

## Science: Section 1

### Fuels

A fuel is a substance that burns to release energy.

When a fuel burns the chemical reaction is known as combustion. When combustion takes place the fuel is reacting with oxygen in the air to release energy in the form of heat and light.

There are various substances that can be used as fuels such as coal, oil, natural gas, ethanol, biomass and biogas. They are incredibly important substances in our modern world as they provide energy for transport, electricity, and heating for homes, but they do have a down side. When some fuels are burned they release pollutant gases and fine particles that can affect the quality of the air that we breathe. This is a big problem in areas such as town and cities where there are lots of vehicles that are burning these fuels.

### Fossil Fuels

Coal, oil and natural gas are known as the fossil fuels. They are called the fossil fuels because they were formed by dead plants and animals kept under pressure for millions of years.



**Coal**



Formed by dead plant material

Used by power plants to produce electricity for our homes



**Oil**



Formed from dead sea creatures and plant material

Has many, many uses such as petrol, plastics, diesel, tar and lubricating oil.



**Gas**



Formed alongside both coal and oil

Known as natural gas it is used to heat homes

All 3 fossil fuels are said to be finite, this means that they are running out and cannot be replaced. The table below shows approximately how long they may last.

Fossil Fuel	Years Left
Coal	100
Oil	40
Gas	50

Governments across the world are planning to stop using fossil fuels altogether by the end of the century, switching to renewable sources.

## Renewable Fuels

Biofuels are produced from plant material, and unlike fossil fuels, they are renewable meaning that they will not run out. Shown below are some examples of biofuels.

- **Ethanol** – Ethanol (alcohol) is produced by fermenting sugar. It can be mixed with petrol to fuel cars. This is already done in Brazil!
- **Biogas** – This is mainly methane. It's produced from rotting vegetable waste and animal manure (POO POWER!). It can be used to fuel cars and produce electricity in power stations.
- **Biomass** – This is plant-based material which can be burned to release energy. Biomass can also be converted to other usable forms of fuel. These include methane gas, ethanol and biodiesel.

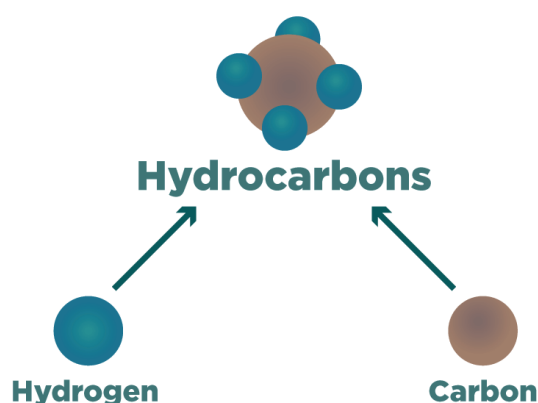
**Hydrogen** is another renewable fuel and is said to be the fuel of the future. It can be produced from water. Some cars can already run on hydrogen. It is an excellent fuel because all it produces when it burns is WATER!

## Science: Section 2

# Crude Oil

Crude oil is a black sticky substance. Hidden in it are many different substances that have essential everyday uses. Petrol, diesel, tar and many other substances that play very important roles in our everyday lives are found in crude oil.

These substances are known as hydrocarbons:-

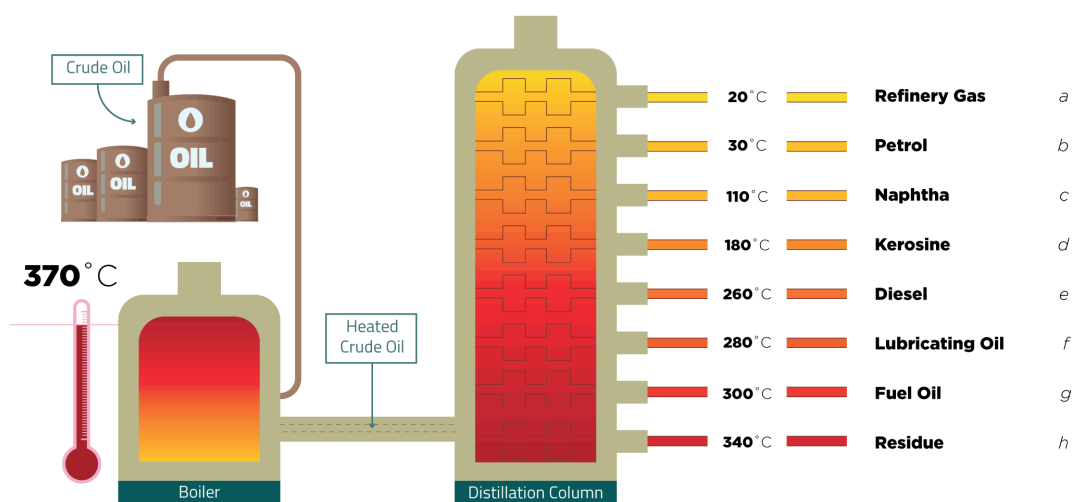


## Fractional Distillation

Fractional distillation is used to separate crude oil into fractions. A fraction is a group of hydrocarbons all with boiling points within a specific range.

Because each fraction has its own boiling point, when the crude oil is heated each fraction will boil at different temperatures and leave the crude oil mixture as a gas. This allows them to be separated and collected.

