WORLD COAL INSTITUTE

SECURING THE FUTURE

FINANCING CARBON CAPTURE & STORAGE IN A POST-2012 WORLD

Contents

EXECUTIVE SUMMARY

Substantial effort is being made to accelerate the development and deployment of Carbon Capture and Geological Storage (CCS), particularly in developed countries, with governments focusing on a post-2012 timeframe.

This report compares the support of CCS to that given to other low carbon technologies, suggests next steps to overcome current barriers, gives funding options and discusses the costs of accelerating the widespread deployment of CCS.

Thirty years from now the world will be at least as reliant on fossil fuels to meet its energy needs as it is today[1]. Fossil fuels supply nearly 80% of the world's energy needs and account for the majority of the world's energy-related greenhouse gas emissions. CCS is the only currently available technology that allows deep cuts to be made in CO_2 emissions from fossil fuels and must be deployed at scale if climate change is to be successfully addressed. The cost of CCS – even during the demonstration phase when the costs are highest – already compares favourably with renewables. According to the International Energy Agency (IEA), without CCS, climate mitigation costs are 71% greater, around US$1.28 trillion more annually[2]. However, this does not mean transferring investment from other low carbon energy technologies to CCS; if climate change goals are to be achieved then investment in all forms of clean energy, including CCS, must be increased dramatically and rapidly.

Current deployment rates for all low-carbon technologies are inadequate to reach government mitigation targets. In particular, current CCS deployment is too slow to allow necessary global GHG emissions reductions goals to be achieved. There is an urgent need to fund demonstration projects and that funding needs to come from both governments as well as a robust carbon market.

However, emissions trading alone will not drive the energy technology revolution. The CCS Roadmap published by the IEA in October 2009 indicates how ambitious governments need to be on all low carbon technologies and that governments have a central role to play in facilitating the necessary research and innovation into CCS[3]. The roadmap calls for a substantial increase in the current number of CCS projects. The World Coal Institute (WCI) fully supports the IEA Roadmap and calls for governments to play a more proactive, catalytic role.

While there are a litany of issues that are often cited as barriers to CCS, the private sector cannot proceed with a deployment programme on its own. The real barriers to widespread CCS deployment are not technological, they are political and financial.

This report concludes that although responding to global warming is expensive, CCS massively reduces the cost of an effective climate change response. In a post-2012 world, government policies need to include CCS as the costs for deploying CCS are at least comparable to, and in many cases better than, the costs for deploying other low carbon technologies.

1. IEA World Energy Outlook (2008)
2. IEA Energy Technology Perspectives (2008)
3. IEA Technology Roadmap: Carbon Capture and Storage (2009)

INTRODUCTION

Current global deployment rates for all low-carbon technologies are inadequate and investments must be increased substantially.

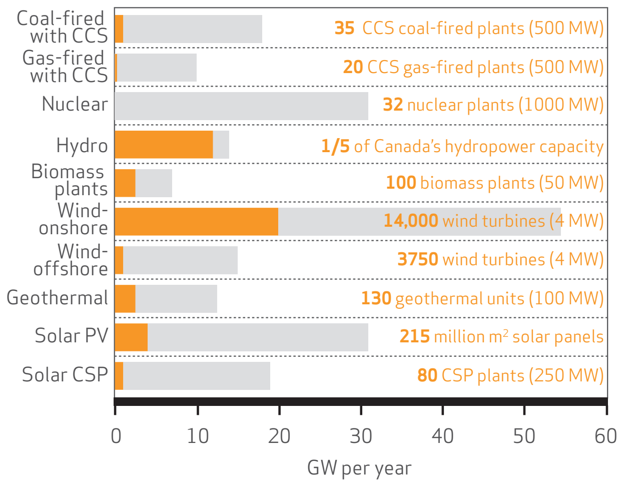
Figure 1 shows the average annual power plant investment needed between 2010 – 2050 to reduce emissions by 50% from current levels. Increased investment in technology deployment will generate emissions reductions and significant co-benefits that include improvements to the environmental and economic performance of technologies. These improvements will enable future emissions reductions to be reached at lower cost. Concerns that investing in CCS will divert investment from other technologies such as renewables and energy efficiency are misplaced; all low-carbon technologies are required and greater investment is needed for all.

The exclusion of any low-carbon technology family from any post-2012 agreement will limit countries' options to respond to climate change and hinder the international mitigation effort. Decisions on which technologies are deployed at the national level must remain with the host country, which is best placed to ensure that technology choices are nationally appropriate and meet national sustainable development criteria.

CCS deployment must occur in addition to massive action to improve energy efficiency and increase the use of renewables and other low-carbon technologies. If CCS is not deployed then the other technologies will have to be deployed at even higher rates than the already ambitious scenario shown in Figure 1. The scale of the challenge to deploy CCS at the levels needed, whilst significant, is not impossible – but deployment must commence now.

