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Carbon Capture, Transportation and Sequestration, the Worldwide Effort to Control the Rise in Global Temperature

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ABSTRACT

This paper was written to provide information on climate change, techniques and efforts to control and manage the increase of global temperature. The Paris agreement was established and its main goal is to limit the global average temperature increase to 1.5C above pre-industrial levels by the end of this century. This agreement was signed by a number of Countries and among them Saudi Arabia, which endorsed this agreement on November 03, 2016. Saudi Arabia likewise other countries are working on the objective of Paris agreement by implementing new technologies including Carbon capture and sequestration as well as promoting green energy sources to generate the required power.

Climate Change and the Carbon Budget

The Carbon Budget is the maximum allowable amount of carbon dioxide emissions that would limit global average temperature increases to a given level. Removing excess of CO_2 and preventing it from entering the atmosphere are two of the main objectives of the scientists for controlling climate change. Accordingly, they started researching, studying, developing and installing several new technologies to capture carbon dioxide and store it in safe locations deep underground for long time, in saline aquifers and in old gas and oil fields. In Europe, there are several studies being conducted and work being made with the intention to permanently store CO_2 carbon within geological rocks formation located underneath the North Sea [1].

CCS Map

Carbon capture and storage (CCS) projects are spreading around the world. There is a plenty of information resources available in the internet for large-scale projects which capture, transport and store CO_2. These pieces of information could be accessed by searching for and accessing the CCS maps available in the internet. CCS maps will provide information on CCS project such as the project location, purpose, phase, project start and operational date as well as the CO_2 capturing and injection or usage capacity per year.

Controlling CO_2 Emission

Sources of CO_2 emissions include manufacturing industries such as steel and cement industries, vehicle, building and electricity generation systems as well as deforestation, land clearing for agriculture, and degradation of soils. In order to achieving net-zero emissions by 2050, energy systems must be controlled and to reduce their emissions. Several governments have plans and laws for regulating and reducing emissions of CO_2 from the energy sector and industries by using electrification, hydrogen, bioenergy to replace technologies that use fossil fuels and by capturing CO_2 and storing it deep underground. Decarbonization from electrification is expected to be 35 %, while 25 % of decarbonization from Capron capturing, 20% from using bioenergy and 5% from hydrogen [2]. Around 30% of all UK carbon emissions come from heating and cooking using natural gas. Converting the UK natural gas grid to hydrogen will be a major step toward reducing the carbon emission. Since July 11, 2016, UK was working to convert the existing large natural gas network to 100% hydrogen such as the one in Leeds [3].

CO_2 capture technologies

Carbon capturing technologies are classified as Post-Combustion Capture, Oxy-fuel Combustion and Pre-Combustion Capture. Post-combustion captures CO_2 from flue gas after combustion, pre-combustion captures CO_2 in the synthetic gas or fossils before combustion while Oxy-fuel captures CO_2 by combusting hydrocarbon fuel in pure oxygen to generate flue gas with high concentrations of CO_2 and water vapor. Water vapor is removed using dehydration process.

Post-Combustion Capture

The flue gas which consists of CO_2 and other gases passes through the bottom of the absorber and contacted with the solvent which enters the absorber from the top. Other gasses will leave the absorber from the top while solvent rich with the CO_2 leave from the bottom of the absorber. The mixer is pumped and heated up before entering the CO_2 desorber from the top, where it will be heated more to sperate CO_2 from the solvent and release it as gas from the top. The CO_2 will be compressed into a liquid to transport, use or store underground. The Solvent leaves at the bottom of the desorber with less CO_2, cooled down, pumped and returned to the CO_2 absorber to complete the circulation loop.