This is done in a fractionating column.



As you go up the fractionating column, the hydrocarbon molecules get smaller and have:

- lower boiling points
- lower viscosity (they flow more easily)
- higher flammability (they ignite more easily)

This means that in general hydrocarbons with small molecules make better fuels than hydrocarbons with large molecules and not just because they burn better but because they produce less fine soot particles as a result of having fewer carbon atoms in their chain.

*A mnemonic can be used to help you to remember the fraction in order. Use this one or make up your own.*

Rich	<b>Refinery Gas</b>
Peoples	<b>Petrol</b>
New	<b>Naptha</b>
Kit-Kat	<b>Kerosene</b>
Diet	<b>Diesel</b>
Loses	<b>Lubricating Oil</b>
Fat	<b>Fuel Oil</b>
Rapidly	<b>Residue</b>

## Properties of the Fractions

The fractions show a change in properties. These properties include:-

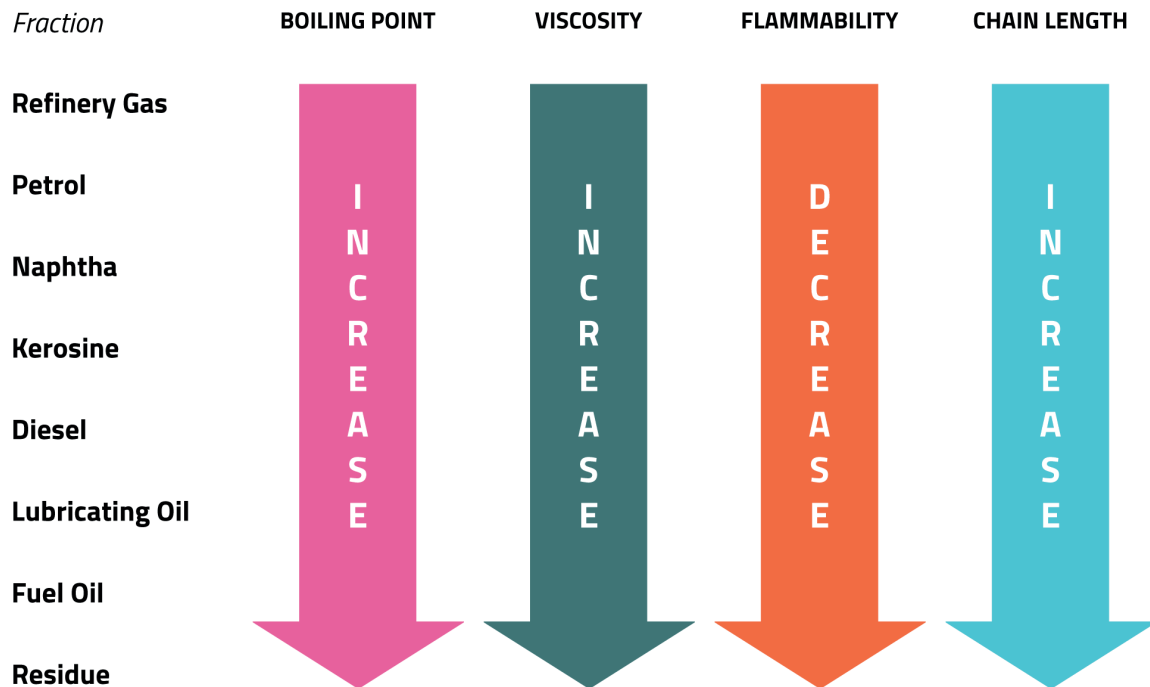
**Viscosity** is a measure of how thick or runny a liquid is. For example treacle has a high viscosity because it is very thick.

**Flammability** is a measure of how easily a substance burns.

**Boiling point** is the temperature that a liquid turns into a gas.

**Chain length** is the number of carbon atoms in each molecule. As the chain length increases the chance of incomplete combustion increases, creating more particles.

