Innovations in Carbon (IV) Oxide Capture and Sequestration for Operations, Engineering and Technology*

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Abstract

Fossil fuel combustion supplies more than 85% of energy for industrial activities and thus it is the main source of greenhouse gases in the form of CO_2. This is expected to remain unchanged for a long time as the world energy consumption doubles. Renewable energy is often a better option since it is environmental friendly but its technologies are not financially available for most countries. Carbon (IV) oxide capture and sequestration (CCS) is necessary for meaningful greenhouse gases reduction in the immediate future. CCS could reduce emissions by 19%. This is an important bridge between our lifestyle and an environmental friendly world. The components of CCS system include; capture (separation and compression), transport, injection and finally monitoring. Power plants, which are gas and coal fired, are the main source of CO_2. Other candidate sources include; cement production plants, refineries, petrochemical industries, oil and gas processing firms and natural gas wells. The methods of capturing CO_2 are pre-combustion, post-combustion and oxy-combustion/oxy-fuel. Possible sequestration places for the captured CO_2 include; geological storage, for example depleted oil and gas reservoir, enhanced oil recovery, un-minable coal seams and deep saline formations, ocean storage, mineral carbonation and algal growth. Each of the methods above has their advantages and shortcomings as discussed in the research paper. CO_2 can be utilized in various ways like, conversion into renewable fuels, formic acid, syngas, methane and methanol, utilizing CO_2 as a feedstock for organic and inorganic carbonates, urea and biodegradable polymers as well as non-conversion use of CO_2 for example as a geothermal fluid, used in enhanced oil recovery and beverage making. The challenges of CCS are; high cost of capture transport and injection, environmental and safety, subsurface uncertainty, legal and regulatory issues. Trappings contribute to storage of CO_2 in a site. They include; Structural and stratigraphic, residual, solubility, mineral trappings. In conclusion, an approach that integrates different methods of capture and storage of CO_2 may be a practical solution for CCS.

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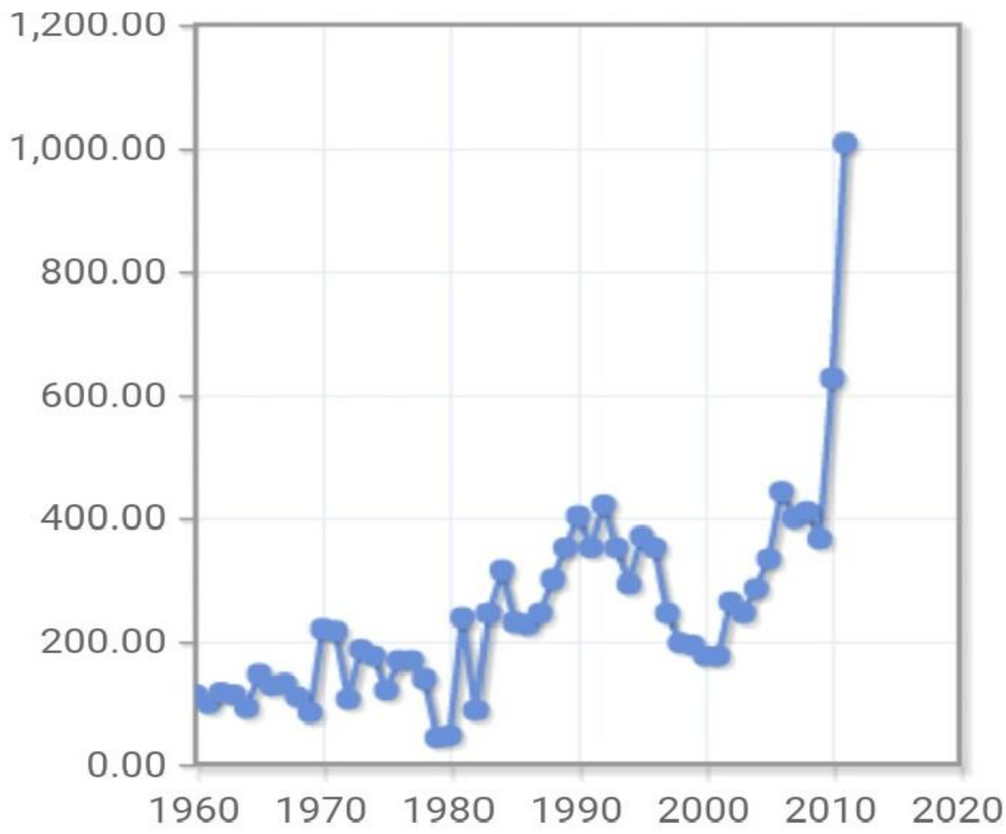
Introduction

