Jupiter Oxygen Corporation

High Flame Temperature Oxy-Fuel Combustion Carbon Capture

Transitional Technology for a Zero Emission Future

Introduction

There is a consensus among climate scientists, economists and policy makers that the link between anthropogenic emissions of greenhouse gases (GHG) and climate change stems from increased industrial activities that modern society depends on. Energy use and energy generation are at the heart of the problem. Estimates from numerous sources are that energy consumption will continue to grow over the next three decades. [1]

The UN (and many other sources) estimates that global population will grow more than 20% in the 21st century, mainly in Asia and Africa. These growing populations will increase global demand for food, water and energy – especially electricity – with concurrent growth in coal consumption in those regions. [2] Fossil fuels will remain a significant part of the energy mix up to 2050 comprising roughly 30% - 80% of global electricity generation.[3]

One of the solutions available to reduce GHG emissions from fossil fuel energy generation is the suite of technologies of carbon capture. This climate mitigation technology solution is successfully gaining ground. One carbon capture technology company, Jupiter Oxygen Corporation, has demonstrated stunning results: the effective removal of virtually all of the pollutants from the emissions of fossil-fueled industrial plants.

Carbon Capture – An Overview

Carbon capture provides the main abatement lever for stationary fossil fuel sources. Renewables such as wind and solar are other opportunities to reduce carbon dioxide (CO_2) emissions. But it is unlikely that these alone will enable the U.S., the EU or other national entities to reach significant abatement targets by 2050. By most accounts, additional measures will be required – such as carbon capture. Carbon capture has a pivotal role as a transitional technology towards a low or zero emission future. It is best viewed as a vital element of the mitigation portfolio.

Carbon capture is the *only* technology capable of <u>directly</u> dealing with emissions from fossil fueled processes. This technology is currently deployed across industrial sectors including power.

[1] International Energy Agency, U.S. Energy Information Administration, PEW Research, Massachusetts Institute of Technology, World Resources Institute, European Commission, McKinsey Consulting, University of British Columbia, Columbia University
[2] United Nations, International Energy Agency, U.S. Energy Information Administration, PEW Research, Massachusetts Institute of Technology, World Resources Institute, European Commission, McKinsey Consulting, University of British Columbia, Columbia University
[3] China and India use a greater percent. Sweden, Switzerland and Norway use a lower percent with their abundant hydroelectric resources.

Utilization

The use of fossil fuel to produce electrical power has traditionally been viewed as being at odds with environmental requirements. There is *no* fundamental reason why electric power generation must cause pollution.

Carbon Capture Utilization and Storage (CCUS) has a valuable role in unlocking profitability of carbon capture. The basic idea of collecting CO_2 and confiding it underground is an expensive proposition. Put to industrial use, the resulting revenues make carbon capture not only environmentally attractive but profitable. Enhanced Oil Recovery (EOR) is a way to amortize the expense of the carbon capture technology making an economically valuable contribution downstream.

The goal of injecting CO_2 into an EOR project is to mobilize oil molecules still in a reservoir after initial and secondary production techniques have removed a percentage of the oil in place. These oil molecules are held in place primarily by tension between the oil and surface of the pores in the rock. (Sometimes water is injected as a secondary production technique. But oil and water don't mix.) The oil and water remain in separate phases. In contract, oil and CO_2 do mix. CO_2 is injected to mobilize the remaining oil. The net result is oil with a reduced viscosity as well as a reduced interfacial tension with the surface of the rock pores. Oil in its newer state moves toward the wellbore of a producing well.

Producing more oil in the U.S. through EOR also further displaces heavier, more carbon -intensive imported crudes from the domestic marketplace and lowers our trade deficit by reducing expenditures in oil imports. Installing carbon capture facilities, building CO_2 pipelines and reworking mature oil fields to revitalize their production through CO_2-EOR brings jobs and investment to key energy and industrial sectors of the U.S. economy.

CO_2-EOR is not a new technology. Currently, it represents approximately four (4) percent of domestic oil production and industry has decades of commercial carbon capture experience across myriad industrial sectors.[4]

Several technical studies of EOR operations have determined that essentially all the CO_2 injected or reinjected remains in the reservoir after the EOR project has ended.[5] Modeling performed for one EOR site projected that 99% of the injected and reinjected CO_2 would remain in the reservoir for 5,000 years[6] addressing concerns from some environmental groups about CO_2 leakage from sequestration.

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[4] Precourt Institute for Energy, Stanford University
[5] US National Energy Technology Laboratory (NETL)
[6] Deel, Mahajan, Mahoney, McIlvried, Srivastava

Oxygen Combustion

Oxy-Fuel Combustion is a technology that has been used in manufacturing since the early 1990's. Near pure oxygen is used in the combustion process instead of ambient air resulting in higher efficiency furnaces. The resulting flue gas contains primarily CO_2 and water vapor with smaller amounts of Oxygen, Nitrogen, SO_2 and NO_x. Consequently, the flue gas can be processed relatively easily, separating and "capturing" the CO_2.

