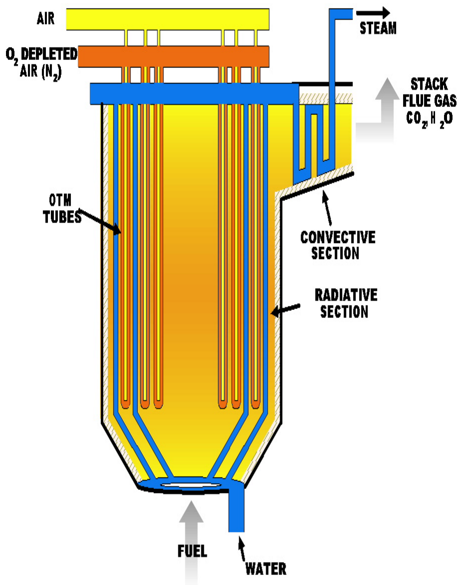
3.0 CAPTURING AND SEQUESTERING CARBON DIOXIDE

3.1. GEOLOGIC SEQUESTRATION

3.1.1 CO_2 CAPTURE AND SEPARATION

Technology Description



Oxyfuel Technology

Integrates air separation, using O2 Transport Membrane (OTM) and oxygen combustion

Fossil- and biomass-based energy conversion processes convert hydrocarbon materials (i.e., substances consisting mostly of carbon and hydrogen) into carbon dioxide and water while releasing energy. The goal of CO_2 capture and separation is to produce relatively pure CO_2 from these processes, preferably at pressures suitable for transport, storage, or reuse.

System Concepts

- *Post-combustion capture*. A chemical or physical separation process extracts CO_2 from the flue gas of a conventional air-fired combustion process. CO_2 is present in concentrations ranging from 3% to 12%. The focus is on technology for retrofitting or repowering existing power plants and industrial processes.
- *Oxy-fuel combustion*. Pure oxygen rather than air is charged to the combustion chamber, producing a flue gas of CO_2 and water. A portion of the CO_2 is recycled and mixed with the oxygen to absorb heat and control the reaction temperature.
- *Precombustion decarbonization*. The hydrocarbon feedstock is gasified to produce a synthesis gas made up primarily of hydrogen and carbon dioxide. The CO_2 is separated from the hydrogen before it is combusted or charged to a fuel cell.
- There are other advanced-system concepts in which fuel processing and CO_2 capture are integrated into a single stage using, for example, membranes or reduction-oxidation agents.

Representative Technologies

- The conventional technology for post-combustion capture (removing CO_2 from flue gas) is amine scrubbing. A solution of amine and water is contacted with flue gas. The amine and the CO_2 undergo a chemical reaction forming a rich amine that is soluble in the water. The rich amine solution is pumped to a desorber where it is heated, reversing the reaction and releasing pure CO_2 gas. The recovered amine is recycled to the flue-gas contactor.
- Other technologies for post-combustion capture include cryogenic distillation, membranes (polymer, ceramic, palladium, mine, or ionic liquid coated), carbon absorbents, sodium absorbents, hydrides, and lithium silicate.

Technology Status/Applications

- Amine systems are used in numerous industrial applications to capture CO_2 from flue gas for use as a commodity chemical. Cryogenic and carbon absorbent systems have been built commercially.
- Other post-combustion capture technologies are being developed at the laboratory and pilot scale.

Current Research, Development, and Demonstration

RD&D Goals

- The metrics and goals for CO_2 capture research are focused on reducing the cost and energy penalty, because analysis shows that CO_2 capture drives the cost of sequestration systems. Similarly, the goals and metrics for carbon storage and measurement, monitoring, and mitigation (MM&V) are focused on permanence and safety. All three research areas work toward the overarching program goal of 90% CO_2 capture, with 99% storage permanence at less than 20% increase in the cost of energy services by 2007, and less than 10% by 2012.

RD&D Challenges

- CO_2 exists in air-combustion flue gas at low concentration, 3-12 volume percent, which makes post-combustion removal very expensive using current approaches.
- Flue gas contains reactive impurities that can adversely affect CO_2 capture systems.
- Transport and/or storage systems may require highly pure CO_2 product, which would increase cost.
- Loss of CO_2 temperature and pressure across the capture system.
- Wide-scale application of any one capture technology will be difficult, due to real estate constraints, availability of pollutant-control equipment, resource limitations, and economic and load demographics.
- Significant cost associated with compressing CO_2 for transportation and storage.

RD&D Activities

- Laboratory-scale experiments with advanced amines, ceramic membranes, high-temperature polymer membranes, vortex gas/liquid separator, ammonium and sodium bicarbonate, carbon absorbents, ionic liquids, aqueous ammonia, and electrochemical pumps.
- Pilot-scale tests with a novel oxy-fuel boiler, a CO_2/water hydrate process, a sodium-based CO_2 sorbent, aqueous K_2CO_2 promoted by piperazine, an oxygen-fired circulating fluidized bed, and a metal reduction-oxidation power generation process.

Recent Progress

- During a short three-year period, a strong portfolio of research projects for the existing and future power-generation fleet has been developed by DOE with more than 40% private-sector cost-share.
- The international community has been successfully engaged through participation in the International Energy Association Greenhouse Gas Programme, the CO_2 Capture Project with the European Commission and other international participants, and other collaborations with Canada, Australia, and Japan.
- Analysis by the Carbon Sequestration Regional Partnership on the likely and probable application of various technologies to different point sources has been conducted and will continue in Phase II (utility and nonutility).

Commercialization and Deployment Activities

- Roughly 15 Mt/yr of CO_2 is captured from anthropogenic emissions sources in the United States and used as a commodity chemical.

Market Context

- Development of approaches for economically decarbonizing fossil fuels will allow the carbon-free production of electricity and hydrogen, and will take advantage of an existing fossil fuel infrastructure that accounts for more than 80% of the energy consumed in the United States and internationally.