Chapter 8
Carbon Capture and Storage (CCS)

8.1 Potential for Carbon Capture and Storage

Worldwide anthropogenic CO₂ emissions were around 26 Gt CO₂/year in the year 2005. This quantity can be attributed to the use of crude oil, coal and natural gas, contributing 40, 40 and 20%, respectively. Around 60% of the total emissions can be put down to roughly 8,000 big emitters, each with annual CO₂ emissions larger than 0.1 Mt CO₂/year. Electrical power production, with roughly 5,000 large power plants having emissions of more than 0.1 Mt CO₂/year, has a share of around 45% of the emissions worldwide.

Energy agencies typically assume that the contribution of the various energy carriers and the share of the primary energy used in electric power production (presented in Chap. 1) will not change substantially in the medium term. In consequence, with the predicted rates of increase of energy consumption and electric power production, CO₂ emissions will drastically rise in the next 20 years. Predictions based on various sources forecast an increase in CO₂ emissions to about 38 Gt CO₂/year up to the years 2025–2030 (IPCC 2005; IEA 2002, 2006; DoE 2005) – see also Chap. 1.

It is obvious that, in the long term, humanity will not succeed in restricting the release of CO₂ emissions by more efficient power plant technologies alone. Fossil fuels can ensure the supply of electric power in an energy mix with renewable energy sources only when there is successful separation of carbon dioxide from the power production process and storage of it in a safe way.

Carbon capture and storage (CCS) is seen today as a way to satisfy the global hunger for energy from fossil fuels on one hand and to limit the impacts on the Earth’s climate on the other. The projected potential of CO₂ capture has been estimated at an annual 2.6–4.9 Gt CO₂ by 2020 (0.7–1.3 GtC) and 4.7–37.5 Gt CO₂ by 2050 (1.3–10 GtC) (DoE 2005). This will only remain an option if suitable methods are developed to separate the carbon dioxide from power production processes and to store it underground.

The following technical tasks arise as a consequence:

– Separation of carbon dioxide in the power production process
– Conditioning and transport of carbon dioxide
8.2 Properties and Transport of CO₂

The physical state of carbon dioxide varies with temperature and pressure as shown in Fig. 8.1. At normal temperatures and pressure, carbon dioxide is a gas. At atmospheric pressure and temperatures far below ambient temperatures, carbon dioxide is a solid. With increasing temperature, the solid will sublime directly into the vapour phase – at atmospheric pressure, carbon dioxide sublimes at a temperature of −78.5 °C. At intermediate temperatures between the temperature of the triple point (−56.5 °C, 5.2 bar) and the temperature of the critical point (31.1 °C, 73.9 bar), a pressure increase results in a gradual state change as a two-phase gas–liquid mixture. At ambient temperature and pressures above 60 bar, carbon dioxide is a liquid. At temperatures higher than 31.1 °C and pressures above 73.9 bar, carbon dioxide is in a supercritical state, where it behaves as a gas. The density of carbon dioxide is given in Fig. 8.2 as a function of pressure and temperature.

The transport of the carbon dioxide is the tie between the emitter and the CO₂ storage location. Depending on the transport and storage mechanisms, CO₂ has to have a certain condition. To give an example, for the injection of CO₂ into depleted oil fields or gas reservoirs, the carbon dioxide ought to be provided pressurised in