliation.

Interviews were semi-structured, and tailored to the interviewee's involvement in the policy-making process and the time periods in which he was involved (all interviewees were male). This allowed topics and questions to be expanded upon, or to be discarded if they were

irrelevant. Interviews started with the interviewee explaining his role in the Air Quality Strategy from their earliest involvement until the then present day (Period 4).

All interviewees were asked about their expectations and visions during the creation of the particulate Objectives for the Strategies with which they were involved, and in the development of the Strategy to achieve them. All interviewees were asked about key points of disagreement (as identified in the documentary analysis and confirmed by interviews), the means by which Objectives were decided; whose expectations, visions and concerns were taken into account when policy was developed, whose were not, and why. All were asked how the contestation of theories and assumptions about the health effects of pollution had impacted on the development of policy. Some questions were specific to the role of the interviewee and their involvement in the policy-making process. For example, interviews with stakeholders asked how the Air Quality Strategies had influenced their expectations and visions and those of others.

From the documentary evidence it was possible to identify changes in actors' public statements of expectations and visions, but not always to identify the reasons for such changes. A key purpose of the interviews was to explain the dynamics of expectations and visions: why some were rejected whilst others were taken up widely, and the reasons for changes in actors' expectations and visions over time. Three types of questioning examined these dynamics:

- Questions about the reasons for differences between the actor's public expectations and what actually happened in the 'future'.
- Questions about the actor's support for failed visions – why they had come to articulate these and then subsequently stopped.
- Questions about other actors' visions and expectations: why had another actor held *this* position; why they changed?

To elicit information on the relative credibility of expectations and visions, interviewees from AEQ and the Department of Health were asked about their reasons for taking up specific visions and expectations.

A potentially problematic issue was that actors may be reluctant to discuss their support for a failed vision (such as those for natural-gas powered technologies) after it had failed. For these reasons a process of triangulation, by which actors were asked about other actors' reasons for

articulating, accepting, or renouncing specific expectations. This gave greater reliability to the analysis, and also contributed to the analysis of the relative credibility of expectations.

Whilst documents were easily categorised into one timeframe, the interviewees' memories were not always so easily separated into the four time periods and versions of the AQS. Strategies to ensure reliability of the analysis included: interviewing multiple interviewees from the same category of actor, the interviewer's own knowledge of events, and testing the recollections of one actor with another.

Providing evidence for the role of wider discourses in the policy-making process, interviewees were asked about their interpretation of key events. They were asked in particular about their own (and others') interpretation of scientific knowledge, how Objectives were set at different times, clashes over how the Objectives should be attained, and the use of models in policy-making. Three points of clash over setting the Objectives (Period 1 – aspirational, Period 2- what could be achieved under 'business as usual' and Period 3 – different targets set for different regions of the UK) were used to discuss the discourses and identify whether the interviewee articulated either (or both) of the discourses. Where actors were known to have taken up a different discourse during the ten years, their understanding of their own discursive shift was discussed.

6.4. Interview Analysis

Due to the focus of the analysis on the constructive and organising effects of language, the interviews were recorded and backed up with written notes. In two cases, the interview was not recorded in its entirety due to equipment failure. Analysis was undertaken from the transcripts (or notes in the two non-recorded instances).

Statements on expectations/ visions collected from the interviews were coded as the documents were: first by time period, then by one or more of the categories of expectation/ vision:

- For technologies
- For policies
- For behaviours
- On the formation of particulate Objectives

Statements on the dynamics of visions and expectations, including relative credibility, sources, the failure of visions and hype, were all coded in the same way: by author/ date/ expectation category.

The evidence from documents and interviews was used to construct an interpretation of the dynamics of expectations and visions in each time period (as described in section 3). Specific points at which multiple visions/ expectations were in conflict were focused on:

- The measurement and level of the particulate Objective
- Visions for the future incorporated and assumed in the Strategy
- The effects of previous Strategies on the expectations and visions articulated by stakeholders
- The positioning of actors by visions and expectations

An assessment was made regarding the interaction of visions with wider discourses: whether one discourse was associated with the articulation of a particular type or source of vision, and whether expectations dynamics could be explained by interactions between wider discourses.

7. Potential weaknesses in this framework

The identification of discourses is inevitably shaped by scholars' interpretations of the literature available on a topic and the use of language within it. Whilst interviews were used to confirm the existence of discourses there remains the possibility that others existed but were not recognised in this data analysis process. This may be because of the preconceptions of the scholar or of the interviewees themselves.

Similarly the examination of texts and interviews to identify how actors assigned credibility to expectations may overlook significant contributing factors to assignment of credibility. This study focuses on analysis of public statements, rather than the informal discussions and negotiations that often determine policy targets and outcomes. Unless interviewees were able to speak about any such negotiations, their existence and their contribution to policy-making are unknown.

Chapter 6. An optimistic Strategy: the development of the NAQS

This chapter examines the development of the NAQS from the first proposals for a Strategy for health protection to the publication of the Strategy in May 1997. It will demonstrate that a consensus around the need for a strategy for health protection arose in the early 1990s, and that this drove the developments of the NAQS. However whilst visions for technological, policy and behavioural change were included in the NAQS were optimistic, their effects were limited.

1. Political momentum for an Air Quality Strategy 1990-1997

Publication of epidemiological studies from the USA coincided with a series of poor air quality episodes in the UK. In 1991 London experienced the highest levels of nitrogen dioxide on record (Maynard, 1993), and the summer of 1994 brought widespread ozone smogs (Williams, 2004). The coincidence of new research, UK smog episodes, and new evidence of an association between levels of childhood asthma and vehicle emissions led to increased media and public attention on this new pollution problem (Lane & Peto, 1995, p. 190).

However in 1990 only two scientists in the UK studied the effects of local pollution on health (interview 1), there were no government funded research units, no funding and very little air quality monitoring (interview 16). Bickerstaff and Walker (2003, p. 48) argued that the rise of traffic-related air quality problems was overlooked in the 1970s and 1980s because the UK's focus on monitoring and regulation was on SO_2 and black smoke – both of which had substantially reduced since the 1950s.

Interviews with scientists and policy-makers from the Air and Environmental Quality (AEQ) division of the Department for the Environment (DoE) who worked on the NAQS were in agreement that both UK scientists and the institutions of government were unprepared for the new epidemiological evidence on health effects (e.g. interviews 1,13, 16 and 28), because of the widespread and deep-rooted assumptions that the problems of local air quality were solved (interview 20).

Interviewees 17 and 28 – policy-makers in AEQ – described their feelings that the UK was lagging behind on pollution management policy compared to other countries. The USA regulated ambient concentration of pollutants including PM_{10} by setting minimum targets for

improvement over a period of time. Japan and the Netherlands also utilised this framework of targets towards a "safe" concentration of air pollution (Archer, 1995). The strategy in the Netherlands had led to policies introducing fiscal measures to promote cleaner vehicle technologies and to remove older vehicles from the road. An air quality monitoring consultant (interviewee 13) cited the UK's reputation as the 'dirty man' of Europe as another reason for this feeling amongst scientists and policy-makers.

This combination of circumstances paved the way for a Strategy. Interviewee 16, a policy-maker in the Department of Health, described the situation:

> *… in 1990 … there was great enthusiasm that something should be done about it – the WHO had published air quality guidelines. The question began to be asked … "What are you doing about air pollution in the UK?" The answer was pretty flat: "We don't have a research unit; we don't have a research programme. We have a lot of monitoring if you're really interested in black smoke and sulphur dioxide and you like it on a 24 hour basis"… And I think it's that sort of concatenation -if that's the word- of activity: the WHO thinking about things, the Americans reviewing their National Ambient Air Quality Standards, us not having air quality standards, the feeling that the EC were going to expand their limit values to other pollutants, my concerns that we didn't know enough about the health effects of low levels of air pollutants …*

In response to the lack of evidence on the concentrations, components and effects of air pollution in the UK, the Department of Health (DH) and the Department of the Environment (DoE) established expert advisory committees to investigate:

- **COMEAP**: the Committee on the Medical Effects of Air Pollution, set up by the Department of Health in 1990. It produced summaries of the evidence of the health effects of air pollutants on health. Such studies were commissioned by the Department of Health. Its first report on particles was published in 1995.
- **QUARG**: the Quality of Urban Air Review Group, set up by the DoE in 1991 to review the state of urban air quality and provide scientific advice on the potential impact of additional reduction policies on air quality (QUARG, 1993a). It consisted of ten scientists specialising in pollutant modelling monitoring and pollutant chemistry. Members came largely from academia, but Netcen and the monitoring network providers were also represented.
- **EPAQS**: the Expert Panel on Air Quality Standards was established by the DoE in 1990 to recommend Standards to policy-makers – the panel's judgement of the ambient concentration at which a pollutant is rendered harmless, on the basis of available evidence. Its membership consists of specialists in the health effects of air pollutants,

the composition and characterisation of pollutants, and one modelling specialist. In 1995 eight out of nineteen members, all health specialists, were also in COMEAP.

In 1994 the DoE, DH and Medical Research Council commissioned research into the health effects and sources of air pollution in the UK (COMEAP, 1995). They made £5 million available in grants.

In 1992 the DoE established a national monitoring network to continuously monitor PM_{10} in urban areas. This grew from six monitors in 1993 to 14 in 1996 (Broughton, 2002). This network was not large, but demonstrates that the DoE believed it important enough to monitor PM_{10}. By providing an indication of UK particle levels this monitoring network enabled forecasts and modelling of future air quality to be undertaken, and provided data for epidemiological studies. The decision to monitor PM_{10} also contributed to the characterisation of particulate pollution as PM_{10} and urban in nature.

The DoE commissioned a third strand of research: pollutant inventories, mapping and modelling. Interviewees 12 and 13 who worked on the *London Energy Study* (Chell & Hutchinson, 1993) claim that this emissions inventory contributed to the DoE's concern for urban pollutants. Another DoE-commissioned study, the West Midlands Atmospheric Emissions Inventory indicated that road traffic was the most significant source of atmospheric pollutants in that area: responsible for emissions of over 96% of carbon monoxide, benzene and 1,3-butadiene, 85% of NO_x and 75% of black smoke (Hutchinson, 1997, p. 35)

The requirement for a Strategy in the 1990 Environment White Paper was utilised by policy-makers in the DoE to create the NAQS, although it presumed the pollutants regulated would be those which contributed to acidification (Department of the Environment, 1990, p. 144). The White Paper outlined what became the basic components of the NAQS: improved air quality monitoring in urban areas, data dissemination to the public (Quality of Urban Air Review Group, 1993a), an effects-based strategy based on the fulfilment of standards. According to interviewees, this momentum was driven by civil servants from AEQ and the Department of Health (DoH) (interview 16, 17 and 28).

Three key individuals in the DoH and DoE also drove the Strategy forward: Richard Mills and Martin Williams at the DoE, and Robert Maynard at the DoH. The latter two were scientists: Williams had been a pollutant modeller at the Government's Warren Spring Laboratory until it closed in 1992. Maynard was an expert in the effects of pollutants on health. Their individual expertise and connections with the scientific communities they drew upon for research were

essential components in driving nascent Strategy forward, and in its evolution (as will be discussed in subsequent analysis chapter).

This discussion suggests that a consensus grew over the requirements to regulate ambient air quality in the UK, as a result of the evidence of effects on health, and in comparison of the efforts of the UK with the actions of other countries. Such concerns were promoted by policy-makers in the DoH and DoE, in their efforts both to establish a research base and bring regulation of ambient pollution concentrations on to the political agenda.

However there were voices in the policy process who questioned the epidemiological evidence in internal government discussions. Significantly, a member of the Department of Trade and Industry (DTI), Trevor Morris, questioned whether the associations between health effects and PM_{10} were more than statistical (interview 1). The implications of these diverging perspectives on the health evidence will be discussed as they come up in this chapter.

2. The development of the NAQS (1994-1997)

In 1994 the DoE published a discussion paper on plans to manage air quality: *Improving Air Quality* (Department of the Environment, 1994). This set out the requirement for a strategy to manage local, urban and "contemporary" air pollutants, the Department's intention to produce health-based Standards (the maximum concentration of a pollutant at which health would be protected), and a framework of policies that would ensure that these Standards were met through progressive improvement (DoE, 1994, p. 14)

A second discussion document, *Air Quality: Meeting the Challenge* (DoE, 1995) contained concrete proposals for the regulation and monitoring of nine pollutants, chosen because of their effects on human health (interview 28). These were: benzene, 1,3-butadiene, carbon monoxide, ozone, particulates as PM_{10}, sulphur dioxide, nitrogen dioxide, polycyclic aromatic hydrocarbons, and lead. This document stated that the Objectives would be based on an analysis of costs and benefits.

A confidential "pre-consultation" Strategy was circulated to selected stakeholders in June 1996. This set out the Objectives – medium term targets for ambient pollution concentrations- for eight pollutants (PAH was removed). This was followed by the official consultation draft in August 1996. The most significant change in the Consultation draft was designation of the Objectives for PM_{10}, NO_2, ozone and SO_2 as 'indicative', to be revised in 1999. The Standards were recommended by EPAQS (or WHO where EPAQS had not yet recommended a Standard).

There were over 500 responses to the consultation draft (Potter, 1997, p. 31) . The final NAQS was published in March 1997.

2.1. The structure and principles of the Strategy

The stated aim of the NAQS was "to render polluting emissions harmless" (DoE, 1997), and comprised of two elements:

- Medium-term targets for maximum permitted concentrations of ambient pollutants– Objectives
- A framework of policies and plans which enable the Objective to be reached (Department of the Environment, 1994, p. 3).

The NAQS took an "effects-based approach" (DoE, 1994, p. 2), by which Objectives were set for maximum ambient pollution concentrations, and were accompanied by a programme of measures expected to contribute to their achievement. *Improving Air Quality* gives two reasons for this: first, an overall Objective for ambient pollution rather than sector-by-sector targets enabled the development of different, "innovative" approaches to policy-making. Second, the Objectives would provide a benchmark by which to judge which potential policies would be cost-effective means of pollution reduction (DoE, 1994, p3).

These aims were attempts to change the institutional structure of pollution management in the UK. Prior to the NAQS, air quality controls had been developed on a sector-by-sector basis, and different regulatory bodies controlled different sectors. *Improving Air Quality* describes previous policy as: "the fortuitous sum of a large number of unrelated regulatory decisions and individual choices" and therefore not appropriate to achieving a constant standard of air quality (DoE, 1994, p. 8). The NAQS claimed that for this reason it was "a watershed in the history of measures to control and improve the quality of air in the United Kingdom." (DoE, 1997, p. 3).

The problem of air pollution was described in the NAQS as peak episodes of smog, rather than normal background concentrations. The aim of the Strategy thus became:

> *Steps to improve the quality of the air will diminish any remaining risks, and provide a more pleasant living and working environment for us all.*
>
> (DoE, 1997, p. 4)

The NAQS stated that this aim was possible, and that a programme for achieving the Objective for NO_2, PM_{10}, SO_2 and ozone would "…tackle the UK's major residual air quality problems…

effectively eliminating significant episodes of both summertime and wintertime smog" (DoE, 1997, p. 23).

2.2. Air Quality Standards and Objectives

EPAQS recommended Standards according to their judgement of the ambient concentration at which a pollutant is rendered harmless, on the basis of available evidence. In setting the Standard for particulates, which have no safe threshold, EPAQS recommended a level where "… adverse effects on the health of *populations* may still be measurable" (EPAQS, 1995, p. paragraph 31). Given the comparative lack of knowledge about particles, compared to other Strategy pollutants, EPAQS recommended that the Standard be reviewed within five years to take into account new evidence.

In contrast the Objectives were judgements about what could be economically, socially, culturally and technically feasible (DoE, 1995, p. 18). The NAQS set the PM_{10} Objective as 50µg/m³, measured as the 99th percentile of a 24-hour running mean on a TEOM monitor[12]: Each year 365 measurements would be taken from each monitor, and 361 were required to be at or below 50µg/m³.

The NAQS argued that setting Objectives as percentiles was appropriate, because some days it would not be possible to achieve the Standard, because of weather conditions or background levels of PM_{10} (such as dust from the Sahara or transboundary particles). Exceedences also occur for cultural reasons: it would not be politically expedient to ban Bonfire Night, for example, although PM_{10} Objective exceedences often occur then (DoE, 1997, p21). Finally, it may not be cost-efficient to implement the Standards, because the costs of doing so would be disproportionate to the health gains.

2.3. Plans and policies for implementation

The NAQS set out the Government's policies, planned but not yet implemented policies, and the principles on which any new measures would be founded. This Strategy was a synthesis of policy measures introduced previously.

This is not to say that the NAQS did not inspire policy measures. The 1996 Budget introduced an "air quality package" of fiscal incentives for the promotion of cleaner vehicles and fuels (DoE, 1997, p. 50):

[12] A TEOM monitor measured PM_{10} continuously. This was the monitor used at this time in the PM_{10} network.

- Three pence per litre duty rise on petrol and diesel as the most polluting fuels (and this was set to rise further under the Fuel Duty Escalator)
- Duty on ultra-low sulphur diesel was made 1 pence less than conventional diesel
- Duty on CNG and LPG was cut by 25% (on top of the 15% cut in the 1995 budget)
- Incentives of up to £500 for lorries meeting very low emissions standard through retrofitting particulate traps or converting to gas

The strategy of local pollutant management was set out in *Improving Air Quality*. LAQM was arguably the most significant change in policy as a result of the Air Quality Strategy, and was the process by which local authorities became responsible for attempting to meet air quality Objectives in their areas. It gave local authorities a much more active role in pollution control than they had previously (Yearley, 2006), and linked their functions for health protection and of planning for the first time (Cannibal & Lemon, 2000, p. 293).

The Environment Act 1995 stated that local authorities were required to review and assess their air quality to decide whether they would meet the NAQS Objectives for 2005. If predicted not, they had to declare an air quality management area, and design an action plan for improving air quality.

LAQM was based in the theory of 'hotspots': local areas of high air pollution which could not be effectively reduced through national measures (DoE, 1997, p. 26; Williams, 1995, p. 4). The NAQS did not require local authorities to achieve the air quality Objectives, but to *attempt* to achieve them: "Where air quality objectives are not likely to be achieved, local authorities must… make action plans for improvement **in pursuit of national air quality objectives**" (DoE, 1997, p58, my emphasis).

3. Visions in the National Air Quality Strategy

The NAQS contained visions: preferred expectations for future outcomes. These are set out in table 6.1. From this table it can be seen that the majority of visions articulated in the NAQS are for future preferred developments in national, local and European policies.

Much of these visions for policy were characterised as statements of the government's preferred direction for policy changes to promote the fulfilment of the NAQS Objectives, for international, national and local policy development. The language of these was imperative: "Government policy must…" and "the principal target of policy in this area must be…" (Department of the Environment, 1997, p. 30 and 45).

These visions also relied on the voluntary actions and enthusiasm of local authorities, businesses and individuals to work to achieve the Objectives. Those visions for technological change, with or without proposed policies to achieve, were vague in their characterisation of 'technologies' (except for future European vehicle and fuel standards which were under discussion in the Commission at the time of publication).

Table 6.1. Visions in the NAQS for future technological change, policy change, and behavioural change, and combinations of these categories (source DoE, 1997)

Visions for Technology	Visions for Technology & Policy	Visions for Policy	Visions for Policy & Behaviour	Visions for Behaviours
By 2005 vehicle technologies and fuels should be capable of greater emissions reductions than currently predicted (p159)	Meeting the PM_{10} and NO_2 Objectives requires successful agreement on the then proposed European vehicle and fuel standards and accompanying technological change. (p18)	European Air Quality Framework should be consistent with UK principles of proportionality, effects-based, and sound science.(p16)	Coordination and cooperation between local authorities required to ensure the Objectives can be met. (p60)	Industry: can take voluntary action to reduce energy consumption and reduce transport emissions. (p34)
…current technology should make it possible to take emissions tests one step further. On-board diagnostic systems could warn drivers if the emissions control system stops working and prompt them to seek intermediate repair.*(p47)*	Government should look to technologies for emission reduction as these are associated with predictable and enforceable outcomes. (p26)	LAQM: should seek cost-effective improvements, from a balance of sources, and draw on public, private and voluntary efforts. (p6)	Government and local authorities will continue to encourage individual behaviour choices which reduce air pollution. (p69)	General public has a role in air quality management: in influencing industrial activity, practising fuel economy, and in transport choices (p54)
Industrial innovation will be important in securing reductions in pollution in the most cost-effective way; not just from industry itself but from other sectors responsible for pollution, such as transport (p34)	New technologies, products and techniques will result from any new environmental targets. (p18)	Policy measures will lead to reductions in number and scope of poor air quality episodes. (p45)	Local authorities should act to reduce the impact of their own activities on air quality (p60)	*The public's role in influencing industrial activity and practising fuel economy is of great importance, but it is in day-to-day decisions about transport choice, that the individual's determining role in air pollution becomes most significant. Everyone has a part to play.* (54)

Table 6.1. (Continued) Visions in the NAQS for future technological change, policy change, and behavioural change, and combinations of these categories

Visions for Technology	Visions for Technology & Policy	Visions for Policy	Visions for Policy & Behaviour	Visions for Behaviours
By 2005 vehicle technologies and fuels should be able to deliver greater emissions reductions than those predicted in the NAQS (p159)	*Adjusting transport systems of traffic management priorities in large and dense urban areas could typically take 5-10 years. Changes within the planning system can take even longer to show significant results…* (46) *For short term improvement, it is necessary to look at vehicle inspection and maintenance and at driver behaviour.* (p46)	Government policy should ensure that predicted road transport emissions happen and accelerated where possible – and then sustain them (p45)	Government expects local authorities to implement local action on traffic management and improved driving practice (47)	.
	The Government views the continued enhancement of the in-service emission programme as an important element of an overall strategy to sustain the environmental improvement from the UK vehicle fleet. (p51)	Further actions is needed to achieve NO_2 and PM_{10} targets (p48)		
	Technology and industrial lead times mean that the improvements the Government supports could not now be implemented and have effect much before the 2005 deadline. (p18)	The Objectives set in the NAQS will change in response to developments in scientific evidence about pollutants (NO_2 and PM_{10}) and their behaviour in the UK (p19)		

Table 6.1. (Continued) Visions in the NAQS for future technological change, policy change, and behavioural change, and combinations of these categories

Visions for Technology	Visions for Technology & Policy	Visions for Policy	Visions for Policy & Behaviour	Visions for Behaviours
	Majority of abatement costs will arise from policy measures to improve emissions from new vehicle after 2000 (p31)	Structures set up by NAQS and Environment Act will be the principal means of fulfilling future EU air quality directives. (p35)		
		Government policy should focus on attaining the predicted reductions in emissions and in sustaining vehicle emission at recommended levels as air quality Objectives are reached (p45).		
		Local authorities should aim for sustainable development and integrate air quality policy into wider policy considerations. (p5)		
		Government will develop mechanisms for ensuring that industry contributes to LAQM (p5)		
		New policy measures will develop in the next few years that could change the costs of meeting the Objectives (p73)		

Table 6.1. (Continued) Visions in the NAQS for future technological change, policy change, and behavioural change, and combinations of these categories

Visions for Technology	Visions for Technology & Policy	Visions for Policy	Visions for Policy & Behaviour	Visions for Behaviours
		Adjusting transport systems of traffic management priorities in large and dense urban areas could typically take 5-10 years. Changes within the planning system can take even longer to show significant results… (46) *For short term improvement, it is necessary to look at vehicle inspection and maintenance and at driver behaviour.* (46)		

4. Expectations and the policy process of the NAQS

It was not simply the policy-makers of AEQ who articulated expectations in the policy-making process of forming the NAQS. Stakeholders involved in the process did also. For example, Friends of the Earth used the opportunity of the NAQS to present visions for policy outcomes as imperatives:

> *Cleaner fuels and cleaner vehicles are essential components in the Government's Air Quality Strategy. Ministers must work with our European partners to impose the toughest standards technically feasible on motor manufacturers and oil companies.*
>
> (Friends of the Earth, 1997)

Along the same lines, the Royal Commission on Environmental Pollution (the RCEP) argued:

> *Even if the present package of measures achieves the proposed objectives for air quality in 2005, it is generally acknowledged that road traffic growth beyond that date will cause air quality to deteriorate again unless further measures are taken. Greater emphasis is needed on assessing the potential next round of European legislation controlling emissions from new vehicles which is due to come into effect in 2005 and, and on what is likely to happen after that legislation has had its full effect in reducing emissions from individual vehicles.*
>
> (RCEP, 1996)

Other groups put forward negative expectations of the future – that they did not want to happen. For example, in their response to the draft NAQS the Confederation of British Industry (CBI) stated that it feared that LAQM would target stationary sources rather than traffic and more diffuse sources (Environmental Data Services, 1996b).

5. Was the PM_{10} Objective set on the basis of expectations of feasibility?

This chapter next examines the three priorities for successful air quality policy outlined in *Air Quality Meeting the Challenge* (DoE, 1995, p. 5) and the NAQS:

- The Objective for PM_{10}
- The policy of LAQM
- And the effective contributions of others sources –focusing on road transport.

For each the relative contributions of scientific knowledge, use of modelled forecasts, and expectations dynamics are assessed, and picture created of the policy process.

Whilst the NAQS developed, the evidence base grew: the monitoring network provided data on concentrations and an investigation into particles by the advisory committee QUARG gave insight into their composition and sources (QUARG, 1996). QUARG provided forecasts for the components of particulate matter: primary, secondary and coarse. This methodology was used to calculate the reductions necessary to end peak episodes of particulates, and then calculate the relative reductions required for each fraction (DoE, 1997, p. 158). This fits with the characterisation of the pollution problem in the NAQS as a local, intermittent problem.

Even considering the contribution of this scientific evidence base, Objectives were political judgement about what could be achieved in the medium-term. In setting them, policy-makers were dependent on expectations about the future. At the very least, setting an Objective made the implicit statement that policy-makers did not expect to achieve the Standards. To answer research question 1, it is necessary to examine how Objectives were set.

5.1. The principles of cost-benefit analysis and proportionality

Cost-benefit analysis was presented in the NAQS and supporting documents as the ideal methodology by which Objectives would be set and policies to achieve them assessed locally, nationally and internationally (DoE, 1994, p. 3; 1997, p. 18). *Improving Air Quality* stated that regulation must not "disproportionately" focus on one industry, and that the best way to ensure that this did not happen was to judge measures on their costs and benefits (DoE, 1994, p. 3).

However, this proposed assessment of costs and benefits was not achieved for the NAQS (Pearce, 1998, p. 93). Data on the impacts of pollutants on morbidity and mortality were subject to such great uncertainties that the monetisation of benefits proved difficult (DoE, 1997, p. 180). One study assessed the costs of achieving the PM_{10} and NO_2 Objectives, and this only assessed the cost of meeting the Euro III requirements for vehicles (DoE, 1997, p. 184).

The NAQS stated that there was an implementation gap of about 10% between the plans and policies in the NAQS and reaching the Objective. The exact size of this gap was dependent on unpredictable factors including the weather in 2005, local authority actions, individual behaviour and the effects of fiscal incentives (DoE, 1997, p. 31). Remaining uncertainties in the understanding of particulate behaviour and composition also contributed.

5.2. Did DoE expect the PM_{10} Objective to be achieved by 2005?

Civil servants in the DoE expected the Objective to be achieved (interview 17 and 28), although they expected them to be challenging. These policy-makers wanted to set ambitious targets

(interviewee 12). However, some actors remember this period differently: for example, a modeller (interview 13) stated that policy-makers did not know what could be achieved.

Interviewee 9, a modeller, stated that he expected the NAQS Objectives to be set at the same level as the EPAQS Standards. This was mooted in *Improving Air Quality* (Department of the Environment, 1994), but policy-makers stated it was only when they decided to introduce separate Objectives and Standards that they fully developed the framework for the NAQS (interview 16).

6. Local hotspot management

The policy of LAQM was in line with the assumptions made by civil servants in DoE and scientists in QUARG that the problem of air quality was confined to peak episodes and local hotspots. Its role was described in the NAQS as "… a fine tuning or corrective system" (DoE, 1997, p. 26). However, the ten per cent implementation gap for particulates was perhaps too large to be described as "fine tuning".

6.1. LAQM as the best means of managing local air quality

One interviewee (interview 7) stated that non-legislative bodies, such as AEA Technology (who managed the monitoring networks) were considered as managers by AEQ, but that local authorities were chosen because they possessed the requisite legislative powers and democratic legitimacy to introduce measures to improve air quality – which consultancies did not. For example, local authorities were responsible already for the regulation of domestic fires and regulation of some industrial processes. They also had responsibilities for areas which affected pollution: transport and land use planning (DoE, 1995, p. 17).

Air Quality: Meeting the Challenge (DoE, 1995, p. 20) stated that policy-makers expected that transport would be the greatest single source of many air pollutants, especially in urban areas. A series of guidelines were issued to local authorities about how to integrate air quality management into land use planning and transport policy (DETR, the Scottish Office, & the Welsh Office, 1997a, 1997b; DETR & the Welsh Office, 1997).

The NAQS recognised that "in certain circumstances, the role of local authorities will need to be enhanced and there may be a case, therefore, for giving local authorities additional permissive powers to manage traffic" (DoE, 1997, pp66). However it did not contain new measures, additional to what was in place prior to 1997, with the exception of roadside emission testing. but contained no new measures, with the exception of roadside emissions testing.

Like the NAQS, LAQM required the co-operation of environmental health officers, land-use and transport planners, and other sections of local authorities, which were not used to working together (Interviews 6 and 19). Elsom (1999, p. 117) predicted that the success of LAQM depended on "… how the process is embedded within other local policy processes and how linkages and inconsistencies are handled". Interviewees from local authorities claimed that they had wanted to play an active role in pollution control (interviews 6 and 19).

6.2. Encouragement to local authorities through statements of expectation

LAQM provides evidence that policy-makers made statements of expectation to encourage others to act. For example, the guidance to local authorities on review and assessment of air quality contains this vision for compliance:

> *The Government does not perceive any lack of enthusiasm from local authorities to complete this task and, moreover, envisages that there will be significant local pressure from local authorities to move quickly.*
>
> *(DETR et al., 1997b, p. 19)*

Encouragement to act was demonstrated in the NAQS, which expected that "local authorities should begin the process to create AQMA's as soon as possible", even before this became mandatory (DETR et al., 1997b, p. 62).

These visions contained the assumption that local authorities were as enthusiastic as the DoE to improve air quality. However, those visions were not backed by a statutory requirement on local authorities to fulfil the Objectives, and there were no sanctions if they did not. There was therefore little incentive for local authorities which did not already prioritise air quality to do so.

6.3. Alternative expectations for LAQM

Whilst policy-makers used visions to encourage others to action, stakeholders responded to the proposals to the NAQS by articulating expectations about how LAQM would work in practice. In a press release entitled, "Royal Commission concerned that National Air Quality Strategy may not achieve objectives" the RCEP stated that:

> *At local level, local authorities are not well prepared for the new air quality management duties that will be placed on them in April 1997. They do not generally have in place either budgetary provision or appropriately qualified and trained staff... and they need guidance from central government on a wide range of issues.*
>
> *(RCEP, 1996.)*

Other commentators echoed this concern and pointed out the need for further government guidance on assessing air quality and controlling it, for example Steve Potter (1997, p. 26) in a research report to the House of Commons on air quality:

> *Whilst a package of measures to suit local needs provides flexibility of approach, there is a degree of inconsistency between the objectives which local authorities will be expected to deliver, and the powers available for them to do so.*

Potter (1997, p. 35) calculated that there was about £30,000 available per authority to support modelling and monitoring over three years. The DoE expected costs to local authorities to be about £6,500 for the initial review process, but this assumed no extra monitoring and that local authorities had access to the information they needed. Potter concluded that "…it is unclear at this stage whether funding will be adequate to carry plans through to the year 2005" (Potter, 1997, p. 26). In a statement to *New Scientist* the National Society for Clean Air (NSCA) claimed that local authorities felt that they needed extra money to achieve the Objectives (Hamer, 1996).

