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Carbon capture and storage as a corporate technology strategy challenge

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ABSTRACT

Latest estimates suggest that widespread deployment of carbon capture and storage (CCS) could account for up to one-fifth of the needed global reduction in CO_2 emissions by 2050. Governments are attempting to stimulate investments in CCS technology both directly through subsidizing demonstration projects, and indirectly through developing price incentives in carbon markets. Yet, corporate decision-makers are finding CCS investments challenging. Common explanations for delay in corporate CCS investments include operational concerns such as the high cost of capture technologies, technological uncertainties in integrated CCS systems and underdeveloped regulatory and liability regimes. In this paper, we place corporate CCS adoption decisions within a technology strategy perspective. We diagnose four underlying characteristics of the strategic CCS technology adoption decision that present unusual challenges for decision-makers: such investments are precautionary, sustaining, cumulative and situated. Understanding CCS as a corporate technology strategy challenge can help us move beyond the usual list of operational barriers to CCS and make public policy recommendations to help overcome them.

1. Introduction

There is now a scientific and policy consensus that stabilizing atmospheric concentrations of greenhouse gas (GHG) emissions will require fundamental technological and associated institutional changes. The pressing technology management question is no longer whether to invest in GHG-reducing technologies, but which technologies to emphasize among the portfolio of promising options. Government policy-makers need to decide how to incent the development of appropriate GHG mitigation technologies; corporate decision-makers face choices on how to develop corporate technology strategies within a carbon-constrained context.

One family of technologies that is almost universally relied upon in future mitigation and stabilization scenarios is carbon capture and storage (CCS). According to the International Energy Agency, widespread deployment of CCS could account for one-fifth of the needed global reduction in emissions by 2050. CCS accounts for one of Socolow's seven "wedges" that each promise reductions of one billion tons of carbon each year by 2050 (Socolow, 2006). Furthermore, CCS is an important technology to reduce the overall cost of stabilization (Akimoto and Tomoda, 2006), with some estimates putting this cost reduction as high as 30% when including CCS in a portfolio of measures (IPCC, 2005).

Developing an integrated system to capture, transport and store CO_2 emissions will rely on technology investments by both firms and governments. The short-term burden of establishing viability will require some public subsidy, but as with most R & D the public funding committed will eventually be dwarfed by corporate investments (de Coninck et al., 2009). The long-term viability of CCS as a solution will depend on the technology being deployed for commercial reasons (Socolow, 2006). Carbon pricing will help: our experience with other emissions abatement technologies shows that market experience leads to cost reductions, and that market expectations frame corporate R & D choices (Grubb, 1997).

The public policy challenge is that waiting for carbon prices to incent market CCS investments is too slow process for the urgent emissions mitigation required (Schrag, 2009). Even with a strong carbon price signal, there are recognized uncertainties about the viability, affordability, effectiveness and public acceptability of CCS (Shackley and Gough, 2006). So far, much corporate activity on CCS, especially among "those whose fortunes are most tightly tied to fossil fuels" (Meadowcroft and Langhelle, 2009a: p. 7) has been focused on basic scientific research and lobbying governments for subsidies and support rather than investments needed to deploy the technology on a commercial scale (Stephens, 2009). Yet CCS remains an attractive option to both governments and incumbent firms since there are lower technical, economic and

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social barriers to lowering CO_2 emissions by modifying existing industrial processes and electricity generation than by more radical low carbon solutions (Gibbins et al., 2006).

There has been a recent flurry of research effort – both in this journal and elsewhere – that places CCS technology investments within a broader political (e.g. Meadowcroft and Langhelle, 2009a, 2009b), socio-technical (e.g. Stephens and Jiusto, 2010) or innovation (Praetorius and Schumacher, 2009) system. A parallel literature is being developed on how and why firms differ in their climate change innovation strategies (e.g. Pinkse and Kolk, 2010) or preparations for energy futures (e.g. Chang and Yong, 2007). Some studies have included industry perspectives in panels of experts on CCS (e.g. Hansson and Bryngelsson, 2009; Dapeng and Weiwei, 2009). However, so far the strategic decisions of the primary CCS technology consumers – the industrial users of CCS technologies – on whether and how to invest in CCS technologies have been neglected. While we have a long list of potential operational barriers to CCS adoption, we have not yet placed these in the context of adopting firms' corporate technology strategy.

In this paper, we develop a corporate technology strategy perspective on CCS investments to diagnose the investment challenges of CCS, and potential solutions to those challenges. We begin with a brief introduction to CCS technologies and to corporate technology strategy, before outlining four distinctive challenges of CCS for corporate strategists. CCS investments are precautionary, sustaining, cumulative and situated. We aim to show that adopting a corporate technology strategy perspective provides both corporate decision-makers and public policy-makers with a more nuanced understanding of the barriers to CCS investments and potential ways to overcome them.