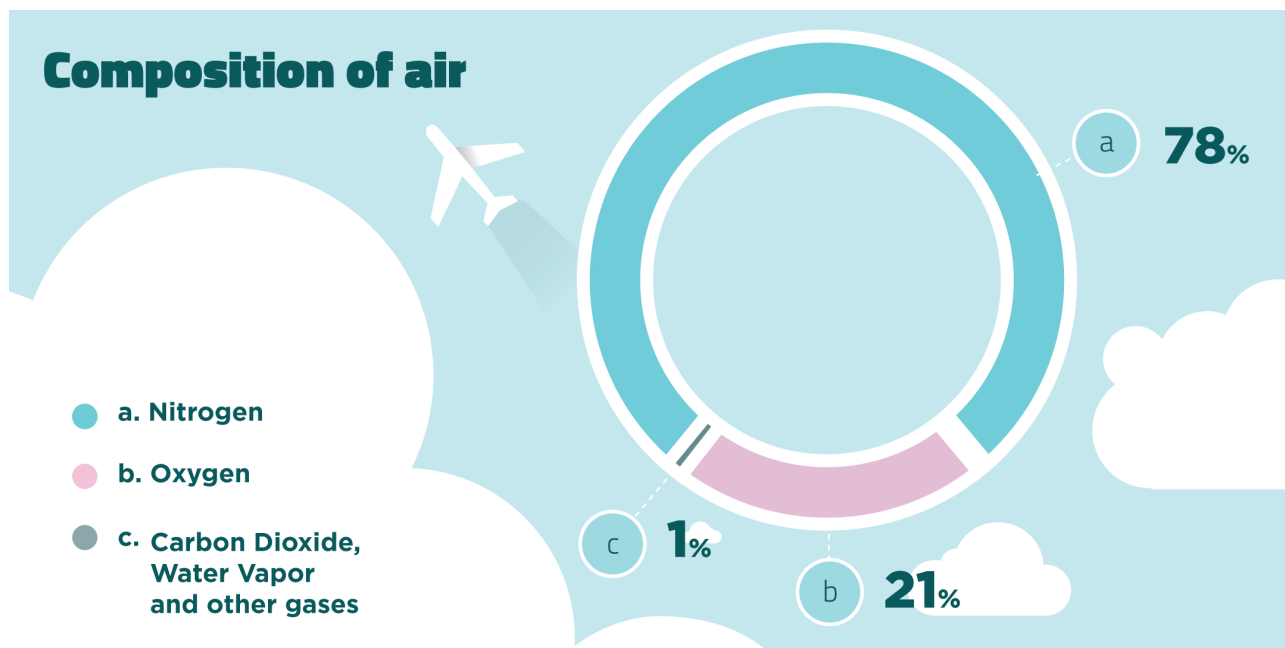
The change in these properties can be shown by the diagram below.



## Science: Section 3

# Combustion of Fossil Fuels

When fuels burn they react with oxygen in the air. Air is a mixture of gases made up of mainly nitrogen and oxygen gas.



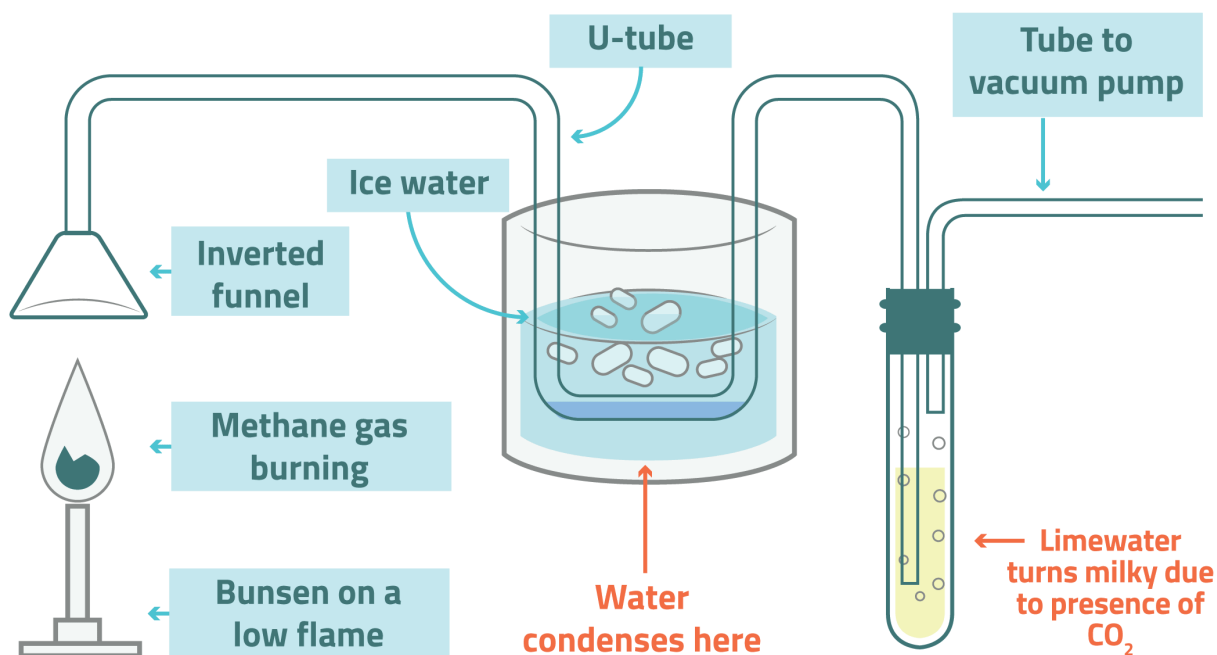
## Products of Combustion

When a hydrocarbon burns in a **plentiful** supply of oxygen, carbon dioxide and water are produced.



This is known as complete combustion

This can be shown by the following experiment:



Instruct the pupils to construct a table of observations that can be made as the reaction proceeds and record colour changes including the soot produced that collects on the funnel.

### Other products of combustion ...

When a hydrocarbon burns in a **limited** supply of oxygen, carbon monoxide and fine particles can be produced which can affect health.

