GLOBAL CCS INSTITUTE

CCS READY POLICY AND REGULATIONS – THE STATE OF PLAY

Progress towards the implementation of CCS Ready policy and regulatory frameworks

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CAVEAT

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Executive summary

In recognition of the importance of the role of carbon capture and storage (CCS) within broader climate change mitigation strategies, governments are increasingly examining the concept of carbon capture and storage ready (CCSR). A number of governments within Europe and North America have moved to deploy CCSR as part of the suite of policy levers being used to mitigate greenhouse gas emissions, in particular carbon dioxide (CO_2), arising from fossil fuel power generation and industrial processes such as iron and steel smelting, cement production, refineries and chemical processing.

A CCSR facility is a large-scale industrial or power source of CO_2 which could and is intended to be retrofitted with CCS technology when the necessary regulatory and economic drivers are in place. The aim of building new facilities or modifying existing facilities to be CCSR is to reduce the risk of carbon emission lock in or of being unable to fully utilise the facilities in the future without CCS (stranded assets). CCSR is not a CO_2 mitigation option, but a way to facilitate CO_2 mitigation in the future. CCSR ceases to be applicable in jurisdictions where the necessary drivers are already in place, or once they come in place.

A CCSR policy can provide a crucial regulatory backstop where a carbon price is absent or insufficient to drive the deployment of new low-carbon technologies. An example of this is the European Commission's complementary approach of the CCS Directive supporting the emissions trading system (EU ETS). The design of CCSR policy intervention is critical to its success, as judged by both economic efficiency and environmental effectiveness. Combining CCSR provisions with emissions performance standards provides a potent policy tool, and is the preferred approach in a number of key countries such as the United Kingdom (UK), Canada and potentially elsewhere in the European Union (EU).

Developing countries are generally adopting a considered approach at this stage to supporting CCS in general, and specifically in regards to CCSR. However, China is actively exploring CCS applications and some others are showing interest in the beneficial re-use of CO_2, primarily for enhanced oil recovery (EOR). CCSR can also be considered a complementary measure to EOR operations that ultimately intend transitioning to permanent storage activities.

The technologies underpinning the various steps in the CCS chain (capture, transport and underground injection for storage) are already proven, but the challenge remains to integrate these at a commercial scale and to move to global deployment. CCSR is a policy option that can ensure new facilities are designed, approved and constructed in a manner that enables a retrofit of CCS technologies at an appropriate future time. This can help avoid locking-in inappropriate higher emitting technologies (carbon lock in) as well as reduce the future cost of CCS retrofits.

A critical component of all CCSR schemes seems to be the incorporation of effective triggers to ensure liable entities move from CCSR design to actual CCS retrofit and abatement of CO_2 emissions.

At the sub-regional level, governments and industry have shown a propensity in some cases (i.e. Queensland and Rotterdam) to move in advance of national government positions in terms of requiring new build coal fired power plant to be CCSR. In some instances industry has moved to incorporate CCSR provisions in anticipation of future regulatory requirements.

While industry experience with CCSR policies is still limited, industry proponents generally consider that a pragmatic approach to CCSR policy design and implementation can incorporate the full range of potential technology providers. This can address concerns that

CCSR design parameters might result in stranded plant if a particular proprietary technology option did not prove economically or technically viable.

There has been much international deliberation as to possible definitions of CCSR, as well as on the actual assessment requirements at the project level. The Global CCS Institute's definition of CCSR is widely accepted, and would benefit from periodic review in light of actual experience especially in relation to transport and storage issues.

Work on assessment guidance is still evolving, particularly as EU member states consider new project permitting in compliance with CCSR requirements under the EC CCS Directive. The UK is the most advanced in this effort having promulgated to law detailed guidance notes. Further development of an internationally accepted and generic set of guidance notes, notably how to assess both transport and storage parameters around CCSR, the economic and commercial viability of design options, and trigger mechanisms (either mandated or commercial), could add substantial value to CCSR implementation.

Until policy drivers support investments in CCS solutions in a commercially attractive manner (i.e. sufficient carbon pricing arrangements), CCSR provisions can serve to enrich policy portfolios aimed at facilitating CCS deployment. Key players in the CCS chain, including environmental non-governmental organisations and the finance community, increasingly perceive CCSR-related principles as an opportunity (among others) to deliver on a range of clean energy, and sustainable and aggressive mitigation ambitions.

While it may be too early to provide a definitive assessment on the success or otherwise of CCSR policy implementation, it does seem from the experiences of those countries that have adopted it, that such approaches are effective in sending very strong government signals to the investment community to expect increasingly strident future emissions reduction commitments, as well as general support for CCS technology and its potential to deliver reliable and competitive baseload energy, and large scale and timely mitigation.

1 INTRODUCTION: CCS Ready

The potential for CCS to play a major mitigation role in reducing greenhouse gas emissions, particularly of CO_2 sourced from fossil fuel power generation and industrial processes (such as iron and steel smelting, cement production, refineries and chemical processing), is generally well established by policy-makers, industry and scientific community alike.

While the technologies underpinning the CCS chain have been utilised by the petroleum industry for decades, the challenge remains to integrate these components at a commercial scale and move to a global deployment of CCS so that the reductions in cost as a consequence of economies of scale and high market penetration can be realised.

In anticipation of the important future role CCS will play in broader climate change policies, governments and industry have turned their attention to the concept of CCSR. CCSR is a policy instrument that aims to ensure that any new fossil-fuelled power and industrial facilities are approved and constructed in a way that can accommodate the retrofitting of CCS solutions at an appropriate time in the future.

The Global CCS Institute (the Institute), in collaboration with others, has actively informed the evolving principles of CCSR policies, and sought to help facilitate government adoption of CCSR as part of a suite of policy and regulatory tools to address CO_2 emissions.

This study aims to further inform the prevailing CCSR policy dialogue by providing a global update to the status of CCSR policy adoption and implementation.

1.1 Scope of study

The report provides an update on the global status of CCSR policies and standards and an analysis of how and whether CCSR policies are delivering on the government objectives they were implemented to achieve. It highlights the actions of governments to implement CCSR approaches and explores the underlying rationale and related policy agendas. It provides information on the regulatory approach, how such regulations are applied, including the stringency of application and the scope for interpretation by the regulator and/or Competent Authority[1].

An examination of several countries has been undertaken, supplementing desk-top research with direct contact with key policy, regulatory and industry players, as well as researchers in the field. Detailed analysis of each country is presented in Appendix A. The countries selected have either adopted CCSR or are actively supporting and promoting the deployment of CCS technology, and as such have taken steps to consider or introduce regulatory arrangements for CCS. In the case of developing countries these considerations may be relatively less advanced compared to developed countries, but all have indicated strong interest in CCS. The report analyses the approaches taken by each government, why particular approaches were adopted, and what the potential impacts were from choosing such approaches.

A number of countries lend themselves to be of particular interest in this regard, and as such have been examined in more depth to explore some key issues:

- Australia's deliberations on CCSR are significant and unique, in that consultation processes were occurring in parallel with discussions on the establishment of an administratively determined carbon price, but then abandoned on the basis that CCSR was not seen by the government as being complementary;

[1] The 'Competent Authority' is the 'person or organisation that has the legally delegated or invested authority, capacity, or power to perform a designated function'

- in the Netherlands, local regulators are pursuing CCSR with apparent support from industry, in advance of both national and EC regulatory requirements; and
- the UK has the most comprehensive policy and regulatory coverage on, and has made the most progress in defining the necessary parameters to satisfy, CCSR requirements.

While the report provides more detail on a few selected countries through case studies, important lessons have been distilled from all approaches adopted or being considered.

1.2 CCS Ready – the drivers

Extensive assessment and modelling by both the United Nations Intergovernmental Panel on Climate Change (IPCC)[2] and the International Energy Agency (IEA)[3+4] indicates that around 70 per cent of all CO_2 emissions are derived from stationary sources (fossil fuel based power generation and industrial processes such as iron and steel smelting, cement production, andchemical processing). The IEA's modelling confirms that fossil fuels will be expected to play a dominant role in power generation for years to come. If concerted mitigation action is not taken by all countries, emissions will rise dramatically over the next few decades (with the growth in emissions sourced mostly from non-OECD countries).

This increase in emissions is occurring at a time when a significant proportion of the existing stationary plant and infrastructure is reaching the end of its economic life and will require replacement. Given the longevity of many of these assets (many have an economic operating life of at least 40 years) it is essential that investment decisions to replace them take into account a need to manage emissions.

The degree to which immediate mitigation action is needed to tackle climate change so that the long-term target of limiting the global average temperature increase to 2°C can be achieved (Box 1) is challenging.

BOX 1: IEA World Energy Outlook 2011*

"Four-fifths of the total energy-related CO_2 emissions permissible … are already 'locked-in' by our existing capital stock (power plants, buildings, factories, etc.). If stringent new action is not forthcoming by 2017, the energy-related infrastructure then in place will generate all the CO_2 emissions allowed … leaving no room for additional power plants, factories and other infrastructure unless they are zero-carbon, which would be extremely costly."

* IEA World Energy Outlook 2011

The IEA's World Energy Outlook 2011[5] also highlights the vital role CCS must play in mitigating CO_2 emissions: "CCS is a key abatement option … accounting for almost one-fifth of the additional reductions in emissions that are required. If CCS is not widely deployed in the 2020s, an extraordinary burden would rest on other low-carbon technologies to deliver lower emissions in line with global climate objectives". The IEA's Technology Roadmap for Carbon Capture and Storage[6] stresses the relevance of CCSR policies, stating that it is "critical that fossil-fuelled plants built over the next 10 to 20 years utilise technologies and practices that enable CCS retrofit".

Virtually all governments have shown a willingness to move to a low-carbon economy, with the timing of such strategies dependent on the right circumstances (such as conditional on an acceptable global climate regime). Many governments are now looking to implement a

[2] (http://www.ipcc.ch/publications_and_data/ar4/wg3/en/contents.html)
[3] IEA World Energy Outlook 2011
[4] (http://www.iea.org/techno/etp/index.asp)
[5] Ibid – IEA World Energy Outlook
[6] (http://www.iea.org/papers/2009/CCS_Roadmap.pdf)

broad range of policy instruments to assist in curtailing CO_2 emissions, including market based and carbon pricing mechanisms, direct policy and regulatory prohibitions, and both general and specific financial assistance.

CCSR policy provides governments with a policy lever that can help encourage future CCS retrofits once targeted solutions are demonstrated to be technically dependable and commercially attractive.

1.3 CCS Ready – some key issues

In the absence of a price on carbon, or a sufficiently high carbon price (as delivered through a carbon tax, an ETS, and/or commercial EOR activities), CCS is unlikely to attract the necessary investment to enable wide-scale commercial deployment. As outlined by the Institute in its CCS Ready Issues brief 2010 no. 1[7], the "implementation of CCSR policies are often seen as an insurance option against carbon lock in, essentially reconciling imminent investment in fossil fuel plants with the uncertainties of future binding carbon constraints".

By adopting a CCSR policy, governments seek to enhance the capacity of long-lived productive capital to reduce future associated emissions by ensuring that they are constructed in a way that can provide for efficient CCS retrofits. This may be at a time when the CO_2 price is sufficiently high or engineering and construction costs have come down, or when the government mandates CCS retrofits as being necessary.

Government decisions to adopt CCSR policies can also provide the market with important policy signals (especially in the absence of explicit carbon prices) to internalise in its capital investment decisions a future shadow value for carbon. CCSR policies do raise a number of key issues that should be addressed, in the design of the instrument and in the regulatory provisions that often underpin compliance with the policy objectives, so as to avoid potentially perverse outcomes. The following issues require careful consideration:

- Carbon lock-in: CCSR requirements essentially provide for future emissions reductions, and as such, do little to address the emissions that are 'locked in' for the period it takes to move CCS technology to commercial deployment. This suggests that policy and regulatory approaches need to be ambitious and stringent enough to drive investment at the earliest possible time, but sufficiently flexible to be able to adapt to any delay in CCS implementation.
- Technology lock-in: Similar to carbon lock-in, CCSR needs to strike a balance between stipulating project capability to allow for retrofit, while allowing an efficient development and evolution of the technologies (some equipment suppliers are already certifying their products as being capture ready).
- Economic rationality: The design and application of CCSR instruments need to ensure there are sufficient triggers to drive future CCS retrofits, while avoiding being overly prescriptive as to what the actual technical solution is (i.e. technology lock in). Failure in respect to either of these parameters runs a high risk of resulting in stranded assets that need to be closed in advance of the end of their economic lifetime.
- Community engagement: CCSR policies can empower the community to express its views both at the initial project-specific level (when project approvals are under consideration including compliance with CCSR requirements), and later when actual CCS-related plant retrofits (including transport routes) seek permitting and approvals.

Environmental non-government organisations (ENGOs) are actively engaging in the broader climate change and clean energy policy debates on relative merits of CCS more generally,

[7](http://www.globalccsinstitute.com/sites/default/files/CCS%20Ready%20-%20Issues%20Brief%20no.%201.pdf)

and CCSR specifically. Policy-makers and regulators seek to provide ENGOs, as well as the broader community (including industry), the necessary assurances that CCSR approaches can dependably deliver on social expectations (i.e. new fossil fuel plants deserve a social licence to operate justified on environmental and economic grounds).

Broadening the discussion on the application of CCSR policies from the power sector to industrial projects is pivotal in the overarching aspiration to widely deploy CCS as there are limited mitigation alternatives in the industrial sector.

As characterised in the CCSR definition developed by the Institute, the IEA and the Carbon Sequestration Leadership Forum (CSLF), CCSR is not considered so much as a CO_2 mitigation policy, but more of a transitional (possibly transient) policy in the absence of sufficient incentives or compulsion for emission intensive projects to manage their emissions. CCSR policy can support the move from 'first-of-a-kind' commercial-scale CCS demonstration, to full deployment of the technology. It potentially ceases to be a complementary measure when sufficient market enablers are evident.

The timeframes for governments to exit from a CCSR policy position are likely to vary according to different sectors and technologies, as well as other localised circumstances. It is highly plausible for example for CCSR policies applied to new coal-fired generation to be phased out in advance of industrial applications like iron, steel and cement production, due to differentiated operational settings such as regulatory compliance and incentives. A key test for any jurisdiction looking to adopt a CCSR approach is how to assess what the commercialisation pathway might be, and how an effective trigger to retrofit can be introduced.

On the basis of the countries reviewed in this report (see Appendix A), a preferred approach to designing a CCSR policy seems to be to establish a sunset clause (where the policy terminates) sometime around 2020 to 2025, after which it is assumed that CCS will be commercially viable (either through a price on carbon or some form of mandated emissions constraint).

1.4 Early progress

The potential role CCS can play in emissions mitigation was recognised by key governments over a decade ago, and subsequently pursued through the CSLF[8]. Much of the initial policy work focused on identifying what the policy and regulatory settings might need to be, coupled with financial assistance considerations to first establish demonstration pilot projects, and then to facilitate early commercial-scale demonstration.

CCSR was considered as a policy concept and tool within the context of the evolving role of CCS as a key mitigation option more generally. The initial and primary focus of discussions was the capture component of the CCS chain, and as such a considerable body of work and literature developed around the concept of 'Carbon Capture Ready'. This reflected a nascent view that the engineering and technical issues concerning the retrofit of capture equipment to coal-fired power plants were the most challenging to resolve, and of principal interest to industry in particular.

At the Group of Eight (G8) Gleneagles Summit in July 2005, the G8 Leaders in addressing the challenges of tackling climate change, promoting clean energy, achieving sustainable development and ensuring energy security[9] committed to "work to accelerate the development and commercialisation of carbon capture and storage technology", including work "to study definitions, costs and scope for 'capture ready plant' and consider economic

[8](http://www.cslforum.org/aboutus/index.html?cid=nav_about)
[9](http://www.unglobalcompact.org/docs/about_the_gc/government_support/PostG8_Gleneagles_Communique.pdf)

incentives". This support was re-affirmed at the following G8 Summit in Heiligendamm in 2007.

Such a global and high-level ministerial call for action stimulated one of the most comprehensive assessments of capture ready in a study by the IEA Greenhouse Gas R&D Programme (IEAGHG) titled *CO_2 Capture Ready Plants*[10], released in May 2007. The study included:

- a summary of capture ready power plant considerations, and review of prior work;
- an assessment of the options for capture ready pre-investments;
- discussion of the risks and uncertainties associated with investment;
- an estimation of the impacts on capital and operating costs; and
- an assessment of the trade-off between investment and savings.

Importantly the IEAGHG went on to develop one of the first operational definitions (i.e. identifying the key elements) of what a capture ready plant is, encompassing a:

- clearly identified strategy by which a credible capture technology can be fitted to the plant;
- space available both within and around the plant to permit the capture technology to be fitted; and
- credible route for captured CO_2 to be removed from site and sent to storage.

The IEAGHG definition did not however attempt to address either transport or storage related considerations.

CCS deployment remained firmly on the G8 agenda over the following three years; the Hokkaido Toyako 2008 Summit (Japan) calling for the development of road maps for innovative technologies including CCS; the 2009 à L'Aquila Summit (Italy) heralding the formation of the Institute and a commitment to mitigation action so that the increase in global temperature should not exceed 2°C; and with the G8 meeting of June 2010 at Muskoka (Canada) adding impetus to achieving the launch of 20 large-scale CCS demonstration projects globally by 2010, and to achieve the broad deployment of CCS by 2020 in co-operation with developing countries.

1.5 Global CCS Institute's development of CCS Ready guidelines

The G8 expressed concern that the IEAGHG definition was too limited in its consideration of the full CCS chain, and as such, the Institute was tasked with managing a comprehensive work program in 2009 to establish an internationally agreed CCSR definition.

The Institute hosted workshops in Washington DC, Amsterdam, Beijing and Tokyo; commissioned two technical reports: *Defining CCS Ready: an approach to an international definition*[11] and *CCS Ready Policy: considerations and recommended practices for policymakers*[12]; and sponsored a wrap-up conference to consider a definition. Following stakeholder consultation, an agreed definition was proposed and included in the IEA/CSLF report to the G8 Muskoka meeting in June 2010. The definition is at Appendix C.

The agreed definition includes the need for:

- site-specific studies to confirm the feasibility of retrofit;

[10](http://www.iea.org/papers/2007/CO2_capture_ready_plants.pdf)
[11](http://www.globalccsinstitute.com/publications/defining-ccs-ready-approach-international-definition)
[12](http://www.cslforum.org/publications/documents/CCS_Ready_Policy_Considerations.pdf)

- demonstration of effective retrofit without major plant outage within the spatial confines available;
- identification of realistic transport and storage options – with sufficient characterisation to enable 'risk informed' decisions around safe and full-volume storage;
- identification of other factors, i.e. water requirements; and
- full chain cost estimation, and public consultation (if appropriate).

Development of the definition was pivotal to allowing governments to effectively move forward in relation to the policy debate around CCSR, and take firm decisions to introduce CCSR policies and standards into national law (or alternatively, adopt different policy approaches in addressing emissions).

2 POLICY ENVIRONMENT: Developing a CCS Ready Policy

Governments have a broad suite of policy options and regulatory instruments to manage and control emissions levels of emitting sources, including:

- carbon pricing arrangements such as the EC's ETS, direct emissions taxes (Norway), setting a minimum 'floor' price to drive technology deployment (the UK's carbon floor price scheme), or a combination of approaches (Australia's initial carbon pricing policy transitioning to emissions trading in 2015);
- other market based and/or technology specific enablers that promote low-carbon or 'clean' technologies, such as guaranteed premium prices for electricity off-take (feed-in tariffs) or portfolio quotas defined as a specific technology (CCS and/or renewables) or energy generation (MWh) for electricity supply companies;
- direct policy and regulatory mandates preventing or limiting the release of emissions, such as emissions performance standards (kg per MWh) as in Canada and UK, direct bans on certain technologies such as no new coal-fired power (Denmark, New Zealand), specific requirements on deployment of some technologies such as new fossil fuel generation (above a certain capacity) to integrate CCS (Scotland), or to undertake a CCSR assessment (EC CCS Directive), and requirements that new plants be CCSR (France, UK); and
- both direct and indirect support for the development and deployment of emerging technologies, such as direct capital assistance (Australia's CCS Flagships program, EC New Entrant Reserve 300 (NER300) grants), and aid for focused research and development (R&D).

In 2011, the IEA released a report titled *SUMMING UP THE PARTS - Combining Policy Instruments for Least-Cost Climate Mitigation Strategies*[13] which outlines and assesses the full range of policy instruments and measures available to governments to address emissions.

2.1 Climate change mitigation – the role of CCS Ready

It is unlikely that any single measure or policy response, such as carbon pricing, is capable of optimally delivering on the complex array of government climate change and energy policy objectives. Good policy outcomes in these agendas rely on a range of complex and complementary measures being deployed in parallel. As the IEA report states: "Carbon pricing is a cornerstone policy in climate change mitigation, but it is not a complete solution on its own. The short and long-term efficiency of carbon pricing can be enhanced … by accelerating the development of new technologies that can allow lower carbon costs in the future. In addition, in real-world implementations of carbon pricing there will always be incomplete coverage or design compromises that may warrant further supplementary policies".

In general, OECD countries demonstrate a preference to harness the power of market-based measures, and preserving a principle of technology neutrality. Additional complementary policies are deployed to address peripheral market failures. For example, most of the developed countries surveyed have mandatory renewables targets coupled with some form of renewable-specific assistance measures (such as feed-in tariffs). Many developing

[13](http://www.iea.org/papers/2011/Summing_Up.pdf)

countries have a similar approach with regard to encouraging the penetration of renewables into their energy mix.

It is unlikely that policy-makers will expect CCSR policies to play anything more than a complementary role in an optimal suite of policy options to address climate change and the development of low-carbon technologies. In part this reflects the competitiveness of alternative mitigation options, the immaturity of CCS technologies, the comparatively lower cost of deploying already mature renewables (onshore wind, hydro), and the public acceptability of policy choices .

A number of countries have determined that CCSR approaches can enrich their prevailing policy portfolios, represented by either a statement of policy principle and/or as a regulatory 'back-stop' capable of supporting ever increasing carbon prices and/or emission performance standards. The UK has adopted this approach in its policy mix, while Canada has a range of supplementary policy approaches (including emission performance standards) in the absence of a consistent regional approach to carbon pricing.

