THE GNCS FACTSHEETS

Carbon Capture and Storage (CCS)

Carbon dioxide (CO_2) emissions from coal-based power generation alone amount to 8.7 billion tons (Gt) – 30% of global CO_2 emissions.[1] As the demand for energy increases, this share is projected to reach 34% in 2030.[2] The demand for coal is forecast to rise by 53% over the next 20 years,[3] faster than any other non-renewable energy source.[4] This growth is driven primarily by electricity needs in emerging markets: CO_2 emissions from coal-fired plants in China alone will represent one-third of global CO_2 emissions from power generation in 2035.[5] Carbon capture and storage (CCS) technologies can help mitigate emissions from fossil fuel use in power generation, industry and fuel transformation,[6] and is particularly critical to allow coal to meet the world's energy needs.[7] However, the prospects for CCS are dimmed by its high costs, currently prohibitive for market actors in the absence of a carbon price, and by the time constraint, due to the risk of "carbon lock-in" over the next two decades.[8]

Status of Capture Technology

Each stage of CCS, from CO_2 capture and compression from stationary sources to its transportation and geological storage, is technically feasible and in use today.[9] CCS is already deployed in the oil, gas, and chemical industries, particularly for enhanced oil recovery (EOR). Capture technologies (post-combustion, pre-combustion and oxy-fuel) are energy-intensive: around 10–40% more energy is required with CCS than without. They can theoretically capture around 90% of CO_2 emissions they are applied to.[10] Post-combustion capture using solvent scrubbing is one of the most established technologies.[11] CO_2 transport via high-pressure pipelines has been used for decades.[12] Carbon has been sequestered into geological formations,[13] but this poses safety and leakage risks that require new regulatory frameworks (see GNCS factsheet on carbon storage).[14]

Bottleneck: Large-scale Demonstration

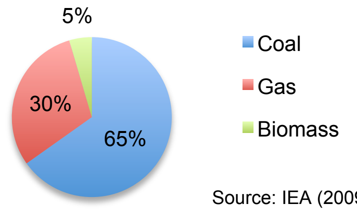
While all the elements of CCS technology are proven and in use, they have yet to be fully integrated into commercial-scale power plants.[15] In 2010, there were 53 CCS demonstration projects underway worldwide (including 17 large-scale[16] projects) and 52 further projects planned.[17] Most of these address just a few elements of the process. There are only nine integrated, operational commercial CCS projects worldwide, most of them linked to EOR and gas production, but none are large-scale.[18] EOR can help early CCS development but has a limited role in the long term.[19] Some 100 additional demonstration projects are needed by 2020 to show that CCS is safe and commercially viable, especially for coal-fired plants, and to bring down costs.[20] Funding pledged for large-scale projects has increased sharply in recent years: proposed government support exceeds $26bn. However, many projects have been delayed or cancelled, due to cost overruns, a lack of funding and regulatory

---

[1] IEA. (2009a). *World Energy Outlook 2009*. International Energy Agency. Annexes (based on 2007 data), p. 623.
[2] 13.87 $GtCO_2$ under business-as-usual assumptions, *Ibid*.
[3] World Coal Association (WCA), http://www.worldcoal.org/.
[4] Coal demand is projected to rise at an average annual rate of 1.9% (only modern non-hydro renewables will grow faster); coal currently represents 27% of the world's primary energy demand; IEA (2009a), p. 91.
[5] 6,737 of 18,931 Mt CO_2; IEA. (2010). *World Energy Outlook 2010*. International Energy Agency. Annexes, p. 621, 673.
[6] Energy efficiency aside; the targeted energy-intensive industries include: cement, iron and steel, chemicals and pulp and paper.
[7] MIT. (2007). *The Future of Coal – Options for a Carbon-Constrained World*. Massachusetts Institute of Technology. p. x.
[8] 40 years or more; IEA. (2009b). *Technology Roadmap: Carbon Capture & Storage*. International Energy Agency.
[9] *Ibid*.
[10] McKinsey. (2008). *Carbon Capture & Storage: Assessing the Economics*. McKinsey & Co. p. 9; WCA website, "CCS Technologies."
[11] *Ibid*.
[12] IEA (2009b).
[13] Mineralization and ocean carbon sequestration have limited capacity and are at an early development stage.
[14] IPCC. (2006). *IPCC Guidelines for National GHG Inventories*. Intergovernmental Panel on Climate Change. Ch. 5. "CO_2 Transport, Injection and Geological Storage." p. 13.
[15] WCA website, "The Role of CCS."
[16] "Large-scale" is defined by the Global CCS Institute as capturing at least 80% of 1 $MtCO_2$ per year for coal-fired power plants and at least 80% of 0.5 $MtCO_2$ per year for gas-fired plants and industrial units.
[17] Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), http://www.co2crc.com.au/.
[18] See definition of "large-scale" at fn.16; the largest existing project captures up to 3 $MtCO_2$ per year at the Dakota Great Plains syngas plant in the US, but this is less than 50% of emissions. CSLF. (2010). *CSLF Technology Roadmap*. Carbon Sequestration Leadership Forum. p. 28.
[19] MIT (2007), p. xii; IEA (2009b), p. 24.
[20] Interagency Task Force on Carbon Capture and Storage. (2010). *Executive Summary: Report of the Interagency Task Force on Carbon Capture and Storage*. US EPA & DOE. p. 3; IEA (2009b), p. 8.

