SEPA's National air quality report
2008

SEPA
Scottish Environment
Protection Agency

Contents

Executive summary

Good air quality is essential for human health and the well-being of the environment. The dense smogs and black sooty smoke that existed in middle of the 20th century have been replaced by pollutants that cannot be seen or detected by healthy individuals. These invisible pollutants can exacerbate health conditions, such as asthma, bronchitis and some cardiovascular problems. Episodes of high pollution have been linked to an increase in hospital admissions and increased mortality.

This report provides a general overview of emission levels and trends for key pollutants across the UK and Scotland specifically. Ambient air quality monitoring data obtained from monitoring sites within Scotland, along with various other UK and Scottish data, are also presented, together with actions being undertaken to improve Scotland's air quality. Where data has been sourced externally, we have provided links to the original source within the report. The report also outlines SEPA's role in the management of air quality and industrial pollution control.

It should be recognised that any air pollutant, or parameter, contained within this report should not be viewed in isolation; the interactions in the environment are complex and there may be synergistic effects. Pollutants are therefore described on an individual basis for the purpose of clarity alone.

The pollutants considered in this report are:

- sulphur dioxide (SO_2);
- oxides of nitrogen (NO_x);
- particulate matter (PM_{10} and $PM_{2.5}$);
- non–methane volatile organic compounds (NMVOC);
- ground–level ozone (O_3);
- ammonia (NH_3);
- greenhouse gases (GHGs) – in particular carbon dioxide (CO_2) and methane (CH_4).

The global perspective on air quality issues, such as climate change and the depletion of the high-level (stratospheric) ozone, are not considered in this report. These, and numerous other environmental issues relating to air quality, are discussed in SEPA's *State of Scotland's environment report*, published in October 2006.

The Scottish Pollutant Release Inventory (SPRI) database was established in 2002. It collects information that relates to emissions of certain substances, above a reporting threshold, from SEPA-regulated installations. Data held within the SPRI database indicates that industrial emissions of pollutants such as SO_2 and NO_x are generally declining in Scotland. There is no evidence to show that emissions of PM_{10} from large industrial sites have resulted in exceedances of air quality objectives, although road traffic and coal-fired domestic heating do have the potential to cause localised problems. Emissions of CO_2 from SEPA-regulated installations increased in 2006, but they have since mostly returned to pre-2006 levels. This increase was mainly due to a requirement for coal-fired power stations to satisfy a short fall in energy generating capacity by stepping-up production. In such circumstances, it should be noted that, while the mass emissions from an installation may increase, this will be due to market-driven forces for operation and any such installations will still have to meet the compliance requirements contained within its permit (for concentration-based emission limit values).

Power generation is responsible for the majority of CO_2 emissions in Scotland; indeed, Cockenzie and Longannet power stations account for almost half of these emissions from industrial sources in Scotland. Road traffic is the second largest source of GHGs and it is also the most significant source of atmospheric pollution in urban centres.

Concentrations of O_3 have generally increased in urban areas, with the main contributing factor being increased traffic emissions reducing emissions of NO, which would normally destroy O_3. With further reductions in emissions of NO, urban concentrations of O_3 may continue to rise. Conversely, background concentrations of O_3 have also increased and this may be due to the increase in the primary pollutants that lead to the formation of O_3 (with atmospheric transport). While concentrations of other pollutants decline, O_3 is likely to become of greater importance.

SEPA applies the Pollution Prevention and Control (PPC) Regulations to ensure that the best available techniques are used to prevent or minimise the emission of pollutants from SEPA-regulated installations. These regulations have brought activities of significant scale, previously unregulated by SEPA (such as the larger intensive agriculture units), under direct environmental regulatory control and increased the emphasis on protecting human health.

There are also a number of significant non-industrial sources of air pollutants over which SEPA currently has no regulatory control, such as transport, small/medium commercial heating systems and domestic heating sources. While SEPA does not have formal powers to regulate emissions in relation to transport, decisions taken in relation to transport policy have environmental repercussions which can affect SEPA's role in managing the air, water and land media, and in responding to the wider issue of climate change.

SEPA can also seek to influence the release of emissions from transport and domestic homes through:

- promoting environmental best practice;
- working in partnership with other organisations, such as local authorities, to address poor air quality;
- contributing to local authority air quality reviews and assessments;
- influencing and implementing incoming legislation, where appropriate.

Local authorities are required to periodically review and assess the air quality within their authority boundaries, and compare their findings against the UK Air Quality Strategy (AQS) objectives for key pollutants. Where breaches of the air quality objectives are found (or predicted), local authorities must declare an air quality management area (AQMA) and produce an air quality action plan to help achieve the objectives. Of the 21 air quality management areas (AQMAs) that have been designated in Scotland, 19 are due to emissions from road traffic.

SEPA will continue to play a key role in ensuring that air quality in Scotland is protected and improved, both though carrying out its duties and also by working in partnership with those organisations who have similar roles and aims.

1 Introduction

This report considers the emissions of key pollutants and discusses some of the air quality management issues that currently exist in Scotland. It contains information on Scotland's air quality, how air quality is monitored, and the trends for individual pollutants. Associated issues including acidification, climate change, nutrient enrichment and hazardous chemicals are discussed in *State of Scotland's environment report*, published in October 2006.

Air quality directly affects human health and the natural environment. Even moderate levels of air pollution can aggravate respiratory diseases, such as asthma, or worsen the condition of individuals with heart or lung disease. Atmospheric pollution can adversely affect the natural environment, particularly through the deposition of acidifying pollutants and nitrogen compounds. This can lead to the eutrophication or acidification of terrestrial and aquatic ecosystems, resulting in damage to crops, forests, and aquatic organisms, and an overall reduction in biodiversity.

Some of the main sources of air pollution in Scotland are road traffic, industry and power generation. The long-range transport of pollutants means that pollutants which have been released in other countries can also have an impact on Scotland's air quality. Similarly, air pollution generated in Scotland can have effects beyond our borders. Scotland's industrial emissions to air represent about 10% of the total UK emissions for most pollutants, and most of these emissions come from central Scotland.

SEPA's Corporate plan 2008 – 2011 contains six long-term environmental outcomes which must be achieved within a specified timescale. One of these, the 'Improved air quality' outcome, is aimed at protecting human health and the environment from the negative effects of air pollution. The outcomes also set out measures to help address global climate change, by promoting a reduction in greenhouse gas (GHG) emissions.

Figure 1 summarises SEPA's current corporate outcome and targets in relation to achieving improved air quality. Specifically, SEPA will look to improve Scotland's air quality through regulating certain installations that emit atmospheric pollutants, and by working closely with local authorities on local air quality management (LAQM) and planning related issues.

This body of work encompasses a range of activities that will include:

- issuing installations with permits to allow operation under specific conditions, to ensure that human health and the environment are protected;
- working with industry to minimise emissions through operational best practice;
- carrying out computer dispersion modelling studies, to better understand dispersion of air pollution;
- undertaking environmental improvement action plans (EIAPs)[1] to assess localised impacts of air pollution.

SEPA is identified as a key agency under the Planning, etc. (Scotland) Act 2006 and we are proactively assisting the delivery of the Scottish Government's commitment to provide a more effective and efficient planning system. We provide formal environmental advice in relation to development plans and on a wide range of development proposals across Scotland.

[1]Environmental improvement action plans (EIAPs) are discrete projects undertaken by SEPA with the aim of achieving a positive environmental outcome. Many are in response to identification of specific issues and involve working with partner organisations.

Figure 1: SEPA's current corporate outcome and targets in relation to achieving improved air quality

Improved air quality	Targets		
	2008-2009	2009-2010	2010-2011
Understanding the state of the environment Enhance and further develop SEPA's air strategy to provide a cohesive framework for interpreting, reporting on and understanding the quality of Scotland's air	Working with Scottish Government, seek to extend the Scottish Air Quality Database (SAQD) to include emissions data from SEPA-regulated activities and be part of the SAQD annual report on Scotland's air quality	Analyse trends of pollutant emissions as part of the work to produce the SAQD annual report on Scotland's air quality	Analyse trends of pollutant emissions as part of the work to produce the SAQD annual report on Scotland's air quality
Working in partnership with public and private sector stakeholders, progress SEPA's understanding of habitat degradation from SEPA-regulated sources in order to address air pollution pressures on habitats	Review and refine current data and modelling techniques	Report information obtained from modelling and continue to refine modelling techniques	Enhance and develop SEPA's biomonitoring strategy
Protecting and improving the environment Ensure licence compliance for regulated activities, progressively improving operator compliance with the conditions of their licence	Maintain Pollution Prevention and Control (PPC) permit compliance at 92% under the current compliance assessment scheme[13] Implement a new compliance assessment scheme	Develop a new target for PPC permit compliance	Compare compliance against the target developed in 2009–2010
	Develop a database of upgrade requirements to measure compliance with PPC regulations	Develop a system for reporting progress for the implementation of upgrade requirements	Monitor and report on progress on the implementation of upgrade requirements
Develop and implement a programme to address poor air quality in partnership with other organisations, to build on current measures both at a local and national level	Undertake modelling of emissions from SEPA-regulated sites and develop and initiate a training programme for local planning authorities	Continue training for local planning authorities and continue modelling and data analysis of emissions from SEPA-regulated sites	Continue training for local planning authorities and continue modelling and data analysis of emissions from SEPA-regulated sites

Figure 1: SEPA's current corporate outcome and targets in relation to achieving improved air quality (cont.)

Improved air quality	Targets		
	2008-2009	2009-2010	2010-2011
An influential authority on the environment With Scottish and UK Governments, influence and provide technical support for policy development at a UK and European level	Develop influencing plans for relevant legislation, including the proposed Industrial Emissions Directive and carbon capture and storage	Develop influencing plans for relevant legislation, including the Industrial Emissions Directive	Monitor and report on the effectiveness of influencing plans for legislation, including the Industrial Emissions Directive
Through the provision of guidance, technical support, briefings and information, influence customers to promote changes in behaviour	Each year, work with the Scottish Government, Environment Agency and Defra to revise and upgrade sector guidance and process guidance notes for Pollution Prevention and Control (PPC) Part A and Part B sites		
Better Regulation Work with the Scottish Government to implement risk-based regulation, adopting General Binding Rules (GBRs) for low risk activities	Investigate GBRs and other suggestions for streamlining regulation	Implement GBRs and investigate further methods for streamlining regulation	Investigate further methods for streamlining regulation
Undertake post-regulatory reviews of legislation to inform and enhance future regulatory approaches	Develop a post-regulatory impact assessment methodology	Use the post-regulatory impact assessment findings to implement changed practices	Continue to monitor progress on legislation implementation

2 SEPA's role in the management of air quality

SEPA's has many roles and responsibilities for ensuring that the quality of air is protected:

Direct regulation

- Issuing and ensuring compliance with environmental permits across a wide variety of industrial activities.
- Inspecting installations and responding to complaints and environmental incidents.

Policy

- Developing policy in relation to air quality and atmospheric pollution issues in Scotland, UK and Europe.
- Delivering integrated national policies and strategies and providing expert advice and support to SEPA staff, the Scottish and UK governments and other external partner organisations.

Science

- Undertaking compliance and audit monitoring of industrial emissions and landfill gas emissions.
- Periodically monitoring ambient air quality.
- Using a range of commercially available computer models for air dispersion modelling.

Partnership working

- Fulfilling SEPA's statutory duty as an appropriate authority for local air quality management (LAQM) and co-ordinating formal responses to local authority LAQM reports in response to SEPA's role as a statutory consultee.

Planning

- Advising on a range of planning proposals, local plans, transport strategies and strategic environmental assessments (SEAs).

Regulation

Under the Pollution Prevention and Control (PPC) Regulations, SEPA is responsible for regulating prescribed industrial activities and emissions from installations to air. In the case of larger activities emissions, this applies to all media (ie air, land and water). These regulations were fully implemented in Scotland on 30 October 2007 and its associated regulatory regime covers a wide range of industrial activities and other environmental issues such as noise, resource utilisation, energy efficiency and waste management. Under the regulations, SEPA requires the operator to use the best available techniques, to prevent or minimise emissions from the operation of an installation in accordance with permit conditions.

SEPA regularly monitors the performance of each installation regulated under PPC. We currently use an operator performance risk assessment scheme (OPRA), which includes factors such as process management, site management, emissions, environmental incidents and record-keeping. The scheme enables us to identify those installations that are performing well (and use them as examples of best practice). It also helps us target our resources at those installations which are performing badly or giving rise for concern, and ensure they achieve compliance through regular inspection, monitoring and enforcement activities. SEPA is also in the process of implementing a new compliance scheme during 2009 which aims to provide a simple consistent framework and approach across various regulatory regimes, which will lead to objective and transparent compliance assessment results.

Scottish Pollution Release Inventory

The Scottish Pollutant Release Inventory (SPRI) contains information on the:

- releases of certain substances into the environment;
- details of the organisations/companies responsible for the emissions;
- locations of the emissions, and the substances and amounts that have been released.

Information is only held on emissions from certain activities, above a reporting threshold. As such, the SPRI is not a comprehensive list of industrial emission sources within Scotland.

The inventory also fulfils Scotland's commitment to the UK's reporting requirement under the European–Pollutant Release and Transfer Register (E-PRTR) Regulation. The aim of the register is to improve public access to environmental information, thereby also contributing to the prevention and reduction of pollution, delivering data for policy makers and facilitating public participation in environmental decision-making. European Union Member States are required to report releases from all activities listed in Annex I of the E-PRTR Regulation on an annual basis.

Addressing climate change

SEPA seeks to promote a reduction in greenhouse gas (GHGs) emissions from SEPA-regulated activities. We also regulate the EU Emissions Trading Scheme (EU ETS) in Scotland, ensuring a common implementation approach is taken with the other UK environmental regulatory bodies. Measures currently under development for implementation include the introduction of aviation into the EU ETS and the delivery of the Carbon Reduction Commitment (CRC). Starting in April 2010, the commitment will provide a new mandatory emissions trading scheme which targets large public and private sector organisations and is intended to have a significant impact on reducing UK CO_2 emissions.

Legislation has been developed with the aim of preventing, or minimising, emissions of specific air pollutants, including those aimed at reducing the formation of secondary pollutants. Such legislation originates through formal international agreements and EU directives. An example of some (but not an exhaustive list) of these legal measures and a brief description of their general aims are listed in Table 1 below.

Table 1: Examples of the major environmental legislation relating to emissions to air

Name of legal instrument	General aims, measures and intended benefits
National Emission Ceilings Directive (NECD)	Sets upper limits for UK total mass emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level O_3 pollution: SO_2, NO_x, VOCs and NH_3. The directive is currently under review to allow revised targets for 2020 to be set. These will include targets for $PM_{2.5}$.
Integrated Pollution Prevention and Control Directive (IPPCD)	Aims to minimise pollution from various industrial activities throughout the EU. Operators of certain industrial installations that are covered by the directive are required to obtain an environmental permit from the authorities in EU countries. These permits provide operational measures to control emissions to the environment. It is implemented in Scotland through PPC.
Large Combustion Plant Directive (LCPD)	Aims to reduce pollutants, including SO_2, NO_x and PM, from certain larger combustion plants. It is implemented in Scotland through PPC.
Waste Incineration Directive (WID)	Contains rigorous technical requirements for the operation of thermal treatment plants such as incineration processes and includes emission limit values (ELVs) for heavy metals and dioxins. It is implemented in Scotland through PPC.
United Nations Economic Commission for Europe (UNECE) VOCs Protocol	Aims to reduce the generation of the secondary pollutant, ground-level O_3, by reducing the primary pollutants (ie VOCs).
Solvent Emissions Directive (SED)	Aims to reduce the emissions of VOCs from industrial sources such as manufacturing, coating and printing. It is implemented in Scotland through PPC.
Paint Products Directive (PPD)	Aims to reduce releases of VOCs from coating materials by setting maximum VOC content limits on products placed on the market.
Petrol Vapour Recovery Directive (PVR)	Aims to reduce the release of petrol vapour VOCs to the atmosphere by setting requirements for vapour collection at petrol service stations and storage facilities. It is implemented in Scotland through PPC.
Sulphur Content of Certain Liquid Fuels Directive (SCLF)	Aims to reduce SO_2 emissions from plants using these fuels. It is implemented in Scotland through PPC.
Ozone Depleting Substances (ODS) Regulations	Aims to reduce the primary pollutants that are responsible for depleting the upper ozone layer.
Fluorinated Gases (F – Gas) Regulations	Aims to contain, prevent and thereby reduce emissions of F-gases, which are powerful GHGs.
EU Emissions Trading Directive (EU ETS)	The EU ETS commenced on 1 January 2005 and establishes a means to promote reductions of GHG emissions in an economically efficient manner, by allowing participants to trade allowances.
Ambient Air Quality Directive	Merges and amends the EU Air Quality Framework Directive (96/62/EC) and subsequent daughter directives. Aims to establish objectives for ambient air quality in order to avoid, prevent or reduce harmful effects on humans and the environment. Common methods of assessing and reporting air quality will be promoted between EU Member States.

Table 1: Examples of the major environmental legislation relating to emissions to air (cont.)

Name of legal instrument	General aims, measures and intended benefits
UK Air Quality Strategy (AQS)	Focuses on nine priority pollutants that have impacts on human health: sulphur dioxide (SO_2); benzene; 1, 3-butadiene; carbon monoxide (CO); lead (Pb); nitrogen dioxide (NO_2); ozone (O_3); polycyclic aromatic hydrocarbons (PAHs) and particulate matter (PM_{10} and $PM_{2.5}$); and sets air quality objectives that are prescribed in regulations for the purposes of local air quality management. There are also objectives to protect vegetation and ecosystems from the effects of acid deposition.
Public Service Vehicles (Traffic Regulation Conditions) Amendment (Scotland) Regulations 2008	Allows local authorities to implement low emission zones (LEZs) in areas subject to poor air quality as a result of traffic hot-spots.
Automotive Fuel Quality Directive	Contains the environmental fuel quality specifications for petrol and diesel fuels. The main focus is on sulphur in both petrol and diesel and lead and aromatics in petrol.

Local air quality management

There are a number of significant non-industrial sources of air pollution that are not regulated by SEPA. Examples include small combustion sources (such as domestic heating and small biomass systems), road traffic, aircraft, bonfires, etc. While these sources are small, they tend to exist in large numbers; therefore the cumulative effect may be more significant. SEPA seeks to influence the sources of air pollution though its involvement in the local authority air quality review and assessment process. SEPA will also provide advice and guidance in the case of any planning application that may have a detrimental affect on air quality.

The Environment Act 1995 laid the foundations for local air quality management (LAQM), which requires local authorities to periodically review and assess air quality within their authority boundaries. The local authorities are then required to report their findings to the Scottish Government. These reports can vary in complexity, depending on the type of assessment that has been carried out. As statutory consultee, SEPA provides a written response to all reports that relate to the LAQM regime.

Local authorities have been monitoring air quality since 1997, and there is now a comprehensive monitoring network that measures a range of pollutants. The seven pollutants included in the Air Quality Regulations for the purpose of LAQM are:

- benzene;
- 1,3-butadiene;
- carbon monoxide;
- lead;
- nitrogen dioxide (NO_2);
- particulate matter (PM_{10});
- sulphur dioxide (SO_2).