The IEA's *World Energy Outlook 2011*[14] modelling indicates that the global costs of mitigation will rise significantly if the deployment of CCS solutions is excluded from the policy mix. Energy security and economic considerations are major policy drivers for countries with large indigenous fossil fuel endowments, or that are seeking to diversify their electricity supply. In such circumstances, governments tend to be strongly inclined to embrace CCS as part of their mitigation and energy solutions. While it is sometimes argued that fuel-switching from coal to gas can provide countries with an effective emission reduction pathway, the need for ever more strident global emissions targets can also imply that the so-called 'dash for gas' will simply accelerate the need to apply CCS to gas-fired generation to deliver deeper abatement outcomes.

It is important to recognise that policies can be mutually reinforcing, can work against one another, or can be redundant depending on how they are designed and implemented. As stressed in the recent IEA publication, managing the policy interactions is a key issue to be addressed (Box 2)[15].

BOX 2: SUMMING UP THE PARTS - Combining Policy Instruments for Least-Cost Climate Mitigation Strategies: - IEA 2011

"Policy packages should be regularly reviewed to maintain coherence over time, particularly if policies interact strongly. To promote investment certainty, reviews should generally be limited to scheduled intervals and follow understood criteria. In the event of a major unforeseen shock, a judgement is needed on whether the benefits of restoring policy balance outweigh the damage to investment certainty caused by intervening."

When applied to the power sector, CCSR policy is generally considered by policy makers as one of many possible options available, and only in rare circumstances will it be regarded as the sole or major emissions management policy response. When it comes to industrial emissions however, CCS solutions and CCSR policy (along with energy efficiency measures) may well be regarded as the preferred policy of choice. This is because CO_2 is produced as an intrinsic part of some industrial processes, for which there are only a very limited number of mitigation solutions available.

[14] IEA World Energy Outlook 2011
[15] (http://www.iea.org/papers/2011/Summing_Up.pdf)

2.2 Regional inter-dependencies

The strength of political and economic alliances or co-dependence of markets and environmental outcomes can be important determinants for the choice of policy tools. For example, given the very significant cross-border trade in electricity between Canada and the United States of America (US), it is difficult for Canada to introduce its own carbon price signals without raising significant cross border competitiveness issues or forcing carbon leakage (emission intensive and trade exposed businesses relocating to lower cost locations). In the presence of these trade related issues, countries like Canada will often opt to consider alternative approaches to carbon pricing and this may position CCSR approaches relatively well within the arsenal of available policy choices.

The EC has also established broad parameters around climate mitigation requiring all member states to adhere to at least minimum requirements (emission targets, transposition of the CCS Directive) thus enabling harmonised regional action. While member states may still choose to take additional actions, or take a more stringent approach in relation to a particular policy tool, the tendency is to adopt the EC provision as the standard.

An interesting policy debate is unfolding in Europe given the collapse of the EU ETS price (allowances in early 2012 were selling for between €6 to 7). On the one hand it is often argued that the ETS policy is highly successful in achieving emissions targets at the least cost; but on the other hand, the low price is doing little to drive the deployment of new (clean) technology, posing a real risk of carbon lock in.

Proponents of the latter view argue that there needs to be further policy intervention to re-design the ETS pricing mechanism so there are clear signals to drive technology change. The adoption of CCSR policy is seen favourably by many proponents in this regard, as it can (depending on the policy design) send strong government signals to the market that can aid CCS technology development.

Nevertheless, carbon pricing is an essential driver of CCS investment. The long-term outlook (and forward prices) for the EU ETS are such that at least some market players are taking early measures (irrespective of any statutory drivers) to ensure current and future plants are CCSR. In some cases this is driven by carbon price expectations, in others in anticipation of future regulatory requirements, including a possible revamp and reshaping of the EU ETS to generate a higher ‘carbon price’.

In North America, the price of CO_2 used for EOR purposes seems largely sufficient to drive deployment of at least some CCS projects (often in conjunction with other support measures), particularly projects with access to low cost CO_2 (i.e. where the CO_2 is effectively captured as part of the industrial process). Whether or not this is stimulating plant operators to consider CCSR implications during the design stage of new plants remains untested (although logically this would be an expected outcome).

With such market drivers at play, governments often do not need to resort to regulatory requirements to stimulate CCS-related investments (EOR), but given the often volatile nature of markets, CCSR legislation can serve as a desirable back-stop. Moreover, the impact of EOR drivers are often limited to sub-regions that can readily service the demands of EOR projects (such as low cost access to CO_2 transportation corridors) whereas CCSR tends to have a more universal application across jurisdictions.

2.3 Emission performance standards – CCS Ready by another name

Some governments are increasingly relying on 'emissions performance standards' as a preferred policy intervention where a carbon price signal is not feasible or insufficient, or in some circumstances as a complementary measure to an ETS. By placing statutory limits on the amount of CO_2 that may be emitted from a plant of a certain type, governments can compel emitters to either install emissions control technologies (such as CCS) or switch to cleaner energy feedstocks (i.e. gas instead of coal).

Performance standards tend to be initially set at relatively high levels, and then ratcheted down over time (as other incentives predominate in investment decisions) allowing project proponents to rationally transition in new emissions management regimes and take advantage of technological advances. Emissions standards may be determined on the basis of size (say all power plants over 300 MW electrical output); fuel type (say applicable only to coal-fired power); economic activity (only electricity generation, not industrial applications); or components and equipment (boilers of a certain design and capacity, say 600 MW thermal); or a combination of these parameters.

Emissions performance standards can clearly drive full or partial CCS deployment (depending on the stringency of standard set and its coverage), and is a preferred approach in a number of jurisdictions (including Canada, UK, and the US) to a reliance solely on CCSR policy. The use of regulated emissions performance standards can provide for high market certainty, implicitly establishing a shadow carbon price, and can be ratcheted back over time depending on the pace of technology development. Standards also allow for the market to guide and determine energy choices and mitigation outcomes.

Regulated provisions can be much more difficult for governments to reverse in comparison to CCSR policies, and they are usually implemented at 'arms length' by independent authorities (such as the US Environment Protection Agency (EPA)) to enhance implementation transparency. Consequently, a number of jurisdictions have chosen to use both instruments in tandem (such as the UK and France).

In certain circumstances, emissions standards can serve as a proxy for CCSR policy in that they are often designed to incorporate delay in the development of mitigation technology. In effect they are putting project proponents on notice that they need to plan now to facilitate abatement at a later stage by enshrining emissions performance provisions in the permit approvals process. Additional complexity may be introduced through embodying triggers and caveats regarding future staged compliance with a standard - for example that all plants will need to conform with the standard by 2025 provided CCS deployment is commercially available. While this seeks to allow for the natural evolution of technology development, it also generates a host of compliance and 'testing' issues.

2.4 The research and development (R&D) trap

A major argument proffered against the introduction of CCSR provisions in Australia was that CCS technology is unproven at a commercial scale, and the requirements are out of step with the evolution of the technology because further R&D is required.

There is no question that further R&D will help facilitate the deployment of CCS, as costs can be driven down through engineering improvements, especially for the capture component where 80 per cent of the costs of a total integrated CCS solution can be vested. But a continuing cycle of R&D will not in itself facilitate deployment, which can drive lower costs through greater economies of scale and higher global market penetration. To this end a

number of countries are continuing to fund significant research, primarily at the applied end of the R&D spectrum. The EC, through its Seventh Framework Programme (FP7) is looking to support further R&D work around a series of pilot storage sites, as well as the sharing of knowledge between projects. The UK, the Netherlands, Australia, Japan and Norway (amongst others) all have dedicated government R&D programs; and industry R&D actions and investments remain strong. Japan, despite limited likelihood of domestic CCS (due to storage limitations), is strongly driving R&D into shipping options, and on capture applications (especially by the Japanese equipment suppliers).

The largest gains will likely come from 'learning by doing' and it is widely acknowledged that this is a critical path to embark upon. The focus is, and must continue to be, on the commercial integration of the technical components of the CCS chain at full commercial scale in conjunction with mutually reinforcing applied R&D efforts. With careful design, CCSR requirements can be structured so that they are a valuable and flexible tool capable of incorporating the expected technological evolution and R&D outcomes.

2.5 Economic positioning

A number of governments have a strong and growing interest in the beneficial re-use of CO_2 such as for: EOR and enhanced gas recovery (clearly the most advanced given its maturity); carbonated beverages; carbonate mineralisation; concrete curing; bauxite residue carbonation; enhanced coal bed methane (ECBM); urea yield boosting; renewable methanol; and a range of emerging chemical processing applications. While many of these are still in the early stages of development (and timing may not align well with expectations around CCS deployment roll out), there is significant potential especially in developing countries such as China and India where demand for some of these products is high. Adopting a CCSR design for certain plants can ensure that the CO_2 initially emitted can be subsequently captured and turned to beneficial uses.

The Clean Energy Ministerial (CEM) initiative recognises CO_2 re-use as an important component of an evolving CCS framework, and have set up a 'Carbon Capture, Use and Storage (CCUS) Action Group' as part of its overall work plan[16]. Extensive work is now being undertaken on the issue. The Institute released a report titled *Accelerating the uptake of CCS: Industrial use of captured carbon dioxide* in May 2011[17], exploring some of these opportunities in detail. While EOR continues to grow in North America, tremendous prospects for significant expansion really arise in the Middle East (especially if CO_2 displaces natural gas as the drive agent thereby freeing up the natural gas for other beneficial uses). The implementation of CCSR policies and provisions at this point in time could in effect place a 'reserve option' on that CO_2 so that it remains available for potential use at an appropriate time in the future.

The IEA's modelling indicates that in the medium term, CCS as a "key abatement option, accounting for almost one-fifth of the additional reductions in emissions that are required"[18], is destined to have significant industrial application, and may be capable of returning comparable economic wealth as sectors such as oil and gas. A number of countries have assessed the overall economic and employment benefits of CCS (such as the Netherlands) and are seeking to position themselves to take best advantage. Early mover advantages and opportunities that may arise from having 'reserved' CO_2 through CCSR approaches may provide the essential competitive leverage.

[16](http://www.cleanenergyministerial.org/our_work/carbon_capture/index.html)
[17](http://cdn.globalccsinstitute.com/sites/default/files/publications/14026/accelerating-uptake-ccs-industrial-use-captured-carbon-dioxide.pdf)
[18](http://www.iea.org/papers/2009/CCS_Roadmap.pdf)

3 GLOBAL STATUS OF CCS READY: Country analysis

A detailed stocktake of supra-national, national and sub-national action on CCSR-related policy is set out in Appendix A. The countries examined were selected on the basis of the following criteria:

- a demonstrated leadership role in actively supporting commercial-scale CCS deployment through a range of actions and measures, including direct financial/capital support for pilot and full-scale projects, extensive R&D programs;
- have established or are in the process of promulgating legal and regulatory frameworks to facilitate CCS deployment;
- have a strong policy interest in facilitating the transition of fossil fuel based generation to a low-carbon basis given rich natural resource endowments or specific energy security and economic drivers;
- an active player in international fora dealing with CCS issues – the Institute, IEA, CSLF, CEM; and
- key developing country players with a strong potential and emerging interest.

Given the strong role of the EU in driving climate mitigation actions, the EC is scanned in its own right as it has set the framework for CCSR considerations which apply to all member states (i.e. the CCS Storage Directive and CCSR provisions).

All 27 member states are required to fully and accurately transpose the CCS Storage Directive including Article 33 - Amendment of Directive 2001/80/EC (which is the specific CCSR provision) into national law. Some jurisdictions have made it clear that while they will transpose the Directive, they will not additionally support CCS projects proceeding as it is considered a low priority policy issue.

3.1 Key trends in CCS Ready approaches

Where CCSR measures have been implemented, they form an important component of a broader suite of policy interventions. Governments look to CCSR policy to help facilitate a range of outcomes such as enhancing a country's ability to meet its emissions targets; to facilitate moves to a low-carbon energy system while addressing energy security; to stimulate economic growth (through facilitating lowest cost energy such as coal-fired generation); and to deliver on social objectives.

The UK has the most comprehensive mix of policy drivers in place. While CCSR is an important component of the UK's suite of climate change mitigation policy, it acts primarily as insurance to underpin CCS investments when market-based carbon price signals are low, which themselves are also underpinned by regulated emissions performance standards. Critically, economic incentives are an important driver in the overall CCS strategy[19] (see Box 3).

[19](http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Carbon%20capture%20and%20storage/1_20100317090007_e_@@_CleanCoalIndustrialStrategy.pdf)

BOX 3: UK Clean Energy Policy Mix: – Driving low-carbon outcomes

An overarching framework

- Comprehensive emissions targets supported by sectoral plans addressing buildings, transport, industry, electricity and agriculture, land use, forestry and waste.
- EU ETS carbon price signals, underpinned by a carbon floor price, to drive new low-carbon technology deployment.

Supported by a range of technology-related initiatives - CCS program details include:

- £1billion in capital funding to support CCS projects;
- Electricity Market Reform, including Contracts for Difference tailored for CCS generation;
- emissions performance standards which in effect require partial fit of CCS to coal-fired generation;
- CCSR requirements to apply to all new build generation of over 300 MW capacity; and
- £125 million over four years for R&D – focussed on cost reduction.

With a real eye to the economic benefits

- The UK Government estimates the CCS industry will sustain 100,000 UK jobs by 2030 and generate up to £6.5 billion per year and ultimately be of a similar size to the oil and gas industry.
- The potential for North Sea EOR and subsequent tax revenue is not to be dismissed.

While never explicitly stated, the hierarchy of policy interventions (market, mandated, voluntary, etc.) implied in the UK policy mix to further drive CCS deployment broadly reflects the approach adopted by most OECD countries.

3.2 The EC – Driving regional action

Europe (see Box 4) and North America (see Box 5) provide for interesting CCSR policy case studies in regards to the implications that arise from different approaches.

***BOX 4*:** EC CCSR policy

Through its CCS Directive (which requires a CCSR assessment of all new combustion plants over 300 MW), the EU has created an overarching framework for CCS storage and CCSR that is to be applied within the 27 member states. Overtly, this provides a degree of certainty to investors and a common approach across what is largely an integrated electricity market. It has without question driven a policy debate and the consideration of CCS in many countries where CCSR was not on the agenda.

Given the transposition of the Directive is mandatory, a regulatory regime enabling CCSR will be established across all 27 member countries. Indeed the EC has launched infringement proceedings against member states that have not fully transposed the Directive, and domestic legislation must be enacted by those member states that wish to avail themselves of the New Entrant Reserve 300 (NER300) CCS demonstration project funding.

Ultimately the construct of the Directive represents a political compromise, and while not 'lowest common dominator' its elements and reach represent a position that is tenable to all 27 countries. Accordingly it is limited in scope (i.e. only combustion plants over 300 MW with minimal consideration of storage and transport options in the assessment process) and outcomes are limited (i.e. sufficient space to be set aside if the assessment is positive). The drivers are loaded towards an assessment outcome that concludes CCS retrofit and CCSR is not feasible – allowing the project to then proceed through the permit/approvals process.

Despite the overarching framework requirements, governments still have significant room to manoeuvre in a policy sense. Governments can still take a policy position banning new fossil fuel generation despite having CCSR provisions within their legislature. They can opt to introduce more stringent assessment rules (UK), only approve a plant proceeding where there is a positive assessment (UK, France), require all new plants to be fully CCSR (Rotterdam area in the Netherlands), and a host of other options. However, competitiveness issues may act as a brake on the degree to which governments are willing to move beyond the EC requirements.

In addition, the certainty provided is somewhat transient in that the EC has foreshadowed a review of the provisions in 2014 (when at least some players believe CCS should be made compulsory). To date the EC has not issued specific guidance as to requirements for the assessment of CCSR under the Directive leaving member states with a significant degree of freedom. However, the EC has confused the situation somewhat with the introduction of an alternate CCSR definition under its draft EU ETS state aid guidelines (see Box 38) – thus creating different rules for those plants partially funded under state aid provisions to those which are not.

As the Directive is still being translated into national law, it is difficult to assess whether the Directive has really driven countries to actively utilise CCSR provisions. Those with a strong interest in CCS were already moving in that direction, ahead of the EC requirements. However, there have been other positive outcomes in terms of industry and ENGO action. The regional interdependencies in North America have impacted CCSR from a different viewpoint (see Box 5).

BOX 5: Regional drivers of CCS Ready in North America

The North American electricity market is strongly interconnected with significant cross-border trade – with Canada a small net exporter to the US. Both Canada and the US realise commercial benefits and improved electricity reliability through trade.

In June 2010 the Canadian Government announced it would take action to reduce CO_2 emissions in the electricity sector by moving forward with regulations on coal-fired electricity generation – noting that the proposed arrangements were not expected to have any impacts on international trade agreements. This decision was taken following detailed consideration of alternate policy levers – in particular an ETS akin to the EU ETS.

While an ETS may have been the preferred market-based approach, the Government concluded given the limited scale and the nature of the Canadian electricity sector, there would be insufficient trade to drive the desired outcomes, and that "these factors would lead to significant constraints on trading opportunities which in turn lead to low levels of market liquidity and create a risk of large fluctuations in the price"*.

The US has clearly signalled that it is not interested in pursuing any form of carbon trading system in the short to medium term, and therefore there is no scope for Canada to participate in a regional ETS system that would address the shortcomings of a 'Canada only ETS'. Thus the lack of regionally coordinated action has limited Canada's policy options, resulting in the uptake of an emissions performance standard. The standard includes elements of a CCSR approach through deferral of retrofit until 2025 for new plant which incorporate technology for CCS – primarily on the basis that CCS technology may not be commercially viable until that time.

*(http://www.gazette.gc.ca/rp-pr/p1/2011/2011-08-27/pdf/g1-14535.pdf)

3.3 Considered but dismissed – the situation in Australia

While all countries have been party to the debate as to whether or not to adopt CCSR as part of their policy considerations, the Australian Government had perhaps advanced the furthest towards adoption before dismissing the approach. The debate in Australia around CCSR was initially driven by sub-national governments, which adopted CCSR policies in varying degrees and also sought to pursue these through the permit and approvals process for individual projects. The Australian Government subsequently released a Discussion Paper (November 2010) proposing a way forward to implement its policy commitment to introduce CCSR on all new coal-fired generation, and also to address the introduction of an EPS.

The Discussion Paper draws heavily on the CCSR definition co-developed by the Institute, and the Institute's subsequent CCSR issues brief which elaborated on the key underlying issues. The Paper included key CCSR criteria such as site planning and sufficient space and access requirements, potential storage including assessment and evaluation of target formations, feasibility of retrofit and preferred technology; transportation of CO_2; environmental impact assessment, and detailed economic feasibility studies/analysis for retrofitting CCS.

A total of 40 submissions[20] were received from stakeholders, with the tenor of the comments summarised in Box 6 below.

BOX 6: Stakeholder comments on Australian CCS Ready proposal

The overwhelming view advanced in the vast majority of submissions was that the Australian Government should rely on non-discriminatory, non-interventionist market-based measures to deliver the desired emissions outcomes. The clear position supported by most was that an effective carbon price or ETS was the desired mechanism, and that once implemented the market (carbon price) would determine the appropriate response by industry in meeting emissions targets. A significant number considered further measures (such as EPS or CCS Ready) to be unnecessary and likely to lead to confusion. However, there were some who considered that such measures could form a useful back-stop while the carbon market matured, or if the price was insufficient to drive new technology deployment.

In a similar vein, there was an overwhelming view that any measure including CCS Ready (and emissions performance standards) should not discriminate between fuels – i.e. apply to coal and gas-fired generation, and major refurbishment as well as new-build. If the Government was to pursue regulatory intervention, the preference was for emissions performance standards (at what level was strongly debated) on the basis that they delivered greater certainty and allowed for the market to guide/determine outcomes. They could also be ratcheted back over time. There were some (mainly NGOs) who suggested that if Government wished to support CCS deployment then it should require CCS on all new coal-fired generation and bypass CCS Ready altogether (a few were willing to consider a delayed start date – 2015/20).

More respondents argued against introducing – or favoured deferring – CCS Ready provisions than supported them, raising a number of issues regarding certainty, such as:

- the technology is unproven at commercial scale, and the requirements are out of step with the evolution of the technology;
- the proposed assessment process is too prescriptive and unwieldy, and would be unable to cope with evolving knowledge;
- there is insufficient knowledge on both transport and storage characterisation to enable assessment and these gaps would not be filled for years (especially storage); and
- storage risk and liability – implementation should be delayed until these are understood.

The area of greatest concern in terms of applying CCS Ready were the tests around economic/commercial availability and the triggers to move from CCS Ready to deployment/retrofit. All (who commented on this issue) considered it complex, filled with tenuous assumptions and highly uncertain. Most felt that such a measure should be determined by the market – preferably a carbon price - to avoid stranded assets. Some argued for a fixed date for compulsory retrofit so as to deliver certainty and prevent 'gaming of the system'.

In light of the issues raised in the submissions, the Australian Government decided not to proceed with the introduction of an emissions performance standard or CCSR requirements for new coal-fired power stations in preference for the introduction of a carbon price. This decision was announced by the Australian Minister for Resources and Energy on 13 December 2011 as part of the launch of Australia's *Draft Energy White Paper*[21]. The state of Victoria has announced that it is adopting the same position for the same reasons above.

The comments made by Australian stakeholders, particularly those concerning issues like the extent of the assessment possible for transport and storage options and the commerciality and deployment triggers for the move from CCSR to actual retrofit, are very much in line with those from other countries. The work done to underpin the scheme as set out in the Discussion Paper, and the subsequent comments, positively inform the body of work and issues that need to be considered by any jurisdiction implementing or considering a CCSR policy.

[20](http://www.ret.gov.au/energy/sustainbility_and_climate_change/cfps/submissions/Pages/submissions.aspx
[21](http://minister.ret.gov.au/MediaCentre/Speeches/Pages/LaunchoftheDraftEnergyWhitePaper.aspx)

3.4 Developing country issues

The focus of activity for developing countries is primarily on sustained economic growth and addressing energy poverty and system security issues. While many are beginning to address climate change policy and mitigation issues, the consideration of CCS (and CCSR) is very much in the early stages. As such, little progress has been made on locationally appropriate CCS regulatory frameworks and where there are examples of CCSR action, they are one-off and project oriented. South Africa is an interesting case in point having decided to impose CCSR provisions on approval for the Kusile power plant (see Box 7).

BOX 7: South African lessons

In June 2007 the South African Government imposed CCSR conditions on the construction of the Eskom Generation Project: 5400 MW Coal-fired Power Station – the proposed Kusile power plant, following a full Environmental Impact Assessment. The Government required the project proponent – as part of necessary measures that must be taken in respect of CO_2 – to include "carbon capture readiness", and submit a report detailing the preferred CCS technology.

