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The Prospects For Clean Coal Plant With Carbon Capture and Storage

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Abstract

Carbon capture and storage (CCS) facilities coupled to clean coal plants provide a climate change and reducing the Co_2 (carbon dioxide) emission .The application of Carbon Capture and Storage (CCS) in the generating electricity is important for reducing the cost electricity and consumer bills. This paper represents new ways to categorize the options for mitigation of cost and consumer bills and Co_2 emissions. A detailed description on the ways to Carbon Capture and Storage in the coal fired plant, the power industry, capture, transport and store Co_2 has been presented. The power penalties and cost can be big Challenges to apply CCS to the generating electricity while a lot of opportunities exist such as the development of the carbon trade market and industrial utilization of Co_2. Carbon Capture and Storage (CCS) connected to clean coal power plants, plays an important role in reducing carbon emission and provide an environmental change. This paper represents a new ways for climate protection, environmental effects, environmental benefits, efficiency benefits, environmental effects and energy analyses in a carbon capture and storage. The power industry, capture, transport and store CO_2 has already been presented in the field of carbon capture and storage in coal fired power plant.

Keywords: *Carbon capture and storage (CCS), Clean coal power plant*

1. Introduction

DOE's (Department Of Energy) clean coal R&D is focused on developing and demonstrating advanced power generation and carbon capture, utilization and storage technologies for existing facilities and new fossil-fueled power plants by increasing overall system efficiencies and reducing capital costs. In the near-term, advanced technologies that increase the power generation efficiency for new plants and technologies to capture carbon dioxide (Co_2) from new and existing industrial and power-producing plants are being developed. In the longer term, the goal is to increase energy plant efficiencies and reduce both the energy and capital costs of Co_2 capture and storage from new, advanced coal plants and existing plants. These activities will help allow coal to remain a strategic fuel for the nation while enhancing environmental protection. The development of new 'clean coal' technologies is addressing this problem so that the world's enormous resources of coal can be utilized for future generations without contributing to global warming. Much of the challenge is in commercializing the technology so that coal use remains economically competitive despite the cost of achieving low, and eventually 'near-zero', emissions. As many coal-fired power stations approach retirement, their replacement gives much scope for 'cleaner' electricity. Alongside nuclear power and harnessing renewable energy sources, one hope for this is via 'clean coal' technologies, such as carbon capture and sequestration (CCS). However in its 2014 Energy Technology Perspectives the IEA notes that "CCS is advancing slowly,

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due to high costs and lack of political and financial commitment. Few major developments were seen in 2013, and policies necessary to facilitate the transition from demonstration to deployment are still largely missing." For its low-carbon 2DS scenario, "the rate of capture and storage must increase by two orders of magnitude" by 2025. Coal, one of the world's most abundant fossil fuel sources, currently meets about 23% of the total world primary energy demand, some 38% of global electricity generation [4]. It is an important input, for example, in steel production via the basic oxygen furnace process that produces approximately 70% of world steel output [5, 6]. But tougher environmental /climate change regulations mean that coal will have to reduce its environmental impact if it is to remain a significant energy source. Co_2 capture and storage facilities coupled to coal-fired power plants therefore provide a climate change mitigation strategy that potentially permits the continued use of coal resources, whilst reducing the Co_2 emission. The CCS process involves three basic stages [4, 8]. Capture and compression Of Co_2 from power stations transport of Co_2 and storage away from the atmosphere for hundreds to thousands of years. The principle of the various capture methods [7] is that the Co_2 is removed from other waste products so it can be compressed and transported for storage. Transport of the Co_2 can be by ship or by pipeline [4, 8].

2. Present Technology of Carbon Capture and Storage

Currently, CCS has been deployed at commercial-scale industrial facilities, and the first commercial-scale power plants with CCS are under construction. As of late 2013, the Global Carbon Capture and Storage Institute (GCCSI) listed twelve commercial-scale CCS projects in operation and around 50 additional projects in various stages of development around the world. Around 20 of these projects are located in the United States. The International Energy Agency (IEA) labels CCS as a critical technology for limiting the rise in global temperature to 2° Celsius (3.6° F) by 2050 and calls for 38 power and 82 industrial large-scale integrated CCS projects to be in place by 2020 to meet this objective [40] Given that only around 20 large-scale integrated CCS projects are estimated to be in operation by the mid-2010s, the IEA has labeled the status of CCS as "not on track" [42]. The status of the component technologies of CCS is reviewed below.

