INFORMATION FOR MEMBERS

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ACID RAIN AGREEMENTS

International negotiations are underway to finalise agreement on reducing emissions of sulphur dioxide, one of the main causes of 'acid rain'. Pressure is on the UK to reduce emissions by ~80% relative to 1980 levels; the Government has offered to cut emissions by 71% by 2005, and is considering whether the 80% target could be met by 2010.

This briefing note looks at the implications of UK options for reducing SO_2 emissions.

ACID RAIN AND ITS EFFECTS

The main sources of acid deposition (commonly known as acid rain) are the gases sulphur dioxide (SO_2) and nitrogen oxides (NO_x). SO_2 emissions account for ~70% of UK acid deposition, and 71% of the 3.56 million tonnes (Mt) emitted in 1991 came from power stations burning coal or oil (**Figure 1**). NO_x form when fossil fuel is burnt and are increasing with the growth in road traffic (responsible for 51% of 1991's 2.75Mt emitted).

The evidence linking these gases to acid rain and its environmental effects has been built up over many years. There is concern over the effects on freshwater fish, amphibians, animals and birds, on soil nutrients, and over corrosion of building materials. The mechanisms of some effects are still not fully understood - the exact role of acid rain in the forest damage widespread throughout Europe is still unresolved, since acid gases may be acting in synergy with other pollutants and stresses such as drought and frost.

The gases may exert their effects directly (dry deposition) or after conversion in the air to acid droplets which then fall in rain or snow (wet deposition). Dry deposition is greatest close to the source, whereas wet deposition may occur hundreds of kilometres downwind (a small percentage of acid rain in the UK originates in the USA and Canada). About three-quarters of the UK's SO_2 is 'exported', and although some of this falls out and is neutralised in the Atlantic Ocean or North Sea, some reaches Scandinavia and other European neighbours. Any country's acid rain is thus a combination of that produced nationally and that imported from other countries. In the UK, most (55-85%) acid deposition originates from the UK. In contrast, emissions from abroad are the dominant source in Norway and Sweden (**Figure 2**), with the UK the source of 20% and 12% respectively of each country's 1991 sulphur deposition.

Figure 1 UK EMISSIONS OF SULPHUR DIOXIDE

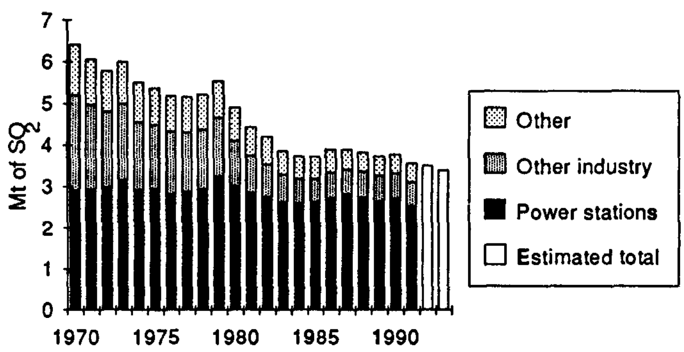
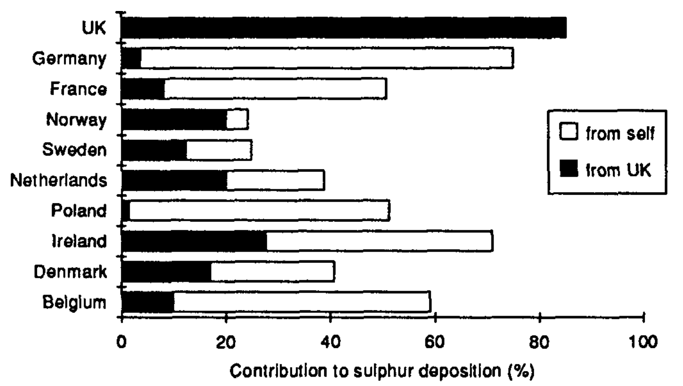


Figure 2 DEPOSITION FROM UK SO_2 EMISSIONS IN 1991



INTERNATIONAL COMMITMENTS

The international dimensions of acid rain led to the adoption in 1979 of the United Nations Economic Committee for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP), aimed at reducing emissions of both sulphur and nitrogen oxides. The Helsinki protocol (1985) agreed to reduce SO_2 emissions by 30% (from 1980 levels) by 1993 and the Sofia protocol (1988) committed countries to reducing NOx emissions to 1987 levels by 1994. The UK signed the Sofia but not the Helsinki protocol, although it is on course to meet both targets. The current negotiations are to agree a successor to the Helsinki agreement.