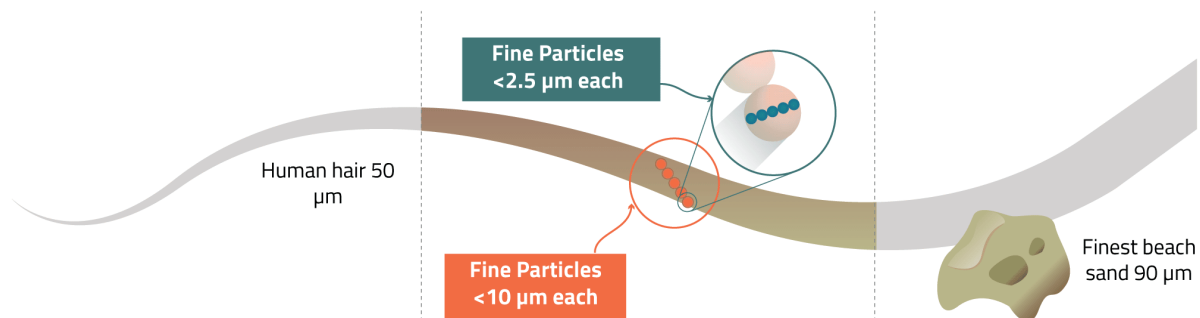


This is known as incomplete combustion.

**Carbon monoxide** - a highly poisonous gas that is both colourless and odourless (nicknamed the silent killer!)

**Fine Particles** - tiny pieces of solid matter or liquids in the air that are released during combustion. Some are large enough to be seen with the naked eye, such as black soot, however others can only be seen through powerful microscopes. The smaller particles can be breathed deep into your lungs and then even go into your bloodstream causing

health problems.



When a hydrocarbon burns at high temperatures in the air nitrogen dioxide can be produced.

**Nitrogen dioxide** is a poisonous reddish, brown gas with an unpleasant smell. Most of the nitrogen dioxide in urban areas comes from exhaust emissions, but it can also be formed naturally by lightning strikes.

**Sulfur dioxide** is a colourless gas that is formed when fuels containing sulfur, such as coal and oil, are burned. It is also produced from natural sources such as active volcanoes and hot springs. Sulfur dioxide is toxic to plants and can cause breathing difficulties and acid rain.

**Ozone** (O<sub>3</sub>) is a colourless gas made up of oxygen. It is formed by hydrocarbons and nitrogen dioxide reacting in the presence of sunlight. Ozone is highly reactive, making it useful for cleaning and disinfecting. But, when it comes in contact with living tissues like our lungs it can cause damage and illness. Ozone can also damage plants, reducing the growth of important food crops such as wheat.





## Science: Section 4

# Air Pollution and Health

Air pollution is harmful to us all, as it can affect our bodies, the food we eat, the places we live and the world we live in.

Our bodies need oxygen to survive. We breathe in thousands of litres of oxygen a day but the air we breathe is not pure. It can contain various substances called pollutants and many of these arise from burning fuels. This pollution can affect our health.

There are many sources of both manmade and natural air pollution. Natural air pollution can come from volcanoes, desert dust and wildfires. Manmade air pollution can come from transport, industry and energy generation.

In urban areas, such as towns and cities, cars, buses and trucks are the main contributor to poor air quality.

### Impacts of air pollution on human health

The quality of the air around us is very important as it directly affects our health and the environment we live in. Air pollution is estimated to reduce the average life expectancy of every person in the UK by six months and causes around 2000 deaths in Scotland each year.

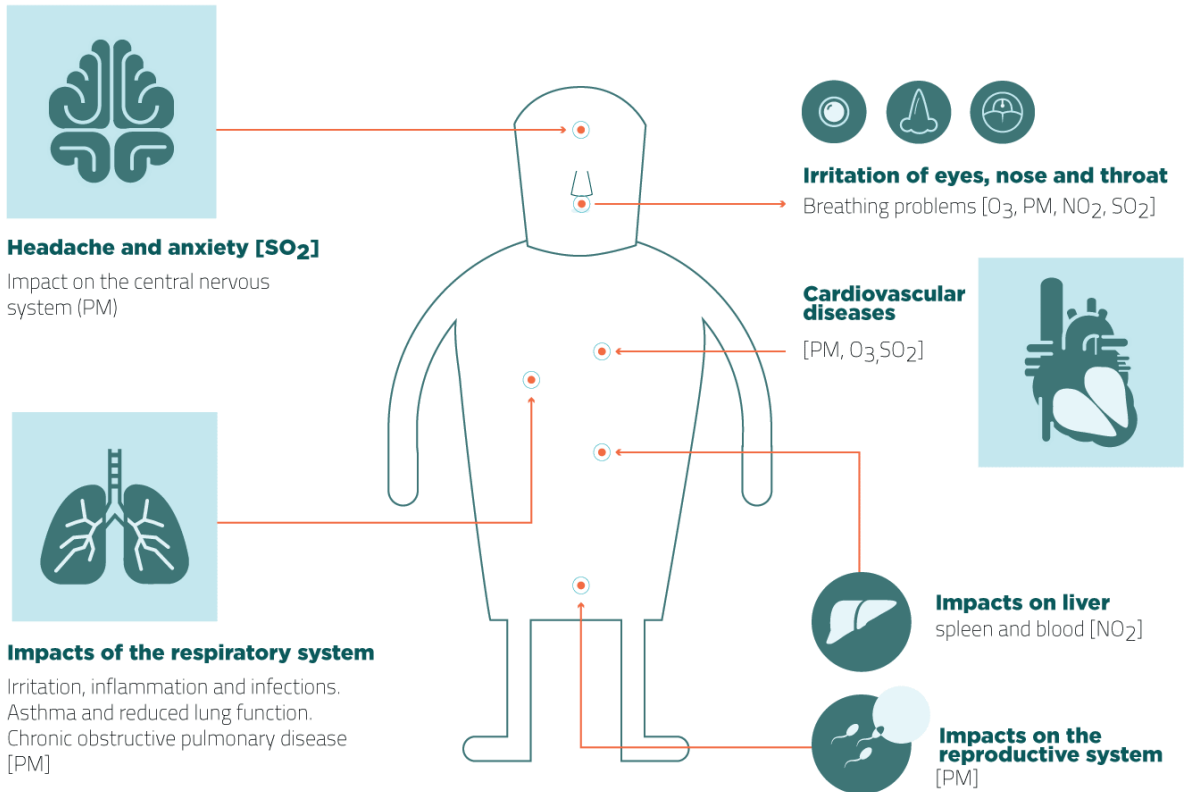
Air pollution has become one of the biggest environmental risks to human health. Unlike the dense smog and smoking chimneys of the past, today's air pollution is largely considered invisible. Health problems are mainly caused by fine particles from car exhausts that can be breathed deep into the lungs.