The air quality objectives have been introduced to protect individuals who are susceptible to the effects of these pollutants and are generally based on standards that have been introduced by the EU; however, some of the more stringent objectives have been introduced by the UK and Scottish Governments in response to expert advice and local environmental conditions. Breaches or likely breaches of these objectives lead to local authorities being obliged to designate an air quality management area (AQMA) in order to improve local air quality.

SEPA works in partnership with local authorities to address poor air quality and contribute to the cycle of LAQM review and assessment. As a statutory consultee on LAQM for Scotland, SEPA comments on air quality reports and provides specialist advice. Once an AQMA has been declared, the local authority has 18 months to carry out a further assessment and to draw up an action plan that will detail the measures that work towards achieving the air quality objectives.

Even where a local authority concludes that the designation of an AQMA is not required, there is still an obligation to conduct reviews of local air quality on a regular basis. It is important to emphasise that the local authorities are not required to meet the air quality objectives, but they must show that they are working to meet them. Failure to meet these limits could mean that the UK Government would face infraction proceedings from the European Commission.

There are 235 AQMAs declared throughout the UK, 21 of which exist in Scotland. Of the 32 local authorities in Scotland, 12 had declared an AQMA at the time of preparing this report. While the majority of these have been designated because of pollution from road traffic, one AQMA is in response to industrial emissions, and another is because of emissions from domestic fires. Table 2, below, lists the AQMAs currently declared in Scotland, and the pollutants on which the designation was based.

The Scottish Government has funded the creation and maintenance of a Scottish air quality website that contains a range of information pertaining to air quality in Scotland. As well as explaining the LAQM process in detail, the website contains:

- real-time monitoring data;
- historic data;
- photographs of the monitoring sites;
- maps that show the location of the monitors and the boundaries of the AQMAs.

Table 2: AQMAs in Scotland (at July 2009)

Local authority	Location	Source	Pollutant		
			NO_2	PM_{10}	SO_2
City of Edinburgh	City Centre & West Port	Road traffic	✖		
	St. John's Road	Road traffic	✖		
	Great Junction Street	Road traffic	✖		
Perth and Kinross	Perth	Road traffic	✖	✖	
Dundee City	Dundee	Road traffic	✖		
Falkirk	Grangemouth	Industrial			✖
Aberdeen City	City Centre	Road traffic	✖	✖	
North Lanarkshire	Motherwell Cross	Road traffic		✖	
	Coatbridge (Whifflet)	Road traffic		✖	
	Chapelhall	Road traffic		✖	
	Harthill	Quarry		✖	
Renfrewshire	Paisley (Central Road)	Road traffic	✖		
	Smithhills Street, Paisley	Road traffic	✖	✖	
East Dunbartonshire	Bishopbriggs	Road traffic	✖	✖	
Glasgow	Parkhead Cross	Road traffic	✖		
	Byres Road/Dumbarton Road	Road traffic	✖		
	Royston Road	Road traffic	✖		
	City Centre	Road traffic	✖	✖	
South Lanarkshire	Whirlies Roundabout	Road traffic		✖	
Midlothian	Pathhead	Domestic heating		✖	
Fife	Cupar	Road traffic	✖	✖	

(Source: Scottish air quality website)

3 Sulphur dioxide

High concentrations of sulphur dioxide (SO_2) can cause irritation to the eyes and the respiratory system. Those suffering from existing respiratory difficulties, such as lung disease and asthma, are particularly sensitive to its effects.

Sulphur dioxide is created by the combustion of fossil fuels (such as coal and heavy fuel oil), with the main sources being coal-burning power generation and large industrial complexes, such as oil refineries or foundries. While the sulphur content of fuel for road vehicles is now greatly reduced at the refining stage, large marine vessels still use lower quality fuels with a higher sulphur content, making merchant shipping a more prominent source of SO_2 emissions.

One of the primary environmental concerns associated with SO_2 pollution is the acidification effects associated with the formation and deposition of sulphate, either as a gaseous aerosol (dry deposition) or through precipitation as acid rain (wet deposition). The problem of acidification caused by SO_2 (and also oxides of nitrogen – NO_x) is further complicated by long-range transport of pollutants over international boundaries. Given the uncertainties surrounding the rates of recovery of ecosystems from acidification, it is important that emissions of SO_2 continue to be controlled and reduced further.

In geologically sensitive areas acid rain dissolves aluminium from the rocks and soil and the concentration can reach toxic levels for aquatic life, including fish (which are particularly sensitive to change in pH). Some lochs in Scotland have lost their fish populations, while many of the rivers have a reduced range of invertebrate fauna and depleted fish numbers. The dissolution of aluminum can also reach toxic levels for sensitive vegetation, thus restricting plant growth and development, resulting in ecological damage. Further information on acidification and its impacts across all habitat types in Scotland can be found on p104 of SEPA's *State of Scotland's environment report*.

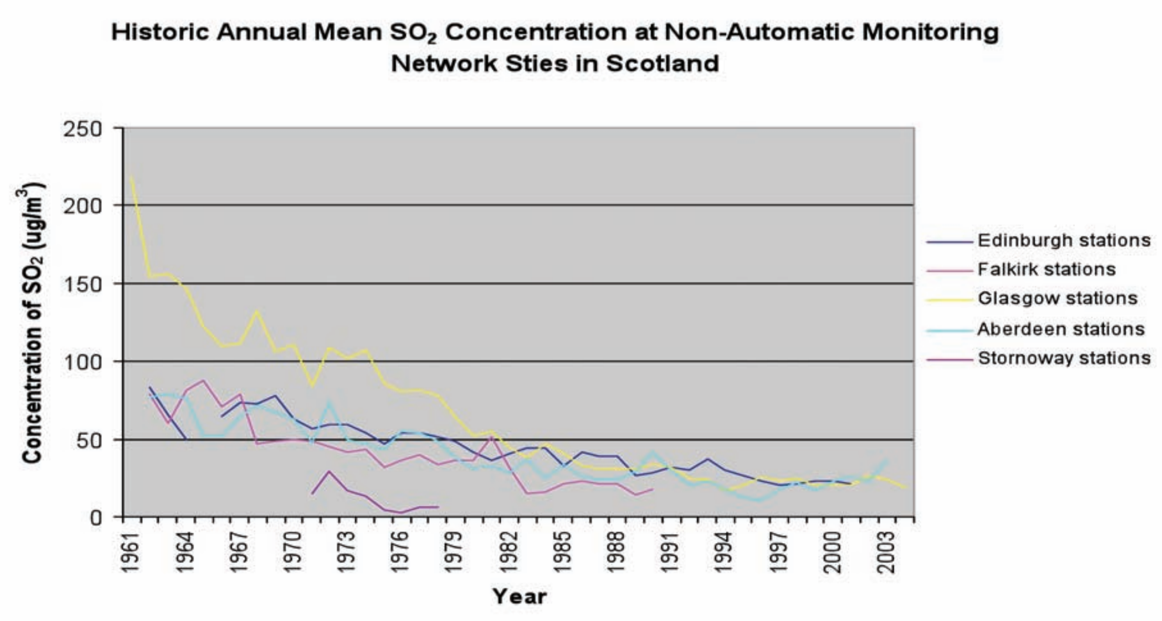
UK perspective

Levels of SO_2 emissions have decreased dramatically over the past several decades. However, the recovery of natural systems experiencing the effects of acidification is much slower. Oxides of nitrogen (NO_x) also act as a key pollutant in generating wet acid deposition, compounding the effects of SO_2 pollution. Data on acidity in soils are sparse, such that there is no definite evidence as yet that acidified soils are recovering. There is some evidence of chemical and biological recovery of some acidified freshwaters, although predicting rates of recovery in many areas can be difficult because nitrogen compounds in the atmosphere also contribute to acidification.

Since the Clean Air Act of 1956, annual urban levels of SO_2 have fallen by around 75%, and are predicted to decline further. This continued reduction is due to a number of factors, including the decline of traditional heavy industry, improved combustion and abatement technologies, and a move from coal to other fuels that are lower in sulphur content (eg gas). Figure 2, below, shows how atmospheric concentrations of SO_2 have decreased at Scottish Air Quality Monitoring Network sites since 1961. Power generation is currently responsible for almost 50% of the UK's total emissions of SO_2 (this had been at almost 80% in 1990), with other combustion activities and petroleum-refining now making up another 20%.

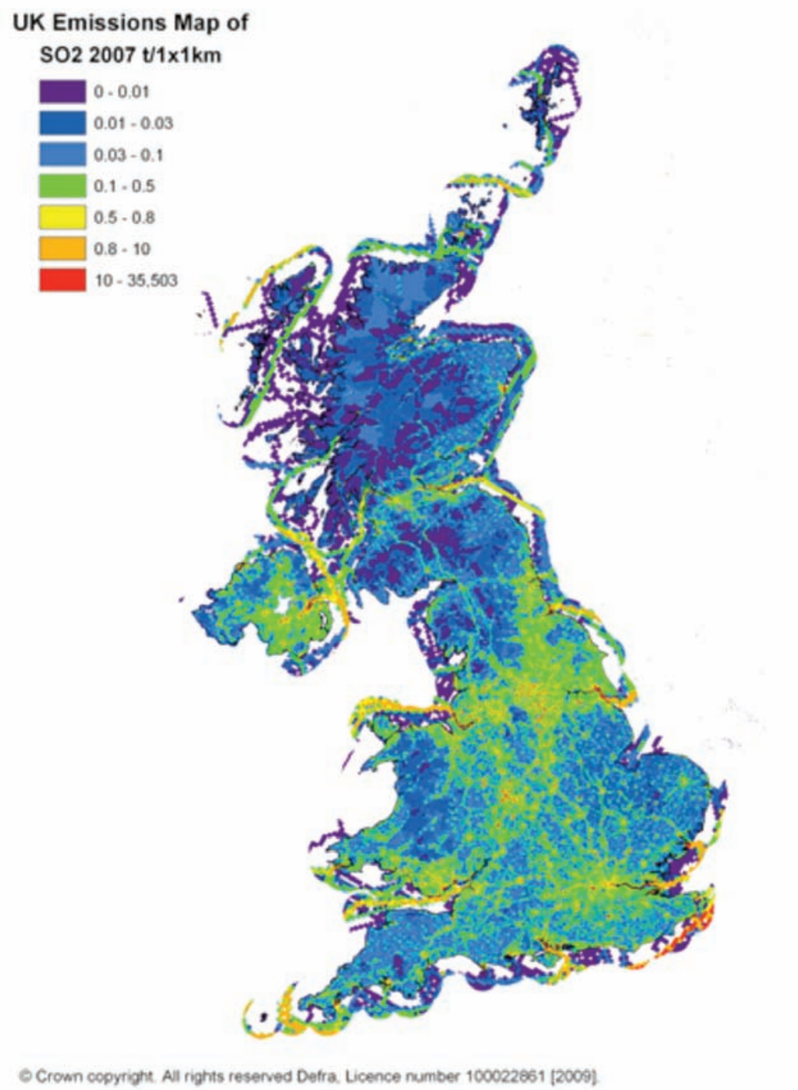
Figure 3 shows SO_2 emissions levels across the UK in 2007. While much of Scotland experiences low levels of SO_2 emissions, key hotspots, especially in central Scotland will require careful monitoring to ensure there are no adverse effects on air quality.

Figure 2: Total annual concentration of SO_2 recorded at five locations in Scotland since 1961



(Source: Scottish Environmental Statistics Online).

Figure 3: SO_2 emissions in the UK, 2007



(Source: National Atmospheric Emission Inventory)

Scottish perspective

The majority of the industrial emissions of SO_2 in Scotland can be found in east central Scotland. The largest emissions come from the Longannet power station in Fife and the Cockenzie power station in East Lothian. While these emissions are significant, there is no evidence to suggest that these sources are having an adverse effect on local air quality. Table 3 shows the annual mass emissions of SO_2 from the 10 largest industrial sources contained within the Scottish Pollutant Release Inventory (SPRI).

Table 3: 10 largest industrial sources of SO_2 emissions in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007
Scottish Power Generation Ltd, Longannet Power Station	67,100	40,900	31,747	33,819	25,038
Scottish Power Generation Ltd, Cockenzie Power Station	19,700	21,039	16,000	22,648	20,901
INEOS Manufacturing Scotland Ltd (Refinery), Grangemouth	7,770	3,740	3,537	6,029	5,618
Lafarge Cement UK, Dunbar Works	5,360	5,670	5,630	4,058	3,468
Tullis Russell Papermakers Limited, Glenrothes	956	1,030	1,047	1,457	1,159
Alcan Aluminium UK Ltd, Lochaber Smelter	782	726	726	711	626
O – I Manufacturing UK Ltd, Alloa	540	581	561	579	604
Scottish & Southern Energy, Peterhead Power Station	No data	193	1,440	2,800	537
Scottish & Southern Energy, Lerwick Power Station	No data	494	454	353	428
Caradale Brick Ltd., Mayfield Brickworks, Carluke	No data	134	185	160	266

(Source: Scottish Pollutant Release Inventory)

Grangemouth

Falkirk Council designated an air quality management area (AQMA) in 2005, when it was found that the concentrations of SO_2 in the Grangemouth area were regularly exceeding the 15-minute air quality objective. This is the only AQMA in Scotland that has been designated because of emissions from an industrial source.

The objective was exceeded every year between 2001 and 2005, but the number of exceedances appeared to be reducing year on year, with fewer exceedances of the threshold value and no exceedances of the objective in 2005 and 2006. It was assumed that the emissions of SO_2 had been reduced to levels that would not result in an exceedance of the objective. However, 2007 and 2008 saw a dramatic reversal, with exceedances of the 15-minute objective measured at the Municipal Chambers and Moray monitoring stations. The increased emissions of sulphurous emissions were due to a new crude oil supply that contained a higher content of sulphur.

SEPA has worked closely with Falkirk Council and INEOS to develop an effective air quality action plan[2]. The plan was published in 2007 and contains several key measures that will work towards compliance with the SO_2 air quality objective. The measures include:

- improving access to data;
- creating a working group;
- setting up an automated text messaging system that sends out a warning when the localised concentrations of SO_2 exceed a pre-determined level;
- extending the monitoring network.

[2] www.airquality.co.uk/laqm/documents/action_plan_reports/E_FAL_026_Action_Plan.pdf

While the highest concentrations of ambient SO_2 in Scotland have been measured in Grangemouth, they do not exceed the category of moderate pollution, as defined in the Scottish Government's Air Pollution Banding and Index Classification Scheme. The classification system is used to assess the effects of poor air quality on people who are sensitive to air pollution, and it can be viewed on the Scottish air quality website. The scheme shows that the effects of SO_2 at the concentrations measured in Grangemouth will be 'mild and unlikely to require action; however some sensitive individuals may be affected'.

SEPA is currently working to reduce emissions of sulphurous gases, in order to ensure compliance with all three of the air quality objectives for SO_2.

SEPA projects

Over recent years, SEPA has completed a number of studies that have assessed the emissions of SO_2, and their impact on local air quality. Examples include:

- *Sulphur dioxide in ambient air at Grangemouth Docks* (2003);
- *Determination of ambient sulphur dioxide, oxides of nitrogen and particulate matter downwind of Lafarge Cement Limited* (2004–2005);
- *Determination of ambient sulphur dioxide at Prestonpans* (2005–2006).

This body of work remains an important part of SEPA's knowledgebase on air quality issues.

Conclusion

Annual mean concentrations of SO_2 have dropped significantly over the past few decades as a result of fuels with a lower sulphur content and improved technology. SEPA's environmental improvement action plans (EIAP) continue to contain plans related to air quality, some of which are aimed at improving knowledge of SO_2-related air quality issues. SEPA will continue to regulate installations in accordance with best available techniques and work with local authorities where AQMAs have been designated for SO_2.

4 Oxides of nitrogen

All combustion processes in air produce oxides of nitrogen (NO_x). 'NO_x' is a collective term for the two main nitrogenous gases that cause air pollution problems; nitric oxide (NO), and nitrogen dioxide (NO_2). NO reacts with oxygen (O_2) or ozone (O_3) in the air to produce NO_2. NO_x occurs both naturally, as well as being produced by human activities. The largest source of NO_x in the UK is road transport, although the contribution from power generation is also significant.

Although NO is the primary pollutant, the impacts on both human health and the environment are generally associated with the NO_2 that is formed when NO is oxidised. High concentrations of NO_2 levels can affect individuals with respiratory conditions, such as asthma. Lung function and airway responsiveness can be affected, and NO_2 may also increase sensitivity to natural allergens. While population studies have shown adverse health effects, the link between NO_2 and poor health is not clear. The World Health Organisation (WHO) has concluded that 'NO_2 is an important constituent of combustion-generated air pollution and is highly correlated with other primary and secondary combustion products, it is unclear to what extent the health effects observed in epidemiological studies are attributable to NO_2 itself or to other correlated pollutants'[3]. This is particularly relevant in the urban environment, where road traffic is the main source of local air pollution. The same report added 'the observed health effects might also have been associated with other combustion products, eg ultrafine particles, NO, particulate matter or benzene.'

High levels of NO_x can damage plant life and, along with SO_2, contribute to acidification through wet and dry deposition. Wet deposition occurs when NO_x molecules are oxidised and dissolved in cloud moisture as nitric acid (HNO_3). Acid gases may also deposit directly onto terrestrial surfaces by dry deposition, and the acidity is generated as the gas is oxidised. Under specific conditions, NO_x also reacts with other pollutants, including non-methane volatile organic compounds (NMVOCs), to form ground-level O_3 (see Section 6). Additionally, deposition of nitrogen can lead to the acidification of soils and surface waters. The process is similar to that for the deposition of SO_2 (see Section 2). Current wet deposition of reduced nitrogen exceeds that of sulphur and therefore the total potential acidification in the UK is now dominated by nitrogen deposition. The deposition of nitrogen may also affect soil biological processes, in particular nitrogen-cycling.