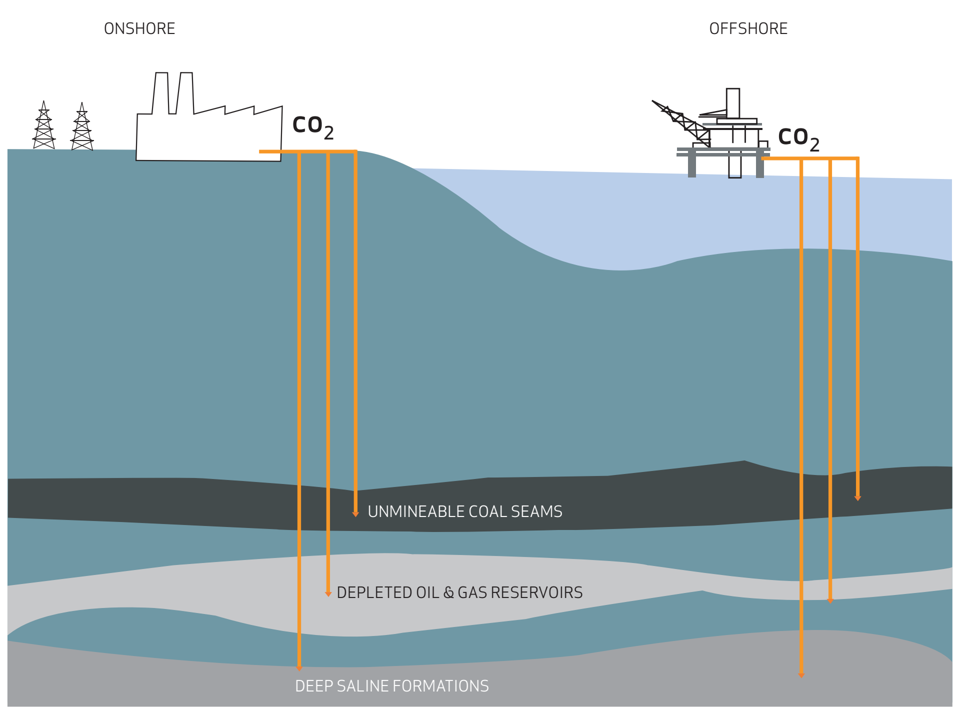
CCS can be deployed now using support mechanisms equivalent to those provided to other low carbon electricity generation options. The cost of electricity generation including CCS already compares favourably to the cost of electricity generated from renewable sources. However, deployment of CCS cannot be left to the market. The substantial experience with designing and implementing renewable energy technology support schemes (in around 60 countries[4]) is directly relevant in determining how to best incentivise development and deployment of commercial-scale CCS. This indicates that government action and investment is essential to bridge the gap between the research and demonstration phase and the widespread deployment of a technology family.

Figure 1. Average Annual Power Plant Investment Needed Between 2010-2050 to Reduce Emissions by 50% from Current Levels



Source: IEA "Energy Technology Perspectives" (2008)

Figure 2. Geological Storage Options for CO_2

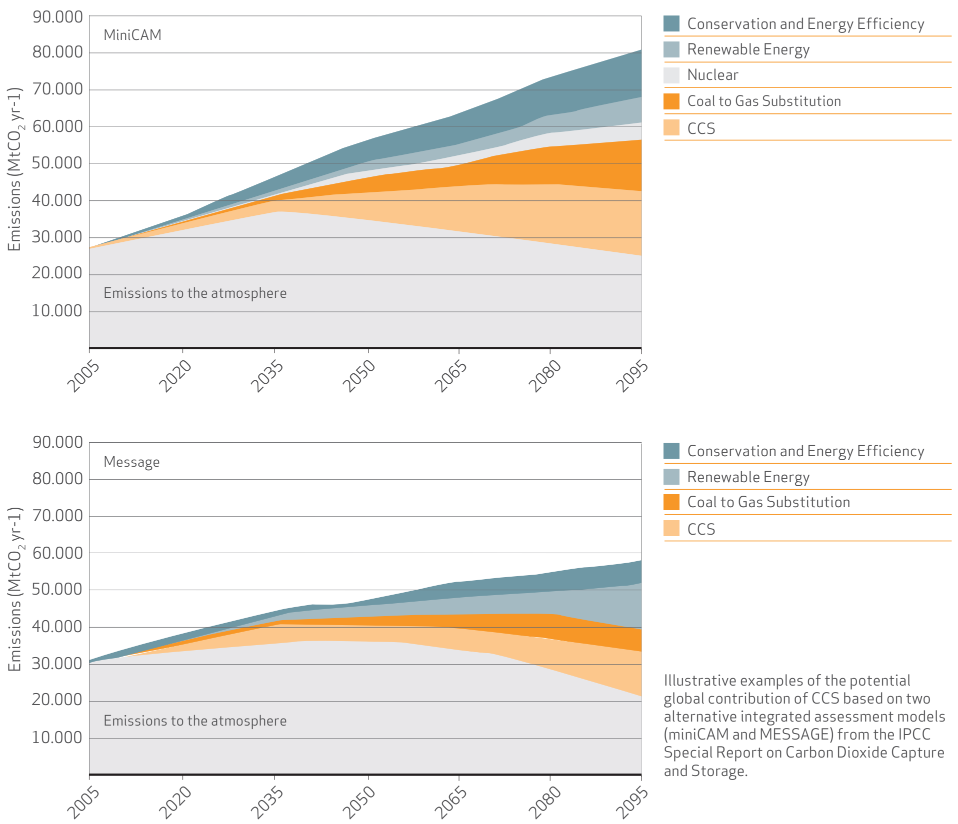


4. REN 21, Renewables Global Status Report (2009); www.ren21.net

WHY CCS IN THE CLIMATE CHANGE RESPONSE?

CCS is not a new or emerging technology. It utilises a suite of component technologies from the petroleum, chemical, and power generation industries that already exist and are commercially available. CCS is simply the novel integration and optimisation of these technologies for the purpose of climate change mitigation.

Figure 3. The Potential Global Contribution of CCS



Illustrative examples of the potential global contribution of CCS based on two alternative integrated assessment models (miniCAM and MESSAGE) from the IPCC Special Report on Carbon Dioxide Capture and Storage.

Worldwide there are several operational large-scale projects, along with numerous smaller-scale projects demonstrating specific components of the technology chain. Currently there over 40 planned research and commercial scale projects around the world[5]. These efforts have successfully demonstrated CCS and shown it to be a technically feasible mitigation technology.

