DEVELOPING CCS PROJECTS UNDER THE CDM

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ACRONYMS AND ABBREVIATIONS

AAU	Assigned Amount Unit
Annex I Party	Countries listed in Annex I of the UNFCCC (mainly OECD countries)
CCS	Carbon Dioxide Capture and Storage
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CMP	Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol
CO_2	Carbon Dioxide
COP	Conference of the Parties
DNA	Designated National Authority
DOE	Designated Operational Entity
EB	Executive Board of the CDM
EOR	Enhanced Oil Recovery
ERPA	Emission Reduction Purchase Agreement
ERU	Emission Reduction Unit
ETS	Emissions Trading Scheme
EUA	European Union Allowance
EU ETS	European Union Emissions Trading Scheme
FEED	Front End Engineering Design
FID	Final Investment Decision
GHG	Greenhouse Gas
JI	Joint Implementation
lCER	Long Term Certified Emission Reduction
LoA	Letter of Approval
LULUCF	Land Use, Land Use Change and Forestry
MDB	Multilateral Development Bank
$MtCO_2$	Million Tonnes of Carbon Dioxide
NAMA	Nationally Appropriate Mitigation Action
Non-Annex I Party	Countries not listed in Annex I of the UNFCCC
OECD	Organization for Economic Cooperation and Development
pCER	Primary Certified Emission Reduction
PDD	Project Design Document
PIN	Project Idea Note
sCER	Secondary Certified Emission Reduction
tCER	Temporary Certified Emission Reduction
UNFCCC	United Nations Framework Convention on Climate Change

1. INTRODUCTION

As set out in Article 12, the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) established a clean development mechanism (CDM). The CDM is a means by which projects that reduce emissions of anthropogenic greenhouse gases, or enhance their uptake - undertaken in developing countries[1] - may generate tradable certified emission reductions (CERs)[2].

A portion of CERs may be used by developed country Parties for the purpose of compliance with emission reduction obligations under the Kyoto Protocol[3]. This reduces requirements for those Parties to reduce emissions domestically, thereby acting as 'offsets'. As such, the CDM provides a means to reduce the cost of climate change mitigation in developed countries whilst also providing a direct means for those countries to finance emission reduction technologies – such as renewable energy or energy efficiency projects – in developing countries. The growth of private sector interest in the CDM, coupled to the creation of incentives for private sector participation in developed countries (e.g. through national laws such as the EU emissions trading scheme) has seen the mechanism bring climate change mitigation to the fore in corporate investment decision-making in many parts of the world. As such, a key achievement of the CDM over the last 10 years has been its success in leveraging private capital into emission reduction investments.

With the exception of land use, land use change and forestry (LULUCF) (for which only afforestation and reforestation activities are presently eligible under the CDM), and also nuclear power, the CDM is largely non-prescriptive in terms of the types of technologies that are eligible as CDM project activities. That said, carbon dioxide capture and geological storage (CCS) has been subject to a considerable amount of discussion over the past five years regarding whether the technology should be eligible under the CDM, and if so, under what terms.

In the past year or so, attitudes towards the technology have changed, and it is now agreed that the technology is eligible under the CDM, subject to the establishment of specific rules governing its implementation under the mechanism. These rules are required to address various concerns about the technology raised by Parties over the past five years.

As we move towards the Durban Climate Change Conference[4] there is hope that these rules can be finalised, paving the way for enhanced financial and technical support for CCS in developing countries in coming years.

Purpose of this report

Taking into account this backdrop, this report sets out some of the key considerations for implementing CCS projects under the CDM and potentially other forms of climate finance in the future. It is structured as follows:

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[1] The Kyoto Protocol allows for country Parties not listed in Annex I of the UN Framework Convention that have ratified the Kyoto Protocol (so called "non-Annex I Parties") to host CDM project activities.

[2] In the case of afforestation and reforestation sink enhancement projects, only temporary CERs or long term CERs; tCERs and lCERs respectively, may be generated.

[3] Often termed 'quantified emission limitation and reductions obligations' or QELROs. The actual obligations are inscribed in Annex B of the Protocol, and mainly apply to those developed country Parties listed in Annex I to the UNFCCC (so called 'Annex I Parties').

[4] The seventeenth Conferences of the Parties to the UNFCCC/the seventh Meeting of the Parties to the Kyoto Protocol (COP17/CMP7) in Durban, South Africa, in December 2011.

- **Section 2** provides further background on the functioning of the CDM, its achievements and considerations for CCS under the mechanism.
- **Section 3** provides guidance on identifying CCS project types that could be developed under the CDM.
- **Section 4** reviews the CCS project lifecycle and considers how it fits with milestones for project development under the CDM, and sets out methodological guidance for developing CCS projects under the CDM within this framework (and potentially other future forms of climate finance).
- **Section 5** considers ways in which CCS project developers using the CDM can gain access to the carbon market.

The aim is to provide the reader with the necessary basic information to begin identifying and conceptualising CCS projects under the CDM, begin building the business case, evaluating methodological aspects, and identifying regulatory issues and risks for establishing such a project in a developing country.