UK perspective

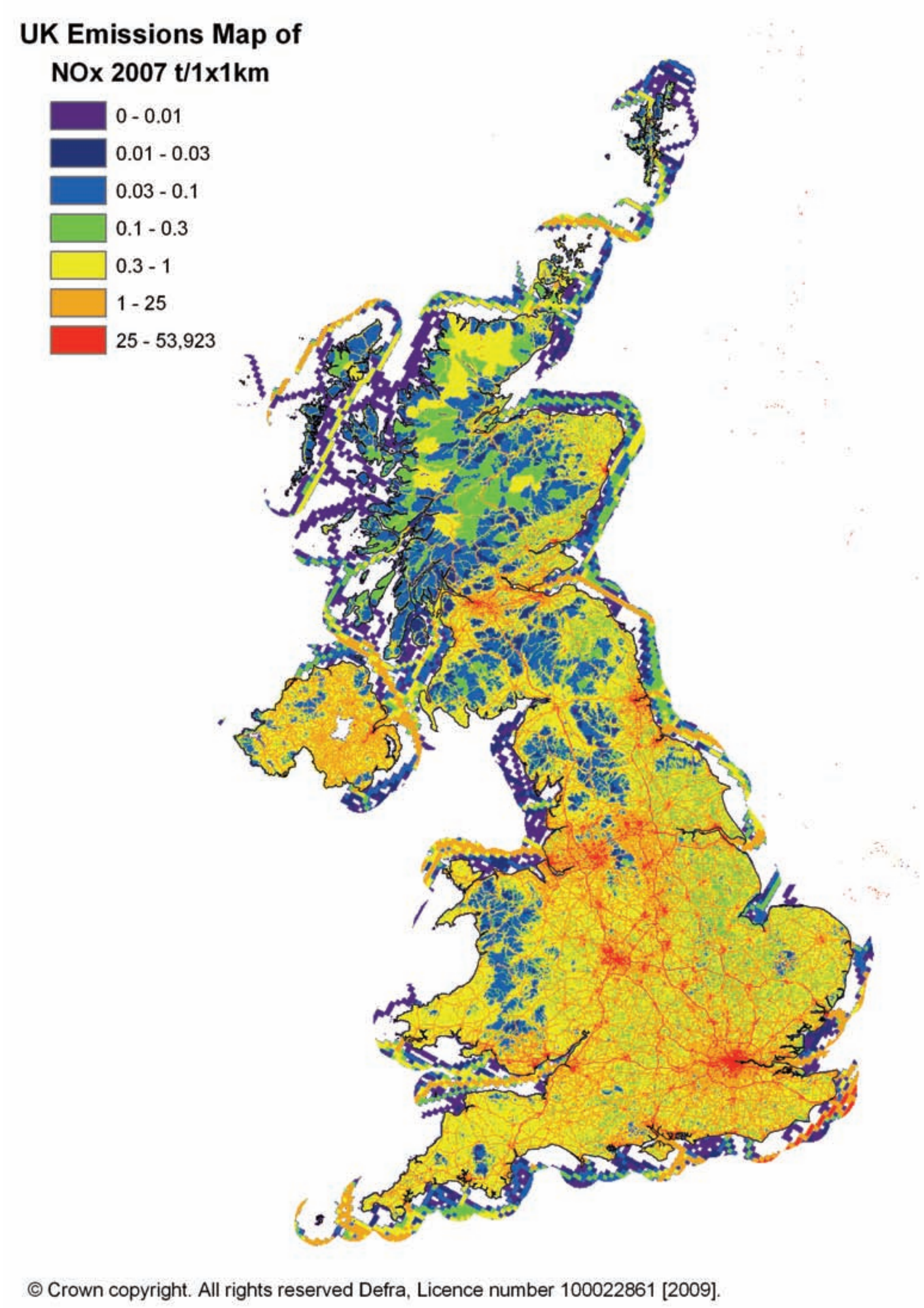
In 2007, approximately 32% of all UK NO_x emissions were related to road transport sources, with energy generation contributing another 30%. There are several other diffuse sources of NO_x that contribute to the total, including aviation, rail transport and merchant shipping[4]. However, the majority of UK emissions of NO_x are exported and can travel distances in excess of 1,000km.

Figure 4, below, shows emissions of NO_x across the UK for 2007. The lowest emissions are in the rural areas, while urban areas are showing moderate to high concentrations of NO_x. Patterns of high NO_x are shown to follow major roads and areas of high traffic and population density, including some of the main commuter routes and urban centres in Scotland.

[3] WHO | Air quality guidelines - global update 2005

[4] www.naei.org.uk/emissions/emissions.php

Figure 4: NO_X emissions in the UK, 2007

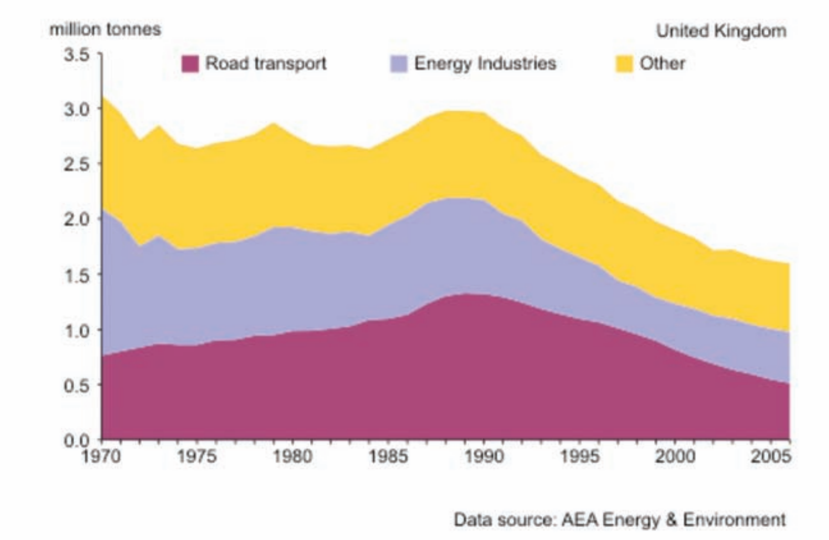


(Source: National Atmospheric Emission Inventory)

Emissions from road transport peaked at just over 1.33 million tonnes in 1989, but have since fallen by 61% to less than 515 thousand tonnes. This is partly due to the installation of catalytic convertors in vehicles. Emissions from the energy industries fell by 51% between 1990 and 2000, but have begun to increase since[5].

[5]www.defra.gov.uk/environment/quality/air/index.htm

Figure 5: Emissions of NO_x by source 1970–2006



Scottish perspective

The majority of Scotland's industrial NO_x emissions are generated in east central Scotland, where the largest emitters of NO_x are the Longannet and Cockenzie power stations near Edinburgh. The annual mass emissions from the 10 largest industrial sources of NO_x in Scotland are given below in Table 4.

Table 4: 10 largest industrial sources of NO_x emissions in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007
Scottish Power Generation Ltd, Cockenzie Power Station	10,700	12,100	11,400	20,294	22,054
Scottish Power Generation Ltd, Longannet Power Station	23,500	19,400	19,087	22,731	14,876
INEOS Manufacturing Scotland Ltd (Chemicals), Grangemouth	1,120	1,110	1,323	1,110	3,247
INEOS Manufacturing Scotland Ltd (Refinery), Grangemouth	5,250	3,269	3,349	3,466	3,047
Scottish and Southern Energy, Peterhead Power Station	1,990	1,980	2,130	2,750	2,110
Scottish & Southern Energy Plc, Lerwick Power Station	2,650	1,530	1,946	1,643	1,676
Lafarge Cement UK, Dunbar Works	1,110	1,695	1,270	1,221	1,459
Ardagh Glass Ltd, Irvine	962	638	475	742	994
Shell UK Ltd, St Fergus Gas Plant	102	992	1,010	922	899
ExxonMobil Chemical Ltd, Mossmorran	1,500	1,840	1,594	1,651	798
O – I Manufacturing UK Ltd, Alloa	807	784	777	821	792

(Source: Scottish Pollutant Release Inventory)

Non-regulated sources: road traffic

Annual average concentrations of NO_x have been decreasing at most background monitoring locations; however, some urban locations are showing a rise in the levels of NO_x as urban development and the volume of road traffic increases. Of the 21 air quality management areas (AQMAs) that have been declared in Scotland (at July 2009), 14 are in response to an exceedance, or predicted exceedance, of one of the air quality objectives for NO_2. Road traffic has been identified as the most significant source of this pollution and it accounts for 88% of NO_x emissions in Edinburgh[6] and 76% in Glasgow[7]. While background monitoring sites are generally showing a decline in NO_2, concentrations at some roadside locations appear to be increasing. Also, some of the original AQMAs are being extended as the monitoring programmes extend in to other areas.

The Air Quality Expert Group[8] report noted that, although NO_x concentrations have fallen at the roadside, the concentration of NO_2 has risen due to the increase in primary NO_2 emissions from vehicles. The report concluded that this was an unintended outcome of the fitting of oxidation catalysts to EURO3[9] light-duty diesel vehicles and heavy-duty vehicles fitted with catalytically regenerative particle traps. Recent studies have shown that this unintended effect can be mitigated, but it is clear that increased consideration needs to be given to the synergistic relationship between pollutants.

The biggest challenge to meeting the NO_2 objective will be reducing emissions from road traffic. Some local authorities have shown that buses and heavy goods vehicles are responsible for a disproportionately high volume of NO_2. City of Edinburgh Council commissioned a low emission study[10] that reviewed the options being considered to improve air quality. The study concluded that reduced emissions from bus and heavy goods vehicles would bring the greatest improvement in air quality.

The local authorities have considered numerous approaches to dealing with the problem of poor urban air quality, and some of these options are included in their air quality action plans. For example, the City of Edinburgh Council considered the introduction of a congestion charging scheme, but this option was later rejected by the public. Some local authorities are looking to work with bus and heavy goods vehicles (HGV) operators, as they are the largest sources of NO_2 in the urban centres. Other measures include road-side testing of vehicles, car clubs, travel plans, altering traffic light sequences and reducing the speed of traffic. The traffic management strategies have resulted in a slight reduction of NO_2 at some locations, but there has been an increase at others.

The situation is such that monitoring has shown that both the annual mean and the one-hourly air quality objectives are being exceeded. Some local authorities now need to extend the boundaries of their earlier AQMAs, as monitoring highlights the full extent of the air quality problem. No AQMAs have been revoked in Scotland and the number of AQMAs is likely to increase, as local authority monitoring networks extend into other areas.

Figure 6 contains plots of the annual mean concentrations of NO_2 at a selection of automatic monitoring stations in Scotland. It clearly shows that the concentrations at some locations are reducing (Glasgow St. Enoch and Glasgow City Chambers), but there are others where the levels are increasing (Glasgow Hope Street and Dumfries). The monitoring station in Edinburgh Centre was relocated in 2002 due to construction work. More detailed information about the monitoring stations can be found on the Scottish air quality website.

This information should be viewed with caution. The automatic monitoring stations are large and they need to be located where they will not cause an obstruction, ie narrow, congested streets where the pollution is likely to exist at its highest levels. A different monitoring technique is used at these locations and this information is available in the local authority annual reports.

[6]Air Quality Action Plan 2008-2010: City of Edinburgh Council

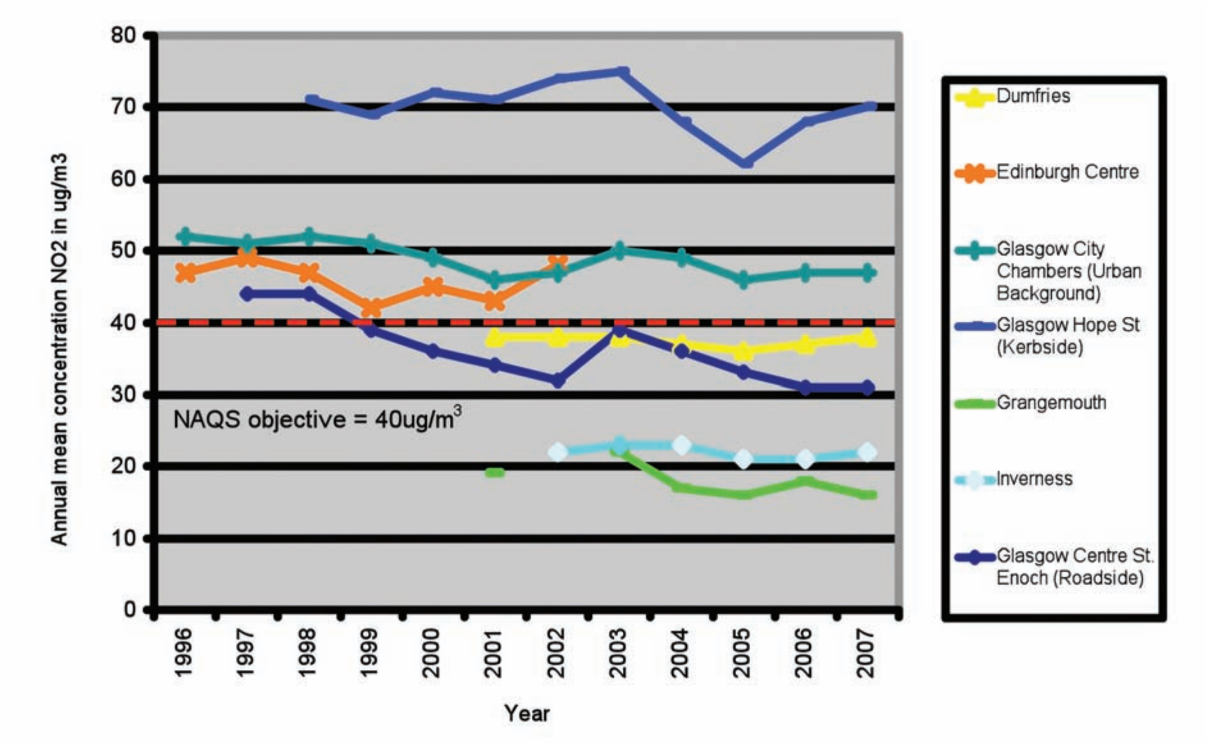
[7]www.glasgow.gov.uk/en/Residents/Environment/Pollution/Air/LocalAirQualityManagement.htm

[8]The Air Quality Expert Group is an advisory group that provides independent scientific advice on air quality, in particular the air pollutants contained in the Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland and those covered by the EU Directive on ambient air quality assessment and management.

[9]European Union emission regulations for new light duty vehicles (cars and light commercial vehicles) are specified in Directive 70/220/EEC. This directive has been amended a number of times and the Euro 4 standards were set out in Directive 98/69/EC.

[10]City of Edinburgh Council: Air Quality Action Plan: 2008-2011: www.edinburgh.gov.uk/internet/Attachments/Internet/Environment/Sustainable%20Development/0809_Air_Quality_Action.pdf

Figure 6: Annual mean concentration of NO_2 recorded at a selection of the Automatic Monitoring Network sites in Scotland, 1996–2007



Note: Annual mean not to exceed 40µg/m³ by December 2005 to meet AQS Objectives.

(Source: Scottish Environmental Statistics Online)

Conclusion

Emissions of NO_x from industrial sources constitute a significant proportion of the Scottish total due to the large contribution from power generation sources. SEPA will continue to regulate installations in accordance with best available techniques.

Road traffic is the most significant contributor to high NO_2 levels in urban centres; 14 AQMAs have been designated in Scotland. An increase in construction activity and the growth in road traffic (particularly diesel-powered vehicles) have exacerbated the problem, despite continuing engine technology improvements. SEPA will continue to work with local authorities where AQMAs have been designated for NO_2.

5 Particulate matter

Particulate matter (PM) is a generic term that describes a wide range of material that can be generated by both natural events and human activity. The current air quality standards and objectives for PM relate to material that is less than 10 m in diameter (commonly referred to as PM_{10}), but there is an increasing focus on the smaller fractions that are known to affect human health.

A significant proportion of the annual mean concentrations of PM_{10} will consist of regional background sources. The exact background contribution at any site will be variable, and it will depend on the geographic location. For example, background levels in the south of England are higher than the levels that exist in Scotland. For analytical reasons, the PM_{10} category has been further divided into primary, secondary and coarse particulates as shown below in Table 6.

Table 6: Sub categories of particulate material

Primary	Material that is <2.5 m in diameter ($PM_{2.5}$)	Particle emissions derived directly from combustion sources.
Secondary		Formed by chemical reactions in the atmosphere.
Coarse	Material in the range 2.5 m to 10 m ($PM_{2.5}$ to PM_{10})	Re-suspended dust from traffic/construction, wind-blown, etc.

Generally speaking, the primary and coarse material is likely to have originated from local sources, such as material that has been disturbed by passing road traffic, agricultural activity, or local combustion source; but there are occasions when it will have been carried in from other areas. Secondary particulates are more complicated, in that they are formed by chemical reactions in the atmosphere; therefore the source of the emission could be located some distance from the monitoring station that has detected them. The Airborne Particles Expert Group (APEG) reported that in a year with typical metrology, about 15% of the total annual average of PM_{10} concentrations (about 50% of the secondary particles) are derived from mainland Europe[11].

Particulate matter can result in a number of impacts on both human health and the environment. It can be carried into the lungs and exacerbate respiratory conditions, such as asthma, and can also enhance sensitivity to allergens. The environmental impacts of PM include:

- covering of vegetation by dust;
- deposition of pollutants changing the nutrient and chemical balance, which can lead to acidification and eutrophication;
- deposition of heavy metals with toxic effects on animals, plants and humans;
- transboundary transport of air pollutants as fine particles;
- light scattering leading to the potential to offset global warming and reductions in visibility.[12]

Numerous studies have linked short-term and long-term exposure to ambient concentrations of PM with respiratory and cardiovascular illness and mortality. The USA has had reduction targets for $PM_{2.5}$ in place since 1997, and it has recently tightened the 24-hour standard from $65µg.m^{-3}$ to $35µg.m^{-3}$. The recently revised UK Air Quality Strategy emphasises: 'there is clear and unequivocal health advice that there is no safe level for exposure to fine particulates', and it now contains objectives that have been introduced to reduce the levels of PM_{10} and $PM_{2.5}$ in the UK. While the new objectives for $PM_{2.5}$ are not currently prescribed in legislation, the recent EU Ambient Air Quality and Clearer Air for Europe Directive of 2008 and has introduced a requirement for Member States to reduce ambient concentrations of $PM_{2.5}$. This directive must be transposed by Member States no later than 11 June 2010.

[11]Airborne Particles Expert Group (APEG), 1999. Source apportionment of particulate matter in the United Kingdom. HMSO.

[12]www.apis.ac.uk/overview/pollutants/overview_particles.htm

Air quality standards

The Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland contains three air quality objectives for PM_{10}. The Air Quality (Scotland) Regulations 2000 introduced an annual mean of 40µg.m^{-3} and a 24-hourly mean of 50µg.m^{-3}. These objectives have also been prescribed as limit values in The Air Quality Standards (Scotland) Regulations 2007.

The Air Quality (Scotland) Amendment Regulations 2002 introduced a tighter annual mean objective of 18µg.m^{-3} that only applies to Scotland and this replaced the 40µg.m^{-3} objective. The regulations also tightened the 24-hourly objective, by reducing the number of allowable exceedances of the 40µg.m^{-3} objective from 35 to seven.

The recently revised UK AQS guidance (2009) contains three new objectives for $PM_{2.5}$, however, these objectives have yet to be prescribed in legislation and therefore there is currently no requirement for local authorities to monitor $PM_{2.5}$. A provisional annual mean air quality objective of 25µg.m^{-3} will apply to the whole of the UK, with the exception of Scotland, where there is a provisional annual mean objective of 12µg.m^{-3} (this objective has been based on the existing Scottish 18µg.m^{-3} annual mean objective for PM_{10} and it assumes that the ratio of $PM_{2.5}$ to PM_{10} will be in the region of 0.6).