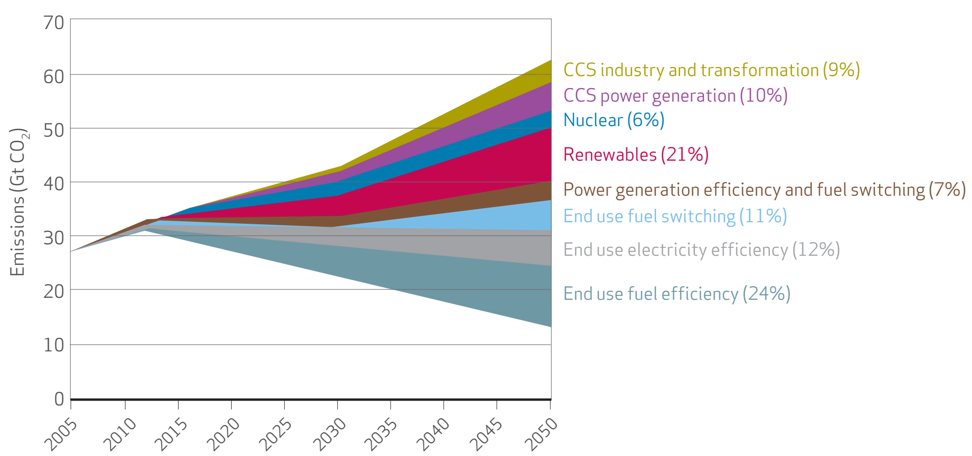
However, five years after the publication of the Special Report on CCS by the UN Intergovernmental Panel on Climate Change (IPCC), there is no fully integrated, commercial scale power plant in operation equipped with CCS.

The next two decades will be of critical importance in reducing future emissions, as a significant proportion of the world's energy generation infrastructure is due to be replaced or constructed[6]. There is considerable inertia in transforming energy systems as they comprise expensive, long-lived investments. To avoid lock-in to high carbon emitting technologies that will operate for many decades, efforts must be made now to deploy low-emitting technologies. Not taking this opportunity will make the global climate change response far more expensive as existing power plants will have to be retired well before their commercial use-by dates. The additional cost of not including CCS in the global package has been estimated by the IEA as 71% greater – i.e. US$1.28 trillion more annually[7].

Reducing GHG emissions will require society to pay costs long before most benefits are realised. Success will therefore require strong political will and leadership. The appetite for this will largely hinge on public acceptance of the costs. The costs themselves will depend on the technologies used to mitigate emissions and the rate at which learning by doing can reduce these over time. CCS dramatically reduces costs and could increase the likelihood that the public will support early action on climate change. Studies on deployment and costs of GHG mitigation technologies show, with virtual unanimity, that CCS will be a leading contributor to emissions reductions (Figure 4) and is essential to reduce emissions cost-effectively.

5. According to the IEA (2008), there are four operational large scale projects worldwide demonstrating various stages of capture, transport and storage. Each one of these projects is injecting at least half a million tons a year. According to the Scottish Centre for Carbon Storage there are over 50 proposed CCS projects (as at October 2009). More information on global CCS activities can be found on the following websites: www.co2captureandstorage.info & www.geos.ed.ac.uk/sccs/storage/storageSites.html. A map of CCS projects worldwide is also available at: www.worldcoal.org/carbon-capture-storage/ccs-map
6. Stern Review, The Economics of Climate Change (2006)
7. IEA Energy Technology Perspectives (2008)

Figure 4. Contribution of Emission Reduction Options 2005-2050



>> It is "not possible" to halve CO_2 emissions by 2050 without CCS – "This indicates the importance of CCS for climate policies"
>> Climate mitigation costs are 71% greater without CCS i.e. US$1.28 trillion more annually in 2050

Source: IEA Energy Technology Perspectives (2008)

Table 1. CCS is recognised as a leading contributor to emissions reductions and essential to reduce emissions cost-effectively

IPCC	The Intergovernmental Panel on Climate Change concluded that CCS would contribute up to 55% of the cumulative worldwide mitigation effort to 2100 and that including CCS in a portfolio of technologies lowered the cost of stabilisation by 30% or more[8].
IEA	The CCS Roadmap published by the IEA in October 2009 indicates how ambitious governments need to be on all low carbon technologies and that governments have a central role to play in facilitating the necessary research and innovation into CCS. The IEA Roadmap raises the ambition for CCS deployment beyond the first 20 projects called for by the G8 in 2008, to the 100 projects necessary to restrict the global average temperature rise to 2°C this century[9]. The IEA has said that CCS is "the most important single new technology for CO_2 savings" in both power generation and industry[10], and demonstrated that CCS is needed to contribute around 20% of the total CO_2 mitigation effort by 2050. Its analysis indicates that attempting to reduce emissions to 50% below 2005 levels without CCS is impossible and will likely result in costs of global electricity generation increasing by a dramatic 71% – an additional annual cost of US$1.28 trillion by 2050.
G8	At the G8 Hakkaido Toyaka Summit 2008, Japan, G8 governments agreed to "strongly support the launching of 20 large-scale CCS demonstration projects globally by 2010, taking into account various national circumstances, with a view to beginning broad deployment of CCS by 2020"[11]. The development of these 20 CCS projects is a welcome and critical first step. However, to enable the "widespread deployment of CCS by 2020" not only must these projects be constructed in a timely manner so that they are operational by 2015 but they must be followed up by second tranche of CCS projects that are operating by 2020.
Stern Review	According to the Stern Review, CCS will be one of the most important technologies to combat global GHG reductions. The review points out that "extensive carbon capture and storage would maintain the viability of fossil fuels for many uses in a manner compatible with deep cuts in emissions, and thereby help guard against this risk"[12].

8. IPCC Special Report on CCS (2005)
9. IEA Technology Roadmap: Carbon Capture and Storage (2009)
10. IEA Energy Technology Perspectives (2008)
11. www.mofa.go.jp/policy/economy/summit/2008/doc/index.html
12. Stern Review, The Economics of Climate Change (2006)

COMPARISON BETWEEN LOW CARBON TECHNOLOGIES

The cost of CCS – even during the demonstration phase when the costs are highest – already compares favourably with renewables. However, investment should not be transferred from other low carbon energy technologies to CCS; if climate change goals are to be achieved then investment in all forms of clean energy, including CCS, must be increased dramatically and rapidly.