While very much a stand-alone decision, it is reflective of a project by project approach whereby developing countries could initiate CCS considerations. While the rationale will differ according to country and project circumstances, it is noted that environmental NGOs are pressurising the global development banks to take far greater account of environmental issues/emissions when considering funding for coal-fired generation in developing countries. CCSR is one option for responding to these calls.

China and the Middle East are examples of developing nations taking proactive stances on CCS deployment. This is driven by consideration around the beneficial re-use of CO_2, particularly for EOR purposes. While a CCSR policy approach could be valuable in 'reserving CO_2 future re-use options', the general perception is that there is more than sufficient natural CO_2 available at this time – a higher order priority is seen as getting CCS technology deployed on a commercial scale.

3.5 Limited embracement

The active pursuit and uptake of CCSR as an integral component of the policy mix has been limited. It is only in the EU (and then only in relation to a limited number of members) and Canada that CCSR application has materially progressed. In some countries like the US, active debate was pursued for several years but has since diminished as a core political agenda. This has occurred because other drivers are now in place and delivering on CCS deployment (see Box 8).

BOX 8: US – where EOR is king

As is clear from the Institute's annual *Global Status of CCS* updates, the US leads the world in terms of commercial-scale CCS projects that are either in the final stages of project planning or have taken final investment decisions and moved into construction. However, that is not to say that all or even most will progress to development. What distinguishes projects in the US (and Canada) from the rest of the world is that virtually every active project incorporates a significant EOR consideration.

Anecdotal evidence suggests CO_2 can command, in the right circumstances, a price of up to US$40 per ton at the plant gate under long-term off-take contracts. These pricing signals (far in excess of the EU ETS price) when coupled with other government support mechanisms are sufficient to drive CCS project financing for at least some projects. To date projects have focussed on 'the low hanging fruit' such as gas processing where the cost of CO_2 capture is largely accounted for.

Whether or not this translates to more than a handful of power generation projects is yet to be seen. It remains unlikely without other revenue drivers or government initiatives. Similarly, whether or not possible future EOR opportunities will induce project proponents to actively build-in retrofit opportunities is also unknown at this stage. However, the market is buoyant and expanding based on the future oil market outlook.

Obviously the EOR market does not operate in isolation. It is underpinned by state-based emissions performance standards and by the USA EPA's recently proposed 'Carbon Pollution Standard for New Power Plants' (with possible delayed uptake – which will in effect force generators to facilitate retrofit), bolstered by government capital assistance. It is this combination of factors that is allowing some projects to take 'final investment decisions'. Given these circumstances there is currently no pressure and no interest in pursuing CCSR in its own right.

In a number of ways the US experience parallels that of Australia where market and price based signals either partially drive CCS deployment or form the preferred government intervention (for the present moment at least). However, while the US experience (based on the EOR driver) suggests that a carbon price signal is vitally important, especially when coupled with other forms of financial support, it is far from clear that the EOR price alone (based on current values) is sufficient.

Norway is the only country where the carbon price is close to 'right', and even there CCS deployment is underpinned by regulatory requirements. Most certainly the carbon price will not be sufficient (at least for the foreseeable future based on current parameters) to facilitate CCS deployment to the extent, or at the rate required to deliver the outcomes considered necessary under the IEA's CCS Roadmap (over 3000 operational projects globally by 2050)[22].

If consideration is limited to just those jurisdictions which have decided to rely on a carbon price signal to drive emissions reductions (and CCS deployment), largely in the absence of EOR considerations, two contrasting positions in terms of overall approach can be observed. On the one hand, Australia has put reliance on an administratively determined carbon price (transitioning to a market determined price in 2015), while the EC has moved to bolster or back-stop its ETS arrangements with a host of complementary regulatory mechanisms including CCSR.

The Australian Government initially proposed a suite of policy mechanisms including a carbon price signal, emissions performance standards, and a CCSR approach. After fully exploring the net benefits of carbon pricing, emissions performance and CCSR options, and having undertaken an extensive stakeholder consultation process, the Government opted to

[22](http://www.iea.org/papers/2009/CCS_Roadmap.pdf)

rely solely on the efficiency of an increasing carbon price signal in the short term to minimise the cost of mitigation outcomes. In contrast, the EU and some member states (such as the UK), with the knowledge and experience of the early operation of the EU ETS, have opted for additional measures including CCSR regulations. But the two schemes are not so different, and are explored in more depth at Box 9 below.

A clear message from the European experience is that CCSR can supplement a market determined carbon price (especially when carbon prices are low), and that policy-makers consider that CCSR does assume a complementary role in driving low-carbon technology deployment. There are some material informational issues confronting policy makers, especially in regards to determining the appropriate performance targets and compliance requirements for a CCSR approach.

It seems the easiest design of CCSR policies is to focus on all new generation investments over a certain capacity threshold, and applied from an agreed date (usually the date the government announces the policy). But the ultimate design features will need to be appropriate to national and regional settings, and the extent to which CCSR can complement and be integrated with other policy measures (such as emission performance standards).

Design issues include:

- the size threshold to apply for new plant (including the option of either a static threshold or one that diminishes over time);
- whether or not to include major refurbishments and how to define targets;
- whether to adopt a fuel neutral approach or focus on coal-fired generation first;
- what to do in relation to co-firing and biomass; and
- whether to gradually make the requirement retrospective over time to embrace generation that is operational at the time of announcement.

BOX 9: Australian and EU ETS comparison

The Australian Government has enacted legislation that will introduce a carbon price, commencing on 1 July 2012. Initially the carbon price will be fixed like a tax (for the first three years), before moving to an emissions trading scheme in 2015. The carbon price will only apply to major emitters of greenhouse gases (around 500 major industry players). Liable businesses will need to buy and surrender to the Government a permit for every tonne emitted.

In the fixed price stage (from 1 July 2012 to 30 June 2015), the carbon price will be set at AU$23 per tonne and rise by 2.5 per cent per year in real terms. From 1 July 2015 onwards, the price will be set by the market and the number of permits issued by the Government will be capped. Commentators have suggested the price will fall at least initially, once it is set by the market.

Within Europe the ETS has now been operating for over six years. While the initial years saw more buoyant prices, through much of 2011 and early 2012 the price languished well below €10 per tonne (between €6-7 for early 2012). The short term outlook is for little change with the over allocation of permits and the economic crisis largely being blamed for the situation. The price is only likely to recover if and when the ETS undergoes a major revamp.

As currently designed, the EU ETS is not in alignment with the EU's broader objectives of driving low-carbon technology deployment – it is part of a complementary set of policies and will not work in isolation (although it can be argued that the ETS policy has been highly successful in achieving emissions targets at the least cost). The general view of industry is that it is not strong or stable enough to incentivise low-carbon investments.

To quote Johannes Teyssen[*], CEO of E.ON (7 February 2012) "Does the price give any signal for new investments? No. None. I don't know a single person in the world that would invest a dime based on ETS signals".

The prevailing wisdom is that a price in excess of €35-40 per tonne is required to really drive investment in low-carbon technologies, and that back-stop policy levers, such as regulatory drivers in emission performance standards and CCSR will be essential through the medium term. Given the similarities between the EC and Australian ETS approaches, perhaps Australia has acted prematurely in removing CCSR from the policy mix.

[*](http://www.bloomberg.com/news/2012-02-07/europe-s-emissions-trading-system-is-dead-eon-ceo-teyssen-says.html)

Having set the framework parameters, the details around operational aspects of the approach will have a significant impact on the success of the measure. This includes details in relation to:

- requirements to demonstrate the full CCS chain:
- the degree of specificity required in relation to transport and storage provisions/options;
- economic/commerciality triggers as they relate to both CCSR feasibility (will it ever be economic to retrofit the plant); and
- timing/triggers for 'forcing' retrofit to be undertaken.

Exactly how the regulator or Competent Authority chooses to interpret and implement these critical operational aspects, particularly through the assessment process, will be decisive in determining the success or otherwise of any CCSR policy approach.

Perhaps the most critical issue, especially in determining whether or not the CCSR policy is effective in driving a transition to low-carbon energy systems is the extent to which there is a fixed date for the cessation to the policy and when compulsory retrofit must occur. Without rigorous enforcement of either retrofit or plant closure, the impact of the CCSR policy may be diminished as old generation plants continue to operate with little to no compulsion to abate.

3.6 Industry applications – all but forgotten

To date the focus of most governments with regard to CCSR has been on electricity generation. As detailed in the IEA's Technology Roadmap - Carbon capture and storage[23], industry and upstream CO_2 capture must also be addressed (Box 10). The importance of CCS application is clear given there are few alternate mitigation options for dealing with process driven CO_2 emissions from some industry sectors.

Subsequent work by the IEA in conjunction with the United Nations Industrial Development Organization (UNIDO), sponsored by the Institute, to develop a Technology Roadmap - Carbon Capture and Storage in Industrial Applications[24] reiterates the importance of tackling industry based emissions, and explores possible action by government and others to pursue CCS in industry.

BOX 10: IEA CCS Roadmap - Industry applications

Under the IEA modelling* "Capture from industry accounts for 1.7 $GtCO_2$/year (16%) and upstream capture (e.g., gas processing and fuels transformation) accounts for 2.9 $GtCO_2$/year (29%) of the total in 2050.

CCS is more than a strategy for 'clean coal'. CCS technology must be adopted by biomass and gas power plants, in the fuel transformation and gas processing sectors, and in emissions-intensive sectors like cement, iron and steel, and chemicals manufacturing."

*(http://www.iea.org/papers/2009/CCS_Roadmap.pdf)

Despite this there has been no specifically targeted government action in any jurisdiction to address CCSR for industrial applications. This reflects a number of prevailing realities, such as: a desire by governments to target the largest source of emissions first (generally power generation), that total industrial emissions may be relatively small on a national scale, and the fact that CCS applications for many industrial sectors lag behind the electricity sector. Nevertheless, some governments have indicated this shortfall may be addressed at a later stage, but that for the present, CCSR for electricity generation is the priority and focus of activity.

Some jurisdictions have designed their CCSR approach such that it targets combustion boilers and turbines of a certain capacity (the French approach), and as such do not discriminate between generation and industrial uses or applications. Interest in this area is beginning to develop at a sub-regional level. In the Municipality of Rotterdam for example, local government and the local environment protection agency are at the forefront of action and are looking to impose CCSR requirements on new industrial plant such as hydrogen production. Industrial application of CCSR policy is an important area for future focus and action.

[23](http://www.iea.org/papers/2009/CCS_Roadmap.pdf)
[24](http://www.iea.org/Papers/roadmaps/ccs_industry.pdf)

4 FROM POLICY TO REGULATION

While the setting of CCSR policy parameters is far from a simple task, translating them into workable, pragmatic legislation, regulation and guidance is far more complex. A key issue is to maintain a balance between providing liable entities with sufficient detail to deliver the desired outcomes without being so prescriptive as to render the instrument ineffective.

The process can be further complicated by multiple tiers of government (maintaining policy coherence while not being overly prescriptive) as well as split responsibilities within the same level of government. These issues arise in virtually all the jurisdictions examined in this report. The EU is without doubt the most complex jurisdiction in this way (Box 11).

BOX 11: EU – exemplifying complexity

The EU represents a multi-tiered and multi-layered system which presents a challenge in terms of developing a coherent policy framework. The EU has a complex combination of incentives in place to drive CCS deployment (direct funding through EEPR and NER300, R&D support), financial drivers such as the EU ETS, and a CCSR policy. As discussed earlier, there is a lack of policy coherence between the current design of the EU ETS and the push for low-carbon technology deployment.

In addition there are different players within the EC bureaucracy, and while the approach of the three separate EC Departments/Directorates General (DG) with CCS responsibilities is generally coherent and mutually supporting, there is an interesting distraction around CCSR. DG Climate Action – responsible for the CCS Storage Directive and Article 33 (the CCSR provision) – has decided not to issue specific guidance as to what constitutes CCSR or how member states might go about its assessment. However, another part of the EC has independently come up with its own (quite detailed and not totally aligned) interpretation of CCSR in the context of financial State aid rules. This is a clear recipe for confusion.

Each of the EU member states are then left to transpose the EU Directive into national law – and provided they reflect the parameters set down there is considerable discretion as to the detail of the provisions, guidance to local regulators and the extent to which they move beyond the minimal stipulations of the Directive. Furthermore, member states can totally circumscribe their own provisions through policy or other legislation (through say a policy of no fossil-fired generation, or spatial permitting restrictions) thus rendering the legislation 'moot'.

Within a member state there is the possibility of different jurisdictions (e.g. the UK and also Scotland) and of multiple levels of policy and regulatory action (e.g. the Netherlands Government and local decision making in the Port of Rotterdam). It is also highly likely that there will be a multitude of agencies involved in any one level of government (in part reflecting the complexity of CCS) – central policy ministries, those responsible for spatial planning and approvals, the CCS regulator, health and safety regulators, building and construction permits, EPA, and the 'crown estate' (state-owned resource managers).

There are also close parallels in the US, Canada, and Australia. The challenge for all these countries is to maintain a consistent, coherent, practical approach, focused on accelerating CCS deployment through pragmatic workable regulatory regimes. There is clear opportunity for governments to share best practice around CCSR assessments and to continually review and refine these approaches in light of their implementation and compliance experiences.

4.1 Making Emissions Performance Standards work - complementing CCS Ready

The UK has announced it will implement emissions performance standards to complement its CCSR approach, the Canadian Government is nearing the end of a consultation process prior to an intent to introduce emissions performance standards, and the USA EPA has also foreshadowed the introduction of standards. Other jurisdictions have examined the option (for example Australia), but decided not to pursue this policy option for the time being.

BOX 12: UK Emissions Performance Standards and CCSR – working together

The UK system is designed to drive the partial capture and storage of new coal-fired generation, while clearly putting industry on notice that they will have to move to full deployment from a specified future date (2025 for plants permitted under these arrangements and immediate for plants permitted after 2018 in Scotland). Importantly, only plants that are assessed positively in terms of their capacity for CCS retrofit will be approved – the permits specifying provisions to enable that retrofit to proceed smoothly.

The approach seeks to ensure that issues around both carbon lock-in and technology lock-in are addressed up front. Project proponents have clear notice of the long-term direction of policy/regulation, and can plan accordingly knowing they will have to fully retrofit CCS within 10-15 years (plus the benefits of applying partial retrofit). While the CCSR assessment process requires the project proponent to examine technology options in detail and set out the preferred technology to be applied, they are able to retain the flexibility necessary to pursue alternatives (although a fundamental change in say pre-or post-combustion may be challenging).

The proposed Canadian system sets an emissions performance standard and then allows for deferral of the application of that standard for project proponents who propose to retrofit the plant with CCS. There is no requirement to undertake any CCS deployment up until 2025 – on the basis that CCS technology may not be commercially viable until that time.

Like the UK, the Canadian Government requirement is that from 2025 the plant must operate in compliance with the standard (in effect the operator is to have completed full plant retrofit by that date) which reflects the Government's expectations as to when CCS deployment will be economically viable. The lack of any assessment as to the feasibility of CCS retrofit means that the implied CCSR policy is never tested, and both project proponent and government may well face all the issues around carbon lock-in and stranded assets in the future (from 2020 by which time retrofit studies need to be completed).

Setting deferral dates can be contentious. Some governments clearly accept that CCS technology has developed to the stage where it can be deployed at full commercial scale. Accordingly they have adopted a 'no new fossil fuel generation without CCS' policy (Norway) requiring full CCS deployment on all new plant, from day one of operation allowing the project proponent to determine commerciality within the market. Others accept that further work is required to roll-out full-scale commercial deployment and generally opt for conservative implementation dates that build in considerable lead-in time.

While providing liable entities with policy certainty, they may perversely contribute to delaying CCS deployment. A preferable alternative could be to build in a series of project-based gateways and/or rolling reviews, considered periodically say every two to three years (while retaining a fixed end dates). This allows the Competent Authority to make an independent assessment as to when it is economical for liable entities to move to partial or full CCS retrofit, and build in the necessary triggers in the initial permit to force that line of action. Under such a system 'getting the assessment test right' becomes a critical factor.

A second issue of concern with an emissions performance standard/CCSR complementary approach is the setting of the level of the actual emissions performance standard. It seems contemporary wisdom suggests setting a standard which is in effect equivalent to the level of emissions from a current best available technology, or state of the art natural gas combined cycle plant. These clearly target coal-fired plants, but allow gas-fired generation to continue unabated.

A ratcheted or declining emissions performance standard that progressively lowers the level of emissions over time, in parallel to more stringent CCSR settings or establishment of next generation policies (ETS) becoming the predominant incentive driver, would be more effective in terms of letting the market determine fuel choices and in meeting emissions targets. This would also facilitate moves towards partial abatement almost immediately

(along the lines of the Scottish approach of requiring any new coal station to be fitted with 300 MW (electrical) of CCS capability from commissioning), giving industry the opportunity to learn from partial deployment prior to moving to complete plant CCS applications.

4.2 Economic/commercial viability tests

The technical and financial triggers for assessing CCS viability and retrofit triggers are complex and can lend themselves to ambiguous and inconsistent interpretations and methodologies. It is vital that they be clearly articulated in any CCSR policy. For example, while CCSR relevant statements such as 'economic viability or commercial availability' can be argued from a range of theoretical positions, a generally accepted departure point is that such statements should better reflect positions of economic feasibility of implementation.

This means that investment should provide a reasonable economic risk-adjusted return (within operating electricity market parameters) after internalising the prevailing carbon price. Alternate triggers that propose using a 'commercially available' trigger for example goes more to market availability of the equipment, and not so much the 'economic performance' of an investment in a competitive electricity market. Ultimately governments are likely to want to consider both.

At this stage the UK has implemented the most rigorous assessment process, based on the EC CCS Directive. The details are outlined in Box 13 below. In setting these arrangements, the UK Government has recognised that the economic assessments will involve a wide range of assumptions on a number of factors, and that there are inherent uncertainties about each of these factors. Further, it accepts that it is not possible to anticipate with complete certainty in what circumstances it will be feasible to retrofit CCS or when those circumstances will arise, but it can clearly indicate the circumstances which would need to be in place for CCS to be economically feasible on a particular plant.

While the UK Government acknowledges economic feasibility parameters may change over time, it has not taken the additional step of requiring regular review and possible update of the assessment (although these may be volunteered). This is primarily because many of the parameters which will determine economic feasibility are not in the control of developers, and also partly because much of the necessary information is readily available to Government, should it wish to consider the impact of any changes on the feasibility of retrofitting CCS.

BOX 13: UK economic assessment process

The EC CCS Directive 2009/31/EC requires that "the economic feasibility of transport and retrofitting should be assessed taking into account the anticipated costs of avoided CO_2 for the particular local conditions in the case of retrofitting and the anticipated costs of CO_2 allowances in the Community. The projections should be based on the latest evidence; a review of technical options and an analysis of uncertainties in the assessment processes should also be undertaken"[*]. This is the starting point for any UK assessment.

The conduct of a single economic assessment encompassing retrofitting of the entire CCS chain is required to ensure the assessments are meaningful and demonstrate the full range of costs and benefits associated with CCS deployment. This avoids the granting of development consent to those plants where there will never be a reasonable business case for CCS. Applicants are required to provide evidence of reasonable scenarios – taking into account the estimated costs of the capture and transport options chosen for the technical assessments and the costs of CO_2 storage – which demonstrates CCS will be economically feasible for the proposed development.

Applicants are required to produce a clear summary of the results and state under which reasonable scenarios and parameter ranges operational CCS would be economically feasible for the proposed plant.

[*](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF)

The UK assessment process is predicated on assumptions around future market dynamics, and the requirement to demonstrate CCS retrofit is feasible in the future (to be operational by 2025 at the latest) before planning permission will be granted. There seems little scope or advantage in 'gaming the policy'. A risk is that if the project proponent 'gets it wrong' they will lose their licence to operate the plant or have to undertake an uneconomic retrofit investment.

The UK is the only jurisdiction to have moved to this level of specificity around economic feasibility, and having now undertaken several assessments, has by far the most direct experience with CCSR policy. There seems to be clear lessons for other jurisdictions in terms of the UK's approach, especially for any that contemplate using an economic test to trigger retrofit directions by the regulator (particularly where CCSR provisions have no close or end date and rely solely on this trigger).

Similar issues arise when applying CCSR and subsequent retrofit provisions to existing plant with effect from a specified date. If there is any question about the economic viability of proceeding with a CCS retrofit, then there is a clear incentive for the plant operator to minimise investment and run the plant right to the specified date with no intention of undertaking any CCSR assessment or pre-investment.

The Canadian approach of requiring a gradual phasing in of CCS technology from an earlier date (in comparison to new build which obviously will not have recovered the capital investment) also potentially prevents 'gaming of the system'. The Canadian proposal is that once a currently operational unit reaches to within six years of the end of its useful life, it will be required to capture at a rate of 30 per cent until 1 January 2025 (after which it must meet the emissions performance standard).

4.3 Storage characterisation and CO_2 transport planning

Transport and storage issues make the setting of appropriate parameters for CCSR assessment processes very complex. Governments may find emission performance standards a preferable policy intervention because they effectively shift the onus for assessing and securing transport and storage to the project proponent. However, emission performance standard approaches tend to place an onus on governments to invest and support common user infrastructure (both transport and storage), and to provide enhanced pre-competitive sub-surface geological data.

The initial focus of the international CCSR policy discussion on 'capture ready' holds little relevance if CCS retrofits are constrained by the lack of transport and/or storage options. The components of the whole CCS chain are clearly sequenced at different stages of development, and are not necessarily best assessed on a project-by-project (or point-source-to-sink) basis.

The assessment of available storage opportunities appears to be one of the more critical and often the most challenging component of assessing CCS readiness (Box 14). Clearly without a good understanding of storage opportunities it is extremely difficult to argue a project is CCSR.

BOX 14: Global CCS Institute's CCSR Issues Brief 2010 no. 1

"The need to identify and assess storage sites in a timely manner is critical to the process of meeting CCSR requirements, and can be influenced by the current state of general storage assessment activities. Where a jurisdiction is still in the early stage in its storage assessment, proponents may be dissuaded from undertaking CCSR activities if they bear the full costs of exploration.

Additionally, there is a risk that not all storage sites identified by CCSR project proponents will be viable when fully characterised at the time of retrofit. This risk is compounded when the associated risks of capture and transport readiness are undertaken in advance of exploration and characterisation of the storage site."

