Air quality

Despite significant improvements, air quality continues to impact on the environment and human health, and further improvements are needed.

Summary

Despite improvements in air quality, it continues to have an impact on the environment and human health, and further improvements need to be made. Transport is the most significant source of emissions. Air quality and climate change are inextricably linked policy areas.

Introduction

The quality of Scotland's air has improved considerably over the last few decades. Overall, the air we breathe today is cleaner than at any time since before the Industrial Revolution. We have achieved this through tighter controls on pollutant emissions from industry, transport and domestic sources. In recent years, concentrations of harmful pollutants in the atmosphere have fallen, and the annual numbers of premature deaths and hospital admissions have reduced significantly.

We continue to make progress in improving Scotland's air quality. Emissions data from the UK national atmospheric emissions inventory demonstrate that, between 1990 and 2009, nitrogen oxides have decreased by 60%, particulates by 60% and sulphur dioxide by 78%. Further decreases are predicted up to 2020 - compared with 2002 levels, oxides of nitrogen are expected to decline by a further 45%, particulates by 19% and sulphur dioxide by 64%.

Despite this long-term trend of general improvement, air pollution continues to harm human health and the environment. It is currently estimated to reduce the life expectancy of every person in the UK by an average of 7–8 months, with associated costs of up to £20 billion each year. Across the UK, air pollution causes up to 24,000 deaths per year – nine times more than traffic fatalities. Air pollution also has a detrimental effect on natural ecosystems, food crops and our built environment.

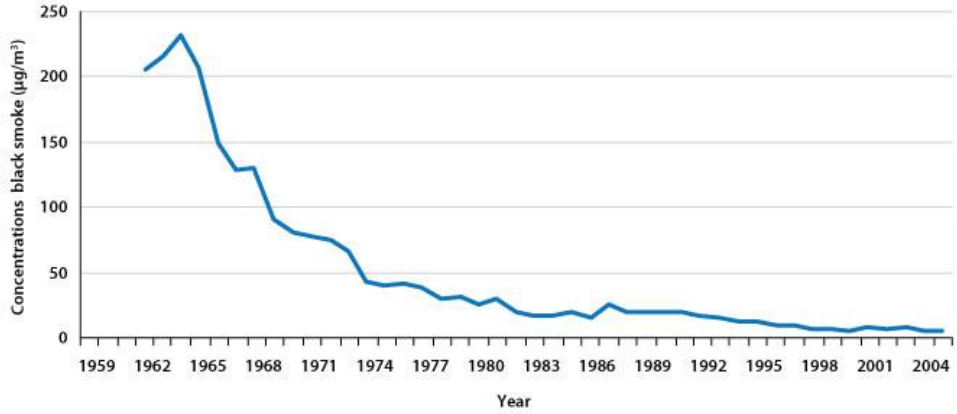
Exposure to air pollution can have a long-term effect on health, associated especially with premature mortality due to cardiopulmonary (heart and lung) effects. In the short term, high pollution episodes can trigger increased hospital admissions. Such episodes can also contribute to the premature death of those people who are more vulnerable to daily changes in air pollutants levels, notably the elderly and those with existing health conditions such as asthma.

The air quality strategy for England, Scotland, Wales and Northern Ireland sets out central government policy on air quality in Scotland and the rest of the UK. The strategy provides a comprehensive overview of the current condition of air quality. There has been a steady and sustained improvement in air quality in Scotland over recent decades. During the first half of the 20th century we started to make the first real progress in tackling industrial emissions, with the Smoke Abatement Act of 1926.

However, domestic sources continued to be a serious problem across the UK, and a series of smog episodes in London in the early 1950s culminated in the 'Great Smog' of 1952, which resulted in around 4000 extra deaths. This episode provided the stimulus for the Clean Air Act of 1956, a landmark piece of legislation, which introduced smokeless zones and the gradual relocation of power stations away from densely populated areas. The result was a dramatic reduction in urban air pollution during the late 1950s and 1960s (Figure 1). A second Clean Air Act in 1968 focused more on industry, and encouraged the building of taller chimney stacks, to aid pollutant dispersion.

As emissions from industrial and domestic sources continued to decline in the 1970s and 1980s, attention started to move towards transport. This remains the most significant source of emissions today in urban areas.

Figure 1: Average black smoke concentrations in Glasgow 1959–2005



The air quality in Scotland website is a comprehensive information source for all aspects of air quality, including current and historical monitoring data. The annual air pollution in Scotland report, produced for the Scottish Government, can be found on the website and summarises key statistics, data and trends.

Description of air quality

European and domestic legislation covers a wide range of air pollutants, but the following four are generally considered to be of most importance in relation to human health and the environment (Table 1).