2. BACKGROUND TO THE CDM AND CCS

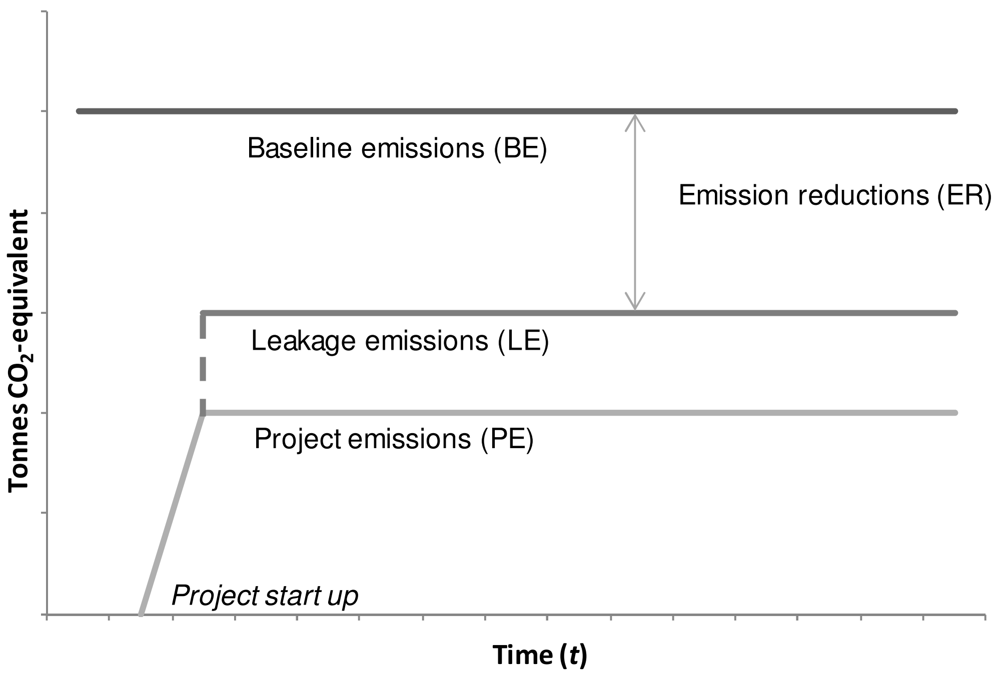
2.1 About the CDM

The CDM is a project-based emissions trading mechanism. To work effectively, it requires detailed rules upon which to base emission reduction calculations so that there is consistency and comparability in the results achieved for different project types. This is fundamental for the functioning of a fair and equitable trading system.

The level of reductions achieved by a specific project is based on several components covering firstly, what the counterfactual scenario would be in the absence of the project (the ‘baseline’) and the emissions associated with such a scenario (‘baseline emissions’). Second the boundary of the activity and the emissions occurring within that boundary (as monitored during implementation i.e. the ‘project emissions’), and third, whether the project leads to any changes in emissions outside of its boundaries (what is called ‘leakage’; Figure 2.1).

Figure 2.1

Calculating emission reductions under the CDM



$$ER_t = BE_t - (PE_t + LE_t)$$

Despite being established in 1997, the CDM was only operationalised once detailed rules – referred to as 'modalities and procedures' – on how it would function were agreed at COP 7 in Marrakesh in 2001[5]. The modalities and procedures for a CDM project include guidance on governance and procedural aspects such as:

- establishing the CDM Executive Board (the EB), and its terms of reference, membership rules and functioning;
- setting out the role for the Conference of the Meeting of the Parties to the Kyoto protocol (CMP) in supporting the EB;
- setting out how host countries would need to approve CDM project applications through the appointment of a designated national authority (DNA) for the CDM; and
- establishing the procedures for how accounting methodologies for projects are validated, verified, certified and how CERs are to be issued, including the role of third party verifiers – or designated operational entities (DOEs) – in supporting these functions (see Figure 2.2).

The modalities and procedures also set out principles underpinning the design of accounting methodologies, including:

- how to determine the baseline scenario and baseline emissions for a project;
- how to determine the project boundary and establish and implement a monitoring plan; and
- various guidance on necessary documentation such as establishing new methodologies (which must be approved by the EB) and project design documents (the documents in which applications for the CDM must be filed).

Since the establishment of the modalities and procedures in 2001 a wide range of additional guidance and modifications have evolved through further decisions of the CMP and the EB, and through the support of various working groups under the EB including the Methodologies Panel (Meth Panel).

[5] By way of Decision 17/CP.7, now established under decision 3/CMP.1. Modalities and procedures for afforestation and reforestation project activities under the CDM were only agreed at COP9 by way of decision 19/CP.9, and established in decision 5/CMP.1.

Figure 2.2

Project cycle and approvals for the CDM

Source: UNFCCC CDM website, 2011

The results of monitoring using prescribed and standardised accounting methodologies for different project types ('approved methodologies') forms the basis for calculating the emission reductions achieved by a CDM project activity (Figure 2.1). This sets the basis for the issuance of CERs to a project proponent. At the time of writing, there are 188 approved methodologies in existence covering a broad range of activities including large-scale CDM (99 including 19 consolidated methodologies), small-scale CDM (71), large-scale afforestation and reforestation CDM (11 including two consolidated methodologies), and small-scale afforestation and reforestation CDM (seven).[6]

2.1 Achievements of the CDM to date

Despite various concerns raised in some quarters about the integrity of the CDM, such as questions over the 'additionality' of certain projects (i.e. whether they really only occurred because of the CDM or whether they are simply business-as-usual),[7] and the potential for perverse outcomes (e.g. in relation to issues for industrial gas emission reduction projects), the CDM is viewed by many as a success for attracting finance into emission reduction projects in developing countries. By the end of the first Kyoto commitment period in 2012 (and the compliance window to 2015), the CDM is expected to have delivered

