# ***European Studies***

## The main causes of environmental pollution in Manchester.

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**M13**

This report looks at the key problems in Manchester, and then compares them with other EU states to see if problems are localised or not, and if things and if the situation for a particular pollutant is worsening, improving or remaining constant.

# An examination of the main causes of pollution in the Manchester area

This report will be looking into the causes of pollution in my local area (city of Manchester), and whether or not they are localised or occur elsewhere within the European Union (hereafter abbreviated EU). In order to examine the causes of pollution it will be necessary to look at the actual forms of pollution that are present in Manchester, then I will give details on their causes. This report will focus on atmospheric pollution as it is the major form of pollution in Manchester, and is certainly the most noticeable. I shall cover all key aspects of atmospheric pollution, including cause and effect.

## Air pollution:

The most noticeable environmental pollution particularly within the city of Manchester and other principal towns in the county is air pollution, the heat wave that United Kingdom experienced in 1995 showed strongly that there was a worrying national problem. As it turned out, Manchester was one of the worst affected areas of the country, and this lead to the subsequent city centre traffic restrictions on busses (one of the largest polluters of the air), which involved major changes to the city centre's bus transport infrastructure, such as reduced waiting times, and major route changes to ensure that busses take the shortest route possible within the city centre. This rapid positive action is still believed not to have gone far enough, particularly when you consider the restrictions that are placed on traffic within cities in other EU member states, this is something I shall deal with later.

There is little doubt that within the city of Manchester the main cause of pollution is road transport, as the other main cause of pollution - heavy industry, lies outside the city centre, and hence leaves road transport as the other major pollution cause. The diagram below shows the types of air pollution in urban areas directly linked with road transport:-

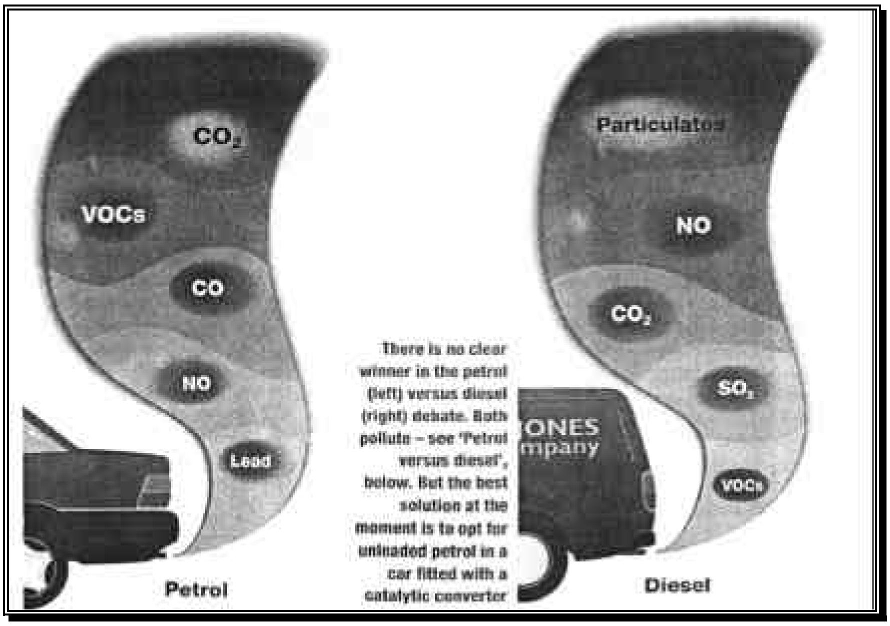



*Figure a - pollutants from car and van exhausts*

You will notice that a number of pollutants are attributable to diesel and petrol use, they are a product of the incomplete combustion of the fuels, if the fuels were burnt completely, then just water and carbon dioxide ($CO_2$), which are less of a problem than the individual pollutants produced when the fuel is not completely combusted, although there are problems with carbon dioxide that I will deal with on the section of greenhouse gases. The following sub-sections are concerned with the pollutants found in air that are produced by cars and other sources.

Nitrogen Oxides ($NO_x$):

Nitrogen oxides are formed form the combustion of the nitrogen present in fuels, and also from the oxidation of that present in the air. Nitrogen oxides[1] have varied effects on health, high concentrations of nitrogen oxides can reduce plant growth, and can have a visible effect on sensitive crops, add to acid deposition (e.g. through acid rain/snow), and can also play a part in the formation of tropospheric ozone (I shall deal with this in the section on tropospheric ozone). If there is acute exposure to nitrogen oxides, then respiratory problems can result. The map below shows the concentrations of nitrogen dioxide between July and December 1991 for the UK, as you can see, Manchester comes in the top category of 30ppb, and in fact has the highest level of Nitrogen Dioxide outside London:-

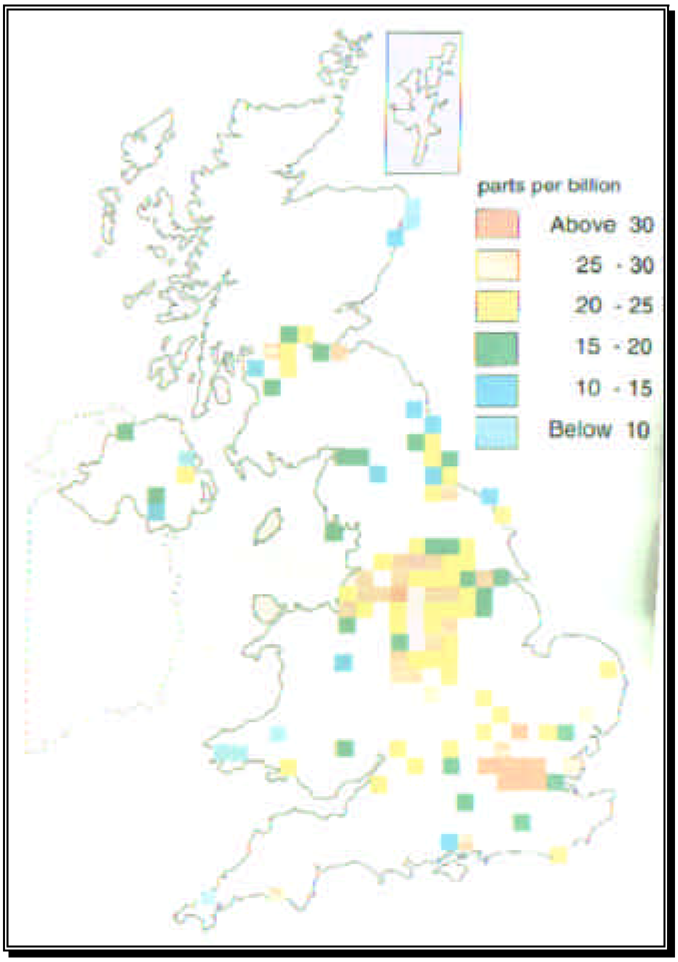



*Figure b - Mean $NO_2$ concentrations in urban areas, July - December 1991.*

[1] In particular nitrogen dioxide.

When it comes to Nitrogen Dioxide, the UK as a whole does not have a good record, between 1986 and 1991, there was a 35% increase in the average concentrations, mainly as a result of increased emissions from road traffic (there has been a considerable increase in the number of cars over this period). One finds that high concentrations of any pollutant occur in the summer or winter when their is no strong wind to disperse the pollutants, hence they become trapped forming smog (before the introduction of smokeless fuels in 1956 these would become like a very thick fog that could last for days, very often with visibility of less than a metre, in London's last major smog in 1952, 4,000 people died from linked heart and respiratory incidents).

The standards the government of the United Kingdom uses to grade the air quality over a particular period, with relation to Nitrogen Dioxide are EU directive 85/203 and the WHO[2] (Europe) air quality guidelines. The figure below shows the number of occasions in 1990, on which the air quality failed to comply with these guidelines, resulting a 'poor' classification, as you can see, outside London, Manchester has the highest incidence of poor air quality compared to the other urban monitoring stations:-

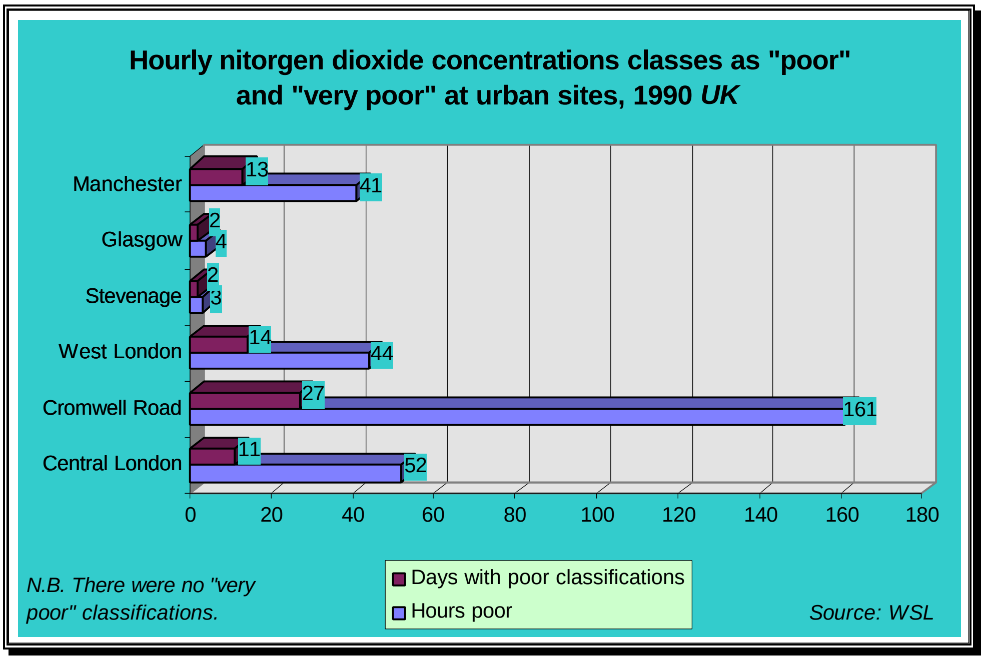



*Figure c - Length of time $NO_2$ concentration exceeded EU and WHO limits.*

As you can see, Nitrogen Dioxide clearly presents a problem in Manchester, although the problem is by no means restricted to Manchester, as you can see, all principal cities in the United Kingdom have Nitrogen Dioxide pollution, although levels are not exceeded in all cities. Road transport is the key cause of Nitrogen Dioxide pollution, it now represents 51% of total Nitrogen Dioxide emissions, compared with only 27% in 1970, while the overall emissions from power stations (the other major contributor) have actually dropped from 37% in 1970 to 28% in 1990, and are set to fall further with the introduction low $NO_x$ burners in the 12 major coal-fired power stations. So while emissions in other sectors are falling, emissions from road transport are increasing due to increased traffic volumes, therefore the total pollution is

[2] World Health Organisation

still increasing. The charts below show the Nitrogen oxides emissions by sector in 1990, and the fuel types and the percentage of total pollutant they produce:-

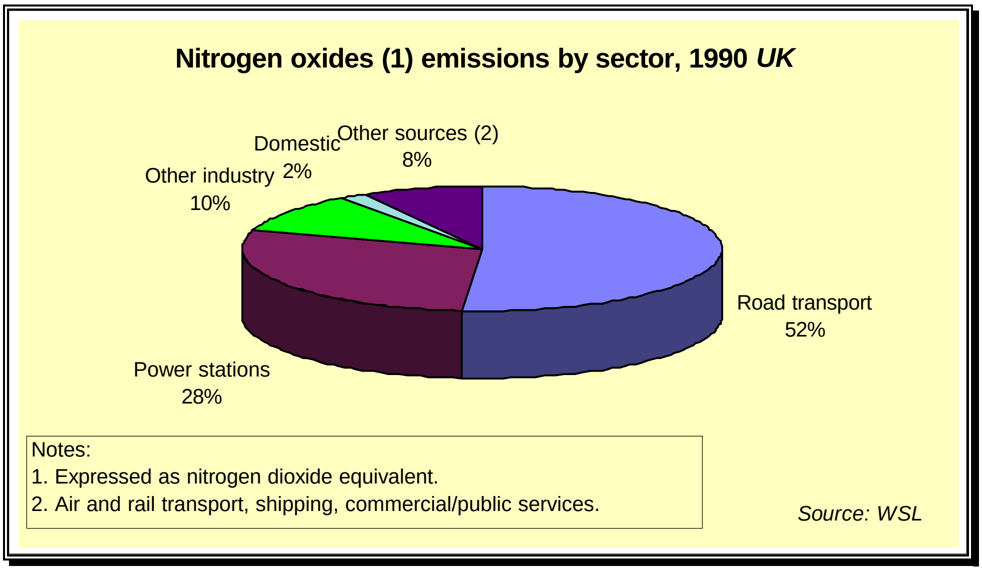



*Figure d - $NO_2$ emissions by sector.*

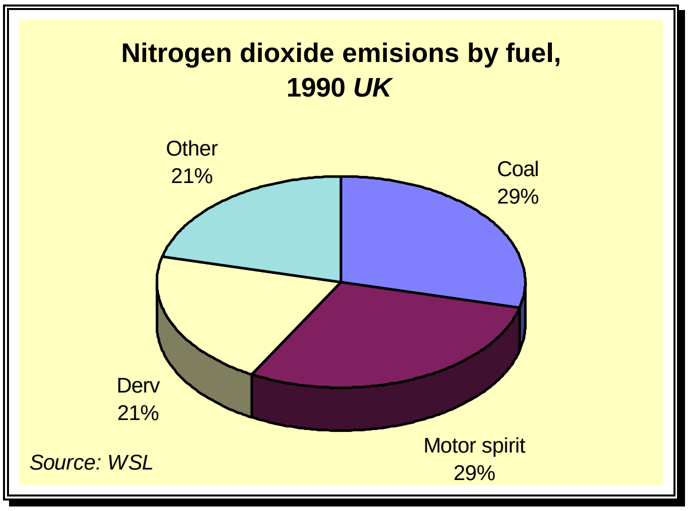



*Figure d (2) - $NO_2$ emissions by type of fuel.*

So the major causes of Nitrogen Dioxide pollution are road transport and power stations, with industry making a small contribution. It is interesting to note that while both petrol and diesel vehicles emit Nitrogen oxides, petrol cars are actually responsible for 80% of the total road transport contribution.

*How the rest of the EU compares as far as $NO_X$ pollution is concerned:-*

One will have noted that in the UK there was a 35% increase in emissions in the period 1986-1991, while between 1970 and 1990, emissions from power stations had actually dropped from 37% to 28%, hence meaning that transport is more responsible for nitrogen oxides pollution. While the UK has seen a rise in emissions of nitrogen oxides, according to the European Commission's statistical service Eurostat, between 1980 and 1988, community wide emissions remained roughly the same.

Figure *d(eur)* shows the emissions of nitrogen oxides across the community in 1985 (only data for the 12 states, minus GDR was available at the time).

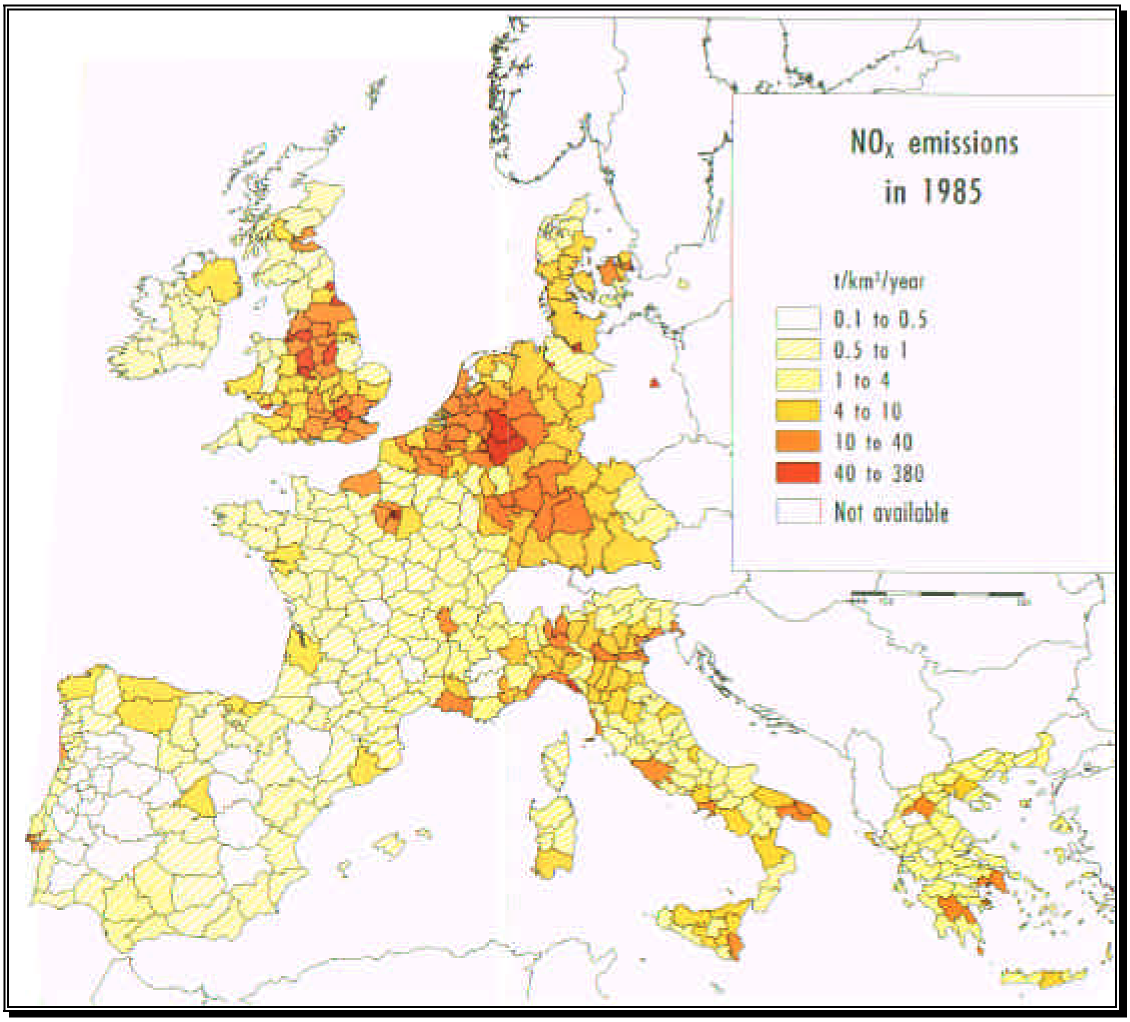



*Figure d(eur) - $NO_X$ emissions across the EU, 1985.*

As you can see, in relation to the rest of Europe, the UK has amongst the worst levels of emissions of nitrogen oxides, Manchester is one of the worst affected areas, as the DoE figures for UK showed. Looking to the continent, we see that Germany as a whole is badly affected, with areas such as the Rhur valley (a large industrial area), West Berlin particularly badly affected. The key reason for Germany's problems lies with the fact that it is a transition country, and very large volumes of traffic pass through the country on the way to Northern and Eastern Europe, as well as Southbound traffic on the way to Austria, and Italy. We had seen from the UK figures that road transport accounted for 51% of emissions (the UK amongst the highest volumes of traffic in Europe, particularly in cities like London and Manchester), in Germany, transport accounts for 55% of emissions. In the UK the next largest contributor is power stations at 28%, in Germany the next largest contributor is industry at 17% followed by power stations 14%. It is interesting to note that the third main cause of nitrogen oxides in the UK was industry at 10%, so both the UK and Germany have similar emission levels, and the same three main causes, but at slightly different concentrations.