These above statements to the press by the RCEP and NSCA used expectations for poor future air quality to highlight their concerns that local authorities were not adequately prepared or supported to address air quality. They used negative statements of expectation (around meeting future targets) to influence a wider audience, and these could also be seen as attempts to influence policy.

Although a case could be made that policy-makers did not know what impact local measures to improve air quality would have, it has been demonstrated above that stakeholders including specialists on clean air and local government believed that not enough was being done.

7. Effective emissions control from other sources

This section examines the expectations and visions for other emissions control sources, focusing on those from road transport. That is because stationary sources were regulated through a European framework, and were not subject to regulatory controls through the NAQS.

QUARG identified road traffic as a major contributing factor to peak episodes of particulates (Quality of Urban Air Review Group, 1996, p. 169). The NAQS quoted the QUARG report and stated that:

> *Given the concentration in urban areas and the contribution to those levels from road transport, the principal target of policy in this area must be the abatement of PM_{10} emissions from urban transport sources.*
>
> (Department of the Environment, 1997)

This vision for the future direction of transport policy was present in the discussion documents:

> *Traffic projections indicate current traffic levels may double by 2005. If further action is not taken, total emissions of many major pollutants will begin to rise again some time after 2010…. Transport policies will therefore need to be at the centre of any long term strategy.*
>
> (DoE, 1995, p. 24)

This vision was about the direction of policy change. *Air Quality: Meeting the Challenge* had set out four "principles" by which the Government would work to reduce vehicle pollution:

1. *Improvements in vehicle and fuel technology to reduce emissions;*
2. *Tighter controls on the existing vehicle fleet, its management and operation,*
3. *Development of environmental responsibilities by fleet operators, particularly public service fleet operators, and by the public at large, in transport and vehicle use; and*
4. *Changes in planning and transport policies which would reduce the need to travel and reliance on the car.*.

These were cited again by the NAQS (Department of the Environment, 1997, p. 46).
The NAQS estimated that a 61-67% reduction in vehicle emissions of PM_{10} from their levels in 1995 was required in order to meet the Objective in 2005 (DoE, 1997, p154). This highlights again the dominance of the road transport PM_{10} fraction in urban areas. Reaching the PM_{10} Objective required a substantial improvement in diesel vehicle emissions. Indeed, the NAQS was criticised for relying on these technological developments (Potter, 1997).

Without the Euro standards it is unlikely that the UK would have been able to set as ambitious Objectives. An article from *the Guardian* following the publication of the Draft Strategy supports this claim:

> *Achieving the targets was put off until 2005 to allow European directives to come into force and fuel refining to be adapted.* (*The Guardian*, 22 August 1996, pp7)

Compliance with planned, implemented and proposed Directives was forecast to reduce tailpipe emissions of particulates by over 40% by 2005 on 1995 levels (Department of the Environment, 1997, p. 158). The forecasts used in development of this 40% figure were wrong –it overestimated the emissions reductions from Euro III and beyond, and underestimated the growth of traffic on the road (interview 5,16, 28).

In negotiations over the post-2000 Euro standards the UK used the EPAQS Standard for PM_{10} as the basis for its negotiations; linking this to reduction in peak episodes;

> *The UK has argued for substantial emissions reductions, consistent both with attaining the level recommended by EPAQS on a percentile basis… in wintertime episodes in the UK by 2005, and maintaining at least this level of air quality (in terms of particles) thereafter*.
>
> (Department of the Environment, 1997, p. 159)

In response, the UK Petroleum Industry Association (UK PIA) and the Society for Motor Manufacturers and Traders (SMMT) stated that "it is far from clear yet just how much harm particulates actually do" (Environmental Data Services, 1995a).

The EPAQS Standards and the concerns over peak smog episodes thus had some bearing on wider government policy.

7.1. Expectations for alternative vehicle technologies in the NAQS

The NAQS identified CNG and LPG as possible alternatives to diesel, and that they would "have considerable environmental advantages for use in urban fleets of Light Duty and Heavy Goods Vehicles, and in bus fleets" (Department of the Environment, 1997, p. 49). Support for these technologies was demonstrated through cuts in fuel duty on these two fuels in 1995 and 1996 and the budget's "intention" of providing an incentive for retrofitting diesel particulate filters or conversion to CNG of up to £500 (Department of the Environment, 1997, p. 50). This measure suggests that policy-makers had decided that these technologies had now reduced in price to the point where they could be retrofitted to older vehicles.

In 1996 the Department of Transport introduced the PowerShift programme: a fund for grants to use in the purchase of CNG, LPG and electric vehicles (Energy Saving Trust, 2002). In 2004 the Department for Transport described the purpose of PowerShift as "…to help overcome market failure issues – early consumer unfamiliarity, doubts about new technology etc…". It was specifically designed to encourage the introduction of vehicles that improved air pollutant emissions (Department for Transport, 2004a). In the first year, 1996-1997, £1million was spent setting up pilot schemes testing alternative fuels – e.g. LPG ambulances in Oxford, CNG buses in the West Midlands and electric vehicles in Coventry (Air Health Strategy, 1997). This again suggests that the visions included in the NAQS and its discussion documents had an effect on some wider government policies.

The NAQS' inclusion of these expectations for CNG and LPG are symptomatic of wider government and advisory committee expectations for these fuels. There were several studies

conducted for the DoE, the Department of Transport, the House of Commons Transport Select Committee and RCEP, all of which reported between 1994 and 1996 (ETSU, 1996; House of Commons Transport Select Committee, 1994; Quality of Urban Air Review Group, 1993b; Royal Commission on Environmental Pollution, 1994). These panels all agreed that CNG and LPG offered the most environmental benefits when compared other alternative fuels including biofuels and electric, and were the most "promising" (House of Commons Transport Select Committee, 1994, p. 21).

Proponents of CNG and LPG used the growing concern to improve urban air quality and to meet NAQS Objectives as a platform from which to promote their fuels. Civil servants from the Departments of Transport and Environment (interviews 10, 28, 29) stated that the vision that CNG and LPG would be viable alternatives to diesel for the improvement of air quality became widespread amongst policy-makers in both departments, and this was articulated in the 1996 Transport White Paper:

> *CNG and LPG seem most likely to take the lead in offering significantly lower emissions than conventional diesel vehicles.*
>
> (Department of Transport, 1996)

The National Society for Clean Air (NSCA) and Friends of the Earth (interview 29 and 26) were also vocal in their support for further adoption of gaseous road fuels.

The vision for these technologies centred on the suitability of these fuels for use in local, urban vehicle fleets – public transport and local delivery vehicles – which have central depots where fuel could be stored.

> *Tom Fiddell, Director General of the LPGA [Liquid Petroleum Gas Association], says that a change to the taxation system could increase annual sales of LPG fuel from 1,800 tonnes to 300,000 within seven years. "We are not trying to carve a huge market share," he says, "but LPG has tremendous promise for heavy vehicles in inner city areas."*
>
> (*Environmental Data Services,* 1995)

Environmental Data Services (1995b) reported that CNG and LPG firms aimed to improve their market share by targeting these fleets. This vision suggested a solution to the limited supply infrastructure for both fuels (ETSU, 1996, p. 26) The potential for transforming local vehicles fleets was expressed by the RCEP (1994) and the Department of Transport White Paper (Department of Transport, 1996)

7.2. The dynamics of expectations for technological change

This study does not aim to be a comprehensive review of all statements regarding alternative fuels and technologies during Period 1, but rather to provide insight into how visions and expectations about these technologies were articulated and spread in the context of air quality improvement policy. By the time of the NAQS Budget in 1996, policy-makers in the Department for Transport and in AEQ had a preference for CNG and LPG over other alternatives to diesel vehicles.

There were practical reasons for the policies and technologies advocated in the NAQS: large numbers of road fuel gas-powered vehicles existed in some other countries, electric vehicles had technological disadvantages, and biofuels lacked a supply infrastructure (as described in chapter 2). The technologies existed for CNG and LPG, as proved by their acceptance in other countries – the challenge for industry actors was to persuade manufacturers to make road gas-powered cars or hybrids, and to improve infrastructure. These technologies also fulfilled the most important criterion for the NAQS: they had lower emissions of particulates and NOx compared to diesel vehicles (ETSU, 1996, p. 2)

8. The utility of the Dynamics of Expectations framework as an analysis of the NAQS

The analysis of visions articulated in the NAQS – outlined in table 6.1. – indicated that many of these visions were concerned with the future direction of government and international policy. The NAQS sent a public message that future policies would be made in this way.

The visions and expectations about appropriate actions and technologies to reduce pollutants were in line with the construction of the environmental problem as 'hotspots' and peak episodes. Those for technological change were representative of expectations that were already dominant in government.

Yet this analysis does little to explain why there were so few new policies in the NAQS – besides LAQM. Interviewees 19 and 9 stated that they believed at the time there would be new measures in the NAQS to reduce emissions from other sources. Evidence from interviews suggest a third explanatory factor is necessary to understand the limited new policies of the NAQS, and the reasons for the visions for the direction of policy: the role of structures and institutions.

9. The role of structures and institutions in development of the NAQS

Many interviewed believed that LAQM passed responsibility of achieving the Objectives from national to local government because the DoE lacked the powers to create further national

policy measures and to influence technical change (for example, interview 27). The NSCA (cited in Environmental Data Services, 1996a) commented that:

> *National air pollution policies are all carrot and no stick… [The Government]…cannot get away with passing all of the dirty work – the politically unpopular decisions to local authorities. By themselves local traffic management measures are simply not going to be enough.*

Whilst the DoE at this time had the powers to establish LAQM, they had no regulatory power over any other source of pollutants. In developing the Strategy, the DoE required the cooperation of the Department for Transport and the Department of Trade and Industry (DTI).

Such support was not always forthcoming in the development of the NAQS – for example, the Draft Strategy was published without the stated support of the Department of Transport and DTI. This was taken by many as disagreement.

Despite the consensus around the need for health protection described in the earlier part of this chapter, the DTI was very critical of the epidemiological evidence. Robert Maynard (2001, p. 288), the head of air quality at the Department of Health, wrote that this was "… in part for good scientific reasons and in part, perhaps, because it was appreciated that they would lead to calls for further and possibly costly reductions in the generation of air pollutants."

Significantly, whilst the Department for Transport put their name on *Air Quality: Meeting the Challenge*, neither they nor the Department of Trade and Industry did so on the Consultation Draft (Environmental Data Services, 1996a). The NSCA commented that "interdepartmental wrangling" had delayed publication of the Strategy (NSCA, 1996, p. 2).

The final institutional issue was the imminent general election in May 1997. Anecdotal evidence suggests that publication was rushed to ensure that the Strategy was published by the Conservative Government, and that John Gummer especially wanted this Government to have the credit for it (interviews 19 and 29). This may provide some explanation for the overarching vision of the Strategy as a roadmap for future policy direction.

10. The reality of LAQM

The reality of implementing LAQM was very different to the expectations of AEQ articulated in the NAQS. Many local authorities had no experience of assessing and predicting air quality, and over the course of Period 2 it became clear that the process of review and assessment of air quality was taking longer than predicted in the NAQS (Air Health Strategy, 1997, p. 2). The deadline for local authority assessments of air quality was moved from December 1999 to June 2000, for reasons including delays in the publication of official guidance (Environmental Data

Services, 1999b). By February 2000, almost three years after the publication of the NAQS, only one local authority – Westminster - had declared an air quality management area (AQMA) (Air Quality Management, 2000b, p. 12). Westminster declared its entire area an AQMA for NO_2 and particles, in contradiction of the expectation of the NAQS that "The Government does not envisage, however, that designated areas will blanket individual or groups of local authorities" (Department of the Environment, 1997, p. 63). High levels of particulates and other pollutants were not always confined to manageable hotspots.

Some of the local policy measures that the NAQS expected to be significant also ran into difficulties. Pilot schemes for local authority roadside emissions testing garnered criticism from the public, some members of parliament, and motoring organisations for issuing fines on first inspection of vehicles, rather than giving warnings (Air Quality Management, 1999, pp. 8-9; Environmental Data Services, 1997b). Bristol – one of the pilot authorities – claimed it lost money on the scheme. A review of the scheme started in January 1999 and was continuing when the Revised Strategy was published in January 2000 (Air Quality Management, 2000b, pp. 8-9; DETR, 2000a, p. 91).

Policy-makers in AEQ also underestimated the complexity of air quality management, and this became evident in the local assessment of air quality. For example, many authorities had air quality problems caused by motorways or large roads in their vicinity (including Birmingham – interview 11) which were out of their control. Similarly, local authorities found that the DETR guidance on setting the geographical area of an AQMA was unclear. In response the NSCA commissioned experts from local authorities, modellers and the monitoring network to produce guidelines for local authorities. Interviewees representing local authorities and those who worked with them (6, 7, 9, 13 and 19) reported that NSCA guidance was more useful than the first set of guidance notes from policy-makers

Local authorities also reported contradictory guidance from different central government departments. For example, planning guidance suggest that settlements should be located around traffic corridors, but this would lead to an increase in ambient air pollution for people who live in these settlements (Cannibal and Lemon, 2000, p294). This suggests that the NAQS did not provide the strategic direction for policy that it was intended to have, and provides further evidence of the disjuncture between government departments.

As indicated earlier in this chapter, many of these issues were raised by actors in the policy process but were not addressed by the DoE.

11. Summary: Expectations and their Credibility in Period 1

This chapter demonstrates that expectations and visions for future technologies, policies and compliance were utilised by policy-makers and actors in the policy-making process, in order to gain support and resources for attaining a vision or expectation.

Actors articulated expectations and visions about the future in the context of the NAQS and air quality policy in different ways. For example, statements of expectation were made by local authorities, NGOs and advisory committees about the effects of LAQM. These appear to be the identification of problems with the policy, and trying to get further changes to help the policy succeed. This may have had the effect of also benefiting their members, but not always.

In the same way, the NAQS contained expectations about the future, about policies, technologies and compliance, which were used to gain support for the Strategy.

Research question 5 asks what makes one expectation more credible than another to policy-makers. It would be impossible to act on the often contradictory expectations of all the actors involved in the NAQS, so policy-makers would have to make this judgement.

The NAQS did not always accept the most accurate expectations of the future. For example, the views of expert groups which expected that local authorities did not have sufficient powers and resources to reach the Objectives were not accepted at this point. Although, accuracy of expectations is only possible with hindsight.

The “collective expectations” around the Euro standards, and their presentation in the NAQS were accepted by stakeholders without comment. These were remembered by interviewees because the reality then differed from the forecasts. These expectations seemed to be more credible than others because they had already been debated, and had become normalised and accepted: interviewed stakeholders also believed that the vehicle emissions reductions forecast in the NAQS would be achieved.

As the NAQS was introduced there were many uncertainties, including whether LAQM would work to reduce hotspots, and whether local authorities had sufficient power to do so, and whether fiscal incentives would encourage the uptake of alternatively fuelled vehicles. All actors were beginning to find their roles in implementation. Then, in June 1997, only a few months after publication, the Strategy went into review and the Objective for particulates was relaxed. The next chapter examines why this happened, how expectations changed, and the new direction of the AQS.

Chapter 7. 1997-2000: Return to Business as Usual

The *Air Quality Strategy* (DETR, 2000a) (the Revised Strategy) was launched by the new Department for the Environment, Transport and the Regions (DETR) in January 2000. The period of review that preceded it introduced national forecasts of pollutant concentrations, a stakeholder forum, an expert group advising on particulate matter, and attempts to monetise health effects of pollutants and conduct cost-benefit analysis on achieving the pollution reduction Objectives.

This review focused more on the Objectives than on any potential measures to achieve them. Yet, the particulate Objectives of the Revised Strategy were *less* stringent that the NAQS Objective they replaced.

The Revised Strategy differed dramatically from the NAQS: the PM_{10} Objectives in the new Strategy were set on the basis of modelled forecasts of what was possible in 2005, and these indicated that the new PM_{10} Objectives were largely achievable under 'business-as-usual'. As a result of the new Objectives, the pollutant expected to exceed its targets most often was no longer PM_{10} but NO_2. However, whilst this meant that more local authorities would subsequently act to reduce NO_2 than PM_{10}, AEQ still regarded PM_{10} as the most harmful air pollutant (DETR, 2000a, p. 55).

Three alternative explanations are examined in this chapter to provide insight into these developments. First, the chapter charts changes in the scientific understanding of particulate matter in the UK and the subsequent adjustment of PM_{10} Objectives. However, changes in scientific evidence alone do not provide sufficient explanation for the choice to reduce the particulate Objective to levels forecast achievable by 'business-as-usual'. The roles of visions, expectations and their dynamics, and the impact of the growth of wider political discourses are examined. First the political and social context in which the Revised Strategy developed is set out.

1. The political and social context of Period 2

The instigation for the early review of the Revised Strategy came with the election of the Labour Government in May 1997. In opposition, Labour and the new environment minister, Michael Meacher, criticised the Strategy as too weak, with deadlines which were set too far into the future (Environmental Data Services, 1997a). Once in power the new government accelerated the review (Environmental Data Services, 1997a). Given this opposition to the

perceived weaknesses in the NAQS, it is striking that the Revised Strategy went on to set a PM_{10} Objective that was less stringent than the original whilst keeping the same deadline.

The new Government came to power promising a new "integrated" approach to transport and the environment (Air Health Strategy, 1997 p1). Practical manifestations of this integration included the attempt to merge transport and environmental policy-making in the new Department of the Environment, Transport and the Regions (DETR) and the publication of the *Integrated Transport White Paper* (DETR, 1998) in July 1998. The latter outlined proposals for the future of all transportation modes in the UK, with the aim of providing solutions to the problems of congestion and environmental pollution (including air quality, climate change and noise) (Begg & Gray, 2004, p. 156). The White Paper acknowledged that forecast growth in traffic levels could not be sustained, and proposed to reverse such long-term trends through demand management (Goodwin, 1999, p. 663). In practice, action from the DETR focused on transport policy rather at the expense of environmental policy (Begg & Gray, 2004; Connolly & Smith, 2003, p. 297).

Scholars have debated whether the White Paper marked a turning point in transport planning, or whether it was the culmination of a longer term policy shift away from accommodating the ever-growing needs of the motor vehicles (e.g. Docherty, 2001; Goodwin, 1999). Such a shift in policy, towards integration, was unforeseen by those policy-makers who developed the NAQS under the previous administration.

1.1. European air quality directives

The European Union adopted the European Air Quality Framework Directive in 1996. This established a programme of air quality improvement similar in structure to the UK AQS. Daughter Directives set European-wide *limit values*: medium-term targets for maximum ambient concentrations for common pollutants, based on the recommendations of the World Health Organisation. Those for PM_{10}, SO_2, NO_2 and lead were incorporated into the Revised Strategy.

The similarity between the UK AQS and European Air Quality Framework was not coincidental. The UK claimed responsibility for the setting legally binding limit values for four pollutants during its period of EU presidency in 1998 (DETR, 2000a, p. 23). One civil servant from AEQ moved to work for the European Union in 1996 to work on the air quality framework (evidence from interview 28). Civil servants who worked on the Revised Strategy agreed that the UK was influential in the European air quality policy-making process, because they had already thought through many of the issues in the development of the NAQS (interviewee 28), and because air

quality monitoring and plans for implementation were more advanced than those of other member states (interviewee 14).

The first air quality Daughter Directive for PM_{10} prescribed the limit values of a 24-hour mean of 50μg/m³ not to be exceeded more than 35 times per year and an annual mean of 40μg/m³, and these were adopted as the PM_{10} Objective in the Revised Strategy. Table 7.1 sets out the particles Objectives of the Revised Strategy and the NAQS. From this table it can be seen that the concentration of particles required by the Objectives did not change, but the permitted exceedences per year did – from 4 in the NAQS to 35 in the Revised Strategy. However, the NAQS Objective and the European limit value were not directly comparable because they were measured in different ways. The NAQS was set on the basis of TEOM monitors, which enabled continuous measurement of particulate concentrations (known as a *running mean)*. The European Directive, and subsequently the Revised Strategy Objectives, was set on the basis of gravimetric monitoring, which did not allow continuous measurement and which measured a slightly different particulate fraction. TEOMs and gravimetric monitors measure particle-bound water in different ways which cause TEOMs to present an underestimation of PM_{10} compared to gravimetric. As particulate matter is perceived and defined through monitoring, the choice of monitor was significant[13]. In practical terms this meant that the TEOM monitors, which comprised the majority of monitoring sites in the UK national network, systematically underestimated PM_{10} compared to gravimetric monitors (Allen et al., 1997) and could provide one mean measurement every 24 hours, rather than a continuously updated running mean. The decision by AEQ to set the Objective for the Revised Strategy at the European limit value thus represented more than a change of permitted exceedences, but also a change in the accepted understanding of the composition of PM_{10}.

Whilst the UK was required to incorporate the European limit values into policy, the Revised Strategy set a more stringent Objective for lead than the limit value directed; added more stringent Objectives for sulphur dioxide in addition to the limit values; and set an early implementation date for the limit value for nitrogen dioxide (DETR, 2000a). The Objectives of the Revised Strategy cannot be explained simply as adoption of the European limit values.

[13] For further discussion of these issues, and of the impact of monitoring standard on policy decisions see my previous work (Smith, 2003).

Table 7.1. The PM_{10} Objectives of the NAQS and the Revised Strategy

	Concentration	Annual permitted exceedences	Permitted exceedences as a percentile of the 24 hour mean	Frequency of measurement	Achievement date
1997 NAQS	50µg/m^3	4	99th	24 hour *running* mean	01/01/2005
2000 Revised Strategy	50µg/m^3	35	90th	24 hour mean	31/12/2004
	40µg/m^3	-	-	Annual mean	31/12/2004

1.2. Institutional and Personnel changes

The DoE merged with the DoT to become the DETR in 1997. Michael Meacher became Minister for the Environment, and the department was represented in Cabinet by John Prescott, the Secretary of State for Environment Transport. In 1997 Richard Mills left AEQ to head the NSCA, and was replaced by Martin Williams. Christopher Leigh led the review of the Strategy. In 1999 the devolved authorities in Scotland and Northern Ireland took responsibility for air quality policy in their regions

To inform the review of the NAQS the DETR established new programmes of evidence and new advisory bodies. The NAQS made a commitment that future Strategies would be informed by an assessment of costs and benefits of any additional measures to reach the Objectives (National Audit Office, 2001a, p. 28). The Interdepartmental Group on Costs and Benefits (IGCB) formed in late 1997 in order to examine the monetary costs and benefits of potential Objectives (National Audit Office, 2001a, p. 28). Its membership is set out in table 7.2.

Table 7.2 Institutions represented in the IGCB

Institutions represented in the IGCB
Cabinet Office
Department of the Environment (Northern Ireland)
Department of Health
DETR
DTI
Environment Agency
HM Treasury
National Assembly for Wales
Scottish Environmental Protection Agency
Scottish Executive

Source: NAO (2001a)

The *ad hoc* group on the Economic Appraisal of the Health Effects of Air Pollution (EAHEAP) consisted of health experts and economists, and had the remit of investigating characterisation of health benefits for cost benefit analysis. It produced one report.

The Air Quality Forum, established in 1997, brought together representatives of local government, business, industry, transport, health and environmental organisations into an informal discussion group on air quality issues and a sounding board for potential air quality policy issues. The representatives of government departments on the Forum also formed the 'Interdepartmental Group' (of which the IGCB was a subgroup) (National Audit Office, p. 28). Forum membership in Period 2 is set out in Table 7.3.

Table 7.3. Nominal Membership of the Air Quality Forum during Period 2 (source: National Audit Office (2001a)

Membership type	Organisations
Government departments and agencies	DETR, Department of Trade and Industry, Department of Health, Number 10 Policy Unit, HM Treasury, Cabinet Office, Health and Safety Executive, Ministry of Agriculture Fisheries and Food (MAFF), Ministry of Defence, Environment Agency
Devolved administrations	Scottish Executive, National Assembly for Wales, Scottish Environmental Protection Agency, Department of the Environment (Northern Ireland), Northern Ireland Industrial Pollution Inspectorate
Local government	Local Government Association, Convention of Scottish Local Authorities, Welsh Local Government Association, Association of London Government, Greater London Authority
Business and Industry	Confederation of British Industry, UK Petroleum Industry Association, Chemical Industries Association, Environment Industries Commission, Federation of Small Businesses, Scottish Federation of Small Businesses, Electricity Association
Transport organisations	The Freight Transport Association, Passenger Transport Executive Group, Confederation of Passenger Transport (UK), Society of Motor Manufacturers and Traders, Transport 2000, The Automobile Association, RAC Motoring Services
Health Groups	British Medical Association, The British Lung Foundation, National Asthma Campaign, British Heart Foundation
Environmental Groups	National Society for Clean Air, Chartered Institute of Environmental Health, Royal Environmental Health Institute of Scotland, Friends of the Earth, National Trust, Royal Society for the Protection of Birds (RSPB)

It is worth noting that whilst the National Audit Office (NAO) identified these groups as Forum members in its evaluation of the Strategy process (NAO, 2001a), not all groups routinely attended meetings. In particular, no evidence was found in meeting minutes that the Ministry of Defence, the Ministry of Agriculture Fisheries and Food, or the Royal Society for the Protection of Birds ever attended. Forum members could not remember the British Heart Foundation attending the Forum.

DETR created the Airborne Particles Expert Group (APEG) in 1997 to examine evidence on current levels of particles in the UK, their sources and how they acted in the atmosphere (APEG, 1999, p. 1). Members included monitoring experts, modellers and atmospheric chemists, drawn from academia, the firm responsible for the PM_{10} monitoring network

(Stanger Science and Environment), the Met Office, the Transport Research Laboratory and AEA Technology (APEG, 1999). The latter three groups had expertise in computer modelling and forecasting. The advisory body QUARG was disbanded after its third report, in 1995.

2. The role of changes in scientific knowledge in the development of the Revised Strategy

Period 2 saw a leap in the scientific understanding of particulate composition and effects in the UK. Much of this resulted from programmes established by the DETR to improve knowledge on air quality in the UK, including the research contributing to the APEG report (APEG, 1999) and the work of COMEAP on the effects on health of air pollution, and EAHEAP's economic appraisal of the costs of these health effects.

2.1. The effects of particles on health

By 2000 the causal association between particles and adverse health effects was no longer widely contested – neither amongst policy-makers nor amongst scientists (interview1). In Period 2 COMEAP and EAHEAP used established and accepted health evidence in new ways, at the request of the Department of Health and the DETR. COMEAP (1998) quantified the health effects of pollutants in the UK. For particles these were expressed as increases in deaths ("all-cause mortality")and increases in hospital admissions per unit of PM_{10} in the atmosphere. COMEAP used these coefficients to calculate the size of these acute effects for the UK, and claimed that the then current levels of PM_{10} caused 8,100 early deaths and 10,500 extra or brought forward respiratory hospital admissions (COMEAP, 1998, p. 3).

COMEAP's quantifications were simplifications of knowledge of PM_{10} and the uncertainties that this contained. In making them, COMEAP assumed that there was no lag time between pollution event and health effect; that every person in the population was affected in the same way; that there was a predictable dose-response relationship between exposure and effect; and the committee did not take into account possible covariance of pollutants. It also deliberately excluded the possibility of long-term effects on life expectancy, due to insufficient UK data (COMEAP, 1998, p. 3).

EAHEAP (1999)drew on COMEAP's work in an attempt to assign monetary values to unit reductions in particulates and other pollutants. However, EAHEAP's report was not used in the cost benefit analysis of potential measures to reduce pollution (IGCB, 1999). This was because Ministers in the Department of Health decided that the range of values assigned using the Willingness to Pay methodology was too wide to be useful (DETR, 2000a, p. 21).

Nonetheless, the idea that the health effects of pollutants could be monetised and thus compared to costs remained influential throughout subsequent reviews.

Both COMEAP and EAHEAP's reports utilised established, largely uncontested health evidence on particulate matter. Away from these advisory groups scientists were investigating the potential chronic health effects of particles, and the relative contribution to poor health of different fractions of particles (for a review see EPAQS (2001) and chapter 2 of this thesis).

The Revised Strategy did not develop in response to changes in health effects evidence, but new forms of scientific evidence were produced in response to the questions asked of the advisory committees by the Department of Health as part of the review of the Strategy. As a result the basis of policy-making moved away from responding to the growing health effects evidence, and towards presenting such evidence in a way that facilitated policy decisions.

2.2. The constituents of UK particulate matter and forecasts for the future

In contrast to the health effects evidence, Period 2 was marked by rapid development of scientific understanding of the sources and behaviour of particulates in the UK. This significantly changed conceptions of possible reductions and of the most appropriate actions to take to achieve them.

The advisory committee QUARG (1996) categorised the PM_{10} into three fractions: primary (from combustion processes), secondary (formed in the atmosphere by reactions of sulphur dioxide, nitrous oxides and ammonium) and coarse (formed by non-combustion and natural processes).

New evidence indicated that the secondary fraction made a much more significant contribution to ambient particle concentrations than previously believed (e.g. King & Dorling, 1997). APEG concluded that the up to 20% of primary particles and 50% of secondary particles were transported from mainland Europe, much more than previously estimated.

This transformed understanding of particulate pollution from a local hotspot problem to an international, transboundary problem. Such transboundary pollution required European-wide agreements and actions to address it. This transformation of scientist's comprehension of the sources of particulates was reflected in the popular press, with headlines such as "Exhausts of Europe are 'choking Britain'" (The Daily Mail, 14 January 1999) appearing shortly after APEG's publication.

APEG (1999) drew on new evidence from the monitoring networks, emission inventories and studies of particulates in the UK, to demonstrate that the composition of primary PM_{10} was more complex than previously suggested. It found that whilst particulates from vehicles dominated in urban areas, in other areas of the country energy production and non-combustion industrial processes (for example, quarrying) were more significant sources. Such findings had potential implications for regulators aiming to target the most appropriate sources in pollution reduction.

2.3. Forecasting future particulates

The final major scientific achievement of Period 2 was the development of national forecasts for PM_{10}. The consultancy Netcen, a division of AEA Technology, developed the national model specifically for the review of the Strategy (Smith, 2003, p. 59), and it was funded by the DETR. It is referred to here as the Netcen model, but had no name in Period 2. An overview of the model, its components and assumptions is provided in table 7.4.

The model (Stedman et al., 1998) drew on the developing evidence base, including data from the national monitoring networks of PM_{10}, nitrates and sulphur dioxide from 1992 onwards. Netcen modelled present and future concentrations of particulates at each PM_{10} monitoring site on the national network, and extrapolated from the monitoring sites to provide maps of current and future PM_{10} for the whole country. To create these forecasts and maps the modellers constructed ambient concentrations of total PM_{10} for each of three fractions: primary, secondary and 'other' (what remained after primary and secondary were accounted for – similar but not identical to the 'coarse' fraction). The primary fraction was derived from projections from the National Atmospheric Emissions Inventory (NAEI) for road transport, whilst estimates for the secondary fraction came from the model EMEP's forecasting of secondary particles over Europe (Stedman et al., 1998, p. 3).

Netcen (Stedman et al., 1998) compared forecast concentrations of PM_{10} for 2005 at each of the thirty-two monitoring sites against the NAQS Objective and European first daughter Directive limit value. The forecasts indicated that under a variety of meteorological conditions, the NAQS Objective could not be achieved under a 'business-as-usual' scenario. However, the European limit value could be met at all background (ie not roadside), even under weather conditions which elevated levels of secondary particles transported from mainland Europe (although it would still be exceeded at some roadside and industrial monitoring stations (Stedman et al., 1998, pp. 33-34)).