The policy challenge is to settle on the 'degree of characterisation' of the site needed to adequately 'de-risk' the storage option. In some jurisdictions there may be extensive pre-competitive reservoir data available that project proponents can access. They may also be able to acquire (from either government or industry sources) information relating to petroleum exploration or even past production that may assist with characterisation (noting that this will be slanted towards petroleum resources rather than CO_2 storage). However, it is extremely unlikely that there will be more than minimal high-level information available for saline aquifers.

Full characterisation is expensive and time consuming, and a site will only be 'de-risked' following the drilling of wells and the conduct of injectivity tests. Even at this stage, performance over time can only be modelled to a certain degree of accuracy and confidence. It would be unreasonable to expect full characterisation at the early stage when initial CCSR decisions are being made.

It is expected that this will change over time as storage experience becomes available and projects begin to exploit the opportunity to connect to already operating sites. Accordingly, governments have tended to approach the issue by limiting the scope of assessment to just utilising the readily available information – along the lines that Australia had proposed (Box 15).

BOX 15: Australia: Identification of potential storage areas*

"Proponents will estimate the total CO_2 to be captured for the plant's life and identify geological formations that could realistically store this amount. A storage assessment will evaluate the formations based on pre-competitive data, such as work completed by state governments, the Australian Government ... A risk assessment must be included, including key environmental considerations, such as post-injection CO_2 leakage and land use conflicts ... "

There is no requirement for the project proponent to acquire new information (i.e. shoot new seismic data) to enable more in-depth assessment and the further 'de-risking' of the chosen storage option.

* (http://www.ret.gov.au/energy/Documents/sustainbility-and-climate-change/MO%20Final%20InterDepartmental%20Discussion%20Paper%20Cleaner%20Future%20Power%20Station%2026%20November%202010%20EMBARGO%20til%2030%20November%20(2).pdf)

While this appears a rational approach, a relatively high degree of uncertainty remains both in terms of the storage cost estimation and physical capacity of the site (including whether or not injectivity will be possible). This can be minimised with effective modelling, and will diminish with experience, but it is still a major judgement call for the regulator and/or Competent Authority. The UK Government has attempted to partially address this risk through its current approach which effectively restricts storage to a pre-designated listing drawn largely from existing oil and gas fields (Box 16).

While project proponents are required to nominate the field they propose to use, and undertake their economic assessment on that basis, no action is required on their behalf to safeguard access to the site (i.e. an access option secured through some form of financial

instrument). Rather the Competent Authority maintains a register of *CO_2 Storage sites – Areas identified for potential usage in CCR reports*[25] which in effect details which project has been allocated which site.

The assessment by the regulator focuses on whether the site nominated is sufficient for the anticipated CO_2 stream. Thus in the UK it is the UK Government that is effectively safeguarding the access to storage.

BOX 16: UK: Demonstration of the storage component*

Selection and demonstration of the storage component for CCSR should involve:

"Identification of a possible storage area, including delineating the geographical extent of that area, and identification within that area of at least two oil or gas/gas condensate fields (or saline aquifers) listed in the range of geological formations identified as 'viable' or 'realistic' for CO_2 storage; the data source relied on for identification of the suitability of these areas and fields/aquifers should be the 2006 DTI study or other similarly authoritative source(s); a short summary including an estimate of the total volume of CO_2 likely to be captured and stored by the power station and an estimate of the CO_2 storage potential of the area identified by the applicant. The purpose of this summary will be to demonstrate whether the proposed storage area has sufficient capacity for the proposed plant's captured emissions, when account is taken of earlier applications which have relied on the same fields or aquifers for this purpose."

*(http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/development%20consents%20and%20planning%20reform/electricity/1_20091106164611_e_@@_ccrguidance.pdf)

In adopting this approach, the UK Government is effectively sharing part of the risk. The risk is minimised to a certain extent given the high density of oil and gas fields in the North Sea, the extensive array of detailed pre-existing data, including reservoir production and performance information, and the significant number of alternative storage sites that could be developed at a similar cost (the UK lists over 120 storage options). Nevertheless, there is scope for further refinement based on upgraded assessment and new information, and to this end the Government is undertaking further work through the Energy Technology Institute.

Given the general paucity of storage data (and lack of applied experience) governments have little option but to take a relatively light handed approach to storage assessments. The need to enhance early stage and pre-competitive characterisation work to reduce storage risk is generally well recognised, as has been highlighted in numerous calls for enhanced government action in this area by the Institute, the CSLF, IEA and CEM.

Where it is intended that the captured CO_2 will be used for EOR purposes, or where it is to be directed to a multi-user storage site (once these are developed), there will be a 'step-change' in the degree of certainty provided. In these cases governments could call for a far more rigorous analysis and impose permit conditions accordingly.

Transport planning, while it involves uncertainty, is less problematic and information intensive than storage. Significant volumes of natural sourced CO_2 have been transported by pipeline for many years and there is a very good understanding of the technical and economic challenges. This allows project proponents to execute and submit to authorities well-informed assessments.

The US and Norway have many years of experience which can be instructive to other jurisdictions. While shipping of anthropogenic sourced CO_2 is less advanced than natural sourced CO_2, experience in the transport of both liquefied petroleum gas (LPG) and liquefied natural gas (LNG) provides valuable insights as to the potential operational and cost issues.

[25](https://www.og.decc.gov.uk/EIP/pages/c02.htm)

The issue of land access and rights of way for transport corridors that introduces considerable uncertainty into transport planning, especially in densely populated regions like the UK and the Netherlands. This is further exacerbated where the storage location is to be determined, and for which prospective locations change following characterisation work.

A number of studies have been initiated looking at the establishment of an integrated CO_2 transport infrastructure for Europe including *CO_2Europipe*[26], and also at a more local level such as the UK study *A Carbon Capture and Storage Network for Yorkshire and Humber*[27]. While such systems can help to drive down costs in the long-run, they are of little relevance to short-term considerations relating to CCSR assessment and multi-user economics.

The UK Government has introduced an innovative approach to its assessment approach, requiring project proponents to differentiate between the initial 10 kilometres of the pipeline route and the remaining distance to where either the pipeline goes offshore or terminates at a ship loading facility (Box 17). For the purposes of assessment it is presumed that sub-sea pipelines will not pose any major approval/routing issues, and landfall issues (while often environmentally sensitive) can be addressed through 'normal petroleum industry practice' currently in use for both oil and gas pipelines.

BOX 17: UK pipeline assessment process*

"Applicants must demonstrate that a feasible route exists from the site to the storage area. In particular, it is important that applicants for Section 36 consent demonstrate that a feasible 'way-out' exists from the power station site for the CO_2 pipeline. In order to do this, for the first 10km surrounding the power station applicants are asked to identify a favoured route for their pipeline, within a 1km wide corridor, and in addition are asked to identify major pre-existing obstacles (arising because of safety or environmental concerns) within a 10km radius of the station.

After the first 10km from the power station, because of the greater availability of alternative routes, applicants are asked to identify a 10km wide corridor to the point(s) on the coast where they envisage either a pipeline going offshore or CO_2 going on board ship.

The corridor widths are not the degree of clearance which must exist between the pipeline and other forms of development, rather they delineate the area in which the applicant thinks it feasible for the pipeline to be routed."

*(http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/development%20consents%20and%20planning%20reform/electricity/1_20091106164611_e_@@_ccrguidance.pdf)

This differentiation is based on the premise that if there is no effective pipeline option to get the CO_2 off-site, then CCS retrofit will never be achieved. It appears that the designated radius of 10 km is somewhat arbitrary, and dependent on local circumstances. For example, in an industrial area there are likely to be existing easements and rights of way that the project proponents should be able to access, while in large and highly urbanised areas options may be far more limited over a greater distance and likely to attract public opposition.

The UK approach goes further than other jurisdictions in terms of the detail in the assessment of transport options, but it does not impose any requirements on the proponent to safeguard access to those options. In a dense industrial region for example, new neighbouring developments could foreclose options thus rendering CCS retrofit impossible. However, this is relatively unlikely given that developments are often localised and the operators of power plants should be able to assess the impact on their future operations. Given power plant operators also have to provide regular reviews of the CCSR aspects of their projects, the Government would be made aware if this was becoming a serious issue.

[26] (http://www.co2europipe.eu/)
[27] (http://www.co2sense.org.uk/uploads/public/CCS%20Network.pdf)

It seems apparent that is in the plant operator's interest to ensure that transport options remain open so as to retain retrofit capability when the market drivers (either the EU ETS or Carbon Floor Price) are sufficiently high to make CCS the economically rational choice.

4.4 Public consultation processes

Public consultation processes relating to CCSR primarily occur at two levels: initially around the overall policy approach, and secondly, at the project-specific level.

The general approach to CCSR has been to consult on the detail of the implementation of the approach, rather than the fundamental policy approach that might be taken to addressing climate mitigation (i.e. assessing a CCSR policy against alternative options).

The Australian Government's consultation process for example effectively explored the fundamental policy question, while outlining and seeking comment on how the Government should implement the policy if it proceeded. Given the tenor of comment received, the Government decided to adopt alternate policy measures. Whether or not alternate policies can drive the scale of CCS deployment outcomes needed to curtail emissions from fossil-fuel based production activities will need to be assessed in hindsight.

Within the EU member states, the fundamental policy debate had already concluded with adoption of the CCS Directive, noting there wasn't extensive consultation undertaken in the lead up to the adoption of the Directive. Accordingly, the focus of country level consultation was on how to go about implementing the CCSR measure, rather than whether to adopt it or not.

The approach taken by both the Canadian Government for its emission performance standards, and the US EPA around its proposed standard for carbon pollution from future power plants (under the *Clean Air Act*) is similar, in that the focus goes to the process of implementation and its key parameters, such as the levels set, dates of required retrofit, etc. Consultation on the CCSR policy measure itself and its operational parameters tends to focus on institutional stakeholders such as industry players (generators, equipment suppliers, business and institutional support services, the financial community), NGOs (both environmental and business associations); the R&D and academic communities, key lobby groups (consumer groups, legal rights/services), and both statutory and non-statutory government bodies.

The approach taken is also quite variable ranging from highly structured and formalised (often adhering to a well-established format applicable to all consultative processes around new regulatory provisions) as epitomised by the UK (and both Canada and the US EPA to a considerable extent) through to informal discussion/meetings between government and key stakeholders (often the approach in parts of Europe), and finally in some jurisdictions, virtually no consultation at all.

There is little doubt that the public consultation process has changed the course of policy outcomes (as in the Australian case), or resulted in refinements to the regulatory package subsequently adopted. The UK approach (Box 18) is a good model, with the Government setting out in considerable detail the process, the responses received and the resulting Government reaction in its report – *Towards Carbon Capture and Storage: Government Response to Consultation*[28].

[28](http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file51115.pdf)

BOX 18: UK consultative process

The UK consultation document *Towards Carbon Capture and Storage* was made available online and also sent to key stakeholder organisations. A total of 79 responses were received, many responding to the 40 listed questions. Responses ranged from general comments on aspects of energy policy to detailed considerations of the questions posed. The written process was supplemented by meetings with key stakeholders held in parallel.

The Government released an extensive report outlining the consultation and its subsequent response: *Towards Carbon Capture and Storage: Government Response to Consultation*[*]. The key messages arising out of the consultation were:

- nothing in the responses challenged the crucial importance of CCS or the CCSR approach proposed;
- power plant operators are willing/agreeable to maintaining appropriate space on site;
- acceptance that the economic assessments will inevitably only provide an outline given the current stage of CCS development, the significant cost and timing uncertainties and many exogenous variables;
- the proposed thresholds are practical;
- a call for greater detail in the guidance as to how applicants can demonstrate CCS readiness (guidance subsequently expanded);
- a call for greater detail as to how the proposed storage regime will work in practice, including issues concerning competing uses (guidance subsequently expanded); and
- the desirability of model permit conditions.

[*](http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file51115.pdf)

Experience with regard to project-level consultation in relation to CCSR provisions is, by nature of the maturity of CCSR implementation, somewhat more limited. It is expected that localised communities as well as key stakeholder groups will become engaged at the same time. It is unlikely however that the focus of input will be on specific issues around the CCS readiness of a plant, but rather on topics such as development approvals, and 'not in my backyard' (NIMBY) related issues.

The UK has the most experience in this aspect of CCSR policy having processed seven applications through the CCSR provisions, with more pending. Given that the CCSR assessment is an integral component of the overall approvals process for projects under Section 36 of *The Electricity Act,* 1989 (and other general project legislative provisions i.e. town planning, hazardous substances and environmental impact), consultation is undertaken as part of a much wider process. As such any specific CCSR issues tend to be swamped by the more general planning considerations. The consultative process is comprehensive, with the Secretary of State (the Competent Authority under Section 36) detailing his response to all issues raised[29].

Further experience in undertaking public consultation is required before it can be determined whether or not these processes can provide a valuable feedback loop to the CCSR process, enabling it to address issues raised over time.

[29](https://www.og.decc.gov.uk/EIP/pages/c02.htm)

5 STAKEHOLDER RESPONSES: Implementation

Governments have only recently sought to promulgate CCSR policy and actions over the past three years, and it is really only over the past 12 to 18 months that the regulatory provisions have been operative. Nevertheless, the key stakeholders have been active in various jurisdictions and their actions provide valuable insight into the value (or not) of a CCSR approach.

5.1 Local regulators

Governments may find that the detailed application and administration of CCSR policy is best delegated (under appropriate legal instrument) to the local level (as with other legal instruments). The local regulator and/or Competent Authority is often best placed to take informed judgements based on more complete 'grass-roots' information, and thus able to give best effect to the regulations.

Local and regional governments can often afford to be more assertive in their policy approach towards both CCS deployment and CCSR conditions and, through local regulatory bodies can drive binding permit decisions. In the Netherlands, the Municipality of Rotterdam is clearly acting in advance of the national government position in relation to project by project approvals and the treatment of CO_2 emissions.

This local government has adopted a clear policy calling for CCS on all new coal-fired power plants and has stressed that it will pursue CCSR through its planning and regulatory procedures. The policy has been developed through an active partnership with industry, fostered through the Rotterdam Climate Initiative (RCI) program.

Given the clear RCI policy position on CCS, and the extensive range of local planning obligations that come into play in permitting individual projects (environmental, spatial planning and best available control technology), project proponents have looked to incorporate CCSR provisions into their siting and approvals applications. Companies are clearly responding to the market signals arising from the RCI policy stance.

DCMR Milieudienst Rijnmond (DCMR) is the environmental protection agency with responsibility for the Rotterdam and Port of Rotterdam area and it is also the local Competent Authority in terms of the Netherland's legal provisions giving effect to the EC CCS Directive as they relate to CO_2 capture installations (but not storage). Therefore it is the DCMR that considers and approves the CCSR requirement as they relate to the plant (Box 19).

BOX 19: Action in the Port of Rotterdam

While DCMR can actively pursue the RCI policy objectives, it does not have a legislative mandate to 'demand' CCSR actions beyond those laid down in the national statutory provisions – that is a strict transposition of the assessment required in Article 33 of Directive 2009/31/EC.

However, local Rotterdam politicians have been persuasive in encouraging project proponents to come forward with proposals that align with the RCI position. DCMR is then in a position to initiate negotiations with the project as to how these 'voluntary actions' are taken forward, and based on the outcomes is able to incorporate agreed undertakings into the permit conditions.

While this enables somewhat ad-hoc progress on a project by project basis, DCMR would rather see changes to the requirements specified in the national approach (including more prescription in relation to CCSR assessment). This would ensure consistency and enable DCMR to plan and regulate with a greater degree of certainty.

The Port of Rotterdam is the principal location outside of the UK where CCSR plants are being constructed. E.ON's Maasvlakte Power Plant 3 was permitted and constructed as fully CCSR, and importantly the effectiveness of the provision will be tested early when part of the plant is retrofitted under the Rotterdam Capture and Storage Demonstration Project (ROAD project). RCI and the DCMR have also looked to examine CCS in relation to gas-fired generation and industrial applications:

- a CCS pre-feasibility study was undertaken in relation to a 840 MW gas-fired combined heat and power project as part of its permitting process (the study proved negative); and
- Air Liquide and Air Products have both incorporated CCSR provisions into the construction of new hydrogen plants (even though this is not a requirement of the operational licenses).

While these (mainly voluntary) actions by Air Liquide, Air Products and E.ON are a reflection of the local circumstances in Rotterdam, they are indicative of wider thinking by at least some industry leaders – and particularly those located in regions where CCS is being strongly championed.

5.2 Industry actions

It might be perceived in some circumstances that industry is moving in advance of government CCSR positions (with the exception of the UK and Rotterdam). Certainly some industries such as the equipment and systems suppliers have a vested interest in being at the forefront of the market. Both Alstom and General Electric (GE) have invested heavily in R&D to optimise plant design for CCSR, and actively promote some of their products in this way (Box 20).

Alstom is focussing on Oxy-Combustion and Post-Combustion Capture, while GE has invested heavily in integrated gasification combined cycle (IGCC), claiming its technology *"can be flexibly configured with up to 90 per cent carbon capture to achieve a CO_2 emission intensity ($C0_2$ tonnes per megawatt hour 'sent out') which is approximately one-third (⅓) that of a natural gas combined cycle power station"*[30].

[30](http://www.ret.gov.au/energy/Documents/sustainbility-and-climate-change/GE-energy-aust.pdf)

***BOX 20**:* Alstom CCS Ready marketing*

"Alstom continues its significant R&D efforts in the field of CCS and is currently validating the technologies at a number of pilot and demonstration projects throughout the world, working closely with our partners toward full scale commercialisation that we believe will be available to market in 2015.

During this validation process of the CCS solutions, to avoid the risk of stranded assets, Alstom offers its customers a 'CCSR' plant concept.

This concept takes into account the needs of customers who purchase plants today that will ensure they are not penalised financially when the technology becomes available. Capture ready will limit the time for plant outages and unnecessary expense and ease the integration at the time of installation of the CO_2 capture plant."

*(http://www.alstom.com/power/fossil/coal-oil/carbon-capture/)

It is not just the equipment suppliers that are adopting CCSR friendly positions. E.ON has also made moves to ensure that at least part of its fleet of new coal-fired power generation in the Netherlands, Germany and the UK is CCSR. It currently has two CCSR plants under construction, a further two in the permitting stage, and had planned the now abandoned Kingsnorth plant to be CCSR.

This action by E.ON partially responds to community expectations around 'clean energy' and also seeks to ensure that the company is well positioned in relation to current and future regulatory approaches. In effect this is an insurance policy against carbon lock-in and to avoid the possibility of stranded assets.

Given uncertainties as to exactly how governments and the Competent Authority will look to interpret CCSR assessment requirements under Article 33 of the EC CCS Directive (except in the UK which has adopted detailed guidance), E.ON has opted to seek certification that its new coal-fired plants are CCSR from the German standards and inspection company, TÜV NORD Group. Responding to a gap in the market, TÜV NORD has developed a commercial assessment service for individual plants and issues a certificate stating that the plant will be CCSR if it meets certain criteria.

TÜV NORD's assessment addresses technological and site-specific feasibility, health and safety, and environmental impacts, plant adaptability and flexibility to incorporate emerging CCS technology, CO_2 transport and storage, and ensures sufficient space is available for the retrofit. The detail of the assessment criteria and process adopted by TÜV NORD is not in the public domain, and therefore it is difficult to determine whether this certification is sufficient to meet the expectations of Article 33.

E.ON is one of the few companies that have signalled its willingness to consider additional investment upfront to facilitate later retrofit. The company has suggested that its economic modelling indicates that any additional upfront investment costs will be more than offset via the savings generated from avoiding a major outage and significant additional engineering work at a later stage. Of course this is all predicated on a forced CCS retrofit sometime over the plant's economic life. It is accepted that fundamental decisions around pre-or post-combustion CCS choices will need to be made up front, but that both design and construction can be sufficiently flexible to incorporate different technology/supplier offerings and new developments. Technology 'lock-in' is not considered an issue.

There are also other examples (beyond the Netherlands, UK and E.ON) where industry is either acting in advance of government regulation or taking on specific project provisions. In Western Australia two companies have sought (and been granted) environmental approval for CCSR plants even though this is not a specific requirement of the Western Australian Government. In South Africa Eskom is moving forward with construction of the Kusile

coal-fired power generation project in compliance with the CCSR conditions imposed by the South African Government.

Clearly some generation companies are beginning to build CCSR considerations (and costs) into their business models, with a view to optimising long-term profits, maximising the economic life of long-lived capital intensive assets, while also addressing future risk. At least some players see value in an approach that prepares the way (CCSR), but will then allow for a choice between either a gradual retrofit or by paying for carbon offsets in response to either carbon price or regulatory requirements. To the extent possible, they are seeking to 'hedge their bets'.

It would be highly contestable to conclude that industry is universally moving in advance of government in regards to CCSR policy. Industry rightly works in compliance with the regulatory requirements, generally choosing to move beyond specified requirements when there is a clear economic driver (ie EOR in North America) or where future government policy intent has been signalled, and it is deemed to be in industry's interest to anticipate and plan for the inevitable.

5.3 Environmental NGOs

While there are some strong ENGO advocates for CCS (Bellona, ZERO), the majority of ENGOs remain cautious (with some in outright opposition) as to the role CCS should play in mitigating global emissions[31]. There seems to be a greater ENGO acceptance of the role CCS needs to play in addressing industrial emissions (i.e. iron and steel and cement production).

Even though there may be guarded support by ENGOs for CCS, virtually all question the implementation of CCSR policies. There appears a general view that while a plant may have an enhanced capacity to accommodate CCS retrofits, it is never likely to be realised. A WWF report in May 2008 – *Evading capture: Is the UK power sector ready for carbon capture and storage?*[32] seeks to address many of the concerns of ENGOs. The WWF's key recommendations to the UK Government at that time are set out in Box 21.

BOX 21: WWF position on CCS Ready

CCSR is not the WWF's favoured option – rather it would prefer the introduction of "….new legal standards setting a limit on CO_2 emissions for all new generating plant that has yet to secure planning consent. This standard should be set at 350g/kWh ... but tightened significantly once CCS technology has been proven.

However, if the government decides to consent to any new 'capture ready' coal stations, it should ensure that it includes (the) criteria on site layout, technology, transport, storage and business plans ... Most critically, it must impose binding requirements that full CCS should be installed by 2020 at the latest – if this does not happen, the government should force closure of that power plant."

The UK Government has in effect implemented these recommendations in terms of its CCSR assessment processes. However, concerns remain around the timely triggers for bringing about retrofit, and more generally governments' resolve and political will to force the closure of high value and still economically productive assets (that may also be important for energy security reasons) should companies not meet their obligations and proceed with retrofit.

