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Methods to Capture Carbon Dioxide from the Atmosphere Apart from Planting Trees : A Review

Tadappa Ganesh Kumar

Faculty & Head, Department of Chemistry, CSSR & SRRM Degree & PG College, Kamalapuram,YSR Kadapa District, Andhra Pradesh, India

ABSTRACT

The goal of carbon sequestration is to take CO2 that would otherwise accumulate in the atmosphere and put it in protected and permanent storage. Most proposed methods would capture CO2 from concentrated sources like power plants. In fact, on-site capture is the most sensible approach for large sources and initially offers the most cost-effective avenue to sequestration. For distributed, mobile sources like cars, on-board capture at affordable cost would not be feasible. Yet, in order to stabilize atmospheric levels of CO2, these emissions, too, will need to be curtailed. This review paper suggests that extraction of CO2 from air could provide viable and cost-effective alternative methods like fake plastic trees, Scrubber devices and Basalt rock cliffs to change the transportation infrastructure to non-carbonaceous fuels.

Keywords : Carbon Sequestration, Non-Carbonaceous Fuels, Fake Plastic Trees, Scrubber Devices, Basalt Rock Cliffs.

I. INTRODUCTION

Carbon dioxide (chemical formula CO2) is a colorless gas with a density about 60% higher than that of dry air. Carbon dioxide consists of a carbon atom covalently double bonded to two oxygen atoms. It occurs naturally in Earth's atmosphere as a trace gas. The current concentration is about 0.04% (410 ppm) by volume, having risen from pre-industrial levels of 280 ppm. Natural sources include volcanoes, hot springs and geysers, and it is freed from carbonate rocks by dissolution in water and acids. Because carbon dioxide is soluble in water, it occurs naturally in groundwater, rivers and lakes, ice caps, glaciers and seawater. It is present in deposits of petroleum and natural gas. Carbon dioxide is odorless at normally encountered concentrations, however, at high concentrations, it has a sharp and acidic odor.

NEED TO CAPTURE CO_2:

This increase in CO_2 level is a problem because CO_2 in the atmosphere acts as a warming blanket for the earth, allowing the sun's heat to be trapped rather than reflected back out into space. Reducing the amount of CO_2 being produced by human beings is important if we are going to stop significant increases in global temperatures and climate change. According to the International Energy Agency (2012), the largest contributing sector to global CO_2 emissions is the generation of electricity and heat. This made up 41% of world CO_2 emissions in 2010, and demand for heat and electricity is set to dramatically increase over the coming years.

II. METHODS WITH WHICH WE CAN CAPTURE CO2

1. FAKE PLASTIC TREES

It is an artificial tree that passively soaks up carbon dioxide from the air using “leaves” that are 1,000 times more efficient than true leaves that use photosynthesis. This technique was first designed by Klaus Lackner, director of the Lenfest Center for Sustainable Energy at Columbia University. There is no need to expose the leaves to sunlight for photosynthesis like a real tree does. So our leaves can be much more closely spaced and overlapped – even configured in a honeycomb formation to make them more efficient. A model of plastic tree is shown in Figure.1

Figure-1: Plastic tree model

Source:https://www.pri.org/stories/2015-08-30/artificial-tree-part-solution-climate-change-these-guys-think-so

The fake trees are in test phase right now in Arizona. After several trials, they have a version that requires very little energy to operate. Basically, they use "tree trunks" that are multiple filters coated in a plastic resin. The leaves look like sheets of papery plastic and are coated in a resin that contains sodium carbonate, which pulls carbon dioxide out of the air and stores it as a bicarbonate (baking soda) on the leaf. To remove the carbon dioxide, the leaves are rinsed in water vapour and can dry naturally in the wind, soaking up more carbon dioxide. It is calculated that this tree can remove one ton of carbon dioxide a day. Ten million of these trees could remove 3.6 billion tons of carbon dioxide a year – equivalent to about 10% of our global annual carbon dioxide emissions. One of these "trees" is 55 feet by 65 feet, and captures 90,000 tons of CO2 each year, equal to 15,000 cars. The technical name for the idea is direct air capture. And it is a tall order — to improve on trees, which have been honed by millions of years of evolution. In fact, the technology will never be efficient or cheap enough.

2. SCRUBBER DEVICES

A carbon dioxide scrubber is a device which absorbs carbon dioxide (CO2). It is used to treat exhaust gases from industrial plants or from exhaled air in life support systems such as rebreathers or in spacecraft, submersible craft or airtight chambers. Carbon dioxide scrubbers are also used in controlled atmosphere (CA) storage. They have also been researched for carbon capture. Scrubber devices have been fitted to the chimneys in different pilot projects around the world so that the greenhouse gas produced during fossil fuel burning can be removed from the exhaust emissions. The carbon dioxide can then be cooled and pumped for storage in deep underground rock chambers, for example, replacing the fluid in saline aquifers. Another storage option is to use the collected gas to replace crude oil deposits, helping drilling companies to pump out oil from hard to reach places, in a process known as advanced oil recovery. Removing this pollution from power plants – called carbon capture and storage – is a useful way of preventing additional carbon dioxide from entering the atmosphere as we continue to burn fossil fuels. It is possible to scrub CO2 from the air anywhere; the technology has been around for decades and used on Submarines and Spacecraft, to name but a couple of examples. So the potential is there to research and build on this technology, scaling it up so it can be positioned to effectively scrub the air in any location.