Table 7.4. Assumptions and expectations in the Netcen model forecasts for PM_{10} for 2005

Fraction	Assumptions	Expectations
Primary	75% city emissions from traffic exhaust 25% from other sources	Projections from the National emissions inventory (NAEI) for road transport, including expectations of the outcomes of planned policies affecting road transport (e.g. Euro standard implementation)
Primary Roadside	The modellers believed that particle concentrations would be greater at roadside. They assumed that this extra portion consisted 50% of fine particles from vehicle exhaust, and 50% from resuspended road dust.	Over time the exhaust emissions were expected to decline and re-suspended dust (part of the coarse fraction) expected to remain at 1997 levels
Secondary		Used the model EMEP's forecasts of secondary particles over Europe, based on current reduction plans of parties to the UNECE Convention on Long-Range Transboundary Air Pollution
'Other'	Total PM_{10} – Primary – Secondary = Other	'Other' component will remain at 1996 levels (assumption made by Netcen)

Source: Stedman et al. (1998)

In addition, Netcen modelled broad scenarios to test the effects of taking action on different fractions of particulates (outlined in table 6.5). These alternative scenarios demonstrated that eliminating the primary fraction would not be enough to achieve the NAQS Objective. These scenarios were unrealistic: it was not possible to remove every vehicle from the road or eliminate every source of primary particles. Nor was it possible to eliminate all secondary particulate precursors from the UK and mainland Europe. However, Netcen's use of these scenarios to test the relative impacts of each component was useful: it indicated the relative contribution of each fraction. The model forecast that removing 100% traffic emission would still leave exceedences of the NAQS Objectives in 2005 at 7 out of 8 modelling sites (Stedman et al., 1998, p. 19), whereas removing 100% of secondary particulates caused 7 out of 8 sites reaching the Objective (Stedman et al., 1998, p. 23). Thus the overwhelming problem was imported pollution.

Table 7.5. Scenarios modelled by Netcen

Scenario ref.	Primary particles	Secondary particles
4.1	50% less road traffic emissions	Business as usual
4.2	100% less road traffic emissions	Business as usual
4.3	50% less road traffic emissions	50% less secondary emissions
4.4	100% less road traffic emissions	50% less secondary emissions
4.5	Business as usual	50% less secondary emissions
4.6	Business as usual	100% less secondary emissions
4.7	50% less road traffic emissions	100% less secondary emissions
4.8	100% less road traffic emissions	100% less secondary emissions

Source: Stedman et al (1998)

3. Expectations for the future of policy: the impact of the Netcen forecasts

The forecasts of the Netcen model changed expectations regarding the reductions in particles which could be achieved, and changed conceptions of possible solutions. The 1999 *Report on the Review of the Air Quality Strategy* used the Netcen forecasts to justify adoption of the European limit value:

> *Modelling suggests that the elimination of all urban traffic emissions of primary PM_{10} would reduce urban concentrations still further but even so would not bring levels down sufficiently to achieve the [NAQS] objective. There would continue to be exceedences of the [NAQS] Strategy objective for PM_{10} over large parts of the UK.*
>
> (DETR, 1999 para. 274)

Ministers representing the DETR also referred to the Netcen modelling and scenarios when justifying the particulate Objective. Michael Meacher described the NAQS Objective as "to be frank, unrealistic" (Environmental Data Services, 1999a). John Prescott, in the forward to the Revised Strategy wrote that:

> *On particles, PM_{10}, it is now clear that the original objective is unachievable. Even if we took every single car off the road – which is neither practical nor desirable – the limit could be exceeded.*
>
> (DETR, 2000a, pp. 3-4)

3.1. How the Netcen model constructed the future

Changes in scientific understanding of particulates in the UK, and notably the development of the Netcen model, changed expectations of what could be achieved and provided insights into the composition of UK particulates which could be used to direct policy more effectively. The

Netcen model created an image of particulate concentrations and of areas of the country most at risk from particulate matter that was missing from Period 1, which drew attention to the international sources of particulate matter, and away from local level pollution hotspots.

The Netcen model contained assumptions, expectations and simplifications, both in regard to the sources of particulates and their behaviour in the atmosphere. These are set out in table 7.4, together with their sources. Such expectations and assumptions were limited in scope, to the quantifiable effects of *some* national and international policies and agreements. This did not enable the effects of local action (including LAQM) to be taken into account. Much of the model data were estimated, including the vehicle emissions forecasts, because of the impracticalities of measuring and monitoring particulates throughout the whole country (NAO, 2001a, p. 26).

In the primary fraction, the many different combustion sources were reduced to 'road transport' and 'other'. Only the NAEI projections for vehicle use were incorporated into the model, and whilst these incorporated the predicted effects of implementing the Euro standards, it could not estimate the effects of local traffic management schemes. LAQM and potential behavioural changes (e.g. shifting from private car use to public transport) could not be predicted by the emissions inventory or the model. So whilst expectations for technological change were incorporated, those for behavioural change could not be. Given the recognised complexity and diversity of the sources of particulates (for example, in the APEG report), it is likely that these factors, like the simplification of the primary fraction, resulted from the limited abilities of the model. There is no evidence that other actors adopted these expectations because of their inclusion in the Netcen model. Rather, evidence suggests that the Netcen forecasts were adopted by policy-makers in AEQ and other departments involved in the AQS as if they contained no uncertainties. The Netcen model generated expectations of feasible emission reductions that subsequently were accepted without question by the civil servants in AEQ and the minsters responsible for it.

Testing assumptions and expectations by using more than one model

Comparison of different models can draw attention to the effects of the different assumptions and methodologies used in producing them. It cannot, when carried out prospectively, provide an assessment of relative accuracy. Different models reached different conclusions about the ability of London to meet the NAQS Objective.

For example, consultants WS Atkins studied the impacts of traffic management schemes on particulates and concluded that the NAQS Objective was achievable in central London, with

sufficient action focused on traffic management and emissions reductions strategies (WS Atkins, 1999). This forecast was considered as part of the attempted cost-benefit analysis, but the cost-benefit analysis was not used to set the Objectives (DETR, 1999).

3.2. The impact of Netcen forecasts on the Revised Strategy

In 1999 the *Report on the Review of the National Air Quality Strategy* (DETR, 1999) announced the relaxation of the PM_{10} Objective to that of the European limit value for 2005, which Netcen had forecast achievable under business-as-usual.

The Netcen model was not a straightforward scientific model. Rather it was a science- policy hybrid, containing both scientific data and non-scientific expectations of the future. In accepting these forecasts, policy-makers accepted a set of assumptions and expectations about technological developments and the outcomes of agreed policies. The Revised Strategy did not discuss the non-scientific inputs into the Netcen model or the uncertainties inherent in it. Evaluations of the Strategy review by the National Audit Office and the House of Commons Public Accounts Committee (2001) were critical both of Netcen's presentation of assumptions and uncertainty and of the DETR's acceptance of them:

> *The Department needs also to assess the scope for future air quality to differ from the forecasts based on these estimates, to consider, in particular, possible mistakes or misunderstandings in the computer models; simplifications within the models; and the effect of factors, such as future levels of car use, whose exact impact cannot be predicted in advance.*
>
> (NAO, 2001a, p. 10)

In 2001 air quality policy-makers from AEQ noted that the uncertainties in the Netcen forecasts were of similar magnitude to those for the emissions inventory – that is, errors of plus or minus forty per cent (House of Commons Public Accounts Committee, 2001).

3.3. Conclusions on Netcen model and the Revised Strategy

The Netcen forecasts and new evidence on the properties and sources of particles changed the perceptions of scientists and policy-makers regarding feasible emissions reductions. However, these developments do not explain the choice only to forecast future compliance with the NAQS Objective and European limit value, and not to examine alternatives.

The Netcen forecast contained expectations about the future: of the impacts on particulate concentrations of European vehicle and fuel regulation, and more obliquely in the secondary particulate forecasts incorporated from the EMEP model which contained the predicted outcomes of the CLRTAP agreement (Table 7.4). The impact of these expectations cannot be

uncoupled from the assumptions and parameters of the Netcen model. Together these created forecasts which predicted the NAQS Objective unachievable and the Revised Strategy achievable. These forecast in turn created expectations of feasibility and they were taken up by policy-makers in AEQ and throughout government.

4. The dynamics of Expectations and Visions in the process of the Revised Strategy

The decision to adopt the European limit value had immediate practical implications for implementation. Under the NAQS Objectives, the majority of local authorities would have had to undertake monitoring and modelling to ascertain whether they could meet the PM_{10} Objective (Chatterton, Woodfield, Beattie, & Longhurst, 2004, p. 851). Revising the PM_{10} Objective had the effect of switching local authority attention from PM_{10} to NO_2 as this pollutant now had the most projected exceedences. In 2004 91% of local authorities declared an AQMA (air quality management area) for NO_2 compared with 46% for PM_{10} (Chatterton et al., 2004, p. 851).

Yet, the Revised Strategy stated that policy-makers believed that "the possible gains from reducing PM_{10} levels are thought to be greater than those for any other pollutant," and that particles were "… the most important air quality challenge for the period covered by the Strategy" (DETR, 2000a, p. 55).

The decision to revise the particulate Objective to a business-as-usual scenario appears more incongruous with the rhetoric of the Revised Strategy and the policy-makers who developed it. Can the dynamics of expectations and visions over Period 2 provide insight into these developments? This chapter has already shown how the Netcen forecasts became accepted and articulated by policy-makers in AEQ and beyond. This next section examines the expectations and visions articulated in the plans and policies for attaining the Objectives, and how they may have contributed to policy outcomes.

4.1. Policies for implementation

The National Audit Office (2001a)(NAO) portrayed the process by which Objectives were set in the Revised Strategy as a linear model: from scientific developments, to Objective setting, to monitoring performance. This is set out in figure 7.1 (Modelling is included in the second stage of the process, although this is not clear from the NAO's diagram). So far this analysis suggests that this is a simplistic interpretation; and that in reality the choice of targets forecast by the model were made by policy-makers prior to modelling, and that the model was developed for the purpose of forecasting the results of these potential targets.

Figure 7.1 National Audit Office (2001) interpretation of the policy-making process fo the Revised Strategy

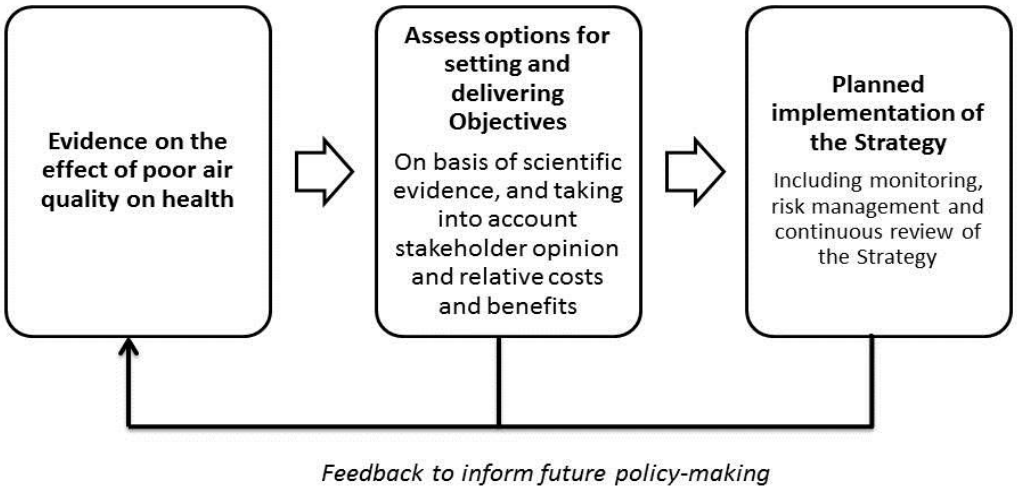
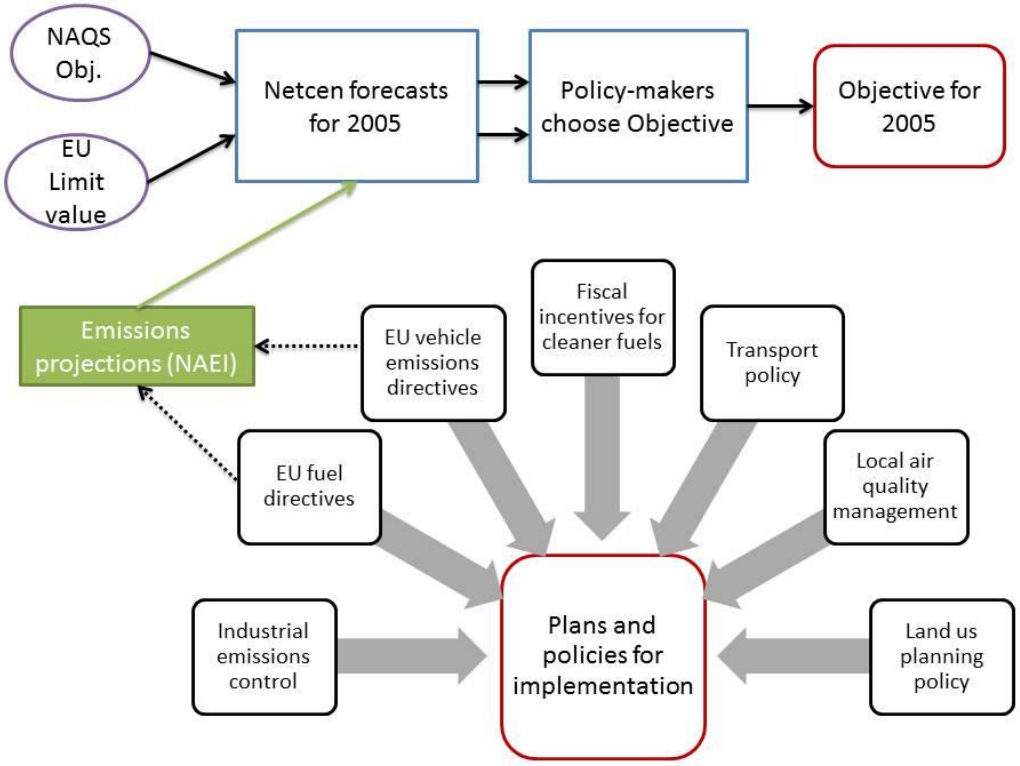


Figure 7.2. The policy-making process of the Revised Strategy



Key to Figure 7.2

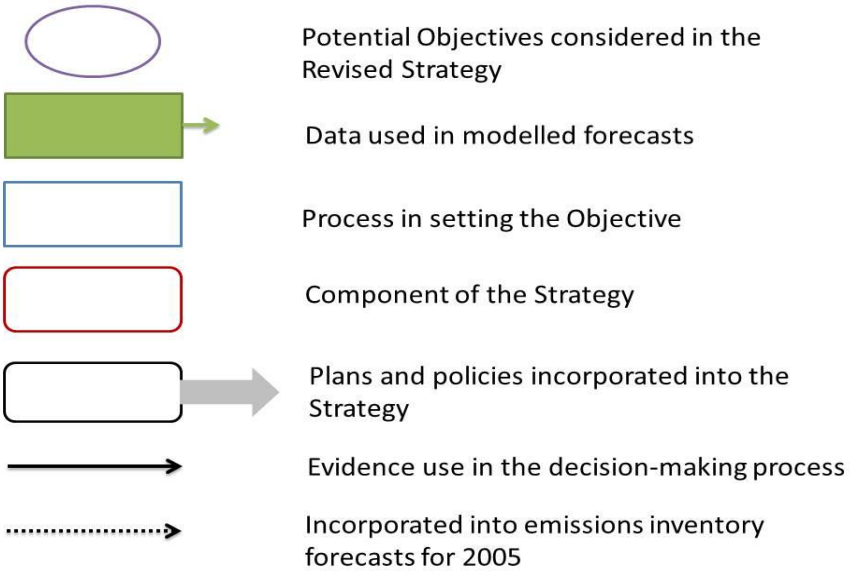


Figure 7.2 outlines the process by which the Objective for PM_{10} was set and the policies to attain it chosen, as interpreted by the analysis in this chapter. This indicated that the process of setting of the particulate Objective was largely independent of the implementation strategy for achieving the Revised Strategy. The point of overlap is in those planned policies, for which the expected outcomes were incorporated into the NAEI and subsequently into the Netcen model. Figure 7.2 demonstrates that these – vehicle and fuel emissions standards– affected only two of several sources which were included in the strategy. The 'business-as-usual' of the Netcen model did not bear much resemblance to the 'business-as-usual' depicted in the pages of the Revised Strategy. Nor was it the linear process from scientific inputs through to strategy development and then to implementation. Rather, the Netcen model tested the suitability of two Objectives already agreed by policy-makers (the European limit value and the UK's NAQS Objective); and the plans and policies for the Strategy were made independently of setting the PM_{10} Objectives.

The Revised Strategy contained no new policies to improve air quality beyond those already in existence. This was consistent with the acceptance by policy-makers of the Netcen forecasts for PM_{10} – under business-as-usual very little except local measures were needed to attain the new Objective.

Appendix 1 outlines all national policy measures in the Revised Strategy which were aimed to reduce road transport emissions. From this it can be seen that all – with the exception of the emissions test component of the MOT (a compulsory annual test of motor vehicles of more than a specific age)(which existed prior to the Revised Strategy) were included in the Integrated Transport White Paper (TWP) (DETR, 1998), published seven months prior to the announcement of the new Objectives.

Appendix 1 shows a variety of measures to reduce vehicle emission ranging from fiscal incentives to purchase natural gas powered cars, to tax incentives to companies which encouraged their employees to use public transport, to local authority transport planning, and the Cleaner Vehicles Task Force. These developed prior to the Revised Strategy. Others including the Powershift and CleanUp programmes for introducing alternative vehicle technologies, fuel duty differentials, and the fuel duty escalator. These policies deliberately set out to improve air quality, but were the products of other government departments, not the DETR.

The predicted impacts of the measures in Appendix 1 were not incorporated into the Netcen forecasts, and thus formed no part of the deliberations over the Objectives for the Revised

Strategy. A further disconnect can be seen here: many of the measures in both TWP and Revised Strategy would have their impacts on the primary fraction of particulates, at a local level. These included public awareness campaigns, road traffic reduction targets, traffic management schemes and bus partnerships. Fiscal incentives relied on voluntary behaviour changes. Implementation of these measures would be in part a result of the political will of the individual local authority, or the results of the choices of individuals and businesses. Again, this was not incorporated into the model, which emphasised the role of transboundary particles and contained no local level forecasts.

4.2. Visions in the Revised Strategy

The visions contained in the Revised Strategy are set out in table 7.6. These were the statements for a preferred future made in the Revised Strategy, rather than *expectations* of what would happen.

There is no evidence to suggest that the visions in table 7.6 came from sources other than policy-makers in the DETR. Those in the 'policy' column are visions for the Strategy itself – criteria against which to measure success. The commitment made in the NAQS of reducing air pollutants to harmless levels remained, although the Strategy was now characterised as a policy driver (DETR, 2000a, p. 33). The Revised Strategy also stipulated that the medium-term Objectives should be achievable and feasible. This vision was realised in the decision to set more stringent Objectives than the EU required for benzene, 1,3-Butadiene, carbon monoxide and lead. However, relaxing the PM_{10} Objective could not have been undertaken for health protection reasons – suggesting that the assumption that cost-efficiency, health protection and feasibility were compatible did not always hold.

Visions set out in the other categories of table 7.6 were visions for the actions of specific actors: industry (in the 'visions for technology' column), business, individuals and local authorities. Visions for these actors were for *voluntary* actions that could be taken by these groups. The Revised Strategy aimed to "encourage" all actors, including the general public and business to take voluntary actions, beyond any statutory duties, to improve air quality. Local authorities were also encouraged to "encourage public, private and voluntary sector efforts in support of air quality" (DETR, 2000a, p. 75).

For individuals and businesses, all actions considered in the Revised Strategy were voluntary. Improvements in air quality were linked to individual transport choices; transport was described as the largest pollution source from businesses (DETR, 2000a, p. 84). The Revised strategy encouraged these actors to use transport with comparatively lower emissions (e.g.

cycling, walking and public transport). Whilst this may appear to be wishful thinking on the part of AEQ, interviewee 8 (A civil servant in the DTI) stated that national government at that time assumed that individuals would act voluntarily to achieve government policy.

Visions for industry and local authorities accompanied overviews of their statutory duties and responsibilities which contributed towards reducing emissions. For both industry and local authorities these were presented as cost-effective, feasible, and non-disruptive. (DETR, 2000a, p. 70). As in the NAQS, the Revised Strategy contained the vision that local authorities would improve air quality voluntarily, even if they were not predicted to exceed any Objectives (DETR, 2000a, p. 75).

Visions for individual sectors set out in table 7.6 were a minor part of the Strategy. The DETR could not go beyond European requirements on industry (DETR, 2000a, p. 71). These appeals for voluntary action suggested that policy-makers wanted further action to reduce pollutants beyond the Objective targets, or were not certain that the Objectives could be achieved. Given the prominence given to the Netcen forecasts (which forecast that the new Objectives were attainable), the former is more likely.

Table 7.6 Visions in the Revised Strategy

Technology	Technology & Policy	Policy	Policy & Behaviour	Behaviours
Industry: voluntary adoption of technologies beyond BATNEEC. Industry: Emissions reduction beyond legislative requirements through innovation and adoption		Objectives to be achievable and cost-effective Strategy to be the best practicable protection of human health Long term aim: to attain the Standards in outdoor areas Air Quality Strategy will influence and drive other policies. If "practicable and efficient" should reach objectives before compliance date, or achieve reductions beyond the Strategy	Local government: should take action on air quality even if already meet targets Local govt.: encourage public, private and voluntary sector actions Local: policies to change behaviour e.g. traffic management measures Local governments encouraged to work together and with other relevant authorities – e.g. Highways Agency – to improve air quality.	Local govt, individuals, business and industry encouraged to take actions to reduce emissions e.g. transport modal shift. All sectors encouraged to work together: industry, transport, local authorities, national government, businesses and individuals

4.3. Expectation dynamics: how did those held by actors in the policy process contribute to the Revised Strategy?

As already indicated, the plans and policies incorporated into the Revised Strategy were those agreed and included in the Transport White Paper (DETR, 1998). The only policies that were included were those *already* present in policy – and the visions in table 7.6 were for voluntary actions to go beyond these. The Transport White Paper was published prior to AEQ's setting of the new Objectives in January 1999. The policies to implement the Revised Strategy were settled before stakeholders had an opportunity for involvement.

When asked whether the NAQS had impacted on other policies, a member of AEQ answered:

> *Yes, it did. … I mean, don't ask how did it do that? How did that work? What it does of course, its firstly something that government signs up to. It's a government strategy, they are government objectives for air quality, and so they act as a yardstick, a benchmark, against which you assess policies.* (Interviewee 28)

The Revised Strategy and the NAQS both followed the expectations for technological change prominent in national government at that time. The Revised Strategy, unlike the NAQS, assumed that uptake of the PowerShift and CleanUp grants would work to improve air quality. The Treasury's fiscal policies which caused favourable duty on CNG and LPG compared to diesel were designed to improve air quality (as indicated in the previous chapter).

The negotiations and discussion between stakeholders and policy-makers regarding future emissions reductions from road transport may have taken place in the context of the Transport White Paper rather than the Revised Strategy. There is some evidence for this: concerns about the AQS were raised by the NSCA in the consultation on the Transport White Paper.

5. Discussion: The role of visions and expectations dynamics during Period 2 and the formation of the Revised Strategy

AEQ used the Netcen forecasts to inform its expectations of potential emissions reductions. The Objective chosen was that which, as forecast by Netcen, was achievable under business-as-usual and LAQM. This is in marked contrast to the NAQS with its more ambitious targets.

As with the NAQS before it, the Revised Strategy also served to summarise the plans and policies already in place. Its expectations for technical change and policy development followed those in the Transport White Paper. The overall vision was for voluntary action by all sectors that contributed to air quality. This is at odds with another vision articulated in the Revised Strategy that it would be a policy driver – if targets are achievable under business-as-usual, then no new actions would need to be taken.

However, the Expectations framework offers no insight into why this situation of business-as-usual emerged. Next, I examine the wider discourses concerning the purpose of targets to ascertain whether and how these discourses may have contributed to the Revised Strategy.

6. Developments in wider political discourses and the Objectives of the Revised Strategy

This chapter has demonstrated that the main differences between the NAQS and the Revised Strategy came in the methodologies by which Objectives were set, and the different rationales of the two Strategies for setting these Objectives.

The differences in methodologies for setting Objectives were the result of the emerging scientific knowledge at the time. The NAQS shared with the Revised Strategy a preferred methodology: of setting medium-term targets based on scientific evidence and an assessment of costs and benefits (Department of the Environment, 1997, p. 18), although neither successfully used that methodology. Several of the developments in scientific evidence used in Period 2 resulted from the specific requirements of the NAQS: for example, the quantification of health effects by COMEAP and the EAHEAP reports (Department of the Environment, 1997, p. 183).

The second major difference was in the underlying principles by which the Objectives were set. The NAQS aimed for the Objectives to drive policy, and as a result set Objectives that were not certain to be achieved:

> *The Government is therefore adopting objectives which present a quantified assessment of the quality of air which it is intended that policies should be developed to achieve by the year 2005. It should however be made clear that in a number of cases… considerable uncertainties remain as to whether these objectives are achievable.*
>
> (Department of the Environment, 1997, p. 19) (my emphasis)

In contrast, the authors of the Revised Strategy rationalised their revised Objectives in this way:

> *We believe that the objectives must be challenging, but they must be achievable and cost effective. There is little point in setting objectives which cannot be met since this provides no incentive for action.*
>
> (DETR, 2000a, pp. 3-4)

This process of setting targets in the Revised Strategy differed from those of the NAQS. The PM_{10} Objective set by the NAQS was meant to be challenging and policy-makers did not know

whether it was achievable; whereas the PM_{10} Objective set for the Revised Strategy was forecast to be achievable. These differences in the approach to Objective by AEQ cannot be explained simply as a result of the changing scientific foundation of the Strategy, although progress in scientific knowledge undoubtedly contributed to them.

The Revised Strategy marked the start of what one interviewee called a "philosophical debate" (interview 29) about the nature of air quality Objectives: what they should achieve and how they should be set. Two such positions were identified in a previous study by this author: the first, held by the DETR, was that the Objectives should be achievable. The second, held by a range of other actors including the NSCA and some local authorities was that health protection was more important than achievability (Smith, 2003, p. 64).

Analysis of expectations and visions so far has emphasised their discursive nature: they exist and develop in discourse before any attempt at translation into physical technologies or behaviours can occur. Can their dynamics over time be explained by the dynamics of larger-scale discourses? This is the subject of research question 4.

If wider political discourses did have a role in the Revised Strategy, then my previous study (Smith, 2003) and interviews conducted for this thesis suggest that any such discourse was about the process by which targets were set and performance measured. Evidence for the existence of wider discourses acting on the Revised Strategy and subsequent Strategy versions is here examined to understand whether and how they contributed to the development of the Revised Strategy. If changes in the Strategy were due to changes in discourse, these should be marked by changes in the language used in the policy-making process; and there should be evidence that the specific language used changed institutions, behaviours and practices in air quality management and beyond.

Two perspectives emerged over Periods 2 and 3 concerning the nature and purpose of air quality Objectives. Interviewee 29 described the two positions as: "a philosophical argument between 'do you set Objectives because that's where you want to be regardless of whether you can achieve them', or 'do you set objectives that you can achieve?'"

6.1. A discourse of 'Performance Management'?

Civil servants who worked on the Revised Strategy and Addendum described their remit for making policy:

> *I think that the criteria that we used when we were setting the Objectives was to make them challenging but achievable. That was the expression that we tried to use. There*

> *seemed to be little point in setting an Objective that we knew could be achieved without doing very much.* (interview14)

This new language concerning the criteria of setting targets was not unique to air quality. It was part of a government-wide change of approach to policy-making.

6.2. The Performance Management culture in the UK Government

The origin of the requirement for targets to be *challenging but achievable* is found in performance targets in business. SMART targets are required to be **S**pecific, **M**easurable, **A**chievable but challenging, **R**elevant and **T**ime bound. Such targets were widespread in the private sector (Marsden & Bonsall, 2006, p. 191). In using the phrase *challenging but achievable*, AEQ was articulating one of the SMART target criteria.

Performance management, target-setting, and other business techniques were used increasingly by the UK civil service from the 1980s onwards (McSweeney, 2006). Use of statutory performance indicators and targets grew under the Conservative governments of the 1980s and 1990s (Martin, 2002). However, under the Labour government, from 1997 onwards, performance targets became more significant in policy-making and implementation. Use of this top-down planning peaked between 1997 and 2003. In 1998 over 300 performance targets (known as Public Service Agreements or PSAs) were introduced by the Treasury to national government departments; all performance targets were explicitly linked to public spending. Each of these targets was in turn divided into lower-level targets for implementation by the agencies for which government departments were responsible (Hood, 2006, p. 515) (there were over 600 of these targets across government in 1998 (Hood & Dixon, 2010, p. 284). This performance target-based approach to policy-making linked performance with funding.

A set of SMART targets were also designed to accompany each performance target (National Audit Office, 2001b, pp. 18-19b pp18-19). This approach claimed to be different from that of previous policy in its attention to *outcomes* - what policymakers were ultimately trying to achieve - rather than on inputs, processes or outputs (immediate results in terms of products or services) (HM Treasury, Cabinet Office, National Audit Office, Audit Commission, & Office for National Statistics, 2001, p. 8 p8). This change in the Government's approach to performance management was used in setting targets for the 10 Year Transport Plan (DETR, 2000b), according to Marsden and Bonsall (2006).

6.3. Evidence for the Performance Management Discourse

Evidence that this rhetoric of performance management was a discourse, around which a discourse coalition build up, was considered by examining four criteria of discourse coalitions, as identified by Hajer (1995, p. 65) (and discussed in Chapter 4):

- changes to institutions as a result of this discourse;
- the extent of a storyline and the distinctive language;
- the practices in which the discursive activities take place; and
- how the particulate problem was given meaning.

Institutional changes in central government

After 1997 there were changes in the institutions of government - including the structures allocating funding and the relationship between Environment and Transport departments - that resulted from the spread of the Performance Management ideas and language. The 2000 and 2002 spending reviews included the target to improve air quality through meeting the Revised Strategy targets for all Strategy pollutants, except ozone. In 2002 this was allocated as a joint target for achievement by DEFRA and the Department for Transport (DEFRA, 2002a).

Joint PSAs and targets were made to improve coordination between departments of central government both in policy-making and in implementation (James, 2004, p. 400); and the joint target of reaching air pollution Objectives can be seen in this context. However, in practice, the joint PSAs and targets had limited success: James (2004) argued that this was because there were less incentives for ministers to prioritise the joint targets than those simply applying to their own department; and that it was difficult to agree the specific departmental responsibilities for fulfilment of joint targets. Hood observed that the UK took this "centralised target approach to public service management further than any other [country] in recent times" (Hood, 2006).

All the institutions of national government were affected by this discourse. James (2004, p. 398) stated that the public sector activity is "generally characterized as various forms of interdependent network relations rather than being part of a unified hierarchical system with the core at its apex". James argued that in 1997 the core executive of New Labour introduced the performance management system to coordinate action and maintain their "strategic direction" (James, 2004, p. 399). It enabled policy-makers to show the public that they were meeting pre-arranged goals, and that progress was being made. Hood and Dixon (2010, p. 295) claimed that Prime Minister, Treasury and top civil servants had much invested in this system of policy-making. As an example of this they cited the thirty-six civil servants in the

Prime Minister's Delivery Unit whose job was to monitor the most "politically salient" targets across government.

A storyline of Performance Management

A storyline links the change in government direction for target setting and the policy process of the Revised Strategy. Christopher Hood (2001, p. 300) characterised it as a 'gospel' held by the Labour Government of the time:

> *That gospel holds that public services can 'work better and cost less' if public managers are encouraged – or obliged – to focus on results, using discretion and imagination to direct and shape the organisations they lead rather than simply following rules. There are many variations on the theme, but the central managerialist credo is the idea of giving those who head public organisations – whether they be schools, hospitals or other service providers – direct responsibility for reaching specified goals, in exchange for commensurate career risk and reward, plus compliance with monitoring and evaluation of the results achieved.*

Hood sets out the discourse that targets are measurable, able to be monitored, and that they give specific individuals or groups responsibility for attainment.