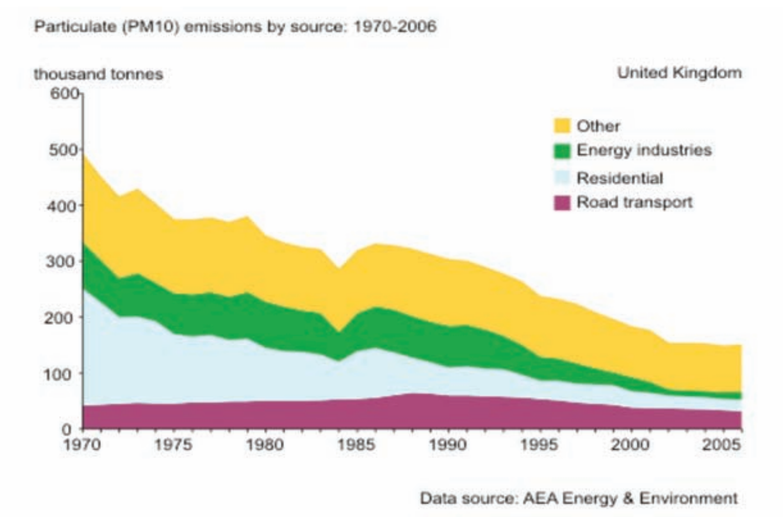
The strategy also contains a percentage reduction objective that requires a 15% reduction of urban background concentrations (in relation to 2010 levels) across the whole of the UK (this approach is referred to as 'exposure reduction'). The percentage reduction objective will provide a relative measure of improvement and the 'backstop objective' (or concentration cap) of 12µg.m^{-3} is designed to deliver a minimum level of protection applicable to all areas.

UK perspective

Between 1980 and 2006 (see Figure 7) total PM_{10} emissions fell by 56% in the UK. Over the same period, PM emissions from residential fossil fuel-use fell by 78% and emissions from the energy industries fell by 84%. Improvements have been associated with a number of factors, such as the installation of better abatement equipment, increased process efficiency and increased use of natural gas for electricity generation. Road transport now contributes 21% of all PM_{10} emissions (in 1980 it was approximately 15%). The main source of PM_{10} emissions from road transport is from the exhausts of diesel engine vehicles.[13]

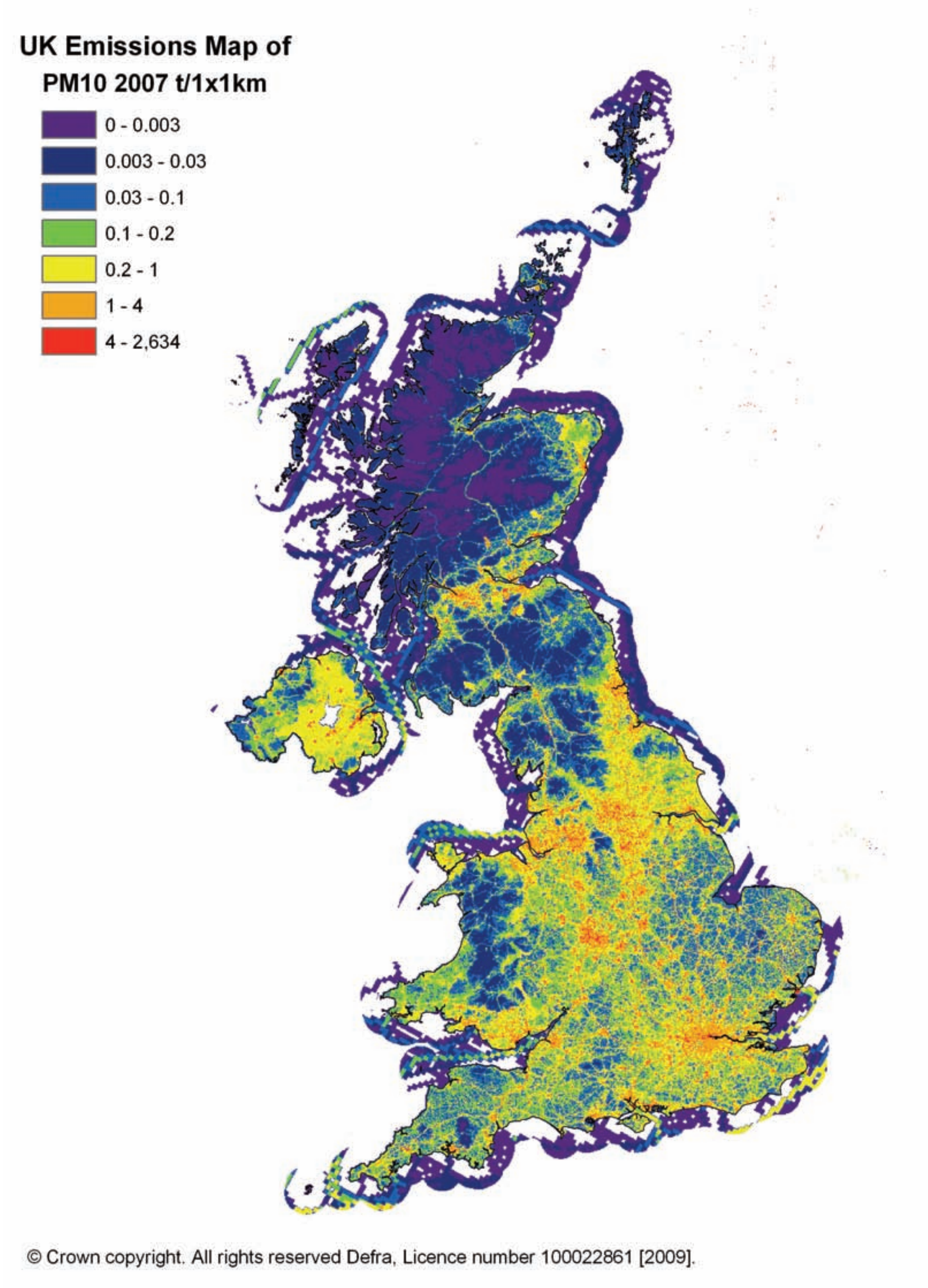
Figure 8 and 9 show emission levels of PM_{10} and $PM_{2.5}$ across the UK for 2007. Patterns of high concentrations of PM_{10} are shown to follow major roads and areas of high traffic and population density. This includes some of the main commuter routes and urban centres in Scotland.

Figure 7: Emissions of PM (PM_{10}) by source 1970–2006



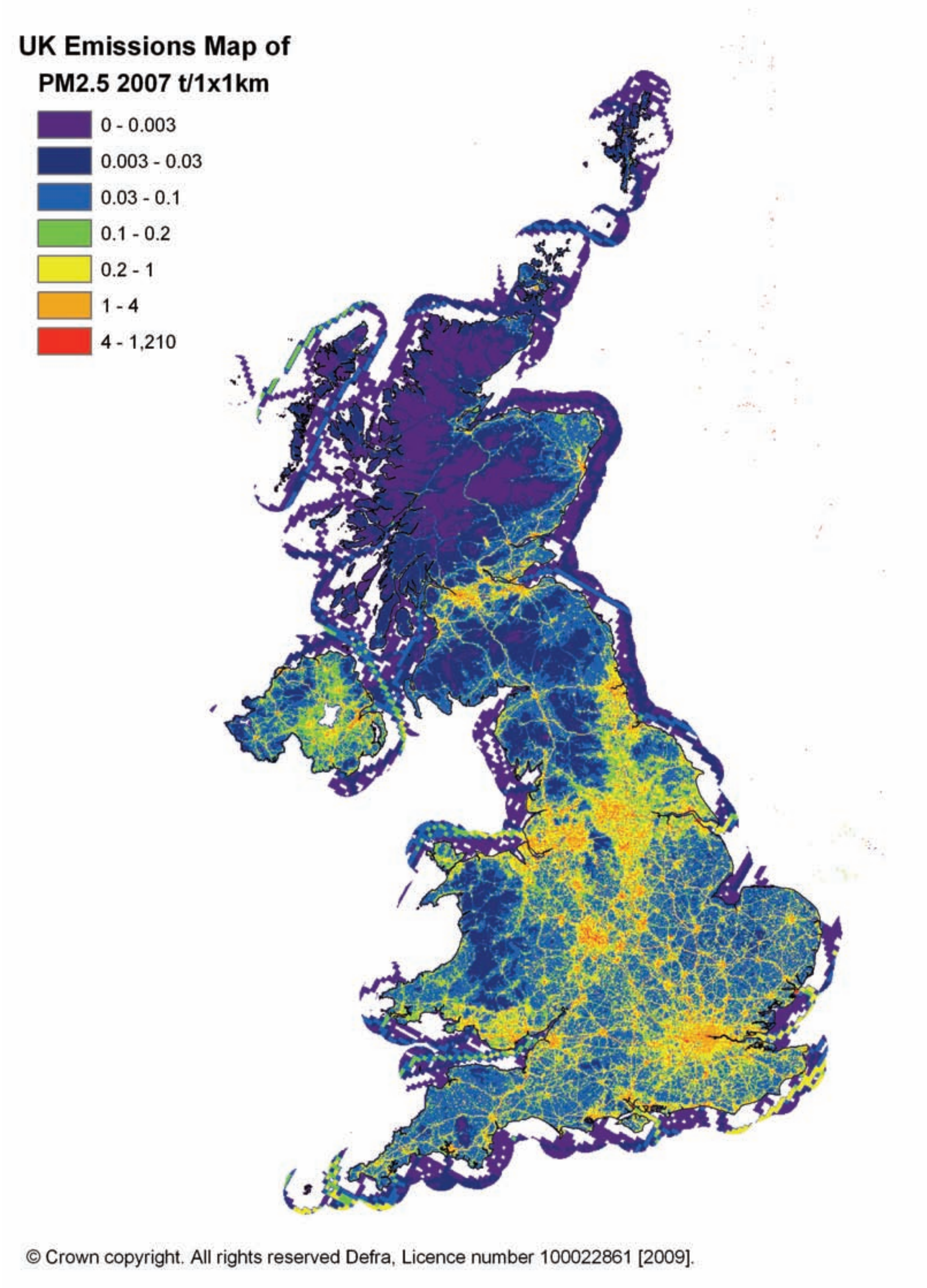
[13]www.defra.gov.uk/environment/quality/air/index.htm

Figure 8: Particulate matter (as PM_{10}) emissions in the UK, 2007



(Source: National Atmospheric Emissions Inventory)

Figure 9: Particulate matter (as $PM_{2.5}$) emissions in the UK, 2007



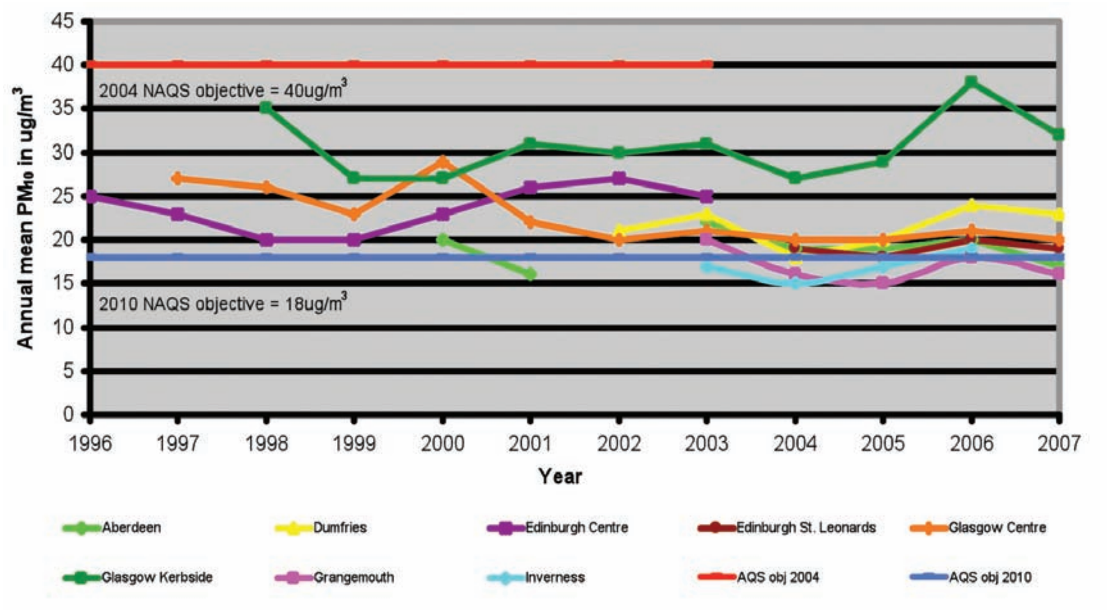
(Source: National Atmospheric Emissions Inventory)

Scottish perspective

While the concentrations of PM across the majority of Scotland are meeting the stringent 18µg.m^{-3} annual mean objective, there are some locations where the objective is being exceeded and air quality management areas (AQMAs) have been designated by the local authorities (see Table 2). Annual emissions of PM_{10} have decreased at most background locations; however, some urban locations are experiencing rising levels of PM as urban development and levels of road traffic increase. Figure 10 shows annual mean concentrations of PM_{10} at Automatic Monitoring Network sites in Scotland. Primarily, these represent urban sites, with the larger urban areas of Edinburgh and Glasgow showing the highest levels of PM_{10}. Only one site in Scotland (Aberdeen Market Street) is currently exceeding the 40 µg.m^{-3} annual mean objective, but there are extensive construction works underway and these are influencing the measurements. The monitoring station in Glasgow's Hope Street is located in a street canyon, where it measures emissions from road traffic, and it is exceeding the 24-hourly objective. Midlothian Council recently designated an AQMA because the concentrations of PM from domestic fires are exceeding the 18µg.m^{-3} annual mean objective.

The requirement to monitor $PM_{2.5}$ is relatively new and while some short studies have been undertaken by SEPA and the Scottish Government, at this time there are no long-term monitoring data that can be used to state the current position.

Figure 10: Total annual concentration of PM_{10} recorded at Automatic Monitoring Network sites in Scotland (urban and rural). 1996–2007



Note: Annual mean not to exceed 40 µg/m^3 by December 2004 and 18ug/m^3 by end 2010 to meet AQS objectives.

(Source: Scottish Environmental Statistics Online)

Background concentrations

Monitoring has shown that background concentrations can have a considerable impact over large areas and they can influence local authority measurements. There are numerous examples of where PM carried in from other areas has increased PM_{10} measurements in the local authority areas. This material can travel from Europe or Africa and such events can affect very large areas. The following examples provide a summary of two events that were investigated by SEPA officers.

Example one

On 12 September 2002, local authority air quality monitoring stations recorded unusually high concentrations of PM_{10} (in the region of 150-200 g.m^{-3}) at Newcastleton, Musselburgh and Whitburn. This event was also recorded by the monitors located in Edinburgh and Glasgow, thus suggesting that the event covered a large area.

On contacting the air quality archive helpline, it was established that the high concentrations of PM_{10} were measured at most of the air quality monitoring sites in the northern half of the United Kingdom. A report written by the UK Met Office[14] confirmed that elevated concentrations of PM were recorded at a number of monitoring sites across the UK, and it went on to suggest that one possible cause may have been forest fires that were burning in Western Russia. Similar observations were reported in a study that was published by NETCEN[15] in November 2002.

[14] www.airquality.co.uk/reports/cat12/russian_forest_fires_ajm.pdf

[15] www.airquality.co.uk/reports/cat12/Ad-hoc_PM10_report_Sept2002.pdf

Example two

On 4 May 2008, 17 complaints were received by the SEPA Pollution Incident Hotline, reporting deposition of dust on cars in the Grangemouth/Polmont area near Falkirk. The dust was fine-grained (almost talc-like) and light tan in colour. Visually it looked like the dust had been deposited when it had been raining.

A number of industrial sites in the Grangemouth area were contacted to identify any possible sources of the dust. None reported any incidents that could have led to a fine tan-coloured dust being released.

Analysis of monitoring data identified higher than normal concentrations of PM_{10} that were seen across Scotland's Central Belt (Edinburgh, Grangemouth and Glasgow) and beyond (Dundee). This suggested that this was a widespread occurrence and not one associated with a localised industrial source.

The analytical results confirmed that the dust came from a natural source and was not related to an industrial process. Furthermore, the Met Office advised SEPA that weather patterns at the time suggested that the fine sand/soil particulates were likely to have been carried from North Africa and Spain, up over England and Scotland, where it was deposited by the rain on 3 and 4 May.

Industrial emissions

The majority of the PM_{10} emitted from industrial processes in Scotland are generated in east central Scotland, with the largest contributions coming from the power generation sector. However, there is no evidence to show that these sources are having a detrimental impact on local air quality. Table 7 lists the annual mass emissions from the 10 largest industrial sources of PM in Scotland.

Table 7: 10 largest industrial sources of PM_{10} (and smaller PM) emissions in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007
Scottish Power Generation Ltd, Cockenzie Power Station	637	738	697	1,257	1,323
Scottish Power Generation Ltd, Longannet Power Station	1,140	700	662	943	555
INEOS Manufacturing Scotland Ltd (Refinery), Grangemouth	212	202	191	194	200
INEOS Manufacturing Scotland Ltd (Chemicals), Grangemouth	244	235	253	158	144
Lafarge Cement UK, Dunbar Works	70	103	33	65	122
The Cheese Company, Lockerbie Creamery	N/A	BRT	BRT	95	98
The Caledonian Cheese Company Ltd, Stranraer	N/A	N/A	BRT	BRT	73
Scottish & Southern Energy, Peterhead Power Station	No data	20	67	64	68
O – I Manufacturing UK Ltd, Alloa	No data	72	68	54	55
Norbord Ltd, Pulp and Board Plant, Cowie	No data	76	159	140	51

(Source: Scottish Pollutant Release Inventory)

SEPA projects

In recent years SEPA has undertaken several short monitoring assessments in response to concerns raised by the public.

Example three

SEPA carried out several assessments in the Cockenzie area, in response to complaints regarding coal dust that was being deposited on properties. The residential housing development concerned is located to the north-east of the coal storage facility for the Cockenzie power station.

The assessment set out to establish:

1) if the levels of deposition could be regarded as being a nuisance;

2) to identify the likely source(s);

3) to measure the atmospheric concentrations of PM_{10}.

Sticky pad analysis and an automated gravimetric PM_{10} unit were used as sampling methods. Wind speed and direction were also measured.

While the results of the study indicated that the coal storage facility is very likely to be a significant source of coarse PM in the local area, the 24-hourly air quality objective for PM_{10} was not breached.

Non-regulated emissions

Of the 21 air quality management areas (AQMAs) that have been declared in Scotland, 12 are because the stringent $18 \mu g.m^{-3}$ annual mean objective for PM_{10} will be exceeded in 2010. Road traffic is the principal cause of elevated PM_{10} in urban centres, through a combination of re-suspended material from the road, particles of metal and brake pads, and some exhaust emissions. However, several local authorities have reported that construction and demolition work is having a very significant impact on local air quality, and these activities have resulted in an exceedance of the standards.

Biomass

Concerns about climate change have resulted in several Scottish Government initiatives that have set out to promote more sustainable forms of generating energy that are not dependent on fossil fuels. The Scottish Biomass Support Scheme was launched to support the biomass sector (with particular emphasis on wood fuel), with £7.5m of funding made available between 2006 and 2008. Local authorities have received numerous planning applications for small-medium scale systems, some of which are already operational. Small domestic wood stoves are also becoming very popular, as they are cheap to install and operate.

Wood fuel is seen to be carbon neutral, and if used to replace a unit that burns fossil fuel, it may help to reduce Scotland's emissions of greenhouse gases (GHGs). However, studies in Europe and the USA have shown that an increase in biomass burning (particularly wood fuel) could increase the local concentrations of oxides of nitrogen (NO_x), polycyclic aromatic hydrocarbons (PAH) and fine PM.

