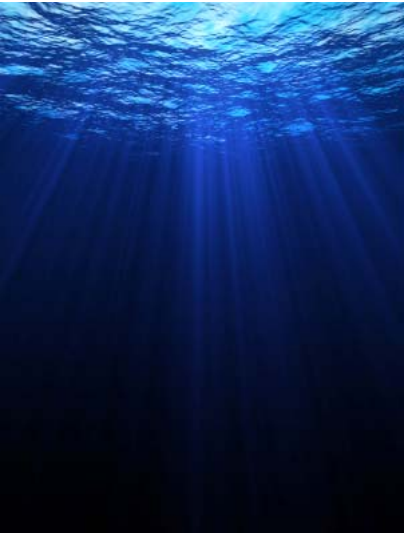


Ocean fertilisation (ocean seeding, iron fertilisation)

What is the technique?

The addition of large quantities of iron or other nutrients to areas to the upper ocean.



How it works

The nutrients act as fertilisers, encouraging the growth of huge blooms of algae and phytoplankton. As these plants grow CO_2 is used up during photosynthesis, so reducing CO_2 in the air. When the blooms die the CO_2 will sink to the sea bed in the dead organic matter.

The positives:

The small scale experiments carried out so far have been successful in proving the theory.

Biological productivity increases which can benefit the marine food chain.

The negatives:

Many scientists question whether this process removes CO_2 permanently, believing it may circulate in the oceans and be released (unsure as to how deep the plankton would sink)

The production of iron is energy intensive so could produce more CO_2 than it removes.

Marine ecosystems have evolved a natural balance over millions of years and therefore the ability to cope with change is unknown.

Long term ecological impacts, particularly on fragile ocean environments are unknown.

Artificial Trees (carbon scrubbers)

What is the technique?

Machines that can capture CO² from the air and filter it out as air passes through them.



How it works

Artificial trees or 'carbon scrubbers' can trap CO² on absorbent plastic sheets called ion exchange membranes.

The CO² can then be removed from the membranes and captured. Once captured it can be stored (See CCS).

If the CO² is combined with sodium hydroxide, a liquid solution of sodium carbonate is produced which can be piped away. The CO² can then be recovered from this and stored.

The positives:

It's estimated that each artificial tree could remove 90000 tonnes of CO² a year, equivalent to 20000 cars.

The units being designed are a similar size to shipping containers, easy to transport & can be located where there are high CO² outputs, or near to CCS plants, so eliminating transport costs.

It is hoped as the technologies advance & costs are reduced, structures similar to trees can be built for locations alongside roads etc.

Currently the UK produces 556 mega tonnes of CO² per year and the 100,000 trees could absorb around 60% of that amount. A study by the Institute of Mechanical Engineers calculated that forests of artificial trees powered by renewable energy & located near depleted oil or gas fields, where the trapped CO² could be buried, would be thousands of times more efficient than planting trees over the same area ([Guardian 27 Aug 2009](#)).

This process does remove CO²

The negatives:

1 million trees would be needed to soak up the world's current emissions and the CO² would still need to be disposed of.

It is uncertain whether technology would be efficient at huge scales required. Cost is approximately £15 000 per unit and the UK would need 100 000.

Many scientists recommend this technology should be developed in conjunction with carbon storage infrastructure.

Making each artificial tree would require energy and materials, although this would be a small amount compared to what it could capture.

Carbon Capture Storage (CCS)

What is the technique?

The trapping of CO² as it's emitted from point sources, such as power plants, transporting it to suitable storage sites and storing it underground.



How it works

There are 3 stages in this process:

1. Capture - CO² is separated from other gases using separation technologies.
2. Transport - the CO² is transported via pipeline in a supercritical state (it behaves as both a liquid & gas) to a storage site
3. Storage – there are several possible options, the most popular at present is to inject it into depleted oil and gas reservoirs and other geological formations such as a sandstone layer underneath the North Sea.

The positives:

Currently there's much scientific research into this option as a viable possibility.

Could reduce emissions directly at source so they do not enter the atmosphere.

