Future without Carbon Capture and Storage

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Abstract - Carbon sequestration: capture and secure storage of carbon that would otherwise be emitted or remain in the atmosphere. Carbon sources: For this article, we are worried with large stationary sources of CO2, e.g. fossil fueled power plants, cement manufacturing, ammonia production, industrial boilers, refineries, natural gas wells. Carbon capture: The separation and entrapment of CO2 from large stationary sources. CO2 storage: The injection of CO2 into geologic or oceanic reservoirs for timescales of centuries or longer. CO2 capture and storage CO2 is emitted basically from the burning of fossil fuels, both in large combustion units such as those used for electric power generation and in smaller, distributed sources such as automobile engines and furnaces used in residential and commercial buildings. CO2 emissions also result from some industrial resource extraction processes, as well as from the burning of forests during land clearance. CCS would most likely be applied to large point sources of CO2, such as power plants or large industrial processes. Some of these sources could supply decarbonized fuel such as hydrogen to the transportation, industrial and building sectors, and thus reduce emissions from those distributed sources. CCS involves the use of technology, primarily to collect and concentrate the CO2 produced industries and energy related sources, transport it to a suitable storage location, and then store it away from the atmosphere for a long period of time. CCS would thus allow fossil fuels to be used with low emissions of greenhouse gases. Application of CCS to biomass energy sources could result in the net removal of CO2 from the atmosphere (often referred to as 'negative emissions') by capturing and storing the atmospheric CO2 taken up by the biomass, provided the biomass is not harvested at an unsustainable rate.

Concise Definition of Subject

One of the approaches for mitigating or reducing potential global climate change due to anthropogenic emissions of CO2 and other greenhouse gases is to capture CO2 from fossil fuel using sources, and to store it in geologic or oceanic reservoirs. The capture technologies are described, and their efficiencies, cost and energy penalties are estimated. Storage capacities and effectiveness are estimated, as well as transportation costs and possible environmental impacts.

I. INTRODUCTION

Carbon Storage and capturing can be defined as capturing and secure storage of carbon that would otherwise be emitted to, or remain, in the atmosphere. The focus of this review article is about the removal of CO2 directly from industrial or utility plants and subsequently storing it in secure reservoirs. We call this carbon capture and storage (CCS).

Concerns about climate change have focused the attention of policy-makers on ways to capture and store carbon dioxide emissions from fossil-fueled electricity generators. Efforts are underway to develop capture technologies, geologic storage opportunities, and the regulatory frameworks that will affect CO2 transport and storage. This article summarizes the high-level technological and policy considerations for CCS, including:

- Differences between capture technologies from a mechanical and chemical perspective;
- There are many research projects undertaken in various university's
- Geological and financial aspects of storage options
- An overview of current storage siting policies
- Questions of financial, environmental, and health and liability risks as well as mitigating factors and practices; and
- Pipeline planning, permitting, and safety concerns

At present, fossil fuels are the dominant source of the global primary energy demand, and will likely remain so for the rest of the century. Fossil fuels supply over 85-90% percent of all primary energy, the rest is made up of nuclear- and hydro-electricity, and renewable energy (commercial biomass, geothermal, wind and solar energy). Currently, non-hydro renewable energy supplies less than 1% of the global energy demand. While great efforts and investments are made by many countries to increase the share of renewable energy (switch from non-renewable to renewable energy resources) as the primary energy demand and to foster conservation, addressing climate change concerns during the coming decades will likely require significant contributions from carbon capture and storage.

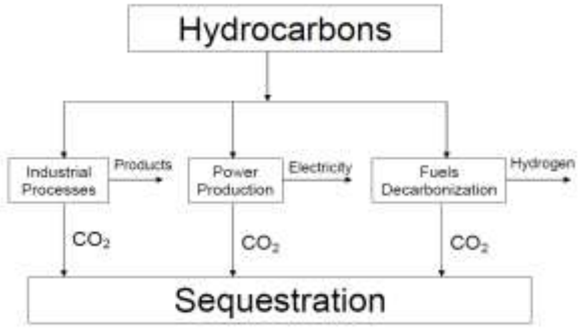

Fig 1: Sources of CO2 for sequestration -- an industrial by-product, captured from power plants, or a by-product of future fuel decarbonization plants

II. What are the characteristics of CCS?

Carbon Capture of CO2 can be applied to large point resources. The CO2 would then be compressed and transported for storage in geological formations, in the ocean, in mineral carbonates, or for use in industrial processes. Large point sources of CO2 include large fossil fuel or biomass energy facilities, major CO2-emitting industries, natural gas production, synthetic fuel plants and fossil fuel-based hydrogen production plants.

Potentially technical storage methods are: Geological storage (in geological formations, such as oil and gas fields, unminable coal beds and deep saline formations), ocean storage (direct release into the ocean water column or onto the deep seafloor) and industrial fixation of CO2 into inorganic carbonates.

III. IMAGE

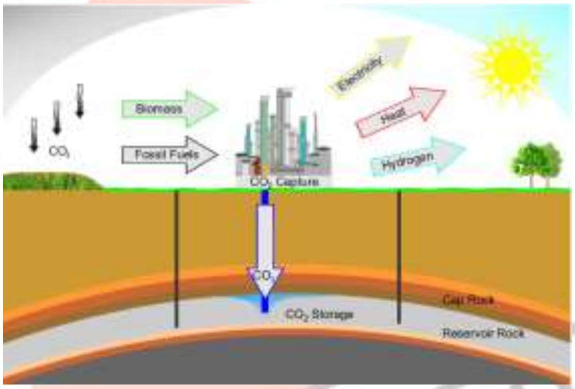

Fig 2: Carbon capture and storage, journal, MIT

What is the current status of CCS technology?