framework, and low public acceptance.[21] Most projects are located in North America, Australia and the EU.[22]

CCS potential in the power sector by 2050 (1140 GW installed)



Source: IEA (2009b)

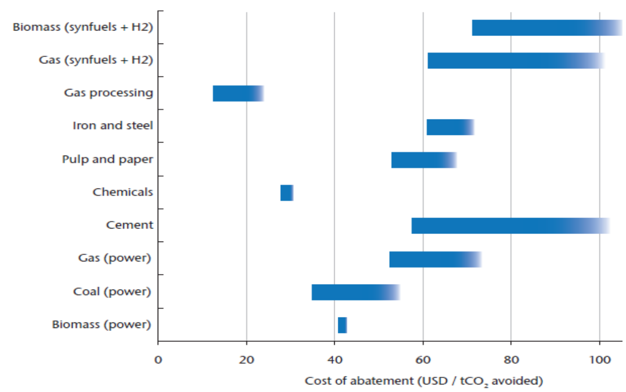
Abatement Potential

CCS could potentially abate between 1.4 and 4 $GtCO_2$ equivalent emissions globally by 2030.[23] Plentiful storage potential exists but exploration programs are urgently required to locate storage sites.[24] Although CCS can be applied to multiple CO_2 stationary sources, its application to integrated gasification combined cycle coal-fired power plants in North America and emerging markets, especially China, offer the greatest potential.[25] By 2050, coal-fired power plants could represent 65% of CCS deployment in the power sector, and one-third overall.[26] Other low-cost opportunities include sectors such as natural gas combined cycle power plants, gas processing, iron and steel, and biomass production.[27] Building new plants "capture-ready" poses a challenge due to the added space required for equipment.[28] Retrofitting existing plants is more expensive than building new ones.[29] The current decade is a key "make or break" period: without CCS, emissions will be "locked-in" during the operational life of the new fossil fuel plants built to meet emerging markets' electricity needs.[30]

Costs of CCS

As capture technologies require high capital costs and are energy-intensive,[31] capture and compression account for 70–90% of the overall cost.[32] CCS deployment in chemicals and enhanced oil and gas recovery represent early, low-cost capture opportunities.[33] The current incremental cost of CCS in new US coal-fired plants is \$60–95/tCO_2 avoided.[34] Projections of abatement costs up to 2050 range between \$35–50/tCO_2 avoided (including \$30–40 for CO_2 capture) in large coal-fired power plants, against \$53–66/tCO_2 avoided for gas-fired plants.[35] CO_2 capture from power plants, without transport and storage, is estimated to add at least 1.5 US cents per kilowatt-hour (kWh) to the cost of electricity generation.[36] For CCS to contribute 20% of emissions reductions, the IEA estimates that investment of \$2.5–3 trillion is needed by 2050 to deploy some 3,400 CCS projects.[37] Without a carbon price, commercial plants and industrial facilities have no incentives to invest in CCS, as it reduces efficiency and energy output and raises cost.[38]

Ranges of CCS abatement costs



Source: IEA (2009b)

Only integrated demonstration projects can prove CCS' long-term viability. Another key barrier to deployment is the lack of regulatory framework. The transport and storage of CO_2 pose regulatory and public acceptance risks (see the GNCS factsheet on carbon storage).[39]

Geraldine Ang; series editor Nico Tyabji

Further resources are available at **www.theGNCS.org**

---

[21] CSLF (2010), p. 30.
[22] Global CCS Institute (2011) offers a comprehensive project database.
[23] McKinsey (2008: 12) cite estimates of 1.4 Gt (Stern, 2004), 3.5 Gt (McKinsey & Vattenfall, 2007) and 4 Gt (IEA, 2007).
[24] IEA (2009b), p. 32.
[25] Interagency Task Force (2010).
[26] IEA (2009b).
[27] *Ibid.*, p. 17-20.
[28] *Ibid.*
[29] IPCC. (2005). *Special Report on Carbon Dioxide Capture and Storage.* Intergovernmental Panel on Climate Change. p. 152.
[30] 40 years or more; *Ibid.*
[31] Interagency Task Force (2010), p. 4; IEA (2009b), p. 9.
[32] CSLF (2010), p. 15; Interagency Task Force (2010), p. 3.
[33] IEA (2009b), p. 22.
[34] Compared to new conventional coal-fired plants; NETL. (2010). *Cost and Performance Baseline for Fossil Energy Plants*. Vol. 1. "Bituminous Coal and Natural Gas to Electricity." National Energy Technology Laboratory, US Dept of Energy (DOE).
[35] *Ibid.*
[36] IEA GHG. (n.d.). *CO_2 Capture in Power Generation.* IEA Greenhouse Gas R&D Programme. p. 2.
[37] According to the IEA *Energy Technology Perspectives 2008* (ETP); in IEA (2009b), p. 5, 21.
[38] IEA (2009b).
[39] *Ibid.*