United Nations

CEP-12/2016/INF.5
Version 2, 20 October 2016

Economic and Social Council

Economic Commission for Europe

Committee on Sustainable Energy

Group of Experts on Cleaner Electricity Production from Fossil Fuels

Twelfth session

Geneva, 26–27 October 2016

Item 7d of the provisional agenda

CCS in mid-2016: a high-level overview

CCS is both criticized and promoted as an essential technology for meeting climate change emission reductions. Despite early ambition and excitement around this technology, a number of significant project cancellations have led to far fewer operating projects than expected by now and created uncertainty on the path forward. This does not change the overarching rationale for CCS, but rather supports consideration for what is the most practical way to support this technology. It is in this context that this short paper briefly considers the history and current status for CCS in 2016 and suggests action areas to support development.

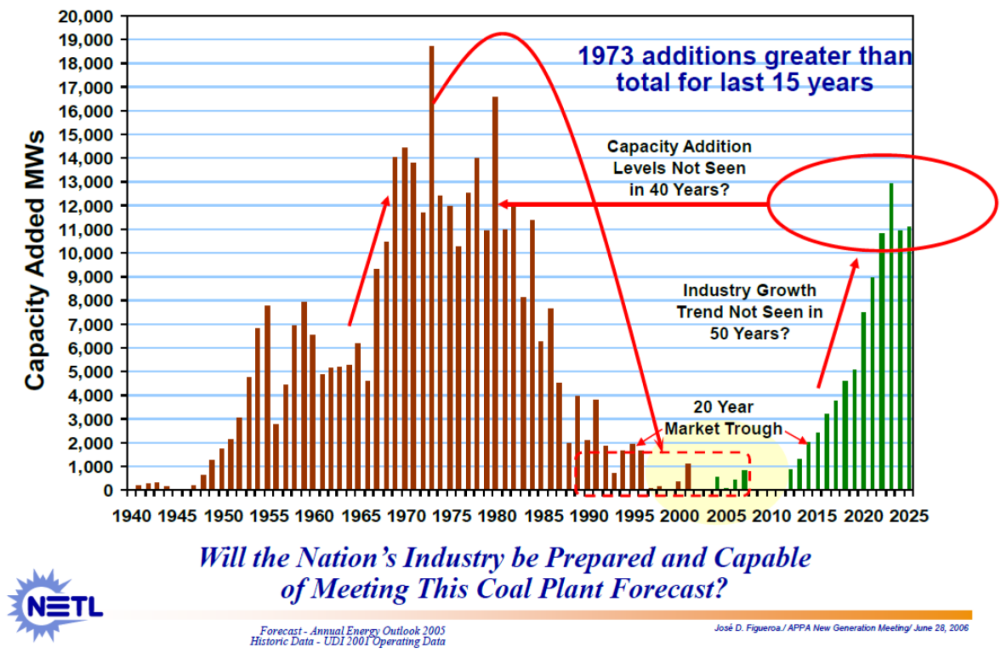
Early Ambition and Drivers for CCS

CCS technologies have been in existences since the 1970's (Table 1), but CCS reached international prominence as a climate change technology in mid to late-2000's. Early phases revolved around gas processing and industrial processes aligned, in some cases, with commercial uses for CO_2. The earliest climate based initiatives included: Sleipner, IEA GHG programme and the GHGT conferences, Gorgon planning, and Boundary Dam's first phases. Increased emphasis on climate mitigation benefits in addition to strictly commercial based approaches were supported by several seminal events:

- Inaugural Meeting of the Carbon Sequestration Leadership Forum: A Carbon Capture and Storage Technology Initiative, June 23-25, 2003, Tyson's Corner, Virginia;
- Gleneagles Conference, July 2005, where CCS first gets major political attention in its communiqué: "We will work to accelerate the development and commercialization of Carbon Capture and Storage technology";
- Australian Prime Minister Kevin Rudd formally launched the Global Carbon Capture and Storage Institute at the inaugural meeting of Institute foundation members in Canberra, January 2009.