It is clear from the map, and is stated by Eurostat in their annotation that nitrogen oxides pollution is something that plagues cities and industrialised area (where there is likely to be large volumes of traffic or combustion of fossil fuels), in the UK, all the urban areas are affected, one can clearly see that most of northern Britain (Cumbria upwards) is not affected to any significant degree. The same can be seen across Europe, looking at France, the country has low emissions throughout apart from large cities, such as Paris, Calais (a channel port - ships, cars & lorries will provide significant pollution), Nantes and Marseilles. Spain is another area where emissions are low, in Spain there are relatively few areas where emissions are significant, these are again regions where there are urban areas, one can see that Madrid is affected quite badly, then to the south the region containing the city of Barcelona. In the north there are about five regions affected to a significant degree, where there are principal towns/cities. Spain is not plagued by large areas with high emissions as there is very little heavy industry The same can be said of Portugal, where there are only significant emissions from around Lisbon, and a small area in the north west of the country. Lisbon correlates with what I have said so far, that urban areas with high volumes of traffic are affected most, Lisbon is particularly unfortunate as far as this is concerned, as it is the centre of the country's highway and railway network, and there is an international airport within the region shown, it also happens that Lisbon is a major port, and there is significant heavy industry in this area (e.g. petroleum refineries). Again the same is true of Greece, where large parts of the country are relatively unscathed, yet areas such as Athens where there is a high population density - therefore large traffic volume, and an industrial Sector, are very badly Affected.

The figures *1* and *2* below show the population density of the EU in 1985 (inhabitants per sq. km), and regions of heavy industry respectively. As you can see when compared with nitrogen oxide emissions across the EU, areas affected badly either have heavy industry (power generation, etc), or more importantly for nitrogen oxide emissions, a large population density (e.g. a large town or city, where there will be a lot of road transport - the main cause of nitrogen oxide emissions). I have shown that this is true in several EU countries, and assume this is the case elsewhere.

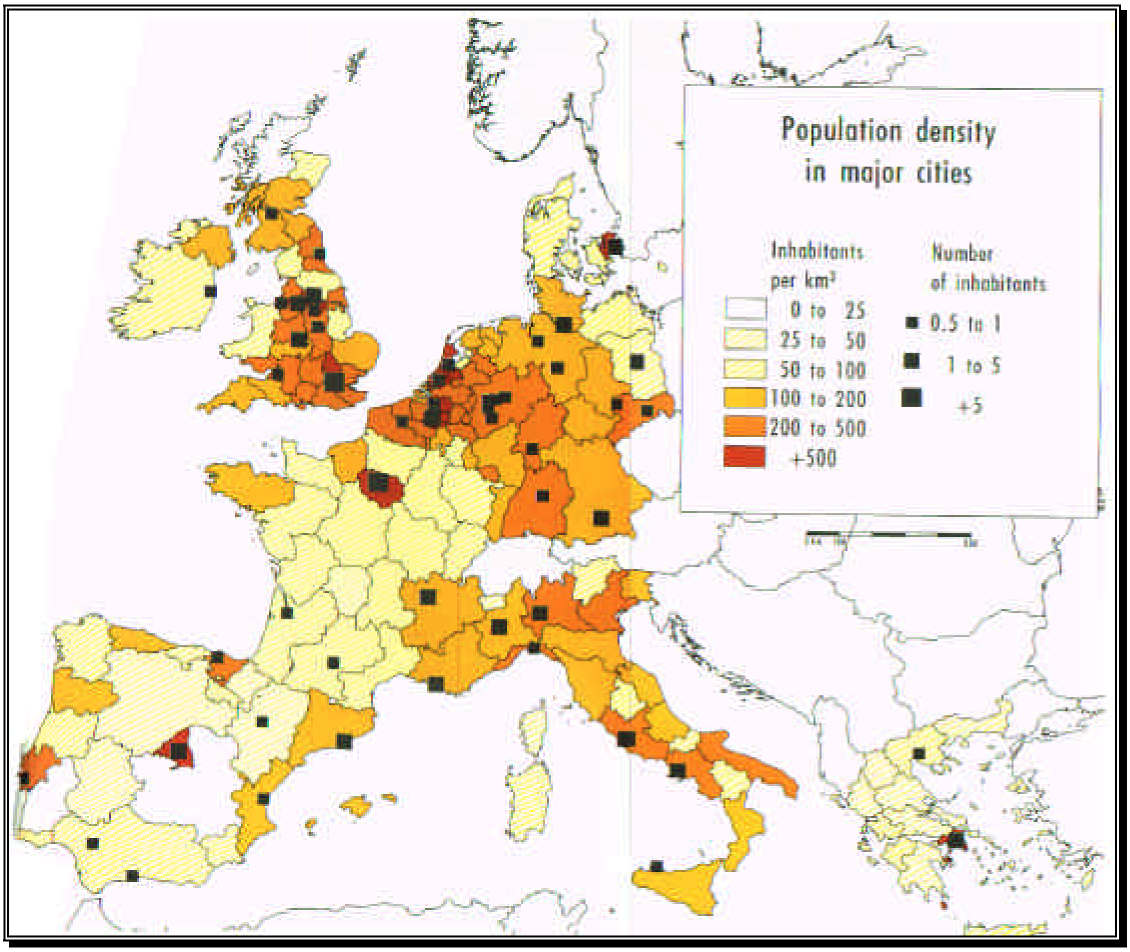



*Figure 1 - Population density of the EU - 1985 (EUR12)*

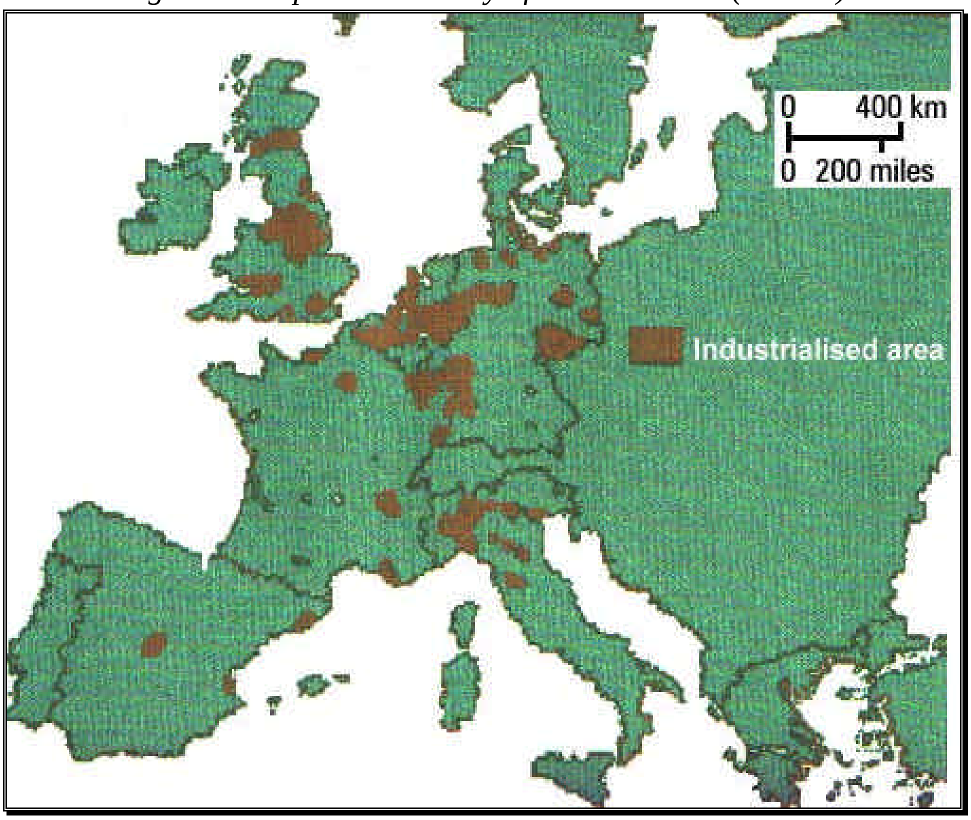



*Figure 2 - Areas of heavy industry across the EU - 1994 (EUR12)*

As far as trends in emissions go, it is not particularly good news, emissions have remained level between 1980-88 according to Eurostat, however certain countries are seeing increases in emissions, even despite reductions in other areas such as electricity generation, the UK is an example of this. Portugal, another country with increasing emissions, has actually seen the largest increase, due to a rush to industrialise, with the added burden of increased traffic volumes. Increasing traffic is a problem for the whole EU, some countries deal with this better than others, many countries on the continent now ban traffic in city centres on certain days, to protect people's health, and other countries impose or intend to impose restrictions on traffic. Austria for example, prohibits lorries of a weight of over 28 tonnes (all other countries allow 44 tonne lorries), however, this has helped in a 16% reduction in emissions between 1980 and 1993 from transport, this still doesn't change the fact that transport is Austria's main cause of nitrogen oxide emissions, well over 3 times the amount of the secondary cause of emissions - industry.

Austria sets a good example to the rest of the EU, between 1985 and 1992 it had the largest total reduction in emissions of all member states, with an 18% reduction (from 245,000 tonnes to 201,000 tonnes). Austria has seen a larger reduction in the period 1980-93 totalling a 26% reduction! In Austria, the sector that witness the largest reduction in nitrogen oxide emissions was from power stations which made a 54% reduction in emissions between 1980 and 1993, quite a feat when one considers the UK's reduction from power stations between 1970 and 1990 was only 9% - however, if one considers that only 30% of Austria's power is produced from fossil fuels, it is put rather more into perspective. Power stations account for the least share of total emissions, quite different from the UK, where power stations are the second main contributors. Austria's industry has also seen reductions, of 48% - remarkable! Most other EU countries, are not so fortunate, out of the 13 member states I have information for, 7 have increased emissions! The trends of nitrogen oxide emissions between 1985 and 1992 for the EU is shown in figure *3*. As you can see, there are seven countries with increasing emissions, and most of these are a cause for concern, as all except Finland, Italy and Belgium are not expected to meat the 30% reduction target defined in Sofia in 1988, by 1998[3]. Countries with reducing emissions are doing well, and provided this continues are an example to the rest of the EU. Countries with increasing emissions need to keep them in check, Spain and Portugal are of particular concern due to their late industrialisation and what appears to be a rush to catch up, which must be controlled, and sufficient environmental measures taken. The problem is particularly difficult to solve as road transport is the main cause, and as this is increasing it is difficult to control, the other main causes - power generation and industry are easier to control, and despite several examples of reductions in emissions made by these sectors, it is likely that they are to be expected to reduce emissions considerably more, even though road transport is the main cause of emissions. Figure *4* below shows the emissions by sector in 1990 for the EU.

[3] This is despite the fact that recently they have seen increases in emissions.

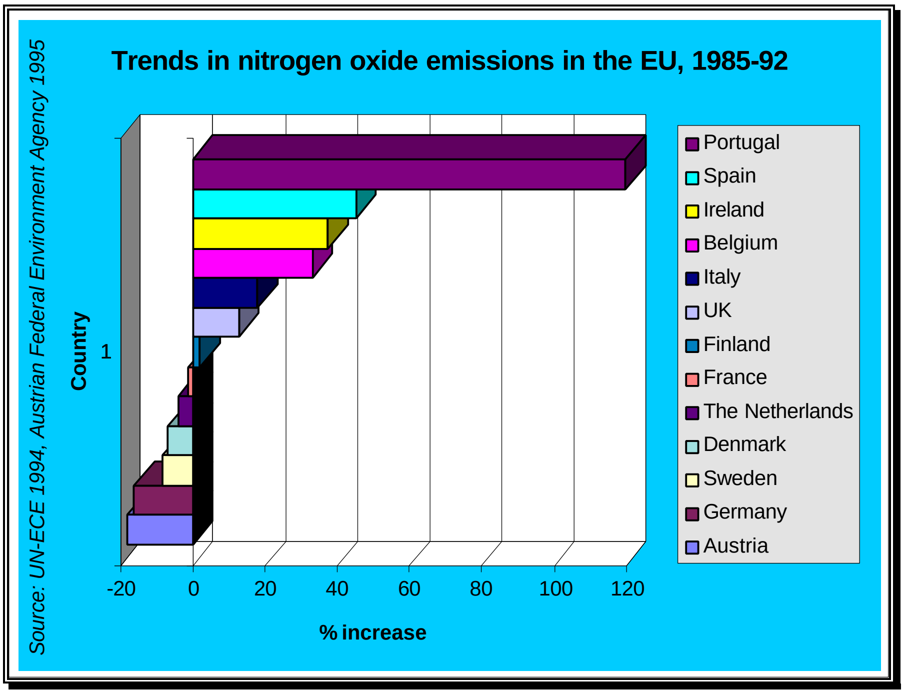



*Figure 3 - Trends in $NO_X$ emissions across the EU.*

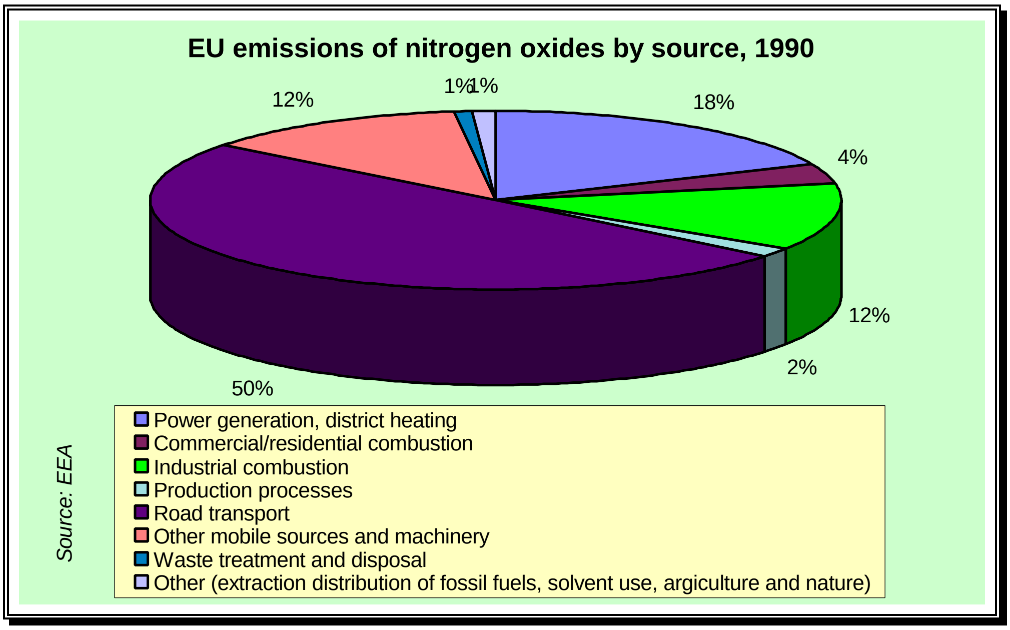



*Figure 4 - $NO_X$ emissions by sector in 1990 (EUR15).*

The sources are the same as those in the UK (with slightly different percentages), i.e. main cause is road transport, followed by power generation and with industry in third. In general one finds that this is the case, although sometimes other mobile sources and machinery can be a major contributor, in countries that have a large agricultural sector (e.g. Greece). The following table shows each of the EU member states, with the primary, secondary and tertiary causes of $NO_X$ pollution (from EEA data based on the 1990 CORINAIR survey):-

| Country | Primary Cause | Secondary Cause | Tertiary Cause |
|---|---|---|---|
| Belgium | Road transport (55%) | Power generation | Industrial combustion |
| Denmark | Road transport (37%) | Power generation | Other mobile sources |
| Spain | Road transport (40%) | Power generation | Other mobile sources |
| Germany | Road transport (55%) | Industrial combustion | Power generation |
| Greece | Other mobile sources (50%) | Road transport | Power generation |
| France | Road transport (65%) | Industrial combustion | Other mobile sources |
| Ireland | Power generation (40%) | Road transport | Industrial combustion |
| Italy | Road transport (46%) | Power generation | Industrial combustion |
| Luxembourg | Industrial combustion (47%) | Road transport | Other mobile sources |
| Netherlands | Road transport (47%) | Power generation | Production processes |
| Portugal | Road transport (48%) | Power generation | Industrial combustion |
| United Kingdom | Road transport (51%) | Power generation | Industrial combustion |
| Austria | Road transport (68%) | Industrial combustion | Commercial/residential combustion |
| Finland | Road transport (44%) | Power generation | Other mobile sources |
| Sweden | Road transport (47%) | Other mobile sources | Industrial combustion |

As one can see from the table, the same three causes mentioned keep cropping up, with 80% of the listed countries having road transport as the primary cause, and 54% of countries listed having power generation as one of the three main causes, with 33% of countries having industry as a main cause. The exceptions were Greece (see above), Ireland which uses a large amount of peat[4] and fossil fuels for power generation, and Luxembourg which has a very large iron and steel industry.