For the majority of people, the health effects of air pollution are relatively minor and go unnoticed; however, sometimes we can experience very mild symptoms following short periods of exposure. This can include irritation to the nose and throat after walking down a heavily congested city centre street.

For those people who have pre-existing health problems such as asthma, or who are exposed on a long-term basis, or to high levels of air pollutants, the effects increase in severity. This can include the worsening of existing medical conditions and increased visits to the doctor, to admission to hospital and, in extreme cases, premature death.

The diagram below shows the impact that air pollution can have on different parts of our body.

# Health impacts of air pollution



**Fine Particles [PM]** are particles that float around in the air. Sea salt, black carbon, dust and condensed particles from certain chemicals can be classed as a PM pollutant.

**Nitrogen dioxide [NO<sub>2</sub>]** is formed mainly by combustion processes such as those occurring in car engines and power plants.

 **2,094**

Tiny particles in the air could be contributing to 2,094 deaths in Scotland a year.

 **2,100 miles**

of cycle routes now in Scotland but journeys by bike represent only 1% of journeys.

 **-33%**

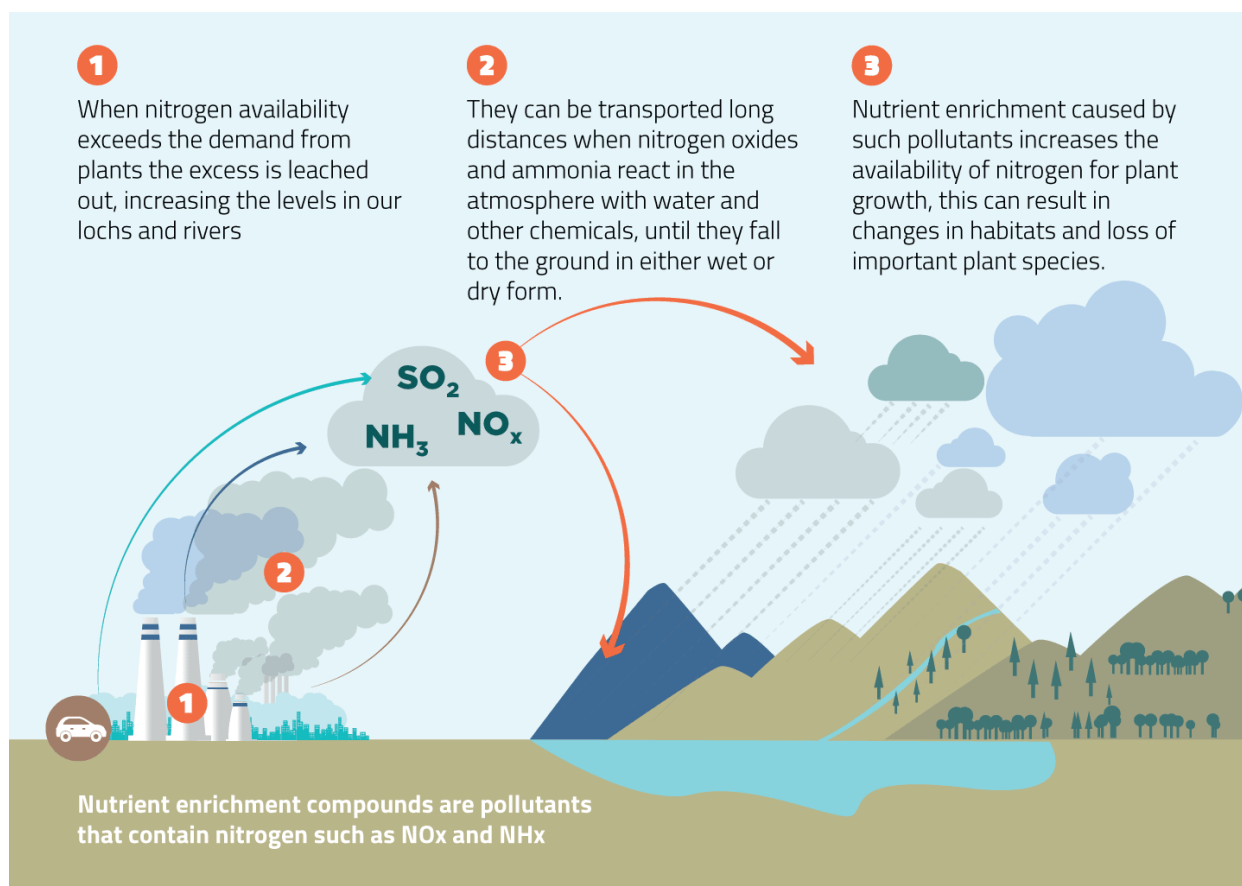
Fine Particle emissions have fallen by 33% from 2000 to 2012.

