SUBMISSION TO
THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC) TECHNOLOGY EXECUTIVE COMMITTEE

Technology Executive Committee decision – Third Meeting:

- technology roadmaps and action plans;
- ways to promote enabling environments and to address barriers to technology development and transfer; and
- actions undertaken by observer organisations relevant to the TEC in performing its functions.

AUGUST 2012

Introduction

Announced by the Australian Government in September 2008, the Global CCS Institute (the Institute) was formally launched in April 2009. It became a legal entity in June 2009 when it was incorporated under the Australian Corporations Act 2001 as a public company and began operating independently and as a not-for-profit entity from July 2009. The Institute works collaboratively to build and share the expertise necessary to ensure that carbon capture and storage (CCS) can make a significant impact on reducing the world's greenhouse gas emissions. Please refer to the following website for further information on the Institute (www.globalccsInstitute.com/Institute).

As an accredited observer, the Institute welcomes the opportunity afforded by recent decisions arising from the Third Meeting of the Technology Executive Committee (TEC) held in Bonn over the period of 28-29 May 2012.

The TEC has called for inputs on:

- inventory on technology road maps and action plans;
- ways to promote enabling environments and to address barriers to technology development and transfer; and
- actions undertaken by accredited observer organisations relevant to the TEC in performing its functions.

The Institute hopes its views will positively assist the TEC in its deliberations on such issues at its Fourth Meeting expected to be scheduled in September 2012.

Overview

CCS is recognised by the United Nations Framework Convention on Climate Change (UNFCCC) as a technically legitimate mitigation option capable of delivering permanent abatement outcomes. It is also recognised as an eligible project level activity in the Clean Development Mechanism (CDM). This demonstrates that CCS activities can be readily and systematically institutionalised and rewarded in market-based mechanisms, and is internationally accepted as being consistent with the sustainability development requirements of developing countries.

CCS consists of four components:

- emissions sources (where CO_2 emissions are produced);
- CO_2 capture (where a physical or chemical separation process isolates CO_2 from other components in the source's exhaust gas);
- CO_2 transport (moving the captured CO_2 from point source to a sink); and
- CO_2 storage (where CO_2 is injected into a geological formation and subsequently isolated from the atmosphere).

CCS has the potential to deliver one of the single largest emissions abatement outcomes of all currently known mitigation options. The International Energy Agency (IEA) estimates that CCS could contribute about 19 per cent of the required abatement by 2050[1]. The Intergovernmental Panel on Climate Change (IPCC) estimates that CCS could contribute between 15 and 55 per cent of the required abatement by 2100.

[1] to hold atmospheric concentrations of greenhouse gases to about 450 parts per million (ppm)

CCS can also drive negative emissions (i.e. remove greenhouse gas emissions from atmosphere) when combined with carbon neutral energy feedstocks (i.e. sustainable biomass) and permanently storing the captured emissions deep into the geological sub-surface.

Third Meeting of the Technology Executive Committee

In May 2012, the Institute attended the TEC's Third Meeting in Bonn. The meeting included a dialogue on technology research, and while no specific discussion on CCS was held, much of what was discussed was directly applicable to the challenges of deploying large-scale clean energy technologies such as CCS.

The meeting included a discussion on the TEC's evaluation of the bids to host the Climate Technology Centre (CTC), noting that it will now begin negotiations with the United Nations Environment Programme (UNEP) whose application ranked the highest. The Institute acknowledges the critical role that the CTC can and must play in assisting the successful deployment and diffusion of environmentally sustainable large-scale clean energy technologies in developing countries, including CCS, and welcomes the decision to appoint UNEP as the host.

The Institute also supports the TEC's intent to continue with its thematic dialogues on technology at its meetings, complemented by consideration of various inputs by relevant public and private sector organisations. The TEC is examining how it might better engage with other UN (i.e. CTC, Green Climate Fund) and non-UN institutions (i.e. intergovernmental organisations such as the IEA and other similar organisations to the Institute).

The Institute strongly applauds the TEC's position of encouraging private sector expression on its capacity to support clean energy technology development and project implementation experiences, and it remains at the ready to enthusiastically engage as is deemed appropriate and allowed in all TEC processes. While no formal reporting relationship exists between the TEC and the CTC, the Institute is also committed to proactively support UNEP in its role as host of the CTC, especially as a potential participant in the supporting technology networks.