A study[16] commissioned by the Scottish Government concluded: 'The modelling study demonstrates that biomass boilers will not be the major source of PM_{10} or $PM_{2.5}$ in urban areas. However, in areas that are already close to PM_{10} Air Quality Objectives, the additional contribution of biomass may lead to an exceedance at some city background locations. Note that this result applies to urban background concentrations and higher particle concentrations may be seen in areas close to other specific sources'. The Scottish Government has produced guidance for the use of biomass and wood-burning systems in response to requests from local authorities. Environmental Protection UK (EPUK) has also published a comprehensive guide on biomass and air quality[17] in which it advises, 'The approach to assessment should therefore have a lighter touch where risk is low (for example in a rural area where air quality is good, and coal and oil are the realistic alternative fuels), and more rigorous where risk is high (for example in or adjacent to an Air Quality Management Area)'. While the EPUK guidance has been created specifically for the local authorities in England and Wales, the advice is very similar to guidance that is currently being prepared for the Scottish local authorities.

As a regulator of medium to large-scale combustion plants, SEPA is currently examining how the new objectives for $PM_{2.5}$ will affect the way it regulates permitted sites. We are also working with the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER)[18] and the Environment Agency on a project that will identify how regulation of industry can reduce the concentrations of fine PM.

Conclusion

While there are significant emissions of PM_{10} from large industrial sites in Scotland, there is no evidence to show that these emissions have resulted in an exceedance of air quality objectives. On a local scale, road traffic and coal-fired domestic heating do have the potential to cause localised problems and these problem areas have been identified by the local authorities. Biomass burning could be an increasingly significant source of localised emissions.

SEPA will continue to regulate installations in accordance with best available techniques and work with local authorities where AQMAs have been designated for PM.

[16] Measurement and Modelling of Fine Particulate Emissions (PM_{10} and $PM_{2.5}$) from Wood-Burning Biomass Boilers, November 2008

[17] Biomass and air quality guidance for local authorities. Environmental Protection UK 2009 (www.environmental-protection.org.uk)

[18] www.sniffer.org.uk

6 Non–methane volatile organic compounds

Non-methane volatile organic compounds (NMVOCs) include a large group of mainly colourless gases and volatile liquids. Emissions of NMVOCs are derived from sources such as the combustion of fossil fuels, industrial processes such as oil refineries and distilleries, and the use of materials such as solvents, paints and aerosols. Natural emissions of NMVOCs originate from vegetation, including forests.

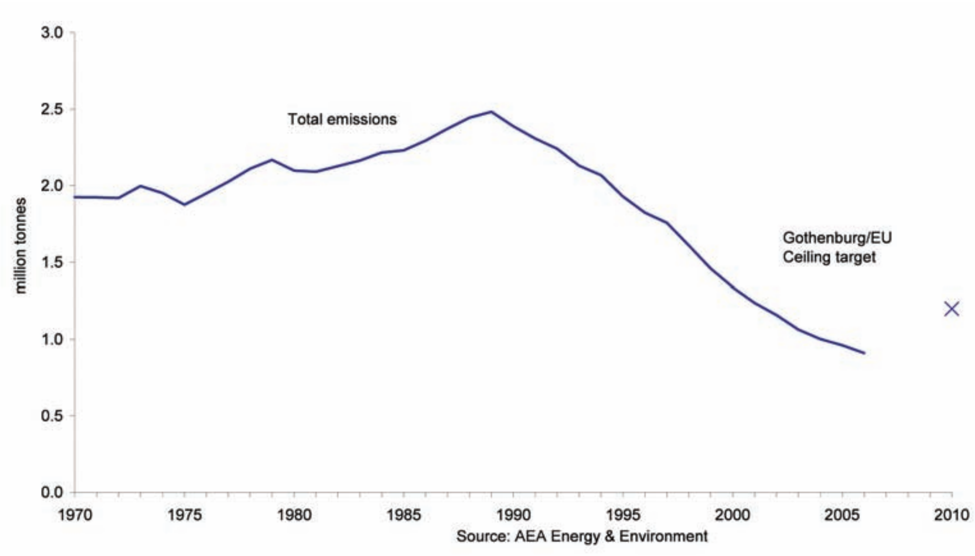
NMVOCs are generally not released in sufficient amounts to have a significant an effect on global warming, but they do have other environmental effects and effects on human health. One of these is the contribution to the generation of ground-level ozone (O_3). NMVOCs react with NO_2 in the presence of sunlight to generate ground-level O_3, which has effects on both the environment and human health. Ground-level O_3 is discussed in more detail in Section 6. While NMVOCs can lead to the generation of ground-level O_3, they have the reverse effect on stratospheric ozone, damaging the ozone layer in the upper atmosphere. NMVOCs as a whole are not included in the Air Quality Strategy objectives, although objectives have been set for benzene and 1,3-butadiene (both of which fall into the category of NMVOCs). NMVOCs are not monitored widely in Scotland, but where they have been, all results have met air quality standards.

UK perspective

UK levels of NMVOC emissions peaked around 1990 and have been decreasing steadily since (see Figure 11). Chemical industry processes and solvent-use activities remain some of the largest sources of NMVOCs. There has been a large reduction in emissions from road transport since 1999, both from petrol evaporation and emissions from passenger cars. This is encouraging, as the numbers of passenger cars has increased in this same time period. Figure 12 shows that emission levels of NMVOCs are greatest in urban and industrialised areas.

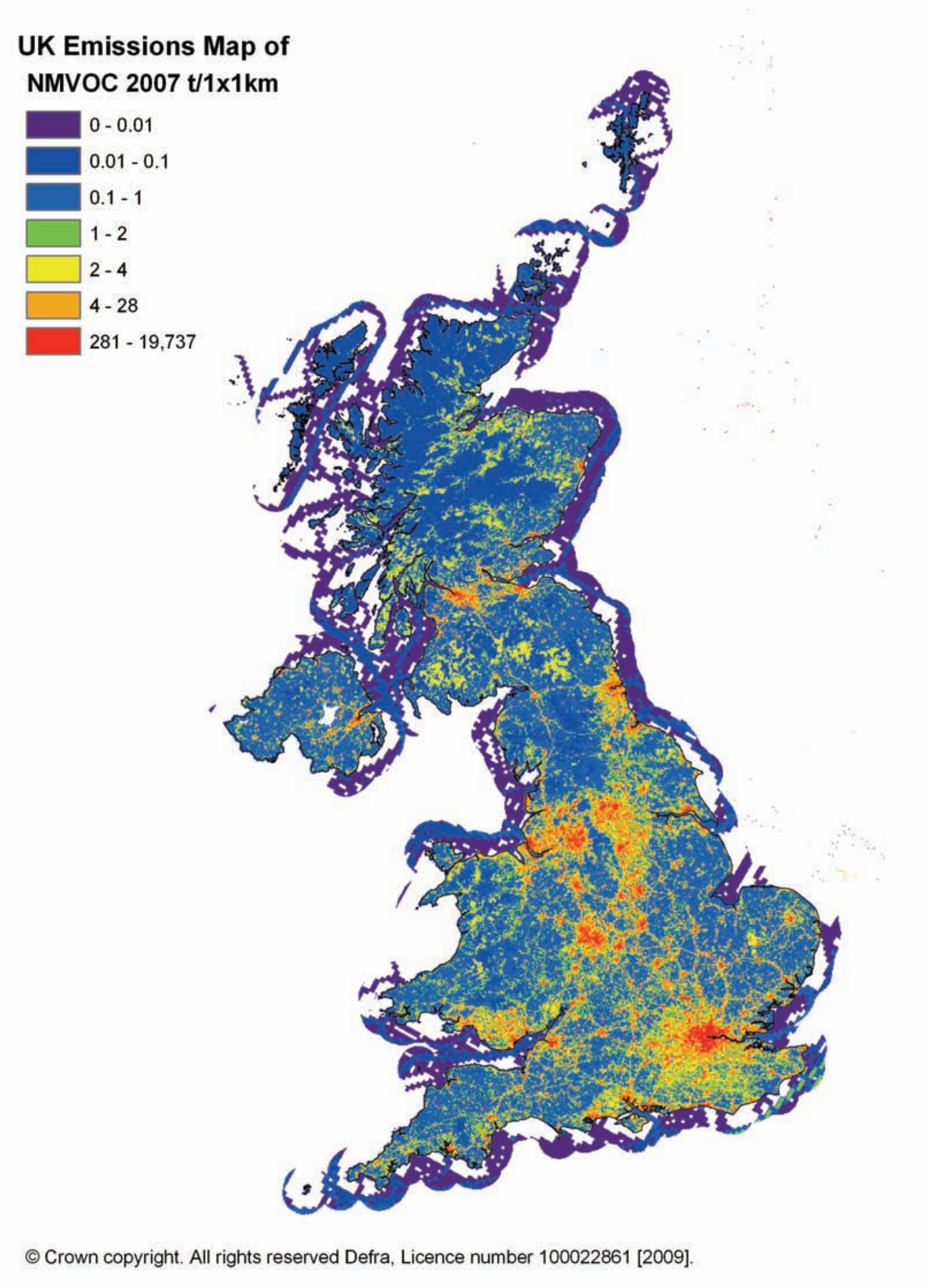
UK NMVOC emissions fell by 62% between 1990 and 2006 to 0.9 million tonnes. This is below the target for 2010 of 1.2 million tonnes under the United Nations Economic Commission for Europe (UNECE) Gothenburg Protocol and the EU National Emission Ceilings Directive (NECD).

Figure 11: NMVOC emissions and targets, 1970–2010



(Source: Defra: www.defra.gov.uk/environment/quality/air/index.htm)

Figure 12: NMVOC emissions in the UK, 2007



(Source: National Atmospheric Emission Inventory).

Scottish perspective

The majority of the NMVOCs emitted from industrial processes in Scotland are generated in east central Scotland, with the largest contributions coming from the refining and chemical production sectors. A further significant source of localised emissions is from the production of alcohol and subsequent evaporative losses. However, there is no evidence to show that these sources are having a detrimental impact on local air quality. Table 8 lists the annual mass emissions from the 10 largest industrial sources of NMVOCs in Scotland.

Table 8: 10 largest industrial sources of NMVOC emissions from industry in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007
INEOS Manufacturing Scotland Ltd (Refinery), Grangemouth	7,080	6,380	5,572	5,648	5,191
INEOS Manufacturing Scotland Ltd (Chemicals), Grangemouth	5,300	4,925	3,551	3,633	4,200
BP Exploration Operating Company Ltd, Sullom Voe Terminal	20,800	16,749	14,869	4,424	4,141
Talisman Energy (UK) Ltd, Flotta Terminal	13,000	3,050	15,000	2,567	2,732
BP Exploration Co Ltd, Kinneil Terminal	1,700	1,609	1,521	1,391	1,790
BP Exploration Co Ltd, Hound Point Marine Terminal	3,340	630	403	1,743	1,760
Diageo Distilling Plc, Cameronbridge Distillery	No data	No data	1,375	1,501	1,640
Smithkline Beecham Plc, Irvine	1,433	1,380	1,200	1,230	1,170
The North British Distillery Limited, Edinburgh	No data	983	605	575	905
Mobil North Sea Limited, St Fergus	No data	121	134	936	894

(Source: Scottish Pollutant Release Inventory)

Industry has taken steps to reduce the amount of VOCs released to the air in Scotland. An example of such a case is highlighted below.

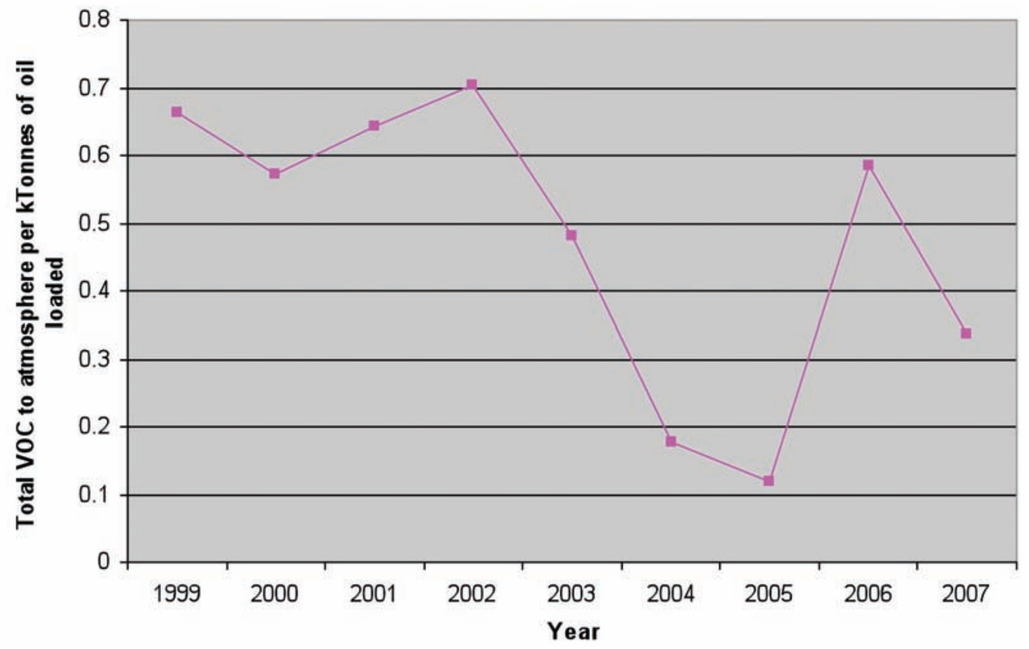
Example four

In 1999, a volatile organic compound (VOC) vapour recovery system was installed at Hound Point Marine Terminal, South Queensferry, with the aim of significantly reducing vapour emissions during tanker loading. Figure 13 shows that VOC emissions to the atmosphere from the installation have considerably reduced, particularly since 2002.

Between 1999 and 2005 VOC emissions to the atmosphere from Hound Point Marine Terminal reduced from 0.7 to 0.12 tonne per kilo tonne of oil loaded.[19] However, in 2006 the downward trend was disrupted by a peak in emissions. This was principally due to the five-yearly major refurbishment carried out on the marine vapour recovery unit. This rendered the vapour recovery unit unavailable for a significant period of time during the year.

[19]Data provided by BP Exploration and Production Co Ltd.

Figure 13: Total tonnes of VOC to atmosphere, per kilo tonne of oil loaded at Hound Point Marine Terminal, 1999–2007



(Source: BP Exploration and Production Co. Ltd.)

Over recent years, SEPA has completed a number of studies that have assessed the emissions of NMVOCs, and their potential impacts on local air quality. An example is provided below.

Example five

SEPA monitored the ambient levels of formaldehyde at residential properties in the vicinity of Norbord Ltd, Inverness, in response to public concerns regarding odour associated with operations at the installation. The VOC sampling sites directly downwind of the plant showed the highest formaldehyde levels, indicating this was likely to be the main source in the area. Formaldehyde concentrations at upwind sites were typically less than 25% than that of downwind sites, and in some cases they were too low to be detected.

The levels of formaldehyde that were detected were relatively low: results show that for the periods sampled, the 30 minute short-term environmental assessment level was not exceeded. Also, the measurements suggested that it was unlikely that the long-term environmental assessment level would be exceeded.

The Solvent Emissions (Scotland) Regulations 2004 came into force in January 2004, bringing a range of smaller businesses which emit NMVOCs (eg dry cleaning) under the control of the PPC Part B regulatory regime. These regulations should contribute to the Solvent Emissions Directive's (SED) aim of reducing VOC emissions from the EU by 50% by 2007, compared to a 1990 baseline. SEPA has recently reported data to the UK Government on the period ending 31 December 2007 and the EC will report on progress and effectiveness with implementation on the SED shortly.

Conclusion

A significant proportion of NMVOC emissions are from large industrial installations in Scotland. Total NMVOC emissions from smaller installations are harder to quantify, but are likely to lead to more localised environmental impacts.

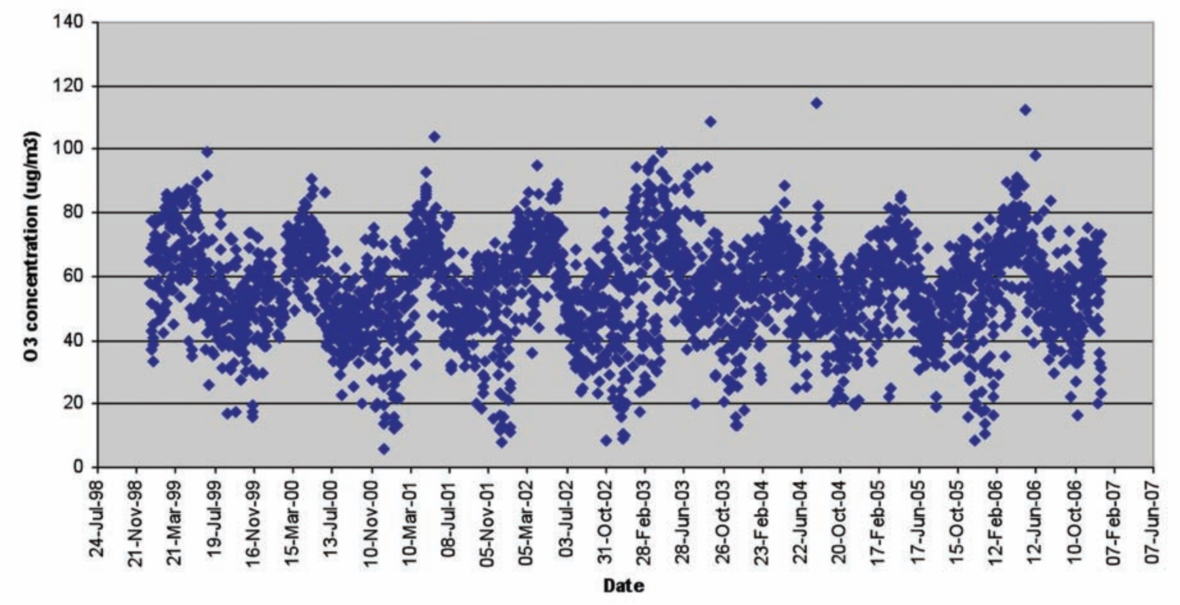
Ongoing implementation of regulations should contribute to reducing and minimising emissions of NMVOCS from these installations and SEPA will continue to regulate installations in accordance with the best available techniques.

7 Ground-level ozone

Ozone is formed in the atmosphere and is generated (and also destroyed) through a series of complicated reactions driven by nitric oxide (NO), nitrogen dioxide (NO_2), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs) in the presence of sunlight. Therefore, in order to decrease ground-level ozone (O_3) concentrations, emissions of these substances (also called precursors) must also be reduced. In contrast to stratospheric O_3, which provides protection from UV radiation, ground-level (or tropospheric) O_3 can lead to adverse effects on human health and the environment. Increased levels of O_3 can cause irritation of the eyes and airways, breathing difficulties, reduced lung function and lung disease. The World Health Organisation has noted that health effects have been observed below 120µg.m^{-3} and there is no clear evidence of a threshold at which the pollutant will not cause a problem[20]. Elevated ground-level O_3 levels can also impact vegetation by damaging the leaves of plants and reducing crop yields.