By way of example the ENGOs point to the history with flue gas desulphurisation equipment in the UK (and parallels elsewhere) where it effectively took 15 to 20 years to realise requirements for the fitting of sulphur scrubbers.

[31](http://www.zero.no/ccs/environmental-organisations)
[32](http://www.wwf.org.uk/wwf_articles.cfm?unewsid=1801)

Notwithstanding these negative views on CCSR, the ENGOs are actively monitoring jurisdictions where CCSR policy has been promulgated, and legally challenging in some cases both governments and the EC (including through direct recourse to the courts) if they consider that the assessment of CCSR is out of compliance with Article 33.

5.4 Finance Community

Global banking institutions are major players in the delivery of the very significant investment needs facing energy sectors over the coming decades. Their policy stance in terms of clean energy issues and efforts to deliver climate change mitigation strategies are an important determinant in characterising the global electricity generation fleet (and curbing industrial CO_2 emissions) going forward.

Banks are under increasing pressure from the broader global community to inform their clients and the public as to their views on the risks and conditions of investing in fossil-fired generation. Given the underlying risk and reputational issues, banks have moved to respond, and a number have adopted specific policy positions and guidelines around how they will deal with investment decisions in relation to coal-fired electricity generation.

There is a differentiated position between the development banks and the purely commercial financiers. The development banks, given that governments are their principal source of liquidity, seem more attuned to government policy, tempered by the needs of their key developing country clients (whose foremost priority is to see energy poverty needs addressed).

The World Bank and the Asian Development Bank (ADB) have both established focused clean energy programs which contain CCS elements. The ADB has developed a very strong 'China program' and is actively funding projects with both CCS and CCSR elements, while the World Bank is involved in funding of the Eskom South African Kusile project.

Both banks, and other development banks, are under increasing pressure particularly from ENGOs to reconsider their lending policies and further tighten project assessment criteria to ensure CO_2 emissions are a key consideration – often with a purpose of restricting funding for coal-fired electricity generation projects. The implementation of CCSR provisions potentially provides banks with an alternative strategy that may partially satisfy ENGO concerns (noting however that the World Bank nor the ADB has indicated a formal position on CCSR).

The two major European development banks, the European Investment Bank (EIB) and the European Bank for Reconstruction and Development (EBRD), are both active in supporting major energy infrastructure projects including fossil-fired generation (both within and beyond European borders).

The EIB also has a major role in undertaking due diligence and assessment for the EC in relation to the NER300 CCS project funding (this process is 'ring-fenced' in relation to its 'normal' investment activities). This work has enabled the EIB to build up considerable internal expertise on CCS issues – including CCSR. The EIB policy on CCS is set out in its *Clean Energy for Europe: A Reinforced EIB Contribution*[33] statement (Box 22).

[33](http://www.eib.org/attachments/clean_energy_for_europe.pdf)

BOX 22: EIB CCS Policy

"New commercial coal/lignite power stations should use best available technology and be 'carbon capture ready'. They should also be cost effective taking into account CO_2 externalities, i.e. be able to exploit CCS once that technology becomes commercially available. In order to avoid a shift towards carbon intensive electricity generation, new plants should replace existing coal/lignite power stations while providing a decrease of at least 20 per cent in the carbon intensity.

The EIB is ready to finance CCS demonstration plants...

Retrofitting projects for existing coal/lignite power stations should be relatively small investments, so they do not delay plant replacement in the medium term, and they should aim at substantially reducing pollution, including by increased energy efficiency."

The EIB does not go on to develop specific screening criteria to facilitate assessment of CCS readiness, rather it notes that in relation to the "question of whether current investments should be selected on the basis that they are already designed for future retrofitting – i.e. being 'carbon capture ready' in some technical sense. In fact, the main constraint implied is that there is sufficient physical space in the vicinity of the power station to install the necessary equipment."

The EBRD has adopted a project level approach and has directed funding to its first CCSR project[34] (see Box 23), albeit with ENGOs claiming that the CCSR assessment is not in accordance with EC requirements.

BOX 23: EBRD financing - Šoštanj Thermal Power Plant, Slovenia

"The Šoštanj Thermal Power Plant ... accounts for one third of Slovenia's electricity production, playing a vital role in Slovenia's security of supply.

The EBRD loan will support the construction of a new state-of-the-art coal-fired unit with a capacity of 600 MW ...

The project will utilise high energy-efficient technology and will contribute to significant carbon emissions reduction ... The new unit is also designed to be carbon capture storage ready (CCS-ready), and will be the Bank's first project able to apply CCS technology."

The commercial banks and other financial institutions are also considering options to respond to calls to better address climate and broader sustainability issues. A number of key European financial institutions (BNP Paribas, Credit Agricole, F&C Asset Management, HSBC, and Standard Chartered) provided input to The Climate Group in its development of a guidance note on the financing of new coal-fired power plant. The note was released in October 2011 – see Box 24.

BOX 24: The Climate Group guidance note - Financing new coal-fired power

"Coal is likely to be part of the energy mix for the foreseeable future. Therefore, to limit dangerous climate change, coal-fired power generation needs to be substantially decarbonised by 2050.

Financial Institutions can help accelerate the uptake of the best available coal-fired power plant technologies by adopting policies ...

CCS is today the only technology with the potential to make the coal-fired power plant emission cuts needed. Fully integrated commercial-scale coal-fired power plant with CCS remains to be demonstrated and is unviable for private sector finance at current operating costs and carbon prices, but it is important that coal-fired power plant built now are made 'CCSR'."

The guidance note goes on to note the various definitions developed (focusing on that developed by the Institute (and others) – see Appendix C), and stresses the need to include "space for future build of a CCS plant, access to transport and storage, and a process for ensuring that planning and resources are in place so that CCS can be retrofitted as soon as practicable".

[34](http://www.ebrd.com/pages/news/press/2010/100721c.shtml)

It is up to the various financial institutions involved to decide how they choose to integrate these guidance note recommendations into their own policy positions, and any conditionality they place around the financing of new coal-fired power plants.

A recently publicly released paper titled *Coal Financing in Europe: The Banker's Dilemma*[35] provides a good summary of the policy approaches adopted by a number of the key European commercial financiers to date. At least three of the major banks, Société Générale, BNP Paribas and WestLB have moved to incorporate a reference to 'capture ready' requirements in their lending guidance.

It is clear that the global banking community has a potentially major role to play in driving CCSR deployment.

[35](http://www.chathamhouse.org/publications/papers/view/179499)

6 BUILDING MOMENTUM: Optimising the value of CCS Ready

The decisions by the EC in 2009 marked a shift in momentum for CCSR, and legitimised its role as a policy measure for curbing emissions from fossil fuel generation and potentially industrial sources as well. CCSR policy attracts considerable policy debate, but little traction in terms of implementation. With applicability across all 27 EU member states (albeit limited in some cases), and its consideration in Canada and Australia, a useful body of practical experience now exists that can be drawn upon to refine the CCSR policy approach and its implementation.

CCSR is considered complementary to many other policy mechanisms. With the exception of occasional one-off project-specific applications, no government has chosen to use it as a stand-alone policy intervention. A clear implementation preference seems to be to use CCSR in combination with market-based measures and regulatory provisions to tackle CO_2 emissions – that is a carbon pricing arrangement, in parallel with either CCSR policy and/or emission performance standards.

A few governments such as Norway have in effect by-passed the CCSR step, moving directly to make CCS mandatory on all fossil based generation. However, they have not mandated CCS on industrial based emissions. Others have signalled relatively rapid progression through the CCSR stage, or are undertaking CCSR in tandem with partial CCS deployment on some plants (i.e. UK and Scotland).

ENGOs rightly continue to question the value and effectiveness of CCSR approaches. Many prefer to see CCS deployment as mandatory on all new fossil fuel generation, but at the same time, are looking to use legislative provisions to address any perceived shortfall in the undertaking of comprehensive CCSR assessments. It is clear that the potential of CCS, along with other supply side (large-scale renewables and energy efficiency) and demand side (energy consumption management) options, need to be allowed to be fully realised if the battle against the adverse impacts of dangerous levels of climate change is to be won.

The role of CCSR policy as a regulatory backstop is presenting as an increasingly common justification for such an intervention. The experience with carbon pricing mechanisms to date seems insufficient to drive the deployment of new clean energy technology. The only exceptions are where the government has administratively established a sufficiently high carbon price (Norway). At this point no significant increase in the EU ETS price is anticipated (major interventions will be required to restructure the mechanism), the North American EOR based CO_2 prices tend to have localised effects (and there are questions as to the extent of demand), and the Australian carbon price and UK Carbon Floor Price remain largely untested.

A major challenge is getting the complementarity of policy instruments ‘right’ in the way they interact. Emission performance standards coupled with CCSR policy can present an effective policy suite, especially if delayed application or partial application of the standard is then used to trigger later CCS retrofits.

However, poor design can allow for the ‘gaming of the system’ and/or lead to inadvertent undesirable outcomes. For example, ‘grand-fathering’ rules that might provide investment certainty and reward early-movers, can allow sectors to avoid the regulation for many years (i.e. gas-fired generation potentially until 2045 in the UK).

At this time, no jurisdiction appears to have adopted a first best policy combination, and some have aspects that seem to detract from their purpose. The very nature of the EU

Directive, for example, tends to induce CCSR assessment outcomes that conclude CCS retrofit is not possible, thereby allowing the plant to proceed to permitting with no further CCS implications other than the EU ETS price. Clearly, the development of a model framework building on experience to date, but retaining sufficient flexibility to respond to specific needs of individual jurisdictions, would be a valuable step forward.

Like many policy interventions of a regulatory nature, the detail of the actual application of the regulations is critical. The EC provides no direct guidance on the detail of undertaking CCSR assessments, whereas the UK has developed extensive advice. Australia elaborated on what CCSR might encompass as part of its industry consultation process, and Canada has the issue under consideration.

The definition of CCSR developed by the Institute, CSLF and IEA provides a starting point, but there is now sufficient experience to review and update the definition, and possibly develop a companion 'Model Guidance as to CCSR Assessment' (using the UK guidance as a starting point).

A key consideration of such a 'guidance document' will be to ensure that a correct balance can be struck in terms of the degree of prescription required. There appears to be a trend by both regulators and industry to desire a greater degree of prescription concerning exactly what is required to satisfy assessment along the entirety of the CCS chain, and to some extent in relation to economic feasibility and assessment as well. With an evolving technology moving into full commercialisation, this seems neither practical nor desirable. Being overly prescriptive may result in technology lock-in, will certainly increase administrative and assessment costs, and may also prove un-responsive to technology evolution.

An 'objectives' based regulatory (assessment) approach, akin to that adopted by the UK, Norway and Australia in relation to offshore petroleum regulation, may be a superior approach. This places the onus on the plant proponent to ensure that the assessment of both transport and storage is of sufficient detail to support future retrofit, while also enabling the proponent to adjust those assessments over time as better information becomes available, or with the practical experience and development of multi-user pipelines and storage.

More importantly it should ensure the proponent is more attuned to taking action as appropriate to secure both means of transport and storage in a timely manner. Again, this is a central issue to be explored further in any generic guidance that might be developed.

The economic feasibility component of the assessment is critical to driving intended outcomes. A number of governments have moved beyond the EC provisions to adopt a policy position that will only allow projects to proceed if the economic outcomes are positive, that is, only plants where CCS retrofit is feasible will be approved.

Given this starting point, the 'incentive' is with the developer to demonstrate that their assumptions concerning the economics of retrofit are sound and that costs can be managed. Coupled with time-based drivers (i.e. emission performance standards to be complied with by a certain date) or carbon cost penalties (say ETS bolstered by carbon floor price), a high degree of certainty can be assured regarding actual CCS retrofit. The economic assessment options would benefit from further elaboration.

As outlined earlier, issues relating to carbon lock-in, technology lock-in, public engagement, and economic rationality have all been potential stumbling blocks to the adoption of CCSR. CCSR can help avoid carbon lock-in by facilitating the construction of fossil fuel generation that can later be retrofitted with CCS, and thus appropriately managing emissions. Poor CCSR design parameters can in effect deliver the opposite outcome.

The EC approach, allows fossil-fired plants to proceed even when it is evident that retrofit will never be feasible, and this has the potential to lock in those emissions for at least the life of the plant. The economic life of the plant may be curtailed if the EU ETS carbon price increases to the extent that the purchase of offsetting allowances renders the plant's operation uneconomic, but this then creates issues around stranded assets.

Similarly, the UK system of allowing for some gas-fired generation to be 'grandfathered' until 2045, locks in associated emissions, and while a switch away from coal to gas may be desirable over the short term from an emissions perspective, in the medium term gas still poses material emission challenges to the atmosphere.

A well designed CCSR approach (perhaps combined with ratcheted emission performance standards) with the necessary triggers to drive retrofit within reasonable timeframes (say by 2025 or earlier) can provide insurance against carbon lock-in. Early adoption of partial CCS, along the lines currently being looked at in the UK, provides a robust policy approach that should drive early commercial-scale deployment of CCS technology.

Technology lock-in seems to be less of a concern, at least to the extent that industry has been able to incorporate CCSR design features into plants in both the Netherlands and UK, without unduly fettering future technology options. While fundamental choices between pre- or post-combustion will need to be taken upfront, these are more likely to be influenced by the overall corporate strategy relating to plant and supplier preferences than CCS considerations (which are after all, only a component of overall project capital). Technology lock-in could become an issue if a government decided to adopt a highly prescriptive approach to plant-specific retrofit requirements.

Provided there is strong certainty that retrofit will be required, companies seem willing to undertake some upfront investment to defray future cost and likely outage on the basis they will secure economic returns later in the plant's life. Moreover, if the retrofit triggers are clear, predictable and in the foreseeable future (say 2025 or earlier), it is doubtful that major transformations in CCS technology, ready for commercial application, will occur within 10 years. Rather, it is likely there will be significant refinement and cost cutting, and improved efficiency around what is largely existing technology, and therefore compatible with existing retrofit frameworks.

As indicated above, different approaches to the assessment of project proposals for CCS readiness are now beginning to emerge with the UK being the most sophisticated. A key component of any 'Model Guidance as to CCSR Assessment' will be the way in which the economic analysis is dealt with, and the degree of detail required around both transport and storage issues.

It is worth reiterating that policy design aspects are critical. If the policy design is such that a positive economic assessment as to the feasibility of CCS retrofit is necessary for the project to proceed, it will be in the proponent's best interest to ensure a robust assessment is undertaken. The same holds for transport and storage options. As the company will wish to avoid both stranded assets and untenable carbon costs, it goes to their self-interest to be certain that storage and transport options are 'real', and to safeguard these 'valuable' options.

In reality, significant work on storage characterisation and transport options for CCSR is unlikely to occur given time and cost issues, and while governments may take action to bolster the level of pre-competitive storage data available, there needs to be a pragmatic approach as to what will be required in any storage assessment.

Where offshore depleted oil and gas reservoirs are likely to be the main source of storage (i.e. for countries bordering, or even with access to the North Sea), a detailed assessment

may not be required. In the future, as knowledge expands and multi-user transport and storage options emerge, assessment will become simplified as project proponents are able to tie into existing operations. Of course, by this time the need for CCSR policy intervention should have largely passed with the deployment of CCS effectively demonstrated.

Governments (including regulators and Competent Authorities) and project proponents are not the only parties with an interest in the CCSR assessment process. Bankers and other financial institutions are under increasing pressure to be seen to address corporate sustainability and environmental goals. Lending policies and approaches concerning fossil-fired generation are becoming more and more closely scrutinised, and banks in particular are looking to adopt screening criteria, including those relating to CCSR.

While such developments are relatively new, the financial sector's interest in, and uptake of CCSR is one that offers good opportunities for fruitful collaboration between leading players.

As previously noted, ENGOs remain cautious of CCSR policy approaches, preferring to see CCS deployment (rather than an enhanced capacity to future retrofit CCS) required on all new fossil fuel generation plants. However, they have demonstrated a willingness to utilise the CCSR regulatory process to ensure that environmental outcomes are achieved within the context of whatever the current policy is. ENGO engagement in CCS and CCSR-related dialogues is also likely to help bolster public confidence in whatever approach is ultimately adopted by governments.

In conclusion, CCSR policy is perceived by many policy-makers (not all) to play an efficient and effective role as a complementary part of a policy portfolio to mitigate CO_2 emissions, including enhancing the effectiveness of market-based policy drivers. There is considerable scope to build on existing momentum through a collaborative approach involving all players – governments, industry and other key stakeholders.

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Appendix A – Country status of CCS Ready policy and regulation

Australia

The option of CCSR requirements has been under active consideration in Australia. In an election policy announcement in 2010, the Prime Minister included in the Government's energy policy statement titled *A Cleaner Future for Power Stations*[36] that "all new coal-fired stations will be required to meet best practice emissions standards, and be carbon capture and storage-Ready (CCS-Ready)" as detailed in Box 25 below.

***BOX 25*:** Carbon Capture and Storage-Ready standards

"Approval will only be granted to new coal-fired generators which are capable of retrofitting CCS technologies. Proponents must adequately ensure that CCS is taken into consideration when designing and building future power plants, including planning for sufficient land, pipelines for removal of CO_2 suitable storage sites and connectivity of the generator to CCS technologies."

In addition, the "… Government will require the owners of new coal-fired generators to agree to retrofit CCS technologies within an appropriate time after they become commercially available."

The standard for CCS-Ready, tailored for Australian conditions, will be determined by the Government in consultation with stakeholders. The new standard will take into account existing draft standards as a starting point.

On 30 November 2010, the Government released a Discussion Paper[37] proposing a way forward for the implementation of the Government's commitment (covering both emission performance standards and CCSR), and posing a series of questions for stakeholder consideration. The Discussion Paper drew heavily on the definition of CCSR developed by the Institute (in conjunction with the IEA and CSLF) and the Institute's subsequent elaboration on the issue in its *CCSR – Issues brief 2010 no. 1*[38+39] which outlines the key questions government's need to consider. Key issues addressed include possible details required in order to meet CCSR criteria, in terms of:

- site planning to demonstrate sufficient space and access on-site and within the facility to accommodate carbon capture and compression facilities for the majority of the plant's CO_2 emissions (determined by design studies);
- identification of potential storage with an assessment/evaluation of target formations (based on pre-competitive data) with sufficient capacity to meet the total CO_2 to be captured for the plant's life, while also addressing risk assessment requirements, environmental considerations, post-injection leakage and land use conflicts;
- feasibility studies for the retrofit of the preferred technology into the plant's design, including an economic analysis of capture implementation and required approvals;
- transportation of CO_2 including an assessment addressing land use conflicts and approvals;

[36](http://www.alp.org.au/getattachment/1c885f7d-da5c-45b8-98ff-a646ff2fb2cd/cleaner-power-stations/)
[37](http://www.ret.gov.au/energy/Documents/sustainbility-and-climate-change/MO%20Final%20InterDepartmental%20Discussion%20Paper%20Cleaner%20Future%20Power%20Station%2026%20November%202010%20EMBARGO%20til%2030%20November%20(2).pdf)
[38](http://www.globalccsinstitute.com/community/blogs/authors/christophershort/2010/11/03/definition-ccs-ready)
[39](http://cdn.globalccsinstitute.com/sites/default/files/publications/8017/ccs-ready-issues-brief-2010-no-1.pdf)

- environmental impact statements outlining measures that will be taken to manage chemical waste and increased water usage, including any environmental approvals required; and
- detailed economic feasibility studies for retrofitting CCS.

The suggested approach did not require proponents to put in place any of the necessary approvals until such time that it was determined CCS must be retrofitted. The final requirement (economic feasibility) was clearly spelt out as the most important issue to be addressed and would therefore be scrutinised more closely. The Australian Government (in consultation with other key international players) proposed to conduct a biennial review, specifically aimed at testing the commerciality of a CCS retrofit. The review would consider:

- the technical viability of CCS, and whether retrofitting a plant is both operable from an engineering perspective and at a comparable scale to the project under consideration;
- the operational viability of the whole chain; and
- Australia-specific factors affecting the commercial availability of equipment.

Further, the Government indicated it would define commercial availability as having been attained once:

- integration of the entire CCS chain has been proven at a comparable scale and technology in several demonstration plants worldwide;
- the systems comprising CCS are readily attainable; and
- safety and environmental risks (CO_2 leakage) have been minimised.

On the basis of a positive assessment that CCS is commercially available, the Minister could then make a declaration requiring that the retrofit proceed.

The Discussion Paper was available for stakeholder comment until 24 December 2010. Extensive comments were received from a range of stakeholders including industry bodies, environmental NGOs, individual generation companies, fuel suppliers and government/regulatory agencies[40]. It is noted that the comments were primarily centred on issues in relation to the emission performance standards, rather than CCSR. The tenor of the comments was that the proposed introduction of a carbon price mechanism meant that both a CCSR policy and emission performance standards were not necessary.

The Government decided not to proceed with CCSR provisions (or with emission performance standards) – as announced by Minister Ferguson[41] in launching the *Draft Energy White Paper* on 13 December 2011 (Box 26) primarily on the basis of the introduction of the carbon pricing regime.

BOX 26: Minister Ferguson launch speech, December 2011

"I am also today announcing that the Commonwealth will no longer proceed with the introduction of emissions standards or CCSR requirements for new coal-fired power stations. With the passage of legislation last month to introduce a carbon price, we need to let the market determine the most efficient investment outcomes within the energy market, carbon price and Renewable Energy Target framework."

As indicated above, state governments in Australia play a major role in relation to energy policy and regulatory issues – the same is true in relation to CCSR, and in many cases they had moved in advance of the national Government. There has been significant action in four of the states – New South Wales, Queensland, Western Australia and Victoria. The New

[40](http://www.ret.gov.au/energy/sustainbility_and_climate_change/domestic_climate_change/cfps/submissions/Pages/submissions.aspx)
[41](http://minister.ret.gov.au/MediaCentre/Speeches/Pages/LaunchoftheDraftEnergyWhitePaper.aspx)

South Wales Government[42] has imposed development conditions on coal-fired power generation (Bayswater B and Munmorah development approvals, 2009), including requirements to:

- "incorporate best commercially available technology to minimise greenhouse gas emissions; and
- design and construct new coal power stations to allow for cost-effective retrofitting of post-combustion carbon capture technology"

BOX 27: Queensland CCSR Policy - 24 August 2009

"No new coal-fired power station will be approved in Queensland unless:

- it uses world's best practice low emission technology in order to achieve the lowest possible levels of emissions; and
- it is carbon capture and storage (CCS) ready and will retrofit that technology within five years of CCS being proven on a commercial scale."