[6] From: http://cdm.unfccc.int/methodologies/index.html
[7] Decision 3/CMP.1 (CDM modalities and procedures) simply states that "A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity". In practice, however, this has proved a major challenge to implement, and the EB has developed tools to support implementation, including an application form for 'prior consideration of the CDM', and detailed financial appraisal methods to be used, as set out in the 'tool for demonstration of additionality'. In addition, some CDM methodologies include project-type specific additionality components.

investment into around 8,000 projects in developing countries, with emission reductions in the order of 590 $MtCO_2$-equivalent per year, and over US$3 billion of financial flows from developed to developing countries per year between 2008-2012 (Figure 2.3, based on estimates by Zakkour et al., 2011).[8]

As can be seen in Figure 2.3, the CDM has been extremely successful for certain parts of the chemical sector, with around 26 per cent of the total CER supply arising from only 3% of the total number of CDM projects. This is a result of industrial gas mitigation projects (HFC-23 and N_2O abatement) which create large numbers of CERs for destruction of several tonnes of the very high global warming potential (GWP) gases.[9] The same figure also shows that China and India have been the most successful countries in attracting CDM finance, with countries in Africa and the Middle East attracting only a small number of CDM projects.

The dominance of China and India in the CDM has led to concerns about CCS inclusion in the CDM and potential effects on perpetuating the unequal distribution of CDM finance across regions, an aspect which contravenes the CMP mandate for equitable distribution of projects. However, while both countries are heavily dependent on coal as a primary source of energy, many of the low cost CCS opportunities that might be supported by the CDM in the near-term occur in other regions, such as parts of South East Asia and the Middle East (see Chapter 3).

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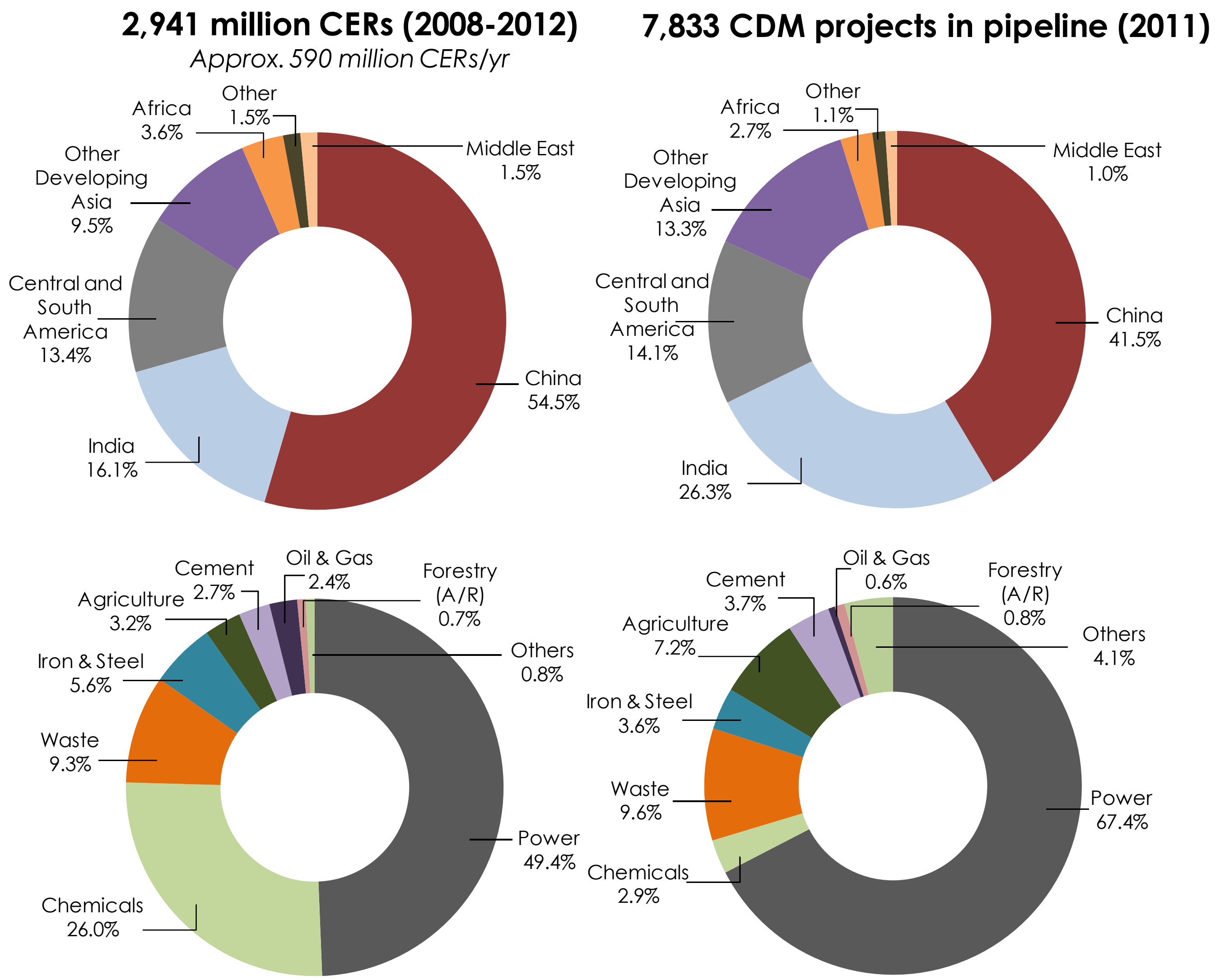
[8] Zakkour, P. D, Cook, G., Carter, A., Streck, C. and Chagas, T. (2011) *Assessment of climate finance sources to accelerate carbon capture and storage deployment in developing countries*. A report by Carbon Counts and Climate Focus for the World Bank. 16th June 2011. Washington D.C.