The TEC established an internal taskforce of Committee members to document existing roadmaps in a report to be potentially presented to the Eighteenth Meeting of the Conference of Parties (COP 18). This current call for submissions will inevitably help the TEC to compile such an inventory of relevant work.

The work of the TEC will be instrumental in providing the COP with the advice it needs to give effect to low-emissions technology (LET) decisions (including both mitigation and adaptation) that can further support and assist deployment in developing countries. The Institute's interest in the mitigation aspect of this agenda is to serve as a primary channel of information on CCS related matters, and influence the institutionalisation of CCS within UNFCCC processes through evidence-based advocacy.

As such, the Institute considers that several current UNFCCC agendas are important to the successful deployment of CCS technologies, including the:

- need for, and the evolution of, ever-increasing carbon constraints through the implementation of the Kyoto Protocol's second commitment period and the development of the Durban Platform for Enhanced Action;
- negotiations on the institutional arrangements supporting the UNFCCC's organisations and mechanisms such as the Green Climate Fund (GCF), the Technology Mechanism (including the CTC&N), and new market based mechanisms (NMBMs);
- finalisation of the outstanding issues affecting the institutionalisation of CCS in the CDM, including the approval of appropriate project level methodologies; and
- operationalisation of UNEP as the host of the CTC, and the processes that will underpin the selection and operation of the supporting technology networks.

Inventory on technology road maps and action plans

In the next decade, CCS technologies will have a significant impact on the ability of the global community to hold greenhouse gas emissions to an atmospheric concentration level where the dangerous impacts of climate change can be avoided.

The benefits of a successful deployment of CCS technologies as a primary mitigation option to prevent emissions to atmosphere will be apparent in terms of: provision of reliable and clean base-load energy; avoidance of many environmental issues that afflict other large-scale clean energy options (such as land-use, fracking processes, substantial water-use, radiation); prevention of many health problems (as a consequence of particulate pollution and/or climate change related impacts), and sustainable industrial production processes capable of supporting continued economic prosperity.

Most roadmaps offer readers analytical insights into the future prospects and transition pathways of technology solutions including: areas of convergence and complementarity with other technologies; development of new applications; and information that aims to inform future deployment strategies, technologies, markets and investment opportunities.

The development of technology roadmaps tend to bring together core stakeholders (governments, industry participants, research community, civil society) who have an interest in better understanding the potential of a particular technology/technologies to deliver on a broad range of stated policy objectives, as well as identifying key roles.

For CCS, roadmaps often cite the policy drivers as: ensuring base-load energy reliability, delivering large-scale, timely and dependable mitigation outcomes, and/or obtaining a social license for projects to operate through the public acceptability of industrial operations. Other potentially relevant global and national challenge considerations, other than those mentioned above, might include:

- capturing economic opportunity (such as optimising the value of natural resource endowments (such as fossil fuels) in a sustainably responsible manner;
- national security issues and energy independence; and
- global competitiveness and productivity of industry.

Roadmaps usually outline future transition pathways derived under varying scenarios, constraints and time horizons, and often include an exploration of variables such as:

- enabling drivers (market push versus market pull instruments);
- resources required (including nature and scale of financial investment);
- commercial opportunity (size of market potential or market penetration capacity);
- policy, regulatory, and technical barriers (including market failures);
- financial and technical risks (including contingency risk management and premiums); and
- potential to address global and national challenges (as referred to above).

Scenarios explored tend to include exogenous constraints as defined in terms of time, mitigation aspirations and/or share of energy contribution. Themes examined tend to include the potential of:

- technologies that are currently considered commercial or mature;
- technologies that are currently under development with expectation of commercialisation within say a decade; and
- long-term (often characterised as 'blue sky') technologies and applications – including step-change and/or disruptive technologies capable of materially impacting on existing production processes.

All roadmaps are products of the scope of their analytical frameworks including assumptions and data generation approaches. This can often call into question the extent to which the reports:

- capture all of the key technological developments and potential applications;
- reflect the most current published and unpublished data and intelligence relative to what is contained in the reports; and
- identify all key issues, opportunities, risks, barriers and potential of technologies to deliver on the stated policy objectives and/or constraints.