The UK also has commitments under the EC Large Combustion Plant Directive (LCPD) with targets to reduce SO_2 emissions from existing large plant[1] by 20% (1993), 40% (1998), and 60% by 2003 (from a 1980 baseline). NO_x emissions must be cut by 15% (1993), and 30% (1998). In 1990, the Department of the Environment (DoE) issued a National Plan to cut emissions by 63% by 2003, and assigned quotas to the relevant industrial sectors for HMIP to implement(**Table 1**).

1. Large Plant refers to large boilers and furnaces in power stations, refineries, and industry; these accounted for 83% of 1991's emissions. The EC will review the LCPD in 1994, and limits may be tightened.

Table 1 SO_2 QUOTAS UNDER THE NATIONAL PLAN (thousands of tonnes of SO_2)

	1980	1991	1993	1998	2003
National Power	{2776	1595	1497	982	660
PowerGen		1085	1019	669	450
Scotland	142	109	104	99	57
N. Ireland	88	92	80	53	35
Refineries	268	100	100	95	90
Other Industry	621	312	276	230	160
TOTAL	3895	3293	3076	2128	1452
% Reduction (from 1980)		15%	21%	45%	63%

THE 'CRITICAL LOADS' APPROACH

During the previous UNECE negotiations, the UK argued that arbitrary targets were an inefficient way of protecting the environment, and that emissions should be controlled to achieve agreed environmental objectives. To this end, the UK helped to develop the critical loads approach in the 1980s, and gained agreement that this would be used as the basis for any new controls.

The approach is based on the fact that the effects of acid deposition on soil and freshwater depend on how much neutralising or buffering capacity is naturally present - for example, chalky soils neutralise acid readily and are relatively unaffected, while thin, poor soils can be highly susceptible. The critical loads approach takes account of the variations in natural susceptibility and identifies for each area of the country what amounts of acid deposition can be absorbed without causing long term damage to the environment (Box).

UK 'critical loads' maps show that sulphur deposition currently exceeds critical loads for soils over 44% of the UK (**Figure 3**), and for freshwaters in 14% of the UK. Calculations suggest that even the EC LCPD's 60% reduction target will not protect the most sensitive areas (upland areas of Wales, N England, NW and SW Scotland), and even larger reductions of 73% will still leave critical loads exceeded over ~5% of the UK.

The current round of CLRTAP negotiations requires a means of predicting the environmental effects of different emission scenarios, and three different computer models are in use. These simulate the atmospheric transport and deposition of emissions over Europe, compare with the European critical loads map (compiled from national maps), and calculate the cost and impact of various reduction scenarios (Box). They show that the cost of ensuring that critical loads are not exceeded anywhere is prohibitive, and instead, the Convention Parties have agreed to aim for a '60% gap closure' where the difference between current sulphur deposition and the critical load will be cut by 60%.

This '60% gap closure' strategy leads to different targets for different countries. For the UK and several other northern European countries, a reduction of about 80% from 1980 emissions would be required, while for some, targets would have to be higher (e.g. Denmark 87% and Germany 90%). Others (e.g. Ireland, Greece and Portugal) have lower targets or can even increase their emissions. At present, the UK is offering less of a reduction (71% by 2005) than required by the models; however, the possibility of making a commitment to an 80% reduction by 2010 is under active consideration.

❒ CRITICAL LOADS APPROACH

The critical loads approach recognises that the impacts of acid deposition vary according to the sensitivity of the environment, and tries to identify the threshold (the critical load) for deposition, below which long-term damage will not occur. For soils and freshwaters this sensitivity mainly depends on the underlying geology of an area, which determines the natural 'buffering' capacity of the soil and water.

