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Emerging and promising applications which lead to reducing CO2 emissions

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Despite announcements whereby the EPA will no longer consider CO2 a hazardous gas; the end result from this is devastating to the environment, our economy, and our lives. On the other hand, whether or not this occurs, there remains a greater push to use more innovative solutions to use the product in industry, tomorrow's plastics – thus replacing hydrocarbons, and the environmental harm which is evermore leading to the worst of climate change. Many efforts are underway to help reduce carbon emissions, and help our planet.

The CO2 industry expands organically, say 3% annually in some markets. The best way to grow more rapidly in the industry, is via the development and implementation of new and unique applications in a wide variety of markets. CO2 applications, of a traditional nature, are tried and true, such as many uses in food processing, beverage carbonation, and a range of industrial uses. On the other hand, new and

green applications help sustain the industry.

As for new or newer applications for the product, most of these are of an industrial nature, generally outside of the food and beverage demands. Food and beverage applications often account for 70% of all tonnage consumed in the merchant sector. There are also demands of a captive and sequestration nature, which in my view, are generally categorized outside of the merchant markets, such as large EOR (enhanced oil recovery) usage. There are many conceptual ideas for the application of CO2 in industry, many of which have a green take, a form of sequestering CO2 molecules in everyday products. There are other applications, which are relatively new to the industry, which are being applied and expanded in the markets, such as concrete dosing.

On a long term basis, given the global interest in reducing carbon emissions, concerns for climate change, and a warming globe, more applications are being developed all the time, many of which have been initially developed in academia, and have not been scaled up, or commercialized. Some of the technologies outlined in this article, may plan to use subsidies in order to make them economically viable, at least for the short term. Of so many technologies which claim to produce a fuel, chemical, plastic; or recover flue gas cheaply, the longer term viable commercial results will speak for themselves. Of the technologies being announced all the time, some will eventually be commercialized, and make their place in the CO2 and sequestration industries; while others will not.

THE APPLICATIONS

There have been a number of emerging technologies which are proposing the use of CO2 in the production of various plastic and building materials; some of which could replace hydrocarbons in plastics, which is a truly green usage. Further on this subject, the ultimate goal of successfully using CO2 from flue gas to produce useful products, along with sequestration would represent a double achievement. Some of the concepts below, could eventually yield true break throughs, when scaled up. The problem with flue gas over the years, has been the very high cost of recovery and production into a viable CO2 product which would meet required standards and specifications. Of course, the industry is often concerned with producing a CO2 product which will meet the standards for use in soft drinks and food processing. Such applications which represent a high percentage the CO2 merchant market in the US, are not those which sequester carbon dioxide, but use the BTU value, and perform via their physical properties to achieve results, and such CO2 is eventually

returned to the atmosphere. Some new or conceptual applications are as follows.

Carbon nanotubes, via molten electrolysis, the process requires electric power for converting CO_2 into carbon fibers, or nanotubes. Such nanofibers could be used in carbon composites. Such composite materials are light weight, alternatives to metal, to make a variety of products such as bicycles, one of which I have which is very light and rigid. Other products could be airplanes, and turbine wind blades. Such sources for the raw CO_2 for this process, could ideally be flue gas from a power plant, or other such stream, like a cement kiln. The startup is staffed by university researchers, now under the name C2CNT.

Concrete dosing with CO_2 is an outstanding way to create a form of sequestration, as well as strengthen the concrete via increasing the calcium carbonate content in the concrete. This is a relatively new application, now being used throughout the country, to a degree.

Bioplastics – nanoparticles for plastics and building materials such as coatings and concrete is a possible sink for CO_2. In some cases, bioplastics have been developed among those in universities, where some technologies have moved to the field, and are looking to commercialize. One startup combines CO_2 with by-product waste materials such as the products of coal and coke combustion, using fly ash, for example.

Another technology with a startup is bioplastics again, using flue gas as a CO_2 feedstock; while microbes along with hydrogen and oxygen yield a biopolymer, which is a plastic material which can be used in the manufacture of many consumer goods and building materials. This licensed technology is a California based company under the name Newlight Technologies.