[9] HFC-23 has a GWP of 11,700. This means that for each tonne of HFC-23 destroyed, 11,700 CERs are generated.

Figure 2.3

Summary of CDM projects in the pipeline by region and sector (November 2011)



Source: UNEP Risoe CDM/JI Pipeline Analysis and Database, November 1st 2011 (updated from Zakkour et al, 2011 *op cit*).

Notwithstanding the success of CDM in mobilising investment into emission reduction projects, estimates of the level of effort needed, and associated scaling-up of financial flows for mitigation activities in developing countries in coming years – potentially exceeding US$100 billion per year by 2020[10] – has led to the idea that new and reformed mechanisms will be required in order to effectively mobilise such amounts. The precise nature of these is uncertain, although there has been agreement that a Green Climate Fund and Technology Mechanism will form two parts of the future framework, and Party's will be able to make unilateral pledges on emission reductions with a view to attracting international climate finance for low-carbon investments via nationally appropriate mitigation actions (NAMAs), the details of which are being worked through in the lead-up to COP 17/CMP 7 in Durban.

[10] According to the Copenhagen Accord pledge, as set out in the Cancun Agreements (decision 1/CP.16).

2.2 Consideration of CCS under the CDM

Whilst the CDM has been successful in mobilising finance for a wide range of emission reduction technologies and activities, when two proposals for new methodologies for CCS projects were submitted in 2005 from CDM project developers, a long and protracted negotiation on eligibility of the technology under the CDM began that continues to the present day.

Initial concerns raised by the CDM EB related to project boundaries, leakage and permanence.[11] Following a UN workshop in mid 2006,[12] at the Nairobi CMP the list of concerns had extended to include transboundary aspects, long-term responsibility for storage sites, site selection, operation of storage sites and remediation issues.[13] However, from 2007 to the end of 2009, little progress was made despite various requests for submissions from Parties, the issuing of two synthesis reports covering Party and observer views by the UNFCCC, and an experts report on the implications for including CCS in the CDM being provided to the CDM EB.

In 2009, some progress was made at the Copenhagen CMP with the list of issues requiring resolution being agreed amongst Parties as:[14]

- non-permanence, including long-term permanence;
- measuring, reporting and verification;
- environmental impacts;
- project activity boundaries;
- international law;
- liability;
- the potential for perverse outcomes;
- safety; and
- insurance coverage and compensation for damages caused due to seepage or leakage.

Approaches to resolving the matter was further augmented at the Cancun CMP in 2010, where it was agreed that, subject to the issues agreed in Copenhagen being addressed, CCS is eligible as a CDM project activity. However, it was also agreed in Cancun that these would need to be resolved via the establishment of new specific rules for CCS projects under the CDM – or new ‘modalities and procedures for CCS’.

The Cancun decision also included a long-list of aspects to be covered in the new modalities and procedures for CCS, including: site selection, monitoring, the use of modelling, project boundaries, trans-boundary issues, risk and safety assessments, environmental and socio-economic impact assessments, permanence and liability (short, medium and long-term), restoration/remediation of ecosystems in the event of seepage and means of redress for affected communities.

In the early part of 2011, Parties and observers submitted views to the UNFCCC secretariat on all these matters, and a synthesis of views was published.[15] Further, as requested by the CMP in Cancun, the UNFCCC hosted a technical workshop with legal and technical experts in Abu Dhabi in September 2011 on the modalities and procedures

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[11] Permanence has been defined as “a qualitative term to characterize whether the carbon dioxide removed stays out of the atmosphere for a long time” Presentation by: Sharma, S. (2006) 2nd IEAGHG workshop on CCS in the CDM. Vienna, 7th August 2006. UNFCCC Secretariat.

[12] UNFCCC, decision 4/CMP.1 (2005)

[13] UNFCCC. decision 1/CMP.2 (2006)

[14] UNFCCC, decision 2/CMP.5 (2009)

[15] UNFCCC, document FCCC/SBSTA/2011/INF.7

for CCS. Most recently, draft modalities and procedures for CCS under the CDM were published in November 2011[16]. These will be considered by the *Subsidiary Body for Scientific and Technological Advice* (SBSTA) in Durban, with a view to a final decision being agreed by the CMP.

Going into the Durban CMP, there is significant belief that an agreement will be reached on the modalities and procedures for CCS, opening up an important new source of finance for CCS projects in developing countries. Moreover, despite the potentially narrow window within which to develop CDM projects[17], the rules and procedures that may be agreed in Durban will provide an important guideline as to how CCS projects might proceed under other new forms of international climate finance that may come into existence after 2012, such as the *Green Climate Fund* and via NAMAs. Consequently, the importance of the modalities and procedures for CCS should not be understated even in light of the short term left for the current CDM.

[16] UNFCCC, document FCCC/SBSTA/2011/4

[17] The Kyoto Protocol first commitment period expires at the end of 2012 and there has been no agreement on a second commitment period.

3. IDENTIFYING CANDIDATE CCS PROJECTS

Existing studies indicate that much of the global potential for CCS is located in developing countries. The deployment pathway described in the International Energy Agency's (IEA) *Technology Roadmap for CCS* envisages that by 2020 around one half of all CCS projects will be built in non-OECD regions.[18] With rapidly increasing industrial output and demand for fossil fuels in emerging economies, this share is expected to increase over the subsequent decades. Several studies, including one recently commissioned by the World Bank,[19] indicate that a range of different climate finance mechanisms and channels will likely be needed to accelerate CCS deployment in developing countries.