Coal capacity expansion and pre-recession forecasts for the USA give an indication of global developments. Historical capacity additions shown below, and projected developments were optimistic driven by increasing demand and high natural gas and oil prices up to the 2009 recession (Figure 1). Figure 1 highlights the pre-recession expectation of increased use of coal and therefore reinforcing the need for CCS.

FIGURE 1: COAL CAPACITY HISTORY AND FORECAST AEO 2005



SOURCE: JOSÉ D. FIGUEROA, APPA NEW GENERATION MEETING, JUNE 28 2006

CCS for coal power plants was expected, with the firm expectation of a major coal build programme in the UK and much of the rest of Europe and in the USA and Canada. It was also anticipated that coal+CCS+EOR would be competitive with natural gas with no CCS (e.g. as at SaskPower's BD3 plant, Petra Nova, with offshore EOR)[1]. High natural gas prices and high oil prices (and hence CO2 sales price for EOR) are all part of a high oil price market and of 'Peak Oil' thinking.

Following the recession some very little of the forecasted coal power generation was constructed. Some CCS efforts continued because of commitments and established positions and, interestingly, because of:

- related technology based economic stimulus (e.g. the incoming Obama administration developed a programme of CCS projects for Stimulus funds but with viability based on them also getting Waxman-Markey Act funding for operating costs);
- CCS by hydrocarbon companies to cut CO_2 from their own production activities as a demonstration or when financially viable (e.g. Gorgon, Snohvit, Quest, InSalah, Peterhead DF1)
- 'Conventional' EOR with anthropogenic CO2 instead of natural CO2 (e.g. Weyburn, Midland Daniel)

[1] Carbon Dioxide Capture and Storage - A Win-Win Option?, UK DTI, 2003. Report number: ED 01806012

TABLE 1: SELECTION OF HISTORICAL AND RECENT CCS PROJECTS AND ATTRIBUTES

Start year	Project	Sector	Steps in the CCS chain deployed	Primary product cost increase	Commercial foundation	Social/political foundation
1972	Val Verde, United States	Gas processing	Capture, injection	Low	CO_2 sales (EOR)	
1978	Searles Valley, United States	Electricity/ chemicals	Capture	Low	CO_2 sales (800 tCO_2/day for soda ash)	
1996	Sleipner, Norway	Gas processing	Capture, injection, monitoring	Low	CO_2 tax, technology development	Technology leadership, climate commitment, fossil fuel revenues
2000	Great Plains, United States; Weyburn, Canada	Refining (coal-to-liquids)	Capture, transport, injection	Low	CO_2 sales (EOR)	
2013	Lula, Brazil	Gas processing	Capture, injection	Low	CO_2 sales (EOR)	
2013	Port Arthur, United States	Refining	Capture, transport, injection	Low	CO_2 sales (EOR), public grant, tax credits, technology development	Climate action, technology leadership
2014	Boundary Dam, Canada	Electricity	Capture, transport, injection	High	CO_2 sales (EOR), public grant, emissions standard, regulated utility rates, technology learning	Climate action, low-cost coal resource
2015	Gorgon, Australia	Gas processing	Capture, injection, monitoring	Low	State mandate, technology development	Fossil fuel revenues, climate commitment
2015	Illinois Industrial CCS Project, United States	Biofuels	Capture, transport, injection, monitoring	Low	Public grant, tax credits	Climate action, technology leadership
2015	Quest, Canada	Refining (oil sands upgrading)	Capture, transport, injection, monitoring	Low	CO_2 tax, public grant, technology development	Climate commitment, fossil fuel revenues
2015	Uthmaniyah, Saudi Arabia	Gas processing	Capture, transport, injection, monitoring	Low	Oil sales (EOR), state-owned company, technology learning	Fossil fuel revenues, climate action
2016	Abu Dhabi project, United Arab Emirates	Iron and steel	Capture, transport, injection	Medium	CO_2 sales (EOR), state-owned company	Fossil fuel revenues, climate action
2016	Kemper County, United States	Electricity	Capture, transport, injection	High	CO_2 sales (EOR), public grant, tax credits, regulated utility rates, technology development	Low-cost coal resource, climate action, technology leadership
2016	Parish, United States	Electricity	Capture, transport, injection	High	Oil sales (EOR), public grant, tax credits, emissions standard, technology learning	Climate action, technology leadership