Particulates:-

This is more commonly known as black smoke, and consists of tiny particles of carbon and unburnt or partly-burnt carbon compounds from fuel and lubricating oil. They are thought to increase the risk of heart and lung disease. The problem of particulate pollution has reduced, and the government of the United Kingdom tell us that they are committed to reducing black smoke emissions in line with EU targets. Particulate pollution used to be a particular problem in the 1950's, when the post-war increase in the number of vehicles and reconstruction of heavy industry lead to emissions of many chemicals on a large scale, at a time when the environment was simply not an issue. The problem had become so bad that dense fogs made up of smoke and other chemicals such as sulphur dioxide would form that could reduce visibility to less than a metre, and such fogs (known as *smog*) could last several days when there was no wind to disperse the pollutants. The last major smog of 1952 in which 4,000 people died from related heart and respiratory problems forced the government to review the situation, which resulted in the clean air act of 1956, and of 1968 which imposed the mandatory use of smokeless fuels and a number of other restrictions such as chimney height restrictions, etc.

Thankfully the problem is not as severe, but is still a cause for concern as our cities are still largely dirty from the oily smoke that deposits on buildings, and in winter/summer smoke can be a very unpleasant problem for the city centre. The major

[4] Peat produces considerable amounts of nitrogen oxides, as it is a natural substance, which contains a lot of nitrogen returned to the ground as part of a natural cycle known as the nitrogen cycle.

cause used to be the burning of coal in domestic fires, however the domestic sector has seen the greatest reduction in the amount of emissions, largely due to the reduction in coal combustion. However, the total smoke emissions have not made any significant reductions since 1984, because while emissions from coal reduced from 59% in 1980 to 37% in 1980, emissions from road transport have increased from 19% in 1980 to 42% in 1990. The net result of this is that the emissions in 1990 were roughly the same as those in 1984.

The diagram (figure e) on the next page shows the major pollutants with regard to black smoke and the percentage of total pollutant they produce, and also the major fuels and the percentage of the total pollutant they produce. As you can see, the major sectors that contribute to black smoke pollution are the road transport and domestic sectors, while the major pollutants with regard to fuels are diesel (derv), followed by coal. These figures correlate with other information I have, that suggests that while 46% of emissions are due to road transport, more than 90% of that is due to diesel vehicles such as busses and lorries, hence the concern over the smoke they produce, and the recent bus restrictions imposed in Manchester.

*How the rest of the EU compares as far as particulate pollution is concerned:-*

Particulate pollution is something that plagues cities and industrial areas, particularly where there is significant combustion of fossil fuels such as coal. There is a lack of information at a community level on particulate pollution and as such, the only information that I have managed to obtain is from the Austrian ministry of the environment.

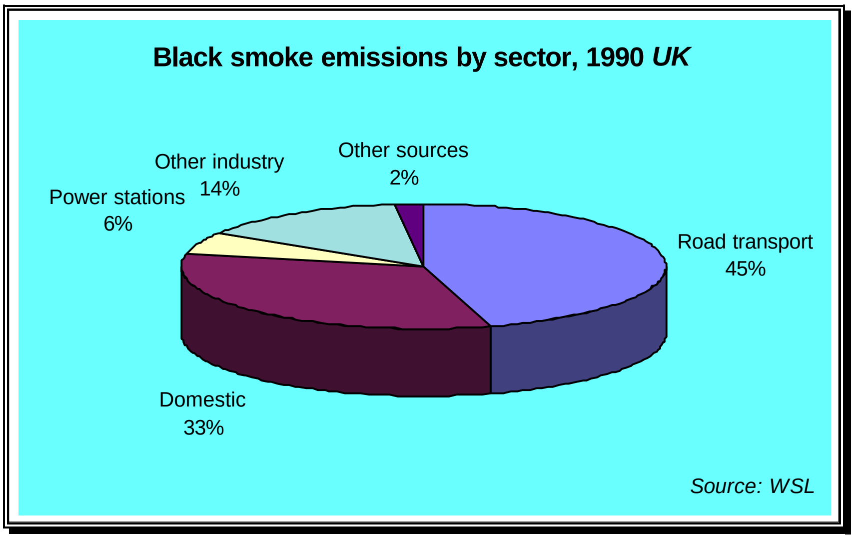



*Figure e (1) - Black smoke emissions by sector, 1990 UK.*

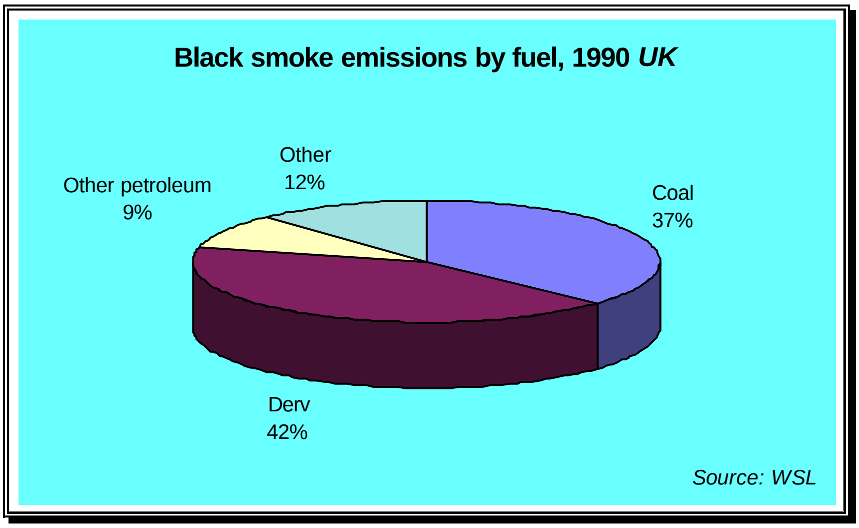



*Figure e (2) - Black smoke emissions by fuel, 1990 UK.*

The data for Austria is more positive than that from the UK, whereas in the 1980's in the UK, emissions remained level from about 1984, they have fallen considerably in Austria, in fact between 1980 and 1993, they have fallen by 42%, with reductions in all sectors *including **road transport***! The reductions are due to stringent regulations present in Austria. The largest emissions of smoke last year, come from the iron and steel industry, centred around Standort, in the Austrian city of Linz. In fact for Austria, the iron and steel industry accounts for the largest proportion of emissions, as one can see from the chart in figure *5*, which shows emissions of smoke by sector in 1993. The second major cause is other industry (34%), followed by road transport (22%). These results are quite different to those in the UK, where road transport is the major cause, followed by domestic combustion, the differences are due to the fact that there are few controls on transport in the UK, compared to many in Austria, including an important measure which limits the weight of lorries to 28 tonnes in Austria (diesel accounts for 90% of smoke emissions from transport), in the UK, there are a large number of lorries, including the large 44 tonne lorries. The UK's large contribution to emissions from domestic use is due to relatively late switching to other fuels such as natural gas, but has been falling for a long time.

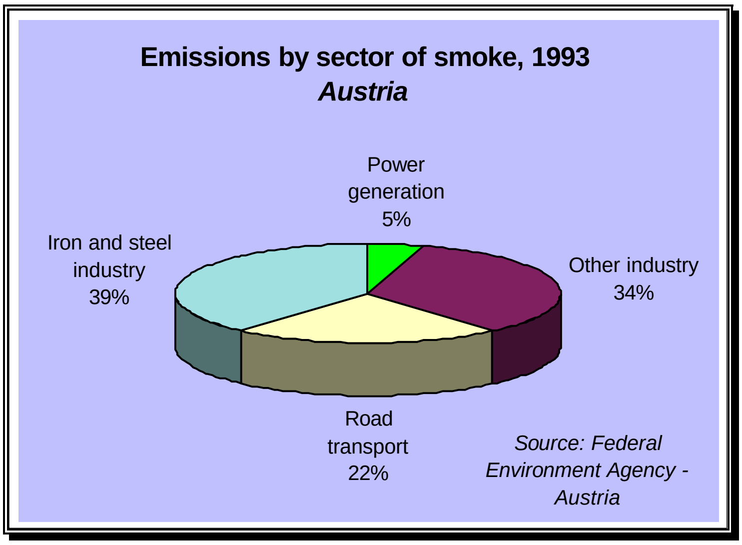



*Figure 5 - Smoke emissions by sector, Austria - 1993.*

Road transport is a major factor in particulate pollution, however, industrial use, particularly in the iron and steel industries contributes to a greater extent than with other forms of pollution, and it is quite likely that in areas where there is heavy industry (e.g. Luxembourg, the Rhur valley and Leipzig/Halle industrial complex in Germany) emissions from industry will exceed those from road transport. Cities like Manchester may have seen greater emissions from industry 30-50 years ago, however, the industrial base has largely left the city centre and in this case, transport is the main cause, however, in areas like Sheffield (well known for its steel industry), the reverse would be true.

The EU has introduced measures to reduce emissions, and aims to gain greater control on fuels, and greater rail subsidies, to try and get freight onto rail, as 90% of transport's emissions are produced by diesel, and sadly freight is generally transported by road due to the expense of rail freight (a particular problem in countries with disintegrating railway networks such as the UK).

The problems of diesel fumes are community wide in cities, I heard recently of problems that they have been having in Athens with particulate pollution. Athens is notorious for its smog cloud (*nefos*), which first appeared in the 1970's and has appeared on days with still weather ever since. The result of this was that the Greek government was forced to introduce an air pollution abatement plan (with some success) for the Greater Athens area, which involved reducing the sulphur and lead content in fuels, as well as shutting down the city's oil fired power station and its gas production plant. Apart from the latter two problems, the main problem is, yes you've guessed it, road transport! One of the problems is that Greek cars are generally very old, it was found that in 1990, the average age of a Greek car was 11 years old, compared to the European average of 6 years old; for years, old cars have been a problem, but many EU countries such as the UK and Germany are able to offer a sort of rebate on old cars, to encourage the purchase of new cars with catalytic converters fitted, unfortunately in Greece there is a chronic shortage of money for environmental purposes. This was demonstrated when a successful pilot scheme was set up to fit the bus fleet with smoke traps which were found to reduce soot and smoke emissions by 95%, however, the transport ministry could not afford to pay the Dr 1bn (£3m) needed to extend the scheme to cover the city's 1,700 buses.

I would expect that there would be problems in areas of heavy industry and where there are large volumes of traffic, this is a general trend that I would expect to be followed by most forms of air pollution, we have already seen that nitrogen oxides pollution correlates with this.

One shouldn't be disheartened by this though, as despite the problems of areas such as Athens, particulate emissions, along with sulphur dioxide emissions are on the decline, due to the desire to rid our cities of the most visible forms of air pollution. The overall UK emissions have remained level, but most sectors have seen reductions, and emissions are set to fall, particularly in the power generation sector which has largely remained constant since 1970 (due to new EU legislation on large combustion plants). Austria is more in tune with general European trends in so far as, emissions are reducing in every major city in the EU except Lisbon. Lisbon is the only EU city where emissions were higher in 1990 than in 1975 (due to traffic congestion). One of the main targets should be transport, as in the UK emissions from transport have risen, and if the same is true of other EU countries, we don't want to ruin the achievements made in other areas, so emissions from transport must be kept in check.

Sulphur Dioxide ($SO_2$):-

Sulphur dioxide is produced by the combustion of fuels that contain sulphur, such as coal, oil and smokeless fuel. Sulphur dioxide can cause temporary breathing problems for some people, and is one of the principal contributors to acid rain[5]. Manchester does have a problem with sulphur dioxide, as the map (see figure f) showing sulphur dioxide concentrations in urban areas across the United Kingdom in 1990 clearly shows. Although as one can see, the concentrations are not amongst the highest category as with Nitrogen dioxide, this is probably due to the fact that there are no power stations within the city of Manchester, there are some in Greater Manchester however, and also in the rest of the North West, hence the sulphur dioxide will disperse across the area showing a relatively high reading (power stations are **the** major cause of sulphur dioxide pollution). The sulphur dioxide levels are typically 12-16/16-20 ppb according to the map.

The standards by which the government of the United Kingdom classifies the air quality relative to sulphur dioxide concentration at any one time, are laid down in EU directive 80/779 (came in to force in 1983), which in turn are based on the WHO criteria for safe levels of pollutants.

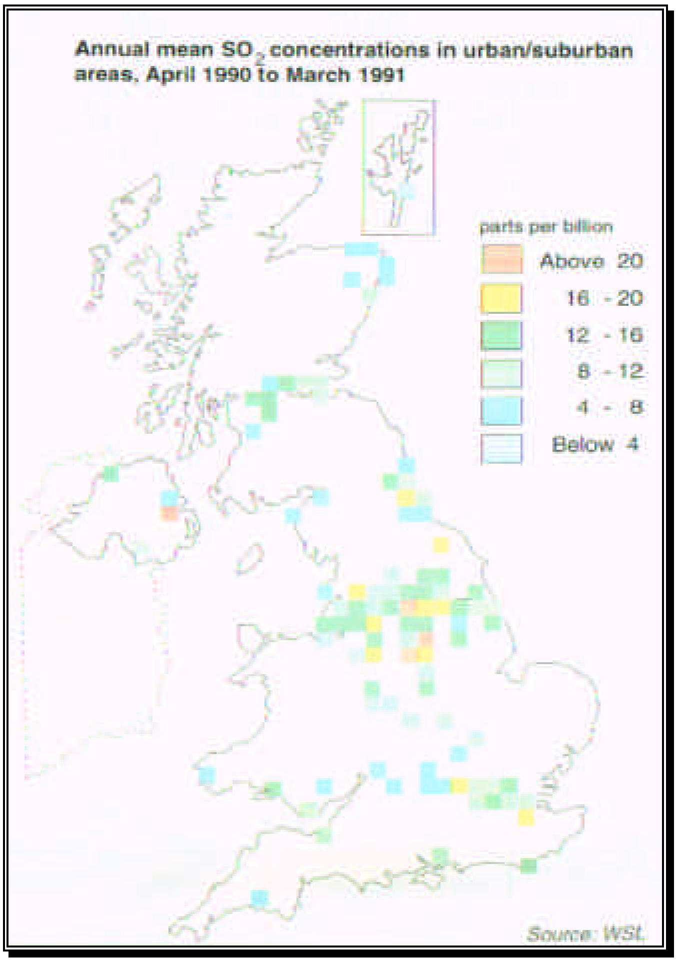



*Figure f - Mean $SO_2$ concentrations in urban areas, April 1990 - March 1991.*

[5] This is a secondary pollutant formed when oxygen and water vapour mix with acidic gases such as sulphur dioxide, the pollutant falls as rain, and can cause significant damage to soil and inland waters.

There is good news as far as sulphur dioxide is concerned, and that is that as figures show, pollution in this area is falling and has done so since the 1960's. This reduction is due to increased use of sulphur free fuels such as natural gas[6], lower industrial energy demand and energy conservation. Emissions from industry other than power stations have reduced from 27% in 1980 to 19% in 1990. The chart in figure g shows the emissions from power stations, other industry and other sectors (domestic, commercial/public services, transport) between 1970 and 1990. As you can see, all sectors except for the power generation industry which has remained constant, have seen a reduction in sulphur dioxide emissions, this is surely good news.

The chart in figure h shows the percentage emissions by sector of sulphur dioxide, as you I said, the chart shows that the power stations are the largest polluter (72%), followed by other industry (19%). It is clear that it is up to the power industry to reduce emissions, as it is the largest contributor by far. Hopefully, the United Kingdom's commitment to the EU Large Combustion Plants Directive will bring about reductions in emissions as stated (20% by 1993, 40% by 1998 and 60% by 2003, based on emissions in 1980). There is a difference when it comes to sulphur dioxide as far as causes are concerned in so far as road transport does not play a significant part (2%) where it has done with all other pollutants listed so far.

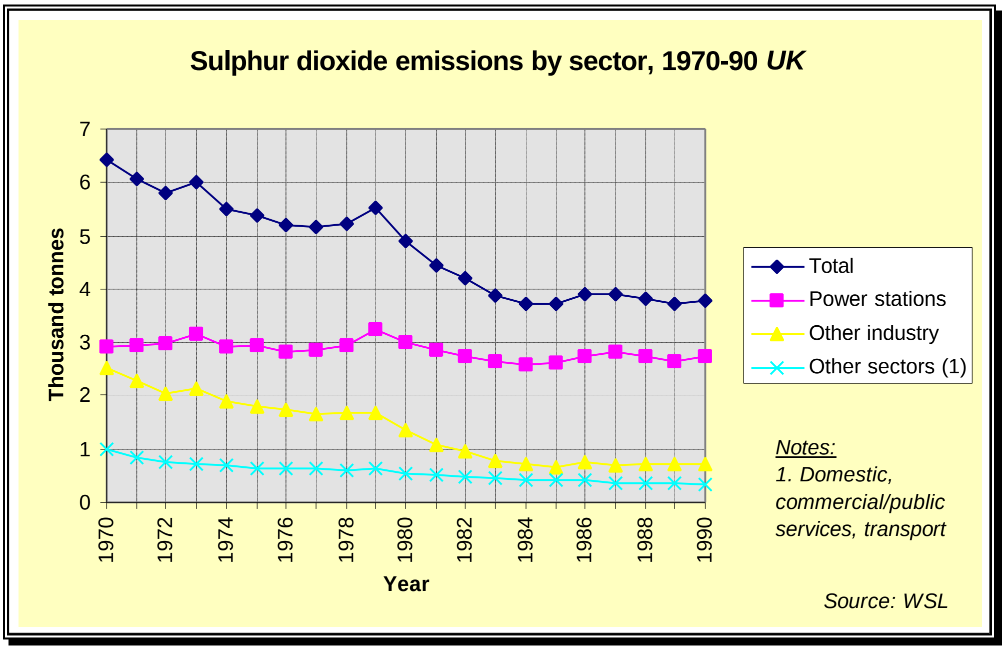



*Figure g - $SO_2$ emissions by sector 1970-90.*

[6] Natural gas is a simple substance extracted from the North Sea that consists of methane and helium and burns effectively to produce water and carbon dioxide. Natural gas is far better than the old town gas that used to be made in big gasworks such as the former Manchester gasworks at Bradford, just east of the city centre. Such gasworks produced a lot of pollution, and because the gas was made from heated coal, elements such as sulphur were present, there were also poisons such as prussic acid (cyanide) present in town gas, hence making it a highly poisonous and polluting substance.