The Natural Environment Research Council's Institute of Terrestrial Ecology and other members of the DoE's Critical Loads Advisory Group have produced a critical loads map for soils (on a 1km grid) on the basis of information on soil types, and maps for freshwaters based on a survey of the most sensitive waterbody in each 10km grid square. Maps of *current* deposition levels are produced by Warren Spring Laboratory, based on measurements of wet deposited sulphur and of gas concentrations. Maps of deposition under future emissions scenarios are produced at Hull University using a computer model of atmospheric transport and deposition of emissions (Hull Acid Rain Model (HARM)). The areas where the critical load is exceeded are found by comparing the deposition maps with the critical load maps.

For the UNECE negotiations, national data on critical loads have been combined into a coarser European map with a grid square of about 150 km by 150 km. The critical load assigned to each grid square is designed to offer protection to 95% of the square.

The impact and cost of emissions reductions and environmental protection strategies are determined using 3 computer models:-

- Abatement Strategies Assessment Model (ASAM) at Imperial College, London.
- Coordinated Abatement Strategy Model (CASM) at the Stockholm Environment Institute at York.
- Regional Acidification Information and Simulation (RAINS) model, at the International Institute for Applied Systems Analysis.

OPTIONS TO REDUCE UK SO_2 EMISSIONS

The main source of SO_2 is the electricity supply industry (ESI). **Figure 4** shows that the amounts emitted depend very much on the fuels used and pollution control policy adopted by the industry. Key factors are:

- The replacement of coal-fired power stations by **gas-fired combined cycle gas turbines (CCGTs)** which emit very little sulphur. The DTI has granted Consents for 18.2GW (capable of providing 40% of electricity supplied in 1992) and estimates that at least 12GW of CCGTs are now committed to construction.
- The balance between **domestic and imported coal**; the latter typically has a lower sulphur content

Figure 3 EXCEEDANCES OF SOIL CRITICAL LOADS IN THE UK

a) 1989-91 b) Predicted with 73% reduction (from 1980 emissions)

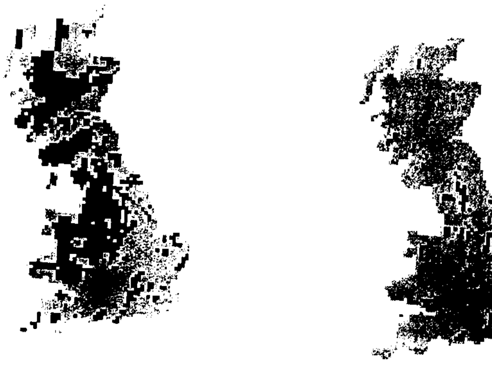
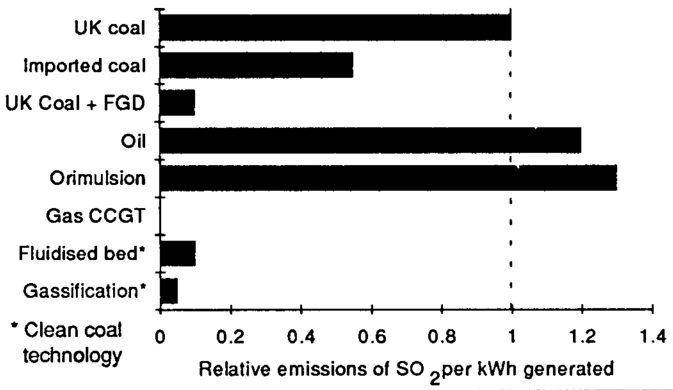


Figure 4 SO_2 EMISSIONS FROM ELECTRICITY GENERATION



(0.8-1.0%) than British coal (average 1.6%).