There's some political support for this option

The captured CO² can be injected into existing depleted oil and gas reservoirs and other geological features

A Norwegian company has been successfully doing this for several in the North Sea

The negatives:

The process is very costly.

There is some concern over longer term effects of CO² storage and whether there is any chance of the CO² 'leaking' – scientists do say this is very low risk though if the appropriate sites are chosen

At present this technology is fairly energy intensive.

Sulphur Screens (Stratospheric aerosols)

What is the technique?

The addition of sulphur particles to the upper atmosphere to reduce incoming solar radiation



How it works

A screen of shiny sulphur particles would be sprayed into the stratosphere by aircraft or balloons. These help to partially reflect some of the sun's radiation back into space, mimicking the natural process that occurs during volcanic eruptions.

The positives:

The experiment has been done! Mount Pinatubo erupted in 1991, emitting 10 million tonnes of sulphur and average global temperatures fell by 0.6°C for two years.

There is some support from scientists.

This is relatively cheap compared to other techniques.

The timescale to undertake this is fairly short.

The negatives:

The problem of increasing CO² emissions is not addressed and the subsequent effects this creates including ocean acidification.

Possible side effects include changes to the global water cycle and rainfall – possible droughts and the knock-on effects this may have on ecosystems.

Increasing amounts of sulphur in the atmosphere can cause acid rain, with devastating effects on plants and animals.

Sulphur in the lower atmosphere can result in an increase in respiratory diseases.

Whilst it may be relatively easy to do, it would require continual effort as the chemicals gradually fall back to Earth.

Increasing reflectivity (modifying the albedo)

What is the technique?

Using reflective materials on rooftops and pavements or painting them white or paler colours.



How it works

The more reflective a surface is the greater the albedo, so greater the reflection rather than absorption of solar radiation.

Research is being carried out into increasing the reflectivity of other land surfaces, including agricultural areas, deserts and ice caps, for example scientists have 'wrapped up' glaciers in reflective blankets to try and reduce melting.

The positives:

This could delay the global warming and the consequences of climate change.

California has adopted this approach; all new and redeveloped residential & commercial structures with flat & sloping roofs must have heat-reflecting roofing.

This technique is relatively cheap compared to others.

The timescale for introducing this is quite short (especially for painting roofs).

The negatives:

The problem of increasing CO² emissions is not addressed and the subsequent effects this creates including ocean acidification.

Increasing cloud reflectivity

What is the technique?

A fleet of specially designed wind-powered ships would spray sea water particles into the atmosphere in order to increase the cloud density, so increase their reflectivity.



How it works

When the seawater in the atmosphere evaporates salt crystals are left behind. These act as nuclei for water droplets to condense on and form clouds. A greater concentration of nuclei increases the density of the clouds and dense clouds reflect more than thin clouds, so the earth's temperature would decrease.

The positives:

Sea water is readily available in the oceans! It's estimated that 1.4 billion tonnes of sea water would need to be converted annually needed annually to increase the albedo enough to compensate for global warming.

Could help buy time for adjusting to a low carbon society.

The ships could be turned off at any time if there are damaging consequences.

The negatives:

This technique does not reduce the CO² in the atmosphere, so does not address problems such as ocean acidification.

Ships will need to be in constant use for this to be effective.

Critics warn that although such schemes might lower temperatures swiftly, they would have to be maintained for long periods and the side-effects on local climate patterns of wind and rain are unknown. Dr Vicky Pope, head of climate change advice at the Met Office, said: "Anything that alters the climate in a different way from reducing carbon has inherent dangers because we don't understand the climate well enough." ([Times](#)).

The technology is not yet developed.

Space Mirrors (space sunshade)

What is the technique?

A giant sunshade in space could block the sun.



How it works

More likely to be a collection of millions or even trillions of small mirrors rather than a giant orbiting parasol that would reflect the incoming solar radiation away from earth.

The positives:

The solar rays that are reflected would compensate for the increase in temperatures created by global warming.

The negatives:

Very expensive.

Many additional rockets would need to be built to enable all the launches, which could cause problems for the ozone layer and create additional emissions.

The reduction in solar radiation could have a major impact on the earth's processes.