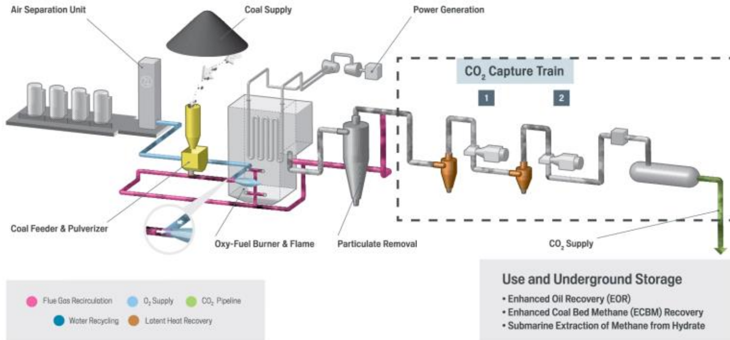
High Flame Temperature Oxy-Fuel Combustion Carbon Capture

Jupiter Oxygen Corporation's patented technology results in **near zero CO_2 emissions** with an additional benefit of reducing the amount of fuel required to run the plant. Designed into new plants or used to retrofit existing plants, our research indicates Jupiter's technology provides a highly competitive cost of CO_2 capture/tonne at <$30/tonne.

Jupiter's oxy-fuel combustion process employs a relatively simple concept in which substantially pure oxygen for the combustion process (in the absence of air) is used to oxidize the fuel. There are several important advantages of using an oxygen gas mixture other than air:

- 95% to 97.5% pure oxygen, no airborne nitrogen
- Lack of nitrogen in the gas mixture reduces NOx
- Increased O_2 content reduces the mass of combustion products
- Recirculation of flue gas offers the potential to recover substantial amounts of heat otherwise lost up the stack
- O_2 content can be adjusted to change flame temperature and control radiant heat transfer

Jupiter Oxygen's technology is capable of economically generating power from coal with ultra-low emissions and increased boiler efficiency using pure oxygen as the combustion agent, excluding air and thus nitrogen, concentrating CO_2 and pollutants for efficient capture with near zero production of nitrous oxides, reducing exhaust mass flow, and increasing radiant heat transfer. V**irtually emission-free power production is the ultimate result.**



Key Barriers and Uncertainties

There are no barriers that are exclusively technical. Cost is the most significant barrier in the short to medium term. Long term, CCUS-EOR is currently one of the most cost effective when compared to other mitigation technologies.

Funding. Scaling up investment to the right projects, sectors and regions is arguably the key challenge. Investment estimates run as high as US$16.5 trillion in energy efficiency over the next 15 years. Public funding alone is not enough. The private sector controls the vast majority of the world's assets. The private sector will invest when risk and returns align.

Infrastructure. The power sector is the largest emitter of CO_2. If, as projected by the International Energy Agency, electricity demand more than doubles by 2060, the resulting CO_2 emissions could reach 15 billion tons per year from power generation alone.

Energy is a highly capitalized commodity business, with complex supply chains and established customer bases, providing essential services at all levels of society. These features lead to systems with considerable inertia focusing on reliability and safety, aversion to risk, extensive regulation and complex politics. The requisite changes to address increased emissions and the existing infrastructure of the industry include a shift in energy demand management through digital technologies covered by smart grids; an expansion and upgrade of electricity grid; regional expansion of power networks and an accelerated deployment of carbon capture utilization and storage.

Public Perception. Public understanding of these technologies is low and there is confusion around its true economics, exacerbated by the wide range of cost numbers quoted and the limited information on how they are derived. Until recently, the publicly available information on carbon capture technologies are dense and complex technical papers making wide public consumption almost impossible. Mainstream media outlets (and often scientific media outlets) offer wide-sweeping conclusions about carbon capture absent of differentiation between the technologies. While there is tremendous value in the growing national conversation about the place of fossil fuels in the energy mix, the “War on Coal” provides politicians and surrogates over-simplified phrases (and memes), ignoring the very real place that fossil fuels will retain in the energy mix – out of sheer necessity.

Conclusion & Key Takeaways

Most climate assessment models project that the concentration of atmospheric carbon dioxide would have to stop increasing (and start decreasing) by the second half of the 21st Century for there to be a reasonable chance of limiting warming and the associated dangerous climate impacts. The challenge today is to stop increasing CO2 emissions in the face of growing population and growing energy use. A full array of carbon capture technologies including Jupiter Oxygen’s technology - with its proven Near Zero Emissions – are crucial and cost-efficient elements in a systemic mitigation solution. Applying this technology is particularly critical as India, China and sub-Saharan Africa continue to build new coal-fired power plants.

Employing CCUS will be essential to meeting the national development priorities of developing countries with projected global energy use in 2040 is 75% according to the International Energy Agency.

With the initiation of a Front-End Engineering & Design Study (FEED) study in Qu. 1, 2020, Jupiter Oxygen is poised for rapid commercial introduction and widespread deployment of its energy-efficient and capital-effective technology for carbon capture.

Jupiter Oxygen’s innovation on a large scale in the U.S. will require alignment of key players, policies and programs among federal, state and local governments and the private sector. Adopters of new climate mitigation technologies, such as utilities, should consider the advantages of Jupiter Oxygen’s innovative technology at the early stage of the Demonstration Project to be positioned to profit from the commercialization. Jupiter Oxygen anticipates its carbon capture technology will be the fastest to Commercialization of any other carbon capture technology.