- Concentration of greenhouse gases (GHG) in the atmosphere is rapidly increasing resulting to global warming and consequently climate change.
- In Kenya, climate change is the most considerable environment challenge in our time. It affects the eco systems, water resources, food security, health, human growth, rising surface temperatures and industrial activities.
- Combustion of fossil fuels is the major contributor of GHGs.
- Fossil fuels supply over 85% of industrial energy and world energy consumption is projected to double.
- Renewable energy is a better option but it is not financially and technologically available for most countries.
- CCS is very crucial in reduction of CO2 emissions by approx. 20% on a global scale.

Carbon (iv)oxide emissions in Kenya

Carbon (iv)oxide emissions from solid fuel consumption



Projects in Existence

- Carbon capture and storage projects both onshore and offshore have been in existence.
- 15 large scale CCS projects are in operation worldwide and have captured a total of 28 million tones of CO_2, mainly from industrial plants.
- 7 projects due to become operational and a further 23 in different stages of planning.
- Total potential number amounts to 45 with expected capture capacity of 80 million tones per annum.
- Commercial scale projects include Sleipner in Norway, Weyburn in Canada, In Salah in Algeria, Salt Creek in the USA and Gordon in Australia among others.

Projects in Existence…

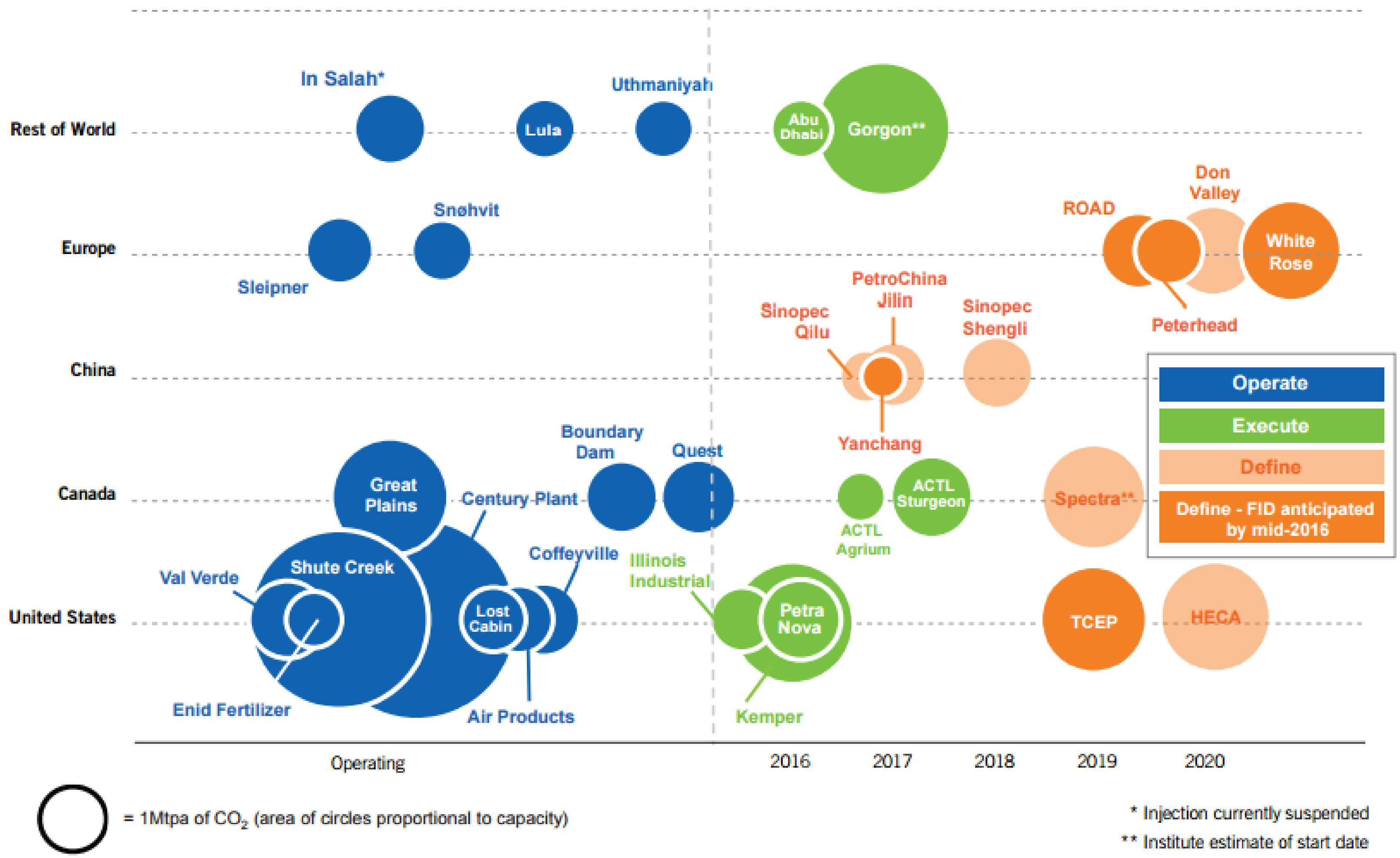


Figure 1: CCS Projects in existence on a global scale.

Sources of CO2 for CCS

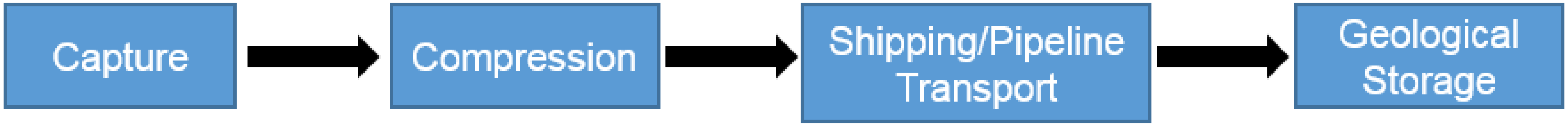
- Coal and gas fired power plants
- Cement production plants
- Oil and natural gas processing
- Refineries
- Fertilizer production factories
- Petrochemical industries
- Natural gas and oil wells
- Steel and Iron mills
- Blast furnace
- Biomass burning
- Deforestation
- Soil cultivation

Table 1: Large stationary sources of CO2 *emissions on a global scale.*

Process	Number of sources	Emissions ($MtCO_2$ yr^{-1})
Fossil fuels		
Power	4,942	10,539
Cement production	1,175	932
Refineries	638	798
Iron and steel industry	269	646
Petrochemical industry	470	379
Oil and gas processing	Not available	50
Other sources	90	33
Biomass		
Bioethanol and bioenergy	303	91
Total	**7,887**	**13,466**

Carbon Capture and Storage (CCS)

- Technological advancements ensure efficient capture, transport and storage.
- Components of CCS
  - Capture
  - Separation and compression
  - Transport
  - Injection
  - Monitoring



Carbon Capture

- The concentration, mobility, size and proximity to geological sites governs the viability of CO2 capture.
- Capture is chiefly applied in large centralized point sources.
- Pre-combustion
  - Involves the capture of CO2 before combustion.
  - High concentration and high pressure of CO2 in the gas stream makes its separation (physical or chemical) easier.