Table 1: Air pollutants, where they come from and their effects on human health and the environment.

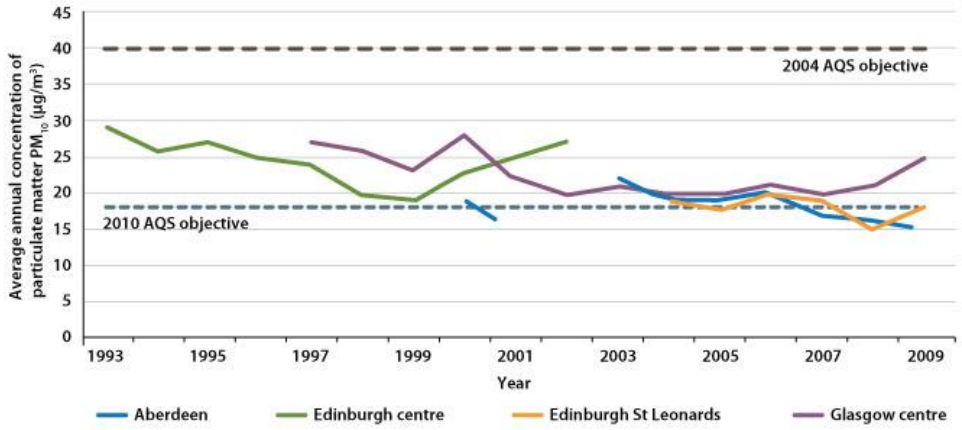
Pollutant	Source	Health and environmental effects
Sulphur Dioxide (SO_2)	Burning of coal and heavy oil, mainly by power stations Domestic coal burning	At high concentrations, tightness in the chest and coughing occur, and lung function of asthmatics may be impaired, to the extent that medical help is required. Moderate concentrations may result in a fall in lung function in asthmatics Symptoms can be more extreme when particulate and other pollutant concentrations are high Reacts with water in the atmosphere to form sulphuric acid (acid rain) Pollutes soil and water causing acidification and detriment to habitats Damage to buildings
Nitrogen Dioxide (NO_2)	Burning of fuels, e.g. motor vehicles, factories Oxidation of nitric oxide (NO) in the atmosphere, derived from road transport emissions and other combustion processes, e.g. the electricity supply industry	Can irritate eyes, throat and lungs May lower resistance to respiratory infections such as influenza Continued or frequent exposure to high concentrations may increase the incidence of acute respiratory illness in children Increases the potential for the formation of ground-level ozone Pollutes soil and water causing acidification, eutrophication and

		detriment to habitats and species Damage to buildings
Particulate Matter (PM_{10} and $PM_{2.5}$)*	Combustion (mainly road traffic) Secondary particles (mainly sulphate and nitrate formed by chemical reactions in the atmosphere) and often transported from far across Europe Coarse particles, suspended soils and dusts (e.g. from the Sahara), sea salt, biological particles, particles from construction work and traffic related particles, e.g. brake and tyre wear, resuspension from road surfaces	Can be carried deep into the lungs, causing inflammation and a worsening of the condition of people with heart and lung diseases May carry surface-absorbed carcinogenic compounds into the lungs Deposition on plants causing physical and toxic effects Reduced visibility (scattering of light)
Ozone (O_3)	Secondary pollutant – formed in lower atmosphere from the sunlight-initiated oxidation of volatile organic compounds (VOCs) in the presence of NOx (NO and NO_2) Sources of VOCs are similar to NO and NO_2, but also include other activities such as solvent use, and petrol distribution and handling The chemical reactions do not take place instantaneously, but can take hours or days, therefore O_3 measured at a particular location may have arisen from VOC and NOx emissions many hundreds or even thousands of miles away	Irritates the airways of the lungs, increasing the symptoms of those people suffering from asthma and lung diseases Damages plants resulting in lower crop yields Damages materials such as rubber

*PM_{10} – particulate matter of 10 microns in diameter or less, $PM_{2.5}$ – particulate matter of 2.5 microns in diameter or less.

Air pollutant trends are summarised in key Scottish environmental statistics on the Scottish Government's website. The overall trend is a gradual decline in concentrations of the major air pollutants over the couple of decades, but with a levelling off in recent years. This is mainly due to emissions from transport continuing to be an issue, as outlined in the following section. Figure 2 gives an example of these trends, for particulate matter.

Figure 2: Particulate matter (PM_{10}) annual average concentrations ($\mu g/m^3$) 1993–2009. (The Edinburgh centre monitoring station was relocated to St Leonards in 2003 due to redevelopment works at the previous location.)