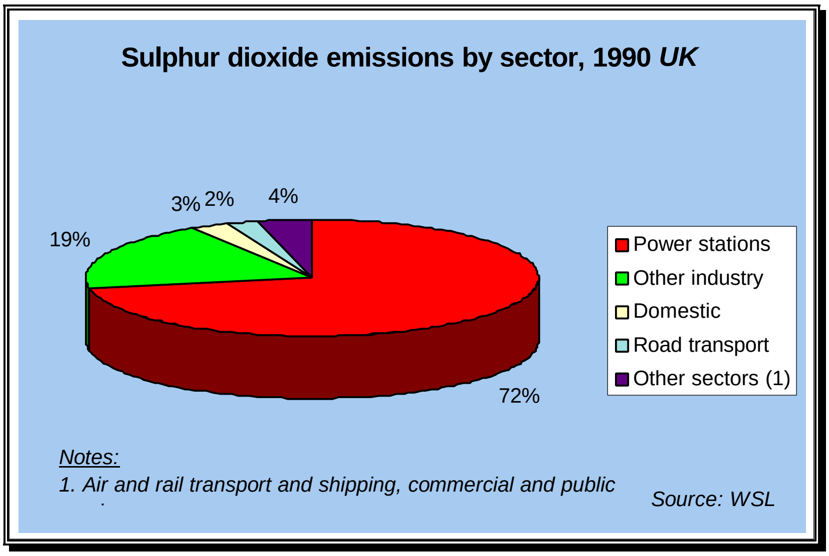



*Figure h - $SO_2$ emissions by sector.*

*How the rest of the EU compares as far as sulphur dioxide pollution is concerned:-*

One will have noted that the main cause of sulphur dioxide pollution in the UK was from power generation (72%), followed by industry (19%). Transport accounted for only 2% of emissions, and therefore is not a major cause in the UK. Looking at figures from the Austrian Federal Environment Agency, the emissions by sector in Austria are as shown in figure *6*.

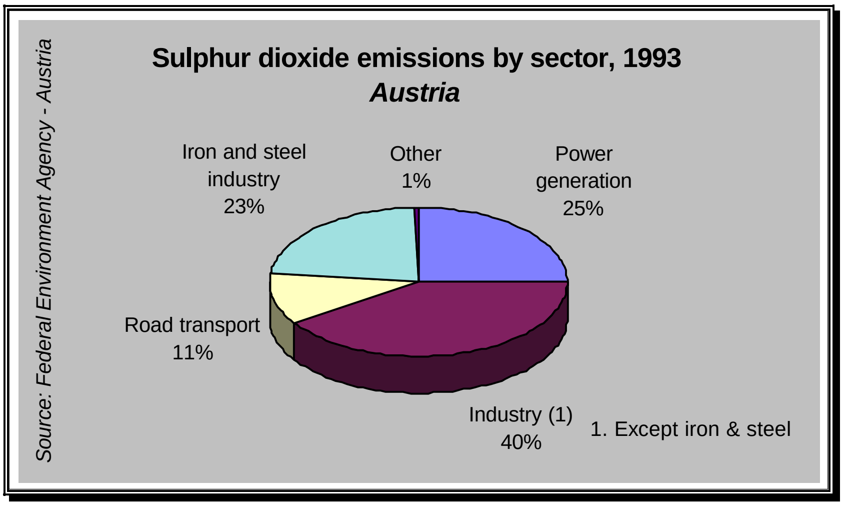



*Figure 6 - Sulphur dioxide emissions by sector, 1993 - Austria*

As one can see from the chart, industry is the primary source of sulphur dioxide pollution (63%), followed by power generation (25%). The UK has the same two main causes but the other way round, one must take note that the UK relies very heavily on fossil fuels for combustion, far more than most other nations, therefore it is likely that industry will take precedence as the main cause in many countries where power is not based to a significant extent on fossil fuels (e.g. France). One should also take note of the fact that only 30% of Austria's power is produced by fossil fuels, this puts the relative low figure into perspective. I would expect in most cases, power generation and industry to be the main causes of sulphur dioxide pollution, due to their extensive use of fossil fuels. Figure *7* shows the level of sulphur deposition in Europe, this is a good indicator of the pollution levels, and where the pollution occurs, one does have to take note that sulphur can be brought into a country from another area of pollution.

If one were to compare figure *7*, with figure *2* which shows one the areas of heavy industry, one would find that areas of heavy industry are in or close to areas of appreciable total sulphur deposition, hence a link between the two is inferred. One could see from UK figures that Manchester was one of the worst affected areas in the UK, well, using figure *7*, one can see that Manchester is one of the worst affected areas in Europe, along with a considerable portion of England, and to the south, a band running from Belgium, through Germany and into Poland. Clearly, those areas are significantly affected.

Germany has had the problem of cleaning up the mess left by the Soviet administration in the eastern states of the country, there were many pollution nightmares left by Ulbricht’s industrialisation programme to meet the USSR’s demands in terms of reparations payments. Before the re-unification, the former GDR has the highest sulphur dioxide emissions per capita in the world, in 1986, the GDR discharged 5 billion tons of sulphur dioxide into the air. It is unfortunate that the GDR had no regard for the environment, as significant areas of eastern Germany are heavily polluted, and the IFO economic research institute in Munich estimates that to clean the mess up, it will cost DM200bn (£70bn). The causes of pollution were inefficient and old-fashion methods of producing goods in large volumes, the town of Bitterfeld is an example of this, which is home to one of the biggest chemical complexes in the former GDR, the town was once christened “the most deadly place in Europe”. Bitterfeld lies at the heart of the Leipzig/Halle industrial complex, and the Bitterfeld produced lignite briquettes which added to the stench and dirt. In the 1980’s, the University of Leipzig Children’s hospital would frequently admit children in the winter with wheezing lungs and blue lips, a classic sign of oxygen deprivation. The Leipzig/Halle complex actually contributed 30% of total air pollution in the former GDR. Thankfully, the former FRG is rich enough to put the problems right, although they will take time, however, many of the old plants have been shut down, and there are many big chemical companies that are building new modern plants. Considering the problems it has had to deal with, Germany has done very well to reduce total emissions between 1980 and 1991 by 41%.

Unfortunately, the figures that I have from the EEA were sampled in 1990, and of course have emission levels from when many of the plants such as the one at Bitterfeld were operating, figures show that in 1990 the former FRG produced 911,761 tonnes of sulphur dioxide, the former GDR however produced 4,345,082 tonnes. This is much better than 1986, but still well over four times the emissions its neighbour produced. One must therefore bear in mind that things may have changed, regarding emissions by sector.

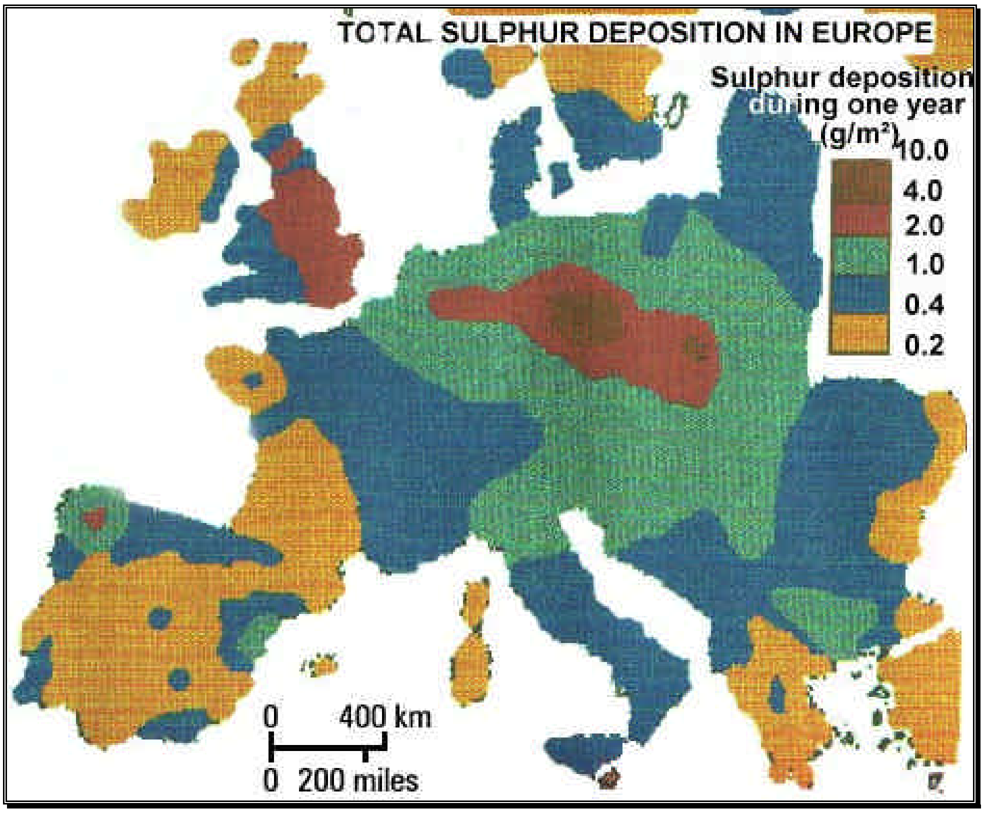



*Figure 7 - Total sulphur deposition in Europe*

The general trend across the EU has been to reduce emissions, and figure *8* shows the reductions/increases in emissions between 1980 and 1993.

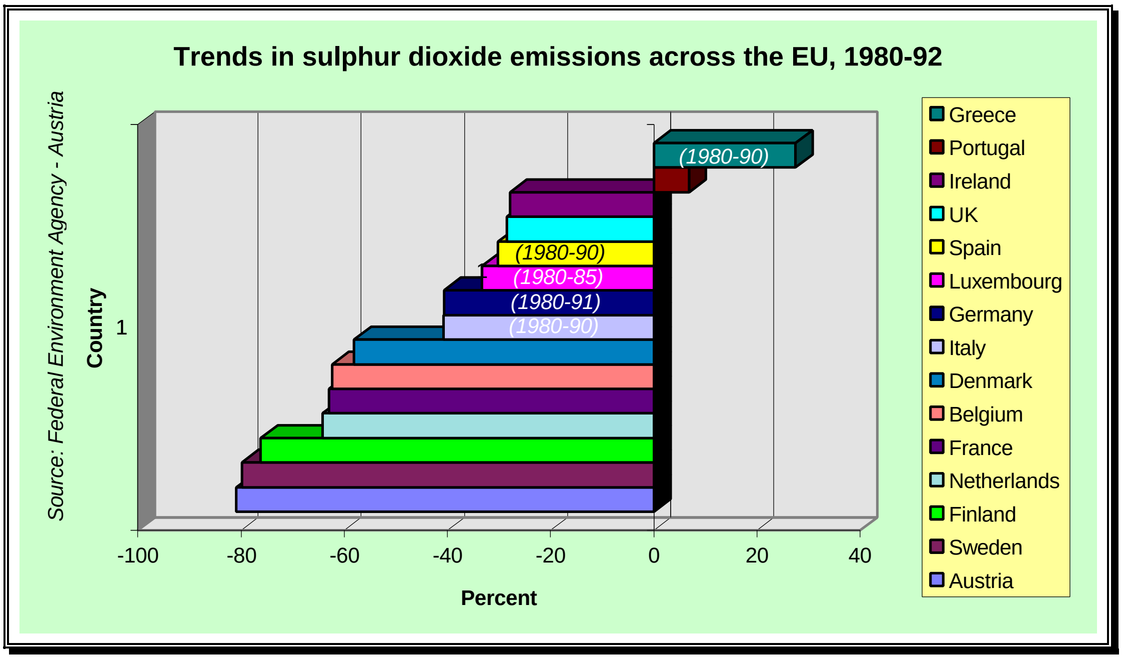
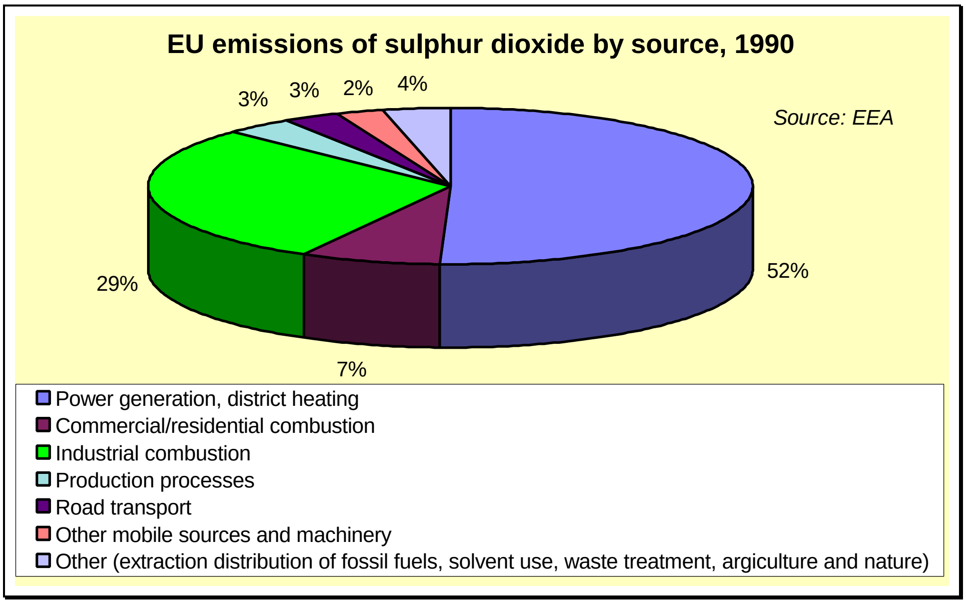



*Figure 8 - Trends in sulphur dioxide emissions across the EU, 1980-92.*

As you can see Austria is setting the trend for the rest of the EU by having the largest reduction in emissions, the UK has reduced emissions but they are not in the same region as these (industry in Austria cut emissions by 88%, and power generation by 80%, and other sectors made significant cuts; in contrast, industry in the UK made an 8% cut in a longer period (1970-90)!). Emissions are as you can see generally falling, which is a good thing, although Greece and Portugal are a cause for concern with increasing emissions, I believe that they have been given extra time to comply with EU rules, lets hope they do. All of the countries listed from top to bottom up to and including Luxembourg have successfully complied with the 30% reduction in emissions of sulphur dioxide as defined in the 1985 Helsinki protocol. That leaves Spain, the UK, Ireland, Greece and Portugal with work to do.

Figure *9* shows the causes of sulphur dioxide pollution across the EU, by sector, as they were in 1990:-




So across the EU, the primary cause of sulphur dioxide pollution is power generation, which contributes to over half the EU's emissions (52%), the secondary cause is industrial combustion (29%), with the tertiary cause being commercial/residential combustion of fuels (7%). The three main causes are the same as those for the UK, and as has been the case so far, road transport is not a major factor (rare for air pollution), contribution only 3% to total emissions. One finds that this is the general case across Europe, the following table shows the primary, secondary and tertiary causes of sulphur dioxide pollution across the EU (based on EEA data from the 1990 CORINAIR survey):-

| *Country* | *Primary cause* | *Secondary cause* | *Tertiary cause* |
|---|---|---|---|
| ***Belgium*** | Industrial combustion | Power generation | Production processes |
| ***Denmark*** | Power generation | Industrial combustion | Other mobile sources |
| ***Spain*** | Power generation | Industrial combustion | commercial/residential combustion |
| ***Germany*** | Power generation | Industrial combustion | commercial/residential combustion |
| ***Greece*** | Power generation | Other mobile sources | Production processes |
| ***France*** | Industrial combustion | Power generation | Road transport |
| ***Ireland*** | Power generation | Industrial combustion | commercial/residential |

| | | | |
|---|---|---|---|
| | | | combustion |
| ***Italy*** | Power generation | Natural sources | Industrial combustion |
| ***Luxembourg*** | Industrial combustion | commercial/residential combustion | Road transport |
| ***Netherlands*** | Production processes | Power generation | Industrial combustion |
| ***Portugal*** | Power generation | Industrial combustion | Road transport |
| ***UK*** | Power generation | commercial/residential combustion | Industrial combustion |
| ***Austria*** | Industrial combustion | Power generation | Road transport |
| ***Finland*** | Industrial combustion | Power generation | Production processes |
| ***Sweden*** | Industrial combustion | Production processes | commercial/residential combustion |

The table shows that in all EU states except the Netherlands, power generation or industrial combustion is the primary source of sulphur dioxide emissions, in 80% of the EU member states, power generation or industrial combustion is a major cause of sulphur dioxide emissions. Due to this, the EU has issued a number of directives, notably the EU's large combustion plants directive that aim to tackle the problem. It is interesting to note that despite the fact that transport produces relatively low emissions of sulphur dioxide, is four of the member states it is a tertiary cause, this is either due to the fact that the country as in the case of Austria has reduced emissions, but transport remains a problem[7], or again like Austria or France, the majority of electricity is not produced by fossil fuels. Italy is the only country in the EU where natural sources play a part, this is because it is the only country subject to volcanic activity (e.g. Mt. Etna), and shows that nature can be as damaging humans in such situations. These results show that power generation and industry are major causes, followed closely by production processes and domestic use in some states.

Thankfully emissions of sulphur dioxide are on average, falling, this is probably due to the fact that road transport is not a major cause across the EU as a whole, and other sources are perhaps easier to control.

Volatile Organic Compounds (VOCs):-

Volatile Organic Compounds (VOCs) include a large number if chemical compounds that are able to evaporate into a gas, or take part in chemical reactions. Certain VOCs are known to cause drowsiness, eye irritation and coughing, while others such as Benzene are carcinogenic. All VOCs are capable of taking part in chemical reactions activated by sunlight, forming oxidants such as ground level ozone (this is formed by reaction of VOCs with nitrogen oxides, another common pollutant), it is also known that some deplete the ozone layer[8].