SOURCE: IEA, ENERGY TECHNOLOGY PERSPECTIVES 2015

The current position: after the recession and shale gas development:

Country Based Initiatives

In contrast to the projections for new coal power plant developments highlighted in Figure 1, minimal amounts of new coal were actually built in CCS-championing developed countries (e.g. USA, UK, Australia, Canada, NL) and there is little no prospect of any more. Additionally, in countries with low growth in electricity demand there is little prospect of new gas power. Significant growth in the deployments of wind and photovoltaic under low or decreasing demand scenarios damages the market prospects for non-subsidised fossil plants with non-zero dispatch costs. Currently, there are very few plans in place for further major fossil power projects in most of the CCS-championing developed countries (e.g. USA, UK, Australia, Canada).

The USA climate bill with incentives for CCS failed to get through the Senate and coal+CCS+EOR in North America can no longer compete with unabated natural gas, even with Government capital support. This situation has been exacerbated by falling oil prices and oversupply in global markets. A CO_2 EOR market exists at some price in North America and it is not clear if natural CO_2 production could be constrained in the future. But while the volumes the EOR market could use are spoken of as being high it appears unlikely that EOR CO_2 prices alone could reliably fund CCS on coal or on natural gas.

Some possibility that small-scale trial projects can be fast-tracked. Norway is planning again, but with a small-scale industry + shipping model. This approach is relevant as it is what would have to be done in many places in the absence of the scale and concentration of CO_2 emission sources required to justify a CO_2 pipeline infrastructure.

From a very recent UK Committee on Climate Change report, major CO_2 reductions from CCS are probably not needed in the UK until around 2030[2], but then after 2030 CCS could be required to be deployed quite rapidly and at scale using pipelines (with the non-CCS alternatives getting progressively more expensive approaching the 2050 80% reduction target and probably extremely expensive for a possible future net zero target). To prove that CCS can be deployed at scale, and to develop the necessary support mechanisms and industrial capacity, all of the key elements (in particular a shared pipeline cluster connected to offshore storage) must be deployed by the mid-2020s at the latest, now quite a tight schedule.

In some places such as the USA development of CCS for coal has continued to receive support, but coal+ partial CCS vs. unabated gas is very unfavourable for coal (and also does not address the significant level CO_2 emissions form unabated gas power). Coal+CCS vs natural gas+CCS, both at high levels of capture (90% +) would be better for coal (and mitigation action), but probably coal+CSS would still be more expensive in developed countries (particularly those with large amounts of renewables in the system and hence uncertain load factors).

If developed countries seen globally as champions for CCS now do not deploy much CCS then there is a significant knock-on effect. Other developed economies will not be inclined to invest in such plants or related infrastructure (e.g. Germany, Poland) nor are developing economies (e.g. China, India) under much pressure to deploy CCS, especially when there is not a sufficient economic incentive (e.g. Clean

---

[2] Meeting Carbon Budgets – 2014 Progress Report to Parliament, Committee on Climate Change, Presented to Parliament pursuant to section 36(1) and 36(2) of the Climate Change Act 2008

Development Mechanism) or immediate GHG emission incentive (e.g. more ambitious level for Paris Agreement nationally determined contributions (NDCs)) to drive it.