Note: In Queensland 'CCSR' means that the proponent must demonstrate plans and milestones for incorporation of CCS.

The former Queensland Government announced a policy statement on 24 August 2009 – *ClimateQ: toward a greener Queensland*[43] in which it set out requirements that all future coal-fired generation would have to be CCSR (Box 27).

In Western Australia, the state EPA has taken a project by project approach to considering CCSR. The most notable case concerns the approval conditions attached to the Bluewaters Power Station Expansion EPA assessment and recommendations released in March 2010[44] (Box 28).

BOX 28: Bluewaters Power Station EPA Approval

If approved for implementation, the Western Australian EPA recommends a number of conditions be imposed on the proponent. These include:

- "Condition 7-1 which requires a plant layout figure to be submitted to the EPA which clearly delineates the area of land to be set aside to accommodate carbon capture related plant, and to quarantine it to prevent the construction of non-carbon capture related plant and equipment within it;
- Condition 7-2 which requires progress made towards the implementation of CCS be reported to the EPA; and
- Condition 7-3 which requires retrofitting of carbon capture and storage within five years of the technology becoming economically and technically proven."

The EPA Approval also stated that the issue of increased demand and a continued reliance on coal in the near term "…highlights the importance of a joint Government/Industry focus on developing real options for geo-sequestration of carbon dioxide in Western Australia. In this regard, the EPA recognises that the Commonwealth Government, Western Australian Government and Industry are jointly investing in the Collie South West Hub Geo-sequestration Project, to research and develop carbon sequestration options for coal-fired power stations in Western Australia. The EPA encourages this initiative."

In making these recommendations the EPA noted the project proponent contended that the proposed generating plants would be designed and constructed to be CCSR in accordance with IEA definitions. However, it also noted that:

[42](http://www.ret.gov.au/energy/Documents/sustainbility-and-climate-change/NSW_Government_Submission_A_Cleaner_Future_for_Power_Stations.pdf)
[43](http://www.climatechange.qld.gov.au/pdf/climategreport/climategreport-chapter10.pdf)
[44](http://www.epa.wa.gov.au/docs/1349/Rep1349Blue3_4PER8310.pdf)

- while the proponent had indicated its intention to make sufficient space available on adjacent land, there were no details as to the site or safeguards regarding its continuing availability;
- scant detail had been provided regarding potential storage sites, and only minimal pre-characterisation work had occurred in relation to the suggested options; and
- no information had been provided regarding the identification of potential transport routes.

As such the EPA did not consider that the proponent had demonstrated that the project met the IEA definition of CCSR. In granting final approval for the plant to proceed (12 July 2010), Western Australian Environment Minister Faragher noted that her decision/advice (which included consideration of CCS), was consistent with the EPA's recommendations, and that the project would be required to adopt a "greenhouse gas abatement program" that would require the power station to achieve "continuous improvements in net greenhouse gas emissions through the adoption of advances in technology and process management"[45].

It appears that the intent of this Western Australian Government decision was that the requirements would apply until the EPA and the Environment Minister determined that they were not complementary to any national emissions trading scheme the Australian Government might introduce. To date it does not appear that such a determination has occurred – but it would be consistent with Minister Ferguson's recent call (in releasing the Draft White Paper) to review "current non-complementary policy interventions from all levels of government that were made in the absence of a carbon price"[46].

The Victorian Government has already moved in this direction with the Government announcing on 27 March 2012 that it will not proceed with CCSR regulations[47] (Box 29):

BOX 29: Victorian Government policy

"In line with the Commonwealth Government's recent announcement that it will no longer proceed with … CCS-ready requirements for new coal-fired power stations, the Victorian Coalition Government will not proceed with a Victoria-specific restriction."

The Australian Government continues to support the fundamental role of the market in delivering clean energy outcomes, as outlined in the Draft Energy White Paper which states that all levels of government must address critical issues including:

- continued consideration of policy settings to ensure that objectives are being delivered;
- review of current non-complementary policy interventions from all levels of government that were made in the absence of a carbon price;
- to actively monitor and refine energy policy settings to ensure delivery of necessary efficient investment;
- to ensure that energy resources are developed in accordance with best practice; and
- to continue work with industry and the research community given the transformational role technology will play in moving to a clean energy future.

[45](http://www.mediastatements.wa.gov.au/Pages/WACabinetMinistersSearch.aspx?ItemId=133750&minister=Faragher&admin=Barnett)
[46](http://minister.ret.gov.au/MediaCentre/Speeches/Pages/LaunchoftheDraftEnergyWhitePaper.aspx)
[47](http://www.premier.vic.gov.au/images/stories/documents/mediareleases/2012/120327_OBrien_-_Victoria_adopts_Commonwealth_position_to_reject_new_emissions_intensity_restrictions.pdf)

Canada

It is only at the national level that specific action has been taken to explicitly address CCSR issues. On 23 June 2010, the Canadian Government announced that it would take action to reduce emissions in the electricity sector by introducing regulations on coal-fired electricity generation that will require new coal-fired power plants (and those reaching the end of their economic life) to meet stringent emissions performance standards.

The regulations were formally published in *Vol. 145, No. 35; Canada Gazette Part I* on 27 August 2011 and were open for public comment for 60 days[48]. The comments received and how they were addressed by the Government will be available in the Regulatory Impact Analysis Summary when the final regulations are published in *Canada Gazette Part II*, later in 2012. The regulations are the joint responsibility of two Government departments – Environment Canada and Health Canada. The intent and scope of the proposed regulations is set out in the Regulatory Impact Analysis Summary – as detailed in Box 30 below.

Box 30: Regulatory Impact Analysis Summary

"The proposed Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations (the proposed Regulations) will set a stringent performance standard for new coal-fired units and those that have reached the end of their useful life. This will phase out high-emitting coal-fired generation and promote a transition towards lower or non-emitting types of generation such as high-efficiency natural gas, renewable energy, or fossil fuel-fired power with carbon capture and storage.

The performance standard element of the proposed Regulations would come into effect on 1 July 2015. In addition, units would be required to begin reporting two years in advance of when they reach their end of useful life date or, in the case of new units, in the first year of operation. Regulated entities would then be subject to enforcement and compliance requirements and penalties as specified under the Canadian Environmental Protection Act 1999."

As detailed in the Gazettal notice, the proposal will "…apply a performance standard to coal-fired electricity generation units. The standard would be set at the emissions intensity level with consideration of natural gas combined cycle (NGCC) technology – a high efficiency type of natural gas generation – and be fixed at 375 tonnes of CO_2/GWh".

While the regulations (as drafted) do not call up the words 'CCSR', they clearly put the operators of coal-fired electricity generation on notice to undertake planning to enable retrofit of CCS on any new plant constructed and also when upgrading existing plant to extend its lifetime. The deferral rules provide the incentive.

The draft regulations propose an exemption until 2025 for new plants that incorporate technology for CCS on the basis that CCS technology may not be commercially viable until that time. The proposed regulation will establish a 'hard compliance date' and plant will have to meet the emissions performance standard by 2025 or close. In effect the Canadian Government has determined that CCS technology will be economic to retrofit by then – industry will have to judge the commercial risk of a potential stranded asset if this assessment proves unfounded. Construction milestones will ensure compliance, and to maintain the deferral rules, plants need to comply with each regulated milestone including:

- completion of studies by 1 January 2020;
- capture of CO_2 by 1 January 2024; and
- compliance with the performance standard by 1 January 2025.

[48](http://www.gazette.gc.ca/rp-pr/p1/2011/2011-08-27/pdf/g1-14535.pdf)

Section 10 of the proposed regulations requires that an annual implementation report must be provided detailing the progress made towards CCS implementation which also demonstrates that the milestone requirements have been met. Schedule 3 of the regulations outlines the technical criteria that must be addressed.

Where the capital investment in old plants has already been recovered, more stringent deferral criteria are to be applied to ensure the operators cannot 'game' the system, by simply taking the opportunity to defer closure until 2025. Construction milestones are still required, but once such a plant reaches to within six years of the end of its useful life it will be required to capture at a rate of 30 per cent until 1 January 2025 (after which it must meet the performance standard).

As an incentive to early movers, the regulatory regime rewards those who capture CO_2 at 30 per cent for five years before they are required to meet the performance standard. They can apply to transfer an 18-month deferral from the performance standard to an old plant in recognition of early action taken elsewhere in their generation portfolio.

There was considerable industry/stakeholder consultation prior to the development of the draft regulations. The Regulatory Impact Analysis Summary outlines the various views and Government's efforts to incorporate these/respond accordingly. The 60 day formal 'public comment' period attracted considerable commentary. Comments are now being reviewed and some fine-tuning of the draft regulations (within the existing framework) is anticipated. Final regulations are expected to be gazetted later in 2012 (probably during the second half of the year).

Canadian Governments, at both national and provincial levels have established the necessary policy and regulatory frameworks and incentives to facilitate CCS development. As outlined in Box 5, the absence of a consistent agreed approach to carbon pricing mechanisms covering North America has limited Canada's policy options, resulting in the uptake of an emissions performance standard as the most effective means of addressing CO_2 emissions. Given the major opportunity afforded by the CCS deferral rules in the draft emission performance regulations, they are effectively CCSR regulations by another name.

The proposed emission performance standards will, without question, stimulate consideration of CCS on new or upgraded coal-fired power generation. Whether or not this leads to actual investment in CCS is a moot point. The market will determine which low-carbon technologies will attract the investment dollar. The power generation sector's view is that the regulation does nothing to encourage CCS, but instead creates an incentive to install gas-fired generation given that the standard is set at the level achievable by NGCC units and natural gas prices are low.

People's Republic of China

There are extensive international co-operation programs established with China on both climate change and emissions more generally (as well as CCS issues) at the intergovernmental level and between commercial partners. In co-operation with the European Commission, China has been exploring the establishment of 'low carbon zones'[49] in a number of cities/provinces, including the introduction of a carbon pricing/emissions trading regime which could expand to national coverage by 2015.

China's expanding R&D efforts will also benefit CCS technologies with MOST's 12th Science and Technology Program[50] setting goals to capture significant quantities of CO_2 from both coal to oil projects and oxy-fuel combustion. In addition, China has made the accelerated development of IGCC a priority which, if it proves possible to increase efficiencies and lower the cost, may well make CCSR plants more economically viable.

China has not developed a comprehensive CCS-specific policy, nor are there specific legal or regulatory frameworks in place to manage CCS activities. Moreover, only limited work has been undertaken to characterise and delineate potential CO_2 storage sites. However, in recent times China has been focused on assessing the economic benefits of CO_2 use, particularly for enhanced oil and gas recovery and in the industrial/chemical processing sectors. Should this yield positive outcomes, CCS may be considered more commercially viable and this in turn could also drive CCSR considerations.

There is currently only limited CCSR work being undertaken in China – primarily driven by international stakeholders – with most interest at the provincial level. The most significant work on CCSR is an analysis in relation to Shenzhen City, Guangdong – 'Feasibility Analysis of CCS-Readiness in Guangdong', launched on 18 March 2010 (co-funded by the Institute). The study is investigating CCS options for Guangdong and will propose a roadmap and policies to support CCS development.

In its Annual Report released on 25 November 2010[51], the study team details its evaluation of the benefits of a 'CCSR Hub' approach – a regional CCSR strategy, which includes new coal-fired power plants, and also integrates existing stationary CO_2 emissions, and potential storage and transport opportunities. The study team have published a number of articles addressing CCSR in the region[52]. The outcomes of a case study of Shenzhen city in the Pearl River Delta area in Guangdong (Box 32) demonstrate a strong case in favour of CCSR.

BOX 32: Case study of Shenzhen city

"A case study of Shenzhen city in the Pearl River Delta area in Guangdong in southern China is presented based on engineering and cost assessment studies and stakeholder consultations and building on existing geological surveys and infrastructure plans. The simulation results show that financing 'CCSR' at regional planning level rather than only at the design stage of the individual plant (or project) is preferred since it reduces the overall cost of building integrated CCS systems. On the other hand, we found the value of considering existing stationary CO_2 emissions sources in CCSR design. Therefore, we recommended that making new plants CCSR or planning a CCSR hub should consider existing large emissions sources when possible."

[49] (http://www.e3g.org/images/uploads/Low_Carbon_Zones_EU-China_cooperation.pdf)
[50] (http://www.google.fr/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CCwQFjAA&url=http%3A%2F%2Ficapco2.org%2Ffiles%2FCCUS_Technology_Development_In_CHina_and_China-EU_CCS_Cooperation--20110918.pdf&ei=ttN6T_SOLsXG0QXKjKXICQ&usg=AFQjCNE5nQAD2F1AtN0eIETt4y6hwH4KcA&sig2=Uf5IWJIoz8XPxvTZ6SDMFw)
[51] (http://cdn.globalccsinstitute.com/sites/default/files/publications/15516/feasibility-study-ccs-readiness-guangdong-2010-annual-report.pdf)
[52] (http://emps.exeter.ac.uk/csm/staff/jl465/publications/)

More recent work has further strengthened the case for CCSR[53]. Modelling of a generic 1GW ultra supercritical pulverised coal-fired (USCPC) power plant in Guangdong showed that capture ready investment can:

- provide up to US$16.9 million value to the project (or up to US$94 million if, in the absence of a capture ready design, the plant could not subsequently be retrofitted);
- increase the retrofitting possibility by around 8 per cent;
- reduce the mean levelised cost of electricity; and
- advance the optimal retrofitting timing by approximately one year.

In addition, the case study undertaken to evaluate the economics of the 'CCSR hub' in Shenzhen shows that CCSR investment will reduce the average CO_2 abatement cost of retrofit by approximately 20 per cent. Furthermore, if capture ready design is adopted at the regional level (rather than at the individual power plant level) there would be an additional 5 per cent reduction in the average CO_2 abatement cost.

The ADB have also initiated some work directly focused on CCSR in China. On 12 December 2011 the ADB approved project funding of US$1.8 million (TA 8001) to undertake a *Study on Carbon Capture and Storage in Natural Gas-Based Power Plants: China*[54]. In summary, the project intends to look to accelerate the application of CCS on gas-fired power plants and CCSR plants, enhance the capacity in planning, management and implementation of gas-fired CCSR plants' and at a project-specific level, identify and develop a CCS readiness plan and financing needs for the Gaojing plant expansion (southwest of Shanghai). This work on CCSR and gas-fired plants is contemporaneous with anything else being undertaken globally.

It is clear coal and gas will continue to play a major part in China's energy mix over the foreseeable future. Investment in low-carbon technologies is now a major plank in China's development strategy and this is driving business investment. There is a clear opportunity for China to position itself as a leader in CCS technology and equipment manufacturing, making it a key component of its economic growth strategy.

China's strong focus remains on improving the efficiency of capture equipment operation, and in driving down the overall costs of CCS deployment, given the technology is not yet mature. Much of this work is leading edge, especially that in relation to CCSR and gas-fired applications.

Accordingly, CCSR remains an issue of interest in China but is a policy measure that is unlikely to be embraced in the short-term. Should significant progress be made in beneficial re-use applications for CO_2, there could be a much stronger interest in CCS applications.

[53]Personal communication Professor Di Zhou, South China Sea Institute of Oceanology, Chinese Academy of Sciences
[54](http://pid.adb.org/pid/TaView.htm?projNo=45096&seqNo=01&typeCd=2)

European Union

Policy responsibility and funding initiatives for CCS, including CCSR issues, primarily fall across three separate EC Departments/Directorates General (others may play a supportive role), as follows:

- DG Climate Action – responsible for leading international negotiations on climate, policy aimed to facilitate the EC meeting its emissions targets, development/implementation of the EU ETS, the NER300 process and the CCS Storage directive;
- DG Energy – responsibilities include securing sustainable, competitive and secure energy supplies for Europe, reduction of carbon emissions from coal-fired power stations; investment and research in clean coal technologies – especially CCS, delivery of the CCS project network; and
- DG Research and Innovation – responsible for overall management of research and innovation through European Framework Programmes including various CCS support mechanisms.

The principal expression of CCSR policy is found in the EU CCS Storage Directive, Article 33 of Directive 2009/31/EC (Box 33). The specific provisions of the Directive do not call up the term 'CCS Ready', nor does it mandate that CCS Readiness is a requirement for new plant. Instead it stipulates that an assessment of the possibilities for installing CCS on the new plant must be undertaken, and if there is a technical possibility of undertaking CCS, then sufficient space must be left around the plant to retrofit it with capture technology.

BOX 33: CCS Storage Directive – Article 33 - Amendment of Directive 2001/80/EC

"Member States shall ensure that operators of all combustion plants … 300 megawatts or more … have assessed whether the following conditions are met:

- suitable storage sites are available;
- transport facilities are technically and economically feasible; and
- it is technically and economically feasible to retrofit for CO_2 capture.

If the conditions … are met, the competent authority shall ensure that suitable space on the installation site for the equipment necessary to capture and compress CO_2 is set aside. The competent authority shall determine whether the conditions are met on the basis of the assessment … and other available information, particularly concerning the protection of the environment and human health."

There are no 'triggers' in the provision to move from site spatial allowances to requiring actual CCS deployment, nor are major refurbishments of existing plants covered. In addition, the 300 MW threshold may mean that most gas plants may not be subject to the provisions (for example, whether a 4 x 250 MW gas Combined Cycle Gas Turbine without a common stack is captured within the current assessment requirements).

The EC has not issued specific guidance notes as to how member states or the Competent Authority might do the assessment, what considerations go to technical and economic feasibility, and what constitutes storage site availability. The interpretation and requisite regulatory framework rest with the member states as part of the transposition process.

The EC has issued draft EU ETS state aid guidelines which seek to define CCSR[55]. The guidelines will set the conditions under which member states may use revenues generated from the auctioning of ETS allowances (between 2013 and 2016) to support the construction of highly efficient power plants, including new power plants that are CCSR. Up to 15 per cent

[55](http://ec.europa.eu/competition/consultations/2012_emissions_trading/draft_ets_guidelines_en.doc)

of eligible costs may be claimed if implementation begins prior to 2020, dropping to 5 per cent post 2020 unless there is a competitive selection process.

The draft guidelines refer to Article 33 of Directive 2009/31/EC, noting that member states must ensure that conditions linked to the future retrofit of CCS are assessed and where positive, suitable space for CCS is then set aside. In the case of the construction of a CCSR power plant, the costs of demonstrating the overall economic and technical feasibility of implementing a full CCS chain, as well as investment costs in the power plant and land to enable cost-efficient CO_2 capture retrofit will be eligible.

The guidelines provide a robust definition for CCSR, and in many areas parallels the definition put forward by the Institute, IEA and CSLF. As such it is a good source of guidance to member states when assessing the CCSR provisions of Article 33 of Directive 2009/31/EC. The definition is set out in Box 34 below.

Box 34: EC GUIDELINES ON CERTAIN STATE AID MEASURES IN THE CONTEXT OF THE GREENHOUSE GAS EMISSION ALLOWANCE TRADING SCHEME POST-2012 – CCSR definition

"'CCS-ready' means that an installation has demonstrated that suitable storage sites are available, that transport facilities are technically and economically feasible and that it is technically and economically feasible to retrofit for CO_2 capture, as soon as sufficient market incentives in the form of a CO_2 price threshold are reached. In particular, CCS-ready requires:

- demonstration of the technical feasibility of retrofitting for CO_2 capture. A site-specific technical study should be produced showing in sufficient engineering detail that the facility is technically capable of being fully retrofitted for CO_2 capture at a capture rate of 85 per cent or higher, using one or more choices of technology which are proven at pre-commercial scale or whose performance can be reliably estimated as being suitable. The study should clearly demonstrate that there are no known insurmountable technical barriers to the connection of retrofitted capture equipment to the full capacity of the existing equipment effectively and without excessive outage periods and that there will be sufficient space available to construct and safely operate the necessary capture and compression facilities on the installation site;
- control of sufficient additional space on/near the site on which capture equipment is to be installed;
- identification of one or more technically and economically feasible pipeline or other transport route(s) to the safe geological storage of CO_2;
- identification of one or more potential storage sites which have been assessed as suitable for the safe geological storage of projected full lifetime volumes and rates of captured CO_2;
- demonstration of the economic feasibility of retrofitting an integrated CCS system to the full capacity of the facility, based on an economic assessment. The assessment should provide evidence of reasonable scenarios, taking into account CO_2 prices forecasts, the costs of the technologies and storage options identified in the technical studies, their margins of error and the projected operating revenues. The assessment will indicate the circumstances under which CCS would be economically feasible during the lifetime of the proposed installation;
- CCSR requires maintenance of the above conditions proven by submission of reports on the technical aspects of the CCS-ready status to the competent authority every two years following the date of commercial operation of the installation and until the retrofitted CCS system becomes operational. The reports should in particular detail any changes to the assumptions used in the technical studies and the economic assessment and their potential impacts on the conclusions therein;
- demonstration that all relevant permits to implement CCS can be obtained and identification of procedures and timelines for this process; and
- preparation of a potential CCS implementation plan, including a potential timetable to entry into operation and a public engagement programme including consideration of health, safety and environmental issues."

The EU also introduced the Industrial Emissions Directive (Directive 2010/75/EU) on 24 November 2010[56]. While it does not directly address CO_2 emissions, except in terms of controlling local pollution (where the focus is on sulphur dioxide and nitrogen oxides), the Directive has implications for CCSR.

It encompasses a series of tests and definitions around 'Best Available Technology' (BAT), a concept that is important in defining when CCS technologies might be available for commercial use. More critically, the new performance standards may well lead to the closure of old fossil-fuel plants that are no longer in compliance, and drive utilities to build new plants which will have to comply with the CCSR provisions of Article 33 of Directive 2009/31/EC.

The EU has an extensive program aimed at addressing climate change issues including comprehensive emissions targets, an ETS providing a carbon price signal, a range of funding programs targeting low-carbon energy research, development and deployment, (including CCS), regulatory frameworks including CCS Storage, and some aspects of a CCSR regime.

This array of measures has placed the EU at the forefront of action to facilitate the commercial deployment of CCS. Responsibility for the implementation ultimately lies with the member states, and application has proceeded at differing rates reflecting individual country circumstances, political will and the applicability of CCS technology.

The CCSR provisions are beginning to take effect. A number of organisations (primarily ENGOs) are closely monitoring the application of Article 33 of Directive 2009/31/EC prior to the permitting of new coal-fired power plants. ENGOs seem prepared to take legal action in circumstances where they consider the assessment inadequate in terms of storage site availability, transport facilities, and the technical/economic feasibility of CCS retrofit.