Pressures affecting air quality

Transport

Major advances in vehicle technology and improved fuel quality, driven by increasingly demanding European legislation, have helped to deliver substantial reductions in transport emissions since the 1980s. However, this downward trend has levelled off in recent years, as the effects of a continually increasing number of vehicles on the road begin to outstrip these gains.

Furthermore, the increasingly stringent Euro standards controlling emissions limits for various pollutants have not delivered the reductions in pollutants that were predicted, especially in relation to NOx.

Industry

Legislation, strict operating conditions and technological advances have been highly successful in reducing the contribution of regulated industry to poor air quality. As a result, the contribution of industry to poor ambient air quality is now very localised.

Climate change

Air pollution often originates from the same activities that contribute to climate change, notably transport and electricity generation. Many of the driving forces – economic growth, increased resource consumption, population changes – are also the same, even though the pollutants of concern and consequences are different. It is important that this significant threat from climate change does not overshadow efforts to improve air quality. It is also necessary to consider whether measures to reduce the impacts of climate change have a negative impact on air quality (e.g. the burning of biomass – see below).

Biomass energy

Biomass is the generation of energy from biodegradable matter, such as wood and waste. The adoption of biomass combustion has been encouraged in recent years in order to reduce greenhouse gas emissions, mitigate against climate change effects and contribute to energy security and rural development. However, biomass combustion leads to emissions of various air pollutants, with particulates a matter of special concern. Although biomass still makes a relatively small contribution to overall emissions, if the trend of increased adoption continues, as is currently forecast, it is likely to become an increasingly significant source.

Consequences of a change in air quality

Human health

Air pollution can have short-term and long-term effects on human health. The size of the effect will vary depending, among other things, on the concentration of the pollutant(s) and the period and types of exposure. An individual's exposure to pollutants can vary greatly. Some people will receive exposure to certain types of air pollutant while at work; others, such as the elderly and parents with young children, will receive the majority of their exposure from pollutants inside the home; whereas for others, who work predominantly outdoors, exposure to outdoor pollutants will be particularly relevant. Overall, air pollution is viewed as one of a number of factors, such as lifestyle choices (e.g. smoking), respiratory infections and exposure to airborne allergens, 'flu and extremes of temperature that can affect our health.

For the most part, healthy individuals will not notice or suffer from any serious or lasting ill effects from levels of pollution that are commonly experienced in Scotland, even when levels are described as 'high' or 'very high'. However, it should be borne in mind that our knowledge of the effects of air pollutants on individuals as a result of their exposure both in the home and at work is still incomplete.

People with existing cardiovascular and lung conditions may be adversely affected by day-to-day changes in the levels of air pollutants; however, air pollution should be regarded as one of a number of factors that may affect people with breathing disorders. In practice, people with asthma are unlikely to know for certain whether an attack has been triggered by air pollution alone or by a combination of factors. The number of deaths and hospital admissions that occur each day varies and both seem to go up when air pollution levels are high, particularly for individuals with these conditions and especially among the elderly. On the basis of current evidence, deaths in such cases are probably brought forward by a matter of weeks or months rather than years. A report published by the Committee on the Medical Effects of Air Pollutants in 2010 suggests that long-term exposure to air pollution is unlikely to be a direct cause of asthma, but it may exacerbate the symptoms of existing cases.

Food production

There is some evidence to suggest that high ozone concentrations can reduce crop yields; although the precise mechanisms are still unclear. Effects include visible damage and the early die-back of leaves (air pollution information system).

Ecosystem health

Although protection of human health is the main focus of air quality policy in Scotland, air pollution can also have adverse effects on the natural and built environments. The Air Quality Strategy sets objectives for nitrogen oxides (NOx) and sulphur dioxide (SO_2) for protection of vegetation and ecosystems, based on a critical levels approach, i.e. concentrations of pollutants in air above which damage to sensitive plants and habitats may occur. Critical loads (the acid deposition load that will not lead to harmful effects) have been used to assess the risks to habitats from acidification and eutrophication. In addition to NOx and SO_2, the other main pollutants of concern for vegetation and ecosystems are ammonia (NH_3) and ozone (O_3). Currently, these objectives are being met across Scotland in the non-built-up areas. They do not apply in built-up areas.

Cultural heritage

Historically, high pollutant concentrations in urban areas, notably black smoke and sulphur dioxide, caused significant damage to the fabric of buildings. Following the rapid decline in levels of these pollutants over recent decades, this is no longer a major issue of concern, although the impacts are still clearly visible.

Response by society

Scotland's rural air quality is generally very good but, despite the major improvements in recent decades, areas of poor air quality remain in many of our towns and cities, almost all related to transport emissions.