A further example of this storyline is provided by Bird et al. (2005, p. 7), in a paper for the Royal Statistics Society:

> *If performance targets are to be set, they need to have a sound basis and to take account of prior (and emerging) knowledge about essential variation…. Indicators should have the statistical potential (known as 'power') to exhibit , or identify, change within the intended timescale of PM [performance management]. Technically, this requires making a reasoned, prior assessment of how much improvement it is plausible to achieve within the PM timescale by taking account of research evidence, local initiatives, organizational culture, and the available or budgeted-for new resources.*

Bird and colleagues link targets and performance management to establishing what targets are possible and likely to be achieved. This storyline can be seen in the Revised Strategy: the *challenging yet achievable* Objectives, the focus on cost-benefit analysis, and the monitoring of results.

A language of Performance Management

Many new civil servants recruited to monitor targets had managerial backgrounds. They brought with them the language of "stocktakes, priority reviews, trajectories, and performance reporting" (Hood & Dixon, 2010, p. 285).

The AQS was already characterised by performance monitoring and trajectories towards both Objectives and Standards. As demonstrated throughout this chapter, this was joined by *challenging yet achievable*.

Changes in practices

Changes took place in practices specific to air quality. As a result of this institutionalisation of this discourse in the new Objectives of the Revised Strategy the focus of LAQM attention switched away from PM_{10} towards NO_2 abatement.

Definition of the health problem of particulates

It is not obvious that the definition of the health problem changed between the NAQS and the Revised Strategy. Evidence for a changed definition of the problem during Period 3 will be examined in the next chapter.

6.4. The role of wider discourses in the Revised Strategy

This section has examined the extent to which the focus on performance management and a distinct approach to target-setting could be described as a discourse. Evidence suggests that it could: it was characterised in both the air quality policy arena and more widely in government by a specific storyline and language. Institutions and practices throughout government, including in air quality policy-making, also changed and reflected this discourse. The discourse perspective suggests that changes in institutions and practices followed the developments in discourse. This will be examined further in the next chapter. The second "philosophical position" identified in interview – that achieving a target was more important than its constant revisions – was prominent in responses to the Revised Strategy. Its significance, and whether it could be described as a discourse, will be discussed in the next chapter.

7. The cumulative strength of the Expectations, and Discourse perspectives in explaining the Revised Strategy

The official explanation, that changes in scientific understanding were responsible for the changes in the particles Objective is useful, but not sufficient - developments in evidence and forecasts provided the evidence that the NAQS PM_{10} Objective was not achievable. However, this 'scientistic' explanation does not explain why no other alternatives to the NAQS Objective and the European limit value were examined in the NETCEN modelling, the first IGCB report, or in the review of the Strategy.

The discourse of Performance Management became widespread in government documents and policy decisions from the late 1990s onwards, and the Revised Strategy reflected this wider discursive shift. This discourse guided the target-setting process of the Revised Strategy

by providing the criteria against which Objectives were judged. The evidence from Netcen demonstrated that the NAQS PM_{10} Objective was unachievable, and thus unacceptable under the Performance Management Discourse. Without the development of the Netcen model, policy-makers would not have been able to set *challenging yet achievable* PM_{10} Objectives with the same degree of confidence. However, in some respects the NAQS had already gone some way towards fulfilling the criteria of the new approach: it focused on outcomes (health protection), required specific outputs (a maximum level of pollution), by a set date, and had a specific means of measurement.

The dynamics of Expectations add little to this analysis. Whilst they shed light on the expectations embodied in the Netcen forecasts, those in the Strategy itself followed the general expectations of government. The voluntary visions of the Revised Strategy are in line with setting achievable Objectives. The expectations that were accepted and taken up by policy-makers in AEQ and beyond were those articulated through the Netcen model. This suggests that modelled expectations may be assigned more credibility than those articulated in other ways.

None of these explanatory factors adequately explains why the PM_{10} Objective was set at a level which required no new actions for its fulfilment.

However some evidence suggests that tensions remained between the previously separate departments of Environment and Transport. Just days before publication of the Revised Strategy, transport minister Gus MacDonald informally briefed the press on a report on air quality in London (Glaister, Graham, & Hoskins, 1999), which he claimed indicated there was little need for extra measures to improve air quality (Air Quality Management, 2000a, p. 1). This seeming undermining of the Revised Strategy before its publication was taken by some to indicate the shift in policy back towards separation of environment and transport policy (Environmental Data Services, 2000).

This chapter has demonstrated that debates about the future of policy, behaviour, and technological change are not always of central importance in policy-making. In the Revised Strategy, the visions put forward by stakeholders played little role in policy-making. AEQ policy-maker expectations of the future were essential in setting the particulate Objective, and in encouraging action by others; but expectations alone – or even in combination with changing science and discourses – could not explain the changes in the Strategy. Rather, the wider political context of policy-making and implementation was essential in understanding

why this situation arose. The Expectations approach cannot adequately explain this because it examines agenda setting, rather than the wider context in which this occurs.

By 2000 the focus of the AQS had changed to setting Objectives rather than policies to attain them. The next chapter examines how this situation changed again; how AEQ brought attention back to implementation and more challenging targets, and how visions for technological and behavioural change were essential in this process.

Chapter 8. 2000-2003: Modelling through

The 2003 Addendum set Objectives for PM_{10} to be achieved by the end of 2010. Different regions of the UK set their own targets: those for Scotland were more stringent than those for England, Wales and Northern Ireland; which in turn were more stringent than those for London. These tiered targets proved controversial: London had the worst air pollution in the country and the least stringent targets, and furthermore did not comply with EU requirements. This afforded Londoners a lower standard of health protection than elsewhere.

Despite this, the Addendum diverted from the path taken by the 2000 Strategy, in that the new PM_{10} Objectives required further new national action to be taken. They could not be attained through a business-as-usual scenario alone. The Addendum was envisioned by its authors as a policy driver, and it assumed extra new national policies would be undertaken for its successful implementation.

Can the changes between the Revised Strategy and the Addendum be explained through shifting dynamics of expectations, or do wider discourses or simply developments in scientific understanding of health and particulate behaviours offer alternative explanations? Each potential explanation is examined in turn: the role of the developing evidence on particulates, the dynamics of expectations, and finally the impact of wider political discourse. First, the content and structure of the Addendum, and the changes in its institutional context from Period 2 are presented.

1. The AQS Addendum and events in Period 3 (2000-2003)

The Addendum to the Revised Strategy (DEFRA, 2003) introduced Objectives for polycyclic aromatic hydrocarbons (PAHs), revised the Objectives for carbon monoxide, and set further Objectives for benzene and PM_{10} to be achieved by the end of 2010. The new PM_{10} Objectives for England, Wales and Northern Ireland matched the indicative European Stage 2 Daughter Directives, whereas the newly devolved Scottish Assembly set a more stringent annual mean than the rest of the UK (see table 8.1). London had less stringent annual and daily mean Objectives than the rest of the UK. All, except for those for Scotland, were described as provisional (DEFRA, 2003, p. 22).

Table 8.1. the PM_{10} Objectives in the Addendum

Measurement	Region	Objective concentration	Permitted exceedences per year	Achievement date
24 hour mean	England, Wales, Northern Ireland	50µg/m^3	7	31st December 2010
	Scotland	50µg/m^3	7	
	London	50µg/m^3	10	
	European indicative stage 2 daughter directive	50µg/m^3	7	1st January 2010
Annual mean	England, Wales, Northern Ireland	20µg/m^3	n/a	31st December 2010
	Scotland	18µg/m^3		
	London	23µg/m^3		
	European indicative stage 2 daughter directive	20µg/m^3	n/a	1st January 2010

Source: DEFRA (2003)

The Addendum, as the name suggests, incorporated the majority of plans and policies of the 2000 Strategy. The Addendum discussed only new and updated policies. With the exceptions of the London AQS and the *Ten Year Transport Plan*, these new policies implemented European Directives.

Whilst the Transport White Paper (DETR, 1998) attempted to integrate transport and environmental concerns, the *Ten Year Plan for Transport* (DETR, 2000b) signalled the return of national environmental and transport policy to separate spheres. Whilst the White Paper had prioritised reducing congestion and pollution, the Ten Year Plan focused on reducing congestion and improving personal travel (Begg & Gray, 2004, p. 157). Congestion had emerged as a more salient political issue than emissions: whilst car ownership and congestion increased during the 1990s, vehicle emissions had significantly decreased.

In 2001 the environment sections of the DETR merged with the Ministry for Agriculture, Fisheries and Food to form DEFRA (Department of the Environment, Food and Rural Affairs). Responsibility for transport and local government transferred to the Department of Transport, Local Government and the Regions (DTLR). In May 2002 this split again: responsibilities for local government were given to the Office of the Deputy Prime Minister, and transport was restored to its own department: the Department for Transport (DfT).

Begg and Gray (2004) argued that the government's new focus on congestion, together with public dissatisfaction with transport policy and its political fallout explains the re-separation of transport and environment policy. In particular, protests over the high price of petrol and diesel in the summer of 2000 had considerable impact. The Fuel Duty Escalator was a casualty of the fuel protests, and was removed from the AQS.

In 2001 Chris Leigh was replaced at AEQ by Rupert Furness. In 2003 Furness left DEFRA to work at the DfT and was replaced by Davide Minotti, who worked on the 2007 Strategy.

1.1. The policy-making process of the Addendum

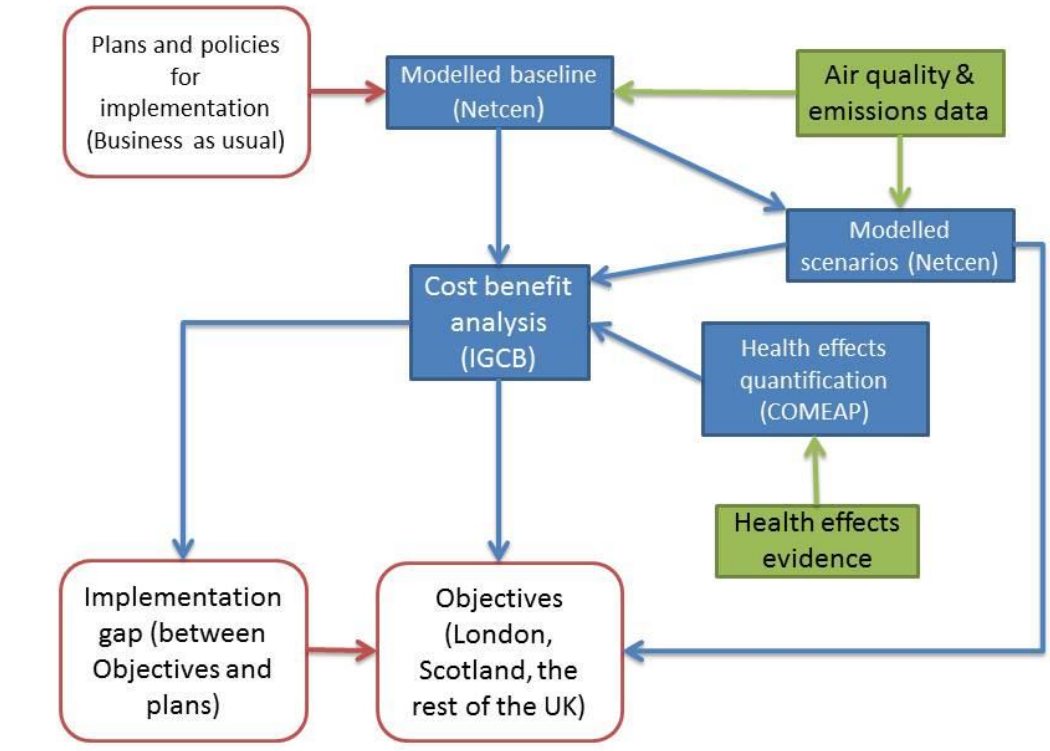
The process by which the PM_{10} Objectives for the Addendum were developed is set out in Figure 8.1 (based on the description of the policy-making process from Defra (2003)). This shows the centrality of the Netcen forecasts in the policy process. The figure demonstrates integration between the process of setting the Objectives and the plans and policies in place to achieve them. Such integration was in sharp contrast to the disconnection of these processes in the Revised Strategy.

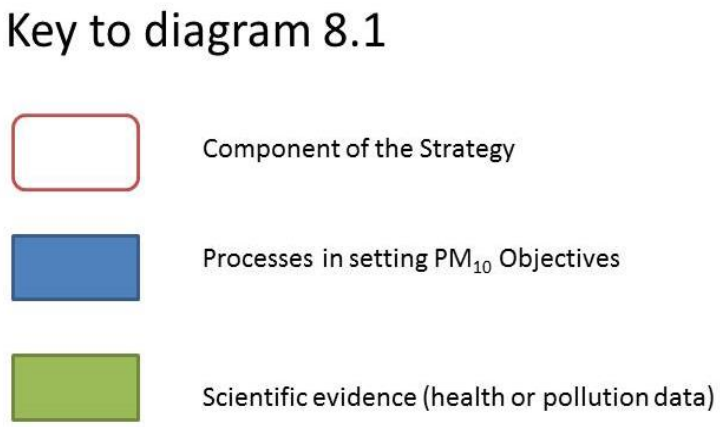
Modelled forecasts of the baseline business-as-usual scenarios indicated that the European stage two limit value would not be met throughout the UK (DEFRA; Stedman, Bush, Murrells, & King). Netcen modelled the impact on PM_{10} concentrations of an "illustrative package of potential new national measures" (DEFRA, 2003, p. 18): potential policy or technology options which could reduce particulate emissions. The modelled forecasts of implementation of these scenarios indicated that the European Stage 2 limit value could be achieved throughout the UK with the exception of London (DEFRA, 2003, p. 18). A cost-benefit analysis of the illustrative measures indicated that they could have beneficial effects on average life expectancy (Interdepartmental Group on Costs and Benefits, 2001). Key to the cost-benefit analysis was the new quantification by COMEAP (2001) of the longitudinal effects of particles on life expectancy: an estimation that for every $1\mu m^3$ drop in concentrations of $PM_{2.5}$ there would be 0.2-0.5 million life years gained across the population of the UK. This analysis predicted that the package of illustrative measures together could contribute a gain of 278,000 -508,000 life

years for the UK population between 2010 and 2110 (Interdepartmental Group on Costs and Benefits, 2001, p. 6). Policy-makers used this evidence to inform the process of setting Objectives for PM_{10}.

This process differed from the linear approach to air quality policy development presented by the National Audit Office report (National Audit Office, 2001a) (See Figure 7.1). This presented the development of the Air Quality Strategy as if first, health evidence was gathered, then Objectives set, and finally the strategy for attainment developed. It also differed from the policy-making process of the 2000 Strategy, in which two potential Objectives were judged against modelled forecasts for 2005, and the one which could be met under a business-as-usual scenario was chosen. In the policy-making process of the Addendum, the Objectives for each region were set after consideration of the potential impacts of the illustrative measures on ambient concentrations. In the cases of London and Scotland the Objectives chosen differed from the requirements of the European Commission.

Figure 8.1 The process of developing the PM_{10} Objectives for the Addendum (DEFRA, 2003)





In contrast to the 2000 Strategy the Addendum explicitly required extra actions to be achieved, and its authors once again viewed it as a policy driver:

> *They [the new particulate Objectives] are seen as policy drivers and have been developed to influence wider long-term policies that impact on air pollution.*
>
> (DEFRA, 2003, p. 21)

Separated from the transport department once again, Defra had little power to set new policies to meet the Objectives. How, and with what purpose then, were these Addendum Objectives decided upon?

2. The role of the developing science of particulate matter in the Addendum

The Addendum saw the return of particulate matter as the pollutant of most concern to the Strategy, after the Revised Strategy had prioritised NO_2. Whilst evidence grew that $PM_{2.5}$ was the fraction more closely associated with ill health, the advisory committee EPAQS (2001) concluded that $PM_{2.5}$ did not warrant regulation in its own right because of its close association with PM_{10} in the UK: to reduce PM_{10} was to reduce $PM_{2.5}$. There may also have been more pragmatic reasons: there was no $PM_{2.5}$ monitoring network and no European requirement to regulate.

Defra (2003, p. 1) claimed that Objective revisions were undertaken both on the basis of new health evidence and on further developments in European air quality requirements. This new evidence took the form of an influential study from the USA. This indicated that long-term exposure to particulate matter was associated with decreased life expectancy (Health Effects Institute, 2000). The advisory committee COMEAP concluded that the association was causal, and significantly more serious than the acute effects (COMEAP, 2001). Moreover, COMEAP believed that the finding concerning this association was transferrable to the UK (COMEAP, 2001).

This enabled COMEAP to develop a series of estimates of gains in life years per sustained reduction of 1µg/m^3 in concentrations of $PM_{2.5}$, which they described as 'quantifications' (COMEAP, 2009, p. 5). Each estimate was accompanied by comments on the Committee's confidence in it. The quantification of health effects that COMEAP believed most likely was a gain of 0.2-0.5 million life years across the population of England and Wales per 1µg/m^3 reduction in $PM_{2.5}$ (COMEAP, 2001, p. 3). The $PM_{2.5}$ metric reflects its status as the fraction of concern to health practitioners, if not to regulators.

COMEAP produced these quantifications for the cost-benefit analysis accompanying the Addendum (Interview 1). The cost-benefit analysis – the second IGCB report (Interdepartmental Group on Costs and Benefits, 2001) – examined the financial costs and the benefits to particle concentrations and subsequently to health of implementing the 'illustrative measures'. That this cost-benefit analysis was undertaken only for particulate matter is

evidence of the relative risks to health of exposure to particulates compared to other pollutants.

The quantification provided an association between population-level health effects and ambient concentrations of particulate matter. This enabled Netcen to provide forecasts of how the illustrative measures scenario could influence the future health of the population. However the requirements of the cost-benefit analysis and the modelled forecasts accompanying it changed how health effects evidence was presented in the Addendum, and how it was considered in the policy-making process. The quantifications inevitably simplified the health effects of particulate matter. The different forms of health effects, individual differences in susceptibility and potentially confounding factors could not be expressed in the quantifications.

Developments in health science did not however cause the developments in the Objectives, but the differentiated Objectives were justified by reference to health protection and equity: Defra aimed for each Objective to reduce particulate concentrations in each area by approximately the same proportion. This was the justification given at the AQ Forum by Martin Williams of Defra:

> *The argument that Martin always gave me, or certainly gave me at the air quality forum, was that actually in order to meet its [objective] London has to reduce by more than the rest of England does to meet its [objectives]. Therefore you're actually putting more effort in in London – and you get more health benefit. Which if you take the non-threshold argument is actually true.*
>
> (Interview 29)

This argument for differentiated Objectives is very similar to the concept of exposure reduction: that each defined geographical area should reduce particulates by the same prescribed amount, rather than all aiming to achieve the same ambient level. The exposure reduction concept became part of the AQ Strategy in 2007, and is discussed in the next chapter.

2.1. Modelling particulate matter

In their review of air quality models, Williams, Barrowcliffe, Laxen, and Monks (2011, p. 6) claimed that in the UK modelling developed in an *ad hoc* manner, according to contemporary policy requirements. The expansion of use and remit of the Netcen model in Period 3 supports this perspective, and goes further: it demonstrates that particulate modelling was constructed through and by the questions asked of it by policy-makers.

Period 3 saw a leap in the scope and sophistication of the Netcen forecasts. Roadside concentration maps were produced, in addition to the forecasts for monitoring sites and background concentration maps (Stedman et al., 2002; Stedman, Bush, Murrells, & King, 2001). The inputs data were more sophisticated. The estimate of the primary fraction of particulates now included not only the NAEI estimates for road transport (incorporating assumptions about emissions standards, fuel use and growth in retrofitted emissions control equipment) but also a range of stationary sources, under assumptions of economic growth provided by the DTI (Stedman, Bush, Murrells, & King, 2001). Netcen conducted sensitivity analysis on some assumptions in the forecasts, including for example the effects of different sources and concentrations of secondary particles (Stedman, Bush, Murrells, & King, 2001).

These developments in the model's input data and its provision for known areas of uncertainty enabled Netcen to provide more precise forecasts compared to those designed for the Revised Strategy. They also enabled Netcen to forecast the effects of the illustrative measures scenario, from changes in emissions to their effects on ambient concentrations, and their impact on population health. As will be discussed in more detail later, the Netcen model became an integral part of the cost-benefit analysis. It not only provided forecasts of future air quality, but also tested the impacts of illustrative measures on population health and their non-health effects. Finally, Netcen used these forecasts to develop population weighted cost-curves for each illustrative measure (AEA Technology, 2001).

Developments in use of the Netcen model were instigated by the requirements of policy-makers (Interdepartmental Group on Costs and Benefits, 2001, p. 22; Stedman, Bush, Murrells, & King), who were required to carry out cost-benefit analysis where possible (DETR, 2000a, p. 21), and for whom the Netcen model had proved a useful tool for justifying their decisions in Period 2.

2.2. Modelled forecasts and concepts of feasible Objectives

In Period 2, for the Revised Strategy, Netcen used their forecasts to test whether the UK could meet the NAQS Objective and the European Stage 1 limit value. In Period 3, instead of testing potential Objectives, the Netcen model forecast national concentrations of PM_{10} in 2010 under the baseline and illustrative measures scenarios.

These forecasts were then used by policy-makers in AEQ to set Objectives for 2010. In contrast to the 2000 Strategy the business-as-usual forecast was not the benchmark by which policy-makers judged potential Objectives. Instead, the illustrative measures scenario forecasts indicated that national action was possible, and that it could improve PM_{10}-

concentrations and health outcomes. For each region of the UK, the Objectives were set on the basis of modelled forecasts of concentrations feasible under the illustrative measures scenario. Figure 8.1 indicates that there was an implementation gap between potential policies and achieving the Objectives. This was justified by the illustrative measures forecasts, which demonstrated that each Objective was largely achievable (DEFRA, 2003, p. 18).

Defra justified these decisions with the claim that the reductions in concentrations required to achieve the Objectives were similar for each region:

> *The UK government have therefore decided to set separate particles objectives for London for 2010 that will require at least as much by the way of improvements in air quality as those required to meet the objectives set for the rest of the UK….[A]chieving the 18µg/m^3 in Scotland will be equivalent to the challenge of 20µg/m^3 being met elsewhere in the UK, apart from in London.*
>
> (DEFRA, 2003, pp. 21-22)

Thus expectations of feasibility, mediated by the model, informed the choice of Objectives, but in a different manner to process of setting Objectives for the Revised Strategy. Moreover, these developments were a response to the requirements of policy: the need to undertake cost-benefit analysis and to set targets which were "challenging achievable" (DEFRA, 2003, p. 21). Whilst developments in the forecasts and models enabled different scenarios to be tested, setting the Objectives for the Addendum entailed policy decisions.

3. The roles of expectations and visions in the policy process

Assessment of the expectations and visions in the Addendum will demonstrate that policy-makers in AEQ set PM_{10} Objectives on the basis of a set of visions for technological and policy futures which required extra action for attainment. These were developed in response to a vision of the AQS as policy driver – missing from the 2000 Strategy, but returned to the Addendum (DEFRA, 2003, p. 21). First, the case is made that the illustrative measures functioned as a set of visions: tools for convincing other actors to accept the Objectives and of the value in taking steps to reduce PM_{10}. It is argued that the visions of the Addendum differed from those of the Revised Strategy in substance, purpose and origins, and that their articulation in the Addendum came at the expense of alternative visions, with potentially detrimental effect.

Table 8.2. Categorisation and authorship of visions in the Addendum

Technology	Technology and Policy	Policy	Policy and Behaviour	Behaviour	Compliance
Illustrative measures: Adoption of cleaner technologies for stationary sources: • **Domestic combustion: switch to smokeless solid fuel and gas fuel; install enclosed appliances.** • **Industrial combustion and processes: fuel switching from coal and oil to gas; use of ceramic and fabric filters.** • **Public & commercial buildings: fuel switching from coal and oil to gas, install ceramic filters.** • **Petroleum refineries: wet flue gas scrubbing/ extra electrostatic precipitators; switch to gas in combustion processes.** • **Iron and steel industries: install fabric filters.** • **Cement production: fit electrostatic precipitators, fabric filters – both in series.** • **Lime production: fit electrostatic precipitators and fabric filters on kilns, adopt wet scrubbers in lime hydrators.** • **Non-ferrous metals production: install electrostatic precipitators and fabric filters.**	**Illustrative measures for transport:** **DPFs to light and heavy duty vehicles through regulation & fiscal measures from 2006** **Early introduction sulphur-free diesel through regulation & fiscal measures** Illustrative measures: Short-term clean technologies retrofit programmes (CleanUp & Haulage Modernisation Fund £90 million in total): DPFs & oxidation catalysts to buses & trucks, convert taxis to LPG and trucks to CNG, and new engines for pre-Euro I trucks and buses.	AQS as policy driver		**Illustrative measure: Quarrying: use of 'best practice'**	**Undertaking the illustrative measures would take the UK largely into compliance with EU 2nd DD** **Objectives are achievable**

Key to origins of visions: **Defra (green);** DTLR (black); **Netcen (orange)**

3.1. Visions in the Addendum

The visions included in the Addendum and their origins are set out in table 8.2. They are dominated by the illustrative measures, which originated from the DTLR (Department of Transport, Local Government and the Regions) and Netcen. These illustrative measures, with the exception of those for quarrying, contained visions for technological change. Those affecting road transport incorporated visions for policy change to encourage their adoption. In contrast, those for stationary sources were not accompanied by visions for policy; it was not clear how these measures could be transformed into policy.

The technological visions for stationary sources encompassed fuel switching and end-of-pipe emissions-reducing equipment. Those for road transport too, involved fuel switching – from diesel to natural gas fuels- or retrofitting particulate filters and new engines. All visions for technological change were for the further adoption of technologies already in use. Similarly, the accompanying options for policies to encourage their adoption advocated continuation of those in existence (government grants for retrofitting and adoption, and preferential fuel duty), not for radical new departures.

The Netcen model forecast that implementation of all illustrative measures would reduce annual PM_{10} emissions by 33% in 2010 (from a 1999 base year) (IGCB, 2001, p. 34), and that reductions would be greater from stationary sources (from 79.2 to 48.2 kilotonnes) than from road transport (from 13.29 to 11.38 kilotonnes) (DEFRA, 2001, p. 31). The stationary source package thus potentially had a greater impact on ambient particle concentrations, and was also projected to be cheaper to implement (£219 million compared to £556-896 million). However, ambient concentrations of particles were greatest at roadside locations, where road transport measures would be more effective and to which a greater proportion of the population would be exposed (DEFRA, 2001, p. 87).

3.2. The characteristics of the visions in the Addendum

The outcome of each illustrative measure was expressed as a predictable and quantifiable decrease in PM_{10} emissions from the source. This included emissions from quarrying, for which the illustrative measures were process changes and adoption of best practice not technical change. All illustrative measures for road transport were associated with policies which could be applied by the national government – a change from the local focus of the NAQS and Revised Strategies.[14] For each measure data on emissions sources were available to

[14] Although emissions modelling for the retrofitting programmes assumed that they would be implemented entirely in London for maximum effect {Stedman, 2001b #257@5}.

predict outcome of their implementation on a national scale (AEA Technology; Interdepartmental Group on Costs and Benefits, 2001). Such features enabled the illustrative measures to be modelled and their effects on ambient concentrations and health to be assessed.

Visions in the Addendum differed from those in the Revised Strategy in content, subject and origin, and this can be seen in the comparison of Table 8.2 (visions in the Addendum) with table 7.6 (visions in the Revised Strategy). The previous chapter categorised visions in the Revised Strategy as visions for local-level and voluntary changes affecting behaviour and technological adoption on the part of local government, industry, business and individuals. In contrast, visions in the Addendum were national, technocratic and accompanied by visions for specific national policy measures to achieve them.

Chapter 7 proposed that the visions in the Revised Strategy were tools to persuade actors to improve air quality beyond the business-as-usual Objectives, with a focus on local level action. The visions in the Addendum differed from this: they provided the evidence that Objectives for PM_{10} beyond the business-as-usual baseline could be achieved. The nature of the visions as precise (but not necessarily accurate), quantifiable and technocratic reflects their origins in the Netcen model and their original purpose; that of demonstrating the possibilities for PM_{10} reduction.

3.3. Use of visions in the Addendum

The Addendum contained the clear statement that the illustrative measures were not signals for future policy:

> *….there is no assumption that they will be introduced or that it is these measures that would need to be set in place if a new objective is to be achieved.*
>
> (DEFRA, 2001, p. 31)

However, the illustrative measures scenario was the only alternative offered to the baseline forecast. They were the means by which Defra's vision for the Addendum as a driver of policy change was justified: they demonstrated that extra action to reduce particulates beyond the baseline forecast was possible, cost-effective, and could improve health and air quality outcomes. More specifically, they demonstrated that it was possible to reduce the implementation gap through carefully targeted *national* policies. Figure 8.2 demonstrates the means by which these visions became integrated into the policy process: the illustrative measures scenario forecasts of particulate concentrations in 2010 were also an integral part of the cost-benefit analysis, which examined only the efficacy of implementing the illustrative

measures. The forecasts and the cost-benefit analysis were the evidence used by policy-makers to set the differentiated Objectives. So even if the illustrative measures were intended to be purely illustrative, their effects on the setting of Objectives were substantial.

Defra could not itself develop any of the illustrative measures into real-world policies and legislation, but was reliant on the DTLR, DTI, Treasury, or the voluntary efforts of the relevant sectors to do so. Interviewee 7, a Forum member and civil servant, interpreted the illustrative measures as a means used by DEFRA to negotiate with the other departments:

> *In a sense the illustrative policies are not in the gift of Defra. … Its back to when one is more into the influencing than the regulating…. Once they've [other government departments] commented on the Strategy it gives you [AEQ] an entrance ticket to go on and discuss them. "Can we come and discuss this; you have accepted this as being the way to go" – no doubt the Department for Transport would have a view about whether they really accepted it or not… What they've done is they've produced a manageable list of possible strategies.*
>
> (Interviewee 7)

A policy-maker from AEQ confirmed this in his description of the decision-making process:

> *DEFRA pretty much doesn't have any policy levers in terms of actually changing emissions. I mean the policy levers we have are the broader ones of setting objectives. And what I wanted to do in this strategy was not go round the loop again in arguing whether it ought to be 20 or 23 or 18 [µg/m^3]. Let's not have another set of endless arguments about what the Objective ought to be. Let's actually see how we are going to deliver the thing this time because we've seen in the first two iterations of the Strategy how difficult it can be to achieve the Objectives, so maybe we ought to be thinking in terms of how we're going to do it. So let's actually do some detailed analysis on policy measures– although we're not actually asking people in this version to sign up to them….*
>
> (Interviewee 28)

As members of the IGCB, other government departments would have agreed in principle that the illustrative measures were feasible when the cost-benefit analysis was carried out. The emphasis placed on the illustrative measures within the Addendum is indicative of their significance: The illustrative measures were the only subject of IGCB's cost-benefit analysis and the modelled forecasts; and the modelled forecasts were used in the Addendum itself to demonstrate feasibility (DEFRA, 2003, pp. 18-21).