While roadmaps are mostly valued as a theoretical tool by policy makers to assist them propose and design approaches to better support technologies through their innovation chain (concept to commercial) and/or project lifecycle (planned to operational), they are also essential in determining the likelihood of global and national challenges being effectively addressed under current policy settings, what sorts of changes to the prevailing policy and regulatory environments may be deemed necessary, and the roles of key entities.

While the Institute has not produced a CCS roadmap, it has supported many organisations and governments in their consideration and development of their own roadmaps. For example, the IEA's CCS Unit depends on substantial financial support from the Institute. The Institute is also a key participant in agendas such as the Carbon Sequestration Leadership Forum (CSLF), and capacity development efforts in many developing countries.

The following two tables represent a broad (not exhaustive) inventory of CCS related (possibly not specific) roadmaps known to the Institute. Table 1 includes roadmaps for specific countries, while Table 2 lists roadmaps of a generic nature. They have been prepared by national governments and/or non-government organisations (NGOs), intergovernmental organisations, or financial institutions.

The Institute is not in a position to express a view on the merits or value of these roadmaps and plans of action, and provides the inventory list on the basis of information purposes only.

Table 1: Country level CCS roadmaps

Country	CCS Technology Roadmaps and Action Plans
Australia	Carbon Storage Taskforce, National Carbon Mapping and Infrastructure Plan – Australia
	National Low Emission Coal Council, National Low Emission Coal Strategy: Accelerating Carbon Capture and Storage in Australia
Brazil	Centre of Excellence in CCS R&D, The Brazilian Atlas of Carbon Capture, Transport and Geological Storage (in process of being published)
Canada	Natural Resources Canada, Canada's Clean Coal Technology Roadmap
	Natural Resources Canada, Carbon Capture and Storage: CO2 Capture and Storage Roadmap
China	Asian Development Bank, People's Republic of China (PRC): Carbon Dioxide Capture and Storage (CCS) Demonstration - Strategic Analysis and Capacity Strengthening
Greece	Bellona, A Bridge to a Greener Greece: A Realistic Assessment of CCS Potential
Hungary	Bellona, The Power of Choice: CCS Roadmap for Hungary
Indonesia	Indonesia CCS Study Working Group, Understanding Carbon Capture and Storage Potential in Indonesia
Malaysia	Global CCS Institute, Ministry of Energy, Green Technology and Water, Clinton Climate Initiative, Malaysia CCS Scoping Study (not published)
Mexico	North American Carbon Storage Atlas (including Mexico)
	Secretariat of Energy, National Energy Strategy 2012-2026

Country	CCS Technology Roadmaps and Action Plans
Poland	Bellona, Insuring Energy Independence: CCS Roadmap for Poland
Romania	Bellona, Our Future is Carbon Negative: A CCS Roadmap for Romania
South Africa	Geological Atlas
	South Africa Centre for CCS, Roadmap Strategy
South East Asia	Asian Development Bank, Determining the Potential for Carbon Capture and Storage (CCS) in Southeast Asia (in process of being published)
United Kingdom	Department of Energy and Climate Change, CCS Roadmap: Supporting deployment of carbon capture and storage in the UK
	Scottish Government and Scottish Enterprise Carbon, Capture and Storage – A Roadmap for Scotland
	UK Energy Research Centre, The UKER/UKCCSC Carbon Capture and Storage Roadmap
USA	DOE/NETL, Carbon Dioxide Capture and Storage RD&D Roadmap
	NETL, Carbon Sequestration Technology Roadmap and Program plan

Table 2: Generic CCS roadmaps

Organisation/Agenda	Technology Roadmap and Action Plans
Asia Development Bank (ADB)	Asian Development Bank, Carbon Dioxide Capture and Storage Demonstration in Developing Countries—Analysis of Key Issues and Barriers
Carbon Sequestration Leadership Forum (CSLF)	Carbon Sequestration Leadership Forum, Technology Roadmap 2011: A global response to the challenge of climate change
Clean Energy Ministerial (CEM)	Global CCS Institute (in collaboration with a sub Working Group of the Clean Energy Ministerial), CCS Funding Mechanisms for Developing Countries
International Energy Agency (IEA)	IEA, Technology Roadmap Carbon Capture and Storage
	IEA, A Policy Strategy for Carbon Capture and Storage
IEA and United Nations Industrial Development Organisation (UNIDO) sponsored by the Institute	UNIDO/IEA, Technology Roadmap Carbon Capture and Storage in Industrial Applications
The World Bank	World Bank, Carbon Capture and Storage in Developing Countries: a Perspective on Barriers to Deployment