A. CO_2 Capture

Carbon capture technologies have long been used for industrial processes like natural gas processing and CO_2 generation for the food and beverage industry. Currently, in the United States, commercial-scale CCS projects include four natural gas processing facilities, two fertilizer plants, a synfuel plant, and a hydrogen plant that capture CO_2 and transport it for use in enhanced oil recovery [43]. In the power sector, the first commercial-scale power plant, SaskPower's Boundary Dam project in Saskatchewan, will be world's first commercial-scale project with CCS. Additional power plants and industrial facilities with CCS are under construction or in design stages [43]. Few or no commercial-scale projects have been proposed for other high-emitting CO_2 sources, such as iron and steel, cement, and pulp and paper production [44].

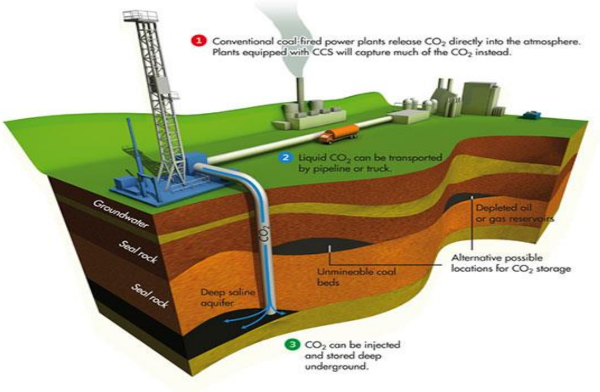

Figure 1. Schematic Showing Terrestrial Sequestration of Carbon Dioxide (CO_2) Emission from a Coal Fired Plant

There are three different of technologies for scrubbing exists: post-combustion, pre-combustion, and ox fuel combustion.

Post-combustion- Capture of carbon dioxide from flue gas streams following combustion in air is much more difficult and expensive than from natural gas streams, as the carbon dioxide concentration is only about 14% at best, with nitrogen most of the rest, and the flue gas is hot. The main process treats carbon dioxide like any other pollutant, and as flue gases are passed through an amine solution the Co_2 is absorbed. It can later be released by heating the solution. This amine scrubbing process is also used for taking Co_2 out of natural gas. There is a significant energy cost involved. For new power plants this is quoted as 20-25% of plant output, due both to reduced plant efficiency and the energy requirements of the actual process. No commercial-scale power plants are operating with this process yet. At the new 1300 MWe Mountaineer power plant in West Virginia, less than 2% of the plant's off-gas is being treated for Co_2 recovery, using chilled amine technology. This has been successful. Subject to federal grants, there are plans to capture and sequester 20% the plant's Co_2, some 1.8 million tones Co_2 per year.

Pre-combustion- Oxy-fuel combustion is similar to the post-combustion technique where coal is burned in oxygen rather than air, it means that the flue gas is mostly Co_2 and hence it can more readily be captured by amine scrubbing – at about half the cost of capture from conventional plants. A number of oxy-fuel systems are operational in the USA and elsewhere, and the Future Gen 2 project involves oxy-combustion. Such a plant has an air separation unit, a boiler island, and a compression and purification unit for final flue gas. The Integrated Gasification Combined Cycle (IGCC) plant is a means of using coal and steam to produce hydrogen and carbon monoxide (CO) from the coal and these are then burned in a gas turbine with secondary steam turbine (i.e. combined cycle) to produce electricity. If the IGCC gasifier is fed with oxygen rather than air, the flue gas contains highly-concentrated Co_2 which can readily be captured post-combustion as above. In China, the first phase of Huaneng Group's $1.5 billion Green Gen project is a 250 MWe oxy-fuel IGCC power plant burning hydrogen and carbon monoxide is due to commence operation by mid 2012. A second phase involves a pilot plant to produce electricity from hydrogen, as below. Phase 3 will be a 400 MWe commercial plant with CCS.

Ox Fuel Combustion- Pre-combustion capture development of the IGCC process will add a shift reactor to oxidize the CO with water so that the gas stream is basically just hydrogen and carbon dioxide, with some nitrogen. The Co_2 with some H2S & Hg impurities are separated before combustion (with about 85% Co_2 recovery) and the hydrogen alone becomes the fuel for electricity generation (or other uses) while the concentrated pressurized carbon dioxide is readily disposed of (The H2S is oxidized to water and sulfur, which is saleable.) No commercial-scale power plants are operating with this process yet. Currently IGCC plants typically have a 45% thermal efficiency. Capture of carbon dioxide from coal gasification is already achieved at low marginal cost in some plants. One (albeit where the high capital cost has been largely written off) is the Great Plains Synfuels Plant in North Dakota, where 6 million tones of lignite is gasified each year to produce clean synthetic natural gas. Oxy-fuel technology has potential for retrofit to existing pulverized coal plants, which are the backbone of electricity generation in many countries. In China, the major utility China Datang Corp is teaming with Alstom to build two demonstration CCS projects. A 350 MWe coal-fired plant at Daqing, Heilongjiang province will be equipped with Alstom's oxy-firing technology, and a 1000 MWe coal-fired plant at Dongying, Shandong province will use an Alstom's post-combustion capture technology, either chilled ammonia or advanced amines. The two projects are expected to be operational in 2015 and each capture over one million tons of Co_2 per year, which would be about 40% of output from Daqing and 15% from Dongying, though Alston says that the actual levels of capture and storage have not yet been defined and will be in the scope of the first feasibility studies of the respective projects. Adjacent oilfields will be used for sequestration, enabling enhanced oil recovery.