WORKING

Despite several different designs currently being in development, they all are based on a common chemical reaction. Air is sucked into the machinery where it is bought into contact with a sorbent material which chemically binds with the Carbon Dioxide. A sorbent material is one that simply absorbs a gas or liquid (e.g. sponge is sorbent as it absorbs many times its own weight in water). The greater the surface area of the sorbent, the more efficiently it will absorb the gas or liquid, therefore different mechanisms have been suggested to maximise exposure of the sorbent to the carbon dioxide, thereby maximising it's scrubbing ability.

The Palo Alto Research Centre has proposed to draw the CO2 through a fine mist of liquid sorbent. Housing this technology in towers that are several metres high, the mist would react with the gas and be collected in a chamber where they would once again be separated. The pure CO_2 could be compressed into liquid form and removed, while the sorbent would be recycled and used again to collect more of the gas.
Klaus Lackner, has created another proposal to maximise the surface area of the sorbent, and this to apply solid sorbent to thin sheets and allow the Carbon dioxide to react with it. Once the initial reaction has taken place, liquid chemicals are washed over the sheets that create a stronger bond with the CO_2 than the sorbent. The liquid can then be collected (as it now is bound to the CO_2), and this can be heated which will allow the CO_2 to be stripped from the liquid, and so once again the pure CO_2 could be compressed into liquid form and removed, while the liquid can be recycled and used again to wash future CO_2 from the sheets.

ISSUES FACING THE TECHNOLOGY

The air-capture machines are electrically powered, and most electricity produced (via non-recyclable methods) has carbon dioxide emissions associated with it. So an important question is whether the carbon dioxide stripped from the air is in excess of the carbon dioxide 'produced' to drive the machine. In fact, Klaus Lackner's prototype uses 100kwh of electricity to remove 1 tonne of CO_2 from the air, and this power required equates to 35kg of CO_2 being produced as emissions, so the ratio of gas removed far outweighs the amount produced. In fact, if the energy used to drive it is derived from renewable energy forms then the figures become even more attractive.
Another issue facing the technology is that the sorbent material cannot be recycled forever, and has a finite lifecycle, after which it has to be replaced so this makes sorbent supply high (and expensive), in addition there will be maintenance costs associated with swapping the sorbent material over. The cost currently associated with removing 1 tonne of CO_2 from the atmosphere is about £150 per tonne when using these carbon scrubber methods, while the cost of trading a tonne of carbon is about £6-£13. Only when the cost of removing a tonne is lower than the trading cost will this become truly commercially viable. Dr Lackner has suggested that he feels that with technical improvements and economies of scale achievable if the products become commercially successful, then the cost will come down to approximately £30 per tonne. In addition trading carbon prices will rise in the future, as countries looking to fulfil their green promises endeavour to make the cost of emitting CO_2 unattractive.

3. BASALT ROCK CLIFFS:

Another option could be the basalt rock cliffs, which contain holes – solidified gas bubbles from the basalt's formation from volcanic lava flows millions of years ago. Pumping carbon dioxide into these ancient bubbles causes it to react to form stable limestone – calcium carbonate. These carbon dioxide absorption processes occur naturally, but on geological timescales. To speed up the reaction, scientists are experimenting with dissolving the gas in water first and then injecting it into the rocks under high pressures.

III. CONCLUSION

Passing the 400 mark reminds me that we are on an inexorable march to 450 ppm and much higher levels. This milestone is a wakeup call that our actions in response to climate change need to match the persistent rise in CO2. Climate change is a threat to life on Earth and we can no longer afford to be spectators. These were the targets for 'stabilization' suggested not too long ago. The world is quickening the rate of accumulation of CO2, and has shown no signs of slowing this down. It should be a psychological tripwire for everyone.

Ultimately, we have to decide whether the cost of the technology is socially worth the price, and that social price is likely to fall as climate change brings its own mounting costs. Economically too, if the price of carbon rises, then this could lead to two effects. Investing in air capture will likely be seen as an equivalent to "avoided emissions". And then it will become a worthy investment.

Finally, removing CO2 out of the atmosphere is difficult. Therefore when we produce the compressed gas as a result of the carbon scrubbing technologies, it is important that we have a use for it. CO_2 is a useful gas in its own right – it can be used to pump into commercial greenhouses to increase plant growth, it can be used to inject into natural gas reserve beds to drive more of the gas out; It can even be transformed into fuel for transport. So we should erect the carbon scrubbers where the CO_2 produced can be then used to perform a useful function. In the future, if the technology takes hold and is profitable (the stored gas can be sold for more than it costs to remove it), then we could see the widespread launch of carbon scrubber ‘orchids’, simply acting to remove the gas from the atmosphere, but until that time it is important that we spend time considering the best places and set ups for these technologies.

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