The formation of ground-level O_3 is also affected by temperature and sunlight, so levels of O_3 show both daily and seasonal fluctuations with episodes of high concentrations of ground-level O_3 lasting for several days during the summer. Figure 14 shows the seasonal fluctuation in daily mean concentrations at the Bush Estate monitoring station outside Edinburgh. The limit value for the protection of vegetation is a daily mean of 65µg.m^{-3}. This value is commonly exceeded, particularly in the spring to summer months.

Figure 14: Daily mean ground-level O_3 concentrations at Bush Estate, 1999–2006



(Source: UK National Air Quality Information Archive)

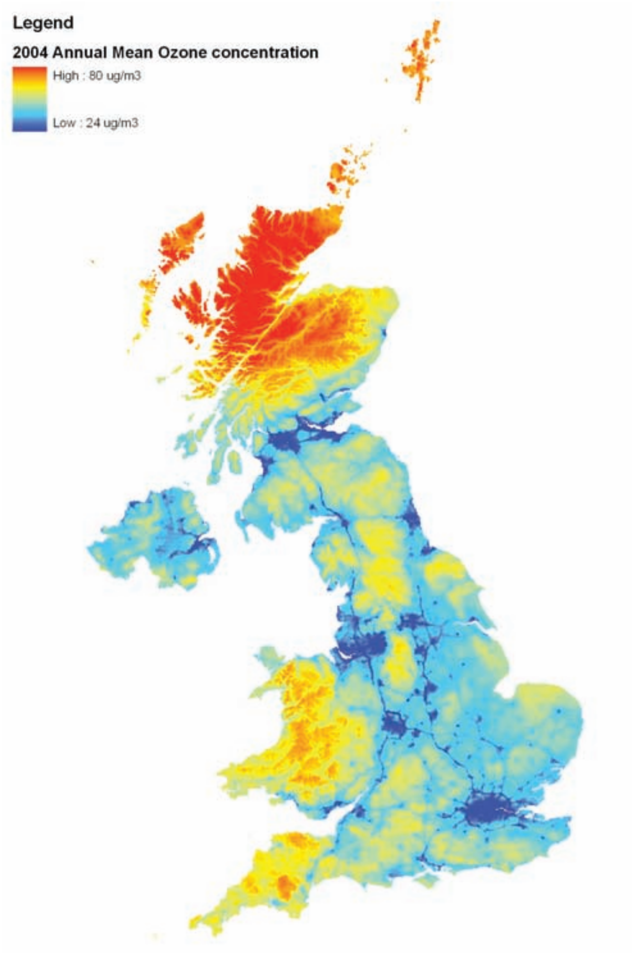
UK perspective

In many cases, atmospheric pollution is far higher in the urban centres. However, ground-level O_3 can, in some circumstances, take some considerable time to form; therefore the highest concentrations are often found in the more remote rural locations, with lower levels found in urban centres (although levels in urban areas are increasing). Local formation of O_3 can result from car exhaust fumes which contain a large amount of NO and a relatively small amount of NO_2 (along with NMVOCs and carbon monoxide). Where O_3 is formed, the NO reacts with the O_3, thereby reducing local levels of ground-level O_3. However, with the advent of emissions control on vehicles it is now the case that levels of NO have reduced (along with oxides of nitrogen – NO_x), resulting in less reactivity between the NO and O_3. This has resulted in localised increases in urban O_3 concentrations. This situation may also be exacerbated by increased numbers of vehicles on the roads in urban areas.

[20]WHO Global update 2005 (Summary of risk assessment)

Figure 15 shows that 2004 annual mean ground-level O_3 concentrations were highest in the north of Scotland, after the transport of the ground-level O_3 precursor pollutants, and subsequent reaction in the atmosphere.

Figure 15: UK annual mean ground-level O_3 concentrations in 2004 ($\mu g.m^{-3}$)

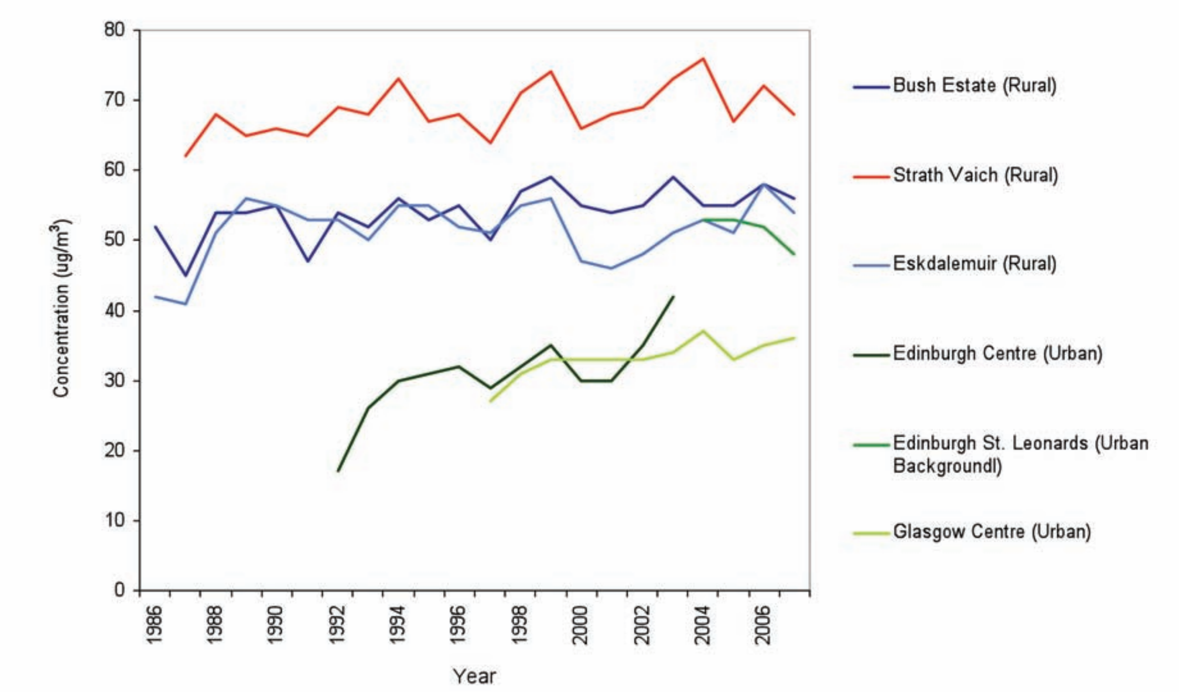


(Source: National Atmospheric Emission Inventory)

Scottish perspective

Figure 16, below, shows annual mean concentrations of ground-level O_3 measured at Automatic Monitoring Network sites across Scotland. The rural sites of Bush Estate, Strath Vaich and Eskdalemuir show higher levels of ground-level O_3 compared to urban sites in Edinburgh and Glasgow, even though the pollutants responsible for its formation (NO_2 and NMVOCs) tend to originate in urban areas. In addition, through long-range transport of pollutants, some of the primary pollutants present in rural areas of Scotland may originate from other countries.

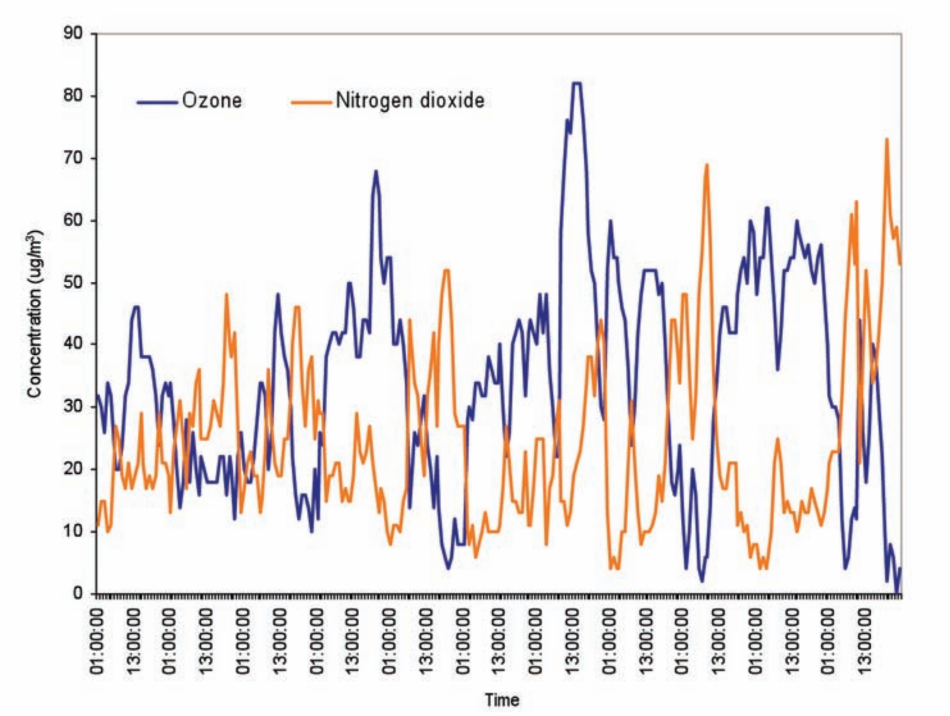
Figure 16: Annual mean concentration of ground-level O_3 recorded at Automatic Monitoring Network sites in Scotland 1985–2007 (urban and rural)



(Source: Scottish Environmental Statistics Online)

Figure 17 illustrates the relationship between NO_2 and ground-level O_3 in the urban environment (Edinburgh St. Leonards). It clearly shows that when the concentrations of NO_2 increase, the concentrations of ground-level O_3 decrease; and vice versa.

Figure 17: NO_2 and O_3 concentrations for Edinburgh St. Leonards (15–25 September 2008)

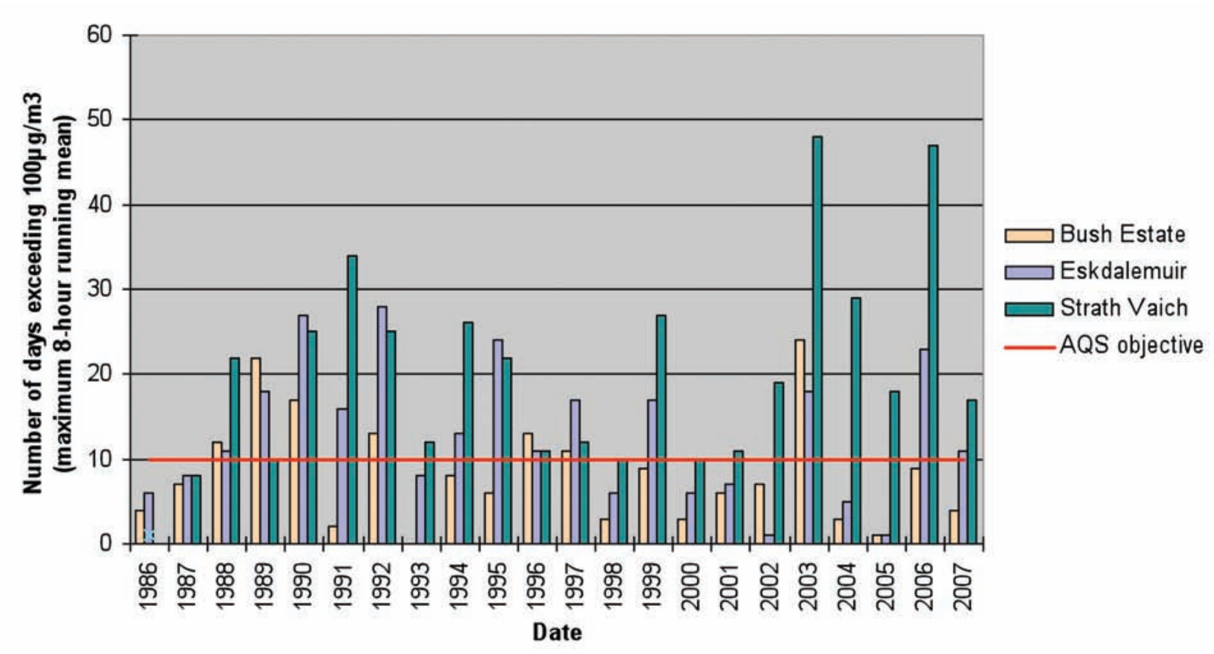


(Source: Scottish Air Quality)

The air quality objective for ground-level O_3 is currently set at 100µg.m^{-3}. This is measured as an eight-hourly running or hourly mean, and the number of exceedences a year should not exceed 10. In 2007, the air quality objective was met in Glasgow Centre, Edinburgh St. Leonards and the Bush Estate, but it was exceeded in Strath Vaich and Eskdalemuir (see Figure 18). There have been 13 and seven exceedances of the objective recorded by the Eskdalemuir and Bush Estate monitoring stations since 1986, and 17 exceedences recorded in Strath Vaich since 1987.

The Air Quality Standards (Scotland) Regulations 2007 contain a target value that is measured as a maximum daily eight-hour mean of 120µg.m^{-3} that should not be exceeded more than 25 days per calendar year, averaged over three years. The attainment date for this target value is 2010.

Figure 18: Number of days ground-level O_3 exceeding 100µg.m^{-3} (maximum eight-hour running mean), 1986–2007

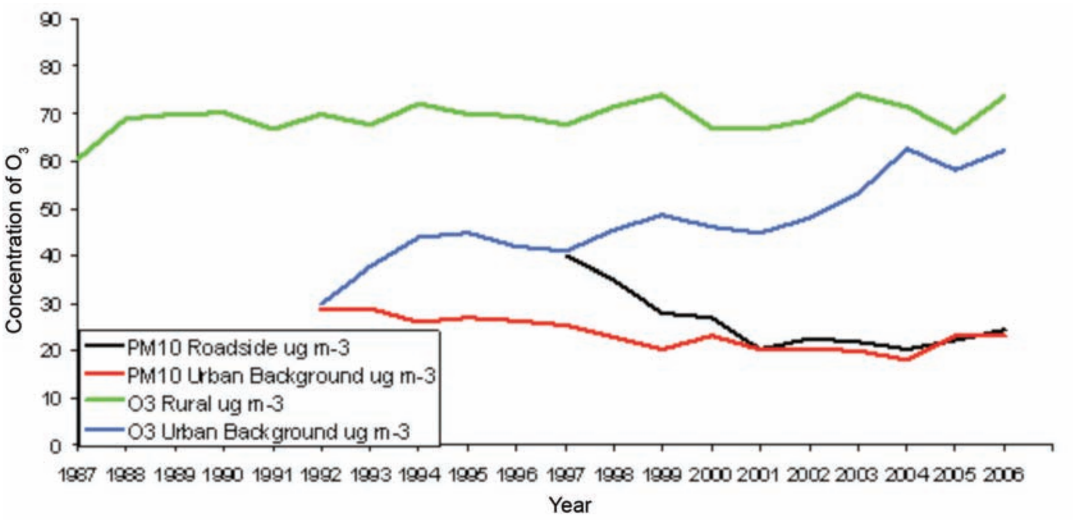


(Source: Scottish Environmental Statistics Online)

The Air Quality Expert Group's report on 'Ozone in the United Kingdom (2009)'[21] recently highlighted that the control of NO_x emissions in the UK has led to an increase in ground-level O_3 in urban areas, although the control of NO_x and NMVOC emissions in the UK and Europe have led to decreases in the intensity of summer ground-level O_3 episodes. The group also concluded that 'over the next two decades ozone will rise and trend towards levels in the surrounding rural areas, since the suppression of urban ozone by nitric oxide (NO) will be reduced, as nitrogen oxide emissions fall'.

[21]www.defra.gov.uk/environment/quality/air/index.htm

Figure 19: Average maximum running eight-hour mean ground-level O_3 levels (average from all Scottish sites) and annual average gravimetric PM_{10}



(Source: Scottish Air Quality)

From Figure 19 it can be seen that, on average, the concentrations of ground-level O_3 in rural areas appear to be showing a gradually increasing trend, perhaps related to the recent warm summers. In urban background areas the increase is much more dramatic, as concentrations of total NO_x are decreasing. Concentrations of ground-level O_3 in these areas are now much more similar to the rural concentrations, which are of great concern for public exposure to this pollutant.

Ground-level O_3 pollution is difficult to address at a local, or even a national scale. There are, nevertheless, a number of activities in which SEPA is involved, which should help to reduce ground-level O_3 concentrations. These involve efforts to minimise emissions of NO_x and NMVOCs to help prevent the formation of ground-level O_3. The work that is being done to minimise the release of these substances is described in more detail under their respective sections of this report.

In 1983, the Convention on Long-range Transboundary Air Pollution (CLRTAP) came into effect, being signed by 34 governments and the European Commission. The convention aims to limit and, as far as possible, reduce and prevent long-range transboundary air pollution. One of the products of the convention was the 1999 Gothenburg Protocol, which contains a multi-pollutant, multi-effect strategy to address several pollutants at once. This protocol set different national emission ceilings for each country for sulphur dioxide (SO_2), NO_x, ammonia (NH_3) and VOCs to be met by 2010. The problem of tropospheric O_3 is one that must be addressed globally.

Conclusion

Concentrations of ground-level O_3 in the north of Scotland show occasional exceedances of thresholds set to protect human health and the environment. Rural areas tend to be more affected than urban areas, where the precursor pollutants are actually generated; however, both background and urban concentrations of ground-level O_3 are increasing. SEPA will continue to regulate installations in accordance with best available techniques to prevent or minimise the emission of compounds from SEPA-regulated industrial installations which can lead to the formation of ground-level O_3.

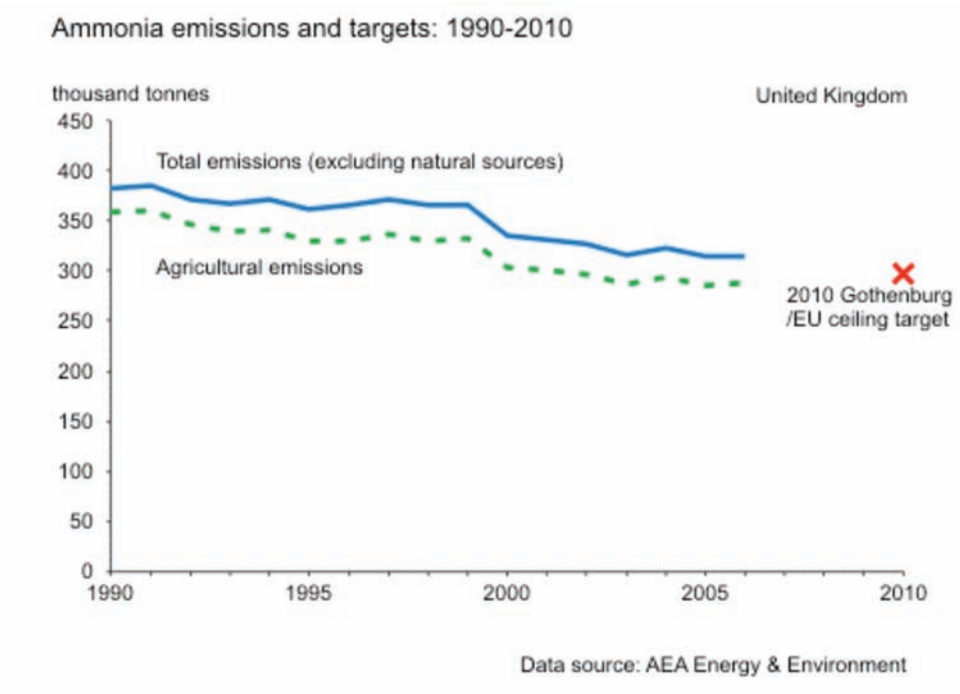
8 Ammonia

The largest man-made source of ammonia (NH_3) is agriculture, deriving in the main from the application of artificial fertilisers and the decomposition of urea in animal wastes. Other sources include waste disposal activities and industrial processes. In general, emissions of NH_3 are released at very low initial levels from large areas such as pastures. Emissions of NH_3 are the dominant source of nitrogen deposition, and most emissions of NH_3 generated within the UK are also deposited within the UK due to its relatively short lifetime in the atmosphere.