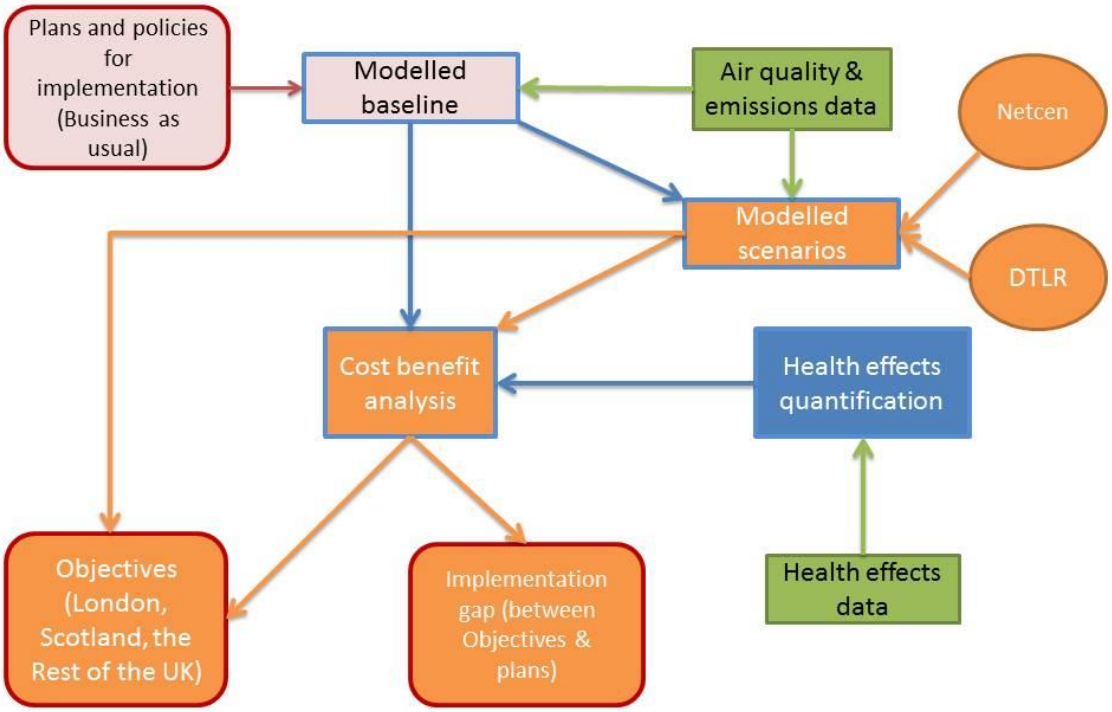
This set of illustrative measures was a tool used by policy-makers in AEQ to convince others to take action to improve air quality, including other policy-makers but also those who engaged in the policy process or who read the Addendum. They were a coherent set of visions,

contributing to an idealised future – one where the AQS was a policy driver and where the more challenging Objectives were achieved.

4. Visions dynamics in Period 3 and their impact on the Addendum

All visions in the Revised Strategy, shown in table 7.6 (in Chapter 7) originated with the authors of the Strategy, the DETR (and within this department, the division AEQ). Table 8.2 indicates that the majority of visions in the Addendum came, not from AEQ and Defra but from the DTLR and Netcen. Only one vision originated with AEQ - that of the Strategy as a policy driver. The paths by which these visions disseminated through the policy-making process of the Addendum are shown in Figure 8.2.

Figure 8.2. The pathways of vision dynamics in the Addendum



Key to diagram 8.2

Component of the Strategy

Processes in setting PM_{10} Objectives

Scientific evidence (health or pollution data)

Uptake of visions in the Addendum

Uptake of expectations in the Addendum

Source of visions in the Addendum

5. Visions articulated by the DTLR

The illustrative measures contained two DTLR-led retrofitting programmes to reduce road transport emissions: the CleanUp grants and the HGV retrofitting programme. These were finalised after Netcen completed the baseline modelling, so were not included in the baseline. They were however incorporated into the illustrative measures scenario (Stedman, Bush, Murrells, Hobson, & Handley, 2001, p. 5). These are characterised here as 'visions' because they were components of the scenario which the Addendum used to justify the challenging Objectives, and because they were partially hypothetical: they assumed continuation of funding after 2004 (Interdepartmental Group on Costs and Benefits, 2001, p. 55).

Significantly, these visions were incorporated in the Addendum *prior* to finalisation of the grants. There was however no guarantee that these fiscal incentives would continue, as envisioned. A representative of AEQ (interviewee 14) stated that, although there was the possibility of change with every budget "…we were dealing with the situation as it was then and I think that the approach tended to be *let's just assume that the status quo would hold.*"

In Table 8.2 these visions articulated by the DTLR are categorised as for future policy and technologies. Each policy option was accompanied by assumptions about the technologies take up as a result, the nature of the vehicles utilising them (table 8.4), of their geographical patterns of use, and subsequent impact on particulate concentration. These were modelled by Netcen, which assumed that the CleanUp and HGV retrofitting grants would fund only vehicles running in the Greater London area (despite the grants being operated nationwide) (Stedman, Bush, Murrells, Hobson, et al., 2001, p. 5).

This differs from previous Strategies' portrayal of the grant schemes for cleaner vehicles, which were of broad incentives for the adoption of unspecified cleaner technologies (DETR, 2000a, p. 92). Instead the Addendum's visions were very precise and for the first time indicated preference for a set of technologies.

Table 8.3. Options for retrofitting technologies modelled to forecast effects of DTLR's retrofitting programme (source: Stedman et al, 2001b, p5)

	Trucks	Buses	Taxis
CNG	✓		
LPG			✓
Diesel particulate filters	✓	✓	
Oxidation catalysts	✓	✓	✓
New diesel engines for pre-Euro 1	✓	✓	

6. Vision dynamics: the growth of expectations for road fuel gases

This next section examines how the DTLR came to provide clear visions for uptake and use of alternative vehicle fuels which were absent from previous versions of the Strategy. It focuses on the dynamics of visions for uptake of CNG and LPG fuels – road fuel gases. Period 3 was the peak of the hype around CNG and LPG vehicles, when a clear vision for their use as a tool for reducing pollutants was promoted by a loose coalition of actors and acted upon by many others.

Interviewees, including policy-makers from DTLR and AEQ, representatives of vehicle manufacturers, and NGOs, described a general *expectation* that CNG and LPG fuels would have success as alternatives to diesel. A representative of AEQ stated that: "… at that time that was the firm belief – and that wasn't government alone saying that, it was also being said by those in industry" (interviewee 14).

These shifting expectation dynamics were consequences of increased uptake and use of these vehicles, increased government subsidies and support, and the articulation of the vision by key actors.

6.1. Growth in the use of natural gas vehicles

Evidence fuelling the spread of the visions for road fuel gases came from substantial increases of vehicles using these fuels. The number of light duty goods vehicles using road fuel gases doubled each year from 2000 to 2002 – from 1118 to 4155 – and in 2003 jumped to 7374. However, at 0.27% of the light duty goods fleet, this remained a tiny proportion of the total (DfT, 2012a). Number of passenger cars using road fuel gases similarly increased from 19,963

in 2000, to 33,651 in 2003, although in 2003 this was only 0.12% of cars on the road (DfT, 2012b).

These usage statistics provided by the DfT amalgamated the two fuels. In reality, LPG was by far the most popular fuel – with approximately 55,000 vehicles on the road in 2002, compared to only a few hundred CNG vehicles (Energy Saving Trust, 2002, p. 14). This was perhaps a reflection of CNG's strengths as a fuel more suited for us by heavy duty vehicles, but also of more costly retrofitting and refuelling, and heavier fuel tanks (Energy Saving Trust, 2002, p. 14). The Energy Saving Trust, which administered the CleanUp and PowerShift grants, argued in 2002 that the LPG market was growing at such a rate that it would soon no longer require subsidies (Energy Saving Trust, 2002, p. 14).

Period 3 also saw attempts to address the problematic and partial refuelling infrastructures which were barriers to growth. LPG refuelling points grew from 660 in 1997 to 1,000 in 2001, to 1272 in 2003 (Brevitt, 2002, p. 20; Niches Project, 2007). The CNG network grew more slowly, with approximately 20 public refuelling points in 2002 (Brevitt, 2002, p. 46). However at least one large CNG filling station opened for HGVs, funded by an EST grant and with the (*Truck*, 2001, p. 16) and Esso CNG offered free installation of CNG fuel stations to lorry fleets which switched 20 or more long-haul trucks to CNG (*Truck*, 2002).

6.2. Articulation of the visions by influential actors

Table 8.4 presents some key actors involved in promotion of CNG and LPG fuel. The lists of actors are not exclusive, but aim to provide an overview of actors promoting each fuel. It can be seen from table 8.4 that whilst some vehicle manufacturers – for example, Volvo - created vehicles utilising both types of fuel, fuel suppliers supplied one type of fuel only.

Interviewees representing vehicle manufacturers and users argued that their members became convinced of the future success of these fuels thanks to successful lobbying by a variety of actors (interviews 2, 3, 4, 23). However, these interviewees were keen to distance themselves from prior support for the fuels after the collapse of the visions in 2005, so one must be cautious in taking at face value their suggestions that their members were simply victims of eloquent and persuasive lobbyists. Instead, this analysis, though limited in scope, suggests that a range of actors from every category in table 8. 4 promoted the vision and reinforced its power by doing so.

Table 8.4. Key actors promoting LPG and CNG during Period 3

Actor type	LPG Actors	CNG Actors
Vehicle manufacturer	Daewoo Daihatsu Ford (vans, cars) Nissan Vauxhall (vans, cars) Volvo (bi-fuel cars) DAF (lorries)	Scania (trucks) Volvo (bi-fuel cars)
Fuel supplier	BP Calor Gas Flo Gas Jet Shell	Esso CNG (previously Mobile CNG) British Gas
Notable fleet uptake	Philips Electronic John Lewis	Safeway British Gas
Trade association	LPG Association	Natural Gas Vehicle Association
Policy-makers	Brian Wilson (Energy Minister) Department for Transport	Department for Transport

Interviewees representing road haulage firms singled out the LPG Association and the Natural Gas Vehicle Association as particularly successful in enrolling other actors to their vision.

> *… a lot of people did a good selling job. And everybody says "oh gas is wonderful; here we are, this is it" and it terms of PM_{10}s it was fairly low…. Natural Gas Vehicle Association – they did a superb job on it – superb lobbying job.*
>
> (Interviewee 5)

The LPG Association was also named in interviews as a very successful lobbying organisation (Interview 2, 5, 29). It promoted the vision of 250,000 LPG vehicles on the road by 2005 (Wilks, 2002, p. 32).

From table 8.4 it can be seen that AEQ and others representing the department of the Environment were not key actors promoting LPG and CNG. However, some policy makers (notably those in the Departments of Energy and Transport) were key promotors of specific visions. DETR minister Keith Hill claimed that his department and the Energy Saving Trust were actively encouraging vehicle manufacturers to develop gas vehicles (Brevitt, 2002). Policy-makers were also the audience of these visions. Vauxhall and Volvo actively promoted the

technologies to government, in the hope that favourably policies would assist sales (Interview 21). Energy Minister Brian Wilson expressed support for LPG over other alternative fuels.

6.3. The impact of these visions on policy choices

Growth in numbers of vehicles using these fuels, and the active support and promotion by specific manufacturers, fuel suppliers, and government was both consequence and cause of to the hype around road fuel gases. The dramatic collapse of these visions and of the accompanying government support in 2004 and the impacts of this on air quality policy will be discussed in Chapter 9.

The dominance of CNG and LPG in visions presented in the AQS Addendum may have curtailed expectations for other road transport technologies previously supported in the Revised Strategy. Electric and hydrogen were dismissed as too expensive in the cost-benefit analysis work (Interdepartmental Group on Costs and Benefits, 2001, p. 57). Hybrid electric vehicles were not discussed in the Addendum, despite growing popularity and less polluting emissions (Energy Saving Trust, 2002). Yet Department for Transport statistics indicate that these were growing in similar proportions to road fuel gas vehicles.

The visions in the Addendum for continuing growth of the CNG and LPG market share, supported by government subsidies, was a consequence of the preference of these technologies in transport and energy policy.

7. Netcen: Visions and the co-construction of the Netcen model and the AQS Addendum

The second major source of visions in the illustrative measures (and hence the Addendum) was Netcen/ AEA Technology (Interdepartmental Group on Costs and Benefits, 2001, p. 36)[15], who were contracted by Defra to quantify the costs of reducing PM_{10}. Effectively, the labels of 'AEA Technology' and Netcen' were two names used for a division of the AEA Technology company. For clarity, the company is referred to here as 'Netcen', apart from documents cited as 'AEA Technology' by policy-makers.

Table 8.5 outlines the stages undertaken in the cost-benefit analysis, whether the Netcen pollution concentration forecasting model was used, and the authors of the research. Netcen not only provided forecasts of ambient PM_{10} concentrations, but also utilised the model to

[15] AEA Technology was Netcen's parent company, and the two shared offices and personnel. Although published under AEA Technology, the 2001 report on costs of abatement starts "NETCEN, under contract reference EPG 1/8/59 "Cost of PM10 and NO2 abatement", has prepared this report…" (AEA Technology, 2001, p. 2).

generate forecasts for each stage of the cost-benefit analysis, including forecasts of the impact of illustrative measures on PM_{10} concentrations, population health, population-weighted costs, and non-health benefits.

Table 8.5. Inputs into the Cost Benefit Analysis

Stage of analysis	Evidence	Utilisation of Netcen model	Authors
Emissions mapping and modelling	Baseline scenarios for the UK: for each monitoring site, for maps of background concentrations, and roadside concentrations for major roads	✓	Netcen (Stedman et al., 2002; Stedman, Bush, Murrells, & King, 2001)
	Illustrative measures scenario for the UK: for each monitoring site, for maps of background concentrations, and roadside concentrations for major roads	✓	Netcen (Stedman, Bush, Murrells, Hobson, et al., 2001; Stedman et al., 2002)
Cost of illustrative measures scenario	Generation of illustrative measures scenario		Netcen (AEA Technology, 2001)
	Identification of costs of illustrative measures		
	Cost curves for emissions reduction		
	Cost curves based on UK particulate concentrations, as weighted by population	✓	
Health benefits of illustrative measures scenario	Coefficient for long-term health effects		COMEAP (COMEAP, 2001)
	Quantification of acute health effects for baseline and illustrative measures	✓	Netcen (Stedman, King, & Holland, 2001)
	Quantification of long-term health effects of baseline and illustrative measures	✓	Netcen (Stedman, King, et al., 2001)
Non-health benefits of illustrative health scenario	Quantification of non-health effects of the baseline and illustrative measures scenario	✓	Netcen (Watkiss, Pye, Holland, Forster, & King, 2001)

Source: IGCB, 2001

7.1. Characteristics of visions presented by Netcen in the illustrative measures scenario

Netcen created the illustrative measures for stationary sources. They based these abatement options largely on information on technologies provided by the UNECE Task Force on Emission Inventories and Projections (whose secretariat was provided by AEA Technology) (AEA Technology, 2001, p. 33), but also from reports written for Defra, DTLR, the Environment Agency, the European Commission, the IPPC Bureau, UNCE, the US Environmental Protection Agency, and from reports from the industries under discussion themselves (AEA Technology, 2001, p. 10). This resulted in illustrative measures for stationary sources which were generic technological fixes, not policies for their execution. Illustrative measures for road transport which originated with Netcen (see table 7.3) were also technocratic solutions: early introduction of 10ppm sulphur fuel, and a "hypothetical scenario" of mandatory particulate traps on new light- and heavy-duty vehicles. Netcen designed the illustrative measures for the purpose of generating forecasts of their effects on particulate concentrations and for undertaking cost benefit analysis. This gave the illustrative measures a set of distinct characteristics. These were that each measure had supposedly predictable, precise and quantifiable effects on PM_{10} emissions from the source, which enabled their impact on ambient concentrations levels to be forecast. The illustrative measures were technocratic rather than about behavioural changes, and for national outcomes rather than local.

7.2. The impact of Netcen's visions for policy and technological development

The result of Netcen's choice and use of this set of visions was that visions in the Addendum differed qualitatively from those articulated by the Revised Strategy. Visions in the Revised Strategy were about voluntary behaviour changes and local government policies and actions to encourage them. The Addendum contained no visions for behaviour change, or for policy development alone – only for policy to encourage adoption of specific technologies.

Such local level measures to encourage changes in behaviours of the general public were essential parts of the Air Quality Strategy. Analysis for Period 1 demonstrated that the process of local air quality management (LAQM) was the only entirely novel outcome of the NAQS. In designating and managing Air Quality Management Areas, local authorities relied upon local actions, traffic management schemes and behavioural change. In Period 3, the London Low Emission Zone, the largest of such traffic management schemes, was planned, and LAQM schemes had reached the stage of implementation. Yet, local level actions had no role in the visions for future outcomes.

The characteristics of the Netcen model determined the potential actions that could be assessed: the scale used ruled out the inclusion of local level, small-scale actions, and the effects of international actions. The effects of such local actions on emissions were not readily quantifiable, nor predictable in the same way as changes in technologies.

The provenance of the illustrative measures with Netcen explains their characteristics as technocratic, quantifiable and predictable. They were selected and designed by Netcen specifically for the purpose of the cost-benefit analysis. These visions in the illustrative measures supported AEQ's visions for further cost-effective action beyond the baseline because they were designed to do so.

7.3. Credibility of the Netcen model to policy-makers

The Netcen scenarios (baseline and illustrative measures) and analysis held a privileged position in the development of the Addendum. What were the factors which contributed to the model's credibility to policy-makers in Period 3, compared to other sources of visions?

There were benefits for Defra in using the Netcen model for assessment of policy options. The model used monitoring data from the UK wide PM_{10} networks to build precise forecasts. Such precision is not necessarily an indicator of accuracy, but may have been attractive to policy-makers seeking an evidence-base for policy. As a result Netcen could provide forecasts for roadside, background, and industrial locations at which there were monitoring sites, and then extrapolate these to create pollution maps for the UK (Stedman, Bush, Murrells, & King, 2001). This meant that very detailed pictures of PM_{10} concentrations could be built up, and the impacts of policies affecting traffic emissions alone could be tested.

Moreover the model was modular: it incorporated the outputs of other models to build rules on how changes in emissions changed ambient concentrations (Williams et al, 2011, p. 41). These enabled it to be both relatively fast to run – essential for the demands of policy – and to quickly incorporate new scientific findings (Williams et al, 2011, p. 14). A modelling expert described it as "fit for purpose: it might appear complicated but actually its very simple. It allows you to produce maps… quite easily" (interviewee 7).

For these reasons the Netcen model held advantages over other pollution models. However, it also held these advantages because it was designed *for* the purpose of setting Objectives, and it evolved with the requirements of the AQS.

The ex-government research centres incorporated into AEA Technology (notably Warren Spring Laboratory and ETSU) had experience of economic assessment of costs and benefits of

policy options for energy and environmental systems, and this continued to be the case when they became part of AEA Technology. Prior to the Addendum AEA Technology had contributed to, or was responsible for, a number of economic assessments. At the time the most noteworthy was ExternE – a European Union project evaluating costs and benefits of the externalities of energy use scenarios for CLRTAP (Holland & King, 1999). Significantly, AEA Technology conducted economic assessments for the European air quality daughter directives for PAH, benzene and carbon monoxide – the other pollution targets incorporated into the Addendum (AEA Technology, 1999; Holland, Jones, Berdowski, Bleekr, & Visschedijk, 2001). All projects used the methodology presented in the second IGCB report (Interdepartmental Group on Costs and Benefits, 2001). The record of AEA Technology/ Netcen in this area was another contributing factor to their use by Defra.

7.4. The consequences of use of Netcen forecasts and visions in the Addendum

Model and policy were co-constructed: both were determined by the requirements and limitations of the other. The model gave the Addendum its national-level, primary particulate focus and the justification for more challenging Objectives. The remit of the model, and its parameters were set by the requirements of policy-makers. Co-construction of model, monitoring network and AQS was previously demonstrated by this author (Smith, 2003).

In Period 3 the Netcen model created perceptions of the possible reductions in particulate concentrations and of the characteristics of the options for abatement. As a result of the model's requirements the many health effects of particulates were reframed as a coefficient linking loss of life in the UK population to particulate concentrations. The modellers created not simply a scientific assessment, but set the parameters of potential policies, technologies and their future use. This conceptualisation of the future was used by policy-makers to justify setting differentiated Objectives, because it indicated that specific reductions had been predicted to be both feasible and "challenging yet achievable".

The Netcen model was no longer simply a provider of pollution concentration forecasts as it was in Period 2, but integrated pollution mapping and forecasting with socioeconomic factors and health impacts in order to test the illustrative measures. Moreover, these changes were not acknowledged or made explicit in the Addendum and supporting cost-benefit analysis.

The Netcen assessment was also the dominant source predicting potential effectiveness of mitigation strategies – both in monetary and health improvement terms. In this it resembled an integrated assessment model (IAM) in which the effects of natural and socioeconomic factors and their feedback throughout a system are modelled. They combine this knowledge

in ways which enable the impacts of alternative scenarios on every part of the system and their interactions to be modelled (van Asselt & Rotmans, 1995, p. 414) (e.g. national emissions generating processes, effects, socioeconomic and policy impacts (Shackley & Darier, 1998, p. 315)). The purpose of such models is to provide assessments and information useful to policy-makers where problems are highly complex and highly interconnected (Shackley, 1998, p. 86). Such integration of socioeconomic and natural systems is a typical part of pollution modelling and policy development (Van der Sluijs, 2002). Examples include the use of the RAINS model of transboundary air pollution in CLRTAP, and the IPCC climate change scenarios.

Tol (2011) described situations where such models could become "knowledge monopolies": systems without competition due to prohibitive costs, perpetuated through continued use in policy development and academic use. The Netcen model became a knowledge monopoly in Period 3, in its dominance in the provision of knowledge of socioeconomic and natural systems. Interviewee 29 (a policy-maker in Defra) stated that Defra were unwilling and unable to justify funding more than one national model, and without their support no other research institution had developed their own national model.

Not only did Netcen hold a knowledge monopoly, they also held a visions monopoly – a monopoly on concepts of the future of policy and technologies. Whilst the Addendum was keen to establish that there was "no assumption that these are the measures that would have to be introduced in order to achieve any new objective" (DEFRA, 2003, p. 19), the extent of their use in the Addendum to justify policy decisions refutes this claim.

At this time the Netcen model was not subject to peer review (evidence from interviewees 28 and 29). There was no other model of national ambient PM_{10} concentrations with which to compare it, and its forecasts could only be verified retrospectively through comparison with measured concentrations (interviewee 28). Interview subjects from Defra and those who were modellers questioned whether even the existence of two or more models to enable comparison would yield a better standard of evidence – how could judgements be made about which forecast for the future was more accurate than the other without comparing them retrospectively to actual particulate concentrations? In contrast the first IGCB report used two models throughout: the Netcen model and the SEIPH model of Greater London, enabling comparison of the results and demonstrating that the use of comparison data to validate forecasts was possible (Interdepartmental Group on Costs and Benefits, 1999). Similarly, there was no consultation on the IGCB report (Interdepartmental Group on Costs and Benefits, 2001); published simultaneously with the consultation draft of the Addendum (DEFRA, 2001)

which utilised its results. Nor was cost-benefit analysis and forecasting changed on the basis of responses to the consultation.

One interviewee characterised the situation in which the Netcen model dominated:

> *Defra can produce a Strategy. It can produce all the modelling results it pays for, all the monitoring trends. It can do the cost-benefit analysis. It can put all the money essentially into the research base, the evidence base, which an NGO can't…. So actually if John Stedman's model says X, how do we actually challenge that?*
>
> (Interviewee 29)

Reactions by stakeholders to the visions promoted in the Addendum, and to the differentiated targets for achievement by 2010 will be assessed in the next chapter, to assess whether and how these visions were taken up and acted upon.

8. Discourses of target setting in the policy process of the Addendum

Chapter 7 identified the Performance Management discourse and demonstrated its impact on the Revised Strategy. Was this discourse still dominant in Period 3, and to what extent can it explain the PM_{10} Objectives of the Addendum and the new reliance on modelled visions for change?

Evidence for dominance of this discourse was sought for the presence of the Performance Management storyline and the distinctive language identified in chapter 6, the practices and institutions in which the discursive activities take place, and the meaning given to the particulate problem.

8.1. Evidence for the Performance Management Discourse

Storyline and language

The Addendum presented the Performance Management storyline: the necessity of setting achievable targets with measurable outputs, so that morale is not lost (as could happen if unachievable targets were set), and policy is more cost-effective (Hood, 2001, p. 300).

The Objectives followed this discourse: they had measurable outputs (ambient particulate concentrations), with reduction targets demonstrated achievable through the Netcen forecasts. They were specific, measurable, and were required to be achieved within a specific time-frame.

As in the Revised Strategy, the Objectives were described as "challenging yet achievable" (DEFRA, 2001, p. 138; 2003, p. 21). Chapter 7 argued that this phrase, used in policy

documents and by interviewees to describe policy-making in these two time periods, was indicative of this discourse in air quality policy.

Yet, differences in PM_{10} Objectives reveal the interpretative flexibility of the requirement for 'challenging yet achievable' targets. Whilst the language used remained the same in Revised Strategy and Addendum, the Strategies differed in their interpretation. As we have seen above, the creators of the Addendum made a deliberate choice to set PM_{10} targets which required further action, to drive wider policy (DEFRA, 2003, p. 21), whilst Revised Strategy based targets on business-as-usual.

Wider institutional and practice changes in UK government

The changes in institutions and practices in wider government resulting from the Performance Management discourse were explored in Chapter 7. During Period 3, between 2000 and 2003 the Performance Management discourse continued and reached its peak. It was institutionalised in every government department through the Treasury's public service agreements, which linked future budgets to demonstration that the department was on course to reach a set of agreed targets. The number of targets included in the Public Service Agreements reduced from 600 in 1998, to 160 in 2000, to 130 in 2002 (James, 2004, p. 404) . This was not indicative of a reduction in the power of this discourse, but because targets changed and merged (Hood, 2001). However, such rapid turnover of PSAs indicated that the proposed four year cycle of setting and reviewing PSAs was not happening as predicted. Indeed, critics have proposed that the target culture was an addition, rather than a replacement to policy-making structures, and constructed in an *ad hoc* rather than strategic manner (James, 2004, p. 404).

Nevertheless, this discourse remained central to clean air policy. Attaining the AQS Review Objectives became a joint PSA for attainment by Defra and the DfT (DEFRA, 2002a). Given the centrality of this discourse and the resulting changes in policy-making practices, it is not unexpected that the discourse was prevalent in the Addendum.

Definition of the environmental problem

Three pieces of evidence were key for establishing the Addendum Objectives: the Netcen forecasts, the COMEAP quantifications of health effects, and the IGCB cost benefit analysis. This evidence conceptualised the particulate 'problem' as one which had effects at the level of the population (rather than the individual), and was solvable through cost-effective action. The illustrative measures were developed for the cost-benefit analysis, to demonstrate that

extra actions would impact both on the output of ambient particulates, and on the outcome of improved health indicators.

This evidence alone is not sufficient to conclude that one discourse determined the scope of the Addendum. Rather, a discourse coalition's hegemony over the construction of problem can be illuminated by demonstrating that there were alternative constructions that were held back because of it. Alternative perspectives on the use of scientific evidence and the construction of the particulate problem were evident during Period 3.

Amongst scientists in the Department of Health and COMEAP there was concern that the Addendum over-relied on one type of evidence on health effects alone: the coefficient relating life expectancy to ambient particulate levels. This coefficient was developed by COMEAP for the cost-benefit analysis (interview 1), and was expressed as life years gained (for the population of England and Wales) per 1μg/m^3 decrease in $PM_{2.5}$. This fitted the storyline of the Performance Management discourse: that improvements and outcomes were quantifiable. Yet such coefficients are necessarily simplistic, and this one carried with it many caveats and uncertainties. For example, nothing was known about the distribution of loss of life expectancy within the population (interview 16).

COMEAP built some of its concerns into the coefficient. They presented five coefficients under different assumptions, each accompanied by a statement of the Committee's beliefs on its likelihood of accuracy. Interviewee 1, an epidemiologist on COMEAP, and interview 16, of the Department of Health were also cautious about the attempts to monetise health benefits, stating that they were the "hardest thing" in the Strategy.

COMEAP and the Department of Health were persistent in communicating these issues to Defra:

> *[DEFRA] asked us [COMEAP] for this number. I said 'you must be very careful with this'. …we told Defra enough: Bob Maynard, myself, Heather Walton spent a lot of time trying to get the message across…* (Interviewee 1)

8.2. An alternative discourse: Action

The strength of the disagreement over setting differentiated targets in the Addendum illuminates the performance management as a discourse. The minutes of the Air Quality Forum, responses to the Addendum consultation, media, and interviewees demonstrated opposition to the two-tier Objectives. 45 out of 74 responses to the consultation on the Addendum did not agree with separate Objectives for London, and only seven respondents registered their support (DEFRA, 2002b). Those opposed included twenty-seven local

authorities, nine London Boroughs, advocacy groups representing local authorities, the Mayor of London, and the Greater London Authority – this despite the Mayor of London and the local authorities' responsibility for attempting to meet the Objectives. The Addendum justified the two-tier Objectives on grounds of equal difficulty, but those responsible for improving air quality in London wanted the more challenging, potentially unachievable Objectives.

The London authorities' response to the tiered Objectives is an example of a second "philosophical position" (interview 29) about Objective setting. This second position encompassed interrelated concepts:

- That Objectives should require action for attainment;
- That Objectives should be accompanied by a period of stability, so that they can be implemented;
- That it is better to keep Objectives which could not be met in order to stimulate action, rather than to keep revising them;
- The Strategy should be primarily about health protection.

Not all these perspectives were articulated at once by all actors. The NSCA, for example, focused on the requirement for stability:

> *If the apparent current philosophy is pursued, i.e. that objectives are set and adjusted according to the predictions prevalent at the time, it is highly likely that the objectives for London will be revised a number of times before 2010. This would clearly be unacceptable, particularly for those whose task it is to prepare actions and policies to meet the objectives.*
>
> (NSCA, 2001, p. 6)

Interviewees also expressed this perspective (including interview 8, 12 and 13, representing local authority and modelling perspectives). For example, interviewee 7, from the Environment Agency, on the London Objectives:

> *…I think it undermines your basis for a Strategy. The basis of the idea is that the Strategy should be health based and surely you should be trying to achieve the same benefits whether you are in central London or in the Highlands of Scotland.*

Actors calling for stability of Objectives over achievability, and what the NSCA termed "measures not numbers" differed in their reasons for articulating such a perspective, although they were either objecting on grounds of unequal health protection (interview 1 and 20) or to require a period of stability. A civil servant from AEQ (interview 10) stated that during the Addendum it was difficult to convince some stakeholders of the need for achievable targets.

Those involved in the Addendum recognised this position as distinct from and in opposition to the Performance Management discourse, providing evidence for a second discourse coalition. Interviewees described the two as a "philosophical argument" (interview 29), different "positions" (interviewee 28), and claimed to see "both sides" (interviewee 21). This second perspective was more specific to the air quality policy process than the Performance Management discourse: articulated by only actors in this field, about the Strategy.

Many actors expressed both positions at different times, and this also provides evidence that these perspectives are best characterised as discourses. For example, interviewee 13 – an air quality modeller who otherwise articulated the Performance Management discourse, said that he was "… not sure that it [the London Objective] is right. It didn't seem to make sense. It protects London to a lesser degree." Indeed, relatively few interviewees presented *only* this second perspective. In 2006, when interviews were conducted, actors were more aware of the problems associated with implementing the Objectives. Interviewee 12 from the Greater London Authority stated that in 2003 the issue of whether London should set aspirational targets was not resolved, but by 2005 the Mayor had decided that they should not.

The growth of this discourse around target setting was not one-sided. The next chapter shows how the policy-makers who designed the Addendum were already developing means by which they could put action at the centre of the next review.

8.3. The impact of discourses on the AQS Addendum

The impact of the Performance Management discourse set out here draws attention to the intersection between wider discourses and specific expectations. The particulate Objectives relied on expectations of future concentrations, and the quantifiable impacts of potential future policies and technological change in order to be presented in the Addendum as achievable. This characteristic of Objective setting corresponds to the Performance Management discourse: its requirement that targets be achievable, and progress measurable. However, this interaction may be specific to this discourse and not necessarily applicable more widely. The Performance Management discourse's discursive hegemony over the air quality policy arena does explain the content and methodologies used in the Addendum.