Depending upon the outcomes of ongoing discussions within the UNFCCC framework, different types of finance may emerge over time. In the shorter term however, the CDM (and other project-based mechanisms which may emerge, including a reformed CDM) represents an invaluable source of project finance for CCS in these regions.

3.1 Assessing CCS potential

Due to economies of scale, CCS is generally applicable only to large point sources of CO_2 emissions. These include fossil-fuel power plants, industrial plants (e.g. iron and steel blast furnaces, cement kilns, chemicals processes) and fuel production and transformation installations. CCS can also be deployed in combination with other low-carbon technologies to achieve even greater emissions reductions. For example, over the longer-term, the use of bio-energy combined with carbon capture and storage (BECCS) offers the opportunity of removing CO_2 emissions from the atmosphere on a life-cycle basis.[20]

Commercial-scale CCS projects developed primarily through CDM finance alone are likely to focus first on the lowest cost 'early opportunity' projects that are most likely to prove financially viable, technically feasible, and therefore attract investment capital. The cost of deploying CCS includes ongoing annual operating costs, in addition to servicing debt and equity used to provide finance for the up-front capital required to build the capture plant and associated CO_2 transport and storage infrastructure. The ongoing costs are an important consideration for project developers and investors, and include, for example:

- additional costs for plant maintenance and materials (e.g. amine solvents used to remove CO_2);
- extra fuel and electricity use arising from the 'energy penalty' associated with CO_2 capture; and
- the cost of transport and storage (which may be paid as a 'cost of service' tariff to a CO_2 pipeline operator).

The resulting cost of abatement for CCS (US$ per tCO_2 avoided) varies across different regions and sectors, reflecting variations in energy requirements and unit costs, capital costs, operating costs and project scale factors. Costs are forecast to fall over time as CCS projects are demonstrated across a range of technologies and project settings and

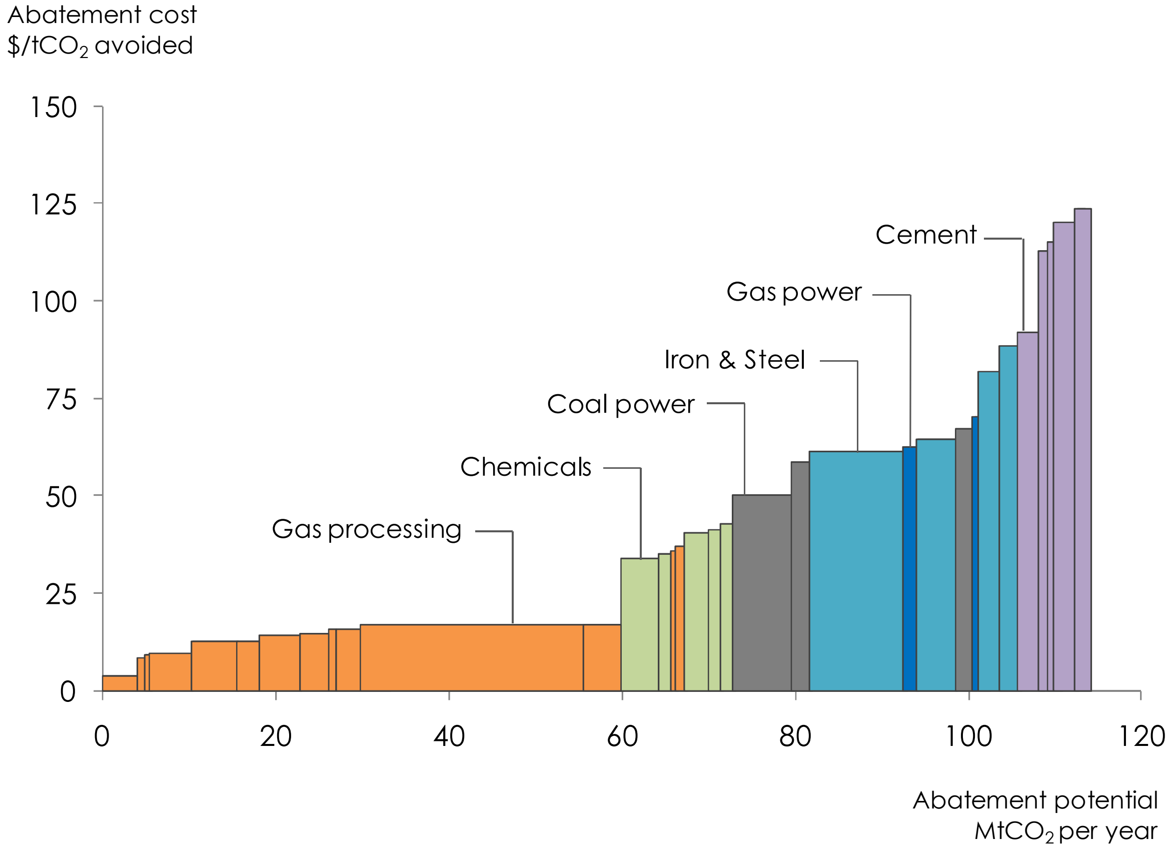
[18] The *IEA Technology Roadmap for CCS* envisages CCS deployment in developing countries achieving emissions reductions of 114 $MtCO_2$ in 2020 from 50 projects, rising rapidly to 850 $MtCO_2$ from 450 projects by 2030. The total investment needed for the infrastructure and capture plant in these regions is estimated at around US$23-25 billion for the next decade, rising to as high as US$300 billion through to 2030.
[19] Zakkour et al, 2011, *op. cit.*
[20] Because biomass (energy crops, agricultural waste etc) absorbs CO_2 from the atmosphere during its growth period, the subsequent capture and geological storage of the CO_2 resulting from its combustion may give rise to net 'negative emissions'.

technology costs are reduced. The cost of CO_2 transport is also expected to fall over time with increasing optimisation of regional pipeline infrastructure.