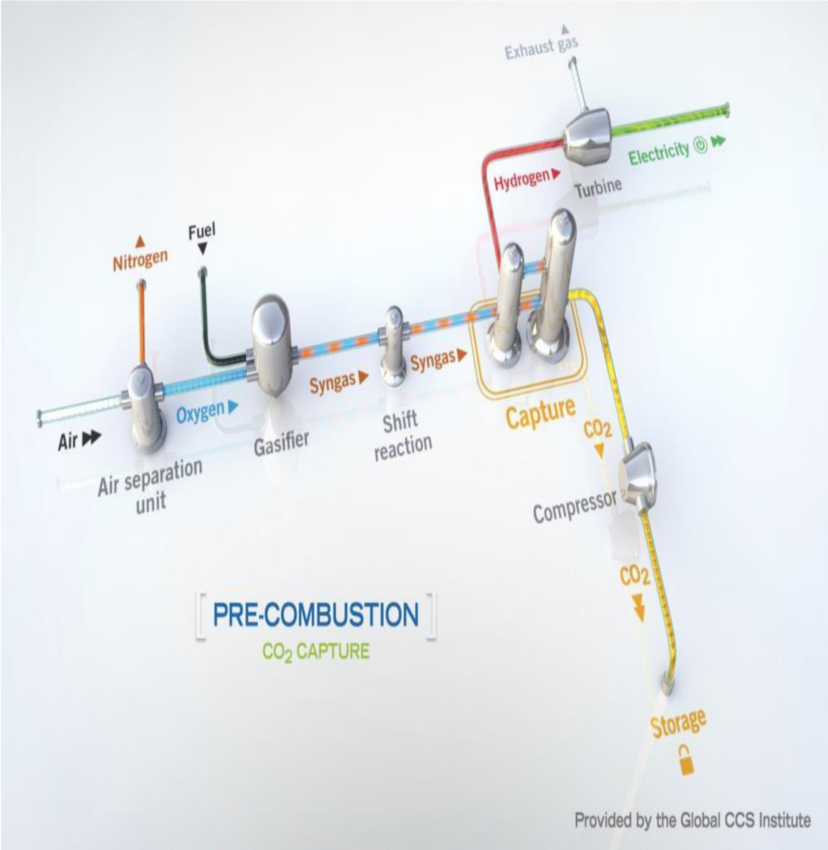


Figure 2. Pre-combustion

Pre-combustion capture

- This is the best carbon (iv)oxide capture technology for Kenya.
- Hydrogen gas produced will be burned for electricity production.
- Fuel vehicles and heat homes with near zero emissions.

Carbon Capture…

- Oxy-combustion capture
  - It involves firing a fuel in an oxygen rich environment.
  - It creates a concentrated stream of CO2 and water hence easier separation.
  - Water vapor is readily condensed and CO2 compressed and transported directly.

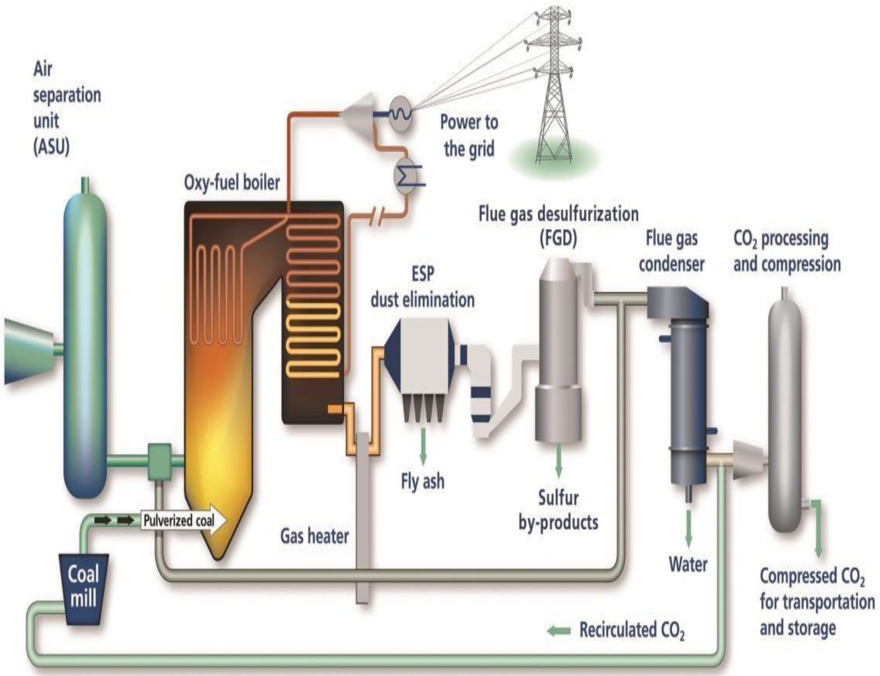


Figure 3. Oxy-combustion capture.

Carbon Capture…

- Post-combustion / flue gas separation capture
  - CO2 separated from the flue gases produced by combustion of a fuel then fed into a compression and dehydration unit.
  - Resulting to production of a stream of clean and dry CO2.
  - Ammonia is the most common absorbent used.