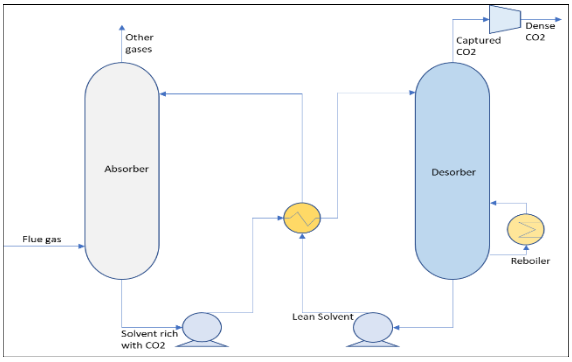

Figure 1: Post-Combustion Capture

Oxy-fuel Combustion Capture

Air separation unit use air to mainly generate oxygen and nitrogen. Oxygen combusts with natural gas in the boiler to produce CO_2 and water vapor, while the nitrogen or a recycled line of combustion gas is used as the diluent to cool down the boiler. The high pressure CO_2 mixture expand to generate electricity through Turing turbo expander, or could be separated into exhaust gas and hot steam, which could be used to drive steam turbine and generate electricity. The exhaust gas consists of around 90 % CO_2 and water, which is cold and water separated and removed resulting in a stream of 95 to 99% CO_2 that compressed and exported for sequestration or commercial use.

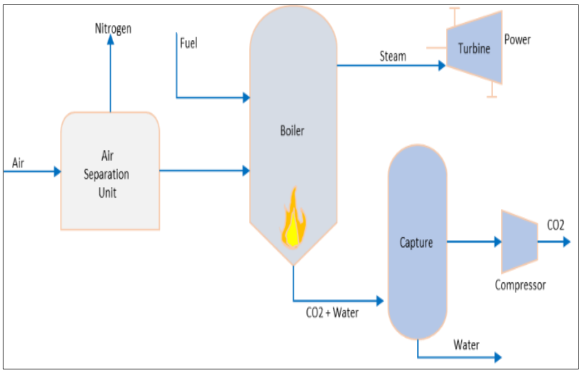

Figure 2: Oxy-fuel Combustion Capture

Pre-Combustion Capture

Air separation unit uses air to mainly generate oxygen and nitrogen. Oxygen reacts with solid fuel in the gasifier at high temperature and high pressure to form high pressure syngas, composes of hydrogen, carbon monoxide, carbon dioxide and water. Syngas will enter shift reaction for the carbon monoxide and water vapor to react and to form more carbon dioxide and hydrogen. The syngas now contains high-pressure hydrogen, carbon dioxide and water. In the capture unit, CO_2 will be removed as it reacts with the solvents while the hydrogen does not. CO_2 after is compressed and transported for storage or commercial use, while the hydrogen can be stored or burned at gas turbine to generate electricity.

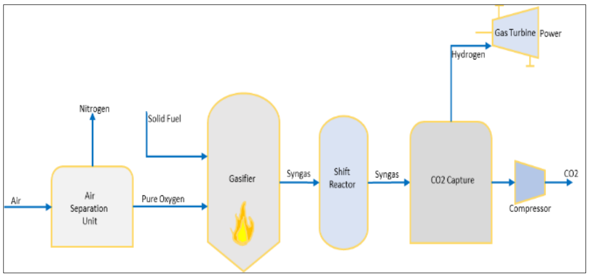

Figure 3: Pre-Combustion Capture

Net-zero emissions

Net-zero emissions can be achieved when any gas emissions released into the atmosphere are balanced with the amount of gas removed from the atmosphere. It is one of the important targets that need to be achieved by year 2050 with the aim to limit average global average temperature increases to 1.5°C above pre-industrial levels. This is the main goal the of Paris Agreement, "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels." [4].

Direct Air Capture technology

Huge fans pull air inside a structure. Potassium hydroxide solution flows over thin plastic surfaces inside the structure and removes CO_2 from the air and form carbonate or salt solution. This carbonate solution will be subjected to several chemical process to increase the concentration and purity of the CO_2, and to remove the salt and Potassium hydroxide solution for reuse in another carbon capture cycle [5].

Paris Agreement commitments

During the UN Climate Change Conference (COP21) in Paris, France, on December 12, 2015, the Paris agreement on climate change, which is a legally binding treaty, was adapted by 196 countries and came into forces on November 4, 2016. The main goal of this agreement is to limit global warming to 1.5C by the end of this century and to manage the global average temperature below 2°C above the pre-industrial level. Since 2020, Courtiers which are part of Paris Agreement are communicating their actions plans to reduce their greenhouse gas emission, which is known as Nationally Determined Contributions (NDCs). The progress made by each country will be monitored and tracked by Enhanced Transparency Framework (ETF) starting from 2024 [6].