B. CO_2 Transport and storage

The United States already has approximately 3,900 miles of Co_2 pipe lines used to transport Co_2 for EOR [45]. Co_2 pipeline transport is commercially proven. There may also be the requirement to insert recompression stages into the pipeline. In the medium-term, it is believed that the Co_2 pipeline network would work most effectively with a number of onshore ‘hubs’ that would compress and clean the Co_2 transported in smaller pipes from several power stations and industrial capture plants. At these hubs, the more highly compressed and cleaned Co_2would be transported through one or two larger, stronger pipes to its offshore storage reservoir [11]. This would not only reduce costs in installation and the length of pipeline required, but would also allow for an interconnected system that could be shared. Such a network would have the potential to evolve into a network of pipes with redundancy and security should a leak or failure occur [11, 12]. A hub-network system also allows better managing of the Co_2 transport with third parties leasing pipe use to the power generators to spread the costs and reduce the maintenance and operation strain on single electricity generator and industry users. The Co_2 transportation needs of the UK will benefit from the fact that its storage reservoirs in the North Sea are typically located only 200 or 300 km away from the power stations. Stake holders feel that there are no long-term technical barriers to the development of a Co_2 pipeline network in the UK [16]. But a Co_2 pipeline operator runs a significant financial risk [16], because of the high cost of the assets and low returns. Indeed, Gough et al. [16] suggest that the cost increase between a network and alternative transmission means could be as high as £3Per tone ($4.5 or €4.0/t Co_2).

There are three main categories of geological storage for Co_2: oil and gas replacement, coal seam storage, and deep saline aquifers. The first can have direct economic benefit offsetting the cost. So far, to 2014, 55 million tones of Co_2 have been sequestered with monitoring.

3. Environmental Issues

Environmental protection is an integral consideration in the U.S. policies concerning natural resources, human health, economic growth, energy, transportation, agriculture, industry, and international trade, and these factor are similar considered in establishing environmental policy, national efforts to reduce environmental risk are based on the best available scientific information, environmental protection contributes to making our communities and ecosystems diverse, sustainable and economically productive, the

United States plays a leadership role in working with other nations to protect the global environment.

A. Environmental effects

Generally, environmental effects the uses of CCS arise during power production, CO_2 capture, transport, and storage. The theoretical merit of carbon capture and storage (CCS) systems is the reduction of CO_2 emissions by up to 90%, depending on plant type. Current technology are using for new super critical pulverized coal (PC) plants, 24 to 40% range the extra energy requirements, while for natural combined cycle (NGCC) plants the range is 11-22% and for coal based gasification combined cycle (IGCC) systems it is 24-25% [IPCC, 2005].main factor fuel use and environmental problems arising from mining and extraction of coal or gas increase accordingly.

IPCC (Intergovernmental Panel on Climate Change) has provided estimates of air pollutions from various CCS plant. While CO_2 is reduced through never completely captured, emissions of air pollutants increase significantly, generally due to the energy penalty of capture. Type and amount of air pollutants still depends on technology.CO_2 is captured with alkaline solvents catching the acidic CO_2 at low temperature in the absorber and releasing CO_2 at higher temperature in a desorbed. All the capture plants amines have in common, that practically 100% of remaining sulfur dioxide from the plant is washed out of the flue gas, and the same applies to dust/ash.

Emission to air from plants with CCS (kg/(MW-h))		
Natural gas combined cycle	**Pulverized coal**	**Integration gasification combined cycle**
CO_2 43(-89%)	**107(-87)**	**97(-88)**
NO_x 0.11 (+22)	**0.77(+31%)**	**0.1(+11)**
SO_x -	**0.001 (-99.7%)**	**0.33 (+17.9%)**
Ammonia0.002 (before: 0)	**0.23 (+2200%)**	**-**

Based on Table 3.5 in [IPCC, 2005]. Between brackets the increase or decrease to similar plant without CCS

B. Environmental Benefits

CCS (carbon capture and storage) technology has potential to reduce CO_2 emission from a coal or natural gas fueled power plant by as much as 90% [3,4].

