Carbon capture technologies: opportunities and future report samples

Countries, United States

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Carbon Capture Technologies

Introduction

Aside from oil, coal is regarded as one of the most important fossil fuel resources being utilized in the global energy mix. However, the use of coal in power generation has resulted in serious air pollution around the world. The use of coal has resulted in the release of almost 14 billion tons of carbon dioxide into the atmosphere, with a majority of these pollutants emanating from power generation activities.

Carbon dioxide sequestration technologies seek to address the release of carbon dioxide into the atmosphere that add to the growing problem of air pollution in the world. Sequestration technologies refer to the removal of liquefied CO_2 when the gas is captured and disposing of the same deep underground. Nevertheless, operators who choose to use one of these technologies must be ready to acknowledge that these will impose significant operating expenditures without any return on the investment; however, the operator may realize a degree of return via the calculation of external costing of carbon taxes (World Nuclear Association, 2014, p. 1).

" Carbon capture and storage" encompass a wide range of technologies that are being researched to permit Co2 releases resulting from the use of fossil fuel such as coal and oil at large source points to be transported to secure underground storage points as opposed to releasing the gas into the atmosphere. However, as earlier mentioned, the use of these CCS technologies will require that the operators will have to use additional energy sources as compared to projects that do not integrate CCS into its operations. There are opportunities, however, that with the advancements in the technology, there can be opportunities to lower the impacts of the operation of the technology and its integration into the financial outlook of the company (Gibbins, Chalmers, 2008, p. 1).

The technology of carbon capture as well as sequestration is significant in that aside from reducing the amount of polluting carbon dioxide being released into the atmosphere, the technology will allow power plants to generate optimum amounts of output and reduce their carbon emission rates at the same time.

These CCS technologies are presently available and being implemented in the United States, and with 40 percent of the carbon dioxide emissions emanating from the power generation sector, the adoption of CCS technologies can reduce by 80-90 percent the amount of carbon dioxide emissions from power plants that use fossil fuels as their fuel stock.

If applied to a 500 MW coal-fueled power plant that roughly emits 3 million tons of carbon dioxide annually, the reduced amount of greenhouse gas emissions that were prevented from being released, integrating the variable of a 90 percent efficiency rating for the technology, would be the same as planting at least 60 million trees, and even having the time (10 years) for them to contribute in cleaning the air, and preventing the release of electricity related pollution emission releases from approximately 300, 000 houses.

Aside from coal-fired plants, natural gas fired plants and industry categories such as ethanol and natural gas processing facilities also stand to benefit from the use of CCS technologies. In the Greenhouse Gas Reporting Program, at least 120 facilities in the United States, mainly involved in manufacturing and production activities, operate carbon capture and sequestration and the captured carbon dioxide is then used in a number of end user applications. Among the end user applications that captured Co2 gases are utilized include improved oil extraction, food and beverage production, paper and pulp manufacturing, as well as metal fabrication activities. As the technology of CCS becomes more and more accepted in the industry, it is anticipated that the part of the Co2 captured in the United States from power generation and manufacturing processes will also rise (United States Environmental Protection Agency, 2013, p. 1).

Discussion

The overriding challenge facing the global community is to realize a substantial amount of CO_2 emission reduction within the parameters of any abatement setting. This challenging objective cannot be just set aside or dealt with traditional reduction strategies; a slew of new programs and policies will be needed to be deployed to achieve the desired reductions from all involved sectors.

These strategies the enhancement of the efficiency ratings of energy conversion technologies as well as end-use, additional use of renewable sources as well as nuclear power, changes in the lifestyles of the individual to decrease the use of power and the use of carbon capture and storage technologies (Florin, Fennell, 2010, p. 4).

Sequestration of CO_2 emissions has been proffered as a critical element among a host of technological portfolios to manage climate change threats as the technology will be able to provide less expensive and faster means to achieve the desired reductions of global emission levels for CO_2. However, the technology is not regarded as a perfect reduction mechanism, as there are instances that carbon dioxide can leak back into the atmosphere, disrupting future CO_2 level predictions and severity estimates. In addition, as sequestration requires additional energy allocation and consumption, the process may even increase the output carbon dioxide from the area source (Keller, McInerney, and Bradford, 2007, p. 267).

The trapping of CO_2 emanating from industrial flue gas emissions has become one of the most critical issues in recent years. The menace of climate change from rising levels of greenhouse gases (GHG) in the air is growing critical. Average global temperatures are steadily rising; a number of adverse and unusual weather patterns have been battering regions in the world. To cite examples, polar ice caps are melting at an alarming rate, droughts are becoming common occurrences across the world and violent weather occurrences are rising in regions across the world (Idem, Tontiwachwuthikul, 2006, p. 2413).

Various technologies and enhanced management mechanisms for the capture and storage and sequestration of Co2 has great potential to reduce emission rates and slow down the increase atmospheric Co2 concentrations. In the review of these technologies, it was found that power generation and supply technologies that integrate carbon capture and storage factors were discovered to be significant contributors to near-zero to negligible levels of emissions in the future.