The discourse hypothesis provides a largely coherent and attractive explanation for setting tiered PM_{10} Objectives in the Addendum, and the change from business-as-usual to a requirement for some action. The Objectives set in the Addendum followed the tenets of the Performance Management discourse: they were specific, measurable, time-oriented and 'challenging yet achievable'. The illustrative measures provided a means for AEQ to set more

challenging Objectives than in the Revised Strategy, but to justify them as achievable. In doing so, these visions were characterised by Netcen's authorship and by the requirements of the discourse: predictable, measurable, and technocratic. The Performance Management discourse thus constrained the range of visions in the Addendum: visions outlined by Netcen were adopted by policy-makers working on the Addendum because they conformed with the prevailing discourse, whilst allowing action to be taken.

Chapter 9. The 2007 Air Quality Strategy: A call to act or "just a list"?

Defra published the most recent version of the AQS in 2007. This differed from those that had come before: instead of revising the Objectives its focus was largely on a set of illustrative measures for improving air quality and an analysis of their appropriateness and cost-efficiency. The particulate matter Objective was the only one to change: the differentiated targets of the Addendum were replaced by an *exposure reduction* target for $PM_{2.5}$. This required all areas of the UK classified as 'urban background' to reduce concentrations of $PM_{2.5}$ by fifteen per cent by 2020. At face value, such developments appear to focus the Strategy on actions to achieve the Objectives, rather than on their revision.

This chapter explores the sufficiency and usefulness of each explanatory factor (science-led policy development, expectations dynamics and discourse coalitions) in characterising and explaining these changes. It begins by outlining the major developments in air quality policy and institutions during Period 4.

1. The 2007 Strategy and events in Period 4

The Revised Strategy Objective for PM_{10} was not achieved throughout the UK in 2005. Over 95% of local authorities who declared air quality management areas did so because of levels of road traffic pollution (Leksmono et al., 2006, p. 495). This happened for a number of reasons, including the fact that local authorities had been slower to act to reduce air pollution than predicted in Period 1 and Period 2 (interviews: 6, 9 and 19). Air quality at local level required coordination and prioritisation between different departments (including environmental health, transport, and land use planning) which had limited resources and multiple priorities (Cannibal & Lemon, 2000).

The exposure reduction principle worked on the assumption that for pollutants for which no safe threshold level of exposure had been found, it may be more effective to reduce concentrations across a geographical area than in one hotspot - both in terms of impact on public health and in the monetary value of implementation (DEFRA, 2007b, p. 24). As an example, the 2007 Air Quality Strategy stated that "the health benefits of reducing the average exposure of 10 million people by 1µg/m^3 are one hundred times greater than reducing the exposure of 10,000 people by 10µg/m^3" (DEFRA, 2007a, p. 43.) Any exposure reduction target would be accompanied by backstop targets – more conventional maximum exposure targets – to ensure the protection of public health (DEFRA, 2007b, p. 24).

1.1. Plans and policies to achieve the Objectives

The plans and policies to achieve the Objectives included the continuation and further agreed developments in industrial pollution control, European air quality directives, and transport policy. Some measures were obviously targeted at reducing air pollution, including the 2003 Scottish regulations enabling roadside emissions testing and enforcement of 'no idling' policies, and the powers enabling local authorities to integrate air quality management strategies with local transport plans (DEFRA, 2007b, p. 28). Missing from these plans and policies were the grant schemes and fuel duty differentials which had previously encouraged uptake of cleaner vehicle technologies.

1.2. The policy-making process of the 2007 Strategy

In a manner similar to the Revised Strategy (Chapter 7) the setting of exposure reduction Objectives and of plans and policies to achieve them were two distinct processes. This does not show whether the Objectives already in existence had an impact on the plans and policies incorporated here, but interviews with policy-makers from Defra, the DTI and the DfT suggest that the air quality Objectives were supposed to be taken into account when new policies were developed (interviews 8, 10, 28).

In contrast to the policy process of the Revised Strategy and the Addendum, the forecasts of the Netcen model were not used to set Objectives, but to provide baseline scenarios and to test the efficacy of illustrative scenarios for reducing pollutants. The illustrative measures of the 2007 Strategy played a much greater role in this Strategy than in the Addendum. The effects of the illustrative measures on $NO2_2$ and PM_{10} were forecast by Netcen, and report of their assessment provided one chapter of the 2007 Strategy and the entire second technical volume (DEFRA, 2007a, 2007b)

There were more actors involved in developing the illustrative measures than in the Addendum. The stakeholders of the Air Quality Forum were involved in the selection of the illustrative measures from a longer list, in a workshop run by Defra, the devolved administrations and the NSCA in 2005 (DEFRA, 2007b, p. 10).

The 2007 Strategy was informed by a cost-benefit analysis undertaken on the illustrative measures (each alone and in groups) by the IGCB (2006). New evidence for this report came in the form of new coefficients linking air pollution and health from COMEAP, and a monetary valuation of the health effects of air pollution deemed reliable enough to use in the cost-benefit analysis (Chilton, Covey, Jones-Lee, & Metcalf, 2004).

The results of the cost benefit analysis were combined with forecasts on the success of the measure in reaching the NO_2 or PM targets and evaluation of their impacts on ecosystems to provide a 'traffic light' rating for the measure (in which measures were rated red, amber or green). Those categorised green or amber were presented in the Strategy as potentially useful measures (DEFRA, 2007b).

2. Were the decision to regulate $PM_{2.5}$ and the exposure reduction approach responses to developments in the scientific evidence base?

2.1. Objectives for $PM_{2.5}$

As shown in Chapter 2, the evidence that $PM_{2.5}$ had greater association with ill health and mortality rates had grown since the 1990s. EPAQS' (2001)examination of the evidence was given in the 2000 Revised Strategy as the reason the UK remained with PM_{10}. The Addendum and Revised Strategy were criticised by some actors for not acting in a precautionary manner to regulate $PM_{2.5}$ (interview 26).

In 2003 the WHO recommended regulation of $PM_{2.5}$, and the Clean Air For Europe (CAFÉ) programme began examining the possibilities for such an air quality directive (interviews 13 and 29). Negotiations over potential European directive were on-going throughout Period 4. Air Quality Forum meeting minutes from May 2004 first expressed Defra's expectation that the EU would propose an exposure reduction target for $PM_{2.5}$. Interviews conducted with policy-makers and scientists involved in the policy-making process confirmed that the level of $PM_{2.5}$ monitoring in the UK was now considered able to support a $PM_{2.5}$ Objective (interviews 7 and 18).

2.2. $PM_{2.5}$ as a vehicle for the introduction of exposure reduction

In both CAFÉ and the UK 2007 Strategy targets for $PM_{2.5}$ took the exposure reduction approach, instead of the traditional maximum limit value or Objective. The exposure reduction approach took the focus of implementation away from hotspot prevention, and placed it on actions to reduce the overall background levels of particulate matter. It was appropriate for pollutants, such as particulates, for which there was no safe threshold below which no significant health impacts would occur.

There were two components of exposure reduction:

1. A backstop: a maximum concentration target which the pollutant must not exceed (similar to a limit value or Objective)

2. A target for exposure reduction – an overall proportional reduction in concentrations of particles throughout an area.

Instead of being the targeted end of the reduction process, the backstop was designed to ensure a minimum standard of health protection for the population. In theory, the exposure-reduction target, if implemented successfully and established at an appropriate level, would reduce ambient concentrations below the backstop. For this reason, the backstop target needed to be set at a more lax level than if a traditional limit value or Objective had been used (interviews 28 and 29).

For these reasons, a policy-maker from AEQ justified the introduction of the exposure reduction framework for $PM_{2.5}$ and not for PM_{10}:

> *If you were to apply that approach to PM_{10} we've already got a limit value for PM_{10} so it would mean relaxing that. … That's messy. I mean you'd get all sorts of trouble come down on you. You know: "Europe relaxes PM_{10} standard – consigns more people to die", all that sort of stuff. So it's far easier to start with a clean sheet… and you've got a clean sheet of paper with $PM_{2.5}$.*

In this interpretation, $PM_{2.5}$ was a pragmatic choice of fraction size: it enabled the introduction of the exposure reduction framework. PM_{10} would be more controversial because a PM_{10} 'backstop' Objective would be less stringent than previous Objectives, to facilitate a more stringent exposure reduction target.

Table 9.1. The $PM_{2.5}$ Objectives of the 2007 AQS

Objective type	Region applied	Target	Measured as	Achievement date
$PM_{2.5}$ backstop	UK except Scotland	25μg/m^3	Annual mean	2020
$PM_{2.5}$ backstop	Scotland	12μg/m^3	Annual mean	2020
$PM_{2.5}$ exposure reduction	UK (including Scottish) urban areas	15% reduction in urban background concentrations	Annual mean	Between 2010 and 2020

Source: DEFRA (2007b)

3. Exposure reduction: Advancing AEQ's agenda through European policy processes

Interviewees from AEQ and the NSCA claimed that exposure reduction did not originate with the European Commission or CAFÉ, but from Defra itself. The NSCA worked to promote the concept in Europe in order to gain the necessary support to introduce it as European directive.

These actors claim to have done so in order to promote their preferred agenda through the European framework:

> *…for tactical reasons… if we had pushed it as the UK Government, other member states might not have got on board, so we had to get other people to do it for us.*

A policy-maker from AEQ claimed to have developed the concept of Exposure Reduction himself:

> *I wrote a paper internally in the department… round about June 2000 , saying that we needed a new way of looking at air quality management, because a single air quality [Objective] isn't sensible. And so you need ways of realigning the legislation to make reductions everywhere.*

AEQ proposed the concept to European policy-makers prior to 2002, but the Commission did not like it: limit values enabled everyone in the EU to enjoy an equal quality of air. Discussions between actors in AEQ and the NSCA at the 2002 commemoration of the 1952 London Smog led to the formation of a small working group led by the NSCA of European scientists interested in the approach. Subsequently the NSCA promoted the concept:

> *… it kind of diverted away from Defra in that I then had to convince NGO colleagues, particularly at the European level. I wanted to try and table it in European meetings and the… target setting and policy assessment working group for CAFÉ …*
>
> (interviewee representing the NSCA)

The NSCA were unable to convince the European Environment Bureau (the umbrella organisation for NGOs in Europe) to support their proposals, but presented a paper to the Commission outlining the approach. The Commission were still concerned that the ER approach would lead to inequality of health protection across Europe. Limit values had also been found to be useful ways of regulating local planning decisions, and

These actors from Defra and the NSCA took advantage of opportunities to present their ideas at meetings and seminars. At the 2004 World Clean Air Congress, representatives of IIASA, the WHO and the Commission met at a NSCA-led event. According to the representative of the NSCA:

> *…They were all able to say 'well look, you are not going to achieve the limit values. Just going after limit values is not the best way of achieving health benefits you need some kind of general exposure reduction'. So you get this weight of opinion starting to build up…But all of a sudden, from the Commission saying 'no we don't think this is a good idea, too complicated, can't do it' – 'yet we'll do that'.*

Defra then commissioned monitoring experts Air Quality Consultants to develop a system of exposure reduction which could be operationalized in the UK (interview 29) (Laxen & Moorcroft, 2005)

> *Defra then took up the baton a bit more, they commissioned work from Steve Morecroft and Duncan Laxen, and they've actually developed a system which you can operationalize.*

3.1. Exposure reduction as a strategy for action

Representatives of Defra claimed that whilst they wanted to regulate $PM_{2.5}$ their priority was to introduce the exposure reduction concept. Their ultimate motivation for doing so seems to be the greater health benefits promised by the exposure reduction concept, and drawing on their past experiences of implementing previous versions of the AQS.

The 2007 Strategy marked a turning point in the history of the AQS, from revising Objectives to focusing on the means to achieve them. The exposure reduction target for $PM_{2.5}$ is part of that: Interviewee 18, a civil servant in AEQ, claimed that the UK championed the concept in the CAFÉ process in order to generate drivers for pollution reduction in both the UK and Europe.

The exposure reduction process was based in scientific evidence of particulates in the UK, and acted upon the latest advice from the WHO and (COMEAP, 2006). However, the impetus for this change of policy was not the evidence base, but the determination of civil servants in AEQ that this Strategy would focus on achieving the Objectives already in place and improving air quality.

4. Expectations and visions in the 2007 Strategy

Accompanying the old Objectives and the new exposure reduction targets were a package of illustrative measures. These now formed a substantial part of the Strategy. Civil servants in Defra were clear that these measures – and indeed the whole Strategy – was now focused on demonstrating to *all* sectors that they could contribute to improving air quality (interview 18). These civil servants believed that illustrative measures demonstrated which options should be tackled first (interview 18).

> *Let's actually see how we are going to deliver the thing this time because we've seen in the first two iterations of the Strategy how difficult it can be to achieve the Objectives, so maybe we ought to be thinking in terms of how we're going to do it.*
>
> (interview 28)

The 2007 Strategy changed significantly from previous versions, both in the focus on the exercise in developing potential new policy measures and in the exposure reduction targets for

$PM_{2.5}$. Yet the illustrative measures were purely illustrative – potential means to reduce the gaps between Objectives and implementation. For this reason some interviewees claimed that it was not a Strategy (interview 7) but was "just a list" (interview 21). A representative of the NSCA suggested that illustrative measures serve to draw attention to Defra's limited abilities to change policy. Others (including interview 21, a commentator on air quality issues) stated that the purpose of the illustrative measures was to steer the DfT and DTI.

4.1. The effects of the requirement for action on the Netcen forecasts

For the new Strategy Netcen provided forecasts of the effects of illustrative measures on all pollutants expected to exceed their Objectives, including PM_{10} and its secondary precursors and NO_2. The IGCB assessment utilised the same assessment methodology as used in the Addendum, but also included a monetary valuation of the projected health benefits of each measure.

Table 9.2. Categorised Visions in the 2007 Strategy (source: Defra, 2007a)

Technology and Policy	Policy	Policy and behaviours	Technology, policy and behaviour
Reduction of emissions from ships (aimed to effect emissions of secondary particulate precursors NOx and SO_2)	**The AQS as policy driver**	"Smarter Choices": a package of local soft measures for improving the environmental effects of road transport	**(Low emission zones for London and 8 other cities)**
Incentivisation of early uptake of new Euro Standards	**For Europe: Introduction of a $PM_{2.5}$ exposure reduction target**	**(A national road pricing scheme, to change driving behaviour)**	
Increased uptake of low emission vehicles			
(Retrofitting DPFs to HGVs)			
(Reducing emissions from small combustion plants)			

Vision source key:

- black – DfT
- **Green – Defra**
- **Purple – illustrative measures designed by Defra and other government departments, including DTI and DfT, with input from the Air Quality Forum.**
- **Visions in brackets: Illustrative measures identified as potentially viable, but requiring further assessment.**

Table 9.2. sets out the visions incorporated into the Strategy – positive, preferred options of future policy, technologies and behaviours. These visions bear similarities to those of the two preceeding Strategies. As in the Addendum the majority of these visions took the form of illustrative measures. The 2007 Strategy envisioned itself as a policy driver, as the Revised Strategy and Addendum had done before it.

However these are substantially different from those of previous Strategies. This is reflected in the categorisation: there are no visions for future technologies alone – all technological visions are linked to policy visions. There are no visions for behavioural change alone – envisioned changes in behaviour were associated with the implementation of policy options. Interviewee

8 (a civil servant in the DTI) believed that this was a consequence of a shift in the direction of wider government policy away from the assumption that individuals would act voluntarily to achieve government's preferred outcomes.

Unlike the Addendum not all the visions were measurable. The DfT's *Smarter Choices* (Department for Transport, 2004b) was a series of soft measures which could be used by local authorities to reduce congestion (and with it emissions). Visions for their adoption were included in the 2007 Strategy (see Table 9.2), but were not included in the illustrative measures.

The London low emission zone (LEZ) incorporated visions for technological adoption and behavioural change (see Table 9.2). It did not fit the schema for categorisation of visions used in other analysis chapters: the LEZ required technologies to reach a specific emissions standard, potentially required drivers and firms to change their behaviours – specifically where and what they drove – and required a policy change to set them in place.

4.2. Visions dynamics: the process of shortlisting the illustrative measures

These unique characteristics of the visions in the 2007 Strategy are a consequence of their origin. The package of illustrative measures was not developed by Netcen, but as can be seen from Table 9.2, was developed by a group of actors including representatives of Defra, the DfT, and the DTI (interviews 2 and 8).

The illustrative measures in table 9.2 were the outcome of a process of selection and assessments. A long list was developed by Defra, in collaboration with other departments (interview 28) (IGCB, 2006). This long list was discussed in the AQ Forum on the 27th May 2004 (evidence from Forum meeting minutes) and the members commented on them.

Visions elicited in the Forum included that besides introducing additional measures, the review should look at modifying existing policies (Environmental Industries Commission), provide incentives for early uptake of Euro Standards (Freight Transport Association), shift its focus away from road transport (UKPIA) and introduce more measures for local level rather than national (Environment Agency). These Forum minutes from the 27th May show a range of visions presented at the Forum. This long list of measures was discussed at every meeting until 29th April 2005 when cost-benefit analysis and assessment of a short list began. The formal inclusion of these stakeholders in developing the visions for setting and attaining the AQS Objectives was very different to their relative exclusion from the setting of visions and Objectives in previous versions of the Strategy.

Thus the short-list of measures was developed with more collaboration with a greater range of stakeholders than was the case in previous versions of the Strategy. This short-list was subject to cost benefit analysis and regulatory impact assessment, and from this a final short-list of potential measures predicted cost-effective was developed. The visions and expectations of stakeholders in the Forum were at least considered by Defra and the other Government departments. The long-list was constructed by the IGCB (interview 8).

Whilst Defra considered the illustrative measures to be their signal to other actors, the representative of the DTI claimed that their department had provided the options (interview 8).

4.3. Dynamics of Expectations and Visions: uptake and use of the visions and expectations in the 2007 Strategy

Some expectations and visions of the 2007 Strategy were taken up and articulated in other settings. The potential measures for incentivising early uptake of Euro standards became "… the basis of a UK line on that Directive in Brussels" (interview 28).

Table 9.2 indicates that one of the visions still requiring work was for a programme to retrofit DPFs on HDVs, buses and coaches. The IGCB assessment suggested that there would be high implementation costs – although representatives of DPF manufacturers were adamant that the IGCB had used the wrong cost figures (old figures for small-scale implementation instead of then-current figures for large-scale implementation) (interviews 15 and 25). These interviewees stated that it was because of the outcomes of this cost-benefit analysis that the Transport Minister then chose to end incentives for retrofitting DPFs.

In these two cases the visions for effective policy measures and expectation of inefficiency were taken up and used by other actors. Civil servants in AEQ (interviews 18 and 28) stated that the vision that they hoped would be taken up was for the use of a similar assessment process in the policy-making processes of European Air Quality Framework.

5. Expectations Dynamics: the Hype and Disappointment over CNG and LPG

The PowerShift and CleanUp grant schemes ended in 2005, and so were absent from the 2007 Strategy. For the first time in the history of the AQS, its vision for uptake of 'zero emission vehicles' was technology-neutral. These two statements are not unconnected. This next section will show how the vision for CNG and LPG, prominent in previous Strategies and government policy, collapsed in 2005, and assess the impact of this on the 2007 Strategy.

Chapter 8 quoted interviewees representing the haulage and bus and coach industries, who claimed that the benefits of CNG and LPG were hyped by their respective industry associations and taken up by government as a result. During the Addendum, civil servants in AEQ were convinced that the PowerShift and CleanUp programmes would continue (interview 14) and so included them in the illustrative measures for the Addendum.

Representatives of those who manufactured the technologies stated they assumed these grants would continue indefinitely (interviews 2 and 25). Interviewees who produce end-of-pipe emissions technologies, such as DPFs, stated that their businesses had been adversely affected as a result of the closure of the grant schemes (interviews 15 and 25).

However, CNG and LPG had not been taken up on as large a scale as predicted by the LPGA or as hoped by government (interview 10). Volvo and Vauxhall were the only manufacturers of new CNG vehicles in the UK, and an interviewee from Volvo (number 23) stated that they had had "massive problems" with CNG. According to this interviewee the fault lay with the infrastructure: there were only eight public CNG refuelling points in the UK in 2006.

LPG and CNG were originally supported by the Conservative government responsible for the NAQS because of their benefits for air quality compared to diesels. The Euro IV standard for petrol cars came into effect on 1st January 2006, and this eroded the emissions benefits of LPG compared to diesel. During Period 3, when road fuel gases were promoted by the DfT and Defra as alternatives to diesel, the air quality benefits of using them diminished. For example, in 2002 the Energy Saving Trust, who administered the grant schemes characterised them as interim technologies, and recommended that in 2006 only the subsidies for LPG should be reviewed by government (Energy Saving Trust, 2002, p. 16). The relative success of the vision for LPG was dependent on it maintaining its emissions benefits over diesel. The reduced environmental benefits and uptake on a level much less than expected led to the collapse of the vision for LPG and its market share.

Interviewees representing end-users of these technologies were quick to present the collapse of the grant schemes as damaging to their industries. They stated that without the grants the cost of a CNG lorry increased by £20,000 – out of reach of haulage companies (interview 5). However, these interviewees also stated that the grant schemes and policies had never been enough to convince them or many of their members to invest in the technologies (interview 4 and 5)

These interviewees (3, 4, 5 and 23) lay much of the blame for this collapse in hype, vision and business opportunity on the government. They stated that they relied on government policy to show them the direction of future technological change (interview 2 and 3).

5.1. The consequences of this collapse in visions

In the Addendum Defra had concluded that the grant schemes brought real benefits to air quality – and civil servants in AEQ still believed this in Period 4 (interview 14). The vision for promotion of low emission vehicles (see table 9.2) assumed some form of incentive-based scheme for their promotion in the IGCB (2006, p. 110) assessment which formed part of the 2007 Strategy. As a consequence of the removal of these grants, AEQ's visions for technological change – as embodied in the Addendum – were out of step with the DfT (which was no longer considering a grant scheme of any kind).

Interviews indicated that a second consequence was a loss in trust in government visions for the direction of technological change. Interview 12, then working on the planned London LEZ, stated that when the grants existed actors did not know whether they would continue from one year to the next; whether the incentive to invest was there if the future infrastructure and support services may not be. Interview 3, representing the haulage industry, stated that the loss of trust in CNG, LPG and the grants was affecting their discussions with the government about biofuels.

5.2. Expectations dynamics: the unintended consequences of the 2007 Strategy

When it was first introduced by AEQ in 2006 (formalised in the consultation draft of the new Strategy), the proposed introduction of exposure reduction led to a feeling amongst interviewees that local authorities were being marginalised from air quality management (interview 14). Interview 21 stated that they suspected that the focus on national rather than local measures in Strategy was another sign of this. A policy-maker in AEQ (interview 29) expressed surprise at the strength of this reaction: the 2007 Strategy had not ended the system of LAQM.

This analysis has shown how the collapse of visions held in earlier versions of the Strategy for technological change affected both the 2007 Strategy and the resulting loss in credence assigned to the DfT and Defra by stakeholders. AEQ continued to be a "follower" – taking up the visions which dominated government thinking on technologies at that time. However, AEQ also aimed to be proactive and drive action on air quality. Some visions explored in the illustrative measures were taken up by other government departments, and this was viewed

as a success by civil servants from AEQ (interview 18 and 28). However it was unclear whether any illustrative measure would actually be adopted as a result of the Strategy.

6. The roles of discourses about target-setting in the policy-making process of the AQS

AEQ determined that the 2007 Strategy would be less about Objectives and more about the actions required to meet them. This was, in part, due to civil servants' acceptance of the criticisms levelled at previous Strategies – that these had focused unduly on Objectives revisions at the expense of actions (interview 28). As indicated above, the exposure reduction target and the body of the Strategy – especially the illustrative measures and the detailed accompanying assessment – were specifically designed to encourage action. To what extent can this be explained as change in the relative dominance of discourses about air quality and its regulation?

6.1. The sufficiency of the 'action' discourse

Chapter 8 presented an potential alternative discourse to the Performance Management discourse, but questioned whether it was a coherent discourse. The statement that targets should drive action was made by many actors in the policy process, but for different reasons.

This next section examines the evidence for this discourse of 'Action' in the creation of the 2007 Strategy, by examining changes in language, storyline, conceptualisation of the environmental problem, and institutional change.

Changes in language and storyline

Absent from the 2007 Strategy was the stated requirement for Objectives to be *challenging yet achievable.* The new exposure reduction target was justified on health protection grounds, with no mention of its feasibility:

> *We have therefore adopted an 'exposure reduction' approach for $PM_{2.5}$ to seek a more efficient way of achieving further reductions in the health effects of air pollution by providing a driver to improve air quality everywhere in the UK…*
>
> (DEFRA, 2007b, p. 24)

As indicated above interviewees from AEQ stated that this Strategy was aimed to encourage action (interviews 14 and 28). The storyline accompanying this discourse is simply that of efficacy of and requirement for action.

Changes in conceptualisation of the environmental problem

The exposure reduction target was set on a different conceptualisation of the problem than previous Objectives. Instead of the focus on hotspot removal, the exposure reduction approach was justified by the non-threshold nature of particulates:

> *For this pollutant, the current policy framework is therefore not going to generate the maximum improvement in public health for the investment made, because it focuses attention on hotspots only, despite much more widespread adverse effects on health being likely.*
>
> (DEFRA, 2007b, p. 24)

Instead of preventing a number of extra deaths, this Strategy conceptualised the problem in terms of loss of life expectancy:

> *Air pollution is currently estimated to reduce the life expectancy of every person in the UK by an average of 7-8 months. The measures outlined in the strategy could help to reduce the impact on average life expectancy to five months by 2020, and provide a significant step forward in protecting our environment*
>
> (DEFRA, 2007b, p. 7)

This contributed to a changed conceptualisation of how the problem could be managed. It became of improving life expectancy throughout the UK. For non-threshold pollutants, *any* reduction would have immediate benefits on health and life expectancy.

Institutional changes

Introduction of exposure reduction required some changes in institutions. These would include a change in how and where monitoring of compliance took place, and it was proposed that implementation would take place on a larger geographical and administrative scale than the local authority (Laxen & Moorcroft, 2005). However the details of this were yet to be decided when this research was carried out, and until the publication of the European framework no action would be taken (interview 18 and 28).

Action: a fledgling discourse

The discourse of Action was supported by many actors in the policy process of the AQS, as identified in the last chapter. AEQ and the 2007 Strategy also articulated it. However within this discourse there were many different opinions on the scale and scope of action – from more funding and powers for local authorities (interview 6), to technocratic solutions such as the installation of DPFs (interview 25), and those hailing the London Air Quality Strategy and low emission zone as a good example of what could potentially be achieved (9 and 29).

These actors were less powerful than those articulating the Performance Management discourse. This latter had changed the institutions of governance and policy-making, and it was within this institutional context that the Action discourse was presented by AEQ.

6.2. The continued dominance of the Performance Management discourse

The requirement for action was conveyed though the institutional structures of the Performance Management discourse. They were assessed by Netcen for the IGCB: their effects on air quality were modelled, and their impact on population health levels assessed. The wider structures of the Public Service Agreements remained in place: In 2007 the target to meet the AQS Review Objectives and deliver the 2007 Strategy was a PSA for Defra, with the DfT and local government departments as formal delivery partners.

The environmental problem of pollutants was still expressed in quantitative terms: the figure which indicated the most likely population-level health effects per unit increase of pollutant. This figure was recommended by COMEAP on behest of Defra, for use in the assessment of costs and benefits (interview 1). The exposure reduction approach utilised this information to provide a new understanding of the health problems and potential solutions.

The exposure reduction target was not a formal target when the research for this thesis was completed. At that time it was unclear whether it would become so: the UK was waiting for the EU to publish its proposals – only the Objectives which matched EU limit values were statutory requirements (interview 1).

7. Expectations and discourses in Period 4

The analysis of the dynamics of expectations in the 2007 Strategy indicated that, as previously, Defra followed the visions for technical change articulated by other, more powerful Government departments. The visions for action to reduce pollutants for the Strategy as a policy driver, in this case, do contribute to Defra's actions and the components of the Strategy. In the assessment of options for policy change AEQ had set out to demonstrate that there were potential cost-effective policy options for improving air quality.

Some of the expectations and visions generated through the assessment of policy options had been taken up by the DfT and in negotiations over future Euro standards. In terms of generating visions and demonstrating their potential utility, civil servants in AEQ felt that they had succeeded:

I'm very proud of it actually as a piece of work; I go round telling everybody I meet that it's a classic example of how to do environmental policy-making.

(interview 28)

8. Conclusions

The AQS had changed since 1997 from a set of Objectives to a set of plans for action in 2007. The process by which each set of Objectives and plans were formed was different. The 2007 Strategy was the culmination of fourteen years work on improving air quality. In this Strategy scientific evidence on $PM_{2.5}$ did not drive the changes, but provided the context by which the exposure reduction approach could be introduced. Visions were essential to this Strategy.

The Dynamics of Expectations approach provides an explanation for the changes in the illustrative measures, and demonstrates once again that the choices of visions available to Defra were determined by the visions and actions of the DfT and the DTI.

Unlike the Addendum and the Revised Strategy, the 2007 Strategy did not rely on the Netcen model to set targets, but continued to rely on the outcomes of forecasts and the cost-benefit analysis assessment to justify them. This provided evidence which fit the requirements and structures of the Performance Management discourse.

Chapter 10. Conclusion

This thesis has been a study of the formation and evolution of a policy framework: of the interactions and contrasting roles of scientific expertise, wider political discourses and the 'futures' presented by actors involved in the policy process. Through the lens of the theoretical framework the research questions were transformed into a study of three potentially contrasting explanatory factors for explaining the changes in the AQS between 1997 and 2007:

1. the role of scientific expertise
2. the role of statements about the future – of expectations and visions;
3. the role of wider discourses

Together the analysis chapters examined the relative influences of these factors in the formation and development of the AQS over a ten year period (with the exception of the first analytical chapter, which did not analyse discourse). This Conclusion chapter answers the research questions set out in the Introduction and developed in the Theoretical Framework chapter, explores the implications for theory development and policy-making, and evaluates the success of the methodologies used in this study.

1. Explaining the development of targets and plans in the Air Quality Strategy: answering the research questions

The thesis asked the question:

> **How were the AQS Objectives for particulate matter set and policies to achieve them developed? Did this change over time – between 1997 and 2007 – and, if so, why?**

To answer this question, five research questions were asked, based on questions raised in my previous study of the AQS and through the development of a theoretical framework. I answer each here:

1. *What role did statements about the future have in each version of the AQS?*

Through the theoretical framework this question was transformed:

1. ***How do expectations and promises of future technologies, policies, and their impacts affect the creation of target-based policies for sustainable development? How do these policies subsequently shape expectations? Can the changes in the AQS between 1997 and 2007 be explained by these dynamics of expectations?***

Statements of expectation and visions were made both in the AQS itself, and by actors in policy-making process, throughout the time periods studied. Each Strategy presented a picture of the future in which the Objectives would be achieved. This created an illusion of certainty in a complex policy area. This finding itself provided the rationale for the application of the Sociology of Expectations to the policy development process.

The roles of visions in the Strategies

Each Strategy contained visions: ideals for the future. The characteristics of these visions, together with the characteristics of the Objectives for particulates are set out in table 10.1. All Strategies contained the vision that the Strategy would be a policy driver.