Deploying CCS in the US post-2020 without a prior CCS demonstration programme to remove barriers and lower technology costs has been estimated to cost an additional US$80 – 100 billion[13]. For every year that the widespread use of CCS is delayed after 2020 the long-term atmospheric stabilisation level of CO_2 is increased by l ppm[14]. Delaying the commercial deployment of CCS by a decade or more would seriously hamper attempts to stabilise concentrations of CO_2 at lower levels. Failure to deploy CCS at all means lower stabilisation targets cannot be achieved[15].

Studies on the technologies deployed to stabilise atmospheric concentrations of CO_2 show that CCS is expected to make a major contribution to emissions reductions that will be equal to, or greater than, that provided by renewable energy technologies. However, current investments in CCS are miniscule relative to those being made in renewables. According to REN21[16] investment in renewables is estimated at over US$120 billion per annum – excluding subsidies.[17]

The G8 has agreed to commit, by 2010, to build 20 CCS plants at a total estimated cost of US$30 – 50 billion over the 35 year lifetime of the projects. Although a number of countries have recently made funding commitments for CCS projects, investments in CCS are just a fraction of global investment in renewables (Table 2).

Price support for renewable energy is equivalent today to a range from US$73/t$CO_2$ for onshore wind to over US$1000/t CO_2 for solar power (Table 3)[18]. This compares favourably with CCS demonstration project costs, in the range US$80 – 120/t CO_2, and expected to decline to US$45 – 70/t CO_2 by around 2020[19]. The difference in funding between CCS and renewables is repeated at the regional level. For example, the European Union has committed to meet 20% of its energy needs with renewables by 2020 at an annual cost of €13 – 18 billion[20]. In comparison, the total cost of EU investment in the first 10 – 12 CCS demonstration projects is expected to cost between €5 – 13 billion[21]. Table 4 shows the cost for a number of different renewable energy sources under best conditions (actual costs depend on a range of specific factors). Costs range from USc3-4/kWh for large scale hydropower to USc80/kWh for rooftop solar PV[22]. This compares to electricity from new CCS plants that is expected to cost in the range of USc9.2-12.8/kWh[23]. As CCS moves from early deployment to full commercialisation this cost range for generation with CCS is expected to reduce further.

13. Pew Center on Global Climate Change, 'Coal Initiative Series White Paper: A Program to Accelerate the Deployment of CO_2 Capture and Storage: Rationale, Objectives, and Cost' (2007). This is an incurred cost if a 30-plant CCS demonstration programme costing US$23 – 30 billion is not deployed
14. Shell International, Quick Guide to Carbon Dioxide Capture and Storage (2008)
15. IEA Energy Technology Perspectives (2008)
16. REN 21 is a global policy network that provides a forum for proponents of renewable energy. Its goal is to bolster policy development for the rapid expansion of renewable energies in developing and industrialised economies (www.ren21.net)
17. REN 21, Renewables Global Status Report (2009)
18. Stern Review, The Economics of Climate Change (2006)
19. McKinsey & Company, 'Carbon Capture & Storage: Assessing the Economics' (2008)
20. European Commission 'Directive on the promotion of energy from renewable sources – Citizens' Summary' (2008) http://ec.europa.eu/energy/climate_actions/doc/2008_res_citizens_summary_en.pdf
21. McKinsey & Company, 'Carbon Capture & Storage: Assessing the Economics' (2008). Based on a funding requirement of €0.5-1.1 billion per project (in net present value terms)
22. REN21, Renewables Global Status Report (2007)
23. Boras (2008) Economic Assessment of Advanced Coal-Based Power Plants with CO_2 Capture, MIT Carbon Sequestration Forum IX – Advancing CO_2 Capture, Cambridge, MA

Table 2. Current Government Public Funding Commitments (October 2009)

Australia

The Australian government has committed A$2.5billion (US$2.2Bn) in funding for large scale CCS demonstration in Australia. State governments have so far committed another A$500million (US$430M) and the Australian coal industry has committed A$1billion (US$860M).

Canada

The province of Alberta has assigned C$2billion (US$1.8Bn) in funding to support the deployment of CCS. In addition, the Canadian Federal government has announced financial support of C$1.3billion for the demonstration of CCS.

European Community

The European Union (EU) has hypothecated the revenue from the auctioning of 300 million credits within the EU ETS for the support of CCS and novel renewables. They have also allocated €1.05 billion (US$1.5Bn) from their energy programme for economic recovery for the support of seven CCS projects in Europe.

Japan

The Japanese government has budgeted ¥10.8 billion (US$116M) for a study on large-scale CCS demonstration since 2008.

Norway

Since 1991, the Norwegian authorities have had in place an offshore CO_2 tax for oil and gas operations with the aim of reducing CO_2 emissions. Since 2008, the sector has also been a part of the EU-ETS (European Union Emission Trading Scheme). The sector is not allocated any allowances free of charge and has to buy all their emission rights in the ETS system. From 1st January 2008 the CO_2-tax was reduced equivalent to the expected EU-ETS price for 2008. The cost of the tax and emission rights combined is approximately US$60/tonne. Norway has announced a €140M (US$205M) contribution towards CCS activities in new EU member states as part of Norway's European Economic Area (EEA) agreement. The Norwegian State has committed NOK 4.3billion (US$700M) to European CO_2 Technology Centre Mongstad, a facility for the development and testing of CCS technology which is currently under construction. In addition, the Norwegian government reached an agreement with StatoilHydro in 2006 concerning a full-scale CCS facility at Mongstad. According to the agreement, StatoilHydro will cover the alternative costs of emitting CO_2, while the State will finance the investment and operation costs of the CCS facility which exceed this level. Furthermore, NOK 180M (US$30M) is budgeted annually for RD&D in CCS technologies.