The problem of exposure to VOCs depends on whether you are a smoker or not, if you are a smoker, then do not worry about VOCs, you are much more likely to

[7] Portugal is an example of a very problematic situation, where road transport is a major an increasing cause, and total emissions are rising, countries such as Portugal have a lot of work to do, and the Portuguese government would do well to implement measures similar to those that the Greek government has in Athens to try and curb pollution.

[8] The ozone layer is in the stratosphere (the band of the Earth's atmosphere from 15-50km above the surface of the Earth), there is also ozone produced at ground level (in the troposphere - the band of the Earth's atmosphere from 0-15km above the surface of the Earth), this is a pollutant at ground level and should not be confused with the problem of ozone depletion in the stratosphere.

be at risk from cigarettes than VOCs. If you are a non-smoker then there is a definite cancer risk.

There are many sources of VOCs, and they can be quite varied. The major cause of VOC emissions in the UK is industrial processes, particularly those using solvents (such as trichloroethane 1-1-1 used in correction fluids), containing coatings, adhesives and cleaning agents - these account for 49% of VOC emissions. The other major cause of VOCs is the from the evaporation of petrol and vehicle exhausts; road transport accounted for 41% of emissions in 1990 (a 12% increase since 1980). In Manchester the primary cause is road transport, as there is no industry in the city centre, but plenty of traffic, particularly on major thoroughfares such as Oxford Rd (the main route into the city from the south), and Cross St, both have had emissions recorded to be well above EU and WHO. The chart in figure i. shows the emissions of VOCs by sector in 1990.

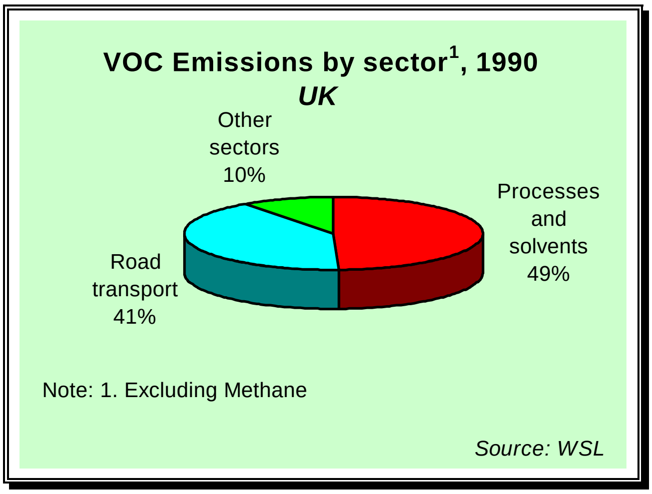



*Figure i - VOC emissions by sector.*

*How the rest of the EU compares as far as VOC pollution is concerned:-*

This is unfortunately another area of atmospheric pollution where there is relative little information, I do not have much information on trends, however the EEA does have some quantitative information. As one can see, emissions of VOCs in the UK have increased, largely due to the fact that a major cause of VOC emissions is transport, which is of course increasing, this was the case in 1990, it is likely that emissions have fallen due to the compulsory use of 3-way catalytic converters on new cars across the EU as of January, 1st 1992, member states have on the whole embraced this legislation. The reason why I believe that VOC emissions have fallen, is that Austria was following a similar trend in the 1980's, with a rise from 374,000 tonnes in 1980 to 434,000 tonnes in 1989 (a 16% increase), the UK recorded an increase in the same period of similar magnitude (a 12% increase), however the most recent DoE data I have is from 1990, yet I have information on Austria emissions up to 1993, which show a decline in emissions between 1989 and 1993 (from 434,000 tonnes to 388,000 tonnes (a 10% decrease)). The Austrian Federal Environment Agency attributes this to the use of catalytic converters (for the 21% reduction in transport emissions, the largest reduction of all the sectors), which were used increasingly from around late

1989, and became compulsory on new cars in 1992. Therefore I suspect that the emissions in the UK will have fallen slightly or at least remained constant.

Given that road transport is an acknowledged major cause, increasing volumes of traffic would aggravate the problem, however, because it is the policy of car manufacturers and the EU to fit catalytic converters, new cars do not pose a problem, it is of course a problem with older cars. Therefore areas worst affected will be those that have a large number of old cars, such as Greece where the average age of a car is 11 years old, compared with a general EU average of 6 years old. It is likely however, that emissions will decline or at least remain constant due to the increasing use of catalytic converters across the EU, although there is always the worry of poorer countries such as Greece and Portugal which have problems with old cars, and traffic congestion, as well as a desire to industrialise, which could cause problems for solvent use and other industrial processes that produce VOCs (found in the UK to be the primary cause of VOC emissions).

Figure *9* below shows the main causes of VOC emissions across the EU:-

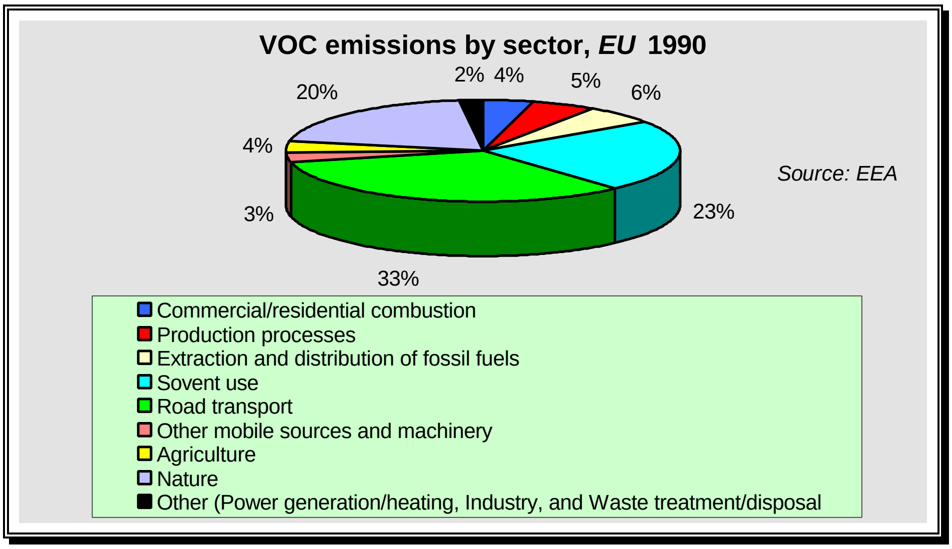



*Figure 9 - VOC emissions by sector in the EU, 1990.*

So across the EU as a whole, road transport is the biggest cause (33%), followed by solvent use (23%), and natural emissions (20%) - a rare case, most other forms do not have nature as a major cause EU wide. There primary and secondary causes are no surprise given the UK and Austrian figures examined earlier (the primary and secondary causes of VOC emissions are the same for the UK and Austria), although the tertiary cause came as a little surprise, given the figures seen previously. The table below shows the primary, secondary and tertiary sources of VOC emissions for each EU member state (using EEA data based on the 1990 CORINAIR survey), just to show how each state compares with the causes for the whole of the EU:-

| ***Country*** | ***Primary cause*** | ***Secondary cause*** | ***Tertiary cause*** |
|---|---|---|---|
| ***Belgium*** | Road transport (48%) | Solvent use | Production processes |
| ***Denmark*** | Road transport (55%) | Solvent use | Other mobile sources |
| ***Spain*** | Nature (41%) | Road transport | Solvent use |
| ***Germany*** | Road transport (37%) | Solvent use | Nature |
| ***Greece*** | Nature (55%) | Road transport | Solvent use |
| ***France*** | Road transport (41%) | Solvent use | Nature |
| ***Ireland*** | Agriculture (40%) | Road transport | Solvent use |

| | | | |
|---|---|---|---|
| ***Italy*** | Road transport (38%) | Solvent use | Agriculture |
| ***Luxembourg*** | Road transport (50%) | Solvent use | Nature |
| ***Netherlands*** | Road transport (40%) | Solvent use | Production processes |
| ***Portugal*** | Nature (68%) | Road transport | Solvent use |
| ***UK (DoE)*** | Solvent use (49%) | Road transport | Other industry |
| ***Austria (ÖFZS - '93)*** | Solvent use (31%) | Road transport | Production processes |
| ***Finland*** | Nature (64%) | Road transport | Production processes |
| ***Sweden*** | Nature (37%) | Road transport | Commercial/residential combustion |

As one can see from the table road transport is the main cause of emissions for 54% of EU member states. The table shows that the secondary cause is either solvent use or road transport, although road transport is predominant (the secondary cause for 60% of states). The tertiary causes are either solvent use, production processes, transport, or nature, although Sweden's tertiary cause is commercial/residential combustion. So, as one can see the figures do correlate with the EU average, 13 out of 15 of the states have either road transport or solvent use as their primary/secondary cause.

The news is generally good, as tougher legislation is being used with regard to catalytic converters, which as I said earlier is likely to reduce or maintain current emissions, I would expect that emissions in many states will have already fallen since 1992, because of the increasing use of 3-way catalytic converters. It is interesting to note that countries that do not have road transport as the primary cause are generally those which have a relatively low population density, this correlates with what I said earlier with regard to nitrogen oxide emissions.

Carbon Monoxide (CO):-

Carbon monoxide is produced when incomplete combustion occurs, this is largely when a car makes a cold start, the engine is choked, or when it's idling at low speeds (for example, in traffic jams). Carbon monoxide is toxic in high concentrations and affects physical co-ordination, vision and judgement. Carbon monoxide can also contribute indirectly to the greenhouse effect.

According to the HMIP/DoE the guidelines on emissions set by the WHO, have not been exceeded in recent years. It is estimated that between 1970 and 1990, total emissions of carbon monoxide have increased by 2 million tonnes (to 6.7 million tonnes in 1990), it is likely that EU vehicle directives will reduce the emissions from road transport. Such measures are necessary as carbon monoxide emissions have been increasing because of the increasing number of cars on the road, and in the current situation will continue to increase. All other sectors responsible (which in total contribute only 10% of the total) are reducing emissions and have done so since DoE records began in 1970.

Moving on to the causes of pollution involving carbon monoxide, the main cause is road transport, which accounts for 90% of all carbon monoxide, it should also be noted that 85% of this is produced by vehicles with petrol engines, diesel engines produce very little if any carbon monoxide. The chart in figure j, shows the carbon monoxide emissions by sector in 1990.

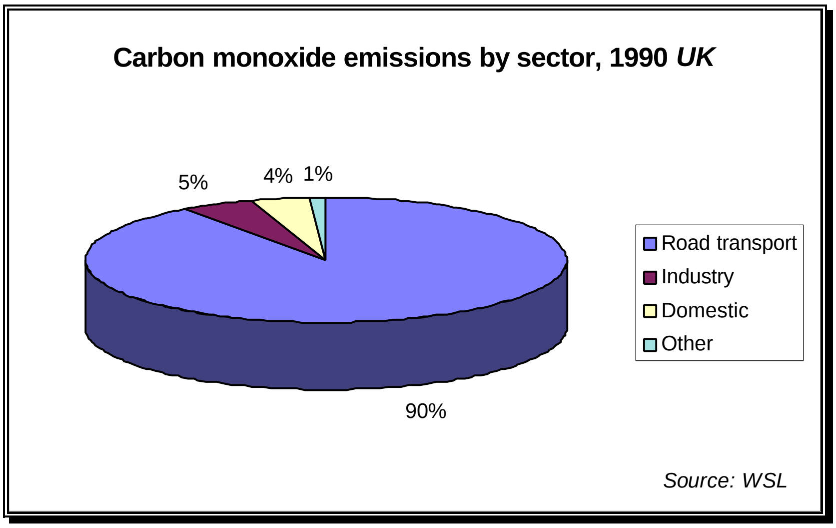



*Figure j - Carbon monoxide emissions by sector.*

*How the rest of the EU compares as far as carbon monoxide pollution is concerned:-*

Carbon monoxide is another pollutant that is formed primarily from road transport, and therefore the general trend is that emissions are increasing, as the volume of traffic is increasing. However, as with VOCs, it is possible to limit the effects of emissions from a car, through the use of a catalytic converter, which can convert the carbon monoxide to carbon dioxide, which while less harmful to health, of course has effects on global warming. Therefore by using a catalytic converter, carbon monoxide emissions are reduced by carbon dioxide emissions are increased.

The UK has seen increased emissions, although Austria, for example has seen emissions increasing up to 1987, and then falling each year (except for 1989 when there was a slight increase). There has been an increase in the power generation sector throughout this time, and also in the iron and steel industry. The other sectors (other industry, road transport, and other sources) have seen reductions in emissions, the biggest reduction came from the transport sector (from 754,000 tonnes to 292,000 tonnes between 1980-93). Unfortunately I do not have any further information about the trends in carbon monoxide emissions, although I would expect that emissions will begin to reduce or remain level as the reductions in other sectors come into force, and also when the effect of catalytic converters begins to bear fruit. Given that the main cause of emissions is transport, it is likely that countries with large numbers of old cars, will have problems with emissions (e.g. Greece).

Just to demonstrate statistically what I have said about emissions, the emissions of carbon monoxide by sector for the EU, are shown in figure *10*. As one can see, the primary cause of emissions, is road transport (62%), as with the UK (although not quite as high a percentage). The secondary cause is commercial/residential combustion (13%), followed by the tertiary cause is industry (6%). The following table shows the primary, secondary and tertiary causes of carbon monoxide pollution for each of the EU member states:-

| ***Country*** | ***Primary cause*** | ***Secondary cause*** | ***Tertiary cause*** |
|---|---|---|---|
| ***Belgium*** | Road transport (80%) | Production processes | Commercial/residential combustion |
| ***Denmark*** | Road transport (70%) | Commercial/residential combustion | Power generation |
| ***Spain*** | Road transport (52%) | Commercial/residential | Waste treatment/disposal |

| | | | |
|---|---|---|---|
| | | combustion | |
| ***Germany*** | Road transport (56%) | Commercial/residential combustion | Industrial combustion |
| ***Greece*** | Road transport (62%) | Agriculture | Other mobile sources |
| ***France*** | Road transport (62%) | Commercial/residential combustion | Production processes |
| ***Ireland*** | Road transport (71%) | Commercial/residential combustion | Waste treatment/disposal |
| ***Italy*** | Road transport (53%) | Waste treatment/disposal | Nature |
| ***Luxembourg*** | Industrial combustion (58%) | Road transport | Production processes |
| ***Netherlands*** | Road transport (61%) | Production processes | Commercial/residential combustion |
| ***Portugal*** | Road transport (57%) | Industrial combustion | Commercial/residential combustion |
| ***UK*** | Road transport (90%) | Commercial/residential combustion | Waste treatment/disposal |
| ***Austria*** | Commercial/residential combustion (46%) | Road transport | Production processes |
| ***Finland*** | Road transport (88%) | Other mobile sources | Industrial combustion |
| ***Sweden*** | Road transport (83%) | Other mobile sources | Commercial/residential combustion |

One can see that looking at each state individually, there is an excellent correlation between the causes suggested from the EU average data, and each member state, all except 2 member states have road transport as the main cause, and in each of those two cases, road transport is the secondary cause - hence clearly a very important factor that must be dealt with. Other than that, the next most frequent entry is commercial/residential combustion which was identified as the secondary cause of carbon monoxide pollution, with other frequently appearing causes of industry and waste treatment/disposal. Many sectors such as industry are reducing emissions, and transport has done in some areas, and will hopefully do so community wide.

Again, as we see road transport as a key cause, one can expect densely populated areas to be affected most, as they will have the most road transport, plus the secondary cause is from small commercial/residential use, which one would only find in areas of high population density (i.e. cities, large towns, etc).

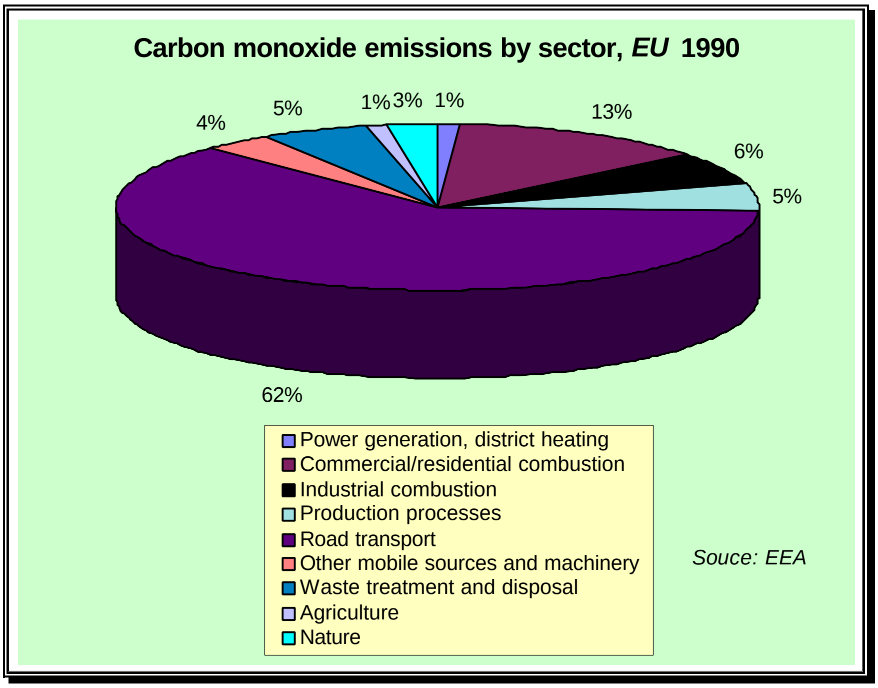



*Figure 10 - Carbon monoxide emissions by sector, EU 1990.*

Lead:-

This is a trace element that is added to petroleum to improve engine performance, however, lead is poisonous if allowed to accumulate in the body, and can stunt the mental development of children. Lead exists in the ground in significant amounts, and therefore does exist in small amounts in extracted coal, therefore the combustion of coal produces lead emissions. Metal works of course are also causes of lead pollution, however, the biggest polluter by far is road transport, and steps have been taken in this area.

Generally it was found that since EU directive 82/884/EEC established a limit of 2.0µg per cubic metre, the eleven monitored UK urban sites have not exceeded this value except for Walsall. Lead pollution was more of problem in the past when there was far more heavy industry and coal mining than now, in fact many areas of the country such as Lancashire now have no mining industry at all, and far less heavy industry than previously, hence road transport is increasingly attributable for the problem.