Table 10.1. Summary of the characteristics of the visions presented in each Air Quality Strategy

Strategy	Characteristics of target setting	Characteristics of visions	Origins of visions
1997 NAQS	Challenging. Based on current understanding of particles and forecasts of emissions from individual sources	The ideal means by which government policies would develop to protect air quality	DoE
2000 Revised Strategy	"Challenging yet achievable". Business-as-usual prediction of the Netcen model	Voluntary, local-level action, behavioural change (beyond BAU)	Defra
2003 Addendum	"Challenging yet achievable". Forecasts of impact of a range of illustrative measures determined differentiated Objectives for London, Scotland, and the rest of the UK.	Measurable and ostensibly predictable technological fixes. Those for road transport linked to successful implementation of policy scenarios from the DfT.	Netcen and DfT
2007 Strategy	Remain as 2000/2003 except for exposure reduction for $PM_{2.5}$. ER based on work in CAFÉ and predictions of achievability under scenario 'Measure Q'.	Measurable, technical change. All ostensibly predicted outcomes of potential national policies.	Defra and other government departments (with input of AQ Forum)

The characteristics of the visions and their origins changed over time. In the NAQS the visions set out an ideal direction of government policy to improve air quality, as held by the civil

servants in the DoE who developed it. These visions changed in the Revised Strategy to promote local and voluntary action. The Addendum and 2007 Strategy articulated visions in the form of illustrative measures – and these developed from the technocratic requirements of modelling, to a full package of potential policy measures promoting technological change created by Defra in conjunction with other departments and the AQ Forum. These visions were all aimed at setting the direction of action and policy for achieving air quality goals. This aim was made more explicit in the latter two versions of the Strategy

How expectations made in the context of the AQS affected policy outcomes

Stakeholders and other policy-making institutions also held preferred visions, which may or may not have included improved air quality, depending on the content of the vision and the aims of the stakeholder. These were presented to policy-makers in AEQ during the creation of each Strategy, through routes including consultation responses, the media, unofficial conversations, and the Air Quality Forum for stakeholders. Given the range of stakeholders involved in the Strategy, there were inevitably a wide range of preferences. In formulating policy, policy-makers selected one articulation of the future and possibilities for technological, policy and behavioural change, in order to create the plans for fulfilment of each Objective.

The visions articulated in the Strategies for specific policy and technical change largely followed the visions held in government and by the departments responsible for the sector or technology. This is not unexpected – the Strategy was a *government* strategy and required the cooperation of different departments.

The exception to this was in Period 3 in which visions were articulated through the Netcen model, and as a result, contained visions for the technologies and their uptake developed by modellers using the more general visions of the DfT.

Collective expectations were accepted by policy-makers in AEQ and used in the AQS. An example of this would be the collective expectation that CNG and LPG would become viable road transport fuels. This evidence suggests that collective, expectations are more likely to be accepted in policy-making than expectations that challenge them. This appears to happen whether or not the actor who accepts them benefits from their implementation.

Dynamics: how the Air Quality Strategies shaped subsequent expectations

The visions in the Strategy for technological developments followed those of the DfT and contributed to the hype around CNG and LPG. This – both directly and indirectly - caused some local authorities to act on visions for those technologies which were incorporated into the

AQS. Visions of the efficacy of options for technical change developed in Period 4 shaped the UK's negotiating position on Euro V vehicle emissions standards.

In other cases the role of visions was not so clear cut, or had unintended consequences. Many local authorities were keen to act on the visions and requirements for LAQM during Period 1 and 2, although AEQ's expectations for LAQM were very different from the reality. In Period 4 some actors saw the visions for national action in the 2007 Strategy as a move away from LAQM – when this was not intended.

Conclusions for Research Question 1

The Sociology of Expectations model attempts to explain developments in the Strategy as the results of shifting expectations about the future. This explanation illuminated the shifting dynamics of expectations, and demonstrated especially how AEQ had sought to change the focus of the Strategy from Objectives to actions through the use of visions for the future. The Sociology of Expectations thus provides insight into the changing Objectives. However it provides little explanation for why some visions were widely taken up and others were curtailed. These issues are examined further in the answers to research questions 3 (on models), 4 (on correspondences between discourses and expectations) and 5 (on the relative credibility of expectations.

2. *How did policy change in the light of new and often uncertain scientific understanding of particulates, their properties and behaviour, and their effects on health?*

Question 2 examines how policy responded to developments in scientific understanding of particles. To distinguish it from Question 3 on models, below, only responses to changing health evidence are discussed here.

From the review of scientific evidence in Chapter 2 it was clear that the scientific evidence base of the Air Quality Strategy was not independent of policy. Instead, with the exception of the majority of epidemiological and toxicological evidence – the scientific evidence base (in the form of knowledge of particulates, their sources and their behaviour in the UK) was developed to answer the questions of policy-makers. UK-based epidemiological studies also relied upon Defra's pollution monitoring networks and research funding.

There are clear examples of when developments in scientific research did cause changes in policy:

- In the decisions to use the Air Quality Strategy prescribed by the 1990 Environment Act to improve local air quality for health protection, rather than for management of acidification.
- The evidence that particles from mainland Europe contributed a greater proportion of total PM_{10} than previously believed was used when developing the Objectives for the Revised Strategy (Period 2)over Objectives for the Revised Strategy
- In the characterisation of the health effects of air pollution: from short-term effects (Period 1) to long-term effects on life expectancy and health (Period 4).
- The use of $PM_{2.5}$ metric data from in COMEAP's analyses from 2001 onwards, which were central to the cost-benefit analyses of the 2003 and 2007 Strategies, and thus in setting Objective and development of illustrative measures for these versions of the Strategy.

COMEAP and the body of scientists on this panel reviewed and assessed the evidence on health effects of particulates for every stage of the Strategy. Much of their work on particles (and other pollutants) was directed by the requirements of policy: specifically, the requirement to develop coefficients linking health effects to particulate concentrations, and updating these coefficients as required by AEQ for new Objective-setting and in response to new evidence. Rather than driving policy, this served the requirements of policy-makers.

Whilst developments in scientific evidence contributed to the development of policy, they alone do not explain the targets set for pollution reduction or the policies contained in the AQS to achieve them. Prevalence of regulatory science – that is scientific evidence developed for the express purposes of answering questions raised in policy - in Objective-setting leads on to the next question:

3. To what extent did modelled forecasts shape policy, and why?

The Netcen model, which provided the forecasts used in the AQS, both shaped air quality policy and was shaped by it. The boundaries between model and policy, (indicated in the sources of the visions modelled in the Netcen forecasts) shifted with the requirements of policy-makers.

Netcen developed its model to meet the requirements of policy-makers in AEQ during the formation of the second AQS (Period 2) and subsequent Strategies. The scope and capabilities of the Netcen model changed in response to the changing requirements of AEQ. For example,

in Period 2 the model provided expectations of what concentrations of particulates could be achieved, and which of the two potential PM_{10} Objectives could be reached. In Periods 3 and 4 the model predicted the impacts of options for technological and policy change. In Period 3 the model gave the Addendum its national-level, primary particulate focus and the justification for more challenging Objectives. In both Period 2 and 3 the model determined the concentrations at which the PM_{10} Objectives were set, but this was in response to the changing requirements of AEQ.

During Periods 2, 3, and 4, The Netcen model generated expectations of feasibility, which were taken up by AEQ and articulated in each version of the Strategy. In Period 3 the Netcen model became a knowledge and visions monopoly: it provided an assessment of what reductions in pollutants were feasible, based on a set of 'illustrative measures' – a set of visions for policy and technological development. Modellers had scope to develop the majority of visions incorporated into this policy and this gave those visions a distinctive set of characteristics: they were precise, measurable and technocratic. Table 10.1 – the summary of visions incorporated into each version of the AQS – indicates the greater uptake of visions from the Netcen model in Period 2 and 3 in the AQS than from other sources.

In Period 4 AEQ used the Netcen models' forecasts to test a range of illustrative policy scenarios and to provide assessments of their feasibility. However, the range of illustrative measures included in that analysis were constrained by the requirements of the Netcen model: they were measurable, technocratic and national (rather than local) in scope.

The analysis of the role of the Netcen model summarised here indicated that from Period 2 onwards the AQS and Netcen model were co-constructed: both were determined by the requirements and limitations of the other. The Netcen model changed with the demands of policy-makers in AEQ, and the AQS developed on the basis of the changing outputs of the model. The remit of the model, and its parameters were set by the requirements of policy-makers. Co-construction of model, monitoring network and AQS was previously established by this author (Smith, 2003). The analysis undertaken here confirms this finding, and demonstrates that the relationship of co-construction continued into Period 4.

Why did this relationship of co-construction prevail throughout the time period studied – and why did it change? Interviewees from AEQ indicated after Revised AQS that they wanted to set Objectives that required further action, beyond the business-as-usual targets of Period 2. The Netcen model and the illustrative measures indicated that policy actions to further reduce air pollution would be practical, feasible and cost-effective. The shift from Objectives to

"exposure reduction" targets during Period 4 supports this answer: exposure reduction targets require action in all geographical areas regulated to reduce pollutant concentrations, rather than to meet a numerical reduction target.

The changing use of these forecasts by AEQ can be further explained in the context of the influence of wider discourses on air quality policy. The answers to question 4 provide the discursive context in which this co-constructive relationship developed.

4. *Are expectations and promises articulated by actors in the process of forming the AQS part of larger discourses about policy and technological change?*

Question 4 was introduced in the developments of a theoretical framework (Chapter 4). This study identified two broad discourses about how targets should be set. These were identified in interviews, and constructed from interview evidence and language used in the AQS and in the wider political context of the time. I labelled these discourses 'Performance Management' and 'Action', although these are not the terms in which those interviewed would describe them.

Characterisation of the two discourses

Table 10.2. The characteristics of the two discourses of Objective setting

Characteristics of discourses	Performance Management Discourse	Action Discourse
Storyline	Targets should be set on the basis of what is achievable. Health protection and cost-effective policy are compatible.	Continuation and consistencyof target is more important than whether it can be achieved. What matters is that action is taken to reduce pollutants.
Definition of the environmental problem	Reduction of health effects to a single coefficient relating mortality rates to exposure. Reduction of complexity and black-boxing of the characteristics of health effects and related incertitude.	Exposure reduction: *any* action to reduce particulates will improve health outcomes across the population. Emphasises non-threshold nature of particulates, and downplays relative susceptibility issues.
Example of characteristic language	"Challenging yet achievable"	"Measures, not numbers"
How this discourse shaped institutions	COMEAP required to produce quantifications for health effects, EAHEAP and IGCB established to provide monetary valuation of health effects. Relative importance of the Netcen forecasts compared to other evidence sources. National governance: increasing centralisation of policy with the Treasury 1997-2003. Top-down target-setting in Treasury-led Public Service Agreements.	No evidence[16]
How this discourse shaped practices	AEQ's reliance on Netcen forecasts to set Objectives and justify any requirement for extra actions. Change of focus of LAQM after 2000 to NO_2 as a result of relaxing the PM_{10} Objective.	Establishment of an exposure reduction target and the potential to change the processes by which progress towards a target is obtained and measured.

The relative dominance of the Performance Management discourse in air quality policy is symptomatic of its dominance in the wider civil service and the UK Government at the time. Its power came from its articulation by the Prime Minister, Treasury and senior civil servants, who

[16] Perhaps a consideration for any future study of developments in European and UK Air Quality targets would be to ascertain whether the exposure reduction approach had any lasting effects on institutions, practices, and positioning of actors.

wanted a more centralised system of governance and indicators against which they could measure performance. Performance Management became embodied in the institutional structures of the Treasury, the Treasury's relationships with and allocation of funds to other government departments, and the centralised approach to target-setting in Public Service Agreements which characterised the Labour government's early years in power.

This is in contrast with the many actors in the air quality policy process who articulated the Action discourse, including at different times AEQ, scientists in COMEAP, the Mayor of London, the NSCA and some representatives of local government. This discourse lacked the centralised institutions and authorities of the Performance Management approach. These actors and groups who articulated the Action discourse had a variety of reasons for wanting a focus on application and action rather than Objective setting. These included genuine concern for health, stability of Objectives so that LAQM could be implemented, or as a critique of the prior history of Objective setting. It became a discourse only through interaction of these groups in meetings, conferences, and the sharing of ideas.

This failure of the action discourse to become institutionalised throughout the governance structures of the AQS is one of the major reasons for its relatively weak impact. When AEQ articulated the Action discourse in Exposure Reduction, it did so through the institutions and structures in existence; those of Performance Management: for example, in the use of health data quantified for the forecasts of the Netcen model.

Expectations as articulations of wider discourses: Evidence from within the Strategies

The visions of the Revised Strategy, Addendum and 2007 Strategy changed more rapidly than the discourses. Whilst the visions in the Revised Strategy and the Addendum were very different, both were compatible with the discourse of *challenging yet achievable targets.* In the Addendum there was the first suggestion that AEQ were considering how to make the Strategy more action focused, in the illustrative measures and targets that required action. These were framed using the Performance Management discourse: they were used by AEQ to justify why Objectives with implementation gaps were challenging yet achievable.

The visions in the 2007 Strategy followed the Action discourse – they demonstrated the feasibility of new measures for achieving Objectives already in existence (and exposure reduction). They served to position actors so that they had to actively reduce particulate pollution, through the structures of modelling and cost-benefit assessment of the Performance Management discourse. However, they were constrained by the institutional structures of the Performance Management discourse. A proposed next step is to examine the impact of the

exposure reduction and Action discourse on the structures and institutions of governance in air quality policy-making.

The visions of the Strategy reflected the constraints of the discourse governing it, but were able to change faster than the governing discourses. Through visions, alternative discourses can be presented and articulated within the constraints and institutions of the dominant discourse.

5. *What made some expectations more credible than others to policy-makers?*

As discussed in the Theoretical Framework (Chapter 4), factors which can assist the uptake of expectations have been largely overlooked by studies in the Sociology of Expectations. These factors were referred to in this study as contributing to the *relative credibility* of expectations to a specific audience – in this case, the policy-makers in AEQ who wrote the Air Quality Strategies.

Through examining the competing expectations articulated in the policy-making processes of the AQS, and identifying which were accepted and articulated in the Air Quality Strategies, this study sought to identify factors which made a vision or expectation more likely to be articulated in the Strategies. The study found that factors which contributed the 'relative credibility' of visions related to the following:

1) the means by which the expectation was presented,
2) the source of the expectation,
3) alignment with prevalent policy discourse,
4) and the effects of hype and its disappointment.

1. Means of presentation

Visions articulated through modelling (specifically, by the Netcen model) were more likely to be taken up in the AQS than those that were only spoken or written. Visions and expectations articulated through the Netcen model and in the IGCB assessments (which used the Netcen forecasts to analyse costs and benefits of reducing ambient particulates) were taken up and articulated by AEQ in the Air Quality Strategies between Period 2 and Period 4. This lead to visions and expectations with particular characteristics being included in the AQS, and to the exclusion of others. Netcen forecasts presented particular visions for the future of policy and

technologies as precise, quantifiable, and with a measurable impact on particulates. During the time periods in which the Netcen forecasts dominated air quality policy decisions, AEQ's acceptance of Netcen's visions for change led to fewer visions for local and behavioural policies of actions being articulated in the Strategy (which were less easily quantifiable and measurable).

This study supports Tuinstra et al. (2006) and Shackley and Wynne (1995a) who argued that the co-construction of policies and models serves to increase the credibility of both to actors outside the model-policy relationship. In the Air Quality Strategies policy-makers in AEQ presented the visions incorporated in the Netcen model as more credible than others. This presentation of policy decisions as if based solely on scientific evidence was most clearly manifest in the Strategies' justifications for specific Objectives in the Revised Strategy and the Addendum.

However, the expectations and visions in the Strategy were not necessarily the beliefs of all the policy-makers in AEQ. Instead, interview evidence suggests that whilst some policy-makers and other actors found the expectations and visions of the Netcen forecasts credible, others were less convinced. The Netcen model nonetheless enabled policy-makers to set more challenging targets than would otherwise have been accepted and to argue that actions to achieve these targets could be cost-effective. This can be seen in the presentation of the Netcen-generated visions as credible in the second, third and fourth Air Quality Strategies. This credibility was then used by AEQ to justify introducing more demanding targets and requirements for further action.

2. Source of the visions

Visions for technological change originating from other government departments (outside of AEQ and the wider Defra/ DETR) were more likely than others to be articulated in the Air Quality Strategies. When the DfT's visions for future technologies for vehicles and fuels changed, the AQS followed suit. For example, between the publication of the Addendum (Defra, 2003) and the 2007 Strategy, the DfT stopped articulating visions for gas-powered vehicles. The Addendum (2003) articulated visions for gas vehicle uptake and use in the UK; the 2007 Strategy reflected the changed DfT visions and priorities in its references only to low emission vehicles.

Thus the Air Quality Strategies' visions for technological change followed the strategic direction of the DfT and DTI. This finding is unsurprising, given both that the DfT and other government departments were involved in setting the Objectives and strategies for attaining

them, and Defra's dependence on other government departments taking action to reach the Objectives. They also indicate that Defra held little influence over such preferred technologies within the UK government.

In Period 4 AEQ consulted the Air Quality Forum about the visions for change to be incorporated into the 2007 Strategy through the illustrative measures. The long-list of potential measures was developed by the IGCB, formed by Defra in collaboration with other government departments. This resulted in a set of illustrative measures that followed wider government preferences, but which had been shortlisted in collaboration with the wider air quality community. This attempt at a more collaborative approach to developing visions for change seems to be both an attempt by AEQ to develop shared visions for improving air quality and to try to gain credibility and action from stakeholders.

3. Alignment with the prevalent policy discourse

A further source of credibility was the vision's alignment with the prevalent policy discourse, and commensurate alignment with storylines, scripts and repertoires already held by actors. The visions incorporated in the Strategy after Period 2, through the illustrative measures, fitted the requirements of the Performance Management discourse: they were SMART (specific, measurable, achievable, relevant and time-bound); they indicated that the Objectives were 'challenging yet achievable'. Modelling of these visions in the Netcen forecasts indicated that their adoption would lead to reduction of particulates throughout the UK sufficient to attain the Objectives.

The illustrative measures modelled in the Netcen model and incorporated into the Strategy fit those criteria of the Performance Management discourse, because they were designed to do so. As discussed earlier, this source of credibility was used by policy-makers in AEQ during Period 3 and 4 to enable Objectives to be set which required extra actions to achieve them (described above (in the analysis chapters) as using the structures and constraints of the Performance Management discourse to articulate the Action discourse). This implies that alignment with the dominant discourse was also used by those developing policy to make these new visions more credible to a wider audience.

These first three factors contributing to credibility: means of presentation, source, and dominant discourse – all strengthened and confirmed one set of visions as more credible (and more likely to be included in the Air Quality Strategy) than others.

4. The Effects of Hype

Scholars of expectations have previously found hype to be a common factor in early visions for technologies seeking credibility and support (e.g. Brown, 2003). The case of the Air Quality Strategy was similar, in terms of the credibility assigned to visions for technologies supported and promoted within it. In the first Strategy (DoE, 1997) policy-makers indicated no specific preference for future vehicle technologies in the NAQS. Subsequent growth in hype around the future prospects of CNG and LPG powered vehicles contributed to their support by the DfT and Defra (and previously the DETR) during Periods 2 and 3. The impact of the hype of these technologies was such that even those who did not support them expected them to have a significant presence in the UK road transport fleet. Incorporation of visions for the uptake of these technologies in the AQS also contributed to the spread of these visions: for example, to local authorities and to trade associations. The common visions for these technologies could be categorised as 'collective expectations' – widely shared expectations that were taken-for-granted within a community (Konrad, 2006).

The subsequent collapse of the visions for CNG and LPG during Period 4 affected the content of the visions held in the AQS. During Period 4 policy-makers in AEQ, Defra more widely, and the DfT were not willing to support visions for specific road vehicle technologies (except those for those with conventional petrol and diesel engines). As actors became more cautious about voicing support for specific technologies, the 2007 Strategy used a generic term 'zero emission vehicles' and focused on projected particulate reductions rather than fuel types.

2. The evolution of the Air Quality Strategy 1997-2007: a synthesis of the research paradigms

None of the explanatory factors provides a full explanation for the changes over time. Rather, for each version of the Strategy each factor held more or less importance. Table 10.3 summarises how far each explanatory factor explains the developments in each version of the AQS.

The development of the Strategy could be described as a long learning process by the policy-makers in AEQ. The first Strategy was optimistic, in its targets and its visions, but constrained by the tense relationship between the Departments of the Environment, Transport, and Trade and Industry, and the reluctance of the latter two to accept the latest scientific evidence or to introduce policies for improving ambient air quality. From table 10.3 it can be seen that modelled forecasts (in the form of the Netcen model) played no role in Period 1. The impacts of discourses were not analysed for Period 1 because it was difficult to isolate either discourse

in this time period. Instead, Period 1 became the comparison for Period 2, enabling the impact of the Performance Management discourse to be identified.

From Period 2 onwards, all explanatory factors contributed to understanding how and why the Objectives and strategies to attain them changed; although the impact of evidence of adverse health effects as a driver for change in the Strategy became less significant. After Period 1 developments in the AQS were constrained by the Performance Management discourse. The dominance of this discourse in governance after 1997 led to a different formulation of the health problems caused by particulates, and to the Objectives of Period 2, which required no further action. This wider discourse of target setting determined how the problem of particulates was constructed and how modelling developed.

The targets and visions of each Strategy after Period 1 were also the outcomes of the Netcen model. For example, targets from Period 2 onwards were justified as achievable through the forecasts of the Netcen model, and visions for policy and technological change were articulated through its forecasts prior to articulation in the Strategy.

Within the framework of Performance Management discourse and Netcen model, the visions for actions to attain the Strategy changed with each version of the Strategy. Visions for behavioural, technological and policy change articulated in the Strategy were made in the context of the dominant Performance Management discourse, and were framed by the capabilities of the Netcen model. However, during Periods 3 and 4 policy-makers in AEQ learned how to use the Netcen model and the requirement of *challenging yet achievable* to create the environment where the Strategy could present their visions for policy, technology and behavioural change and put them on the wider political agenda. During Periods 3 and 4 there were at least two discourses articulated by actors in this policy process about the nature of the pollution problem, how targets should be set and strategies to meet them developed. The development of more collaborative visions and the expansion of the range of visions to include behavioural and social aspects made a difference to the policies that were subsequently articulated.

From this discussion it can be seen that each factor can be used to explain aspects of the developments of the Air Quality Strategy between 1997 and 2007. From Table 10.3 and this discussion it can be seen that no one explanatory factor alone is responsible for the developments in the Strategy between 1997 and 2007, although each contributed in varying degrees at different times, and in different ways. Indeed, the explanatory powers of visions

and expectations, discourses, and the Netcen model are interlinked and dependent on each other.

Table 10.3 A summary of the explanatory factors in explaining the Particulate Objectives and strategies for their attainment in each version of the AQS

	Policy follows science	Role of Netcen model	Expectation dynamics	Discourse Coalitions
NAQS 1997	Strategy created in response to epidemiological evidence. Challenging Objectives set to reduce risks. Explains origins of the AQS and the targets in P1.	n/a	Visions in the Strategy aim to set the direction of government policy in areas relating to air quality.	(Not used in this analysis)[17]
Revised Strategy 2000	PM_{10} Objective revised in response to new evidence about the relative contribution of secondary transboundary pollutants	Used to judge the feasibility of two potential Objectives at the request of policy-makers in AEQ.	Revised Strategy contained expectations of business-as-usual to achieve the particulate Objectives, as presented in Netcen forecasts.	Growing dominance of the Performance Management discourse changed the criteria by which the Objective was set: from challenging to 'challenging yet achievable'.
Addendum 2003	COMEAP provided coefficient for Defra to enable cost-benefit analysis: regulatory science driven by the requirements of policy.	The model became a knowledge monopoly: Objectives and illustrative measures were determined by its forecasts.	Visions were articulated through the Netcen model and followed the dominant visions of the DfT for technical change. Visions were for national policy change and technological development, precise, measurable and technocratic.	Dominance of the Performance Management discourse in the policy process: demonstrated in three regional Objectives based on understanding of feasibility and effectiveness of illustrative measures. Second "Action" discourse articulated by range of actors and recognised as such by policy-makers and others
2007 Strategy	$PM_{2.5}$ target introduced, but 6 years after adopted as metric by COMEAP. Although health benefits of adopting, done to introduce Exposure Reduction. Policy changes not response to changing scientific evidence.	Used to test the efficacy of a set of illustrative measures and the costs and benefits of implementation for all pollutants.	Visions were developed in a more collaborative manner: long-list developed with the Air Quality Forum Expectations of behavioural change incorporated.	The Action discourse shaped the behaviour of AEQ, the introduction of Exposure Reduction and the illustrative measures, but through the structures of the Performance Management discourse.

[17] Discourse analysis was not undertaken for Period 1 and the NAQS because this was viewed as the background against which subsequent discourses became visible.

3. The utility of each explanatory factor

In a study examining the comparative explanatory power of separate analytical frameworks, Graham Allison argued:

> *These conceptual models are much more than simple angles of vision or approaches. Each conceptual framework consists of a cluster of assumptions and categories that influence what the analyst finds puzzling, how he formulates his question, where he looks for evidence, and what he produces as an answer.* (Allison, 1971, p. 245)

This has proved to be the case with the frameworks used in this study. This next section summarises the explanatory power of each theoretical position, how they account for and conceptualise the case study, and their strengths and weaknesses. Table 10.4 presents a summary of how each of four theoretical constructs used in this study define the research questions asked, analyse the development of the AQS and explain its key issues, and identifies the weaknesses of each framework

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Table 10.4 Summary of the four explanatory factors and their strengths and weaknesses

	Changes in expert knowledge regarding particles and their health effects	Expectation dynamics	Discourses	Co-construction of policy and model
Subjects of analysis	Published research on health effects, COMEAP and EPAQS reports into particles, and extent of integration into AQS	Articulations of expectations and visions made in the public domain	Discourses about targets and target-setting: how they should be set and progress towards them measured.	Contents and boundaries of Netcen model and AQS, and how they interacted.
How it frames the overall research question	*How did policy change in the light of new and often uncertain scientific understanding of particulates, their properties and behaviour, and their effects on health? (Research question 2)*	*Can the changes in the AQS between 1997 and 2007 be explained by these dynamics of expectations? (Research question 1)*	*Are changes in the Strategy and expectations articulated by actors in the process part of larger discourses about policy and technological change? (Research question 4)*	*To what extent did modelled forecasts shape policy – and why? (Research question 3)*
Role of health effects evidence	Focus of analysis.	Context in which actors present their visions and expectations. Scientific evidence is captured as an articulation of an expectation of the future.	Definition of the health problem constrained and determined by the dominant discourse.	Evidence integrated into model as technological capacity allows, and is the basis for measuring impact of modelled scenarios.
Explanation for the role of Netcen model and forecasts	A tool for demonstrating the efficacy of policies for meeting health-based targets (Linear model of science/ policy development)	One voice amongst many articulating expectations, but privileged over others by AEQ at some points.	Developments in the model follow the requirements generated by the growth of the Performance Management discourse. Focus on the model in P2-4 because it could set SMART targets.	Model and AQS develop together, and are dependent on each other for their existence and content.

Table 10.4 (continued) Summary of the four explanatory factor and their strengths and weaknesses

	Changes in expert knowledge regarding particles and their health effects	Expectation dynamics	Discourses	Co-construction of policy and model
Explanation of plans and policies for attaining targets	Focus on formation of Objectives and the extent to which they were determined by advances in research.	Plans and policies as the embodiment of prevailing expectations in government of medium-term social, policy and technological change.	Plans and policies in the Air Quality Strategies conform to requirements of dominant discourse (e.g. specific, measurable, attainable, relevant and time bound).	Determined by the constraints of the model (for example, policies to attain quantifiable and predictable reductions in pollutants)
Explanation of illustrative measures in Addendum and 2007 Strategies	A means of indicating that the health-protection targets could be met. (Linear model of science/ policy development)	Visions made by AEQ to inspire action in the present and change actors' expectations for the future	Points at which 'action' discourse is articulated in the AQS, within the institutional structures of the PM discourse	Modelled scenarios created by modellers to determine the feasibility of potential targets.
Roles of industry, NGO and stakeholders outside the science/ policy nexus in policy development	Excluded from this analysis.	Each articulate expectations; changes in which expectations are articulated by actors over time indicate spread or curtailment of specific expectations.	The inclusion of interest groups depends on the definition of the problem and of the solution as determined by the dominant discourse.	Excluded from co-constructed relationship and thus from analysis, except in cases where they have a direct impact on the model.
Explanations of relative credibility of expectations	Excluded from this analysis.	Credibility of visions/ expectations demonstrated in their uptake by actors.	'Credibility' of expectations/ visions is determined by their alignment with discourses, and the relative power of the discourse.	Inclusion in the model itself lends credibility to a vision, expectation or outcome of a potential objective.
Weaknesses and gaps as explanatory factors	Linear approach to policy development; does not account for policy requirements directing science, or other factors in policy development.	Focus on expectations dynamics at expense of institutional changes, developments in scientific evidence.	Does not account individual agency and ideas, or for developments outside of the discourses identified in this study.	Focuses on science/ policy relationship at expense of that with other stakeholders and institutions of government

3.1. The role of science

Whilst the Air Quality Strategy exists because of considerable developments in scientific evidence, it is clear that this was not the only factor at work in determining the Objectives or the developments in strategies to reach them. The answer to research question 2 (How did policy change in the light of new and often uncertain scientific understanding of particulates, their properties and behaviour, and their effects on health?), showed that whilst scientific evidence drove the development of the first Strategy, and informed subsequent Strategies; developments in scientific evidence alone were not responsible for all the changes in PM Objectives or strategies to achieve them.

Chapter 4, the Theoretical Framework, recognised that attempts to explain policy changes by reference to developments in science may be a naive approach to examining a strategic policy framework. The thesis asks research question 2 to provide a baseline of scientific evidence against which to compare other theoretical perspectives, and also as a means of challenging the 'rational model' of policy development presented by the National Audit Office (2001a).

The evidence discussed in the analysis chapters refutes the rational model of policy development in this case. Inevitably, air quality policy changes lagged behind developments in scientific evidence, and developments in policy resulted not only from responses to science, but also a consideration of the political, economic, social and technological contexts in which the strategies developed.

Moreover, policy requirements often drove development in research: the majority of scientific research conducted into monitoring, modelling and health effects of air pollution in the UK was funded and commissioned by Defra or by the Department of Health. Leading civil servants in both Departments were scientists – with specialisms including atmospheric modelling, epidemiology, and health economics. The introduction of Exposure Reduction in Period 4 is the clearest example of scientific-civil servants' attempts to change policy to reduce air pollutants as far as possible, in response to scientific evidence.

Testing the impact of developments in scientific evidence highlights the different forms of interactions between scientists and policy-makers, but at the exclusion of the complex web of factors which were taken into consideration as part of air quality policy development.

3.2. The dynamics of expectations

The Sociology of Expectations framework focuses on the outcomes of interactions between actors (in the form of the agenda for air quality policy and any shared expectations and

visions); not only the scientists and policy-makers examined in previous studies of air pollution strategies, but also those stakeholders and policy-makers who offer potential solutions and stumbling blocks to the issues of air quality. This approach widened the subject of study, from the tightly knit air quality science/policy community in the UK, to their relationships with other stakeholder bodies and institutions of governance.

Analysis of expectations drew attention to the extent to which statements and debates about the future were prevalent in the AQS. It gave a common unit of analysis with which to compare the expectations about the future contained in the Netcen model and expectations embodied in technologies with those articulated (through speech and text) by stakeholders and policy-makers. This enabled the dynamics of expectations to be traced over time, revealing which were picked up and articulated by groups of actors, and which were discarded.

This analysis framed the developments in the AQS as the results of the dynamics of many different expectations and visions. Expectations about the future were made in every version of the AQS about the potential possible pollutant reductions (embodied in the Objectives), the means by which the reductions could be achieved (in the body of the Strategy and in illustrative measures, where appropriate), and about the preferred and expected futures for technological development, behavioural change and policy in achieving these reductions. Visions and expectations regarding future air quality, polices, technologies and public behaviour were also articulated by stakeholders involved in the policy-making process and in the Strategies themselves.