United Kingdom

The UK has announced funding for up to four CCS projects. The first of these projects will be selected from a short list of three projects that have entered the UK CCS competition. The winner of the competition will have the additional costs of CCS covered by the government as a capital grant. The UK has recently announced that the remaining projects will be funded through a levy on electricity suppliers that will come into effect in 2011 .

United States

Through 2010, the US Congress will be debating legislation that could both levy electricity sales and provide bonus allowances under a cap-and-trade scheme. Together this is expected to equal an estimated US$100 billion in incentives for coal use with CCS through 2030 and nearly US$240 billion for 2050. The American Recovery and Reinvestment Act (ARRA) of 2009 includes US$3.4billion in funding to advance research, development and deployment of CCS technologies. US$1.52 billion will support industrial CO_2 capture, US$800 million will expand and extend funding under the Clean Coal Power Initiative Round 3, geologic storage site characterisation will receive US$ 50 million, US$20 million will support CCS education and training and US$1 billion is directed to the FutureGen project. In addition to ARRA funds, the US Department of Energy's budget request for its Carbon Sequestration Program in FY2010 is US$179.9 million. FY2010 funding will support CCS site selection and characterisation, regulatory permits, community outreach, and completion of site operations plans for large-scale, geologic carbon storage tests. It will also fund large-scale injection and infrastructure development and pursue research on low-cost/low energy penalty carbon capture technologies for power plants.

Carbon Sequestration Leadership Forum (CSLF)

The CSLF, representing 23 nations, established a CCS capacity building programme for developing countries in late 2009; with Canada, Norway, the UK and the GCCSI promising €1.85 million in addition to the amounts detailed above.

Global Carbon Capture & Storage Institute (GCCSI)

In 2009, the Global Carbon Capture and Storage Institute was established in Australia. The GCCSI has funding from the Australian Government of A$100 million per year for the rapid deployment of CCS.

Sources: CSLF 2009, GCCSI 2009, IEA 2009, Pew Center on Global Climate Change 2009

Table 3. Stern Review Comparison of Renewable Energy Costs

Country	Technology	Imputed Carbon Price ($ / tCO_2)
Germany	Onshore wind	73
	Offshore wind	146
	Solar	1048
	Electricity from biomass	146
Austria	Wind	122
	Electricity from biomass	171
Spain	Wind	73
	Solar	804

Source: Stern 2006

Table 4. Costs for a Number of Different Renewable Energy Sources Under Best Conditions

Technology	Size	Typical Energy Costs* (US cents/kWh)
Large Hydro	10 – 18,000 MW	3 – 4
Small Hydro	1 – 10 MW	4 – 7
Onshore Wind	1 – 3 MW	5 – 8
Offshore Wind	1.5 – 5 MW	8 – 12
Biomass	1 – 20 MW	5 – 12
Geothermal	1 – 100 MW	4 – 7
Rooftop Solar PV	2 – 5 kW peak	20 – 80
Concentrating Solar Thermal Power (CSP)	10 – 500 MW	12 – 18

*Economic costs exclusive of subsidies or policy incentives. Typical energy costs under best conditions, optimal conditions can yield lower costs and less favourable conditions can yield substantially higher costs.

Source: REN21 2007

The high cost of renewable energy relative to conventional electricity generation has led many countries to implement support for renewable technologies to ensure they are deployed, since the private sector would not otherwise invest in them. This support is provided by a variety of mechanisms including:

- Feed-in-tariffs, where power generated from renewable electricity is bought at a guaranteed price that covers the additional costs;
- Capital grants and subsidies to cover the higher cost of renewables;
- Tradable renewable energy certificates that have a stand-alone value on redemption;
- Tax credits or relief on renewable energy investments or electricity production.

The support offered by these schemes is substantial. Feed-in-tariffs range from USc8–20/kWh for wind power – depending on whether the turbines are sited onshore or offshore – up to USc83/kWh for solar (Table 5). In the UK, tradable renewable energy certificates indicate a cost of carbon abatement in the range US$112 – 240/t$CO_2$[24]. Comparison of these figures with CCS costs show that the level of support offered in most countries and regions for renewable energy would be more than sufficient to support CCS demonstration plants.

Table 5. Comparison of Renewable Energy Feed-in Tariffs

Feed-in Tariffs (US c/kWh)		Wind	Biomass	Solar	Hydro	Landfill Gas	Geothermal
Europe	Germany	8 – 12 Onshore 11 – 12 Offshore 20	11 – 13	61 – 83			
	Netherlands	10 – 13					
	Spain	12		13 – 40			
	Austria	10	4 – 22	63 – 80	5 – 8		
	France	Onshore 11 Offshore 17		40 + construction bonus 33	8		12
United States	Minnesota	10.5 – 25	10.5 – 14.5	50 – 71	6.5 – 10	8.5 – 10	
	Rhode Island	10.5 – 11.5	10.5 – 14.5	48 – 54	6.5 – 10	8.5 – 10	9 – 19
	Michigan	10. 5 – 25	10.5 – 14.5	50 – 71	6.5 – 10	8.5 – 10	9 – 19
	Hawaii					45 – 70	
	Illinois	10.5 – 25	10.5 – 14.5	50 – 71	6.5 – 10	8.5 – 10	9 – 19

Source: Anderson 2006 'Costs and Finance of Abating Carbon Emissions in the Energy Sector', & Rickerson, Bennhold, Bradbury 2008 'Feed-in Tariffs and Renewable Energy in the USA – a Policy Update'

24. 'Ofgem's Response to UK Department for Business, Enterprise & Regulatory Reform (BERR) Consultation on Reform of the Renewables Obligation' (2007)