Ways to promote enabling environments and to address barriers to technology development and transfer

The Institute's flagship report on the global status of large-scale integrated CCS projects (LSIP), *The Global Status of CCS: 2012*, is expected to be publicly released in October 2012. The latest status of CCS projects, as at June 2012[2], indicates that there are currently 73 LSIPs around the world. This includes 15 LSIPs that are currently operating or in construction, and capturing some 35.4 million tonnes of CO_2 per year ($MtCO_2$). A further 58 LSIPs are in the planning stages of development (i.e. pre-financial investment decision stage, covering from concept identification to financial and technical feasibility evaluations), with an additional potential capture capacity of more than 115$MtCO_2$ per year.

These projects provide examples of viable business cases for CCS technology given specific circumstances. *The Global Status of CCS: 2011* revealed that a number of LSIPs had been cancelled or put on hold over the previous 12 month period, with reasons anecdotally given as adverse project economics under their current design, reflecting an insufficiency of prevailing policy environments rather than engineering failures.

The 2011 Report also indicated a healthy evolution of early stage CCS projects, in that there had been substantial movement over the two previous years between the early project lifecycle stages. The report cites: *that the low number of projects in the Identify stage should not … be viewed as an adverse development ... as projects are advancing through the project lifecycle out of the Identify stage*.

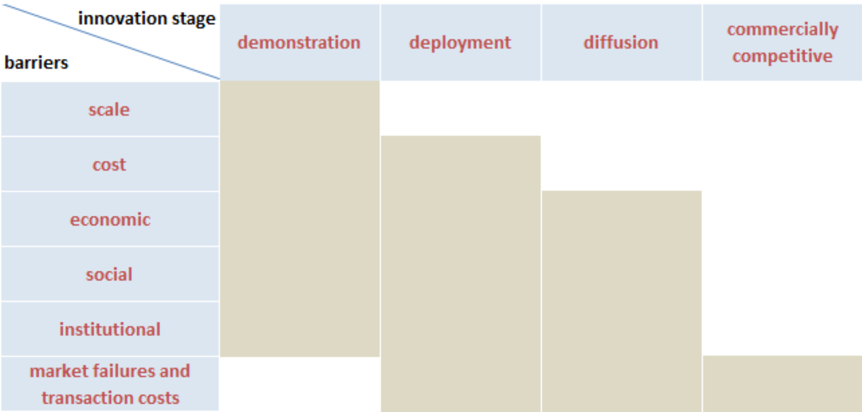
CCS project activity is predominantly in the demonstration phase, and this partly explains why the focus of many governments to date has been mostly on providing public funding for pilot and demonstration-scale projects. But it is vitally important that governments continue to send strong policy signals during the demonstration phase that the institutional arrangements (including legislative and regulatory frameworks) can and will be in place in a timely manner to efficiently support the early stages of commercial deployment.

In the absence of stable and predictable carbon regimes, private sector participation in CCS projects is typically reliant on the transitional pathways afforded by governments. These pathways need to be sufficient and robust enough to provide businesses with options to hedge their medium to longer term emission risks in a commercially attractive manner.

As illustrated in Figure 1 below, the nature of the barriers that afflict the demonstration and deployment of large-scale clean technologies, including CCS, change over the innovation stage. The efficiency and effectiveness of policy responses depend on the innovation stage being supported, and the extent to which complementarity between policies is implemented. It might be expected that as more market based policies are established, existing policies will be reviewed, revised and possibly even abandoned over time.

[2] http://www.globalccsinstitute.com/publications/global-status-ccs-update-june-2012

Figure 1: Barriers to deployment



source: UNFCCC/SB/2009/3 7 May 2009 (Figure 5)

Many countries are engaging in robust public policy discussions on major next generation climate change policies (refer to the Institute's *The Global Status of CCS* for updates on policy developments). There are also innovative industry led initiatives which aim to secure broad support for policies that increase energy security (i.e. domestic oil supply or electricity supply) while limiting and managing emissions through CCS.