- The extent of fitting of **Flue Gas Desulphurisation** (FGD) which removes up to 90% of sulphur. 6GW (National Power (NP)'s 4GW Drax and PowerGen (PG)'s 2GW Ratcliffe-on-Soar station) should be fully operational by 1995/96. In the longer term, 'clean coal technology' offers an alternative to FGD[2].
- Authority to use **Orimulsion** (a bitumen-based fuel with a sulphur content of 2.7-3%) has been granted by HMIP for PG's Richborough (0.36GW) and Ince (0.5GW) stations, subject to an assessment of 'appropriate sulphur abatement techniques' by September 1994, to be fitted by April 1998. Burning Orimulsion without FGD generates 25% more SO_2 than typical UK coal (for the same power output). The stations' permitted SO_2 emissions are equivalent to burning ~2.5Mt coal p.a.
- Future reliance on nuclear and renewable sources which produce effectively zero SO_2 emissions.

The ease with which the UK can meet reduction targets thus depends very much on the future fuel mix of the ESI, particularly on how much UK coal and oil/Orimulsion is burnt without FGD. Illustrative scenarios are in **Table 2**. Under a scenario where UK coal retains a major share of the power station fuel market, an 80% target would require additional measures such as FGD. However in the scenario involving rapid run-down of the UK coal industry, the '80%' target could be met without further steps.

Table 2 POSSIBLE REDUCTIONS IN SO_2 EMISSIONS (from 1980 levels) in 2000

FUEL MIX SCENARIO	FGD Installed 6GW	8GW	12GW
A: 'High' Coal Use (56 Mt) (42 Mt UK coal, 14 Mt imports)	52-63%	57-68%	67-77%
B: 'Low' Coal Use (48 Mt) (35 Mt UK coal, 13 Mt imports)	60-70%	66-76%	75-86%
C: 'Low' Coal Use (48 Mt) UK coal used at FGD stations only (16,21 and 31 Mt respectively) balance made up by imports	71-81%	73-84%	78-88%

N.B. Range of values reflects possible variations in oil and orimulsion fired generation.

ISSUES

Scientific Basis of Critical Loads

While there is consensus that the critical loads approach should offer a cost-effective way of targeting reductions to achieve the maximum environmental benefit, scientists accept that the methodology is still at an early stage and that uncertainties remain in setting the critical loads and in the modelling calculations. One cause for concern is that the three models in use (Box) give different reduction targets for the UK (76, 79 and 88%) to achieve the '60% gap closure' level of protection. Another is over the detailed scientific criteria (e.g. freshwater chemistry) which are used to define the sensitivity of the local environment. There is some national discretion in these and some countries have adopted more stringent criteria than others, leading to very low critical loads which in turn mandate large emissions reductions. This caused some 'teething' problems - for example, critical loads calculated for some parts of Norway and Sweden were below the natural background deposition from the sea. Where such unachievable goals arose, convention scientists agreed a formula which gives a critical load slightly above the natural background. The models were very sensitive to this adjustment (the UK reduction targets fell from 85% to 76% according to one model), and concern remains over the possible disproportionate influence of other areas assigned very low critical loads.

On the other hand, environmental groups and others are concerned that since critical load values are set to protect only 95% of the area of each 150 km grid square, the most sensitive 5%, which may contain ecologically important areas, may still be unprotected even when critical loads are met. They see this as over-riding concerns over the detailed methodology and justifying rapid action on the basis of the existing models. Moreover, they see such an approach as most consistent with the precautionary principle.

2. See POST Briefing Note 38. The Coal White Paper increased funding for coal R&D from £3.2M in 1992/3, to about £7M p.a. for the next three years, but promised no public funding for demonstration projects. The extra funding is mainly being spent on developing British Coal's 'Topping Cycle'.

UK Targets: The Case for 70 % or 80%

If the model results are accepted, the UK (and some other States) will continue to be under pressure to achieve the full cuts indicated (80% for the UK). In this case, environmental groups argue that the UK should abide by the results of the critical loads approach (which it has advocated for several years), and by its Environment White Paper objective ("to reduce acid emissions to a rate that is sustainable by the natural environment") and offer an 80% cut. They also suggest that an early target date of 2000 should be set, since HMIP's aim is that existing plant should meet emissions limits set for new plant by 2001 (the generators must submit upgrading plans by April 1994).