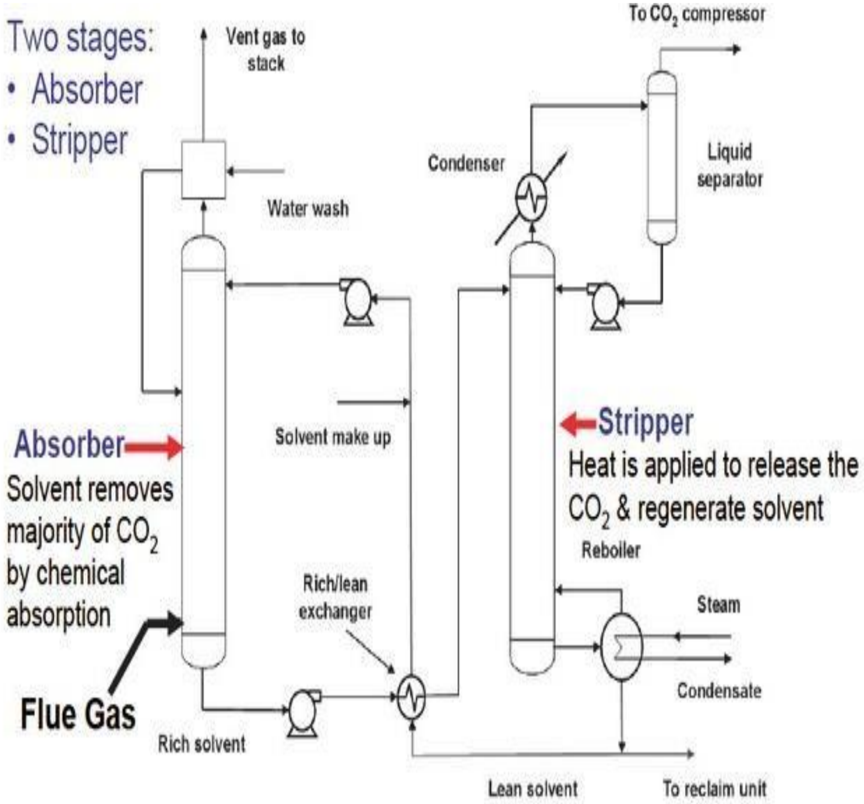


Figure 4. Post-combustion capture.