The deposition of NH_3 onto soils and plants, either dry as NH_3 gas, or dissolved in rainfall and deposited wet, contributes to the processes of both eutrophication and acidification. The deposition of NH_3 from the atmosphere can lead to eutrophication in many habitats, with the extent of damage closely related to the sensitivity of the species within the habitat. Deposition of NH_3 can also cause soils to become acidic. Once deposited on soil, NH_3 may be oxidised to nitrate which increases the acidity of the soil. Acidification is discussed in more detail in sections 2 and 3.

Ammonia is an important contributor to the overall concentrations of particulate matter, through the formation of secondary particles. It can also disrupt the delicate balance of plant species in valuable ecosystems by adding to the problems of acidification and eutrophication.

Figure 20: Emissions of NH_3 and targets, 1990–2010



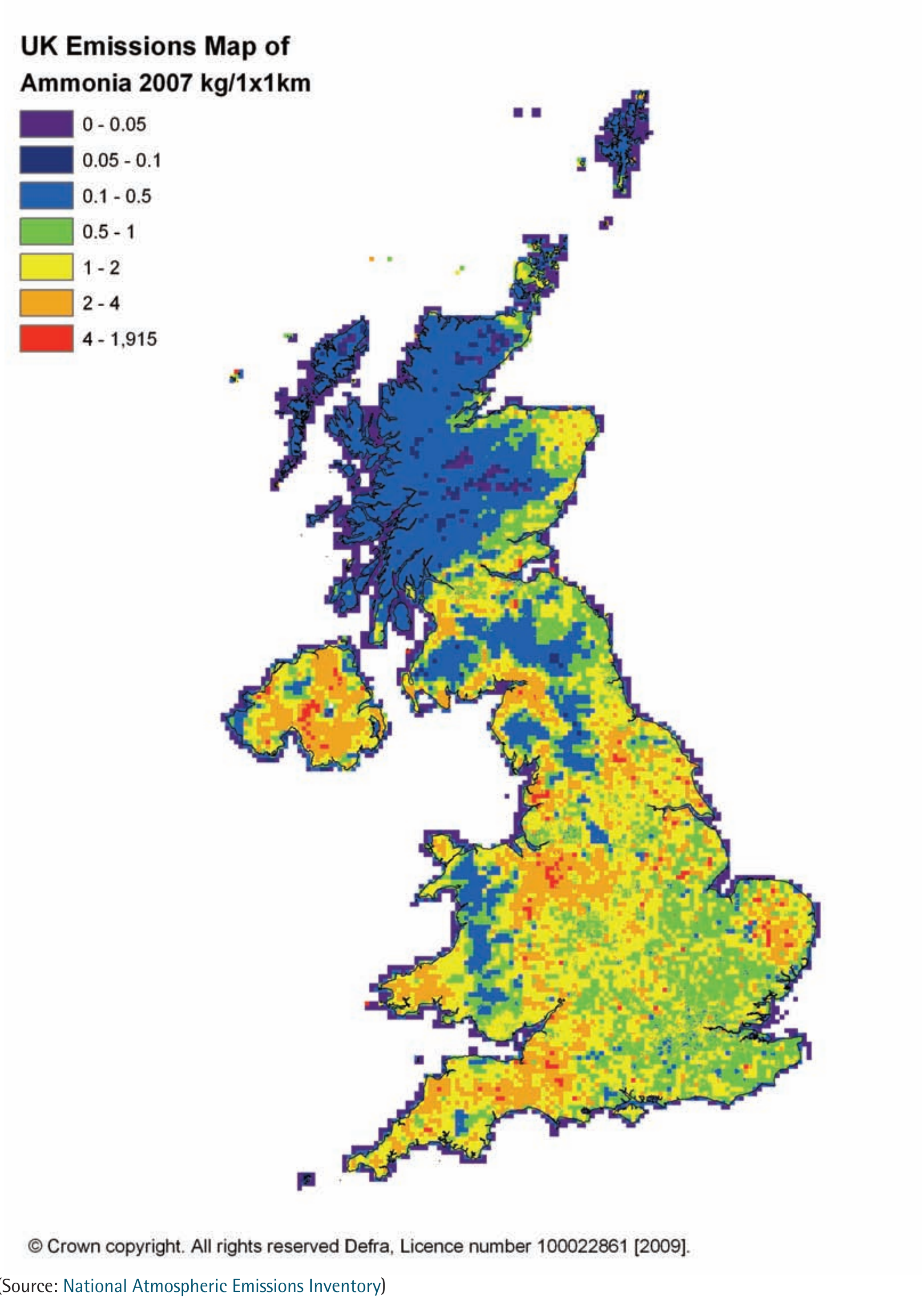
(Source: www.defra.gov.uk/environment/quality/air/index.htm).

UK perspective

Emissions of NH_3 (excluding natural emissions from wild animals and humans) fell overall by 18% between 1990 and 2006 to 315,000 tonnes. This compares with the target for 2010 of 297,000 tonnes set under the UNECE Gothenburg Protocol/EU NECD (Figure 20). Emissions in 2006 were similar to those in 2005. The NECD has set a modest target of reducing UK NH_3 emissions by approximately 11% by 2010, compared to a 1990 baseline.

Due to the nature of the emission sources, and ongoing changes in agricultural practices, it is extremely difficult to quantify total annual emissions of NH_3. Figure 22 shows estimated emission levels of NH_3 across the UK for 2007. In general, emissions arising in Scotland are low compared to the rest of the UK.

Figure 21: NH_3 emissions in the UK, 2007



(Source: National Atmospheric Emissions Inventory)

In 2006, 91% of total NH_3 emissions came from agriculture. Agricultural emissions fell by 20% between 1990 and 2006, with little change between 2005 and 2006[22].

Scottish perspective

There is no Air Quality Strategy objective for NH_3, but air concentrations and deposition rates of NH_3 are monitored at a number of sites across Scotland. Table 9 lists the 10 largest industrial sources of NH_3 emissions in Scotland. Certain intensive agriculture installations were brought into regulation under the Pollution Prevention and Control (PPC) regime for the first time before and during 2007 and have only been required to report to the Scottish Pollutant Release Inventory (SPRI) since they have been regulated. As a result, less data are available (at this time) for these installations.

Table 9: 10 largest sources of NH_3 emissions from industry in Scotland (tonnes/yr)

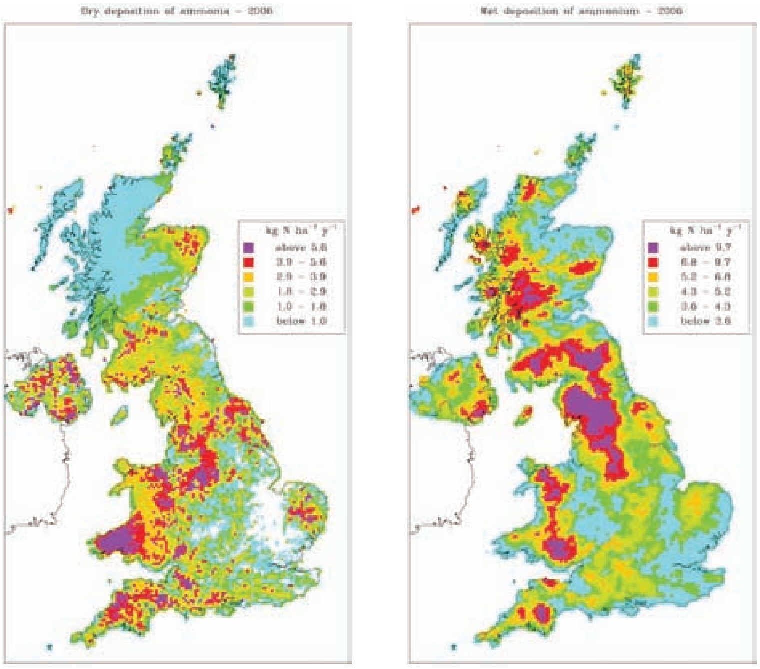
Source	2002	2004	2005	2006	2007
Deans Foods Ltd, Strathore Food Processing Plant	No data				182
Superglass Insulation Ltd, Stirling	No data	118	189	86	145
Glenrath Farms Ltd, Tile Works Field	49	49	138	172	72
Glenrath Farms Ltd, Easter Deans Farm	No data				59
Grampian Country Chickens (Rearing) Ltd, Alloa					44
Grampian Country Chickens (Rearing) Ltd, Livingston					36
Grampian Country Chickens (Rearing) Ltd, Kinross					31
Grampian Country Pork Buckie Ltd, Turriff					26
Glenrath Farms Ltd, West Linton					24
John I Forbes, Crowhillock Piggery					24

(Source: Scottish Pollutant Release Inventory)

The highest rates of wet deposition of NH_3 are in the south west Highlands and south west Scotland (see Figure 23 below). The pattern of dry NH_3 deposition is radically different, however, and reflects the distribution of the major emission sources, particularly livestock agriculture. Some areas show high levels of NH_3 concentrations, which can be attributed to areas of intensive agricultural sources such as a high concentration of poultry and pig-rearing units within a localised region. Dry deposition is greatest in central Scotland and along the east coast, particularly Aberdeenshire.

[22] www.defra.gov.uk/environment/quality/air/index.htm

Figure 22: Wet and dry deposition of NH_3 in the UK, 2006



(Source: www.uk-pollutantdeposition.ceh.ac.uk/?q=image/tid/19)

SEPA recently completed an environmental improvement action plan (EIAP), and this has helped us develop our capability to monitor and assess the effects of atmospheric emissions and deposition of NH_3 and nitrogen on terrestrial ecosystems. As part of a SNIFFER[23] funded project, we have tested and validated different biomonitoring techniques for measuring the impact of NH_3 and nitrogen deposition on sensitive habitats. Through the plan, we have also strengthened our working relationships with external partners, in particular the Centre for Ecology and Hydrology (CEH), Joint Nature Conservation Committee (JNCC) and the conservation agencies. The EIAP has also led to the start of several new projects to further develop biomonitoring methods that can be used by SEPA staff to assess NH_3 and nitrogen impacts on sensitive habitats.

SEPA is also involved in a number of initiatives to reduce overall emissions of NH_3. Some of these initiatives are centred on improving farming practices and protecting Nitrate Vulnerable Zones (NVZs). We provide farmers with considerable advice on best agricultural practice, much of it being contained in the code for the Prevention of Environmental Pollution from Agricultural Activities (PEPFAA code). While this code is predominantly aimed at preventing pollution of watercourses, the guidance it contains about fertiliser and manure applications to land should maximise the amount of nitrogen used by crops, and indirectly reduce the amount of gaseous NH_3 released to the atmosphere.

With the larger intensive agriculture units now under direct environmental regulatory control for the first time through the PPC regime, NH_3 emissions from these activities should further reduce.

Conclusion

Emissions of NH_3 come from a variety of sources, in particular intensive agriculture, and contributes to both eutrophication and acidification. The PPC regulations have brought larger-scale intensive agriculture units under SEPA's direct regulatory control for the first time. This has enabled SEPA to ensure that defined best available techniques are applied to prevent or minimise emissions of NH_3 from these sources. SEPA is also undertaking research in conjunction with partner organisations to develop biomonitoring capability for assessing the effects of NH_3 and nitrogen emissions.

[23] Scottish and Northern Ireland Forum for Environmental Research (SNIFFER)

9 Greenhouse gases

The world's climate has always been varied. However, temperatures have risen significantly since the mid 20th century. Most of this change is due to greenhouse gas emissions (GHG) from human activities, including:

- carbon dioxide (CO_2);
- methane (CH_4);
- nitrous oxide (N_2O);
- sulphur hexafluoride (SF_6);
- perfluorocarbons (PFCs);
- hydrofluorocarbons (HFCs).

These GHGs absorb infrared radiation and trap heat in the Earth's atmosphere. By 2006, emissions from Scotland accounted for 9.1% (up from 8.3% in 2005) of the total UK emissions of GHG[24].

Scottish perspective

The main emission sources for Scotland in 2006 are summarised in Table 10, below. They are expressed as a percentage of the total of all six GHG emissions of 59.0 Mt CO_2-equivalent.

Table 10: Summary of main emission sources of GHGs, Scotland 2006 (kt CO_2e)

Gas	Sector	Emission (Mt CO2-equivalent)	Percentage of total GWP[25] weighted emissions (total was 59 Mt CO_2-equivalent)
CO_2	Power stations	19	32%
CO_2	Road transport	10	17%
CO_2	Residential combustion	7	12%
CO_2	Land converted to cropland	6	11%
CO_2	Other industrial combustion	6	10%
N_2O	Agricultural soils	3	6%
CH_4	Landfill	2	4%
CH_4	Enteric fermentation – cattle	2	4%
CO_2	Commercial and institutional combustion	2	3%
CO_2	Refineries	2	3%

(Source: Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2006)

Together, these 10 categories account for 100% (although in actuality they add up to more than 100%) of the Scottish total net GHG emissions. This is because there are large carbon sinks in the land-use, land-use change and forestry category, which amount to a removal of 12 $MtCO_2$ in 2006.

This section focuses upon two of the main greenhouse gases, carbon dioxide (CO_2) and methane (CH_4). These substances occur naturally in the environment; however anthropogenic sources are much more of a concern.

[24]Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2006
Joanna Jackson, Yvonne Li, Neil Passant, Jenny Passant, Glen Thistlethwaite, Amanda Thomson & Laura Cardenas (Reports)

[25]The Global Warming Potential (GWP) is an attempt to provide a simple measure of the relative radiative effects of the emissions of the various gases. The index is defined as the cumulative radiative forcing between the present and some chosen time horizon caused by a unit mass of gas emitted now, expressed relative to that of CO_2.

Carbon dioxide

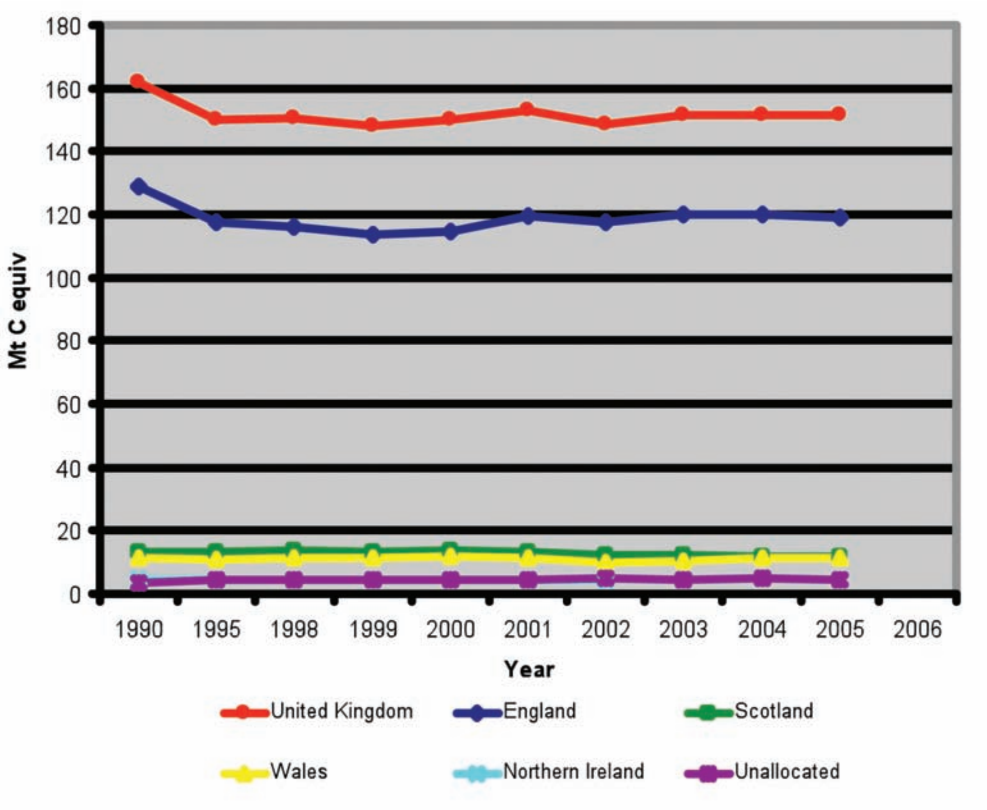
Carbon dioxide (CO_2) is the most significant anthropogenic contributor to global warming. The UK contributes about 2% of global anthropogenic CO_2 emissions, which are estimated to range between 6.2 and 6.9 billion tonnes per year. Carbon dioxide accounted for about 85% of the UK's anthropogenic GHG emissions in 2007. It is a product of combustion of fossil fuels, large sources of which include power generation and vehicle use.

In 2007, 40% of CO_2 emissions in the UK were from the energy supply sector, 22% from road transport, 17% from business and 14% from residential fossil fuel use. Since 1990, emissions from road transport have increased by 11%, while emissions from the energy supply industry have reduced by 12% and business emissions have reduced by 19%[26]. Figure 23 shows the amount of CO_2 emissions from different parts of the UK[27].

The reductions are mainly driven by the installation of combined cycle gas turbines in the power generation sector in England and reductions in CO_2 emissions from industry in England, Scotland and Wales. The Air Quality Strategy objectives are health-based standards and there is therefore currently no objective for CO_2.

Total emissions of CO_2 in Scotland accounted for 8.5% of the UK total in 2006 and have declined by 6.8% overall since 1990. Energy industries (including power generation, refineries, solid fuel transformation processes and the oil and gas industry) are, at over 40%, the largest source of CO_2 emissions in Scotland, just above the UK average of 33.1%. The next largest source of CO_2 in Scotland is road transport at about 17% of the Scottish total. However, from activities relating to land-use change and forestry (LUCF) Scotland is a net sink[28] of CO_2. The size of this sink is estimated to have increased by 78% from -2.5 to -4.5 Mt CO_2 from 1990 to 2006. This is due to a small reduction in overall LUCF emissions and a 20% increase in LUCF removals, primarily through a growth in forestry[29].

Figure 23: UK regional emissions of CO_2, 1990–2005



(Source: National Atmospheric Emissions Inventory)

[26] www.defra.gov.uk/environment/quality/air/index.htm

[27] Carbon equivalent is a metric measure used to compare emissions of different greenhouse gases based on their Global Warming Potential (GWP). GHG emissions are expressed as "million metric tonnes of carbon equivalents" (Mt C equiv). GWPs are used to convert GHGs to CO_2 equivalents, and then they can be converted to carbon equivalents by multiplying by 12/44 (the ratio of the molecular weight of carbon to CO2).