As indicated, the current enabling environment for large-scale clean energy technologies such as CCS is largely reliant on governments adopting appropriate policy settings to: address inherent market failures; their public sectors to subsequently and efficiently implement the policy settings (i.e. policy in many cases drives the economics of projects); and the capacity and propensity of the private sector to respond to those settings.

There are a number of reasons why governments intervene to address market failures, including to:

- correct for externalities (i.e. either in terms of the harm caused by the release of CO_2 in the atmosphere or an inability to monetise the full benefit of investing in research and development activities);
- provide public goods (i.e. as learn-by-doing (LBD), information generation);
- address imperfect markets (i.e. monopolistic structures often found in distribution networks);
- address imperfect information (i.e. information asymmetry between decision makers and market participants); and
- oversee vertically integrated markets (i.e. different ownership structures between markets can result in the undersupply of a service or capacity).

The capacity of any bureaucracy to give effect to overarching policy settings and implement programmes is critical to the successful deployment of any technology. If implementation is inefficient (i.e. made overly administratively burdensome or prescriptive) or ineffective (i.e. insufficient or not dependable) then the policy objectives are unlikely to be met, and can often impose undue cost on related economic activities – further undermining and/or slowing the rate of LET deployment.

Capacity development for policy makers, regulators and project developers is very much a priority focus of the Institute's work program in its efforts to enhance the global capacity to accelerate the deployment of CCS (refer to the next section).

While government programs are often implemented on the basis of supporting technology development to deliver positive spillover effects (such as LBD), the success of large-scale clean energy projects is also linked to the: ability of project proponents to strike compelling business cases; and the extent to which proposals can deliver on a broad range of investor/s interests, such as (among others):

- investment viability under current and likely future policy regimes (including expected duration of policy frameworks);
- sovereign risk associated with changes to prevailing (or announced) policies or incentives, and the way this affects existing investments;
- financial attractiveness of projects relative to other investment opportunities (including outside the energy sector); and
- maturity and risk of the technologies being considered.

Investors (both private and public sector) often need to strike a balance between the likelihood of realising the benefits of risk-adjusted rates of return over time (i.e. risk premiums reflect the nature of the associated risks), with the ability to minimise the cost of delivering a broad range of objectives, such as sustainably operating in carbon constrained environments and/or satisfying eligibility requirements to claim project level abatement as tradable offsets. If investment hurdle rates rise unacceptably over time, project developers may decide to mothball a project completely or to put it on hold indefinitely.

As shown in Figure 1, government support for large-scale and pre-commercial demonstration projects (such as CCS, solar thermal with energy storage, geothermal) can help drive the benefits of scale. Most technologies have learning or experience curves which arise from the positive spillovers of experience and LBD at and across the various stages of a technology's lifecycle. This can often drive over time, as a technology's footprint globally expands and engineering efficiencies gained, material reductions in the price point per unit installed. This clearly has a subsequent positive impact on the future cost of mitigation efforts.

Positive LBD effects for CCS are currently being generated by countries with a high reliance on fossil fuels to drive economic activity, as well as high emitting sectors with either relatively low CCS costs (such as natural gas processing and enhanced oil recovery) and/or low trade exposure (such as the power sector). This is driven to a large extent by the common nature of CCS operational requirements such as geological site characterisation, emissions monitoring, reporting and verification (in both the surface and sub-surface), and project approvals processes (including risk assessments and securing public acceptability).

Evidence that positive spillovers result from these learning curves is demonstrated by the price of photovoltaic (PV) modules, which have fallen by some 60 per cent per megawatt (MW) since 2008, and wind turbine prices which having fallen by 18 per cent per MW over the period 2009 to 2010[3]. The potential economies of scale for CCS, especially for capture technologies (which can contribute between 60 to 80 per cent of the total cost of an integrated system) and CO_2 pipelines is significant, especially when considering the scale of

[3] Investment Grade Climate Change Policy - Financing the Transition to the Low Carbon Economy, p7 (2011)

opportunity to apply CCS to global industrial applications such as power generation and steel production, and the volume of CO_2 needing to be transported (i.e. the daily volume of CO_2 needing to be handled by 2050 could be some 2.5 times the current volume of oil being produced and transported[4]).

