CO_2 CAPTURE TECHNOLOGY

ADRIANA FOANENE, *Constantin Brâncuși University of Târgu Jiu,* ROMANIA
ADINA TĂTAR, *Constantin Brâncuși University of Târgu Jiu,* ROMANIA

Abstract: There is growing concern that anthropogenic carbon dioxide (CO_2) emissions are contributing to global climate change. Therefore, it is critical to develop technologies to mitigate this problem. CO_2 capture from coal-derived power generation can be achieved by various approaches: post-combustion capture, pre-combustion capture, and oxy-combustion. All three of these pathways are under investigation, some at an early stage of development. This paper discusses the current status of the development of CO_2 capture technology.

Key words: Carbon dioxide capture, post-combustion, pre-combustion, oxy-combustion.

1.INTRODUCTION

Although there is not universal agreement on the cause, there is a growing consensus that global climate change is occurring, and many climate scientists believe that a major cause is the anthropogenic emission of greenhouse gases (GHG) into the atmosphere.

Due to their low cost, availability, existing reliable technology for energy production, and energy density, fossil fuels currently supply over 85% of the energy needs.

The combustion of fossil fuels produces carbon dioxide (CO2), a emission of greenhouse gases with an increasing potential for by-product end-use in the industrial and energy production sectors.

The use of CO2 as a by-product would not only have economic benefits but would simultaneously mitigate global climate change concerns.

No single nation can sufficiently reduce GHG to stabilize their atmospheric concentrations.

The effort must be unified and cost effective to sustain domestic and global economic growth while reducing GHG emissions.

One approach that holds great promise for reducing GHG emissions is carbon capture and sequestration (CCS).

Under this concept, CO_2 would be captured from large point sources, such as power plants, and injected into geologic formations, such as depleted oil and gas fields, saline formations, and unmineable coal seams . This approach would lock up (sequester) the CO_2 for thousands of years.

Current state-of-the-art CCS technologies may be used for initial mitigation of GHG emissions, but in the long-term low cost solutions to meet the growing demand for energy will be required, not only to meet environmental standards, but also to increase the standard of living worldwide.

Five technological avenues aimed at reducing GHG emissions: CO_2 separation and capture; carbon storage (sequestration); monitoring, mitigation, and verification of stored CO_2; control of non-CO_2 GHG; and breakthrough concepts related to CCS.

These five avenues encompass a broad spectrum of opportunities for technology development it become necessary to impose mandatory limits on CO_2 emissions.

Capture and separation costs are a significant portion of the cost to sequester CO_2. Transportation and storage are generally a minor fraction of the total cost.