When combined with similar sequestration technologies designed to capture carbon dioxide from the atmosphere, it was found that there were instances where the emission rate was reduced, avoided or sequestered, compared to benchmark cases, found that the emission rate ranged from a low level to almost 300 gigatons in the course of the 21st century. It is seen that at prevailing production and output levels continuing into the calculable future, the resource of fossil fuels will still be regarded as the staple of the global energy mix production well into the 21st century.

The United States Energy Information Administration (EIA) predicts that by 2025, a large portion (estimated at 88 percent) of global energy requirements will be filled by fossil fuel resources as fossil fuels will continue to maintain a high level of competitive advantage compared to other substitute sources of energy, as cited in the 2004 report of the EIA. In the context of the United States, the use of non renewable energy resources for the power generation sector made up roughly 39 percent of the cumulative energy related carbon dioxide released into the atmosphere, with the volume of Co2 emissions coming from this sector seen to rise to 41 percent by 2025 (United States Climate Change Technology Program, 2006, p. 113).

Present Technologies

As sequestration holds great potential to decrease the amount of carbon dioxide releases at pint sources as well as remove the pollutant from the air, research into the technology has grown over the last half decade have been raised from small focused research studies to become one of the primary technological endeavors. Federal bodies are currently exploring innovative or advanced concepts on carbon capture as well as a number of forms of terrestrial, geologic as well as oceanic. The ocean as well as a number of terrestrial environments that can be considered as “ carbon sinks” that can be potentially improved.

The United States Department of Energy (DOE) research and development program on carbon sequestration is inclusive of research needed to provide a scientific basis that is required to establish and comprehend the possible effectiveness of various policies to improve carbon sequestration in land based ecosystems as well as in the oceans (Climate Technology Program, 2003, p. 1).

Current Research Activities

The Massachusetts Institute of Technology (MIT) is currently implementing its Carbon Capture and Sequestration Technologies Program to conduct research into various technologies to arrest, use, and store Co2 emissions emanating from vast fixed sources. A significant component of the program is the Carbon Sequestration Initiative, launched in 2000. Among the projects being monitored by the group includes several power-related, non power related as well as manufacturing plants in the United States as well as across the globe.

These facilities include the Kemper County power generation facility in Mississippi run by Mississippi Power, Southern Energy and KBR. The feedstock of the plant is coal (Mississippi ignite), generating approximately 580 megawatts of electricity. The plant uses “ pre-combustion” TRIG technology that allows the plant to capture at least 65 percent of its Co2 emissions. This translates to more than 3. 5 million tons of Co2 prevented from being released into the atmosphere.

The captured carbon dioxide will then be transported onshore for improved oil extraction purposes. The plant was selected in the second round of the DOE’s Clean Coal Power Initiative. The project was allocated $270 million for the demonstration of improved power generation systems with the use of IGCC technology.

Another project being assessed is the Boundary Dam project located in Saskatchewan, Canada, and operated by a conglomerate composed of Neill and Gunther, Air Liquide, and SNC Lavalin-Cansolv, among others. Similar to the Kemper County facility in the United States, Boundary Dam uses coal as its fuel stock, and generates 160 MW , 110 MW on the average year round. The project received $240 million in funding from the Federal government in 2011, of which $180 million has been used. The plant uses post combustion amine as its carbon capture technology, with the harvested carbon dioxide to be transported via pipeline to the Weyburn field for " enhanced oil extraction" purposes. The technology allows the plant to capture at least 90 percent of the Co2 emitted by the plant.

On the other side of the Atlantic, the White Rose Project for the Carbon Dioxide Capture and Storage Project located at the Drax power generating facility in North Yorkshire in the United Kingdom. Another coal fired power generating facility, the 426 MW plant uses Alstom's " oxyfuel combustion" technology, allowing the facility to capture 90 percent of the Co2 emitted by the plant.

The captured Co2 will then be ferried to an offshore saline aquifer storage facility. In addition, the project is currently evaluating possible " enhanced oil extractions" options. The project is due for final decision in 2015, with construction activities expected to begin in 2016, and barring any issues and delays, will begin operation in 2020 (Carbon Capture and Sequestration Technologies at MIT, 2013, p. 1).

In Australia, Chevron is slated to open operations for it elephantine Gorgon LNG project, considered as the world's most ambitious carbon sequestration project and designed to inject more than 120 million tons of carbon dioxide into the ground. This comes in the wake of Prime Minister Tony Abbott pledging to dismantle the country's carbon tax structure.

The Gorgon project is seen to be the new " template" for carbon capture projects in the world, as the LNG project is twice the capacity of existing projects, and has shown that preconceived notions or barriers regarding improving the capacity of the industry can be hurdled. Also, the Gorgon Project will inject the gas into a saline aquifer as compared to existing practices of injecting the CO2 into old or abandoned oil fields. Saline aquifers can store CO2 gas quantities ranging from 1. 6 to 20 trillion tons, compared to 60-120 to unviable coal beds and 120 billion tons in old and abandoned oil fields (Kemp, 2013. p. 1).