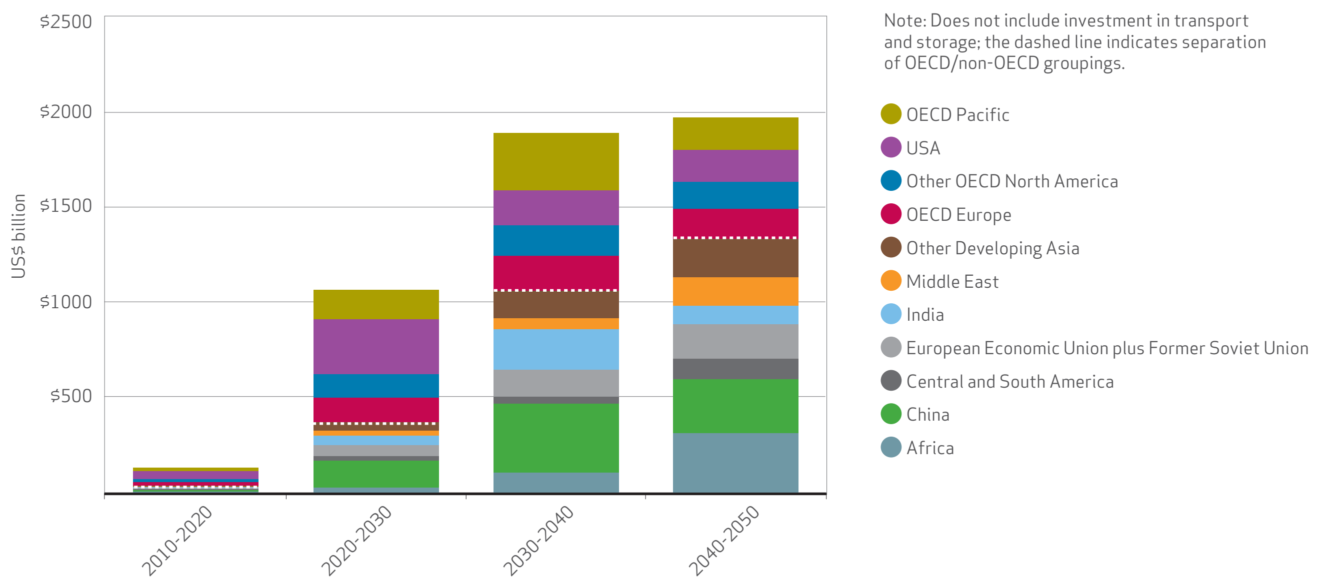
NEXT STEPS: OVERCOMING THE BARRIERS

There are a litany of factors often cited as barriers to the widespread deployment of CCS, but the real barriers are political and financial. Costs for initial commercial-scale CCS demonstration projects will be too high to be supported by expected CO_2 prices in the period to 2020. The private sector cannot therefore proceed with this deployment programme on its own.

The widespread deployment of CCS will require government–industry partnerships to develop the technology, share costs and risks, and address first-mover barriers. In the past, government support has been critical for the successful development and deployment of almost all new energy technologies[25].

Stern found that developers deploying a new technology experience a range of first-mover barriers, unique to first-of-a-kind projects, increasing the risk that they will fail. First mover barriers are not experienced by subsequent CCS developers as a result of spill-over effects[26]. Currently, the first mover barriers for CCS project developers are so large that they prevent projects from proceeding to construction and operation without assistance from governments.

Figure 5. Total CCS Investment 2010-50 by Region



Source: OECD/IEA, Technology Roadmap: Carbon Capture & Storage © (2009) [Figure 11, p.21]

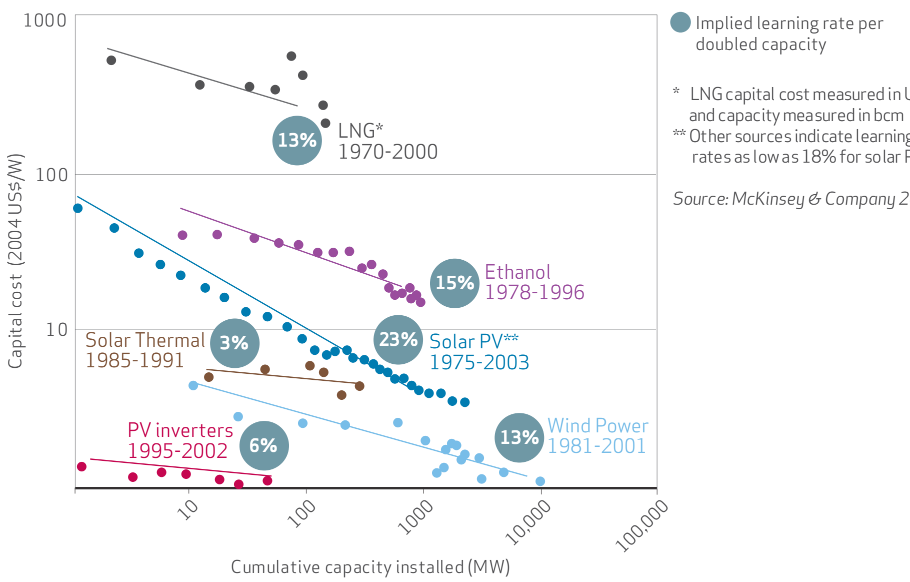
25. Stern Review, The Economics of Climate Change (2006); A study by Norberg-Bohm in 2000 found that, of 20 key innovations in the past 30 years, only one of the 14 they could source was funded entirely by the private sector and nine were totally public. Recent deployment support led the PV market to grow by 34% in 2005
26. Spill-over effects occur when a company is affected by an activity that they were not directly involved in

Work by McKinsey has compared learning rates (see Figure 6) for LNG, ethanol, solar thermal, solar PV, PV inverters and wind power, they have also looked at SO_2 and NOx and, on the basis of this, believe that the likely learning rate for CCS would be 12%. The work indicates that the returns from the early deployment of CCS may be greater – and therefore the costs of mitigation significantly lower – than that experienced with renewables.