Technology Development

With no market for CCS it seems unlikely that many new technology concepts will be brought to commercial readiness by the next stage of CCS deployment since this would require major, speculative and high-risk funding for a reference plant.[3] Recent gasification-based trial plants (e.g. Kemper) have faced difficulty. Post-combustion capture (PCC) projects at BD3 and Parish (PetraNova) are proceeding reasonably as planned. It seems possible that when the next large-scale power CCS projects are built PCC may be the only commercially-proven choice available for coal and gas power and quite possibly the most competitive. PCC is also the only capture technology with full-scale experience available that can be used, with design studies and pilot-scale testing, to produce improved second generation PCC technologies for the next stage of CCS deployment.

CCS for non-coal Applications

Other non-coal CCS applications - such as energy-intensive industries, natural gas, biomass and hydrogen - are recognised as vital in CCS champion countries (and globally) but there is currently no immediate GHG constraint nor public opinion driver to make CCS as imperative as it was for new coal power plants in the pre-recession 'dash for coal'.

Energy-intensive Industries are usually grouped together but in practice are usually a very heterogeneous range of applications (technology, scale, cost, location etc.). In addition, sales of their products are almost always exposed to global competition so production costs cannot be raised without import controls. This acts as a significant barrier to both technology development and deployment prospects.

Natural gas CCS is limited due to limited new natural gas plant in many places. Construction of new plants are under pressure from intermittent renewables. Additionally, there may be reluctance by some stakeholders to get CCS associated with natural gas power because it may then become effectively impossible to build.

Biomass and waste combustion with CCS is of interest for negative emissions but no developed proposals to incentivise negative emissions seem to have been made anywhere yet.

Hydrogen is receiving more attention again, not only in its 'traditional' role as a transport fuel, but also for heat in buildings, industry and electricity production in markets where (subsidised) zero-dispatch-cost renewables make CCS plant load factors uncertain. Hydrogen production from fossil fuels with CCS is likely to be the lowest cost CO_2 route to 'low carbon emission' hydrogen in most economies.

There is some realisation that in a carbon-constrained world with unburnable fossil fuel reserves that fossil fuel prices will be low. The final position, in a net-zero emission world, is that fuel suppliers will only be able to sell fossil fuel at a price that allows CCS to be applied. Competing non-fossil energy service costs then set combined fossil+CCS prices. But we are not in such a world at present, nor is it certain when or if we will be. Lastly, the uncertainty in the timing and scope for new nuclear power

---

[3] The Allam Cycle is a possible exception.

plants also makes the timing and scope for CCS deployment uncertain in many places such as the USA and UK

Action areas to contribute to the next stages of CCS deployment:

CCS Ready: Generally, the idea of building new fossil infrastructure to be CCS ready is becoming more accepted and understood, although anecdotal evidence suggests that this is deliberately not stated in some cases to avoid pressure to undertake CCS before competitors. This also requires some thought to be suitable for specific infrastructure and to accommodate changes as CCS technology develops. Defining future shared pipeline routes would help in many countries.

Fast-track small scale projects: These could help to raise the profile of CCS and to partially rebuild industry confidence and also can be used (in conjunction with other activities, see below) as part of a programme of cost and/or risk reduction for future projects. Small-scale CCS could also have direct applications in some markets, not least for flexibility to cope with intermittent renewable outputs. Shipping CO_2 is also in this category.

Policy Parity: The idea that CCS should be supported in analogous ways to renewables appears to be getting more traction in the UK (with CfDs for electricity) and the USA, but there has probably been limited attention to this elsewhere. Additional development of such concepts is needed.

Storage: Significant additional effort is needed to better identify and quantify the potential for CO_2 on a global basis. New areas need to be identified and studied and sites currently identified need to be de-risked further for prospective storage applications. There will be potentially significant storage development costs, especially for offshore storage.

Regulation and policy: National and international laws and regulations need to allow CCS (e.g. the London Protocol amendments for cross-border CO_2 transfer is not ratified yet). CCS treatment in GHG accounting may still have issues. Long term liability for stored CO_2 is a potential show-stopper for private companies.