Methanol is the product of a team looking to develop an artificial photosynthesis process to convert CO_2 into methanol. Of course methanol is a common solvent or industrial chemical, used as a fuel, and in a variety of personal and industrial products. Here is another example of a sequestered or converted CO_2 into a useful common solvent. A

team in India under the name Breathe is working on this process.

Chemicals and bio composite foam plastics. This is another take on recovered CO2 for the production of ethylene glycol, methanol, and foam based plastics. In this case, natural materials such as sawdust, wood, and rice hulls are the backbone for such products. The entity looking to produce such products is C4X, a Chinese company.

Enhanced geothermal systems (EGS), using CO2 as a working fluid. Supercritical CO2 could be utilized in these systems as a circulating heat exchange fluid. In this case, using the density difference between cold CO2 flowing down the injection wells, and the hot CO2 traveling up these wells would eliminate a need for a circulating pump. Further, CO2 could be used as a working fluid in supercritical power cycles. This application works well with compact turbo machinery.

Polymer production, where CO2 could be used as a feedstock via transformation of CO2 into polycarbonates, using proprietary zinc catalysts.

Transformation of CO2 from power plant flue gas could be chemically transformed into industrial fuels and chemicals. Such a process which is under development, would use renewable electricity to reduce CO2 to CO. the carbon monoxide is a key product used in various industrial processes. The CO2 would be fed into catalytic reactors which chemically transform CO2 into fuels and chemicals which emit only oxygen. Some technologies like this, are being developed by university researchers.

SUMMARY

The above technologies are a few of those which have been discussed, developed and even implemented to a degree. The ultimate challenge is to move applications from the lab to a successful pilot project in the field, and scale up in order to make it economically feasible. As with all other developments, industries, and processes, such applications need to be competitive, as stand alone, scaled up technologies; or they would need to have ongoing subsidies in order to commercialize. I often think of most current day, proven technologies which have been used successfully, albeit expensively, to recover CO2 from flue gas. The agent of choice over the

years has been MEA (monoethanolamine), or a similar amine solvent. In the front end of most commercialized plants, such as those which once operated by companies in the US like The AES Corporation. AES operated flue gas recovery operations from coal fired cogeneration facilities for decades in America, which were developed under now defunct energy laws which used the co-generated steam as a thermal host in the MEA process. This subsidy essentially included the capital cost of the expensive CO2 recovery plant in the cost of the power plant, thus considering the cost of CO2 production to only be that of utilities, labor, and maintenance. With today's 45Q/IRA tax credits, a significant number of companies are looking to recover CO2 more cheaply, and/or apply the CO2 in useful products. This is a form of subsidy which would provide a performance – based tax credit to power plants and industrial facilities which capture and store CO2, which would have otherwise been emitted to the atmosphere. The credit is linked to the installation and use of CO2 recovery equipment on industrial sources, such as gas or coal power plants, or facilities which would directly remove CO2 from the atmosphere. The recovered CO2 would then be applied in products such as construction materials, biofuels, EOR, and sequestration via class VI wells, for example. The value of the credit depends upon the type of CO2 storage which results from the process. Eligibility for industrial facilities begins with 100,000 metric tons per year, including ethanol and fertilizer production. The value of the credits range from $85 to $180/metric ton, depending upon destination, permanent storage or utilization; and the term of such credits would be 12 years, where projects must begin by 2032. Of course, there is much more than EOR, as related to technologies and products which these developers hope to commercialize, such as fuels, plastics, and chemicals for industry, and algae for example.

There are many takes on technology, and desired products which could be produced should the technologies actually be scaled up successfully. Often, despite the initial cost estimates to achieve such ends fall short, possible subsidies, such as 45Q/IRA could be a means of making such advances work, at least for a period of time, until additional advances occur or improvements in such technologies take place. Long term, I believe some of these technologies will be scaled up successfully, and affordably, often with subsidies, so opportunities in these developments will eventually occur without subsidies. The earth is our home, and there is no replacement; therefore a reduction in carbon emissions is key for the earth to prosper. For the gas companies, all applications are important, as well as methods for sequestering CO2 into useful products for everyday life.

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