The estimated marginal abatement cost of deploying CCS in developing countries in the year 2020 by sector and region is shown below (Figure 3.1 and Figure 3.2).[21]

Figure 3.1

Marginal abatement cost curve for CCS in 2020 by sector



Source: Zakkour *et al.* (2011 *op cit*). Data based on IEA *Technology Roadmap for CCS*. © OECD/International Energy Agency, 2009
Note: includes the cost of capture, transport and storage.

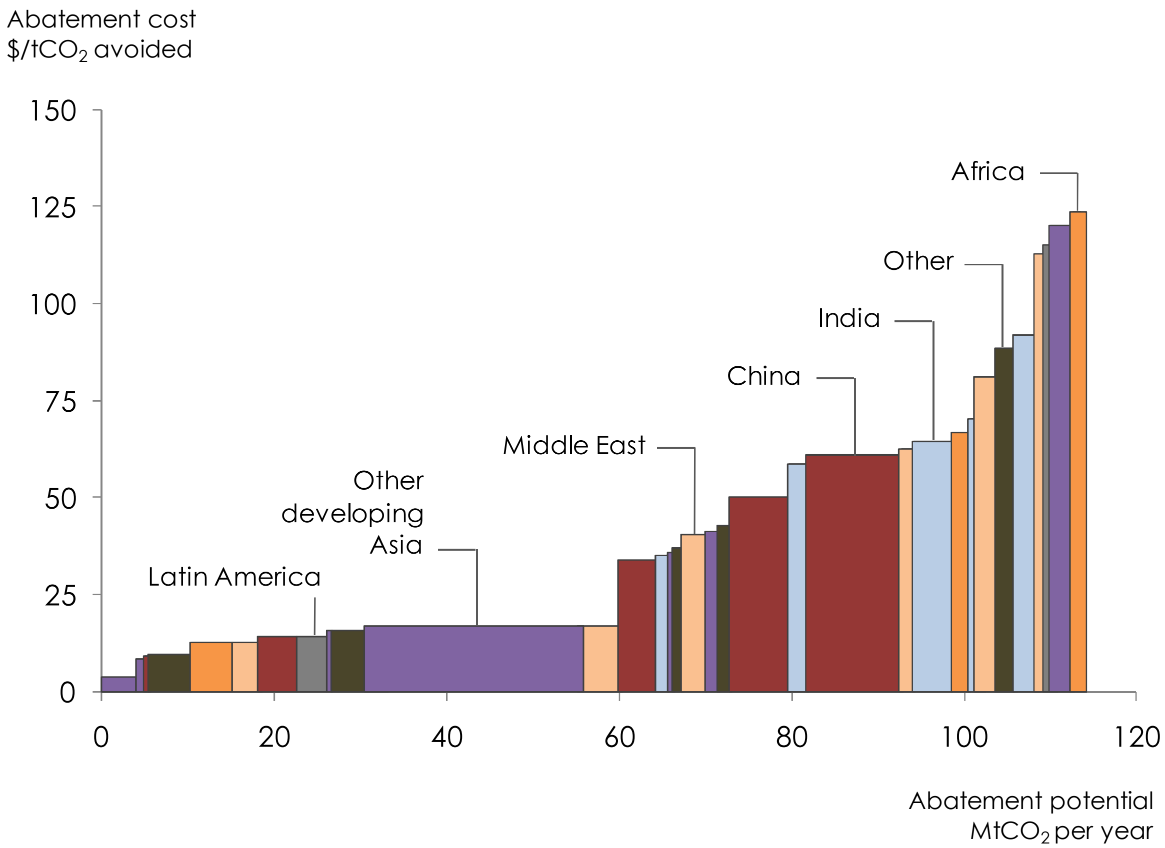
The marginal abatement cost curves show that over the next decade CCS abatement potential and costs vary widely across different sectors and regions. Most noticeably, capture projects within the gas processing and chemicals sector are predominant in the lower cost portion of the curve; power, cement and iron and steel projects generally represent higher cost opportunities on the upper end of the curve. CCS deployment in certain chemical production processes and natural gas processing represent early low-cost capture opportunities – capture costs are comparatively low because costly CO_2 removal processes are not required from these 'high-CO_2 purity' sources. Transport costs are also typically lower for upstream projects where integrated capture and injection may often be possible; for example, associated with 'in situ' capture and storage from the

[21] The marginal abatement cost curves demonstrate the total estimated abatement potential in 2020 (114 $MtCO_2$ avoided emissions) disaggregated into different cost-ordered tranches. The different cost tranches presented within each colour-coded sector reflect regional cost differences and/or the varying economics of different project and technology options within sectors and sub-sectors

processing of gas from high-CO_2 natural gas fields where the capture step is integrated within the underlying process (see Box 3.1).

Figure 3.2

Marginal abatement cost curve for CCS in 2020 by region



Source: Zakkour *et al.* (2011 *op cit*). Data based on IEA *Technology Roadmap for CCS*. © OECD/International Energy Agency, 2009
Note: includes the cost of capture, transport and storage.