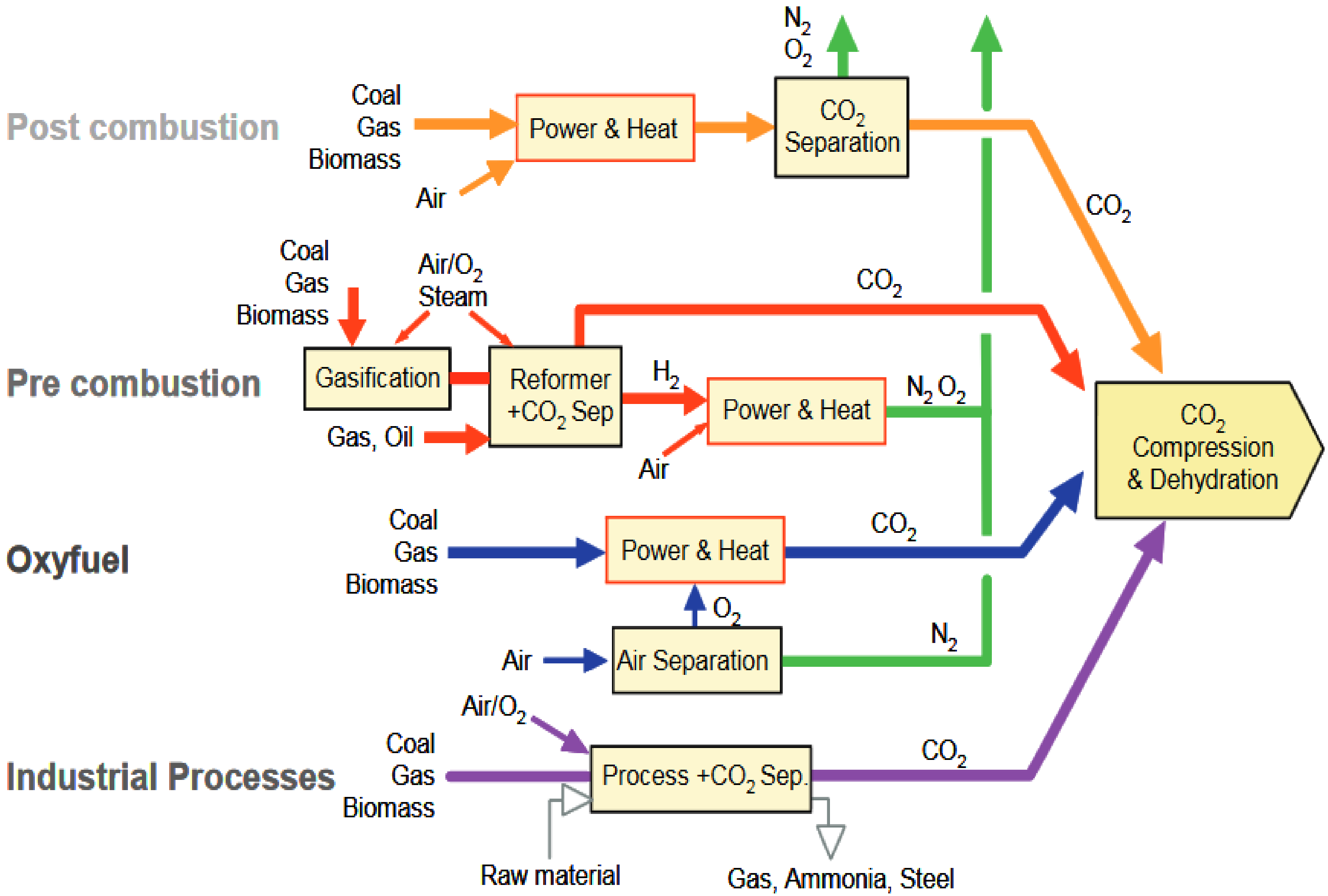


Figure 5. Overview of the processes used in CO2 capture.

Carbon Sequestration

- Storage of CO_2 involves injection into the storage site.
- Consists of an injection system comprising of storage facilities, distribution pipelines, measurement and control systems, compressors, well heads and injection wells.
- Main storage options include:
  - Depleted oil and gas reservoirs e.g. Salah and Weyburn CCS projects.
  - Deep saline aquifers e.g. Swooned, Snohvit and Gorgon CCS projects.
  - Producing oil and gas reservoirs coupled with enhanced oil recovery (EOR).
  - Deep un-minable coal seams.
  - Coal beds coupled with enhanced coal bed methane (ECBM).
  - Ocean sequestration.
  - Algae.

Trappings

- CO_2 is monitored after storage to ensure almost all of it stays out of the atmosphere for thousands of years.
- Trappings are used to prevent escape from escaping to the atmosphere.
- Trappings include:
  - Primary/structural trapping: - It occurs immediately after injection of CO_2.
  - Secondary trappings: – solubility trapping, residual trapping, mineral trapping and adsorption trapping.

Challenges facing CCS

- Problems in identifying adequate storage resources.
- Problems when developing safe, permanent and cost effective storage facilities.
- Failure to detect and quantify leakage out of storage units to the surface.
- High energy penalties of capture and uncertainties surrounding the storage phase.
- Cost of capture, transportation, injection and storage are very high.
- Policy and regulatory frameworks are needed to manage the economic, social and environmental risks of CSS.

Conclusion

- CCS is proposed as the potential viable way towards mitigation of global warming and consequently climate change.
- Need to critically assess the various capture, transportation and storage options for the successful application of CCS at a commercial scale.
- Need to sensitize and involve the public on the use and application of CCS and ensure necessary measures are taken to prevent any potential leakage of captured and stored CO2 back to the atmosphere, groundwater or soil acidification.
- Need to address the knowledge gaps in terms of environmental risks, cost implication, storage capacity assessment, monitoring techniques, polices and regulations before implementation of CCS.
- Pre combustion is the best technology that can be used by Kenya. However, different technologies can be integrated to give the best results.

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THE END

THANK YOU FOR LISTENING