## Science: Section 5

# Pollution and the Environment

Poor air quality not only harms our health, it can also harm the environment. The main adverse effects are acid rain, nutrient enrichment and the greenhouse effect.

When we burn fossil fuels such as petrol and coal they release gases containing nitrogen and in some cases sulfur into the air. These gases are carried up high into the air and can be blown by the wind over other countries a great distance away. Once in the air, the gases dissolve in water in the atmosphere and are changed into chemicals called acids.



When it rains these chemicals fall back to earth. This is called acid rain. The chemicals are deposited in rivers, on land and on buildings, and over time they can cause problems. Some of the air pollution produced in the UK can end up in countries in northern Europe including Sweden, Norway and Denmark.

- Acid rain can cause many problems such as:
- Corrosion of iron bridges
- Corrosion of limestone buildings
- Damage to plants and the soil they grow in
- Damages wildlife especially fish

The good news is that new laws have been brought in to reduce the emissions of sulphur which has led to a big reduction in acid rain. However emissions of nitrogen are reducing much more slowly and it may take some decades for the soil and water environments to recover.

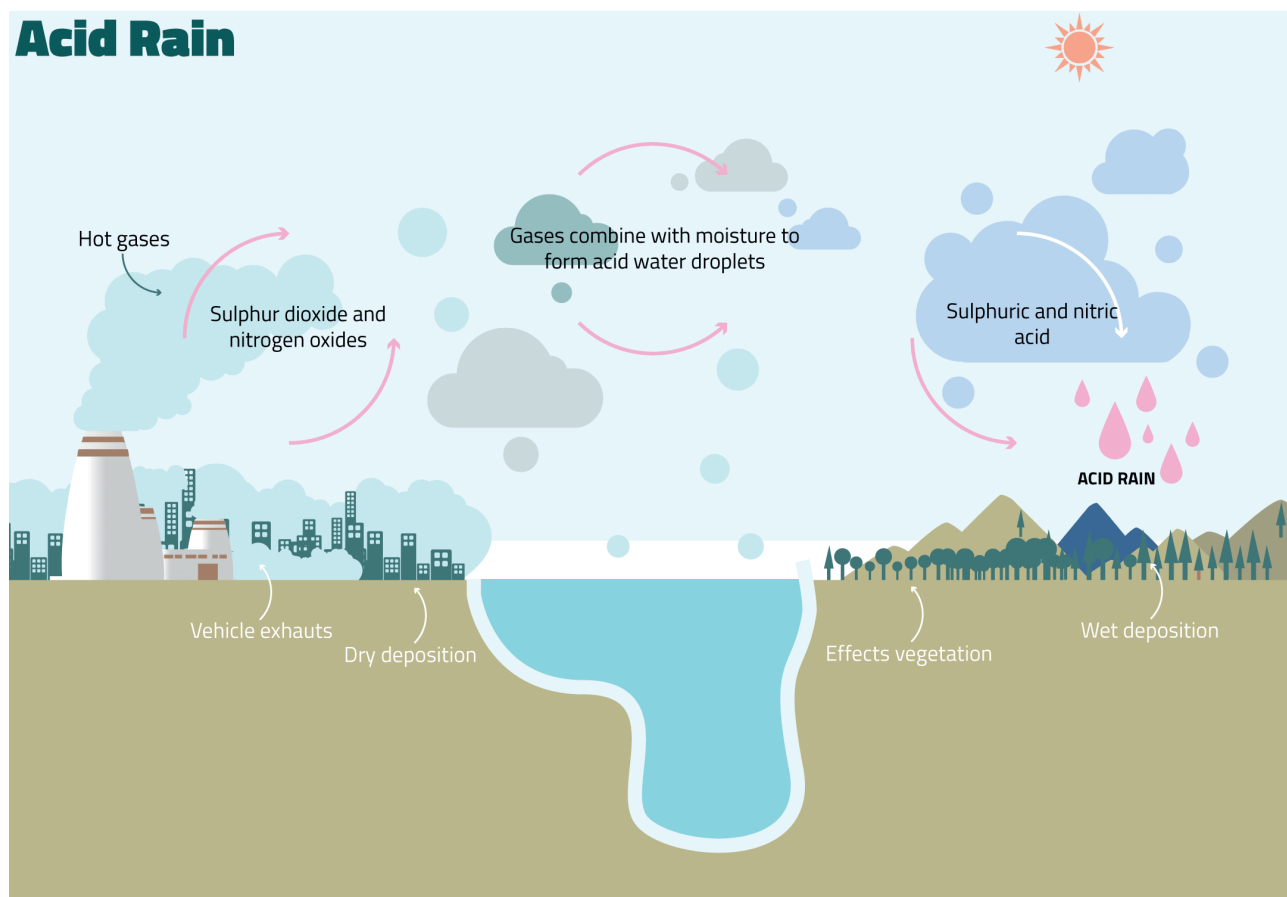
## Nutrient Enrichment

Nutrients are the things that all living things need in order to grow and nourish. Plants require the 3 essential nutrients, nitrogen, potassium and phosphorus to grow however too much of any one of these nutrients can be harmful.