Saudi Arabia Support Paris Agreement

Saudi Arabia signed Paris Agreement on November 03, 2016. Saudi Arabia's climate targets and initiatives are known as Saudi Green Initiative (SGI). The main target is of the SGI is to reduce carbon emissions by 278 Million Tonnes per Annum (MTPA) by 2030. The SGI main targets include using renewable energy to generate 50% of Saudi Arabia's required electricity by 2030, implementing new carbon capture projects, leading the production and exporting of clean hydrogen, enhancing energy efficiency and deploying waste management transformation projects [7].

Saudi Arabia Capron Capture Project

On May, 2022, a new project to build the world largest Carbon Capture and Storage (CCS) hub in Jubail Area was announced by Saudi Arabia's Minister of Energy, His Royal Highness Prince Abdulaziz bin Salman Al-Saud. The project will be completed by end of 2026 and will be on operation by 2027. It will be implemented on phases, with the aim to extract, transport and store 9 Million MPTA of CO_2 in the first phase, 22 MTPA at the second phase, and target 44 MTPA of CO_2 by 2035 [8].

The CO_2 streams are to be taken from Acid Gas Enrichment (AGE) units of several Saudi Aramco northern area gas plants; compressed, dried and fed into a collection pipeline system. Additional CO_2 will enter the pipeline collection network from several companies in Jubail after compression and drying. These CO_2 gaseous will be compressed at CCS centralized compression hub into dense phase CO_2 and sent for sequestration through the pipeline. The CO_2 will be injected underground into saline aquifer wells.

CO_2 Transport

Several methods are used to transport CO_2 from the source to the sink area for long term storage under the ground. Co_2 could be transported as gas or dense liquid phase using pipeline network, large-scale ships, train and truck. Pipeline and large-scale ships are the most common methods for transporting

CO_2. However, the cost of transporting CO_2 on ship is higher than transporting it on pipeline. Train and truck could be used as well for transporting CO_2, however, for small quantity.

Pipelines are the most practical method to transport CO_2 captured from different resources. CO_2 pipeline networks which serve multi-users are being developed globally; and being implemented onshore and offshore. In Saudi Arabia, the currently being designed to serve Jubail hub, will transport CO_2 onshore from five CO_2 emitters sources at the first phase, and around eight CO_2 emitters at the second phase. Another example, is the 1,000 Km CO_2 pipeline which is implemented offshore and connecting Belgium to Norway to transport 20 to 40 mtpa of captured CO_2 for safe and long term storage in the North Sea [9]. CO_2 transporting has not been demonstrated using large-scale ship, however, CO_2 shipping on small scale ship was demonstrated for a capacity of less than or equal 2000 ton of CO_2 [10].

Geological storage of CO_2

The geological structure of the earth contains trapped fluids for millions of years, because of this, it was found practical to store the CO_2 streams in underground geological formation. CO_2 is usually stored at depth of 1 to 3 km from earth service, where pressure is high and keep CO_2 at high density for better utilization of the underground storage volume.

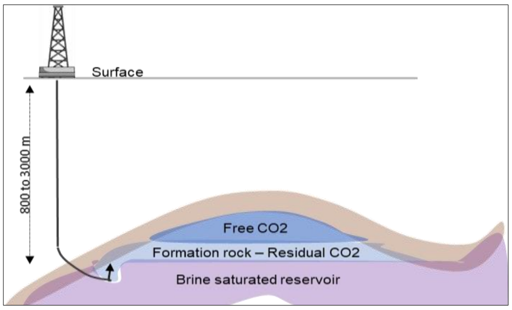

Figure 4: CO_2 Underground Storage

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References

1. CO_2MultiStore Joint Industry Project (sccs.org.uk)
2. Energy Technology Perspectives 2020 – Analysis - IEA
3. H21 Report (northerngasnetworks.co.uk)
4. The Paris Agreement | UNFCCC
5. Direct Air Capture Technology | Carbon Engineering
6. Reporting and Review under the Paris Agreement | UNFCCC
7. Saudi & Middle East Green Initiatives
8. Saudi Arabia to build largest CCS hub in Jubail (zawya.com)
9. Fluxys and Equinor launch solution for large-scale decarbonisation - Equinor
10. CO2 Transport and Storage – Analysis - IEA