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Seeing is believing?

Dr Nick Riley, Chair of CGS Europe, provides a geoscientist's perspective on the potential of CCS, and why policymakers may have been slow to act on CO_2 emissions...

Born in the mid-1950s I was brought up in the Lancashire Coalfield of the North West of England, a region located in the Industrial Revolution's 'womb'. Its lifeblood was energy from coal. As a young boy, the landscape around me was a 'Lowry canvas' of power plants, gasifiers, coke works, cotton mills, brick works, metal foundries, coal mines, steam trains, canals, quarries and cement kilns. Trees around me were dying. Streams and rivers flowed bog-iron orange, tainted by acid mine water, or took on the colour of whatever dye was being used in the mills upstream. Winter brought choking, blinding, smogs (in which I became a casualty). War veterans, like my granddad and his pals, whose lungs had survived the phosgene of Europe's World War I battlefields, coughed and spat thick phlegm. Once-majestic Millstone Grit buildings were 'widow black', coated in grime. Snow turned speckled grey, dappled with soot. Birds died. You could taste and smell the sulphurous air.

My mum bought me my first book on geology, 'The World in the Past', with its prose and images of the 'Age of Sea Lilies', and 'Age of Ferns', evidence of which was strewn about the coal tips and quarries in which I played. She also bought me Rachel Carson's 'Silent Spring', which linked the insecticide DDT with thinning of bird eggshells and the resultant breeding failure, especially in birds of prey. One day I came home from school and told my dad he would die from lung cancer unless he stopped smoking. He was so shocked at his own child telling him this that he stopped immediately. Little did I know then of the extent to which vested interests in the tobacco industry tried to distort, confuse or deny the scientific evidence that smoking caused cancer and vascular disease.

It was easy to create political will, justify legislation and bear the cost of cleaning things up because people could see the air pollution and experience its immediate effects on their environment and health. The air in our cities had become intolerable. So, Britain began to modernise and start its post-industrial journey. The Clean Air Act was first introduced in 1956 and subsequent, ever tighter legislation ensued. Our manufacturing and raw materials industry started its decline, as countries that once exported their raw materials to the UK for manufacture into products, themselves industrialised. Britain began to import manufactured products from them.

Correspondingly, our emissions and pollution were 'exported' abroad as we became a consumer-led society. Imports exceeded exports and our economy got out of balance. The newly constructed National Grid, with its huge pylons and cables that linked electric power from new nuclear (with its promise of cheap, clean and limitless power) built on the coastlines, and new coal plants built on new coalfields, now came through our valley. The pound devalued. As the 70s arrived, John Lennon sang 'The Dream is Over' and Jimi Hendrix departed his and our 'Third Stone from The Sun'. The moon had been trodden on. We had seen our beautiful fragile Earth from space for the first time. Remarkably, some still believe to this day that the Earth is flat and the moon landing was a hoax.

Coal was still king and far from being a secure indigenous supply, overdependence on coal brought the UK to near economic and societal collapse as miners withdrew their labour, power supplies failed and the working week was reduced to three days. The government, which had recently joined Britain into the European Common Market that Sir Winston Churchill had inspired decades before, was brought down.

The Clean Air Act reduced the smoke from burning fossil fuels – the pollution that could be seen – but it did not deal with the unseen. Transparent gases such as sulphur dioxide belched increasingly into the sky, as our demand for electricity grew. The gas was blown across the North Sea, driven by our prevailing rain-laden south-westerly winds, combining with the cloud moisture to fall as 'acid rain'. Consequently, delicate and pristine Scandinavian lake ecosystems had their crystal clear waters acidified. Fish and the molluscs and insects on which they fed died. This same scenario was repeated with lakes in North America. Like the DDT issue, it was becoming ever clearer that pollution was a transboundary problem. We all share the same sky and ocean. Against protests that it would be too expensive and damage the economy, and that no commercially suitable technology existed to remove sulphur from power plant emissions, political will and diplomatic necessity ensured that regional and international standards on sulphur emissions were emplaced. Power plants were retrofitted with newly developing sulphur scrubbing technology and high sulphur coals were no longer fed into power plant boilers.

CO_2 bubbles rise from an ancient volcanic lake, Laacher See, Germany: volcanic emissions of CO_2 to the atmosphere are less than 1% of those arising from fossil fuel burning

The source of the problem was solved, lakes began to recover, and building stones on our valuable historic monuments, which had survived the Great Fire of London and centuries of wars, floods and tempest, stopped dissolving away.

During the 1970s, it became clear that new 'inert' and mainly transparent, odourless, virtually indestructible gases, not found in nature, but created and synthesised by humans from halogens and hydrocarbons (chlorofluorocarbons or CFCs), were building up in the atmosphere in ever-increasing amounts. Used in many products and applications to propel aerosol cans, extinguish fires and enable air conditioning and refrigeration, CFCs were now very much part of modern life and its 'creature comforts' and 'ideal body image'.