2. An introduction to CCS technologies

"CCS technology" can more accurately be thought of as a chain of technologies designed to separate CO_2 from industrial sources, transport it to a storage location and isolate it for the long-term from the atmosphere (IPCC, 2005). CCS technology can reduce CO_2 emissions from large industrial sources and coal-fired power stations by approximately 85% depending on the type of non-capture plant displaced (IPCC, 2005). Each stage of the CCS chain – capture, transport and storage – has different technological options, technology maturity, cost implications and industry players.

The most expensive element of the CCS technology chain is the initial CO_2 capture (McKinsey, 2008; IPCC, 2005). Two types of CO_2 capture systems are well developed: post-combustion and pre-combustion. In post-combustion capture, CO_2 is separated from the flue gas emitted from an industrial process such as a coal-fired power plant. Pre-combustion requires the initial gasification of a fuel source, but yields a purer stream of CO_2 for capture at the end of the process (Hertzog, 2009). Thus "although the initial fuel conversion steps of pre-combustion are more elaborate and costly, the higher concentrations of CO_2 in the gas stream and the higher pressure make the separation easier" (IPCC, 2005: p. 5). These two CO_2 capture technologies use separation processes, based on solvents, membranes, cryogenic technologies or other chemical or physical processes that are already applied in industry, for instance in the petrochemical industry to increase the yield in the lighter fractions in oil distillation, or in the food industry, to produce CO_2 for fizzy drinks (European Commission, 2007: p. 4). Oxyfuel combustion is another promising capture technology that has been built and operated at the scale of a pilot plant, but this is a less mature technology than the pre- and post-combustion technologies. Estimates of the costs of these capture technologies range from \$15 to \$115 (US) per ton of net CO_2 captured, depending on the particular process configuration (McKinsey, 2008; Rubin et al., 2007). The CO_2 capture technology industry is dominated by energy equipment manufacturing firms that have expertise in boilers, plants, turbines, etc. such as Alstom, Siemens, BASF AG, Mitsubishi, Doosan Babcock and GE.

CO_2 transportation is mostly by pipeline, though CO_2 shipping may become economically feasible under specific conditions. There are already over 3400 miles of CO_2 pipelines in the USA, transporting CO_2 from naturally occurring reservoirs to the oil fields of West Texas and the Gulf Coast for enhanced oil recovery (Hertzog, 2009). The cost of CO_2 transportation is an order of magnitude less than for capture (\$1–8 US per ton CO_2 transported), and pipeline technology is established and mature (IPCC, 2005). Thus the key issues in this part of the CCS technology chain are more about the siting and routes of pipelines, the purity of CO_2 transported, and the potential for future pipeline tie-ins, than the intrinsic technologies associated with compression and pipeline integrity. Established players include major oil and natural gas pipeline companies.

There are several CO_2 injection and storage technology options, of which the most mature are geological storage, either in depleted oil and gas reservoirs or in deep saline formations, and enhanced oil recovery (EOR). In the UK, Norway and other North Sea oil-producing countries, the focus of CCS projects is on offshore storage (Shackley and Gough, 2006), though in Canada and the US projects tend to focus on geological storage onshore (Schrag, 2009). The costs of geological storage are roughly equivalent to the costs of transportation, and there are relatively constant costs across a wide range of storage capacity. Currently, no large companies specialize exclusively in CO_2 storage services or long-term stewardship (Hertzog, 2009), though oilfield services companies such as Schlumberger and Halliburton, and firms familiar with the extraction and storage of oil and gas (e.g. E.ON, Statoil) may be well positioned to do so.

In this paper we will adopt the perspective of the primary technology consumers: the users of CCS technologies. CCS is most likely to be deployed initially by large electricity utilities (such as Vattenfall, RWE Power, American Electric Power Corp. or TransAlta), especially those with extensive assets in coal-fired power plants, though several oil and gas firms (such as Shell and BP) and even cement or steel producers (such as Lafarge and Emirates Steel Industries) have publicly considered CCS projects. Managers in these CCS technology consumer firms face a range of strategic options on how to respond to calls to dramatically reduce carbon dioxide emissions. Adopting CCS is one of these options. Common explanations for delay in corporate CCS investments include operational concerns such as the high cost of capture technologies, technological uncertainties in integrated CCS systems and underdeveloped regulatory and liability regimes. In this paper, we move beyond these barriers to address four distinctive challenges of the strategic CCS technology adoption decision: such investments are precautionary, sustaining, cumulative and situated. Developing a corporate technology strategy perspective on CCS investments can help us coherently frame the barriers to CCS, and potential solutions to those challenges.

3. CCS as a corporate technology strategy challenge

Much of the discussion on CCS has so far focused on CCS technology management, that is, the optimal integration of CCS technologies into energy systems (e.g. Akimoto and Tomoda, 2006; Gibbins et al., 2006). This has led CCS advocates to focus on operational issues such as how to reduce the cost of the