Trends in air quality, current conditions and future projections are assessed using a combination of monitoring and modelling techniques. There is an extensive network of air quality monitoring stations located across Scotland, operated by both central and local governments. Monitoring is based on the requirements of both European and domestic legislation and is driven primarily by human health concerns.

Monitoring undertaken by the Scottish Government relates to the requirements of a series of EU Directives on air quality. These set limit values (concentrations of pollutants in the air that should not be exceeded) for several pollutants of particular concern for human health, and dates by when they should be achieved. All Limit Values have been achieved throughout Scotland except for nitrogen dioxide, and current indications are that this will be achieved by 2015.

The Environment Act 1995 established the system of local air quality management (LAQM), whereby all local authorities in Scotland (and the rest of the UK) are required to regularly review and assess air quality in their areas against a number of objectives for air pollutants. As with the EU limit values, these objectives are set with the primary intention of protecting human health and dates are set by when they should be achieved.

If the review indicates that any objective will not be achieved, the local authority concerned must declare an Air Quality Management Area (AQMA) and produce an action plan outlining how it will tackle the issues identified.

Currently, there are 27 AQMAs in Scotland, all but two declared for emissions of nitrogen dioxide and/or particles from transport. The remaining two are for industrial emissions of sulphur dioxide at Grangemouth, and a combination of transport and domestic emissions of particles at Pathhead, Midlothian. All local authorities with AQMAs now have either draft or final action plans in place.

The Scottish Government, together with the other UK administrations, is conducting a major review of the LAQM system. A report produced on behalf of the government makes a large number of recommendations for improving and streamlining the system and is currently under consideration.

Transport

The national transport strategy sets out the long-term vision for transport policy in Scotland. Although emissions from transport have declined significantly, the rate of decline has started to level off in recent years. Without additional measures to tackle transport-related pollution, it is possible that emissions will begin to increase again. Central and local governments have a range of options available to them for improving air quality, such as Low Emission Zones (LEZ), congestion charging, alternative fuel vehicles and initiatives to encourage a shift from private to public and/or greener fuelled transport.

There is also a responsibility on the population to use their vehicles less and, where possible, use public transport. This would reduce the amount of fuel burned and reduce congestion, resulting in significant reductions in emissions. This requires both a shift in people's thinking and also an effective, low emissions and integrated system of public transport.

There has been limited progress in introducing larger scale improvement measures that will have the biggest impact on reducing air pollution. This is for a variety of reasons, including the significant costs involved and political and public acceptance, although there are signs that some of these barriers are beginning to be overcome, for example consideration of the feasibility of LEZ introduction by several Scottish local authorities.

Industry

Considerable progress has been made over recent decades in controlling emissions from industrial sources, to the extent that around 95% of regulated industry is now in compliance with its permit. Robust legislation and stringent operating conditions, in combination with technological developments, have been highly successful in significantly reducing the contribution of industry to poor air quality in comparison to other sources, notably transport, which is now by some way the main source of pollutant emissions in most urban areas.

Climate change

Co-ordination of policies to maximise the benefits for both air quality and climate change will be essential over the coming years. Air pollution: action in a changing climate was published jointly by the four UK administrations in 2010 and considers how additional benefits can be achieved by closer integration of these policy areas. Air quality and climate change benefits can be realised through actions such as promoting low carbon vehicles and renewable sources of energy that do not involve combustion. At the same time, actions that tackle climate change but damage air quality should be avoided. Analysis undertaken to inform this document suggests that optimising climate policy decisions to account for air pollution could yield additional health-related benefits of approximately £24 billion by 2050.

Biomass

Emissions from well operated and maintained modern biomass boilers are generally lower than for coal or oil equivalents and, where biomass replaces these fuel types, the effect on air quality will be largely positive. However, when biomass boilers replace gas-fired appliances in urban areas, where poor air quality may already be an issue, there is the potential for emissions to increase, unless appropriate abatement technology is employed and operating conditions set.

Careful control of biomass uptake in urban areas, both domestic (i.e. wood-burning stoves) and large scale, will also be necessary in the future, particularly where:

- the proposed development is inside or adjacent to an AQMA;
- the development could result in designation of a new AQMA;
- the granting of planning permission would conflict with, or render unworkable, elements of a local authority's air quality action plan.

With commitments to both an increase in renewable heat and protecting air quality and public health, the Scottish Government is working to manage any conflicts that may arise, while at the same time taking into account its core purpose of sustainable economic growth. Guidance produced by Environmental Protection UK's Scottish division provides advice on how biomass uptake can be effectively managed with compromising air quality.