Curiosity-driven science in the laboratory showed that far from being inert, these gases were extremely powerful in preventing heat escaping out into space from Earth – indeed, many thousands of times more potent than naturally occurring greenhouse gases. There was also strong evidence that CFCs could damage the ozone layer, high up in the stratosphere, which shields us from the dangerous ultraviolet (UV) radiation embedded in sunshine – too much exposure to which can cause skin cancer, cataracts, and degradation of the retina. UV can also damage the ability for plants to photosynthesise, thus threatening the base of the food chain. Scientists developed atmospheric models that predicted how much ozone would be depleted. International negotiations began, aimed at limiting and phasing out the use of CFCs, except for specialised applications where no substitute propellant gas could be found. Some countries and vested interests took the position that the science was unproven, others claimed that no economic substitutes for CFCs were available, and that it would damage global economic growth to limit CFC use. Negotiations stalled, with resistant nations dragging their feet.

Meanwhile, at the southernmost tip of the planet, polar scientists of the British Antarctic Survey (BAS) had been taking daily measurements of UV radiation reaching the surface of Antarctica since the 1950s. By measuring the ratio between the two types of UV radiation reaching the ground – UVa and UVb – they could very accurately calculate the amount of ozone in the atmosphere directly above their 'simple' instrument, as ozone selectively absorbs UVb. Then, one Antarctic spring day, the instrument showed that ozone levels had decayed rapidly to such an extent that there was an ozone hole over the Antarctic. Nothing like this had been observed before. By this time satellite measurements were being taken. These aimed to phase out the primitive land-based BAS instruments in favour of much more sophisticated satellite-borne technology. News of the ozone hole from BAS was rejected, since the new satellites could not detect it. However, the ground-based instruments used basic physics to measure the ozone, and had a long and reliable track record. Satellites used newly programmed computer

The ongoing burning of fossil fuels risks major changes in terms of global climate, sea level rise and ocean acidity

software, based on informed assumptions about the atmosphere, to filter and distil the ozone-relevant data from billions of other data points.

Months passed, and the scientists at the BAS stood firm. Eventually, the space scientists discovered that the computer software used by the satellites was at fault – it was not sensitive enough. Updated software revealed the extent of the ozone hole, the BAS was vindicated, and the world was shocked. Scientists realised they had oversimplified their atmospheric models. Some atmospheric scientists had learned the hard way that the models used to screen satellite-based data had to be ground truthed by accurate and reliable measurements from sources where it is clear what is being measured, such as the UVa/UVb ratio. The models had predicted an average rate of ozone destruction at all latitudes; but the predictions were wrong, reality was much worse, and the hole came as a complete surprise. The role of noctilucent clouds in the upper atmosphere had been omitted from the ozone depletion atmospheric models, despite such clouds having been observed since Victorian times.

The Montreal Protocol restricting and phasing out CFCs globally was quickly put in place. Regarded by former UN Secretary General Kofi Anan as the most successful UN agreement ever, it was supported by the majority of the member states. Although it will take until almost the end of this century before we know if the world acted fast enough, CFC concentrations are gradually falling, and except for a few very specialised applications (e.g. medical), substitute gases have been found, without detrimental effects to the economy. Perhaps we acted just in time?

Today another colourless, odourless gas, carbon dioxide (CO_2) is entering the atmosphere at ever-increasing rates and building up in concentration, despite dissolving in the ocean. The world finds and burns more and more fossil fuel. This is risking, in human terms, a permanent and major change to global climate, sea level rise and ocean acidity. There seems to be little effective political will around the globe to take action with the urgency that the scientific evidence suggests is needed. If only CO_2 was as visible as the smoke that caused the smogs that I experienced as a child?

The properties of CO_2 as a greenhouse and ocean acidifying gas have been known for over a century, and proven many times over, both in the lab and in nature (even in military applications and research during World War II). Despite the overwhelming evidence, there are very effective and powerful lobby groups with short-term vested interests who deliberately distort and confuse the science, in the vain hope that their climate change denial will win the day and delay action. Then there are those who accept the science, but consider it uneconomic to deal with emissions now, or favour renewable and/or nuclear energy, thinking that we can phase out fossil fuels quickly enough. This latter thinking is clearly failing, and the former view is taking massive risks with our future, relying on a blind faith that we can all adapt to any consequences.

In my view, we either get rid of fossil fuels – and there is no sign of that happening any time soon – or we deal with them directly. So if you, or I, still want to burn fossil fuels we have to face up to applying the only technology that can deal with them directly: carbon capture and storage (CCS). This technology captures the CO_2 at the source where the fossil fuel is burnt, compresses it and then injects the gas deep underground in the same way natural gas is stored in many parts of Europe. CCS needs to be demonstrated at large scale in the context of power generation. Each part of the CCS chain has already been separately done, but it needs political will, an informed public and effective policies to ensure it happens at scale as an essential component of an integrated and diverse low-carbon emitting energy system. So far this has not happened, and it may be our last chance to act. To fail to act is a gamble with very high stakes, and the cards are definitely stacked against us.

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