This was clearly demonstrated in the case of the Opole power plant expansion project in Poland where several NGO groups filed formal complaints on the basis that the environmental impact assessment lacked the necessary CCSR feasibility studies. The project permit was suspended by the regional court of administration in January 2012 (see Box 35). This trend is anticipated to continue, and it is likely that future power plant permits will be challenged unless the approvals process can clearly point to a robust assessment of CCS readiness.

There is also growing interest amongst ENGOs (led by the European Climate Foundation) concerning CCS readiness for all new gas-fired generation in the EU. A report commissioned by the Foundation titled *The CCS challenge: practical potential for gas carbon capture and storage in Europe in 2030*[57], recommends the introduction of regulations and incentives to ensure that gas-fired generation plants are fitted with CCS. The report targets not only the EC, but also the five biggest EU member states – Germany, France, Italy, Spain and the UK, along with the Netherlands and non-EU member Norway – given these countries are likely to be the early movers on both CCS deployment and on new-build generation capacity. The Foundation has now called for new regulatory action and financial incentives to ensure that all new gas-fired power plants in the EU are CCSR.

[56](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:en:PDF)
[57](http://www.green-alliance.org.uk/grea_p.aspx?id=6334)

BOX 35: Environmental NGO Legal Actions – Article 33 - Amendment of Directive2001/80/EC

The Environmental Law Service and Focus (Slovenian NGO) made a formal complaint to the EC in relation to the permitting of the Sostanj plant, Slovenia (and a separate complaint to the European Investment Bank – co-funder of the project). The issue at the core of the complaint relates to when Article 33 became applicable in Slovenia – the complainants claiming it should apply to the project regardless of the timing of Slovenian transposition. On the basis that the Article should apply, the complainants contend that a proper assessment was not conducted.

The WWF sent the EC a formal complaint on 11 January 2010 against Germany for its failure to fulfil a legal obligation under Article 33, claiming a faulty approval procedure for a new coal-fired power plant at Mannheim ('The Block-9 project' approved on 27 July 2009). The WWF considered the 'CCSR' requirements had not been fulfilled and asked the EC to investigate further with a view to starting infringement proceedings.[*]

Following formal complaints by environmental groups ClientEarth, STE Silesia Opole and Eko-Unia, the environmental permit for Polska Grupa Energetyczna (PGE) Opole power plant expansion project was suspended by the regional court of administration in January 2012[**]. The groups filed a complaint against the project on the grounds that, amongst other things, the environmental impact assessment lacked the necessary CCSR feasibility studies. PGE's report on the project's environmental impact will now need to address these issues which may take up to a year to complete. As of April 2012, PGE was yet to decide whether it would file an appeal to the Supreme Administrative Court against the ruling or proceed with the necessary CCSR studies.

[*] http://wwf.panda.org/what_we_do/how_we_work/policy/wwf_europe_environment/?186021/Legal-Complaint-Filed-Against-Germany-Over-New-Coal-Plant

[**] http://www.cleantechpoland.com/en/tag/clientearth/

France

France, through the office of the General Directorate for Energy and Climate Change, has been steadily progressing on the transposition of the EU CCS Directive. The EC has now determined that the transposition has been completed.

The details of the transposition can be found in law n°2009-967, 19 VI for coal-fire plant[58] and the associated 'arrêté du 23 juillet 2010'[59].

Article 33 of the CCS Directive 2009/31 states that "Member States shall ensure that operators of all combustion plants with a rated electrical output of 300 megawatts or more….." must assess whether certain conditions are met in relation to CCS storage. This Article has been transposed by "arrêté du 23 juillet 2010 relatif aux chaudières présentes dans les installations de combustion d'une puissance thermique supérieure ou égale à 20 MWth...", art 13 V. The three key points in the 'arrêté' are:

- for any combustion plant (boiler) with a thermal output equal or higher than 600 MW, sufficient space should be set aside for capture and compression equipment;
- for any combustion plant (boiler) with a thermal output equal or higher than 600 MW, a feasibility study shall be undertaken; and
- for coal-based combustion plants in the electricity sector, a comprehensive CCS Readiness program shall be submitted as part of the administrative authorisation process.

(Note: thermal output 600 MW ≈ 300 MW electrical output – assuming 50 per cent efficiency)

The French regulations appear to go beyond the EC directive in that the need to set aside space (for CCS equipment) is not determined by the feasibility assessment (it is compulsory), and that for coal-fired generation a comprehensive CCS Readiness program is compulsory, regardless of capacity. Furthermore, the regulations target any boiler-based combustion installations, and in doing so capture coal, gas and some industrial processes. Similar regulatory text is currently being drafted for turbines.

France is playing a leadership role in terms of CCS deployment (including CCSR applications) in industrial applications, and to a lesser extent with regard to gas-fired electricity generation.

[58] (http://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006074220)
[59] (http://www.apave.com/nous-decouvrir/flash-reglementaire/detail-alerte/actu-article/0470-installations-de-combustion-de-puissance-superieure-ou-egale-a-20-mwth-sous-etroite-surveil.html)

Japan

The Strategic Energy Plan of Japan makes explicit provision for CCSR (Box 36) as follows:

> ***BOX 36:*** Advanced utilisation of fossil fuels - Japan
>
> "Accelerating the CCS technology development for an early commercialisation (around 2020s), requiring new coal thermal plants for future planning to be CCSR and to be equipped with CCs technology by 2030, on the precondition of commercialisation."

However, this remains a policy statement, and at this stage no action has been taken to promulgate this in regulation or to provide guidance as to its implementation. This may well change following the review of the Government's *Strategic Energy Plan*[60].

With limited opportunities for geological storage in Japan (based on current work), options for shipping CO_2 could be vital to advancing CCS deployment. Accordingly, CCSR may well be a viable policy option, particularly as without the need for project by project storage characterisation (as it will primarily be in other jurisdictions) the process and associated procedures can be simplified. It may also afford Japanese industry the opportunity to develop first mover advantages around CCSR technology and approaches as it impacts on the capture (and transport) sections of the CCS chain.

[60](http://www.meti.go.jp/english/press/data/pdf/20100618_08a.pdf)

Republic of Korea

An important project under the five-year *Green Growth Plan* is work on the development of a facilitatory legal and regulatory framework for CCS activities, coupled with appropriate environmental protection (these tasks primarily fall to the Ministry of Land, Transport and Marine Affairs and the Ministry of Environment). Work will include the preparation of regulations, guidelines and investment incentives for CCS facility construction and operation and the development of systems for life-cycle processes in relation to CO_2 storage and use.

The Korea CCS Association (which was established under the Plan to drive industrial action) is responsible for the development of ideas for policy and regulation of CCS deployment, and advice on guidelines/standards amongst other tasks. The Association recently undertook a review of existing legal and regulatory systems which involved three stages:

- analysis of model regulatory frameworks developed by international CCS bodies;
- identifying gaps between existing Korean regulation and international best practice; and
- making recommendations on amending/developing CCS legislation and regulations.

The review is not publicly available at present.

The Government looks to be seeking to ensure that Korean industry is well placed to apply the technology both internationally and domestically. There seems to be limited domestic storage opportunity in Korea, and so without the need for storage characterisation, a CCSR option may well be a relatively simple approach to implement.

The Netherlands

The EU CCS Directive has been transposed into Dutch law (to the satisfaction of the EC) through amendments to the *Mining Act*[61] and subordinate legislation. The provisions will come into effect on 16 September 2012. While these provisions apply to on shore and offshore storage of CO_2, Government policy to only support offshore storage (at this time) is exercised through its spatial planning powers – that is the Government will not release or authorise on shore CO_2 storage sites.

Amendments have also been made to the Dutch *Environment Management Act*[62] to ensure the comprehensive coverage of all aspects of the CCS Directive. By and large the amendments to both pieces of legislation merely aim to ensure the strict and correct implementation of the CCS Directive into Dutch law. The majority of the provisions are or will be enshrined in subordinate legislation, such as general administrative orders (AMvB), ministerial regulations (Ministeriële Regeling) and Royal decrees (Koninklijke Besluiten).

To the extent possible the amendments follow the structure and the licensing system of the existing legislation. Further they do not go beyond the strict interpretation of the Directive, and certainly do not provide guidance or clarification of issues such as provisions on the preconditions for CCS, financial commitments and liability issues. This also applies in relation to Article 33 of Directive 2009/31/EC, the CCSR clause.

The Ministry of Economic Affairs, Agriculture and Innovation and the Ministry of Infrastructure and the Environment share responsibility for the implementation of the legal framework for CCS, although local and regional regulatory bodies may be the Competent Authority when it comes to the detailed administration of the regulations and permitting decisions.

Internal discussion and consultation with both local/regional regulatory bodies and industry have occurred in relation to Article 33 and possible guidance as to how the Competent Authority might go about the assessment including what considerations must go to technical and economic feasibility, and what constitutes storage site availability. At this stage the Ministries have no plans to issue specific guidance notes. The EU ETS state aid guidelines which seek to define CCSR have been noted and may form the basis of future work.

The Municipality of Rotterdam, through its Rotterdam Climate Initiative (RCI) program, has released a report *CO_2 Capture, Transport and Storage in Rotterdam Report 2009*[63], which clearly makes the case for CCS on all new coal-fired power and stresses that it will pursue CCSR through its planning and regulatory procedures. DCMR is the EPA of the Rotterdam and Port of Rotterdam area (and Competent Authority for CO_2 capture installations). DCMR has been actively pursuing this objective and has specifically stated its *"preference for mandatory use of CCS for coal‑fired power plants"*[64].

With full knowledge of the Rotterdam policy, and given the range of local environmental, spatial planning and best available control technology obligations that come into play in permitting individual projects, proponents have actively embraced CCS/CCSR in their siting and approvals applications, clearly demonstrating the value of a strong policy signal.

With these 'voluntary actions' and through an interactive, negotiated process, DCMR was able to incorporate such undertakings into permit conditions. Accordingly, E.ON's Maasvlakte Power Plant 3 was permitted and constructed as fully CCSR, with the provisions to be 'road-tested' through the ROAD demonstration project. Notwithstanding this approach,

[61] (http://www.lexology.com/library/detail.aspx?g=293c6316-444d-4b1b-8737-881335e440af)
[62] (http://rechten.eldoc.ub.rug.nl/FILES/root/2010/enviancci/Kars_de_Graaf__Jan_Jans_over_m_1.pdf)
[63] (http://www.rotterdamclimateinitiative.nl/documents/RCI-English-CCS-report_2009.pdf)
[64] ibid

DCMR's preference would be for some prescriptive guidance for CCSR assessment from the national Government in order to plan and regulate with a greater degree of certainty.

The RCI has moved beyond the provisions of the CCS directive in that it has also actively examined options for CCS on gas-fired generation and industrial applications. In 2008, the proposed Eneco Energie 840 MW gas-fired combined heat and power project undertook a CCS pre-feasibility study as part of its permitting process. The study proved negative, hence CCSR provisions were not included in the final permit approvals.

RCI is also looking at CCS in relation to industrial projects, with Air Liquide's new hydrogen plant in the Botlek area in Rotterdam (the NER300 applicant) built as 'capture-ready', with the potential to incorporate a cryogenic purification unit (CPU) that could capture up to 0.5 million tonnes of CO_2 per annum. Air Products has taken a similar approach and its new hydrogen plant will also be constructed as 'capture ready'. Notably, CCS readiness has not been incorporated as a requirement in either of the operational licences.

The (mainly voluntary) actions by Air Liquide, Air Products and E.ON are indicative of wider industry thinking, particularly in regions where CCS is being strongly championed. E.ON has already moved in this direction with regard to new coal-fired power generation, with two CCSR plants under construction, and a further two in the permitting stage (its actions are not solely specific to the Netherlands, and also include Germany and the UK). In taking these actions, E.ON has signalled it is willing to undertake additional investment upfront to facilitate later retrofit, with associated costs being more than offset via the savings of avoiding a major outage at a later stage.

Beyond fundamental decisions regarding pre-or post-combustion, design and construction can provide sufficient flexibility to incorporate different technology/supplier offerings, and hence technology 'lock-in' is not considered an issue by E.ON and other industry players. While some minor plant efficiency losses are to be expected with a CCSR design, these have not significantly impacted the bottom-line economics.

Industry has expressed some concern over exactly how the provisions of Article 33 of Directive 2009/31/EC will be interpreted and applied, and wishes to avoid an overly prescriptive approach. Accordingly, E.ON has opted to seek certification that its new coal-fired plants are CCSR from the German standards/inspection company, TÜV NORD Group. The certificate for Maasvlakte Power Plant 3 was recently renewed – see Box 37.

E.ON argues that the TÜV NORD process is comprehensive and that both the Government and the Competent Authority should accept the certification as proof that they have fully complied with the requirements of Article 33. Not only does the certification indicate that there has been a comprehensive assessment of the potential for CCS, it confirms that they have moved beyond mere 'consideration' to the incorporation of CCSR into the actual design and construction. However, this perception is yet to be tested with the Competent Authority (DCMR).

TÜV NORD is currently the sole supplier of such certificates, having moved quickly to fill this market niche. The European Power Plant Suppliers Association (EPPSA) and other industry bodies have indicated that they would support such an approach[65]. To date, neither the Netherlands Government nor the Competent Authority has indicated whether or not such certificates may be taken to satisfy Article 33.

[65](http://www.eppsa.org/fileadmin/user_upload/News_and_Events/EPPSA_Presentations/PG_2009_Presentation_EPPSA_ID39.pdf)

TÜV NORD is focused on Capture Ready rather than the full CCS chain, although their certification documents (see Box 37) claim that the assessment encompasses:

- technological and site-specific feasibility;
- availability of sufficient space;
- impact on health and safety, environmental impacts, operational efficiency effects;
- plant adaptability/flexibility to incorporate emerging/new CCS technology; and
- feasibility of CO_2 transport and storage.

To date, the Maasvlakte Power Plant 3 certificate has not been submitted as proof of compliance with CCSR provisions of the permit, and hence its validity has not been assessed by the Competent Authority.

Box 37: Maasvlakte Power Plant 3 – TÜV NORD CCSR certificate

CERTIFICATE TÜV NORD

TÜV NORD CERT Standard TN-CC 006
"Carbon Capture Readiness"

Proof of correct application of the standard has been provided and is certified according to the TÜV NORD CERT procedure for the company

E.ON Benelux N.V.
Europaweg 911
3199 LD Maasvlakte
Rotterdam
Netherlands

e·on | Benelux

As an independent certification body, TÜV Nord Cert GmbH has examined the suitability of the power plant named below for retrofit of a Carbon Capture System (here: "post-combustion capture").

Maasvlakte Power Plant
Coloradoweg 10
3199 LA Maasvlakte
Netherlands

The examination with reference to the above standard specifically includes:

- Technological and site-specific feasibility
- Availability of an area of sufficient size at the plant location
- Appropriate R&D contribution of the plant operator in the area of CCS
- Effects on plant safety and the environment
- Effects of preparatory measures on the efficiency of the plant
- Flexibility of the plant with regard to further developments in CC technology
- Feasibility of CO_2 transportation and storage

The company is entitled to make use of the "Carbon Capture Ready" certification mark for advertising purposes.

Certificate Registration No. 44 813 099005
Audit Report No. 8000363610-CS09/03

Valid until 2014-05-18
Next audit until 2014-04-18

Certification Body
TÜV NORD CERT GmbH

Essen, 2012-03-07

TÜV NORD CERT GmbH Langemarckstrasse 20 45141 Essen www.tuev-nord-cert.com

The Netherlands Government continues to be a strong supporter of CCS development, and has both the policy and regulatory frameworks and appropriate financial incentives in place to drive early project deployment. While the regulatory provisions do not extend beyond those stipulated in the EC CCS Directive, both industry and local regulators are showing leadership in taking the initiative and moving beyond the minimum stipulated legal requirements.

Importantly, both coal-fired power generation and industrial projects are being constructed as CCSR. Project proponents are willing to invest in CCSR up front (and in advance of regulatory requirements), and do not appear to be overly concerned by additional costs, impacts on plant efficiency and possible technology lock-in issues.

Accordingly, the Netherlands (and the Rotterdam region in particular) is a real test-bed for determining how effective CCSR can be in facilitating the deployment of commercial-scale CCS. With local policy makers and regulators showing a willingness to pursue CCSR provisions on both coal-fired and gas-fired generation as well as industrial plant, the

Netherlands provides an opportunity to assess the merits of the CCS case without merely seeing fuel-switching outcomes driven by an ‘uneven playfield’.

The Kingdom of Norway

Norway is not a member of the EU and is not subject to the EU CCS Storage Directive. As a member of the European Economic Area (EEA) Agreement, Norway (and other members) may eventually have to implement the Directive if it is agreed that it be incorporated within the EEA Agreement (the CCS Directive qualifies as 'EEA Agreement relevant', but members have not yet agreed to its incorporation).

Nevertheless, in March 2009 the Norwegian Government indicated it would begin work to develop rules and regulations comparable with the Directive, and incorporate these into its national legal system in order to provide a more coherent national legal framework for CCS. The new CCS legislation, based on both the Directive and existing Norwegian petroleum legislation, was originally expected to be made available for public consultation in 2011.

While delayed, the Government has signalled that it intends to release two new sets of regulations relating to transport and storage of CO_2 in sub-sea reservoirs on the Norwegian Continental Shelf, with responsibilities split as follows[66+67]:

- the Ministry of Petroleum and Energy to cover transport and storage of CO_2 in geological reservoirs as natural resources (resource management), as well as issues related to health, safety and the work environment; and
- the Ministry of Environment to regulate the environmentally safe storage of CO_2.

These draft regulations are expected to be released for public comment in 2012. Given Norway's existing oil and gas legislation provides a sound legal basis for regulating CCS (and goes some way to meeting the provisions of the Directive), the delay reflects competing legislative drafting demands, rather than any particular legal challenge posed under the Directive.

The focus of the new legislation is on the transport and storage of CO_2 in subsea reservoirs on the Norwegian Continental Shelf, and will not explicitly address Article 33 of Directive 2009/31/EC (i.e. that dealing with CCSR). Given the already established policy that all new coal-fired generation incorporate CCS from the time of commissioning and operation, and the tax arrangements imposed on CO_2 emissions from petroleum operations, the need for a CCSR policy has in effect been by-passed. Norway has the necessary drivers in place to encourage CCS deployment.

Norway continues to play a leading role in relation to CCS deployment facilitated by the extensive knowledge derived from two commercial-scale operational projects, broad R&D efforts and ongoing financial support for emerging economies.

South Africa

CCSR has formed part of the policy dialogue in South Africa over the past couple of years, but has not been articulated in any formal policy statements, either in terms of support for the approach or an intention to embrace it as part of the regulatory regime. The South African Centre for CCS does have a CCS project in the pipeline, for which preliminary work is currently being done to further address issues around the definition of 'Plant Readiness'[68]. The project started in January 2011 and is due for completion by mid-2012, and it will release a report that will put forward a series of options for Government consideration in relation to pursuing CCSR in the future.

Notwithstanding the work in progress nature of the CCS regulatory framework, the South African Government (Department of Environmental Affairs and Tourism) has, in its 2007 Record of Decision for the construction of the Eskom Generation Project 5,400 MW Coal-fired Power Station (the proposed Kusile power plant), imposed the CCSR conditions set out in Box 38, following a full Environmental Impact Assessment[69].

Having met the CCSR requirements to the Government's satisfaction, the plant has now moved well into construction. The case study learnings from the South African approach are limited, as much of the negotiation and interpretation as to exactly what was necessary to satisfy the requirements remains confidential. The decision is one of the very few cases in a developing country where CCSR requirements have been imposed on an actual project which has subsequently moved forward.

Box 38: KUSILE ENVIRONMENTAL AUTHORISATION

Specific condition, under the heading 'air quality abatement', which requires:

- that end of pipe measures be taken in respect of CO_2;
- the inclusion of "… carbon capture readiness"; and
- a further obligation that the applicant for the authorisation (Eskom) be required to submit "…. a report detailing the preferred technology, for approval, before proceeding with construction".

The focus for South Africa in the short to medium term is implementing its CCS roadmap (particularly the test injection of CO_2), and putting in place the overall regulatory framework to facilitate CCS operations.

[68] (http://www.sacccs.org.za/proposal-requests/)
[69] (http://www.sacccs.org.za/wp)

United Kingdom

The principal legislation covering CCS in the UK is *The Energy Act 2008*[70]. In November 2008, amendments were made to the Act to establish the enabling provisions for regulating offshore CO_2 storage in the UK. This reflects current Government policy which limits CO_2 storage to offshore areas only (due mainly to the extensive storage options offered by the North Sea oil and gas fields, plus saline aquifers).

Once the legal framework for storage was established, the UK Government embarked on a round of consultations in September 2009 to discuss the detail of the proposed offshore CO_2 licensing regime, including draft regulations to implement that regime[71].

As part of this consultation process the UK also sought comments on draft regulations[72] that would explicitly transpose the EC CCS Storage Directive. These are only aimed at the storage aspects of the Directive and do not address Article 33, Amendment of Directive 2001/80/EC, which addresses the CCSR provisions. Article 33 is implemented administratively as part of the consenting arrangements under *The Energy Act 2008*. The full list of regulations transposing the Directive (and their status) can be found on the University College London Carbon Capture Legal Programme website[73].

The Government undertook a separate set of consultations in April 2009 aimed directly at addressing Article 33[74]. The consultation, which foreshadows amendments to the consenting process under *Section 36 of The Electricity Act 1989*, works through each of the key elements of Article 33 (then Article 34 of the draft Directive) as follows:

- demonstrate the project site has sufficient space to accommodate CCS in the future;
- undertake an assessment into the technical and economic feasibility of retrofitting CCS;
- propose a suitable area for offshore storage of the captured CO_2;
- undertake an assessment into the technical and economic feasibility of transporting the captured CO_2 to their proposed storage area; and
- if necessary, apply for and obtain Hazardous Substance Consent.

If granted consent, developers would then be required:

- to retain the additional space on or near the site for the carbon capture equipment;
- where their application includes plans for off-site capture and compression of CO_2, to retain their ability to build on that site in the future; and
- to submit reports to the Secretary of State for the Department of Energy and Climate Change (DECC) on the effective maintenance of the plant's CCSR status.