The situation has been improving since the mid-1980's, with restrictions imposed on leaded petrol (by EU directives 78/611/EEC and 85/210/EEC), forcing the amount of lead to be reduced, also in 1986, unleaded petrol was introduced, which has had pleasing results. Sales of unleaded petrol were initially slow as only new cars could use it without conversion, and even as late as the end of 1988, only 10% of petrol stations in the UK actually sold it. However, an increasing duty differential between leaded and unleaded petrol, which reached 5p a litre in 1990, encouraged sales, and by 1992, nearly all UK petrol stations sold unleaded petrol. The best reduction of lead emissions came in 1985-1986 when they halved, and are continuing to decrease. Even better news that the usage of unleaded petrol is increasing, for example, in November 1988, unleaded petrol made up only 3% of deliveries, yet by April 1992, it made up 46% of deliveries and is continuing to increase, however, this is being offset by increasing volumes of traffic.

*How the rest of the EU compares as far as lead pollution is concerned:-*

Lead is accepted as a problem community wide, hence the many directives that are being put into force, which one can see mentioned in the above paragraph. According to EU law, leaded petrol can still be sold, and measures have been taken to promote unleaded petrol and remove the lead content of petrol. Germany and Luxembourg have however, completely banned the sale of regular leaded petrol, therefore there is not a problem in these countries. Other EU states have not gone as far, simply promoting unleaded petrol and warning of the dangers of leaded petrol, of course, the big problem in countries like Greece and the UK where there are many old cars, is that it is expensive to replace them with new ones, however, while the old cars remain running, lead is still being put into the surrounding atmosphere. Thankfully, sales of leaded petrol have fallen sharply across the EU, although less sharply in some countries than others. Between 1988 and 1990, sales in unleaded petrol across the EU rose from 13.2% in 1988 to 32.1% in 1990, and have been rising since, although more gradually. The EU has a number of clean air directives, the famous 1989[9] 'clean car' directive made the use of catalytic converters mandatory on all new cars, the catalytic converter is designed to reduce emissions of chemicals such as carbon monoxide, and nitrogen dioxide by converting them into less harmful forms (carbon dioxide and nitrogen). The twist comes with the fact that the catalytic converter contains certain amounts of precious metals and is poisoned by lead, therefore unleaded petrol must be used - a subtle way of forcing new cars to use unleaded petrol and the gradual conversion to unleaded petrol, without actually banning lead (therefore not harming countries like Greece which have a large number of old cars). So community wide, emissions of lead will be reduced and are reducing.

**N.B.** ***I shall deal with Ozone and carbon dioxide problems in the specific sections on Ozone and the greenhouse effect respectively.***

## *Stratospheric and Tropospheric Ozone problems:-*

I do not think that anybody could have failed to be aware of the problem of the depleting ozone layer, which was originally noticed above Antarctica, where there is a large area with no ozone layer, and others with very low concentrations. The reaction to ozone depleting chemicals in Antarctica had been particularly severe because of the environment there. The big question at the time of discovery was what had caused the hole? After all, the only population on Antarctica is a small scientific community, and as such does not pollute the surrounding environment. Investigation found that there were certain chemicals produced by industry, etc, that contributed to the thinning of the ozone layer, and they were produced elsewhere and dispersed throughout the atmosphere. It has since been found that not only is there a hole in the ozone layer above the south pole (has an area of 18 million sq. km between early September and mid November), but the ozone layer is actually thinning at quite an alarming rate across certain areas of the world, Europe in particular.

The ozone layer lies in the stratosphere[10] and serves the very important purpose of blocking the very harmful short wavelength ultraviolet radiation from the sun, whilst letting visible and infra-red light reach the surface of the Earth. The ultraviolet B

[9] EU wide enforcement of the regulations did not occur until January 1992, when the last of the states imposed the legislation (e.g. the UK).

[10] A layer of the atmosphere that lies between 15 and 50 kilometres above the Earth's surface.

radiation ($\lambda$=280 to 320nm) can cause cancer in humans, and can have harmful effects on plants and marine organisms.

There are a number of trace and natural man-made gases that are known to deplete the ozone layer, however, we are far more concerned with the large increase in man-made gases since the 1950's that are now causing significant ozone depletion. This problem is clearly a global problem and its causes are present not only in the UK but across the EU and elsewhere.

There is convincing scientific evidence that the ozone layer is being damaged, and the 'holes' in the ozone layer being created, by the high chlorine content of chlorofluorocarbons (CFCs) and other chemicals. Chlorine is known to react with the ozone to produce other chemicals, thus depleting the ozone. CFCs are the main culprits, others are halons, mainly 1,1,1 trichloroethane (a solvent commonly found in substances such as correction fluid), and carbon tetrachloride, a chemical used in dry cleaning. About 40% of CFCs are used as coolants in fridges, freezers and air conditioners. CFCs are also used as propellants in aerosols, in the production of plastic foams and solvents, and also as blowing agents in fast-food packages such as those for hamburgers.

Fortunately the ozone layer works on something like a self-repairing basis. In Europe, the ozone layer is thinned during the cold winter months, and then gradually restores itself over the rest of the year. Having been 15%-20% damaged during December and January 1994, the ozone layer began to recover slightly during February and March, with levels 5%-15% down on the long term average. The diagram in figure *k*, shows the effects of the gradual loss of the ozone layer, indicating the overall increase in European ozone layer reduction which as you can see, has gone from a previous low of about 7% to about 10% in winter 1991/92 near Munich, and to about 18% near Brussels and in the Shetland Islands[11] in the same winter. Clearly the whole of the EU is affected, with continental Europe as well as the UK.

Depletion of the ozone layer is perhaps of greatest public concern as people have actually experienced the serious effects of UVB penetration, i.e. there has been a considerable increase in the amount of skin cancer. As one can see from the figures, the annual restoration is not a solution to the problem, it is merely a damage limitation exercise, and other steps are necessary. Increased public awareness has helped considerably, and as the following table of figures, which shows the consumption of CFCs across the EU between 1986 and 1993 (figure l). Areas such as aerosols, have seen a decrease from 46% of total CFCs in 1986 (largest component of CFC emissions), to 11% of total CFCs in 1993 (smallest component of CFC emissions). All areas except CFCs from refrigerators have seen reductions in emissions since 1986.

[11] Both places are a significant distance apart, thus this shows that ozone depletion is spread across Europe, with the heart of the EU (Brussels) and the most northerly part of the EU - the Shetlands (at the time, before the entry of Sweden and Finland) being affected worst at the same time.

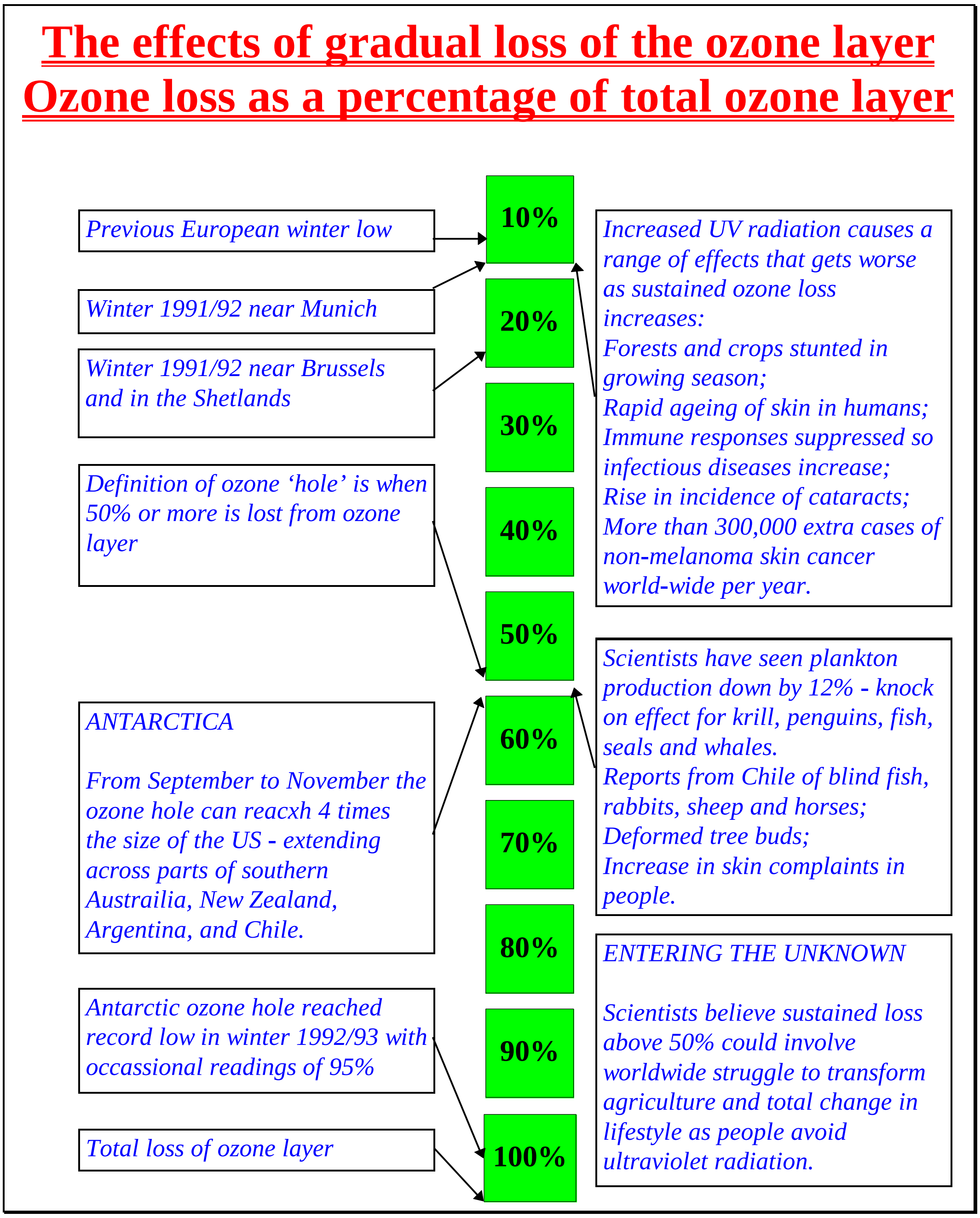



*Figure k. The loss of the ozone layer, and the impact of it.*

***Thousand Tonnes***

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|---|
| **Refrigeration** | 29.9 | .. | 31.0 | .. | 30.2 | 31.2 | 31.4 | 35.6 |
| **Foam blowing** | 85.5 | .. | 102.9 | .. | 83.2 | 74.6 | 57.8 | 46.4 |
| **Aerosols** | 142.0 | .. | 113.7 | .. | 21.4 | 15.4 | 14.5 | 13.7 |
| **Solvents** | 52.9 | .. | 59.7 | .. | 49.0 | 41.7 | 33.4 | 24.3 |

*Figure l - EU consumption of CFCs in primary areas of application: 1986-1993. (Source: CEFIC)*

The figures clearly show a drop in all areas of production consumption, except for refrigeration, it is also true that the production and consumption of halons throughout the EU is decreasing, and both should continue to do so in accordance with the Montreal protocol and EU regulation 3093/34. Drastic cuts are necessary due to the long life of these chemicals in the atmosphere, hence they are still active long after they are produced, so even if production/consumption completely stopped now, it could take until well into the next century before we have recovered from the legacy of CFC and halon emissions since the 1950's. CFCs are by far the largest ozone depleting substances, and 1993, causes of CFC emissions were by sector as shown in figure *m*, with foam blowing the largest contributor (think before you buy a burger!).

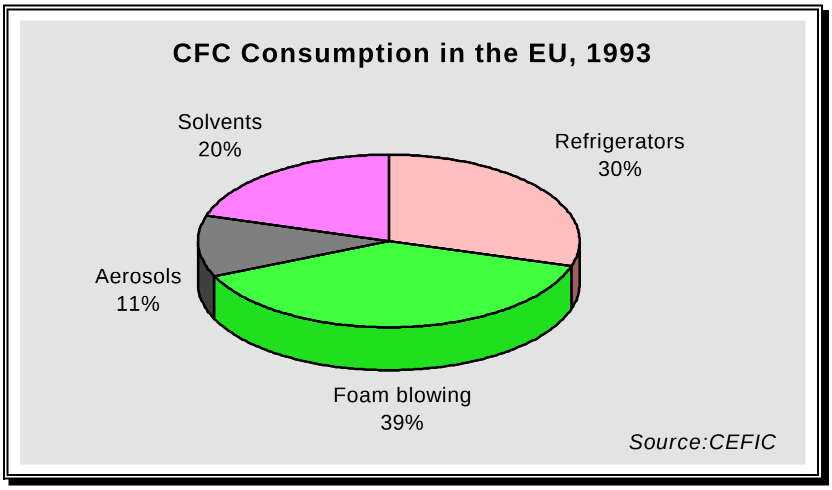



*Figure m - CFC consumption in EU (1993) by sector.*

While CFC emissions are falling in the EU, sadly they are still rising globally, it is hoped that the Montréal protocol will have an impact on the rest of the world. Due to the EU reduction in emissions, whilst the rest of the world is still increasing its emissions, the EC's share of total CFC emissions has according to Eurostat fallen from 39.8% in 1980, to 33.2% in 1987. Hopefully, as total emissions eventually reduce, there should be a slow stopping and reversal of ozone depletion. As you can see, this is a problem that affects the whole of Europe, and is best dealt with by the EU, rather than national governments alone. Therefore the EU is taking action to impose a total ban on CFC production and consumption by 1997.

## Tropospheric Ozone

The troposphere is the layer of the atmosphere that goes from the Earth's surface to 15km above it. The problem with ozone here is paradoxically that there is **too** much of it. Tropospheric or ground level ozone as it is sometimes referred to, is what one calls a secondary pollutant and is produced by photochemical reactions[12]. During the heat wave of 1995, Manchester suffered particularly badly from ground-level ozone. Ozone is produced by a complex series of chemical reactions in the presence of sunlight, between nitrogen oxides and VOCs. Ozone levels encountered in the UK can irritate the eyes, and have small effects on people's lungs. Ozone is also known to reduce the yield of some sensitive crops and damage natural vegetation and organic materials, it also contributes to damage by acid rain by promoting the oxidation of pollutants to the acidic variety.

Ground-level ozone exists naturally in small concentrations, that were thought to be around 10-15ppb before the industrial revolution. Industrialisation and the

[12] Chemical reactions that take place in sunlight (they require sunlight).

resultant increased atmospheric pollution have resulted in a doubling of background concentrations over the past century to around 30ppb. In summer, concentrations can rise considerably above background levels when there are periods of bright sunlight, with temperatures above 20°C, and light winds. Once formed, ozone can persist for days and can be transported long distances.

Figure n shows the distribution over the UK, of incidents where the ground level ozone has exceeded the 100ppb hourly mean concentrations in 1990. The figure shows the contours of concentration, that increase in a north/south direction. Thus from this distribution it is clear that pollution transported with continental air masses plays a significant role UK ozone episodes. As you can see from the distribution, Manchester is affected by ozone, although not as seriously as London, or the extreme south of the country. Ozone episodes occur more frequently in the south of the country due to larger volumes of traffic and the impact of continental air masses.

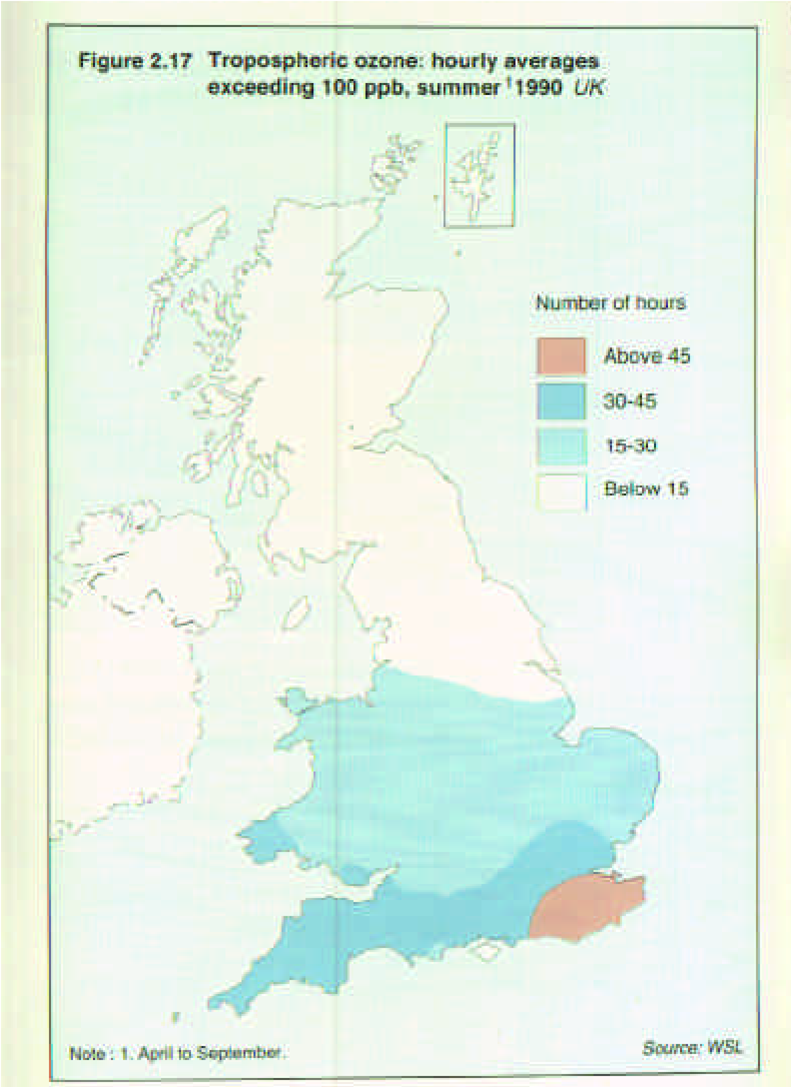



*Figure n - Tropospheric ozone - hourly averages exceeding 100ppb, summer 1990.*

*How the rest of the EU compares as far as ground level ozone is concerned:-*

The problem of ground level ozone is experienced by all cities in the EU, it is a result of a build up of traffic emissions, which form ozone in the presence of sunlight, ground level ozone is a summer problem on the whole. The problem is increasing because of course, traffic volumes are increasing and the main causes - VOCs and nitrogen oxides are not reducing. Unfortunately I have been unable to access data about ground level ozone for the rest of the EU, although I expect that the causes will be the same across the EU. One interesting point that I did find, was that on days when the ozone levels were or were likely to be high, certain EU cities ban cars to ease the problem, this is not done in the UK however, much to the discomfort of the city centre shopper/visitor.