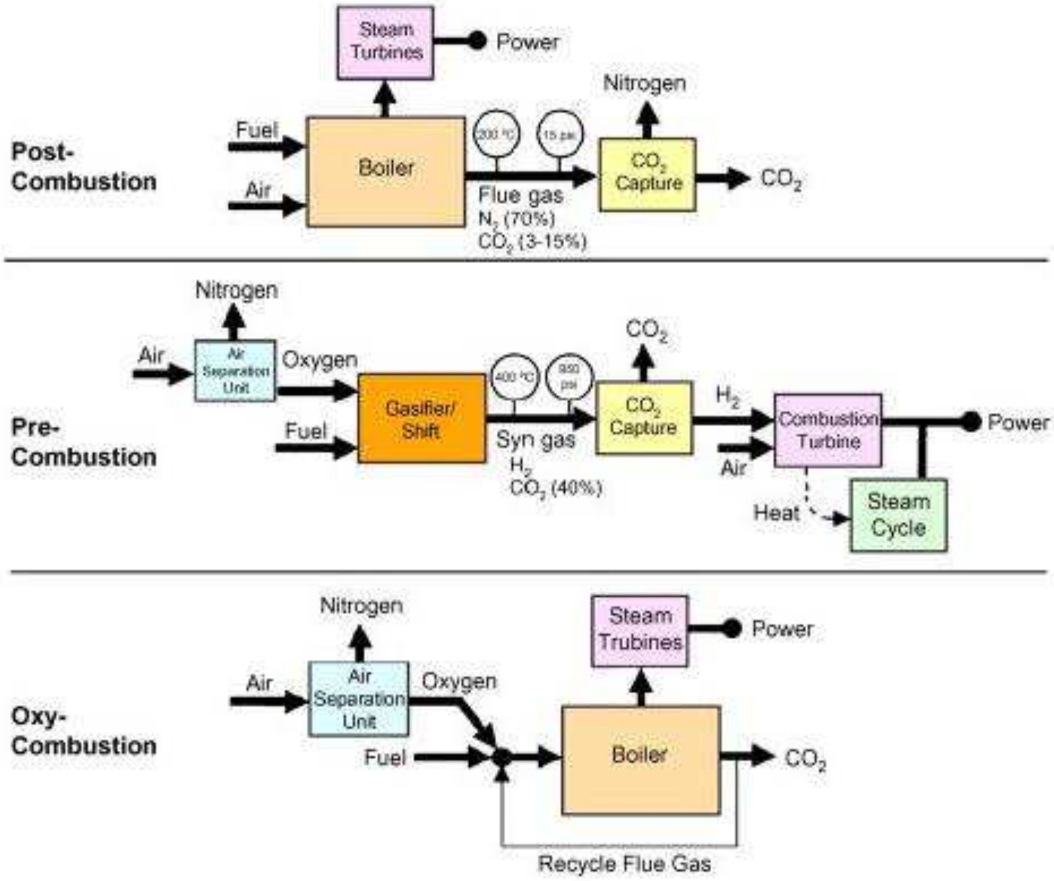

Fig.1. Post-combustion, pre-combustion, and oxy-combustion systems

If CO_2 capture from power plants is to be a mitigation option,then research and development will be critical to achieve wide-scale deployment with acceptable economic and environmental impacts.

There are four approaches that can contribute to reducing CO_2 emissions from the large number of new power plants that will be required to meet this growing demand. The first is to reduce carbon intensity.

The second is to increase the efficiency of power generation cycles.

The third is to develop new power production technologies, such as oxy-combustion and chemical looping.

The fourth is to develop innovative and cost effective capture technologies that are scaleable to the size needed by the power and nonpower sectors.

CO_2 sequestration in geologic formations shows great promise because of the large number of potential geologic sinks.

CO_2 can be sequestered in the formations identified so far. Also, with higher petroleum prices, there is increased interest in using CO_2 flooding as a means to enhance oil recovery ; and with higher gas prices, there will be growing interest in using CO_2 for enhanced coal bed methane production.

However, none of these activities will be possible unless CO_2 is first captured. None of the currently available CO_2 capture processes are economically feasible on a national implemen tation scale to capture CO_2 for sequestration, since they consume large amounts of parasitic power and significantly increase the cost of electricity. Thus, improved CO_2 capture technologies are vital.

2.CO_2 CAPTURE TECHNOLOGIES

In consideration of how best to improve CO_2 capture, there are three technological pathways that can be pursued for CO_2 capture from coal-derived power generation: post-combustion capture, pre-combustion capture, and oxy-combustion, as illustrated in fig. 1.

In post-combustion capture, the CO_2 is separated from other flue gas constituents either originally present in the air or produced by combustion. In pre-combustion capture, carbon is removed from the fuel before combustion, and in oxy-combustion, the fuel is burned in an oxygen stream that contains little or no nitrogen.

Post-combustion capture applies primarily to coal-fueled power generators that are air fired. Pre-combustion capture applies to gasification plants. Oxy-combustion can be applied to new plants or retrofitted to existing plants.

2.1. POST- COMBUSTION CO_2 CAPTURE

Post-combustion capture involves the removal of CO_2 from the flue gas produced by combustion. Existing power plants use air, which is almost four-fifths nitrogen, for combustion and generate a flue gas that is at atmospheric pressure and typically has a CO_2 concentration of less than 15%.

Thus, the thermodynamic driving force for CO_2 capture from flue gas is low creating a technical challenge for the development of cost effective advanced capture processes, post-combustion carbon capture has the greatest near-term potential for reducing GHG emissions, because it can be retrofitted to existing units that generate two-thirds of the CO_2 emissions in the power sector.

2.2. PRE-COMBUSTION CARBON CAPTURE

In pre-combustion CO_2 capture, the CO_2 is recovered from some process stream before the fuel is burned. To the extent that the concentration and pressure of the CO_2 containing stream can be increased, then the size and cost of the capture facilities can be reduced.

This has led to efforts to develop combustion technologies that inherently produce concentrated CO_2 streams or CO_2 containing streams at high pressure, for which there are existing capture processes.

2.3.CHEMICAL LOOPING COMBUSTION AND GASIFICATION

Chemical looping combustion enables the production of a concentrated CO_2 stream without the need for an expensive air separation unit. In this process, oxygen is supplied by a solid oxygen carrier, rather than by air or gaseous oxygen. In one potential configuration, chemical looping is carried out in two fluidized beds.