Nitrogen released into the air from burning fuels can cause an excess of nutrients in soil and water.

In soil, nutrient enrichment can cause some plants such as grass to grow well, but others to grow less well. The plants that grow however can eventually stop the other plants from growing at all.

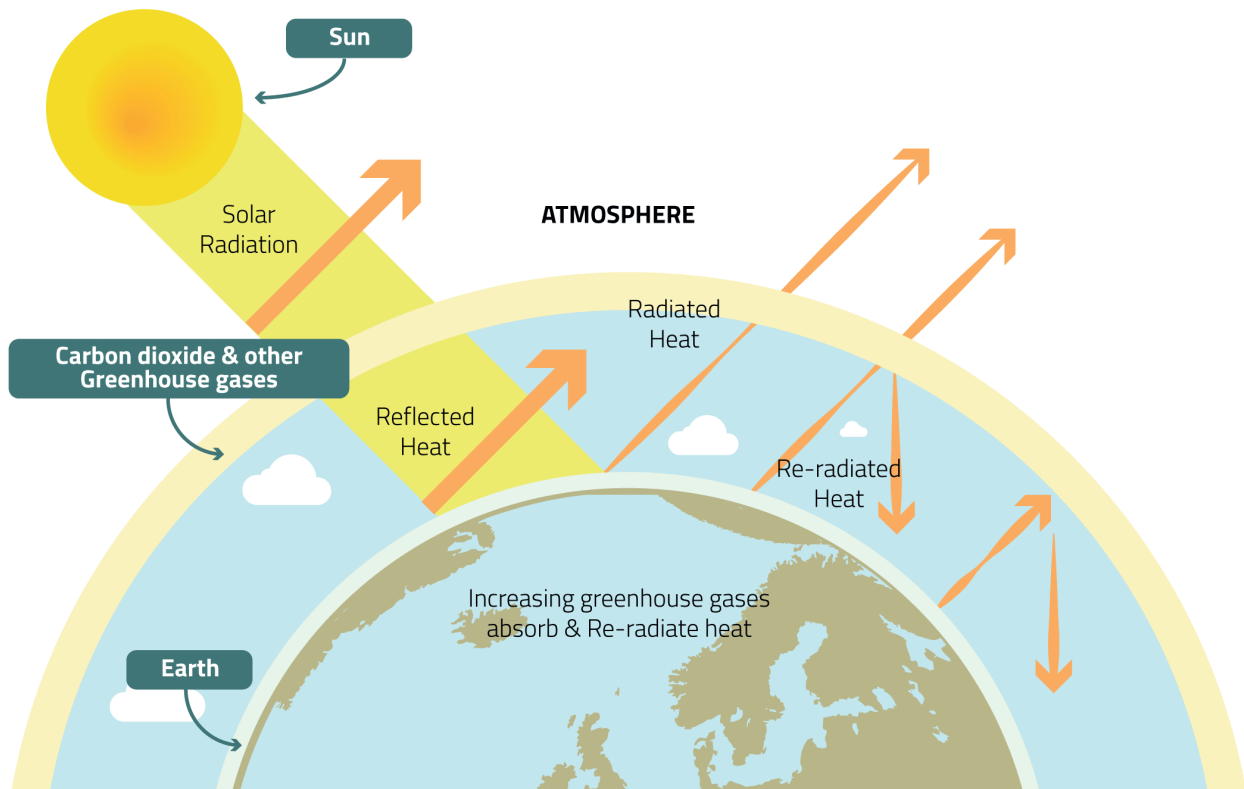
In water, nutrient enrichment can lead to the growth of microorganisms such as algae. These microorganisms can use up the oxygen in the water and stop sunlight getting to the plants that live there. This can be harmful to both plants and fish in the water that need the oxygen to breathe.



## Greenhouse effect

### Carbon Dioxide

Carbon dioxide is produced when any hydrocarbon burns completely in air. It contributes to the greenhouse effect which leads to global warming. Global warming can change the weather causing glaciers to melt and making sea levels rise. It can cause drought and floods in some places and affect people, plants and animals.



## Science: Section 6

# Solutions: What can we do about it?

Although our air quality in Scotland is relatively good, when compared with other areas of the world, there is still room to make it even better. The Scottish Governments, Local Authorities, SEPA and other organisations all help to reduce air pollution, either in direct or indirect ways. Perhaps one of the most important people involved in tackling air pollution is you.

### You and Your Family

We, as individuals, can work together to help make our air cleaner and air pollution levels will fall. There are many ways you and your family can help improve the air quality in Scotland. It might not seem like much, but if everyone does a little, it will have a great effect.

## Travel and Transport

### USE CAR TRAVEL LESS

Think about your journey: Do you have to go by car, or could you use another method?