An effective programme to accelerate the widespread deployment of CCS should:

- Build public confidence in and acceptance of CCS as a mitigation option;
- Inform the development and refinement of relevant legislation and standards;
- Accumulate and share operational experience and performance data for the full range of CCS component technologies across a variety of conditions;
- Determine reliable cost data for the full range of component technologies and conditions;
- Lower the cost of CCS technologies through improved technical performance, innovation and economies of scale;
- Shorten the time needed to commercialise CCS technologies at a scale allowing deployment of close to the number indicated by the IEA CCS Roadmap to enable CCS to make its required contribution to GHG mitigation;
- Begin early and result in substantial and verifiable reductions in emissions that would otherwise be vented to the atmosphere.

Figure 6. CCS Learning Rate Compared with Other Industries



* LNG capital cost measured in US$/t and capacity measured in bcm
** Other sources indicate learning rates as low as 18% for solar PV

Source: McKinsey & Company 2008

MECHANISMS TO SUPPORT THE DEPLOYMENT OF CCS

Lessons from the deployment of renewable energy highlight the need for public policy to help create long-term, predictable returns on investment that increase levels of technology deployment and encourage private sector innovation.

The establishment of long term predictable returns on investment for CCS will address the learning costs and commercialise the technology enabling it to compete with other low carbon technologies and attract substantial private sector investment[27].

Although power and industrial sectors in different countries operate in many different ways, governments have a number of mechanisms at their disposal to deploy CCS. Some options are discussed below. These are not mutually exclusive.

Market-wide Averaging Basis

Under this mechanism, the cost of CCS deployment is passed to the consumer – often the electricity customer – on a market-wide averaging basis. The economic costs of cutting a country's GHG emissions are ultimately borne by the public[28], therefore the benefits from the deployment of CCS – the reduction of mitigation costs – accrues to the public as a lower economic cost. Supporting CCS through the electricity market has a number of advantages, including:

- Politically more acceptable through reduced cost through government to the taxpayer;
- More equitable as electricity consumers pay costs for CCS development then accrue the benefits of lower electricity costs when the technology is fully commercial;
- Very small incremental electricity costs can raise significant funds;
- Most electricity markets are domestic and cannot relocate to avoid additional costs;
- Market-based tendering systems promote technological innovation and cost reductions.

Auction and Carbon Tax Revenues

Under this option, governments raise revenues through emission trading schemes auctioning or a carbon tax. These revenues should be reinvested into low carbon technologies, including CCS. For example, in the European Union auctioning of allowances to the power sector alone is expected to generate €28 billion annually from 2013[29]. By contrast the total cost of the European Union flagship programme is only €5 – 13 billion[30]. Financing the EU CCS flagship programme over 20 years would therefore only cost 0.9 – 2.4% of the total revenues raised over that period. Point Carbon has estimated that if all allowances were auctioned under a similar emissions trading scheme in the US, annual revenues could be US$100 – 300 billion[31].

Bonus Allowances

Under this mechanism, free or bonus emission allowances could be issued for CCS plants. These could then be sold at market prices to offset CCS costs. This process may be politically easier than hypothecating government's auction revenues and offers a less certain alternative to 'direct' government support for CCS deployment. The number of permits that would be needed to support CCS in most regions with an emissions trading scheme is low relative to the total allowances, and would not distort the market. In Europe, 300 million allowances have been reserved to help fund the CCS flagship programme of 10 – 12 commercial-scale plants. From 2013 – 2020, this would be only 2% of the allowances under a total cap of around 14,000 million allowances[32].

In the US, the 2009 Waxman-Markey American Clean Energy and Security Act (ACES Act) proposes, in addition to financial support for the first commercial-scale CCS demonstration projects, bonus GHG cap-and-trade allowances to subsidise the cost of deploying CCS (cumulatively 4% of cap-and-trade allowances are allocated for this purpose through 2050)[33]. The Act will also create a Carbon Storage Research

27. Stern Review, The Economics of Climate Change (2006); A study by Norberg-Bohm in 2000 found that, of 20 key innovations in the past 30 years, only one of the 14 they could source was funded entirely by the private sector and nine were totally public. Recent deployment support led the PV market to grow by 34% in 2005
28. Stern Review, The Economics of Climate Change (2006)
29. Assuming a carbon price of €35 tCO_2, Deutsche Bank, Banking on Higher Prices (2007)
30. McKinsey & Company, 'Carbon Capture & Storage: Assessing the Economics,' (2008). Based on a funding requirement of €0.5-1.1 billion per project (in net present value terms)
31. "Obama's Allowance Auction Could Raise $300bn" – Point Carbon, 18 September 2008
32. Eurelectric Comments on Funding Mechanisms for CCS Demonstration
33. Under cap-and-trade, the scarcity of emission allowances (i.e. the permission to emit 1 metric ton of CO_2 or its equivalent of another GHG) makes them valuable. Since cap-and-trade allowances will be tradable on an emissions market, free allocation of bonus cap-and-trade allowances to coal power plants that deploy CCS is equivalent to a cash incentive for CCS where the value of the incentive is the product of the quantity of bonus allowances and their market price. Up to 15% of the cap-and-trade allowances allocated to CCS deployment can be used for industrial CCS projects other than coal-fuelled electricity generation with CCS.

Corporation (CSRC) which will be funded by an electricity levy. For the initial phase of support for first-mover CCS projects, the ACES Act defines a formula for awarding bonus allowances on a first-come, first-served basis equivalent to fixed cash payments for each ton of CO_2 emissions avoided via CCS for ten years. The formula for these bonus allowances rewards coal plants that deploy higher levels of CO_2 capture. In a second phase of commercial deployment incentives, the ACES Act includes additional bonus GHG allowances for up to another 66 GW of coal-fuelled generating capacity with CCS. The CSRC and the CCS commercial deployment provisions in the ACES Act provide an estimated US$100 billion in incentives for coal use with CCS through 2030 and nearly US$240 billion through 2050[34].