Higher additional costs of capture technology (and associated energy penalties) typically occur in projects such as those capturing emissions from iron and steel and cement plants. Capture costs from power plants can vary significantly depending upon the chosen capture technology (pre-combustion, post-combustion, oxy-firing) and the relative price of coal or natural gas. In order to incentivise these higher cost projects, it is likely that the revenues provided by the CDM will need to be supplemented by additional non-market based support involving both public and private sector finance. The support provided by CER revenues alone for these types of projects is unlikely to be sufficient to attract project finance, at least under the current framework.

Because CO_2 can be captured from a wide range of sources and processes, the technology is applicable in most parts of the world, subject to the availability of suitable geological formations. As shown in the second cost curve, low-cost 'early opportunities' are expected to exist in most regions of the developing world eligible for CDM finance. As well as being host to multiple high-CO_2 purity capture sources (e.g. ammonia, hydrogen plants); many of the world's known high-CO_2 gas fields are located in the developing world (see Box 3.1).

A key element in the initial stages of CCS project assessment is the identification of a suitable storage site. There is significant uncertainty regarding estimates of viable storage capacity worldwide, particularly for deep saline formations which typically represent the best candidates for long-term geological storage.

The site selection process involves a thorough geological appraisal to assess the suitability of a particular geological formation for the storage of CO_2 (discussed further in Chapter 4). Storage also represents an important project cost factor that can impact the viability of a CCS CDM project. Costs include, for example, site appraisal, well drilling and completion, building the required facilities (e.g. compressors, platforms etc), site closure, and well plugging. The proximity of the storage site to the capture source is also a key economic and technical factor; early opportunity CCS projects are typically considered to involve transportation distances of less than 50km (IPCC, 2005)[22] although many factors may influence this including the potential to develop a cost-effective common carriage networks involving CO_2 capture from multiple point sources.

Box 3.1

Early opportunity CCS projects from natural gas processing

Capturing and storing CO_2 from high-CO_2 content natural gas fields present some of the least cost earliest opportunities for large-scale deployment of integrated CCS projects worldwide. Gas processing facilities typically have access to *in situ* or close proximity storage sites of known geological characteristics and there is a considerable skills and knowledge base within the oil and gas industry required to undertake large commercial-scale projects.

There are currently four fully integrated, commercial-scale CCS projects in operation worldwide involving the separation of CO_2 from natural gas. The Sleipner and Snøhvit (Norway) and In Salah (Algeria) projects involve the stripping of CO_2 from high-CO_2 content natural gas to achieve sales-grade quality natural gas. The CO_2 is stripped, collected and stored securely in underground geological formations. The Rangely project (United States) also uses CO_2 captured from natural gas processing at the ExxonMobil LaBarge gas plant in Wyoming, but uses the CO_2 for enhanced oil recovery (EOR) and storage at the Rangely field in Colorado. ChevronTexaco is currently in the final planning phases for one of the largest CCS projects in the world involving the capture of CO_2 from the Gorgon natural gas field located 130km off the north-west coast of Western Australia. The project comprises the establishment of a gas processing and LNG facility on Barrow Island, which lies directly between the gas fields and the Australian mainland. The Gorgon natural gas reservoirs contain naturally occurring CO_2 at levels of around 14 per cent, which requires removal before the gas can be liquefied. Current standard practice by nearly all operating LNG facilities worldwide is to vent this CO_2 to the atmosphere

Many of the world's known high-CO_2 content natural gas reservoirs are located in the developing world. These include the giant Natuna D-Alpha gas field located in offshore Indonesia and other fields in development across the South China Sea (e.g. in Malaysia, Thailand, Indonesia and China), in Central Asian FSU countries, in Pakistan, and parts of the Middle-East, North Africa and some fields in South America (e.g. recent gas discoveries in Brazil have been characterised by CO_2 contamination).

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[22] Metz, B, Davidson, O., de Coninck, H. C., Loos, M., and Meyer, L. A. (eds.). (2005) IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change Cambridge and New York: Cambridge University Press.

Sources: *CCS Roadmap for Industry: high purity CO_2 sources* (UNIDO, 2010); *Assessment of climate finance sources to accelerate carbon capture and storage deployment in developing countries* (Zakkour et al, 2011).

To date, there has been very little site-specific storage exploration undertaken. Much of the data required to determine the viability of storage sites is held by national and private energy companies and is not made publicly available. There are, however, several ongoing initiatives aimed at increasing the knowledge of regional storage capacity, which may provide a first-order assessment of a region's storage potential and the ability to match 'sources' with 'sinks' (see links at the end of this report for more information).

Some potential storage sites are located in hydrocarbon reservoirs where enhanced oil recovery (EOR) may be economically viable. EOR could play a valuable role in providing supplemental revenue for some CCS projects in developing countries, by providing additional sources of revenue (sales of recovered crude oil) for more costly and complex sectors. EOR has the capacity to radically alter project economics, and therefore alter and reshape the viability of certain higher-risk early projects that are likely to require a combination of climate finance such as the CDM and other supplemental revenue streams. At the current time, the extent to which EOR might be supported by climate finance is uncertain, and greater clarity may be forthcoming after the Durban CMP.

3.2 Which CCS projects are best suited to the CDM?

Existing studies suggest a range of CCS opportunities exist across many developing countries which can potentially be incentivised through CDM finance. However, certain sectors and project types are likely to be more readily suitable for early stage development. The lower costs typically associated with capture from the processing of high-CO_2 content natural gas, the production of ammonia and hydrogen (and certain other chemicals) and some power generation projects are those sectors that offer the most likely early opportunity candidates for attracting private sector involvement.