## ***Global Warming:-***

Another pan-European issue of concern is global warming, one might argue that the recent changes in climate (i.e. lower levels or rainfall, hotter summers) are due to the rising temperature of the Earth, due to global warming. Global warming is related to what is known in the greenhouse effect, which in itself, under natural conditions is helpful, as without it, the average surface temperature of the Earth would be -18°C, rather than the current average of 15°C (33°C warmer). If the greenhouse effect goes beyond its natural mandate, due to man-made pressures, then the effects are potentially catastrophic. The diagram in figure *o* shows the greenhouse effect in action.

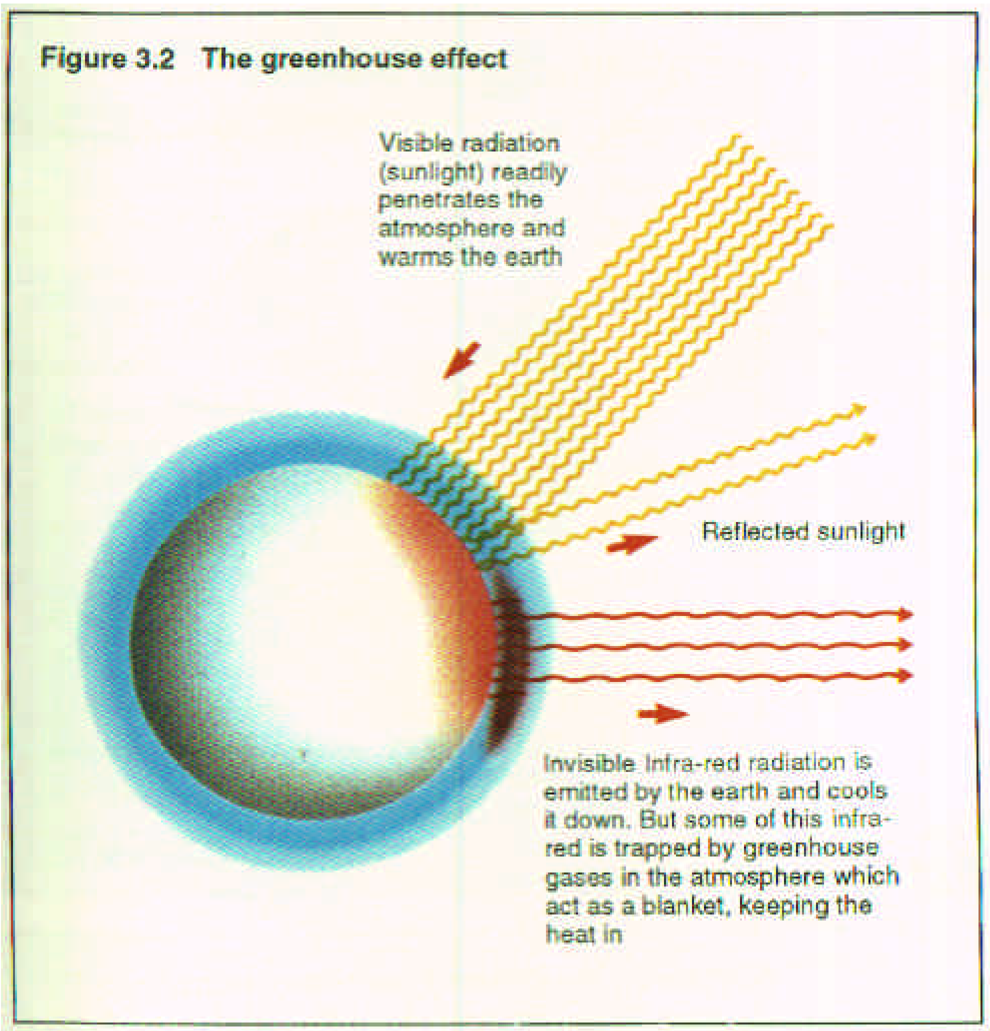



*Figure o - The greenhouse effect.*

As you can see, the infra-red light (heat) penetrates the atmosphere, and a large proportion heats up the surface of the Earth, and the warmed surface heats up the atmosphere by convection, and radiates heat as long-wave infra-red radiation, which absorbed by greenhouse gases, thus heating up the air. Some of this heat is then re-radiated back to the ground, thus keeping the Earth much warmer than it would otherwise be, and hence habitable.

The problem that we are facing is that the increase of greenhouse gases is causing the greenhouse effect to work much better than it would normally, therefore significantly increasing the temperature, which has all sorts of implications. The major worry with the increase of surface temperature, is climate changes that could result in droughts and flooding in certain areas of the world, as far as Europe is concerned, we would mainly be troubled by the latter. The increase in average surface temperature above the norm started around 1850, when the industrial revolution was just tasking hold. Since 1850 there has been an average 1°C rise in temperature, and temperatures are set to rise further. The long term effects will include the possible melting of the polar ice caps, causing a rise in sea levels of up to 6cms per decade in the next century, and even with rapid and considerable action, the IPCC[13] estimates that by the year 2030, there will a rise in sea levels of between 8cms and 29cms, with the best estimate given as 18cms. This will obviously affect the low lying areas of Europe, such as Venice in Italy, the Netherlands, and many areas in the UK (the coasts of East Anglia, Lancashire, and the Yorkshire/Lincolnshire area, the Essex mudflats, the Somerset levels, the Sussex coastal towns, and the Thames estuary. Other vulnerable areas would be the north Wales coast, the Clyde and Forth estuaries in Scotland, and Belfast Lough in Northern Ireland.). Another possible result of global warming could be the shifting northwards of the grain belt, which scientists estimate would cut cereal production by 5%-10% by the year 2030. We already know that advanced stages of global warming have started, the biggest indicator in northern Europe is the thickness of the arctic ice sheet, which in 1976 was 6-7 metres (20-23 feet) thick, by 1987 it’s thickness had reduced to 4-5 metres (13-17 feet), this is very significant when you consider the huge area covered by the arctic ice sheet.

The principal cause of the greenhouse effect is carbon dioxide, produced from the combustion of fossil fuels (coal, oil and gas), globally, combustion of fossil fuels accounts for 5.7 billion tons of carbon dioxide that is emitted into the air annually, 13% of this total (≈0.79 billion tons) is produced by EU member states. Other greenhouse gasses include nitrous oxide ($N_2O$), methane ($CH_4$), and CFCs. Here we have CFCs cropping up again, so not only do they destroy the ozone layer, they also contribute to the greenhouse effect, thankfully, emissions of CFCs are reducing as I mentioned earlier in the section on CFCs within the section on ozone. The other three principal causes I shall deal with in this section. For your information, the contribution that each of the pollutants mentioned makes to global warming, is shown in figure *p* below.

[13] Intergovernmental Panel on Climate Change.

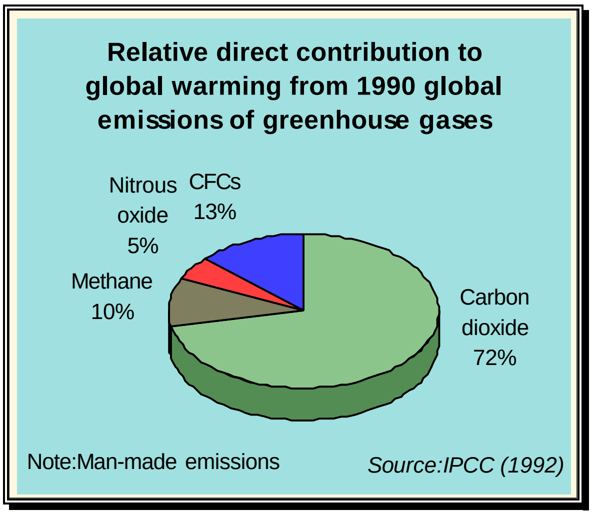



*Figure p - Contribution of key greenhouse gases to global warming.*

As carbon dioxide is the main cause of global warming, the affects of the other chemicals on global warming, are measured in relation to the effects of carbon dioxide. The table in figure *q*, shows the key greenhouse gasses, their concentration in the atmosphere, rate of change, GWP (global warming potential - i.e. the likely contribution to global warming of each gas relative to the same mass of carbon dioxide over a period of 100 years), and the type of indirect effect they have. As you can see from the table, some of the most potent chemicals have a long lifetime, therefore it is essential that international direct action is taken now, as even if a total cessation of emissions took place now (somewhat impossible), the effects of emissions so far would last at least until the year 2128!

As you can see, by far the most dangerous chemicals as far as the greenhouse effect is concerned, are CFCs, which can have up to 7100 times the effect of carbon dioxide, and last almost as long in the atmosphere too! The worrying thing is that globally, CFC emissions are still rising, although tough regulations and increased consumer awareness in the EU means that the EU's one-third share of this total is now falling, and the EU has undertaken to have a total ban in place by 1997. One can get more information on the sources, production and usage of CFCs throughout the EU by referring to the subsection of CFCs earlier in the document, in the section on tropospheric and stratospheric ozone. One should take care to note that while CFCs are many times more detrimental to the global warming than carbon dioxide, that is if the ***same*** mass of CFCs as carbon dioxide were in the atmosphere, however, as you can see from the table, CFCs have a very small concentration indeed relative to carbon dioxide, therefore carbon dioxide is the main cause of global warming, due to the large and worrying concentrations of it. Therefore while it is essential that CFC emissions are limited due to their powerful nature in relation to both the ozone layer and global warming, we must also make a concentrated effort to limit carbon dioxide emissions, as these at the moment have a greater effect on global warming.

| Properties of key greenhouse gases | | | | | |
|---|---|---|---|---|---|
| | *Current ('91) average atmospheric concentration* | *Current rate of change (% per annum)* | *Direct Global Warming Potential* | *Lifetime (years)* | *Type of indirect effect* |
| | *(ppmv)* | | *(GWP)* | | |
| *CO2* | 355 | 0.5 | 1 | 120 | none |
| *CH4* | 1.72 | 0.6-0.75 | 11 | 10.5 | positive |
| *N2O* | 0.31 | 0.2-0.3 | 270 | 132 | uncertain |
| *CFC 11* | 0.000255 | 4 | 3400 | 55 | negative |
| *CFC 12* | 0.000453 | 4 | 7100 | 116 | negative |
| *CO (1)* | | | | months | positive |
| *NMHC (1)* | | | | days/mths | positive |
| *NOX (1)* | | | | days | uncertain |

Note; 1 Emissions affecting tropospheric ozone concentration
Carbon monoxide (CO)
Non methane hydrocarbon (NMHC)
Nitric oxide and nitrogen dioxide (NOX)

*Source: IPCC*

*Figure q - The properties of key greenhouse gases.*

So let's take a brief look at the gases not already mentioned that contribute to global warming.

<u>*Carbon dioxide:-*</u>

Carbon dioxide ($CO_2$) is a natural substance, that is exhaled by animals and humans, and inhaled by plants (which exhale oxygen), it plays a key part in global warming as already mentioned. Carbon dioxide plays a key part in the carbon cycle, which involves the exhalation of carbon dioxide by animals, and the inhalation by plants, which in turn exhale oxygen that we can breathe. However, the man-made emissions of carbon dioxide have perturbed the carbon cycle, resulting in an increase in the concentration of carbon dioxide since the start of the industrial revolution. It is known that the levels of carbon dioxide have risen from 280ppmv before the industrial revolution, to the current (1991) level of 355ppmv. The IPCC estimates that in 1990, 6000 million tonnes of carbon were released into the atmosphere as a result of burning carbon dioxide, the UK contributed 160 million tonnes to this. The UK currently emits 2.8 tonnes of carbon per capita per year, which is close to the European average.

Figure *r* below shows the main causes of carbon dioxide pollution in the UK, as you can see, power stations are the main cause, producing 34% of total emissions, followed closely by industry at 26% of total emissions. The big difference with carbon dioxide is that road transport is not the biggest cause, it is however one of the main causes of pollution, and as you can see from figure *s*, while most other sectors are declining or staying fairly constant, road transport's share is increasing, due to increased traffic volumes, and is offsetting achievements in other areas. Figure *s* shows that between 1970 and 1990, the highest carbon dioxide emissions were in 1979, when 181 million tonnes of carbon were released into the atmosphere, this then fell during the 1980's, reaching an all time low during the 1984-85 miner's strike, when nuclear power generation was maximised, and other sources such as gas took precedence. Then emissions began to rise due to coal fired power stations running at normal capacity, and then increases due to traffic volume increases.

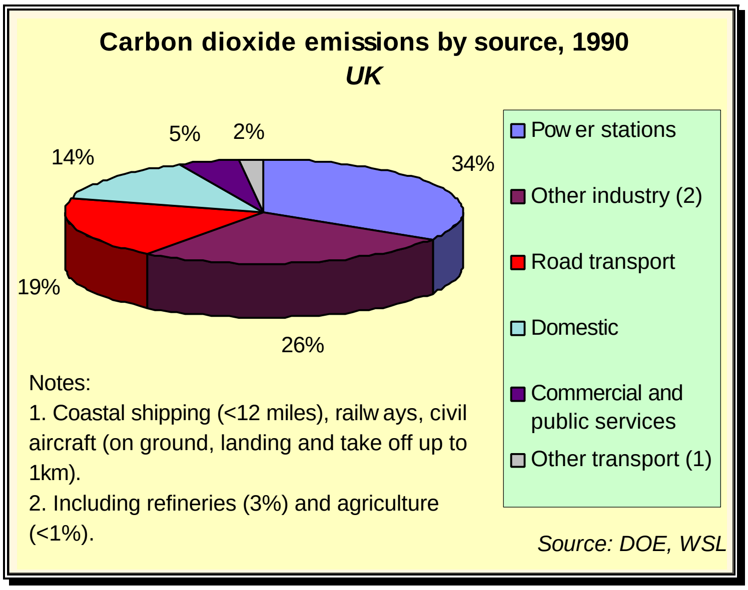



*Figure r - CO2 emissions by sector, 1990 (UK).*

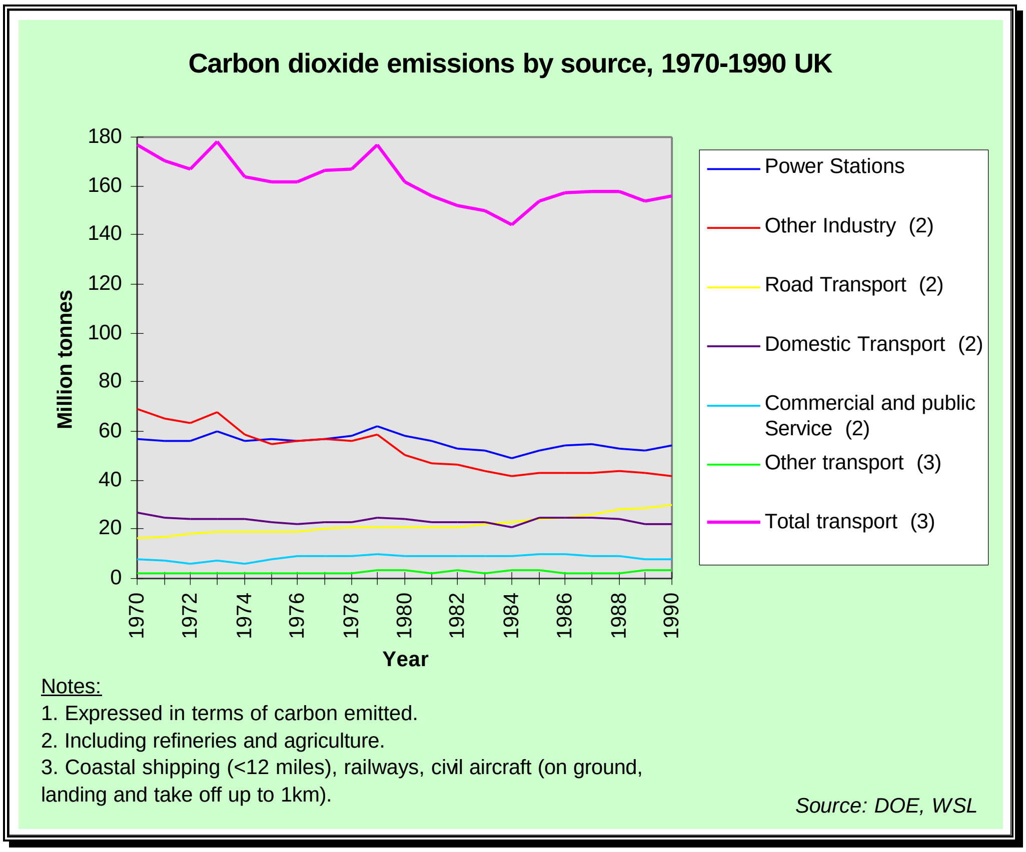



*Figure s - $CO_2$ emissions by source, 1970-1990 (UK).*

Increasing carbon dioxide emissions are not only a problem in the UK, but globally, and as such many states in the EU have problems with carbon dioxide emissions, some more than others. I showed earlier that in the UK up to 1990, whilst there had been a drop in emissions in the mid 1980's, the increasing trend had begun again towards 1990. According to the European Environment Agency (EEA), up to 1990, carbon dioxide emissions had been steadily increasing, then fell between 1990 and 1993 during the economic recession. I identified earlier in the UK section on carbon dioxide that emissions from industry have decreased, yet this is offset from increasing emissions from the transport sector, the EEA has found this to be the case across Europe. The cornerstone of EU policy seems to be to stabilise carbon dioxide emissions at 1990 levels by the year 2000, it is however uncertain as to whether or not this target will be built due to a number of factors:-

- Continuous transport growth across the EU.
- Continuing low energy prices.
- The slow improvement of energy efficiency.
- The fact that many of the measures in member state's national programmes will not be completed by the year 2000.