[28] Sinks absorb carbon and lock it in. This is the opposite of sources which release carbon. Trees act as a sink of carbon because as they grow they absorb and fix carbon.

[29] Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2006
Joanna Jackson, Yvonne Li, Neil Passant, Jenny Passant, Glen Thistlethwaite, Amanda Thomson & Laura Cardenas. www.naei.org.uk/reports.php?list=GHG

Data held on the SPRI database for the 10 largest industrial sources of CO_2 is given in Table 11. Power generation is the largest industrial source of CO_2 emissions in Scotland.

Table 11: 10 largest sources of CO_2 emissions from industry in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007
Scottish Power Generation Ltd, Longannet Power Station	11,000,000	8,830,000	8,508,000	10,023,000	6,782,114
Scottish Power Generation Ltd, Cockenzie Power Station	2,650,000	2,960,000	2,796,576	4,990,156	5,397,014
Scottish and Southern Energy, Peterhead Power Station	3,420,000	3,600,000	2,550,000	3,450,000	3,240,000
INEOS Manufacturing Scotland Ltd (Refinery), Grangemouth	2,310,000	2,302,000	2,402,837	2,207,956	2,240,443
INEOS Manufacturing Scotland Ltd (Chemicals), Grangemouth	1,140,000	1,151,000	1,317,170	1,118,138	1,063,510
ExxonMobil Chemical Ltd, Mossmorran	651,000	802,554	719,209	842,987	764,075
Fortum O&M (UK) Ltd, (CHP Plant) Grangemouth	816,000	764,227	708,000	745,367	723,444
Lafarge Cement UK Plc, Dunbar Works	671,000	661,336	639,000	659,000	659,000
Mobil North Sea Limited, St Fergus	245,000	710,260	881,294	649,000	549,427
BP Exploration Co Ltd, Kinneil Terminal	460,000	409,401	421,026	384,881	498,000

(Source: Scottish Pollutant Release Inventory)

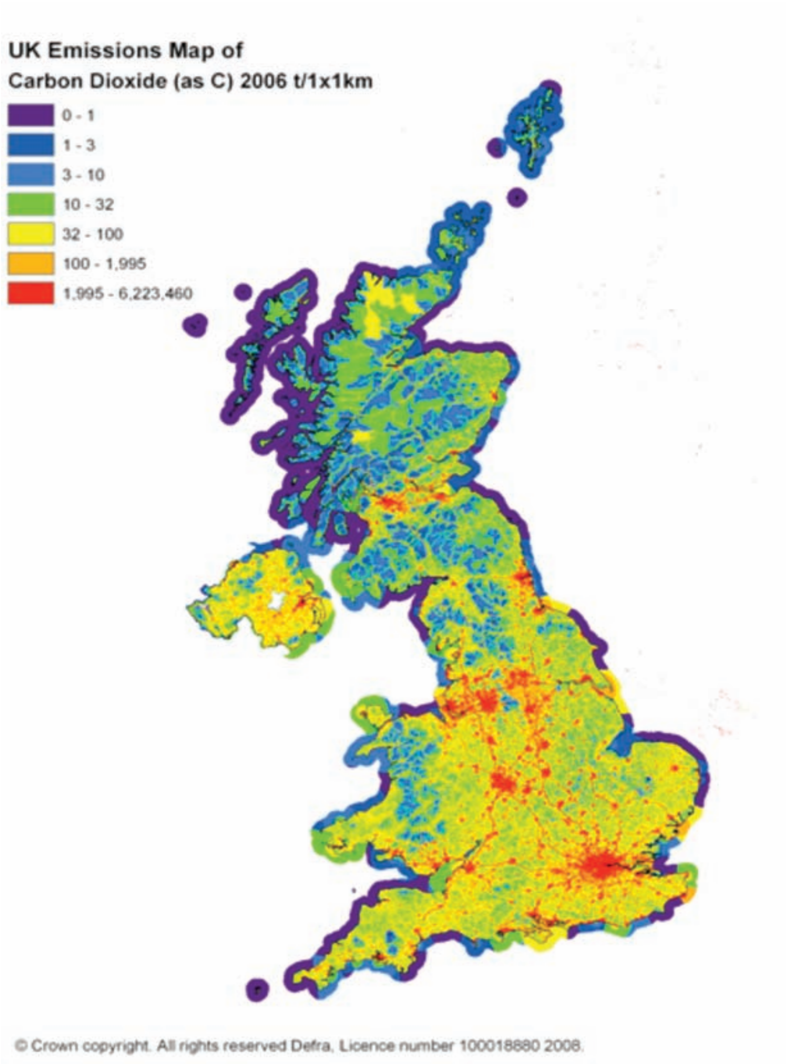
In 2007 Longannet and Cockenzie power stations accounted for almost half of all CO_2 emissions (from installations above reporting threshold). In 2006 Longannet increased by 18% and Cockenzie by almost 80%. The increase of CO_2 emissions in 2006 was primarily due to the following:

- an increase in demand for electricity;
- permanent closure of two nuclear power plants in England;
- temporary shutdowns at two Scottish nuclear power plants;
- an increase in gas prices.

As a result, coal-fired power stations increased production and this led to elevated emissions of CO_2.

Figure 24, below, shows estimated emission levels of CO_2 across the UK for 2006. As would be expected, the map shows that emissions are highest in highly populated areas where there are more domestic and industrial emissions. Many parts of northern Scotland have relatively low emissions of CO_2.

Figure 24: CO_2 (as carbon) emissions in the UK, 2006



(Source: National Atmospheric Emissions Inventory)

EU Member States are signatories to the Kyoto Protocol (the United Nations Framework Convention on Climate Change – UNFCCC). The protocol commits all signatories to reducing emissions of GHGs by specific amounts within the period 2008 – 2012. The EU collectively agreed a target to reduce GHG emissions by 8% from 1990 levels by 2012. This 8% was then shared around the Member States. The UK agreed a target of a 12% reduction of its GHG emissions. The Kyoto targets are due to be discussed and reviewed at the forthcoming United Nations Climate Change Conference to be held in Copenhagen at the end of 2009.

The EU Emissions Trading Scheme (EU ETS) has been introduced to help the EU Member States achieve their respective GHG reductions targets and was started on 1 January 2005. Initially the scheme only covers CO_2, although other GHGs will be included in the scheme. The use of emissions trading gives companies the flexibility to meet emissions targets according to their own strategy. By allowing participants to trade allowances, overall reductions in emissions are achieved in the most cost-effective way possible. Limits on the number of allowances that permitted installations receive for free are set by Defra.

The scheme covers the highest energy using industries such as:

- energy production activities;
- the production and processing of ferrous metals;
- the production of cement clinker or lime;
- the manufacture of glass and glass fibre;
- the manufacture of ceramic bricks;
- the production of pulp from timber or other fibrous materials;
- the manufacture of paper and board.

Each installation currently covered by the scheme has had to obtain an ETS permit from SEPA and must monitor and report CO_2 emissions annually. Those Scottish installations covered by the scheme have been working hard to ensure compliance and had surrendered sufficient allowances to cover their emissions by 30 April 2007.

In the future the scheme will be expanded to cover activities such as aviation and the Carbon Reduction Commitment (CRC). This commitment will provide a new mandatory emissions trading scheme starting in April 2010, which targets large public and private sector organisations.

Conclusion

The largest industrial sources of CO_2 emissions in Scotland are from power generation. Cockenzie and Longannet power stations account for almost half the CO_2 emissions from industrial sources across Scotland. In general, emissions from these large, SEPA-regulated installations are declining (although this is sensitive to the price of various fuels, energy sources and demand), but this decline is being offset by increased emissions from other sources, most notably transport.

SEPA will continue to implement the requirements of the EU ETS in order to minimise emissions of CO_2 from SEPA-regulated installations (including expansion to cover activities such as aviation and the Carbon Reduction Commitment). This work will contribute towards reaching targets for CO_2 reduction by 2012, which the UK Government (including Scotland) is committed to under the Kyoto Protocol.

We will also use the Scottish Pollutant Release Inventory (SPRI) data to follow trends in emissions above the baseline reporting level and use the regulatory means provided by the PPC regime to minimise CO_2 emissions from SEPA-regulated industrial installations using the best available techniques.

Methane

The UK's greatest contributions to anthropogenic sources of methane (CH_4) are from decomposing waste in landfills together with agricultural sources (mainly fertilisers, livestock and manure management). Coal mines and the distribution of fossil fuels (eg coal, oil and gas) also contribute to CH_4 emissions. Although levels of CH_4 in the environment are relatively low, it has a high 'global warming potential' (21 times that of CO_2) which ranks it among the most significant of the GHGs.

Global CH_4 concentrations in the atmosphere have been rising at a rate of seven ppb per annum in the last few decades, although the rate of increase has slowed down in recent years. The global release of CH_4 emissions to the atmosphere, including those from natural sources, is estimated to range between 410 and 660 million tonnes per annum. Anthropogenic emissions alone are estimated to range between 300 and 450 million tonnes per annum. The UK's total CH_4 emissions have been declining since 1990; in 2006 the UK contributed 2.3 million tonnes (it was 5 million in 1990)[30].

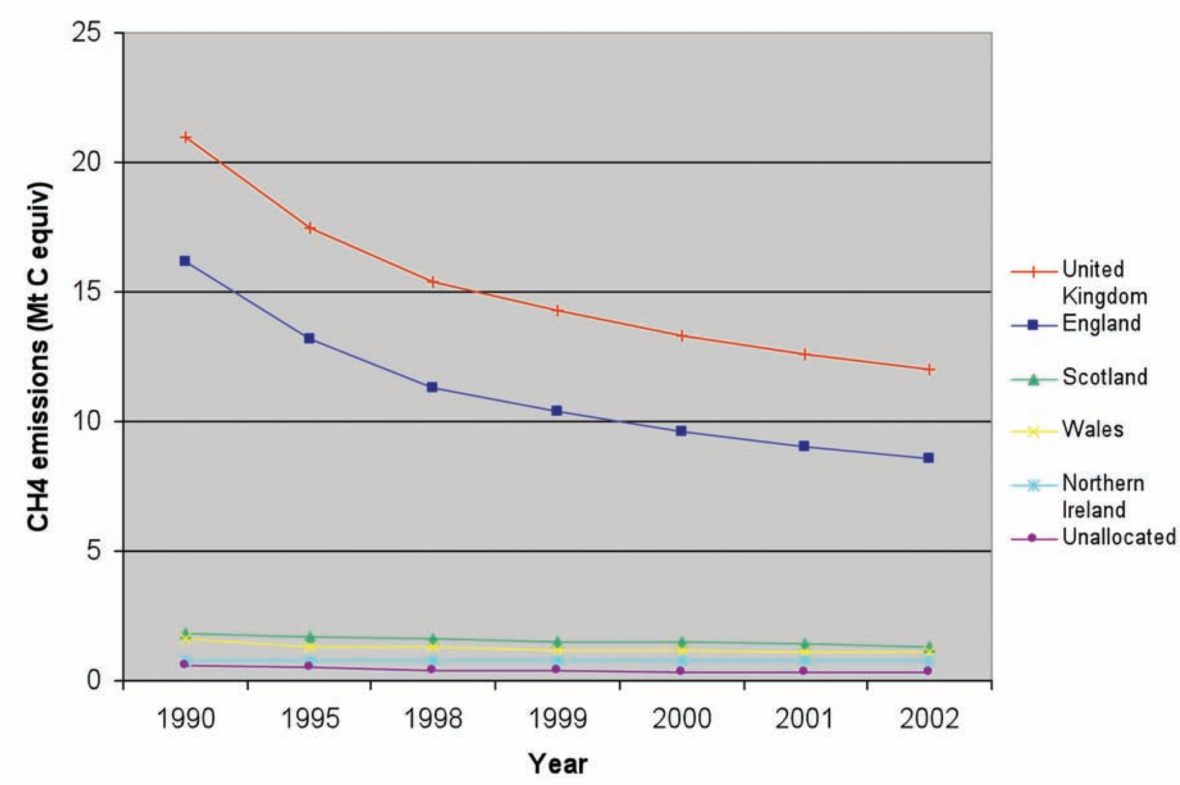
Methane accounted for about 8% of the UK's basket[31] of GHG emissions in 2007, with the main sources being landfill sites (41% of the total) and agriculture (38%). Emissions of CH_4, excluding those from natural sources, were 53% below 1990 levels. Emissions from landfill have reduced by 59% and emissions from agriculture by 17% since 1990.[32] Figure 25 shows the CH_4 emissions from different parts of the UK.

[30] www.defra.gov.uk/environment/quality/air/index.htm

[31] The 'basket of greenhouse gases' are carbon dioxide (CO_2), methane (CH_4), dinitrogen (nitrous) oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).

[32] www.defra.gov.uk/environment/quality/air/index.htm

Figure 25: UK regional emissions of CH_4 1990 to 2002.



(Source: National Atmospheric Emission Inventory)

Emissions of CH_4 in Scotland have declined by 43% between 1990 and 2006 and in 2006 accounted for 12.7% of the UK total. The major sources of CH_4 in Scotland are waste disposal, agriculture, coal mining and leakage from the gas distribution system. The largest single source of CH_4 in Scotland arises from waste disposal. Most of this comes from landfill sites but a small amount is from wastewater treatment. Enteric fermentation (digestion by ruminant animals) from cattle is the second largest source of CH_4 emissions in Scotland (101 kt CH_4), contributing 34% of Scottish CH_4 emissions. A fall in the number of cattle and sheep has led to emissions from agriculture falling by 6% from 1990–2006[33].

Table 12: 10 largest sources of CH_4 emissions from industry in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007
North Lanarkshire Council, Auchinlea Landfill	4,130	9,200	9,480	8,070	8,180
Avondale (Non-Hazardous) Landfill Site, Avondale Quarry	554	3,930	5,360	4,610	7,230
Paterson's of Greenoakhill Ltd, Greenoakhill Landfill Site	N/A	2,716	3,650	1,280	5,870
WRG Waste Services Ltd, Greengairs Landfill Site	3,120	4,030	669	BRT	3,960
SITA UK Ltd, Binn Farm Landfill	2,940	1,640	1,840	3,560	3,720
North Ayrshire Council, Shewalton Landfill Site	960	2,990	3,230	3,230	3,230
Stoneyhill Waste Management Ltd, Stoneyhill Quarry Landfill site	No data	No data	6,460	4,080	2,850
The Moray Council, Nether Dallachy Landfill Site	1,117	1,150	3,740	1,210	2,590
Scottish Borders Council, Easter Langlee Landfill Site	1,050	2,100	1,890	1,380	2,110
Glasgow City Council, South Cathkin Landfill Site	No data	2,540	1,660	1,330	1,810

Note: BRT = Below Reporting Threshold (10 tons for CH_4)

(Source: Scottish Pollutant Release Inventory)

[33]Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990–2006
Joanna Jackson, Yvonne Li, Neil Passant, Jenny Passant, Glen Thistlethwaite, Amanda Thomson & Laura Cardenas. www.naei.org.uk/reports.php?list=GHG

Landfill emissions have fallen by 58% since 1990, although some variability is observed in the data from individual sites. This is due to an increase in the use of CH_4 recovery systems, though this reduction assumes the UK trend. It has been assumed that the degree of CH_4 recovery from Scottish landfills reflects that of the UK[34].

Internationally, the main controls over CH_4 as a volatile organic compound (VOC) are the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) and the Basel Convention concerning the Transboundary Movement and Disposal of Hazardous Wastes. Also, the UK Government is committed to reaching targets of reduction of CH_4 emissions by 2008–2012 through the UNFCCC (Kyoto Protocol, 1997).

Through the regulation of landfill sites, SEPA is working towards improving the control and management of landfill gas in order to minimise the impact on local air quality and the effect of CH_4 and CO_2 on the global climate. Advancements are being made in the management of landfill gas and control through legislation, permitting, guidance and regulation. The Landfill (Scotland) Regulations 2003 require strategic reductions in biodegradable waste sent to landfill, collection of landfill gas produced and its use for energy recovery or flaring (the specifics are tailored to each individual landfill site). Where the landfill gas is not in sufficient quantity or of the right quality it must be flared. The National Waste Plan also aims to reduce the amount of biodegradable waste sent to landfill.

Landfill permits require the operators of landfill sites to undertake regular monitoring of landfill gas at designated monitoring boreholes. Monitoring results not only provide the operator with information to inform decision-making on the management of landfill gas, but can also provide an early warning of elevated levels of landfill gas. Where levels are found to be at, or in excess of, trigger levels which are outlined in published guidance, the operator is required to take all appropriate steps to reduce levels and ensure that no landfill gas escapes beyond the site boundary where it could cause pollution of the environment or harm to human health. In addition to monitoring being undertaken by the operator, SEPA also regularly monitors levels of gas at landfill sites to assess compliance with permit conditions.

Conclusion

The largest sources of anthropogenic CH_4 in Scotland are from agriculture and waste management activities. Emissions of CH_4 in Scotland have significantly reduced between 1990 and 2006.

Through the permitting and regulation of landfill sites SEPA is working towards improvements in landfill gas control and to improve air quality at both local and global scales. Through the implementation of the National Waste Plan, SEPA will continue to work with local authorities towards reducing the amount of waste sent to landfill, which will reduce CH_4 emissions. SEPA will continue to use the regulatory means provided by the PPC regime to minimise CH_4 emissions from SEPA-regulated landfill sites.

[34]Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990–2006
Joanna Jackson, Yvonne Li, Neil Passant, Jenny Passant, Glen Thistlethwaite, Amanda Thomson & Laura Cardenas. www.naei.org.uk/reports.php?list=GHG

10 Conclusions and future work

Scotland's air quality is generally improving, but there are areas where the levels of atmospheric pollution are exceeding the air quality standards and objectives that have been introduced to protect human health. Local authority monitoring has shown that there has been a reduction in the background concentrations of some pollutants, but there are locations where concentrations of pollutants are increasing. Road traffic is the most significant source of pollution in the urban centres. The number of air quality management areas in Scotland has increased to 21 and some of the original areas are being extended, in response to new monitoring data.

SEPA will continue to seek to improve Scotland's air quality through:

- monitoring and regulating industry to reduce pollutants and minimise harm to the environment and human health;
- requiring the use of best available techniques by SEPA-regulated industry, and promoting improvement initiatives;
- assessing the effectiveness of SEPA's regulation of industry and quantifying the impacts of non-regulated activities;
- providing input to the planning process to ensure that air quality is highlighted as a material consideration;
- implementing a new operator compliance assessment scheme;
- working in partnership with other organisations, such as local authorities, to address poor air quality at a local and national level;
- working with the Scottish Government to seek to extend the Scottish Air Quality Database (SAQD) and work in partnership to produce an annual report on Scotland's air quality;
- contributing to local authority air quality review and assessments;
- regulating the EU ETS and, where appropriate, ensuring a common implementation approach is taken with the other UK regulators;
- providing technical support to Scottish Government on the design and implementation of incoming legislation as appropriate;
- developing and enhancing a biomonitoring strategy.

These actions, and more, will contribute towards SEPA's overall outcome of improved air quality contained within *SEPA's Corporate plan 2008–2011* and *SEPA's Annual operating plan 2009–2010*. For a more comprehensive list of measures proposed please refer to these documents. Information on how SEPA is progressing with its targets can be found in *SEPA's Annual report 2008–2009*.