Carbon Recycling: An Alternative to Carbon Capture and Storage

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ABSTRACT

Carbon capture and storage (CCS) is a classical "end of the pipe" techno-fix for the problem of carbon dioxide pollution of Earth's atmosphere. In contrast, carbon recycling has the potential to be a partial alternative to CCS that could shift the whole paradigm of the generation and use of energy. Many innovative carbon recycling methods are currently being pursued, including biochemical, electrochemical, photochemical, and thermochemical processes aimed at converting CO_2 to a variety of commercially valuable products. All such processes require a net input of energy to drive endothermic reactions, but some are slow and others require extreme operating conditions. Electrochemical methods may have an advantage here, because they operate at moderately high rates under mild conditions, with electricity from any source, thus opening the door to carbon-neutral recycling systems based on non-fossil energy.

Carbon capture and storage (CCS) is being hailed as the answer to the globe's most pressing question: what to do with the 27 billion metric tons of carbon dioxide emitted yearly from the burning of fossil fuels? Touted as the most promising interim solution to deal with the greenhouse gas responsible for global warming, CCS still remains unproven and costly, and it is commercially unavailable for another 10-20 years. Meanwhile, scientists are exploring alternatives to CCS by capitalizing on CO_2 as a commodity instead of treating it as a waste.

While 27 billion tons of CO_2 is already a hefty number, energy-related carbon dioxide emissions are projected to reach 43 billion metric tons per year by 2030, an increase of 60 percent. A new report by

the International Energy Agency (IEA) estimates that growing energy demands from emerging giants like China and India, coupled with a lack of cost effective alternatives to fossil fuels, mean that by 2050, 77 percent of the world's power will still be derived from fossil fuels. "*We will require immediate policy action and a technological transition on an unprecedented scale,"* IEA Executive Director Nobuo Tanaka said in Tokyo after releasing the report.

Carbon capture and storage (CCS), the process of capturing carbon dioxide and storing it in deep geological formations, in the ocean, or as mineral carbonates is being promoted by the IEA and others as the most promising technology to deal with fossil-fuel derived emissions. Not negating the role of alternative energies, the IEA is merely realistic about the enduring use of fossil fuels and the urgent need to deal with the resulting carbon dioxide.

On May 15th, 2009, U.S. Secretary of Energy Steven Chu announced at the National Coal Council that $2.4 billion from the American Recovery and Reinvestment Act will be used to expand and accelerate the commercial deployment of carbon capture and storage (CCS) technology, including financing to train a generation of engineers and geologists to work in the field. Chu said, "*To prevent the worst effects of climate change, we must accelerate our efforts to capture and store carbon in a safe and cost effective way*."

Governments in Europe, Australia, Canada, and China are also strongly investing in the technology. Nevertheless, several massive hurdles still stand in the way of full-scale CCS deployment. UK consulting firm McKinsey & Company figures that adding CCS to the next generation of European power plants could lift their price by up to $1.3 US billion each. Their thorough analysis (www.mckinsey.com) shows that the typical cost of a demonstration project is likely to be in the range of $80-$120 US per tonne of CO_2 sequestered.

Legally, there are concerns over whether CO_2 transport and long-term storage present human- or ecosystem-related risks and who is ultimately responsible if a leak occurs. While progress is underway in some countries, no country has yet developed the comprehensive, detailed legal and regulatory framework that is necessary to effectively govern the use of CCS. In fact, no full-scale CCS project that captures and sequesters carbon dioxide from a coal-fired power plant as of yet exists. The IEA is hopeful that 10 full-scale demonstration plants will be up and running globally by 2015, meaning it may be 10 to 20 years

before CCS technology is readily available.

So why expensively transport and store the CO_2 underground when it could be profitably recycled post-capture? Researchers and start-up companies are now investigating a wide range of CO_2 conversion methods.

"The market is open for innovation," states Larry Kristof, CEO of Mantra Energy (www.mantraenergy.com), a company gaining international recognition in the field of carbon recycling. *"It is likely that governments will soon legally mandate carbon capture from industrial plants, and there needs to be a cost effective way to implement it,"* says Kristof. Mantra's technology, named the electro-reduction of carbon dioxide (ERC), aims to take CO_2 directly from industrial waste gases and convert it to formate salts and/or formic acid, both valuable chemicals used in a variety of industrial applications. Formic acid also has the potential to play a leading role in fuel cell development, both as a direct fuel and as a fuel storage material for on-demand release of hydrogen.

The ERC technology could provide a net revenue of up to US $700 per tonne of CO_2 recycled, with an ROI previously forecast at 20 percent per year, depending on local costs. Ensuring a carbon-neutral process, the energy input must come from alternatives. Compared with CCS, the ERC provides a positive return on investment, not an unrecoverable cost. Plus, a demonstration ERC unit could be installed at a client's premises within a year and at a commercial plant within two years, much faster than for CCS.

In a speech to the United States Senate, Margie Tatro, Director of Fuel and Water Systems at Sandia National Laboratories (a US Department of Energy run research center formed to develop science-based technologies that support national security), advocated that carbon recycling is the way of the future. "*We must act now to stimulate this area of research and development. Other countries are exploring reuse and recycling of CO_2, and it would be unfortunate if the U.S. became dependent on imported technology in this critical area*," said Tatro.

Carbon recycling options being developed globally vary considerably. Apart from electrochemical processes, the range includes the biochemical conversion of CO_2 into algal biofuel, the thermochemical conversion into methanol, and the biocatalytic or solar photocatalytic conversion of CO_2 to fuels. Each has its own set of advantages and disadvantages, and some are more believable than others.

At this stage, what sets Mantra and a handful of others apart is

that it has a publicly disclosed patent application, backed up by several technical articles in reputable journals. Thus, it has already established market interest for its products.

As fear of climate change grips the globe, businesses and governments are desperate to find an answer to our CO_2 problem. Relying solely on CCS is an incredibly risky and, in many places, unworkably expensive solution. More imaginative thinking shows us that the 27 billion metric tons of CO_2 per year may actually represent a business opportunity. A budding industry, carbon recycling for profit offers an exciting and viable alternative to carbon capture and storage programs. Without a doubt, as a portfolio of solutions will have to be developed to address climate change, carbon recycling is destined to be at the forefront.

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