Feebates

Using this option, revenues would be raised by charging a fee directly on unabated fossil fuel use. The funds generated could then be used to support CCS costs. Since the installed capacity of unabated fossil fuel plants is many times greater than the total capacity of CCS plants that would be funded under the programme, fee levels would only need to be low to generate the funds needed for commercial-scale CCS demonstration plants. Fees can be applied either to utilities' costs or to customers' bills and can also be used to assist CCS in regions that do not have a direct price on carbon. In the US, a fee of only USc0.12 – 0.15 /kWh could raise US$23.5 – 30.1 billion to support the deployment of 30 commercial-scale CCS demonstration projects and ten CO_2 storage sites from industrial sources[35].

Clean Development Mechanism (CDM) or Similar Technology Mechanism

Including CCS in the CDM (which is the only suitable mechanism under the Kyoto Protocol) would encourage developed countries to finance mitigation projects in developing countries. Including CCS projects under the CDM would play an important role in incentivising the development of early opportunity, low-cost CCS projects. The inclusion of CCS in the CDM or in a similar multilateral mechanism is the only means by which CCS deployment in the developing world can be financed at any rate close to that demonstrated by the IEA CCS Roadmap as needed to ensure global warming remains below 2°C this century.

Subsidies

A number of options exist to subsidise the additional cost of CCS. Many have been previously used to support renewables and can be delivered via tax credits, loan guarantees, market mechanisms or direct payments. Price guarantees that have been provided to renewables, such as feed-in tariffs, have proved successful in deploying greater levels of renewables. Subsidies are best applied to technologies for which learning effects are significant for early deployment and where existing GHG mitigation policies – such as an emissions trading scheme – would not deploy the technology. Economists generally believe that positive externalities such as spill-over benefits and knowledge creation are best addressed by providing positive incentives – such as subsidies – which lower the cost of the activity[36].

Tendering

Most options to accelerate CCS deployment require allocation of funds to bridge the cost gap between conventional generation technologies and those with CCS. Tenders or 'reverse auctions' are one way to ensure minimum CCS costs are achieved and provide transparency and control in allocating these funds.

Tendering also allows governments to focus on specific technology aspects that have been identified as requiring priority development, even if they are not currently the lowest cost option.

CCS Mandates and Emissions Performance Standards

Emissions Performance Standards[37] (EPS) can prescribe maximum emissions per unit of electrical output. This is the most contested mechanism as mandates and EPS will not commercialise CCS in the near-term. In the short term some generators will have the option to install more natural gas generation. In most regions increasing reliance on natural gas will also worsen security of supply and raise energy costs. Natural gas plants will eventually still have to be fitted with CCS and the same issues for accelerating development and deployment will remain. This may create short-term gains for those individual generators, but it would fail to address the need to accelerate CCS. Mandating and EPS will have a role to play but only if it is coupled with CCS; otherwise many will see this as a risk to CCS deployment citing that while mandates and EPS appear to offer certainty of policy outcome, they create significant risk of policy failure.

34. Pew Center on Global Climate Change, 'What the Waxman- Markey Bill does for Coal' (2009)
35. Pew Center on Global Climate Change, 'Coal Initiative Series White Paper: A Program to Accelerate the Deployment of CO_2 Capture and Storage: Rationale, Objectives, and Cost' (2007)
36. Newell Deployment Policy Report – www.rff.org/rff/Publications/upload/31817_1.pdf
37. EPS, such as the 500 gCO_2 / kWh proposed in California, means that only coal-fired plants fitted with CCS can be constructed, although unabated gas plants are still permitted

CONCLUSION

Climate change demands governments to be ambitious. Failure to deploy CCS will be costly and undermine the environmental effectiveness of global mitigation programmes.

Governments have a central role to play in facilitating the necessary research and innovation into CCS. Parallel programmes of demonstration, research and technological innovation will be needed to improve the technical performance and lower the costs of CCS. The impacts on global energy affordability and security of supply could be severe if widescale commercial deployment of CCS as a cornerstone of the world's GHG mitigation efforts is not achieved by 2020 and fossil fuels subsequently have to be forced out of the energy mix and replaced with more expensive technologies.

Unbalanced energy policy resulting in intermittent or very expensive energy services will impact negatively on efforts to address climate change. A successful approach to energy policy necessitates that the three objectives for energy policy – security of supply, affordability and environmental sustainability – are balanced simultaneously, otherwise the likely result is that none of the objectives can be maintained. Delaying commercialisation of CCS or worse, total failure to deploy CCS, will seriously undermine global efforts to stabilise atmospheric concentrations of CO_2.

WORLD COAL INSTITUTE

The World Coal Institute is a global industry association comprising the major international coal producers and stakeholders.

Membership is open to companies and not-for-profit organisations with a stake in the future of coal from anywhere in the world, with member companies represented at Chief Executive level.

The World Coal Institute promotes:

- coal as a strategic resource that is widely recognised as essential for a modern quality of life, a key contributor to sustainable development, and an essential element in enhanced energy security; and

- the coal industry as a progressive industry that is recognised as committed to technological innovation and improved environmental outcomes within the context of a balanced and responsible energy mix.

WCI and its member companies engage constructively and openly with governments, the scientific community, multilateral organisations, non-governmental organisations, media, coal producers and users, and others on global issues, such as CO_2 emissions reduction and sustainable development, and on local issues including environmental and socio-economic benefits and impacts from coal mining and coal use. The WCI's mission is to:

Deepen and broaden understanding amongst policy makers and key stakeholders of the positive role of coal in addressing global warming, widespread poverty in developing countries, and energy security.

Assist in the creation of a political climate supportive of action by governments to include:

- Coal in national and regional energy portfolios
- CCS in climate mitigation strategies and plans
- Coal technologies in environmental strategies
- Coal to liquids technologies (CTL), with CCS, in energy security considerations

Inform and educate communities of the benefits of coal, the contribution that can be made through CCS and other advanced coal technologies, and the constructive role played by the coal industry in improving its environmental performance, enhancing energy security, and strengthening social and economic development.

Support improved performance in mine safety globally.

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