2.4.OXY-COMBUSTION

An alternative to capturing carbon from fuel gas or flue gas is to modify the combustion process so that the flue gas has a high concentration of CO_2.

A promising technology for accomplishing this is oxy-combustion, in which the fuel is burned with nearly pure oxygen mixed with recycled flue gas.

In the most frequently proposed version of this concept, a cryogenic air separation unit is used to supply high purity oxygen to a PC-fired boiler. This high purity oxygen is mixed with recycled flue gas prior to combustion or in the boiler to maintain combustion conditions similar to an air fired configuration. This is necessary because currently available materials of construction cannot withstand the high temperatures resulting from coal combustion in pure oxygen. For a new unit, it should be possible to use smaller boiler equipment due to increased efficiency. The main attraction of this process is that it produces a flue gas which is predominantly CO_2 and water.

The water is easily removed by condensation, and the remaining CO_2 can be purified relatively inexpensively.

Conditioning of the flue gas consists of drying the CO_2, removal of O_2 to prevent corrosion in the pipeline, and possibly removal of other contaminants and diluents, such as Ar, N_2, SO_2, and NOx.

The cost of carbon capture in an oxy-combustion power plant should be lower than for a conventional PC plant, as a result of the decreased flue gas volume and increased concentration of CO_2, but the cost of air separation and flue gas recirculation significantly reduces the economic benefit.

If the flue gas can be recycled before SO_2 scrubbing, the SO_2 scrubber can be reduced in size, and significant cost savings are possible. Engineering studies are necessary because of the different physical properties of CO_2 compared to N_2.

Alstom Power is developing an oxygen fired CFB combustor that would produce a concentrated CO_2 flue gas. As CO_2 has different properties than nitrogen, a pressurized fluidized bed combustor would require a redesigned gas turbine. Alstom

Power is also conducting modeling studies to better understand and predict the combustion characteristics of oxy-combustion technology. To drastically reduce the cost of oxy-combustion, systems will need to be developed to reduce the cost of oxygen production. Current research is expanding this technology's potential to operate with various coal ranks. A ceramic membrane and seal assembly has been developed for thermal integration between the high temperature membrane and the combustion process. Prototype single and multitube reactors have been built and operated without membrane failure.Another technology to reduce the cost of oxygen production for use with oxy-combustion, called ceramic autothermal recovery (CAR). The CAR process uses the oxygen storage properties of perovskites to adsorb oxygen from air in a fixed bed and then release the adsorbed oxygen into a sweep gas, such as recycled flue gas, that can be sent to the furnace. The process is made continuous by operating multiple beds in a cycle.

3. CONCLUSIONS

CO_2 capture and separation from large point sources, such as power plants, can be achieved through continued research, development, and demonstration. Worldwide research is being performed to abate global climate change.

Research to develop technologies and processes that increase the efficiency of capture systems while reducing overall cost is critical to creating a feasible GHG control implementation plan, covering not only power plants and industrial facilities but also the infrastructure required to support that implementation.

These technologies, while focused on the power sector due to the volume of its CO_2 emissions, are also applicable to other sectors.

Research and development is driven by a commercialization focus to satisfy the requirements of identified market segments and to substantially improve performance with a significant cost reduction.

REFERENCES

[1].V.Paliţă –Combustibili. Generatoare de abur, Ed.Didactică şi Pedagogică, Bucureşti, 2003

[2].Racoceanu C., Power plants environmental impact., Publishing House Focus, Petroşani, 2001

[3]. C.Ungureanu, N. Pănoiu, ş.a. - Combustibili. Instalaţii de ardere. Cazane, Ed. Politehnica, Timişoara, 1998.

[4].ALSTOM 2006. ALSTOM signs exclusive license agreement for carbon capture technology, 31 May 2006 http://www.power.alstom.com/2006

[5].Reteaua Europeana de Execelenta CO_2 GeoNet, Ce inseamna, de fapt stocarea geologica a CO_2;

[6].Acharya, D., Krishnamurthy, K.R., Leison, M., MacAdam, S., Sethi, V.K., Anheden, M., Jordal, K., Yan, J., 2005. Development of a high temperature oxygen generation process and its application to oxycombustion power plants with carbon dioxide capture. In: 22nd Annual International Pittsburgh Coal Conference, Pittsburgh, PA

[7]. Filip, R., Programul național pentru captarea si stocarea CO_2, cu orizont de timp 2020, Tehnologii de captare si transport, Târgu-Jiu, 2010;