There are different types of CO2 capture systems: Postcombustion, pre-combustion and oxyfuel combustion. The concentration of CO2 in the gas stream, the pressure of the gas stream and the fuel type (solid or gas) are important factors in selecting the capture system. In Post-combustion capture of CO2 in power plants it is economically feasible under specific conditions. It is used to capture CO2 from part of the flue gases from a number of existing power plants. Separation of CO2 in the natural gas processing industry, which uses similar technology, operates only in a mature market. The technology required for pre-combustion capture is widely applied in fertilizer manufacturing and in hydrogen production. Although the initial fuel conversion steps of pre-combustion are more elaborate and costly, the higher concentrations of CO2 in the gas stream and the higher pressure make the separation easier. All this results in high CO2 concentrations in the gas stream and, in easier separation of CO2 and in increased energy requirements in the separation of oxygen from air.

What is the geographical relationship between the sources and storage opportunities for CO?

Large point sources of CO2 are concentrated in proximity to major industrial and urban areas. Many such sources are within 300 km of areas that potentially hold formations suitable for geological storage. Preliminary research suggests that, globally small proportion of large point sources is close to potential ocean storage locations.

What are the costs for CCS and what is the technical and economic potential?

Application of CCS to electricity production, under 2002 conditions, is estimated to increase electricity generation costs by about 0.01–0.05 US dollars 16 per kilowatt hour (US$/kWh), depending on the fuel, the specific technology, the location and the national circumstances. Inclusion of the benefits of EOR would reduce additional electricity production costs due to CCS by around 0.01–0.02 US$/kWh17. Increase in market prices of fuels used for power generation would generally tend to increase the cost of CCS. The quantitative impact of oil price on CCS is uncertain. However, revenue from EOR would generally be higher with higher oil prices. While applying CCS to biomass-based power production at the current small scale would add substantially to the electricity costs, cofiring of biomass in a larger coal-fired power plant with CCS would be more cost-effective.

Costs vary considerably in both absolute and relative terms from country to country. Since neither Natural Gas Combined Cycle, Pulverized Coal nor Integrated Gasification Combined Cycle systems have yet been built at a full scale with CCS, the expenditure of these systems cannot be stated with a high degree of confidence at this time. In the future, the costs of CCS could be reduced by research and technological advancement and economies of scale. Economies of scale could also considerably bring down the cost of biomass-based CCS systems over time. The application of CCS to biomass fired conversion facilities would lead to lower or negative CO2 emissions, which could reduce the costs for this option, depending on the market value of CO2 emission reductions.

IV. What are the local health, safety and environment risks of CCS?

The local risks associated with CO2 pipeline transport could be similar to or lower than those posed by hydrocarbon pipelines already in operation. For existing CO2 pipelines, mostly in areas of low population density, accident numbers reported per kilometre pipeline are very low and are comparable to those for hydrocarbon pipelines. A sudden and large release of CO2 would pose immediate dangers to human life and health, if there is exposure to concentrations of CO2 greater than 7–10% by volume in air. Pipeline transport of CO2 through populated areas requires attention to route selection, over pressure protection, leak detection and other design factors. No major obstacles to pipeline design for CCS are foreseen.

V. Gaps in knowledge Conclusion

The gaps in knowledge covers aspects of CCS where increasing knowledge, experience and reducing uncertainty would be important to facilitate decision-making about the large-scale deployment of CCS. Technologies for capture and storage Technologies for the capture of CO2 are relatively well understood today based on industrial experience in a variety of applications. Similarly, there are no major technical or knowledge barriers to the adoption of pipeline transport, or to the adoption of geological storage of captured CO2. However, the integration of capture, transport and storage in full-scale projects is needed to gain the knowledge and experience required for a more widespread deployment of CCS technologies. R&D is also needed to improve knowledge of emerging concepts and enabling technologies for CO2 capture that have the potential to significantly reduce the costs of capture for new and existing facilities. More specifically, there are knowledge gaps relating to large coal based and natural gas-based power plants with CO2 capture on the order of several hundred megawatts (or several MtCO2). Demonstration of CO2 capture on this scale is needed to establish the reliability and environmental performance of different types of power systems with capture, to reduce the costs of CCS, and to improve confidence in the cost estimates. In addition, large-scale implementation is needed to obtain better estimates of the costs and performance of CCS in industrial processes, such as the cement and steel industries, that are significant sources of CO2 but have little or no experience with CO2 capture. With regard to mineral carbonation technology, a major question is how to exploit the reaction heat in practical designs that can reduce costs and net energy requirements. Carbon Capture and Storage (CCS) is a technology that can capture up to 90% of the carbon dioxide emissions produced from the use of fossil fuels in electricity generation and industrial processes, preventing the carbon dioxide from entering the atmosphere, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological formation. CCS leads the world’s future low-carbon energy portfolio. Leading energy and climate change institutions agree on the crucial role for CCS in cost effectively realising global emissions reduction targets. International evidence shows CCS contributing 17 per cent of the necessary global emissions reductions in 2050 and delivering 14 per cent of the cumulative emissions reductions needed between 2015 and 2050.

VI. References

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