In another project, the Office of Fossil Energy reports that Ohio State University researchers have been successful in test running their patented Coal Direct Chemical Looping (CDCL) technology, described as a " one-step process to produce both electric power and high level carbon dioxide, for a continuous period of 200 hours. The test represents the longest period of an integrated operation for the demonstration of chemical looping technology in the world up to the present time.

Conducted under the ambit of the Carbon Capture Program of the United States Department of Energy, the test was done at OSU' 25 kilowatt (kWt) CDCL sub pilot unit. The program is in the process of developing cutting edge environmental management control processes to support the use of the United States significant coal resources. Regulated by the National Energy Technology Laboratory of the Office of Fossil Energy, the particular objective of the program is the development of CO2 capture and compression technologies that can decrease the capital expenditure and energy penalties by more than one half-equivalent to the penalty of $40/metric ton-when incorporated into a new or online coal fueled power generation plant. With the success of the OSU tests, this signals the nearing approach of the technology into the mainstream among CCS technologies.

Chemical looping is cutting edge technology that provides several distinct advantages over the traditional combustion based methods in current use. In a chemical looping mechanism, metal-based oxides, such as iron oxides, gives off oxygen for the combustion process. The metal oxide discharges the oxygen in a fuel reactor with a reducing atmosphere. The reduced metal loops back into an oxidation chamber where the oxide is regenerated by contact with the air.

The metal oxide is then reushered into the reactor, and with this, the loop is then completed. As the separation process of CO2 process occurs in simultaneous fashion with the coal conversion process, the process can offer a low expense option for carbon capture practices. In addition to electric power and high purity carbon dioxide, the process can also produce synthesis gas or hydrogen (Office of Fossil Energy, 2013, p. 1).

Conclusion and Highlights

With the development of more advanced technologies, such as post combustion carbonate looping and chemical looping combustion, the emission rates of plants can be significantly lowered. With regards to post combustion carbonate combustion, the swift evolution of the concept from small-laboratory scale testing to a possible 10 MW demonstration over a period of 5-10 years is indicative of the time frame that is mandated to develop these cutting edge technologies from laboratory to planned full size demonstration.

Nevertheless, it must be recognized that having the concept pass from testing to demonstration stage still poses innate risks. Here, the project can be vulnerable to exposure of having to exceed initial project costs. In this light, demonstration of the projects in the more advanced stages is more urgent; nevertheless, there is still an imperative motivation to allocate sufficient funding as well as research activity to the progression of other CO2 capture and sequestration projects (Florin, Fennell, 2010, p. 3).

Bibliography

Carbon Capture and Sequestration Technologies at MIT, 2013. About the MIT CC and ST Program, [online] Available at:< https://sequestration. mit. edu/> [Accessed April 3, 2014]

Climate Change Technology Program, n. d., Capturing and Sequestering Carbon dioxide [online] Available at:< http://www. climatetechnology. gov/library/2003/currentactivities/sequester. htm> [Accessed April 3, 2014]

Florin, N., Fennell, P, 2010. Review of Advanced Carbon Capture technologies [online] Available at:

[Accessed April 3, 2014]

Gibbins, J,. Chalmers, H., 2008. Energy policy. Foresight Sustainable Energy Managament and the Built Environment Project , [online] Available at: http://www. sciencedirect. com/science/article/pii/S0301421508004436 [Accessed April 3, 2014]

Idem, R., Tontiwachwuthikul, P., 2006. Preface for the special issue on the capture of carbon dioxide from industrial sources: technological developments and future opportunities, [online] Available at:< http://pubs.

acs. org/doi/pdf/10. 1021/ie0680019> [Accessed April 3, 2014]

Keller, K., McInerney, D., Bradford, D. F., 2007. Carbon dioxiude sequestration: how much and when? [online] Available at:< http://link. springer. com/article/10. 1007/s10584-008-9417-x#page-2> [Accessed April 4, 2014]

Kemp, J. 2013. World's largest carbon capture begins even as Abbott tax repeal looms. The Sydney Morning Herald 11 September BusinessDay

Office of Fossil Energy, 2013. DOE-supported project advances clean coal, carbon capture technology [online] Available at:< http://energy. gov/fe/articles/doe-supported-project-advances-clean-coal-carbon-capture> [Accessed April 3, 2014].

United States Climate Change Technology Program, 2006. Capturing and sequestering carbon dioxide[online] Available at:< http://www. climatetechnology. gov/stratplan/final/CCTP-StratPlan-Ch06-Sep-2006. pdf.> [Accessed April 3, 2014]

United States Environmental Protection Agency, 2013. Carbon Dioxide capture and sequestration, [online] Available at:< http://www. epa. gov/climatechange/ccs/> [Accessed April 3, 2014]

World Nuclear Association, 2014. " Clean Coal" technologies, carbon capture and sequestration [online] Available at: < http://www. world-nuclear. org/info/energy-and-environment/-clean-coal--technologies/> [Accessed April 3, 2014]

Bibliography