Analysis of visions and expectations showed that the shifting dynamics of expectations over time were associated with changes in the targets and strategies of the AQS. Analysis of which visions and expectations were taken up in the Strategy at a particular point in time, and which were rejected enables the identification of patterns in the data. For example, this analysis drew attention to the Revised Strategy's Objectives for which no action was required, and its focus on voluntary actions for changes. Analysis of expectations demonstrated how visions developed and incorporated into the Netcen model were taken up by policy-makers; and how – when a vision for technology failed, this also impacted on policy development.

The weaknesses of this framework come from the same source as its strengths: provision of a common currency by which the impact of expectations held in different forms by a range of actors can be analysis. The Expectations framework cannot explain patterns of expectation dynamics; nor explain why different types of expectations (for example, those for technologies or for voluntary action) were articulated in the Strategy at different times. Nor can this

framework explain how characteristics of the author (for example, relative power), the audience (for example, personal interest), or of the message itself (for example, evidence of the effects on particles on health) affect the uptake of statements about the future or their perceived credibility to other actors. With the exception of some work by scholars on the effects of hype, and its role in a 'hype-disappointment' cycle of innovation (Borup, Brown, Konrad, & Van Lente, 2006) there is no means of assessing how expectations gain credibility, from within this framework.

Nonetheless, this framework did provide the evidence base for discussion of expectations dynamics with interviewees. The analysis identified a range of factors which seemed to make some expectations more credible to policy-makers than others. All of these factors appear to be generalizable to other situations in which credibility is determined by policy-makers. An area for future study would be to test these in a different policy area in which visions are central to policy development.

3.3. Discourse coalitions

Similarly to the Sociology of Expectations, Discourse Analysis examines how ideas become institutionalised in specific settings. In this case study the two discourses examined (Performance Management and Action) concerned the premises on which policy targets should be set and progress towards them measured.

The strength of the Discourse perspective in examination of the Air Quality Strategy case study was its ability to explain the broad shifts in direction of the AQS: from optimistic in Period 1, to constrained by the business-as-usual forecast in the Revised Strategy under the discursive hegemony of the Performance Management perspective. This perspective also provides a rationale for AEQ's use of illustrative measures in Period 3, and their reliance on modelling: AEQ worked within the structures of Performance Management to present the Action discourse and introduce Exposure Reduction targets. This framework explains changes in how the health effects of particulates were framed over the course of the AQS as a result of the relative strengths of different discourses at different times.

Analysis of these discourses provides an explanation of why some visions may have been taken up and others curtailed, why specific sources of vision (for example, the Netcen model) and types of vision were given preference over others in versions of the AQS. However, the tools of the assessment process of the AQS, including cost-benefit analysis, modelling, and integrated assessment were not the outcomes of one discourse – they have been part of environmental policy for many years, both before and after the dominance of the Performance Management

in the UK. They are and have been used in policy-making in many countries and institutions of governance.

Discourse analysis enables us to identify and help explain these large-scale changes in policy and strategies to achieve targets. Action discourse was less powerful than the Performance Management discourse: held by a smaller coalition, with fewer influential members, and it was not so easily transferred to other policy arenas – yet was still influential in air quality policy. From evidence in this case study, the strength of the Action discourse was in its interpretative flexibility which enabled it to appeal to a range of stakeholders (including medical scientists, local authorities, some modellers, clean air advocacy groups and policy-makers in AEQ). Whilst many interviewees recognised the strengths of the Performance Management discourse and expressed it in their descriptions of the limits of air quality policy; many also used the constructs and phrases of the Action discourse.

Discursive analyses run the risk of focusing on the discourse, at the expense of the agency and beliefs of individuals. Keeley and Scoones (2003) claim that discursive policy analysis can often present a simple cause-effect explanation for the establishment of an environmental problem and policy for its management: an environmental problem becomes the result in a change in dominant discourse. The AQS conception of the health problems of particulates changed as the Performance Management discourse grew in influence. The health problems caused by particulates were reframed by the discourse, from affecting specific groups in the population (children, the elderly and those with illnesses affecting lung function) in a variety of ways, to an overall figure estimating effects on average life expectancy for the whole population. This change in definition was acknowledged by some interviewees; who accepted the change in definition even when not agreeing with it. Discourse analysis provides a useful explanation for this: it can acknowledge that discourses are not necessarily the same as the beliefs of individuals, and that individuals can articulate different discourses around the same issue.

The Expectations analysis demonstrates that there are many contingencies in policy development, incorporating hype and failure of predicted technologies, competing expectations and visions, and adaptation to unexpected events. The Discourse perspective does not explain these well in this case, although this may be because the discourses identified did not deal with the content of policy.

3.4. Co-Construction of Air Quality policy and the Netcen model

This study confirmed the co-construction of Netcen model and Objectives in the AQS (from Period 2 onwards) as found in my previous study (Smith, 2003). Analysis through this

framework explains the developments in the AQS as the results of the close interactions between policy-makers and modellers, and policy and model. Under this analytical framework, developments in health science are understood as part of the wider context within which the relationships between policy and model develop. Health evidence was even reframed as a result of the model: during Period 3 and 4, the use of one coefficient of reduction in life expectancy per unit of particulates supported the development and use of illustrative scenarios in determining Objectives and strategies for meeting them. Under this framework, inclusion of a vision as a scenario in the model lent credibility to that vision (whether that was for a technology, policy, or feasible level of particulate reduction).

The weakness of this explanatory factor is its limitation in explaining events and actions outside the policy-model relationship. It cannot, for example, explain the Objectives or plans to achieve them for the NAQS in Period 1, because the model did not at that point exist. It cannot account for the impact of the multiple, varied stakeholders acting in the air quality policy arena. Nor can it account for other developments in the Strategy, including the integration of air quality policy with wider government policies (e.g. with the Department for Transport's transport policies).

The use of other analytical frameworks suggest that the co-construction of model and policy between 2000 and 2007 cannot be viewed separately from the wider policy environment. For example, the role of the Netcen model as 'visions monopoly' in Period 3 was an outcome of the Performance Management discourse and the requirement for SMART targets, which the model seemed to provide.

4. Contributions to Theory Development

4.1. The use of Sociology of Expectations for analysis of policy development

This study demonstrated that actors involved in the development of environmental policies made statements of expectations about future technologies, policies and preferred behaviours. Those actors were shown to use visions and expectations to attract support and resources, and with the aim of turning 'promises' into 'requirements'; in a similar way to the use of expectations in case studies of technological development.

This was the first study to examine the dynamics of multiple sources of expectations and visions, over an extended time period (in contrast to a 'snapshot' at one moment in time) and in a policy arena. It created a methodology for recording and categorising the visions and expectations and tracing them over time. This methodology may prove useful for studying other policy arenas and technological developments marked by long-term planning and

multiple, potentially conflicting stakeholders. It may be particularly fruitful in the analysis of long-term environmental policies and targets, both national (e.g. infrastructure planning) and international (e.g. carbon reduction targets).

However, it is recognised that the construction of 'time periods' using the natural breaks of the publication of each Strategy would be more difficult to emulate in some studies of innovation. It may be a useful tool for the examination of technologies and policies marked by cycles of constant, active revision or upgrades (e.g. mobile phone technologies), in examining the impact of multiple actors and futures over time. For some policy areas, not in constant active revision, as the Air Quality Strategy was, this may also prove difficult.

By tracing the dynamics of visions over time, this study highlighted the unintended and unexpected consequences of visions (e.g. for example, in the perceived marginalisation of Local Air Quality Management in Period 4, through the focus on visions for widespread technological change). This has previously been neglected by the Sociology of Expectations approach.

However, despite its utility, the Sociology of Expectations perspective neglects the wider context in which the Air Quality Strategy set targets for pollution reduction and the means to fulfil them. Whilst showing how expectations can be widely adopted, and others sharply curtailed, it does not offer an easy explanation of why some visions are taken up and others rejected. Instead, scholars must look outside of the Expectations framework for more comprehensive answers.

4.2. Analytical distinction of 'expectations' and 'visions'

This study separated and defined 'expectations' and 'visions' as different concepts:

- Expectation: a statement about the future, either positive or negative.
- Vision: a coherent, positive and consistent vision of a specific future, made to guide action in the present (a subset of expectations).

This analytical distinction proved useful and profitable, enabling the separation of ideal visions from the more negative and neutral expectations. For example, it enabled identification and contrast of the Revised Strategy's presentation of both a business-as-usual scenario (expectations) and an ideal scenario (visions) to demonstrate potential cost-effect actions for reducing particulate levels.

This also has an impact on the conceptualisation of hype-disappointment cycles (e.g. the Gartner group, cited in Borup et al, 2006). It suggests that for some actors, such cycles may be more accurately characterised as 'fear and relief' cycles, depending on their perspective on the proposed future. Interviewees highlighted something of this in their reactions to the failure of the hype around LPG and CNG vehicles. However, this would need to be confirmed through further research.

4.3. Relative credibility of expectations

The Sociology of Expectations framework has little to say on what makes actors more likely to assign credibility to any particular expectation or vision. This study proposed that the following contributed to relative credibility to policy-makers (each described in more detail in Section 1 of this chapter):

1) the means by which the expectation was presented,
2) the source of the expectation,
3) alignment with prevalent policy discourse,
4) and the effects of hype.

All those factors are potentially generalizable to expectations and visions in other policy-arenas. Together they form an initial framework for assessing the credibility of expectations in other policy areas, and the likelihood of their uptake by policy-makers, which could be the basis for further development through testing credibility of visions in other areas of policy-making.

This study indicates that both source and means of presentation can lend credibility to a vision. The means of presentation can obscure a source, as this study found in its analysis of the sources of visions which were modelled by Netcen and subsequently adopted into the AQS. Such credibility assigned to a model does not come necessarily from the model's basis in scientific expertise, but on the precision and purported certainty of modelled forecasts. The credibility assigned by policy-makers to the Netcen model confirms the claims of Tuinstra, Hordijk and Kroeze (2006), and of Shackley and Wynne (1995a) who argued that the co-construction of policies and models can serve to increase the credibility of both to actors outside the model-policy relationship.

This study links Sociology of Expectations and some literature on boundary work between science and policy-making: scholars of Expectations have proposed that the medium in which the future is portrayed can affect its credibility (Michael, 2000). The findings of this study

indicate that this can be the result of negotiations of credibility and of expertise between parties involved in constructing visions for the future.

In terms of content, visions which aligned with prevalent policy discourses were more likely to be articulated in the AQS than those that were not. In later time periods (after Period 1) these were also more likely to be modelled, and presented through modelling or one of a small number of sources. However, this does not mean that the visions always followed the more dominant Performance Management discourse, but were aligned to the structure and institutions which developed during its dominance. The three factors: source, means of presentation and alignment to discourse, were all interlinked, and such links are potentially generalizable to other policy areas.

Hyperbole around visions for unproved technologies has been shown to have been important in bringing actors together around a vision early in innovation processes. This appears to have happened in the UK around CNG and LPG fuels, creating a situation where there was a collective expectation that these technologies would play a role in the future transport system. This thesis suggests that hype and disappointment can be matters of perspective – that for some actors, such cycles may be more accurately characterised as cycles of fear and relief. Further investigation is needed to understand whether this a useful analytical perspective and response to the hype/ disappointment cycle. After the withdrawal of support for CNG and LPG, the resistance shown by actors to supporting any particular technology indicates that the 'disappointment' of a failure of a vision can lead to credibility being less easily given. This suggests that credibility of a vision can be a function of the success of previous visions.

4.4. Comparing expectations dynamics in policy-making with expectations dynamics and innovation studies

Dialogue about the future and articulations of expectations and visions continued unabated throughout the ten year period of study. This contrasts with characterisations of the use of expectations in innovation, which portray visionary statements as more prevalent in the early stages of the process than in later ones (e.g. van Lente & Bakker, 2010). It also contrasts with Geels and Smith (2000) portrayal of a 'promise-requirement' cycle, which characterises such dynamics as important only in the early stages of innovation.

From this study it appears that policy developments are more able than 'the innovation process' to absorb and adapt to changing visions and expectations. This can be seen in large scale changes: when governments, government priorities, and ministers change in the UK, the direction of policy can change almost instantaneously. This was also seen on a smaller scale in

the Air Quality Strategy: in the expectations for technological change articulated in the Strategies, which changed over time. This is less likely to happen in technological development for a number of factors, including path dependencies, lock-in, and the investment of individuals, firms and industries in a small number of technologies.

4.5. The interplay of expectations and discourses

This study is the first practical examination of the interactions and overlaps between the Sociology of Expectations and the Discourse Coalitions frameworks for analysis. Whilst both the Expectations Dynamics and Discourse Coalitions theorists assume that sociotechnical change is shaped through discourse, the Theoretical Framework (Chapter 4) set out two proposals about the intersection of discourses and expectations: first, were that expectations and visions were either small aspects of larger discourses, or second, they are simply discourses about 'the future' and a separate discourse to others.

This study found that it is simplistic to characterise expectations as discourses about 'the future'. As this analysis has demonstrated, there are many different 'futures' that are contested simultaneously. The analysis of expectations and discourses takes place at different levels of abstraction: Expectations theories assess the dynamics of statements about the future, whereas Discourse Coalitions theorists have focused on wider discourses governing how and why policy develops.

This study examined the alignment of expectations and wider discourses in the AQS, and found that visions in the Strategy (in Periods 2-4) reflected the constraints of the more dominant discourse. Significantly, visions incorporated in the Strategy changed more rapidly than the governing discourse. In this case, operating within the structures and context of the Performance Management discourse, visions which conformed more to the Action discourse presented in the AQS in 2007 and in the 2003 Addendum were focused on creating opportunities to take action and demonstrated the feasibility of achieving the prevailing Objectives.

This suggests that alternative discourses can be presented through visions, within the constraints, institutions and storylines of the dominant discourse. In the case of the AQS, at least, visions changed more rapidly than, and in advance of discourses. This indicates that changes in visions were among the first indicators of a discursive shift. Whilst this could be tested in other policy fields for confirmation, this is a significant finding.

5. Recommendations for policy-makers

5.1. Stability and learning

Recommendations for policy-makers involved in further development of air quality policy can be drawn from this analysis. The Air Quality Strategy group had a stable core of policy-makers and scientists (both modellers and those involved in research into health effects) working on it throughout the period studied. This stability seemed to encourage policy-makers in AEQ to work to make the Strategy more effective; enabled them to learn from their experiences, and update the Strategies to address issues they saw as problematic, for example, in the move towards a policy which required action throughout the UK in Period 4. A long-term stable core of actors involved in policy may lead to increased effectiveness in policy design and implementation.

Such effectiveness requires similar effective cooperation and integration between those developing policy and those implementing policy. Other scholars have drawn attention to the lack of integrated action and policy development of the Air Quality Strategy at a local level (Cannibal and Lemon, 2000). In my own study, the frequent change in national particulate Objectives were cited by local authority representatives as disrupting their actions to address particulate pollution.

There was a similar lack of integration and low prioritisation of air pollution policy at a national level: Departments and Ministers have their own preferences and priorities, of which air policy is a relatively minor concern. For successful air quality management, cooperation is needed throughout the policy-making process. In the AQS these included the establishment of the Air Quality Forum, and the cooperative development of scenarios for future air quality improvement. Another strand of learning was in the establishment of structures by which actors from different departments and levels of government could come together and develop a shared future. This similarly may take several years.

5.2. Hyperbole, Visions and Disruption

Results from this study indicate that policy-makers would benefit from being aware of the sources of representations of the futures they are contemplating and avoid over-reliance on one set of futures, such as those for technologies, policies or behaviours. Whilst the funding of two national pollution models may not be feasible, the consideration of other perspectives and scenarios would alert policy-makers to alternative perspectives and futures, the impacts on population health of not achieving the Objectives, and to more local systems of improving

particulate levels. Potentially, one way of doing this could be to widen the sources of visions and expectations: to include new pollution models, new pollution monitoring (e.g. personal monitoring), new sources of experience and stakeholders involved in policy development. AEQ moved towards this in the use of the Air Quality Forum to develop a shortlist of potential measures in the AQS 2007.

Reflection and recognition of reliance on one set of visions may also reduce the shock of the collapse of hyperbole around a technology. Policy-makers can learn from the collapse of the visions around LPG and CNG between Period 3 and 4 and AEQ's response. In Period 4 AEQ went from predicting a future where LPG and CNG played a significant role in particulate reduction, to developing scenarios which did not mention future technology development; and this seemed to cause confusion to stakeholders. A balance must be struck by policy-makers between the over-investment in a particular untested future, and in removing all guidance and visions. Evaluation of the effects of previous versions of the Air Quality Strategy can assist policy-makers to identify points where they may be vulnerable to over-reliance on one technology or set of visions.

6. Evaluation of Methodology

This study developed a methodology for identifying, categorising and analysing statements of expectations and visions made by multiple sources and tracing their dynamics over a ten-year time frame. This methodology enabled the assessment of these statements about the future, and served to capture both dynamics of individual actors' expectations over time, and those of multiple actors in the same time frame. This methodology was supplemented by an analysis of discourses, based on the framework of Maarten Hajer (1995), for the purpose of understanding the relationships between wider discourses and expectations and visions. A summary of developments in research into the properties of particulates and their effects on health provided another frame of reference for analysing developments in each time period.

This methodology proved suitable for answering the research questions. However, some issues were raised that require further examination and refinement for future studies adopting this methodology.

6.1. Categorisation of expectations

Statements of expectation or vision did not always fit into one clear category (about policy, technologies, and behaviours); instead many could be assigned to two or more categories. For example, visions for technological change were often accompanied by visions for policy change.

Van Lente's (1993) original conception of expectations was that they were sociotechnical: they embodied both expectations for the technology and assigned roles and responsibilities to actors. Konrad (2006) criticised studies of expectations dynamics as focusing on the technological rather than the social aspects of expectations. My original categorisation was at risk of doing the same. In practice it became necessary to combine expectations categories in analysis. Rather than weakening the analysis, this combination of categories drew the focus of analysis to the means by which policy-makers and others used visions to position other actors, gain support and encourage actions from others. For example, the 2007 illustrative measures combined visions for technologies and for policies; a development from the 2003 Addendum's illustrative measures, which did not always accompany a vision for technology with a vision for policy or behavioural change for attaining the technological shift.

This study also drew primarily on statements of expectation and visions that were in the public domain, and relied on interviews to expand on how these factors interacted in the policy-making process. However, it is likely that many of the conversations in which expectations and discourses were articulated happened off the record – in meetings between policy-makers, scientists and other stakeholders. This was especially evident in the analysis of Period 4 and the developments of the 2007 Strategy, during which a group of policy-makers in AEQ used the NSCA to promote their preferred option of exposure reduction amongst European pollution modellers and policy-makers, in order that the exposure reduction approach became politically viable both in Europe and in the UK.

This study took steps to test the validity of the findings of the documentary analysis with interviews with actors involved in the process to minimise the risk of overlooking off-the-record decision-making and discussions. This is recommended for all future studies of expectations.

6.2. Retrospective examination of expectations and visions

Interviewees (to a greater extent those representing business and industry interests rather than policy-makers or those from local government) had a tendency to retrospectively present their views as neutral and not 'taken in' by the failed expectations and hype around CNG and LPG. Interviewed after the failure of the natural gas visions, some actors suggested that whilst others had been taken in, they had remained impartial. Others stated that they had innocently accepted the visions for CNG and LPG presented by actors from government departments. Such disassociation from a failed expectation is perhaps inevitable, but confirms the approach taken in the interviews, that for a more representative picture of past expectations, the

interviewer should ask each interviewee about the expectations presented by others, as well as their own. Triangulation and validation of visions, expectations and motives for articulating them reduces the risk of the interviewer presenting the retrospective justifications of an actor as an accurate representation of their visions in the time period studied.

Inevitably, the interviews undertaken were more representative of those involved during the later time periods, than in the earlier (although many actors were involved throughout the ten years studies). Memories fade and, unsurprisingly given the complexity of events, interviewees were not always able to remember different time periods clearly. Again, triangulation of different interviews and documentary sources were used to test findings and to bring clarity to the analysis.

6.3. Identification of discourses

The two discourses identified in this study were put together after my previous study (Smith, 2003) revealed them in actors' conceptions of the developments in the policy process. The discourses were developed through the interview testimonies, examining the language in documents relating to the formation of Objectives, and examining the wider policy studies literature for evidence of these positions.

The discourses identified in this study were undoubtedly of significance to the policy-makers in AEQ, the NSCA, representatives of local government, an air quality journalist, and scientists from COMEAP and other advisory committees. These were the actors for whom the AQS was of central importance to their work. Other actors – those representing vehicle and fuel industries, the concerns of drivers, and environmental technologies – did not place as much significance on the AQS. These discourses were not as obvious in their priorities, or how they talked about the AQS. There remains the possibility then that other discourses were significant in the development of the AQS, which this study has missed.

7. Proposals for further research

This thesis presents a framework for analysing expectations over a medium or long-term policy development, tracing their dynamics and interactions, for the purposes of understanding how the future is constructed and negotiated in environmental policy. This chapter has assessed the strengths of this framework and identified some areas for further investigation.

Since the publication of the 2007 Strategy much has changed in the UK Air Quality Policy arena. The financial crisis and the prioritisation of climate change have changed the context in which policy is made. Key individuals, who were central to the developments in the AQS and in its scientific evidence base have retired or moved sector. The influence of the NSCA has

waned, and more adversarial interest groups such as Client Earth have emerged to challenge current government plans for air quality. Local air quality advocacy groups (e.g. Clean Air for London) have been set up, and encouraged personal air quality monitoring and grassroots action to tackle local air pollution.

As of December 2012 Defra formed new expert advisory committees to examine modelling. An assessment of the roles of science, discourses and visions in these processes would test some of the findings of this thesis. An ethnographic study, in which the researcher attends Air Quality Forum meetings, advisory committees and conferences may provide solutions to some of problematic aspects of methodology identified here, including the retrospective disassociation from failed visions, misremembering by interviewees, and identification of points where decisions are made. Such study could also be expanded to the analysis of recent developments in the European Air Quality Framework would provide insight into how the visions generated nationally interact with those of other countries and interests.

The AQS was a useful case study for this methodology of examining the dynamics of multiple expectation sources over time. It was facilitated by a stable core of policy-makers and stakeholders, a rapidly changing scientific understanding of the health effects and behaviour of particulates, and was constantly under review. In its focus on setting targets for future reduction of pollutants, it made the future the site of contestation. To test the applicability of the framework further, it would be prudent to examine an area of policy which is not in an active state of review by policy-makers, to find out how expectations and visions are presented and interact when there is no framework for review.

The framework of expectations dynamics developed here may be usefully applied to emerging environmental policy issues, such as those of synthetic biology and endocrine disruptors, in order to understand how visions are formed and act in early stages of policy development. This again, suggests an ethnographic approach, in addition to retrospective interviews and documentary analysis. Such analysis may support policy-makers to develop strategies which acknowledge and identify the multiple possible futures under negotiation.

7.1. Discourse coalitions and expectations

A significant finding of this study was that visions can serve as signals of a discursive shift, within the framework of a dominant discourse. This finding suggests a point at which Discourse Coalitions and Sociology of Expectations theories can inform and strengthen each other. However, it should be replicated in another set of expectations, visions and discourses.

Further study – both of the more recent developments in air quality policy, or in another policy framework – could examine and confirm this.

Within the air quality policy field, this study identified the Action discourse as gaining traction within the discursive and institutional structures of the Performance Management discourse through visions incorporated into the 2007 Strategy. A proposed next step, to understand whether these visions were the forerunners of a decisive change in dominant discourses, could be to examine the impact of the Action discourse on the more recent structures and institutions of governance in air quality policy-making. Linked to this, a future study of developments in the European air quality framework could ascertain whether the exposure reduction approach adopted there had any lasting effects on discourses, institutions, practices and positioning of actors.

7.2. Developing a framework of relative credibility of expectations and visions

This study identified a cluster of factors which contribute to relative credibility of a vision to policy-makers, and proposed that these may be generalizable to policy-makers in other areas. Three factors cluster together and reinforce each other: the source of expectation, means of presentation and alignment with previous policy discourses. These factors should be tested in a different policy area in which visions are central to policy development, to understand how far this generalisability is the case.

The relative credibility assigned to modelled visions by policy-makers in the case of the AQS has been found in other areas of policy development (for example, developments in the proposals to address climate change). However, actors outside the science-policy relationship may not assign the same degree of credibility to modelled visions. To develop a framework of relative credibility of visions in a policy community (not limited to policy-makers as this study was), it will be necessary to examine the relative credibility of visions to actors who are not decision-makers, and to identify whether the factors identified above are at work in the same way. This would involve an assessment of the relative credibility of the science/policy relationship to those outside it, with the purpose of understanding why differences in relative credibility emerge. One proposed subject for study is the European air quality framework, where multiple actors were working to develop a framework for the regulation of pollutants across Europe.

The fourth factor, the role of hyperbole and of promotion of a specific technology, can be a positive or negative factor, depending on the perspective of the actor and the relationship between the envisioned future and its subsequent realisation. This investigation of the AQS

demonstrated that hype can lead not only to a change in visions and expectations, but draw attention and resources to a particular set of visions, for example, for CNG and LPG fuels during the earlier time periods studied. When the hype around these technologies collapsed, so too did the vision for their future, and at the time in which interviews took place, this lead to cynicism and disengagement from some interviewees in discussions around future technologies. Another topic for further investigation could be how the effects of a collapse in hype around a vision changes a policy community, and how the community reacts to a new promised breakthrough.

This emerging framework for understanding relative credibility of visions does not yet account for *lietbilder* or visions built by a group through consensus. Van Lente and Bakker (2011) (in their examination of expectations dynamics for hydrogen storage technologies) found that actors use different narratives to make visions credible to those inside a community and those outside. This study examined consensus visions only in the case of a shortlisting of visions for future actions and technologies to achieve particulate Objectives during Period 4. Their relative credibility was discussed only by actors within the policy-making process. It would be interesting to understand whether these are viewed differently (more or less credibly) than other visions, and how they are portrayed by those on the outside of the group building the vision.

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Appendix 1. Policy measures in the Revised Strategy which affected road transport and their relationship to the Transport White Paper and other government policies

Measure in the Revised Strategy	Actor responsible for implementation	Source	Aim	Transport White Paper (DETR 1998) reference
Fuel duty escalator	HMT	1993 and all subsequent budgets	To provide an incentive to drivers to use more fuel efficient vehicles/ drive less/ find alternatives to the car (DETR 2000, 67)	Page 108 (6% increase per annum
Fuel duty differentials: • Diesel – 50.21p/ litre; • Unleaded petrol – 47.21p/litre • ULSD – 47.21p/litre	HMT	ULSD – 1998 and 1999 budgets.	Taxation to provide incentives to attain environmental objectives –improved air quality and reduced vehicle emissions. Specific aim of encouraging diesel users to switch to ULSD.	Page 107-108.
Fuel duty differentials on road fuel gases (CNG, LPG) – 15.00p/litre	HMT	1998 budget	Taxation to provide incentives to attain environmental objectives – "In recognition" of their air quality benefits, especially when substituted for diesel in urban areas. (DETR 2000 68)	Pages 107-108
Vehicle Excise Duty: concession of up to £1000 for buses and lorries which met stricter particle emission standard. To be met through fitting a DPF, a new engine conversion to road fuel gases.	HMT	March 1999 budget (extension of 1996 budget measure)	To encourage improved air quality and reduced vehicle emissions.	pages108-109
Reduced rate of Vehicle Excise Duty on	HMT	March 1999 budget	To encourage greater fuel efficiency and	page109

Measure in the Revised Strategy	Actor responsible for implementation	Source	Aim	Transport White Paper (DETR 1998) reference
cars with smaller engines.			emissions reductions.	
Taxation measures to reduce company car use.	HMT	March 1999 budget	To improve pollution and congestion in urban areas.	page109.
Introduction of tax measures to encourage businesses to develop green transport plans, to assist employees in finding alternatives to driving to and from work.	HMT	March 1999 budget	To reduce car use.	Green transport plans for business, government and other institutions discussed throughout.
Greening Government: including transport plans for government departments.	DETR/ all govt. departments	Transport White Paper	To cut vehicle emissions.	Target set, page130.
Government information campaign to encourage voluntary action by individuals and businesses. E.g. *Are you doing your bit?*	DETR/ local authorities	Established use by government and local authorities by the time the Transport White Paper was published in 1998	To raise awareness of the impacts of different forms of travel and enable the public to make better choices	Pages 137-138
Powershift grants	DETR / Energy Saving Trust	Established in 1996.	To encourage commercialisation of cleaner technologies (road fuel gases and electricity) to improve air quality	Page 65.
Transport planning	Local authorities	Transport White Paper	Revision of planning guidance in light of Transport White Paper objectives.	Discussed throughout

Measure in the Revised Strategy	Actor responsible for implementation	Source	Aim	Transport White Paper (DETR 1998) reference
Local Transport Plans (England and Wales) and Local Transport Strategies (Scotland).	Local authorities	Transport White Paper	Local implementation of the integrated transport policies of the Transport White Paper. Strategies to tackle transport problems including congestion and air pollution. Close relationship with LAQM planning.	Discussed throughout (e.g. p9)
Road Traffic Reduction Targets	Local authorities	Road Traffic Reduction Act 1997	Local reviews of existing and forecast traffic levels and prepare targets for reduction of traffic levels or traffic growth rate.	e.g. pages 9 and 11.
Local authority measures which could be used to change traffic flow, or restrict traffic in an area (e.g. traffic regulation orders)	Local authorities	Road Traffic Regulation Act 1984	Local powers to manage traffic (not specifically for air quality purposes).	Discussed throughout e.g. p48.
Clear Zones	DTI Foresight programme	Foresight programme	To encourage R&D and adoption of technologies that will reduce vehicle emissions and congestion in urban areas, whilst maintaining accessibility.	Page 52
ALTER (Alternative Traffic in Towns)	Local authorities	European project launched during UK Presidency.	To reserve some urban areas for low emission vehicles only and to introduce low or zero emission vehicles into local authority fleets.	Page 52
Bus Quality Partnerships	Local authorities and bus operators	Pre-Transport White Paper.	To improve bus services – reducing social exclusion and congestion, and being used to set environmental standards.	Pages 99-100

Measure in the Revised Strategy	Actor responsible for implementation	Source	Aim	Transport White Paper (DETR 1998) reference
Freight Quality Partnerships and Sustainable Distribution	Local authorities, the haulage industry and local businesses, and the DETR.	Pre-Transport White Paper	Agreements to improve distribution in urban areas – e.g. on delivery hours, promotion of cleaner lorries	Page 38.
Road user charging	DETR/ local authorities	Transport White Paper	Commitment to introduce legislation for local authorities to charge drivers for entering an area or using certain roads.	Discussed throughout e.g. p9, 99.
Workplace parking levy	DETR/ local authorities	Transport White Paper	Commitment to introduce legislation for local authorities to charge for workplace parking.	Discussed throughout e.g. p105
Cleaner Vehicles Task Force	Advisory committee composed of representatives of government, automotive and fuel industries.	Set up prior to the publication of the Transport White Paper	Examining means to promote the use of less polluting, fuel efficient, quieter vehicles– manufacturing, adoption and use.	Page 127
Review of speed policy	DETR	Transport White Paper	Review to understand how best practice (e.g. in engineering and publicity) can be used to contribute to environmental, social, economic and road safety objectives (DETR 2000 p91).	Pages 12 and 75
Emissions testing in MOT	Vehicle Inspectorate approved garages	Already part of the MOT	To improve emissions from older vehicles	Not mentioned.
Local authority emissions testing review and roadside emissions testing.	DETR (review), local authorities (testing)	Under review 1998-2000	Roadside emissions checks – to raise awareness and improve emissions.	Page 118

Measure in the Revised Strategy	Actor responsible for implementation	Source	Aim	Transport White Paper (DETR 1998) reference
LAQM	DETR/ local authorities	NAQS	Management of local air quality where there are predicted exceedences of Objectives	Overlap with local transport plans, p111.