Capturing Carbon: An Alternative Way of Dealing With Carbon Dioxide Emissions

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It is now widely accepted that carbon dioxide emissions, resulting from human activity, are having a small but measurable effect on the world's climate. Data from ice cores indicate that since the industrial revolution, carbon dioxide levels have reached their highest point in the past 2000 years *(1)*.

The biggest manmade source of carbon dioxide is the burning of fossil fuels. There has therefore been considerable attention with regard to alternative energy sources, such as nuclear, wind and solar which do not emit carbon dioxide, as well as biofuels which, at least theoretically, absorb as much carbon dioxide in production as they release in burning. However, there is also a completely different approach: burn fossil fuels, but don't let the carbon dioxide reach the atmosphere. Instead, hoard it away somewhere where it won't do any harm. But the arrestingly simple idea of Carbon Capture and Sequestration (CCS) has failed to find favour with environmental lobby groups.

The first question is how to capture the carbon dioxide from other flue gases such as nitrogen and water vapour, when fossil fuels are burnt. Current technology involves passing the waste gases through a weakly alkaline solution, which traps carbon dioxide, releasing it again on heating. However, energy is needed both to force the gases through the liquid and heat the solution afterwards, decreasing the power station's efficiency. Another technique is to burn the fuel in pure oxygen *(2)*, but this also requires energy to separate oxygen from the air. Research is being carried out into various alternative techniques, including gas separation membranes and the possibility of chemically processing the fuel so that the carbon dioxide is released before it is burnt.

Sequestration, although technologically simpler, is still not easy. Globally, we now emit more than 25,000 million tonnes of carbon dioxide every year *(3)*. Even to store a small fraction of this would take a massive amount of space, and if it were to leak out, the environmental justification of using energy to capture it would be lost. Geological storage—deep underground—is generally considered the most obvious way to solve these problems.

Geological formations are expected to be stable for a long time to come, so anything sealed in them should stay put. As carbon dioxide is gaseous and not particularly dangerous, it can be stored rather more easily than nuclear waste. Drilling equipment, similar to that used for oil extraction, would reach the necessary rock formations, and carbon dioxide would be 'injected' through pipes. A cavity need not be made to contain it, as it can be stored in porous rock. In fact, this technique is already used in places to extract oil, so the fossil fuel industry has experience of storing carbon dioxide underground. Additionally, natural stores of carbon dioxide have given us confidence that it is possible to store gases underground for long periods *(4)*.

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To evaluate the cost of these processes, we can compare them with emissions trading schemes, such as that of the EU *(6)*, designed to help participants reach their Kyoto targets. Under such schemes, businesses are allocated permits to emit a certain amount of carbon. A lower emission allows them to sell the excess part of their quota—to emit more, they must buy permits. As long as carbon capture is recognised as reducing emissions of carbon dioxide, its price can be compared with that of making the emissions.

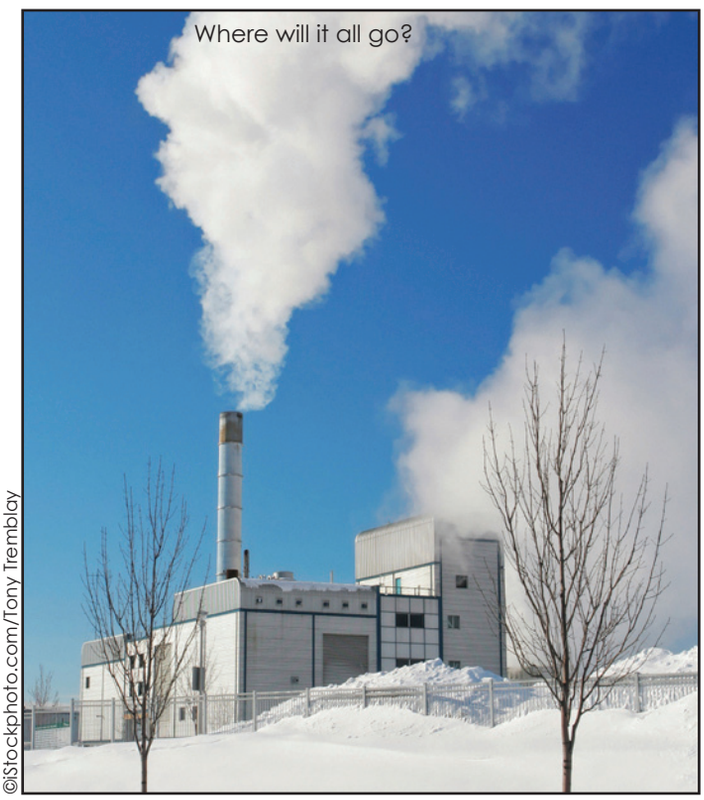
It is difficult at present to quote an exact price for carbon dioxide emissions, as the emissions market is relatively young and prices have varied between €1 and €18 per tonne of CO_2 *(7)*. Each member state has submitted a new allocation plan for 2008, however, so there is also considerable uncertainty about future prices.