- Walking
- Cycling – tried and tested for 190 years. Still zero emissions
- Public Transport – put your feet up and relax, catch up on your reading
- Car Sharing – share the journey, have a laugh

### IF YOU MUST TRAVEL BY CAR

Try to travel outside peak times where possible: less congestion means faster journeys, which in turn creates less pollution. We can't always change when we go to school or work, but less important journeys, such as shopping or visiting friends, can be done at quieter times of the day.

Avoid leaving your engine idling when not in use: New laws mean your parents could be issued with a fine!

Service your car regularly: Keep the engine properly tuned and the tyres at the right pressure. A happy car is an efficient car!

### REDUCE ENERGY USE AT HOME

- Conserve energy wherever possible. Turn off appliances like your television or radio when not in use.
- Don't forget to switch off lights when you leave the room.
- Recycle paper, plastic, glass bottles, cardboard, and aluminium cans. This conserves energy and reduces production emissions.
- Turn down the thermostat in your home.

- Wash clothes with warm or cold water instead of hot.
- Buy rechargeable batteries for devices used frequently.
- Try growing your own fruit and veg rather than buying it
- Plant trees to help green our cities

## What are the Governments doing?

The Scottish Government works with Local Authorities and the Scottish Environment Protection Agency to identify areas with poor air quality and improve it if required. A Low Emission Strategy is being developed for Scotland which sets out how air quality will be improved across the country.

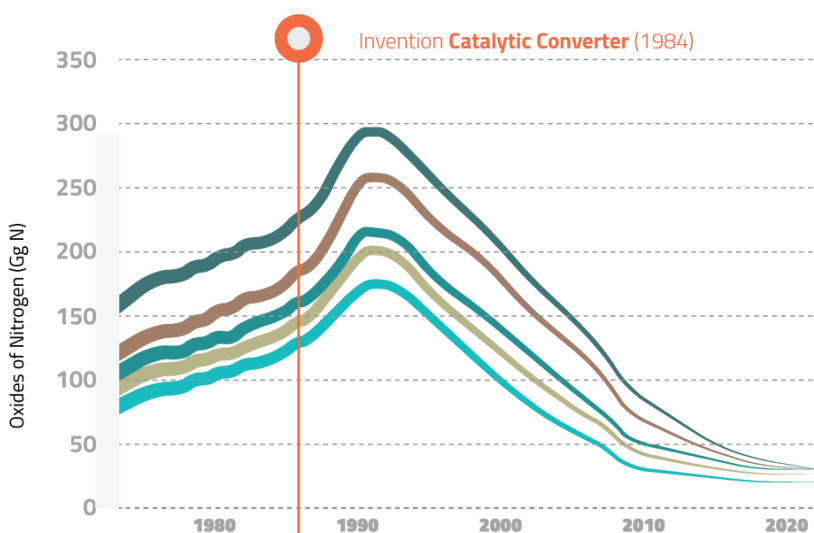
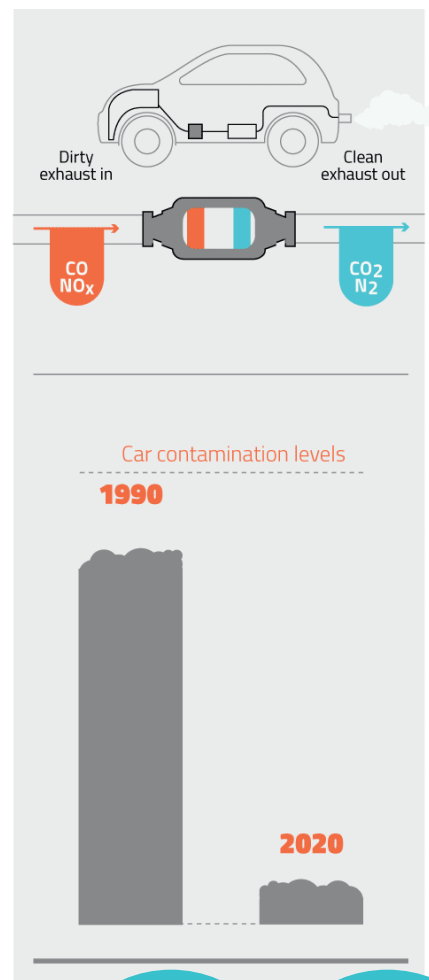
The Scottish Government have also committed to produce the equivalent of 100% of Scotland's energy from renewable sources by 2020.

Scotland has the largest offshore renewable energy resources in the EU! (25% of EU offshore wind, 25% of EU tidal and 10% of EU wave power).

Getting energy from these renewable sources will all help to reduce carbon emissions.

## Catalytic Converters

### Catalytic Converter



As cars are one of the main contributors to urban air pollution, many things have already been done to make them more eco-friendly.

Since 1993, all new cars sold in the European Union have to be fitted with a catalytic converter. This is part of the exhaust system of a car that can convert harmful gases into less harmful gases. It contains some very expensive metals such as platinum and can change carbon monoxide and harmful nitrogen dioxide into carbon dioxide, nitrogen and oxygen.

Even with all of these improvements and changes, pollutants such as carbon dioxide and nitrogen dioxide can still be produced when fuels burn. In order to get 'clean' air we need to use 'clean' energy.