Importantly, the consultation process not only addressed the specific requirements of Article 33, but also outlined the Government's approach to implementation of CCSR. In several areas it went further than the EC. For instance, it is required that the CCS retrofit assessment be positive in order for the plant to be approved (i.e. all new plants over 300 MW must be CCSR), guidance as to expectations relating to plot size and the information required to satisfy the assessment of each stage of the CCS chain were both set out in greater detail than appear under Article 33), and finally, specific expectations as to the

[70](http://www.decc.gov.uk/en/content/cms/legislation/energy_act_08/energy_act_08.aspx)
[71](http://www.decc.gov.uk/assets/decc/Consultations/carbondioxidestorage%20licensing/1_20090925094606_e_@@_offshoreco2storagelicensingconsultation.pdf)
[72](http://www.decc.gov.uk/assets/decc/Consultations/carbondioxidestorage%20licensing/1_20090925105115_e_@@_offshoreco2storagelicensingconsultationannexb.pdf)
[73](http://www.ucl.ac.uk/cclp/ccsdedlegnat-UK.php)
[74](http://webarchive.nationalarchives.gov.uk/+/http:/www.berr.gov.uk/files/file51117.pdf)

thoroughness of the economic assessment. The Government's response to the consultation[75] resulted in some further modifications to:

- clarify the requirements of the economic assessments of retrofitting and CO_2 transport – with only a single economic assessment covering the full CCS chain to be required;
- clarify the requirements of the two yearly review of the CCS assessments - a set of model conditions on CCS developed; and
- to further amend other assessments to take account of minor clarifications following suggestions from respondents.

Following this process the Government confirmed its policy position of 'no new coal without CCS' with its program of support for commercial-scale CCS demonstration projects, and a requirement for any new coal power station to demonstrate the full CCS chain at commercial scale. It also announced a rolling review process (to report in 2018), which will consider the case for new regulatory and financial measures (Box 39).

BOX 39: Government position on CCSR: - November 2009

"Government ambition is to see CCSR for wider deployment from 2020. Government expects demonstration plant will retrofit CCS to their full capacity by 2025, with the CCS Incentive able to provide financial support if the technology is not commercially viable under the EU ETS at that point."

The Government's final 'Guidance notes' were released in November 2009[76]. In parallel with this process the UK Health and Safety Executive also ran a consultation process and in December 2009, finalised proposed amendments to onshore and offshore pipeline safety regulation in the UK, including the treatment of pipelines carrying CO_2.

Contrary to the views of some industry players who appeared to want each and every step fully detailed, the guidance provided by the Government appears to implement CCSR by building in some options for flexibility and change while not being overly prescriptive. The overriding premise is that project proponents need to clearly demonstrate that plant design and construction will be such that there will be 'no barriers' to future CCS retrofit. Importantly, these barriers also include those of an economic and commercial nature.

In essence, to be approved the project must clearly demonstrate that retrofit is possible from a technical perspective (along the whole CCS chain) and also from an economic and commercial viewpoint (within realistic assumptions around future costs, electricity market conditions and the carbon price).

Clearly the UK guidance goes significantly beyond that of the EC in that it begins to look to specific requirements around the whole CCS chain rather than focus solely on capture. In relation to transport, the assessment must show practical and feasible routes are available for off-take from the plant with detailed considerations covering the initial 10 kms, and to a lesser extent beyond that.

However, having demonstrated available options, there is no requirement for the operator to safeguard these routes (unlike the availability of on-site space for actual retrofit), and they could well be compromised over time with new construction, consents, etc. Nevertheless, the real possibility of this is minimal given that developments are likely to be localised and the operators of power plants will be able to assess the impact on their future operations. Power plant operators also have to provide regular reviews of the CCSR aspects of their projects.

[75](http://www.decc.gov.uk/assets/decc/consultations/guidancecarboncapturereadiness/1_20091106164507_e_@@_ccrgovresponse.pdf)
[76](http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/development%20consents%20and%20planning%20reform/electricity/1_20091106164611_e_@@_ccrguidance.pdf)

Therefore, the Government would be alerted by these reviews if this was becoming a serious issue.

Potential storage sites also have to be nominated from the list of possible sites identified by the Government when no additional characterisation work is required. The Government has developed the list of possible sites based on historic petroleum industry data. While the level of information available (for what are primarily depleted oil and gas fields) is superior to that for saline aquifers, these storage resources are far from 'proven'. Further detailed characterisation work including injectivity tests will ultimately be required to ensure these sites are suitable. However, this level of investment will not occur until industry enters the detailed project planning/execution phase.

Meanwhile, the Scottish Government was working in tandem with the UK Government to roll out its policy and regulatory approach. On 16 June 2009 Scotland announced that CCSR assessments (on the same basis as outlined in the UK consultation document) would be required and would "apply to all new gas, oil, biomass, waste-to-energy and also coal power station applications on or above 300 MW"[77]. While the initial Scottish approach was generally based on the same principles as those adopted in the UK, since that time it has undergone further refinement and now goes further in several key areas.

In November 2009 the Scottish Government outlined its policy approach in relation to the building of any new thermal-based stations above 50 MW (which require consent from Scottish Government Ministers under *Section 36 of The Electricity Act 1989* – see Box 40).

BOX 40: Electricity Generation Policy, November 2009: Scottish CCS/CCSR requirements

"From 9 November 2009, any application for a new coal plant in Scotland will need to demonstrate CCS on a minimum of 300 MW (net) of capacity from their first day of their operation.

Further new builds from 2020 would be expected to have full CCS from their first day of operation.

With regard to retro-fitting of existing coal plants, a 'rolling review' of the technical and economic viability of CCS will take place with the aim of taking a final view on retrofitting by 2018, with the likelihood of having existing plants retrofitted by no later than 2025.

If CCS is not proven to be technically or financially viable then we will consider low-carbon alternatives which would have an equivalent effect."

In its *Draft Electricity Generation Policy Statement 2010: Scotland – A Low Carbon Society*[78], the Scottish Government effectively maintains its position at the forefront of UK CCS policy by reiterating the November 2009 announcements and further requiring that "CCS [is] to be fitted to all new coal-fired power stations". The Scottish Government went on to elaborate on this position in its March 2012 *Electricity Generation Policy Statement*[79+80] which extended the policy beyond coal generation noting that the "Scottish Government's position on gas, oil and thermal stations is that for stations over 300 MW, applicants will have to demonstrate that any new applications demonstrate carbon capture readiness".

The Statement also invites stakeholders to comment on the option of "introducing an Emissions Performance Standard (EPS) … to act as a regulatory back stop on the amount of emissions that a new fossil fuel power station can emit" (along the lines of the UK proposal). Given the Scottish Government's requirement that any new coal plant be fitted with 300 MW of CCS capability from commissioning (moving to full CCS capability over time), the Scottish Government's view is that "….it is unclear that the UK EPS would have any additional practical impact.". The Scottish Government has also signalled some concern that the UK

[77] (http://www.scottish.parliament.uk/parliamentarybusiness/28877.aspx?SearchType=Advance&ReferenceNumbers=S3W-24912&ResultsPerPage=10)
[78] (http://www.scotland.gov.uk/Publications/2010/11/17094217/3)
[79] (http://www.scotland.gov.uk/Resource/0039/00390216.pdf)
[80] (http://scotland.gov.uk/Resource/0038/00389294.pdf)

position may rule out CCS on gas-fired generation until 2045, which is contrary to its position that gas-fired plants over 300 MW must be CCSR.

In terms of the specific provisions relating to CCSR (and the transposition of Article 33 of Directive 2009/31/EC), the Scottish Government undertook a parallel set of consultations to those of the UK, and released guidance on the application of CCSR provisions in Scotland in March 2010[81]. Details of the guidance entitled *THERMAL POWER STATIONS IN SCOTLAND - Guidance and Information on Section 36 of the Electricity Act 1989* (under which Scottish Ministers determine consents relating to thermal power stations) are at Box 41.

BOX 41: Scottish Government position on CCSR: March 2010

"The Scottish Government has determined that, in Scotland, these (CCSR) assessments should be undertaken (and space be required to be set aside) as part of the process of granting development consent under Section 36 of the Electricity Act 1989. The Scottish Government has made clear its intention that no new combustion plant covered by the threshold for CCSR would be consented unless the application demonstrated it would be CCSR when built."

The Scottish provisions around assessment are broadly the same as those of the guidance developed by the UK Government covering England and Wales, except where reflecting background policy differences in preambles.

Administrative responsibility for CCS and CCSR issues in England and Wales rest with DECC's Office of Carbon Capture and Storage. The Secretary for State (DECC) is the Competent Authority under the Act and is responsible for the permitting of new power plants (including CCSR aspects), the permitting of most pipelines and for the permitting of storage. The Crown Estate[82] 'owns' the seabed, and while not responsible for offshore storage permits, it is responsible for policy advice to enable CCS. The Scottish Government takes the lead in Scotland primarily through the Scottish Environmental Protection Agency (SEPA)[83].

The UK is clearly at the forefront of actual application of CCSR regulations. A number of applications have been received and processed with several more pending. While the guidance is 'light-handed', the assessments submitted by industry in seeking approvals under *Section 36 of the Electricity Act 1989* are comprehensive. For instance, the *Scottish Power: Damhead Creek 2, Consolidated Carbon Capture Readiness Feasibility Study* runs to over 100 pages and is comprehensive, covering the details outlined at Box 42.

These assessments are in the public domain as part of the documentation lodged in support of a consent application, and are available on request (as is all evidence before the Competent Authority).

[81] (http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Infrastructure/Energy-Consents/Thermal-Guidance/Thermal-2010)
[82] (http://www.thecrownestate.co.uk/energy/carbon-capture-and-storage/)
[83] (http://www.sepa.org.uk/climate_change/solutions/carbon_capture_and_storage/sepa_ccs_position_statement.aspx)

BOX 42: Scottish Power Damhead Creek 2, CCS Readiness Feasibility Study

The study includes details on:

- background on the legal context and methodology;
- details as to the proposed Damhead Creek development with the addition of CCS (estimation of size of CCS chain);
- the proposed capture plant technology (post-combustion amine scrubbing);
- the technical assessment of: CCS space requirements (including illustrative site plans), retrofitting and integration of CCS, CO_2 storage areas (including proposed storage sites), transport; and
- an economic assessment (which covers the assessment methodology, scenarios, results and conclusions).

DECC manages a comprehensive register available online which provides details of recent decisions on applications for approval[84], along with a second register of applications currently under consideration[85] (these include all applications under *Section 36 of the Electricity Act 1989*, not just CCSR applications). Since March 2010, the Infrastructure Planning Commission and the Planning Inspectorate have been responsible for administering new applications of this type in England and Wales[86].

Perhaps the most useful is the register dealing with '*CO_2 Storage sites – Areas identified for potential usage in CCR reports*'[87]. This not only lists the storage sites associated with each approved project, but also attaches the detailed rationale and discussion that underpins the Competent Authority's decision. Scotland maintains a separate online site covering decisions made in that jurisdiction[88].

The body of reports and associated work, together with the decisions and rationale will expand to become an important resource for both governments and industry in determining what is necessary to meet CCSR requirements (at least as stipulated under UK regulation).

The UK (including Scotland) has the most sophisticated policy and regulatory framework in relation to CCSR in the world. The regulatory provisions extend well beyond those stipulated in the EC CCS Directive, with significant practical guidance provided on its application. Moreover, the UK is now benefiting from the pragmatic insights and experience that only direct application of the regulations can bring. A number of project approvals (in relation to CCSR for both gas-fired and coal-fired generation) have already been granted, and the prescribed assessment processes have delivered sufficient detail to enable the Competent Authority to take informed decisions.

The Government has seemingly developed a pragmatic approach for dealing with some of the unknowns around both transport and storage, but assessment is relatively broad brush. With both experience and more detailed knowledge (especially as the first storage sites are developed) there will be scope to refine the approach regarding storage and transport considerations. The UK Government has contributed to a detailed atlas of storage sites compiled by the Energy Technology Institute which may assist in the way storage is assessed going forward. While the economic assessment under the process appears robust, the capacity for the Government to move projects from CCSR to actual retrofit remains largely untested.

[84] https://www.og.decc.gov.uk/EIP/pages/recent.htm
[85] (https://www.og.decc.gov.uk/EIP/pages/applications.htm)
[86] (http://infrastructure.planningportal.gov.uk/)
[87] (https://www.og.decc.gov.uk/EIP/pages/c02.htm)
[88] (http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Infrastructure/Energy-Consents/Applications-Database)

The UK Government has no current plan to implement a compulsory CCS requirement for all fossil fuel plant, beyond those which already apply to coal-fired generation. The intention is that the primary driving force for CCS deployment will be the range of market mechanisms that have already been implemented, or are in the process of being implemented, as part of the Electricity Market Reform described earlier – in particular the 'Feed in Tariff Contract for Difference', the EU ETS (supplemented by a Carbon Price Floor), with a regulatory backstop provided through an emissions performance standard. Early stage projects will receive additional capital support.

The UK Government continues to be a strong supporter of CCS development, and moreover has a suite of appropriate financial incentives and regulatory drivers in place to facilitate early project deployment. CCSR has been carefully positioned as part of these enabling policies.

United States of America

While there is considerable commercial interest in CCS this is almost exclusively driven by EOR opportunities. Regulatory responsibility rests primarily with the state Governments and many have promulgated regulations to govern the long-term storage of CO_2, to address liability and 'pore-space' ownership issues, and to regulate pipelines. At the federal level, the US EPA has been active on 27 March 2012, it proposed the first *Clean Air Act* standard for carbon pollution from future power plants[89] – the proposed standard being flexible and achievable for the next generation of power plants.

The Best Available Control Technology (BACT) mechanism under the *Clean Air Act* (administered by the EPA) could potentially act as a de-facto CCSR policy. The BACT mechanism is an emissions limitation based on a case-by-case decision that takes into account technical feasibility, cost, and other energy, environmental, and economic impacts.

The EPA guidance notes that CCS is classified as an add-on pollution control technology that is 'available' for facilities emitting CO_2 in large amounts. The guidance points out that CCS is a promising early stage technology, and while it should be identified as an available control measure in BACT assessments, is unlikely to be selected, due to cost considerations[90].

It is the EPA's proposed *Clean Air Act* standard for carbon pollution from future power plants that comes closest to embracing the concept of CCSR. The standard, which will "apply to new fossil-fuel-fired electric utility generating units" that begin construction from March 2013, limits emissions to 1,000 $lbCO_2$/MWh measured annually (in effect the level of emissions from a current state of the art natural gas combined cycle plant).

To ensure continued use of US fuel sources (i.e. coal), the proposed standard provides flexibility for new power plants to phase in CCS technology. One option is for new power plants that employ CCS to use a 30 year average of CO_2 emissions to meet the proposed standard, rather than meeting the standard each year. The second approach envisaged is essentially CCSR with CCS to be added later in the plant's life[91] (see Box 43).

BOX 43: Proposed Carbon Pollution Standard for New Power Plants

"PRACTICAL, FLEXIBLE, ACHIEVABLE

A company could build a coal-fired plant and add CCS later. For example, a new power plant could emit more CO_2 for the first 10 years and then emit less for the next 20 years, as long as the average of those emissions met the standard.

CCS is expected to become more widely available, which should lead to lower costs and improved performance over time."

The proposed standard, open for public comment for 60 days from 27 March 2012, explores options allowing for an initial delay in installation of CCS provided there is uptake from year 10 of operation. That is, operators will be allowed to construct and begin operations without CCS, and then install and operate CCS at some time in the future. However, they must then operate in a manner that allows them to meet the 1,000 $lbCO_2$/MWh standard, on a weighted average basis, over the full 30 year period. The EPA is considering a number of options to ensure compliance and prevent 'gaming of the system' such as requiring operators to meet a 600 $lbCO_2$/MWh standard for the final 20 years to be measured/acquitted on an annual basis (rather than a rolling average).

[89] (http://epa.gov/carbonpollutionstandard/)
[90] (http://www.epa.gov/nsr/ghgpermitting.html)
[91] (http://epa.gov/carbonpollutionstandard/pdfs/20120327factsheet.pdf)

Some states, including Washington, Oregon and California, currently limit CO_2 emissions, while others, including Montana and Illinois, require CCS for new coal generation. These requirements tend to be imposed through either emission performance standards for new generation facilities (and in some cases existing facilities that are being upgraded), portfolio standards for CCS (requiring generator companies to have a minimum mix of low-carbon generation in their overall fleet), or direct permit requirements. While these regulatory requirements may drive the deployment of CCS (or encourage alternate low-carbon generation) in that CO_2 that is sequestered is not counted as emitted, they do not constitute CCSR regulation.

The Washington State provisions (*Substitute Senate Bill 6001 3 May 2007*) come closest to facilitating CCSR in that they make provision for CO_2 storage to begin within five years of the new/upgraded plant commencing operation. In effect, operators have a five year grace period to make CCS operational, but will need to have designed and built the plant as CCSR if they are to meet the standards. Given there is very little discretion for the regulator to continue to allow non-compliant plant to operate (threats to the integrity of the grid being one case), the total investment is at jeopardy if full CCS planning has not occurred.

There is anecdotal evidence to suggest that at the early stage of project planning for new coal-fired generation units, some project proponents have indicated a willingness to consider and/or incorporate CCSR primarily in an attempt to assuage public opposition. None of these projects have advanced to the formal submission or permitting stage, hence it is not possible to assess how serious the consideration of CCSR has really been.

CCS deployment in the USA will mainly be driven by commercial EOR opportunities and to a lesser extent, by emission performance standards in more progressive states. In the foreseeable future, this may change dramatically if the proposed EPA *Clean Air Act* standard for carbon pollution from future power plants comes into effect. Under the standard, CCSR, coupled with commercial CCS deployment, will be essential for any new coal-fired plant that commences construction after March 2013.

Appendix B – Glossary and list of abbreviations

In the Report, terms and names used regularly are generally spelt out on the first occasion and then abbreviated.

ADB	Asian Development Bank
AMvB	General administrative orders (The Netherlands)
BACT	best available control technology
BAT	best available technology
CCGT	combined cycle gas turbine
CCS	carbon capture and storage
CCSR	carbon capture and storage ready
CO_2	carbon dioxide
CDM	clean development mechanism
COP17	Conference of Parties 17th meeting (under the United Nations Framework Convention on Climate Change)
CPU	cryogenic purification unit
CSLF	Carbon Sequestration Leadership Forum
DCMR	DCMR Milieudienst Rijnmond (Rotterdam)
DG	Directorates General
EBRD	European Bank for Reconstruction and Development
EC	European Commission
ECBM	enhanced coal bed methane
EEPR	European Energy Program for Recovery
EEA	European Economic Area (Agreement)
EIB	European Investment Bank
EMR	electricity market reform
EPA	Environment Protection Agency
EPPSA	European Power Plant Suppliers Association
EOR	enhanced oil recovery
ETS	Emissions Trading System
EU	European Union
FP7	Seventh Framework Programme (European Commission)
G8	Group of Eight (world's largest economies)
GDP	gross domestic product
Global CCS Institute	Global Carbon Capture and Storage Institute
g/gms	grams (mass)
Gt	gigatonne (mass)
GW	gigawatt
GWh	gigawatt-hour
HPAD	Hydrogen Energy Abu Dhabi
IEA	International Energy Agency
IEAGHG	IEA Greenhouse Gas R&D Programme
IGCC	integrated gasification combined cycle
lb	pound (mass)
kms	kilometres
KWh	kilowatt-hour
LEMIGAS	Research and Development Centre for Oil and Gas Technology (Indonesia)
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MENA	Middle East and North Africa (Region)
METI	Ministry for Economy, Trade and Industry (Japan)
MW	megawatt
MWh/MWth	megawatt-hour
MOST	Ministry of Science and Technology (China)

NDRC	National Development and Reform Commission (China)
NER300	New Entrant Reserve 300 (European ETS allowances)
NGCC	natural gas combined cycle
NGOs	non-government organisations
OECD	Organisation for Economic Co-operation and Development
PETRONAS	Petroliam Nasional Berhad (Malaysia)
R&D	research and development
RCI	Rotterdam Climate Initiative
ROAD (project)	Rotterdam Capture and Storage Demonstration (Project)
SEPA	Scottish Environmental Protection Agency
SNG	substitute natural gas (synthesis)
TERI	The Energy and Resources Institute (India)
UAE	United Arab Emirates
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
United Nations IPCC	United Nations Intergovernmental Panel on Climate Change
USA	United States of America
USCPC	ultra supercritical pulverised coal-fired (power plant)
WWF	World Wildlife Fund
^{o}C	degrees Celsius (temperature)
£	British pounds sterling
€	euros

Appendix C – CCSR definition

Definition of carbon capture and storage ready (CCSR)

A CCSR facility is a large-scale industrial or power source of CO_2 which could and is intended to be retrofitted with CCS technology when the necessary regulatory and economic drivers are in place. The aim of building new facilities or modifying existing facilities to be CCSR is to reduce the risk of carbon emission lock-in or of being unable to fully utilise the facilities in the future without CCS (stranded assets). CCSR is not a CO_2 mitigation option, but a way to facilitate CO_2 mitigation in the future. CCSR ceases to be applicable in jurisdictions where the necessary drivers are already in place, or once they come in place.

Essential Requirements of a CCSR facility

The essential requirements represent the minimum criteria that should be met before a facility can be considered CCSR. The project developer should:

- carry out a site-specific study in sufficient engineering detail to ensure the facility is technically capable of being fully retrofitted for CO_2 capture, using one or more choices of technology which are proven or whose performance can be reliably estimated as being suitable;
- demonstrate that retrofitted capture equipment can be connected to the existing equipment effectively and without an excessive outage period and that there will be sufficient space available to construct and safely operate additional capture and compression facilities.
- identify realistic pipeline or other route(s) to storage of CO_2;
- identify one or more potential storage areas which have been appropriately assessed and found likely to be suitable for safe geological storage of projected full lifetime volumes and rates of captured CO_2;
- identify other known factors, including any additional water requirements that could prevent installation and operation of CO_2 capture, transport and storage, and identify credible ways in which they could be overcome;
- estimate the likely costs of retrofitting capture, transport and storage;
- engage in appropriate public engagement and consideration of health, safety and environmental issues; and
- review CCSR status and report on it periodically.

Definition application

These essential requirements represent the minimum criteria that should be met before a facility can be considered CCSR. However, a degree of flexibility in the way jurisdictions apply the definition will be required to respond to region and site-specific issues and to take account of the rapidly changing technology, policy and regulatory background to CCS and CCSR, both globally and locally. More specific or stringent requirements could be

appropriate, for instance, in jurisdictions where the CCSR regulator is working on the assumption that CCS will need to be retrofitted to a particular facility within a defined time frame.