Furthermore, if environmental improvement is measured in terms of reducing the area where critical loads are exceeded, then reducing emissions by 70% (compared to the 60% commitment of the LCPD) would achieve only ~a third of the benefits of a cut of 80%. Thus a study by the UK's Joint Nature Conservation Committee of Sites of Special Scientific Interest (SSSIs) at risk from acidification, shows that the area of SSSI sites in England and Wales at risk under current 60% reduction plans (321,420 ha) is only reduced by 15% at a 70% reduction, but is almost halved with an 80% cut.

The counter argument by many in industry is that the critical loads approach is not yet sufficiently well validated and should be subjected to more open scientific debate before being used in international negotiations. In addition to the concerns over the effects of different countries' criteria above, there are concerns that the UNECE has not taken into account the impact of planned reductions by the USA (35% by 2005, 40% by 2010) and Canada (46% by 2000 in Eastern Canada) - if this were done, UK reduction targets could be lower by ~3%.

Industry thus argues that the target reductions suggested by the models should only be considered as indicative, and the costs and practicality of reducing emissions should also be weighed carefully. Most existing coal-fired plant will retire between 2005 and 2010, and thus the most economic way of achieving targets is to set them beyond 2005. The ESI thus supports the lower target of 70% achieved over a longer timescale (by 2005), and believe any more stringent targets should be after the planned retirement dates of coal-fired plant.

They also see little environmental benefit in an earlier target, as modelling work suggests that acidified lakes may take several decades to recover after deposition is reduced below the critical load level. Environmental groups however argue that it is the long timescale for recovery that makes urgent action necessary, so that recovery can start as soon as possible. Moreover damage may be less readily reversed if acid deposition stays above the critical load level for too long.

Achieving the Targets

Table 2 showed that 8GW of FGD, imports of low sulphur coal and CCGTs would achieve a 70% reduction without imposing constraints on the market for British Coal. Meeting the 80% reductions would require additional FGD, or would constrain the market for British coal, necessitating its replacement by imports and CCGTs. UNECE models predict that achieving an 80% reduction would cost the UK ~£1B p.a., but this figure is widely regarded as an overestimate, as it does not take into account recent changes which are reducing the amount of coal burnt.

The case for FGD is a matter of particular controversy. In 1989, the (former) CEGB estimated that compliance with the LCPD would require 12GW of coal-fired plant to be retrofitted. The Energy Select Committee however found in 1990 that the generators were proposing to fit only 8GW and expressed concern that this breached understandings given by the UK during the Directive's negotiations. Since then, 6GW have been fitted; PG has approval to fit another 2GW at Ferrybridge C, but no decision has been taken on installation. Some argue that the 12GW originally envisaged should be fitted so that SO_2 targets can be achieved without restricting the use of British coal; also that plans to burn Orimulsion should be contingent on the use of FGD. The ESI points out however that FGD brings its own environmental problems (from limestone quarrying, gypsum disposal etc.) and would be costly - fitting an additional 4GW of FGD to help meet an 80% target would have capital costs of about £500M and running cost of £50M p.a. The resulting increase in generating costs (which could exceed the current FGD costs of 0.5p/kWh due to limited plant life over which to spread costs) could make stations uncompetitive, so that they would only be run at peak times and the investment in FGD would not be fully utilised.

If no more FGD is fitted to existing plant (any new coal or oil plant would have to fit FGD or use clean coal technology), the ability to meet SO_2 targets will depend on HMIP's policy on existing plant and the generators' policies on coal use. The use of British coal by the generators is set to decline - NP and PGs' contracts for British coal will fall from 65 Mt in 1992/93 to 40 Mt in 1993/4 and then 30 Mt until 1998/99 (the Coal White Paper offered a subsidy for any additional sales, but none have so far been announced). Some energy observers believe that NP and PG will burn even less coal after 1998, allowing the UK to meet an 80% target with ease before 2010. Others believe that this decline in British Coal use should not be presumed, and that the UK should not agree to a target which would further constrain the market for British coal.