By comparison, carbon capture and sequestration costs about €28 per tonne of CO_2 at November exchange prices *(8)*, suggesting that it cannot compete with emissions trading schemes until technology reduces costs or trading prices rise significantly.

One possible economic advantage to carbon capture is the possibility of retrofitting existing power plants. At present, 73% of electricity generation in the UK uses fossil fuels *(9)*. The capital costs of replacing this capacity (some 281 GWh per year) with nuclear or renewable energy would be huge, but existing power plants could have carbon capture simply added on. Estimates of the capital cost of this are between $640 and $2,000 per kW generating capacity *(5)* whereas estimated costs for new nuclear power stations range between $1050 and $5,250 per kW *(10)*. The disadvantage of this possibility, however, is that older power plants are less efficient, so the cost for capturing each tonne of carbon dioxide may be around 35% greater *(5)*.

Savings could potentially be made by using carbon dioxide in oil and gas extraction, as mentioned above. Enhanced Oil Recovery (EOR) is already carried out commercially, with carbon dioxide being purchased for the purpose. Estimates of the economics of EOR combined with carbon capture range from €62 saved versus just sequestering a tonne of CO_2, to an extra cost of €45 per tonne CO_2. Technologies for extracting gas using carbon dioxide are not yet used commercially, but savings may also be possible there *(5)*.

Carbon Capture and Sequestration could also advance due to those it benefits. The fossil fuel industry is still big business,


Where will it all go?

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and CCS allows it to be, or at least be seen as, environmentally friendly. While the oil and gas industries both have an interest in CCS, the coal industry is perhaps even more concerned as it releases the most carbon dioxide per unit of energy. It is unsurprising that the US, Australia and China, which between them account for 60% of world coal production *(11)*, are among the nations apparently most focused on CCS. Coal is also politically favoured because of 'security of supply'—unlike oil and gas, coal is largely available in the countries that need it, so supply is less at risk from international tension.

The environmental lobby, however, is not generally in favour of CCS. Greenpeace, for example, in an article on carbon capture and sequestration, admitted that it may be useful in the future but called for immediate action and "the massive and widespread deployment of available renewable energy and energy efficiency technologies combined with energy conservation." *(12)* CCS is also viewed as an attempt by the fossil fuel industry, the environmentalists' usual enemy, to look environmentally friendly. Suggesting that the carbon dioxide captured could then be used to extract more fossil fuels does not enhance this image. Complying with this view, some of the key players in carbon capture and sequestration, including the US and Australia, have not ratified the Kyoto protocol, instead forming the 'Asia Pacific Pact'. Environmental groups often see the pact as no more than a token gesture, without the binding emissions targets of the Kyoto Protocol *(13)*.

Despite the environmental lobby's suspicions, carbon capture and sequestration is a pragmatic solution that cannot be ignored. Although with present technology it is not quite economically viable, we can expect that new technology will make it so. Carbon capture can achieve significant reductions in emissions within our existing infrastructure, and, perhaps more importantly, fits with the interests of many powerful organisations and governments.

Offsetting

Another possible approach is biological sequestration, sometimes referred to as 'offsetting' emissions. The carbon cycle naturally moves carbon between gaseous carbon dioxide and organic compounds such as carbohydrates. A certain amount of the carbon in these organic compounds is preserved or fossilised, so that it is kept out of the atmosphere for thousands or millions of years. If the balance of the carbon cycle could be altered so that more carbon was locked away, some of the carbon released by burning fossil fuels could be 'cancelled out'. There have been experiments looking at fertilising the oceans for this purpose *(14)*, but it is not fully established whether this would work *(15)*, either practically or politically.

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