All countries in Europe have experienced rises in carbon dioxide emissions, even Austria, which has a very good reputation for having reduced emissions in many gases. According to figures from the Austrian Federal Environment Agency (Österricher Umweltbundesamt), between 1950 and 1995, carbon dioxide emissions have risen from 28 million tonnes in 1950, to 59 million tonnes in 1995 (over double!).

The area graph in figure *t (see back of booklet)* produced by the Austrian Federal Environment Agency, shows carbon dioxide emissions from 1955-1994, as you can see, there has been a large increase in emissions since 1955 (due to obvious expansion of industry, etc). The highest emissions were in 1991 at 64 million tonnes, and have since began to fall, if this trend continues and is accelerated then there is little to worry about. I have decided to mention Austria as it is a country that has a good reputation on emissions, and in the case of carbon dioxide, comes at the middle of the group of EU member states as far as emissions are concerned with emissions of 7.84 million tonnes per head, and therefore is a good model for observing the trends of the EU as a whole. Austria has followed other EU countries in so far as emissions fell between 1991 and 1993 and then went up again slightly, this is due to transport increases, as all other sectors have seen reductions between 1991 and 1994. Something that you will notice about Austria that is certainly different from the UK, and most probably different several other EU countries, is that electricity generation (*Stomerzeugung*) is **not** the main cause of emissions, transport (*Verkehr*) is. The reason for the difference is due to the Alps which provide great opportunity for electricity generation through hydro-electric power, which Austria uses to it's advantage to produce 70% of all the country's electricity requirements. You will notice that transport is the main cause of emissions, which produced 31% of all emissions in 1994, I believe that the same is true of France, which has the amongst the lowest emissions of carbon dioxide in Europe (4.44 million tonnes per head), 8$^{th}$ in the league table. As with all European countries, generally, emissions are reducing or remaining level in all sectors apart from transport which is increasing and offsetting achievements in other areas. Looking back at UK data, transport actually comes third (19%) in carbon dioxide emissions, behind industry (26%), and power generation (34%), this is probably due to the large number of power stations and industrial plants that still use fossil fuels in the UK, so there are clear differences between the UK and Austria. The data below shows the trends in carbon dioxide emissions in Austria between 1988 and 1994:-

| | 1988 | 1991 | 1994 |
|---|---|---|---|
| Electricity Generation | 8.1 | 12.5 | 9 |
| Industrial combustion | 9.4 | 9.1 | 8.8 |
| Industrial processes/cement production | 6.5 | 6.4 | 5.3 |
| Transport | 15.1 | 17.6 | 18 |
| Commercial/residential combustion | 12.7 | 13.9 | 13.1 |
| Energy sector (natural oil, gas and coal) | 2.9 | 2.7 | 2.7 |
| District heating | 1.3 | 2.2 | 2 |
| *Total (rounded to two significant figures)* | **57** | **64** | **59** |

*Figure u - Trends in $CO_2$ emissions in Austria, 1988-94 (figures in million tonnes of $CO_2$ emitted). (Source: Umweltbundesamt).*

As is clear from the figures, all sectors except industrial processes peaked in 1991, when Austria's total emission were the highest during the period 1955-1994. All other sectors then witnessed a reduction/levelling of emissions, except for transport, which following a pan-European trend is increasing. Figure *v* shows the emissions by sector based on the data shown above. It shows that as mentioned, transport contributes the most, followed by commercial/residential combustion of fuels (22%), and third in the ranking is power generation (15%), with industrial combustion the last large contributor. It is interesting to note that a country that produces only 30% of it's power from fossil fuels (nuclear electricity generation is prohibited in Austria), contributes 15% of total carbon dioxide emissions in this way (3rd in emission rankings), yet a country like the UK which relies more heavily on fossil fuels for power generation, has power stations as the prime cause of carbon dioxide emissions, with 34% of total emissions produced in this way. This I believe, shows that power generation produces significant amounts of carbon dioxide, and although transport is a main and increasing contributor, it is power generation that is the more damaging at the moment, and in the case of heavily industrialised countries like the UK and Germany, heavy industry (e.g. iron and steel) is a more worrying cause than transport, and perhaps easier to deal with.

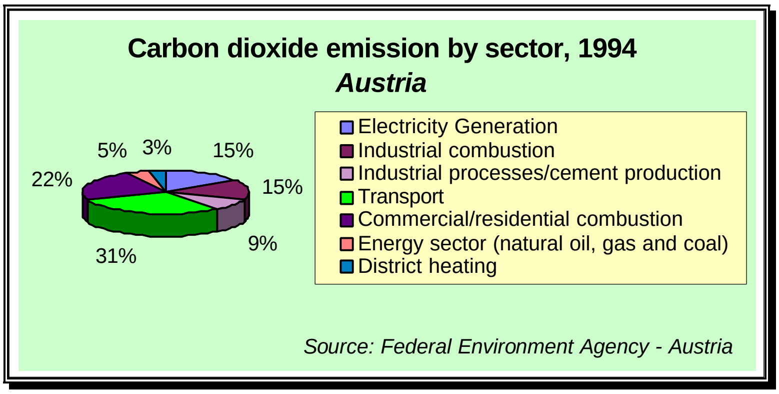



*Figure v - $CO_2$ emissions by sector, 1994 - Austria.*

Most EU member states follow the pattern stated, generally with either power generation, followed by industry, followed by road transport, or the same causes in different combinations, as the first to third main causes of carbon dioxide emissions. There are exceptions to this rule, notably:

- France - Combustion for commercial residential use ranks top (112 million tonnes), followed by emissions by nature in second place (109 million tonnes), but transport comes in third (no surprises there!) with 97 million tonnes. This is mainly due to an extensive nuclear power programme.
- Luxembourg - Industry comes top (6 million tonnes), followed by power generation (2 million tonnes), with commercial/residential use third (1 million tonnes). In this case road transport comes in third (768,000 tonnes). These emissions are the lowest in Europe, however Luxembourg is the smallest country, things are fairer when examined on a per capita basis.
- The Netherlands - Power generation is top (40 million tonnes), followed by commercial/residential use (31 million tonnes), with industry in third place (28 million tonnes). In the Netherlands, road transport ranks $5^{th}$ (24 million tonnes) - the only EU country where transport is not in the top four contributors to carbon dioxide emissions.
- Portugal - Industry is top (16 million tonnes), followed by power generation (14 million tonnes), with natural emissions in third place (10 million tonnes). Road transport ranks fourth (9 million tonnes). Portugal is one of the lowest emitters of carbon dioxide in the EU given its late industrialisation, problems that have plagued other member states such as inefficiency have been largely avoided, and man-made emissions are in the same region as natural emissions, therefore pollution is not a major problem - much the same could be said of France.
- Austria as stated above.
- Sweden - Natural emissions are actually top here (84 million tonnes), followed by waste treatment and disposal (30 million tonnes), with industry third (16 million tonnes). Road transport comes in fourth (16 million tonnes). Sweden is an interesting case, as natural and man-made emissions are more or less equal in size (man-made emissions are 2 million tonnes higher than natural emissions). The fact that natural emissions come top is that Swedes are generally very energy conscious, with power generation ranking $6^{th}$ in total emissions - due mainly to a large nuclear power programme. Waste disposal emissions are a result of Swedes being very conscious about the degradability of materials, hence much waste is burned to protect animals and soil from such material.

The other 9 member states seem to fit the pattern mentioned earlier. Figure *w* shows emissions by sector of carbon dioxide in 1990 for all of the current EU member states:-

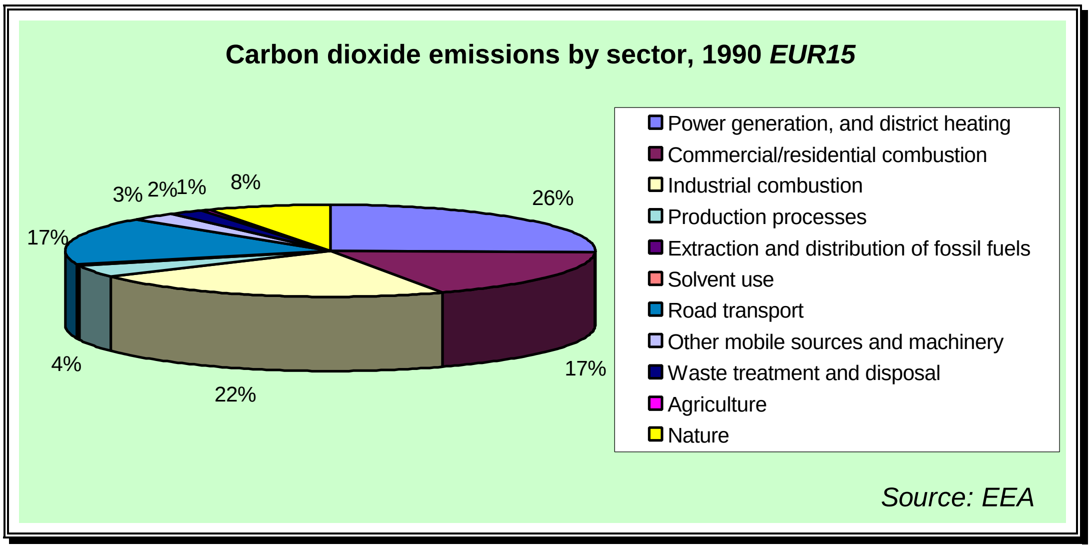
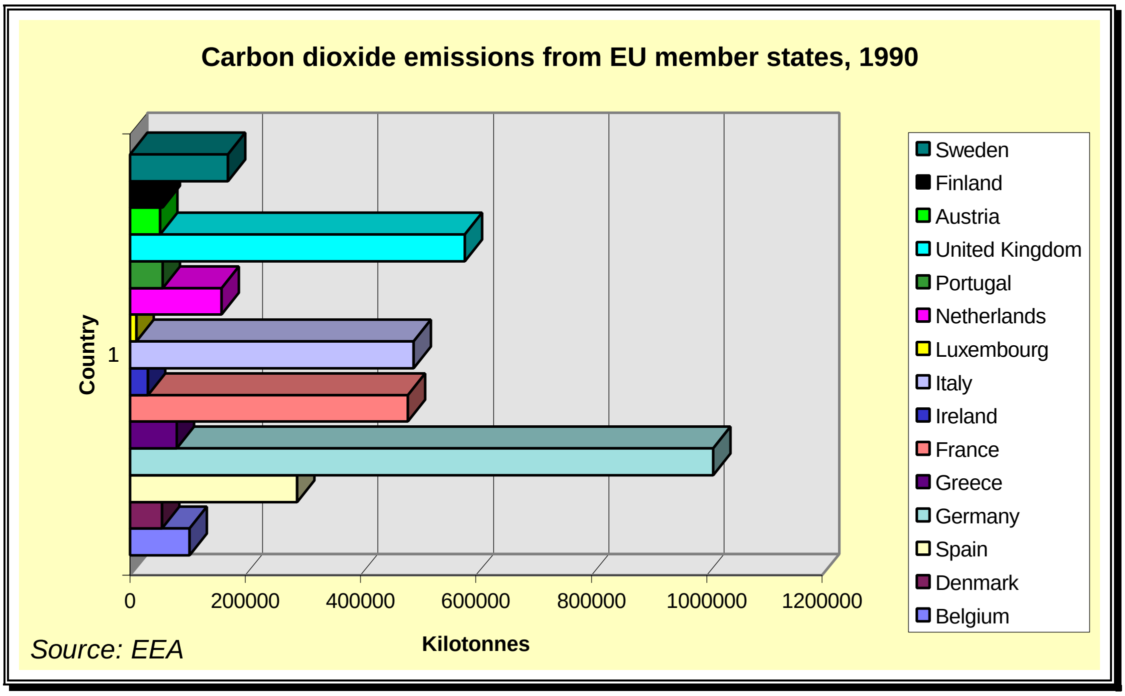



*Figure w - $CO_2$ emissions by sector, 1990 for all current EU member states.*

The figures show more or less what I had said, power generation contributes the most to emissions, as we had found earlier, with industry being the second largest contributor. Join third are transport and commercial/residential combustion, which tallies with what we found (in many cases transport was in the top three, although on the odd occasion it was fourth or lower in the rankings). These are followed by nature at an 8% share of emissions. Clearly the EU must work on power generation and industry as these are perhaps the easiest to rectify and do produce the largest emissions, transport is much more difficult to deal with but does need attention due to the increasing share it has in carbon dioxide emissions. There are two areas (solvent use and waste treatment and disposal) that despite being listed in the legend, have emissions of such small magnitude (relative to the others) that they do not make a slice of the pie, these areas are of little concern at the moment, so are other emissions below natural emissions as they will not have a real impact, it is emissions from the main sources listed that are of concern and are to be dealt with.

It is clear that carbon dioxide emissions are a problem for most areas of Europe, although, as the figure below shows, emissions are more of a problem to some areas (e.g. the UK and Germany) than others (e.g. France, Spain):-




As you can see, the countries that have the highest emissions, are Germany, the UK, and Italy, closely followed by France. The top three countries are heavily industrialised and have traditionally relied on fossil fuels, it is only now that emissions are beginning to reduce, but these must be concentrated on. As these figures are not on a per capita basis, they can be misleading, for example, Luxembourg is shown to have the lowest carbon dioxide emissions in the EU, one must remember that it is a very small country, and when worked out on a per capita basis, Luxembourg actually has the largest carbon dioxide emissions in Europe (26 tonnes per capita) due to its disproportionately large iron and steel industry. Countries which appear not be a threat, e.g. Portugal, could well be, as Portugal started industrialisation late and is eager to catch up, often and stupidly adopting a cavalier attitude towards the usual environment considerations. The chart is useful in showing us the countries that currently have the lowest/highest **total** emissions, and they are as we would expect (well advanced nations like Germany having high emissions, whereas less well advanced nations (mainly southern European countries, where agriculture is predominant) have the lowest emissions).

If one were to look at the emissions on a per capita basis, one would find that the country with the greatest total emissions shown above (Germany), also has the highest emissions at 12.26 tonnes per capita (apart from Luxembourg), and the second largest emitter of carbon dioxide (the UK), is fourth largest emitter on a per capita basis at 9.99 tonnes per capita. The lowest emitters per capita were Spain (5.44 tonnes per capita), and Portugal (4.24 tonnes per capita), which makes more sense given the level of development of both countries. One might like to note that the IPCCs 1990 recommendation of the maximum acceptable level of carbon dioxide in the atmosphere was 1.69 tonnes per capita, all EU member states greatly exceed this value, and need to work towards it, some much more than others!

The other greenhouse gases:-

Due to limited space and time, I do not intend to cover Methane and Nitrous oxides, as they pose much less of a threat than CFCs and carbon dioxide, which I have dealt with.

## ***Conclusion to report:-***

The problems to do with air pollution in Manchester, certainly aren't just local problems, the main forms of air pollution occur right across the community, although they are generally found in densely populated areas, or areas with a heavy industrial base, or both. Also, areas close to areas of heavy industry can be affected, by sulphur that is deposited by air/rain, as I mentioned earlier. Generally the causes of air pollution seem to be the same, with road transport being a major cause if not the cause of a particular form of pollution in almost every case. As we have seen all the figures suggest common causes of pollution, with certain regional variations, which are due to the impact of nature, the level of development, national environment policy, and many other factors. Thankfully most forms of pollution are gradually ceasing to be a threat, although one must bear in mind that in a lot of cases, such as the ozone layer, just because emissions have been curbed, the problem has not gone away, and emissions from previous decades will still be affecting the atmosphere. The main problem that will face the EU in years to come is the increasing amount of road traffic, as nearly all forms of pollution are related to transport in some way, and while reductions have been made in sectors such as electricity generation, emissions from road transport are still increasing, offsetting achievements. Areas of particular success are lead pollution which is being reduced thanks to the 1989 clear car directive; the reduction in emissions of ozone depleting substances; the reduction of sulphur dioxide emissions in nearly all EU member states; and the levelling out of nitrogen oxides pollution (although we do need to see reductions); the measures implemented to reduce VOC emissions (through 3-way catalytic converters). Carbon dioxide emissions do need to be reduced, and this is a serious problem that is still on the increase and needs to be reduced. Particulate pollution also needs to be curbed, as again, reduction in industrial sectors are being offset by increases in the transport sector. One of the best ways to deal with the problem of road transport is to divert people and freight onto rail where possible, this will need significant effort though.

[N.B.] Throughout the book I have used various abbreviations for organisations, and chemical formulae, a glossary is provided below for your reference:-

Glossary:-

- CEFIC - European Council of Chemical Manufacturers' Federations for EU figures.
- CFCs - Chlorofluorocarbons - volatile but inert compounds of carbon, chlorine and fluorine.
- CO - Carbon Monoxide
- $CO_2$ - Carbon Dioxide.
- $CH_4$ - Methane
- DoE or DOE - Department of the Environment (UK).
- EEA - European Environment Agency.
- EC - European Community (the EEC, called EC from 1967).

- EU - European Union (the community, called EU from 1992).
- EUR12/EUR15 - European Union with 12 or 15 members respectively.
- FRG - Federal Republic of Germany (former West Germany).
- GDR - German Democratic Republic (former East Germany).
- HMIP - Her Majesty's Inspectorate of Pollutants.
- IPCC - Intergovernmental Panel on Climate Change.
- $NO_X$ - Nitrogen oxides.
- $N_2O$ - Nitrous oxide.
- $NO_2$ - Nitrogen dioxide.
- ppb - parts per billion.
- ppm - parts per million.
- ppmv - Parts Per Million by volume.
- $SO_2$ - Sulphur dioxide.
- UK - United Kingdom.
- UNECE - United Nations Economic Commission for Europe.
- USSR - Union of Soviet Socialist Republics.
- WHO - World Health Organisation
- WSL - Warren Spring Laboratory.
- VOCs - Volatile Organic Compounds - organic compounds which evaporate readily and contribute to air pollution.

By Anthony J. Truhlar, M13 (31/05/96).