- The environmental benefits of gasification steam from the capability to achieve extremely low SO_x, NO_x and particulate emission from burning coal derived gases.
- Coal gasification may offer a further environmental advantage in addressing concern over the atmospheric buildup of greenhouse gases, such as CO_2.
- The U.S. Energy Information Administration (EIA) modeling analysis of the Waxman-Markey American Clean Energy and Security Act of 2009 projected that, under the proposed cap and trade program, coal power plant s with CCS could provide 11% of electricity by 2030, and that new coal power plants could account for 28% of new generating capacity. In contrast, under a business as usual scenario and without legislation, new coal power plants would account only for 11% of new generating capacity.
- Due to rising global demand for energy, the consumption of fossil fuels is expected to rise through 2035, leading to greater CO_2 emissions.

- Under its 2 degree scenario (2DS), the International Energy Agency (IEA) estimates that CCS will provide 14% of cumulative emissions reductions between 2015 and 2050 compared to a business as usual scenario.
- Oil produced by CO_2-EOR projects can be considered relatively lower carbon than oil produced by other technique. For example, the carbon stored by the Weyburn EOR project can offset approximately 40% of combustion emission resulting from the oil it produces, not including emission from electricity use due to compression, lifting, and refining.

C. Efficiency Benefits

In a typical coal combustion based power plant, heat from burning coal used to boil water, making steam that drives a steam turbine generator. In some coal combustion based power plants, only a third of the energy value of coal is actually converted in to electricity. The fuel efficiency of a coal gasification power plant in this type of combined cycle can potentially be boosted to 50% or more. In fact, coal gasification power processes under development by the Energy Department could cut the formation of CO_2 by 40% or more, per unit of output, compared to today's conventional coal burning plant.

The capability to produce electricity, hydrogen, chemicals, or various combinations while eliminating nearly all air pollutants and potentially greenhouse gas emission makes coal gasification one of the most promising technologies for energy plants of the future.

D. Energy Analysis

- Environmental Activities: Analysis include potential environmental impacts (e.g. on water quality, air emissions, solid waste disposal, climate change) of fossil fuel use a large scale deployment of different generations of CCS. Of particular interest are the life cycle environmental emissions for existing and advanced fossil fuel technologies.
- Technical and economic analysis: The technical and economic analyses element support program strategic planning by identifying major challenges, technologies, and advanced concepts that have the potential to improve the efficiency, cost and environmental performance of fossil energy systems.

4. Case Study

In Juliette, Georgia, southern company operates a coal-fired power plant that is the single largest source of planet-warming carbon dioxide emissions in the United States. In Kemper County, Mississippi, the same company is pioneering a technology that many experts believe will be crucial to preventing a climate disaster: It's building the world's first new power plant designed to capture and store most of its carbon. Carbon capture and storage (CCS) has been hailed for decades by some as an essential solution to the climate problem, and pilloried by others as unworkable and a dangerous distraction. This year, at last, it will be tested at full commercial scale. The test ground won't be only a new power plant in Mississippi. It also will be about 1,600 miles north of here, in Saskatchewan, Canada, where a public utility is attempting to show that an old coal-fired power plant can be cleaned up. Saskpower has almost finished retrofitting one 110-megawatt unit of its Boundary Dam Power Station to capture 90 percent of the CO_2 before it flies out the smokestack. In Saskatchewan as in Mississippi, the CO_2 will be pumped underground into a partially depleted oil field and after it has helped squeeze valuable oil to the surface stored there indefinitely. A new generation of energy processes describes that sharply reduce air emissions and other pollutants from coal burning power plants by clean coal technology.

For environmental protection and Global warming a new technology is provided "Clean Coal" technology in Kemper country, Mississippi, which can be to capture and store most of its carbon. Due to this technique could be preventing a climate disaster. The project will produce 110 MW of base load electricity and reduce greenhouse gas emission by one million tons of CO_2 each, but the coal fired technique is expensive. The Nations lowest cost electric power sources for the foreseeable future, the United States has pledged a new commitment to even more advanced clean coal technologies.

Conclusion

The recently "Clean Coal" technique has proposed better response in Environmental protection and Global warming. Prevent the GHGs (Greenhouse Gases), such as CO_2, Methane, N_2O (Nitrogen Oxide), and H_2O (Water Vapor), amongst other and occur naturally from entering the atmosphere by the clean coal technique. From this technique can reduce capital cost and increase the power generation efficiency. The carbon capture, utilization and storage R&D (Research and Development) program advance safe, cost effective, capture and permanent storage and use of carbon dioxide (CO_2).These activities will help allow coal to remain a strategic fuel for the Nation while enhancing environmental protection.

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