

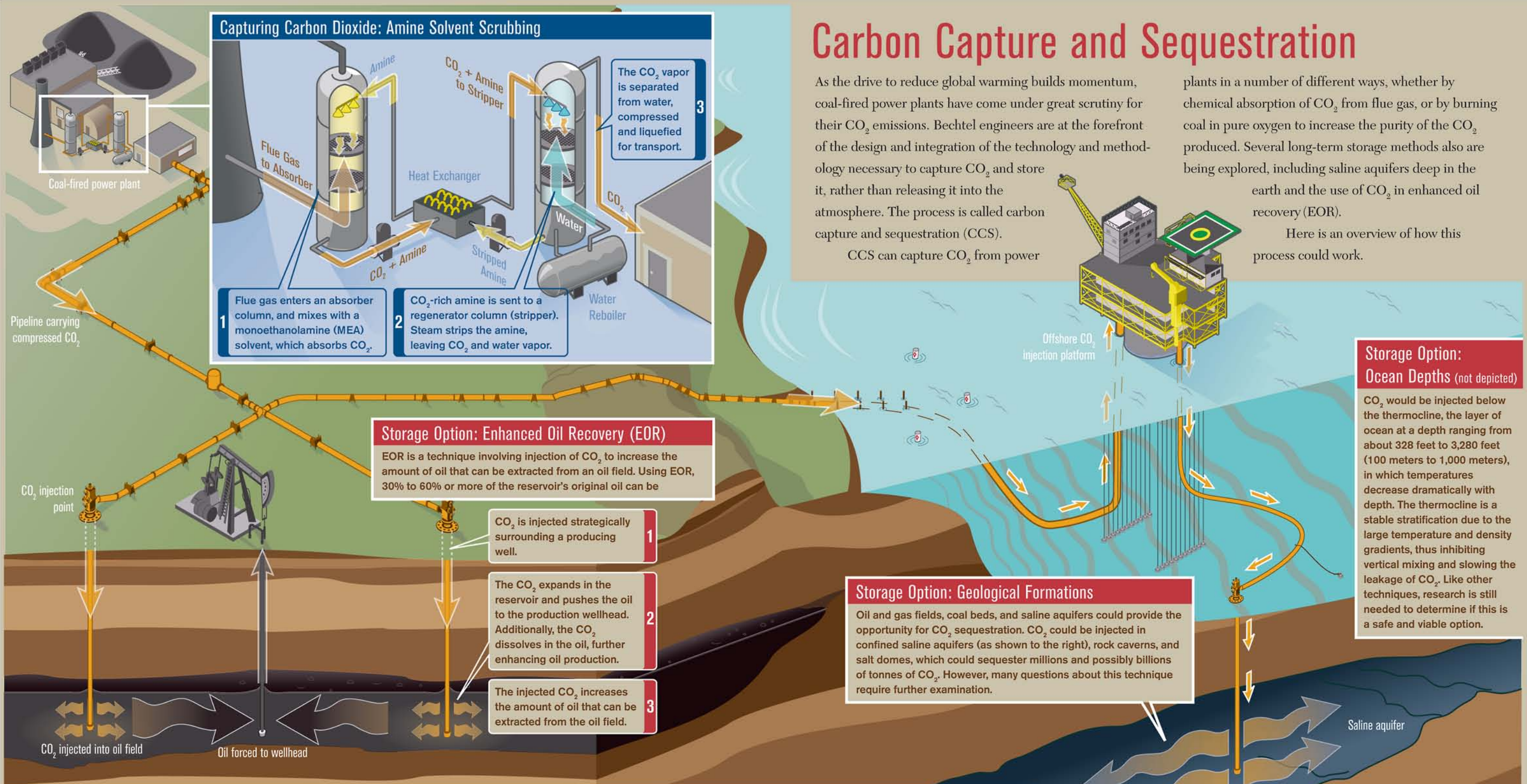
# Carbon Capture and Sequestration

As the drive to reduce global warming builds momentum, coal-fired power plants have come under great scrutiny for their CO<sub>2</sub> emissions. Bechtel engineers are at the forefront of the design and integration of the technology and methodology necessary to capture CO<sub>2</sub> and store it, rather than releasing it into the atmosphere. The process is called carbon capture and sequestration (CCS).

CCS can capture CO<sub>2</sub> from power

plants in a number of different ways, whether by chemical absorption of CO<sub>2</sub> from flue gas, or by burning coal in pure oxygen to increase the purity of the CO<sub>2</sub> produced. Several long-term storage methods also are being explored, including saline aquifers deep in the earth and the use of CO<sub>2</sub> in enhanced oil recovery (EOR).

Here is an overview of how this process could work.



### Capturing Carbon Dioxide: Amine Solvent Scrubbing

- 1 Flue gas enters an absorber column, and mixes with a monoethanolamine (MEA) solvent, which absorbs CO<sub>2</sub>.
- 2 CO<sub>2</sub>-rich amine is sent to a regenerator column (stripper). Steam strips the amine, leaving CO<sub>2</sub> and water vapor.
- 3 The CO<sub>2</sub> vapor is separated from water, compressed and liquefied for transport.

Labels in diagram: Flue Gas to Absorber, Amine, CO<sub>2</sub> + Amine to Stripper, Heat Exchanger, Stripped Amine, Water Reboiler, Water, CO<sub>2</sub>.

### Storage Option: Enhanced Oil Recovery (EOR)

EOR is a technique involving injection of CO<sub>2</sub> to increase the amount of oil that can be extracted from an oil field. Using EOR, 30% to 60% or more of the reservoir's original oil can be

- 1 CO<sub>2</sub> is injected strategically surrounding a producing well.
- 2 The CO<sub>2</sub> expands in the reservoir and pushes the oil to the production wellhead. Additionally, the CO<sub>2</sub> dissolves in the oil, further enhancing oil production.
- 3 The injected CO<sub>2</sub> increases the amount of oil that can be extracted from the oil field.

Labels in diagram: CO<sub>2</sub> injection point, CO<sub>2</sub> injected into oil field, Oil forced to wellhead.

### Storage Option: Ocean Depths (not depicted)

CO<sub>2</sub> would be injected below the thermocline, the layer of ocean at a depth ranging from about 328 feet to 3,280 feet (100 meters to 1,000 meters), in which temperatures decrease dramatically with depth. The thermocline is a stable stratification due to the large temperature and density gradients, thus inhibiting vertical mixing and slowing the leakage of CO<sub>2</sub>. Like other techniques, research is still needed to determine if this is a safe and viable option.

### Storage Option: Geological Formations

Oil and gas fields, coal beds, and saline aquifers could provide the opportunity for CO<sub>2</sub> sequestration. CO<sub>2</sub> could be injected in confined saline aquifers (as shown to the right), rock caverns, and salt domes, which could sequester millions and possibly billions of tonnes of CO<sub>2</sub>. However, many questions about this technique require further examination.

Labels in diagram: Saline aquifer.

### Carbon Capture R&D

#### Algae Bioreactor

Flue gas is sent through a bioreactor containing specially selected sun-bathed micro-algae which consumes the CO<sub>2</sub>.

#### Chemical Looping

Employs circulating metal (Me) or calcium oxide to carry oxygen for combustion, resulting in highly pure CO<sub>2</sub> for capture.

#### Chilled Ammonia

Flue gas chilled to 35° F enters a system with a CO<sub>2</sub>-absorbing slurry of ammonium carbonate (AC) and ammonium bicarbonate (ABC).

#### Oxy Combustion

Oxygen, rather than air, is used to combust fuel. This results in highly pure CO<sub>2</sub>, which is then recycled to regulate combustion.