The IEA has recently released an information paper titled *A Policy Strategy for Carbon Capture and Storage* (January 2012), as a guide to policy makers to assist them in designing national and international policy related to CCS. It highlights that CCS policy needs to address: the creation of new markets (such as new mechanisms currently being explored under the UNFCCC agenda and national emissions trading/offset schemes); market barriers and failures, and promotion and regulation of infrastructure. The IEA observe that not only is the policy architecture (i.e. what the policy objectives are, such as addressing certain types of market failures) important but so too is the selection of policy instruments to address certain issues, and to support technologies as they inevitably evolve and mature over time.

The IEA examine a 'gateway' approach to CCS policy development that provides for changes in policy focus over time as CCS technology matures. For example, CCS is currently in a pre-commercial large-scale demonstration phase. This phase aims to not only firm up manufacturer engineering performance guarantees that can reduce the technical risk of commercial project investments, but also to enhance the LBD effects and information generation that ultimately helps drive down the cost of deployment over time.

Demonstration projects also provide time for the necessary institutional arrangements to be established such as appropriate regulations to govern industrial-scale activities, and the required distribution infrastructure (i.e. pipelines and other transport networks).

While first and second of a kind technology projects are less about providing short-term abatement, as large-scale and generally long-lived (40+ years) assets, many will ultimately need to transition to commercial operations after the demonstration phase is completed (say between 5 and 10 years).

A policy framework that can deliver on the needs of large-scale CCS demonstration projects is very different to the commercial needs of CCS deployment, and so a 'gateway' approach can help trigger a need to revise, and provide for, a predictable transitioning of a prevailing suite of policy settings to a new and more appropriate suite of policies in a timely manner.

Currently, CCS projects need policy support to generate LBD to drive the costs of construction and operation downwards. Over the short to medium-term, CCS projects will need the type of policy support that drives commercially attractive mitigation and energy. The former application may benefit from a policy portfolio of strong international collaboration and direct funding support to assist with the high upfront capital costs. The latter from more regulatory and/or market based approaches to assist with the longer-term operating costs. The IEA report provides a sound synopsis of the policy options at the various stages of CCS developments.

[4] M Bonner, Carbon Dioxide (CO_2) Distribution Infrastructure: The opportunities and challenges confronting CO_2 transport for the purposes of carbon capture and storage (CCS), Global CCS Institute

Actions undertaken by accredited observer organisations relevant to the Technology Executive Committee in performing its functions

The Institute has been engaged in the UNFCCC since 2010 (COP 16). The UNFCCC agenda continues to evolve since COP 16 (Cancun) and COP 17 (Durban) with many new agendas arising that either directly affects the ability of CCS to be deployed globally and/or national climate change policy settings capable of supporting the development of CCS.

The Institute has a number of work programs that aim to: leverage the LBD from the existing global fleet of planned and active CCS projects; enhance the capacity of policy and rule makers to implement policy architectures capable of efficiently supporting and effectively governing CCS activities; and a capacity development program aimed at facilitating the development of enabling environments in developing (non-Annex I) countries.

The Institute's focus on projects, policy and regulatory culminates in the release of its annual flagship report, *The Global Status of CCS*. The Institute regards the active interaction and dialogue between governments (for which it has 37 national and provincial Members), policy makers and regulators, and industry (for which it has over 310 Members) essential in distilling information to optimise the LBD effects, optimise planning and policy deliberations, and ultimately helping to bring down over time the cost of construction and operation of CCS plants and integrated systems.

The Institute's capacity development approach is tailored to the specific needs and situation of each country, and involves:

- conducting a needs-based scoping study, ideally with a key country stakeholder as the lead author;
- undertaking a capacity assessment, in consultations with key stakeholders;
- a tailored capacity development program of activities based on the scoping study and capacity assessment, as well as designed in consultation with key stakeholders;
- implementation activities, and evaluations and refinement of the capacity development program; and
- development of reports, case studies, webinars and the like that can be assessed by a broader audience.

In addition to the information provided in Attachment 1 (as the TEC requested), the Institute would be pleased to present to the TEC its current work plan in more detail and discuss ways in which the Institute may value-add to the TEC's decision making and functional operation.