Overall project costs are clearly an overriding consideration in assessing which projects could be developed under the CDM, depending upon market prices for the credits generated (see Chapter 5). There are also characteristics of the CDM, and the applicability of CCS across different sectors, which are likely to determine the relative suitability of the CDM as a source of project finance for CCS. These include, for example, the fact that the CDM does not provide up-front project finance (CER revenues are earned annually subject to the verification of project emissions reductions); the need to demonstrate additionality against an established emissions baseline is a pre-requisite; and there are uncertainties over the suitability of new build or retrofit CCS projects.[23]

On this basis, it is likely that project-based finance mechanisms such as the CDM may be more readily suitable to supporting CCS in certain sectors, when compared to sector-based mechanisms (which may emerge within the international climate policy framework). Some of these considerations are discussed further in Section 4 (and summarised in Table 4.2). Project-based approaches such as the CDM – or a reformed version – may be most readily applicable to low-cost single-operator CCS projects such as those associated with isolated natural gas field developments. In this sector, the technology is more mature and

[23] Capture equipment can be retrofitted to existing facilities or designed and built as part of a new facility. Retrofits can include both 'end-of-pip'" and integrated projects, the latter essentially representing a new build project (i.e. replanting or repowering).

operators often have considerable in-house expertise suitable for project development – in particular in relation to subsurface aspects. In some cases, they may also have direct drivers for accessing the CDM market (e.g. compliance with existing emissions trading schemes such as the European Union ETS; see Zakkour *et al*, 2011, *op cit* for more details).

On the other hand, projects undertaken in the power and industrial sectors may also be suitable, depending on the specific details of the project and the development of new CDM methodologies. Baseline approaches will likely be a key factor in determining which sectors and types of project may be more or less suitable for creating CCS-derived CER revenues. This factor is discussed further in the next section, as one of several to be considered when developing a CCS project under the CDM.

4. DEVELOPING A CCS PROJECT UNDER THE CDM

Broad country and sector-wide analysis of candidate CCS projects under the CDM have been highlighted in the previous chapter. Taking initial concepts through to development of a full-scale CCS project is a complex, costly and resource-intensive undertaking. In the following sections, approaches to detailed project evaluation and development across the life-cycle of a CCS project are considered. Further, the life-cycle for a CCS project is considered in the context of its alignment with financial, regulatory and technical and methodological aspects that will be involved in developing a CCS project using climate finance such as the CDM.

4.1 What are the key project elements?

The development of a CCS project under the CDM could involve various elements in the decision-making process across the project life-cycle including:

1. **technical design** – involving matters such as site characterisation, risk assessment, and planning of the storage site development;
2. **investment appraisal** – involving key investment decisions for project finance;
3. **regulatory permitting** – covering dialogue with national regulators, and the permitting of a storage site; and
4. **climate finance** – funding approvals for a project to gain access to climate finance such as the CDM as a means of investment support.

The CCS project lifecycle includes: identification (concept studies), evaluation (pre-feasibility studies), definition (feasibility studies and final investment decision), execution (construction), operation (commissioning) and closure (decommissioning).

Establishing an early-stage project concept involves effort in terms of e.g. matching sources of CO_2 for capture to potential storage sites, planning transport options and rights of way (for pipelines), and making initial evaluations of the business case for action. If a viable project is identified and further conceptualised into a more detailed proposal, the project moves into the Evaluate phase involving initial technical pre-feasibility assessments of the various options. In parallel, a more robust evaluation of the business case is made based on a detailed cost-benefit analysis of the various project concepts. At this point, a decision is made whether to take a particular concept forward or not. If the case is good, the project moves into the Define phase involving more detailed and rigorous technical design considerations, often referred to as front end engineering design (FEED). As well as providing enhanced information on the technical viability of the project concept, the FEED allows more accurate cost estimates to be made based on a more detailed understanding of the engineering work involved. The enhanced engineering feasibility studies and the improved cost estimates form the basis of the final investment decision (FID) that must be made by the project proponent on whether to proceed with the project or otherwise; this is the most critical stage for the project. If a positive FID is achieved, the project moves into the Execute phase, involving construction and permitting of the project.

In a developing country context, a critical consideration across these phases is how to align the different technical and investment milestones with the different elements involved with CDM validation and registration and national regulatory approvals; careful alignment of these factors will be essential to avoid projects failing at the FID stage because of uncertainties regarding financial and/or regulatory aspects which support the business case. Therefore, any variations in the timing of different requirements may hinder project developers in reaching the Execute phase in an efficient and/or effective manner. In part the challenges will be enhanced by the novel nature of CCS projects, where there is limited experience with practical implementation. This uncertainty means that it becomes essential to ensure that the project milestones and CDM aspects can all be aligned in order to reduce complexity and foster confidence in project proponents about developing a specific project.

These different aspects are summarised graphically in Figure 4.1.

4.2 Financial issues

Reaching final investment decision

Project developers will only begin identifying investments into CCS projects where there is a high degree of confidence in obtaining sustainable sources of revenue for the project. In developing countries, climate finance, such as the CDM, will be a principal factor to support investments into CCS. However, the uncertainties present over the last few years regarding eligibility of the technology has largely deterred investor’s from going beyond initial high-level identification and conceptualisation exercises.

With agreement on modalities and procedures for CCS, interest could be renewed. Notwithstanding such a potentially positive development, it will also be essential that developers have early-phase assurances that climate finance will be obtained on commissioning and operation of their project. Only then will project developers be able to build a robust business case for action and reach a positive decision at the FID stage of a project.

Securing climate finance

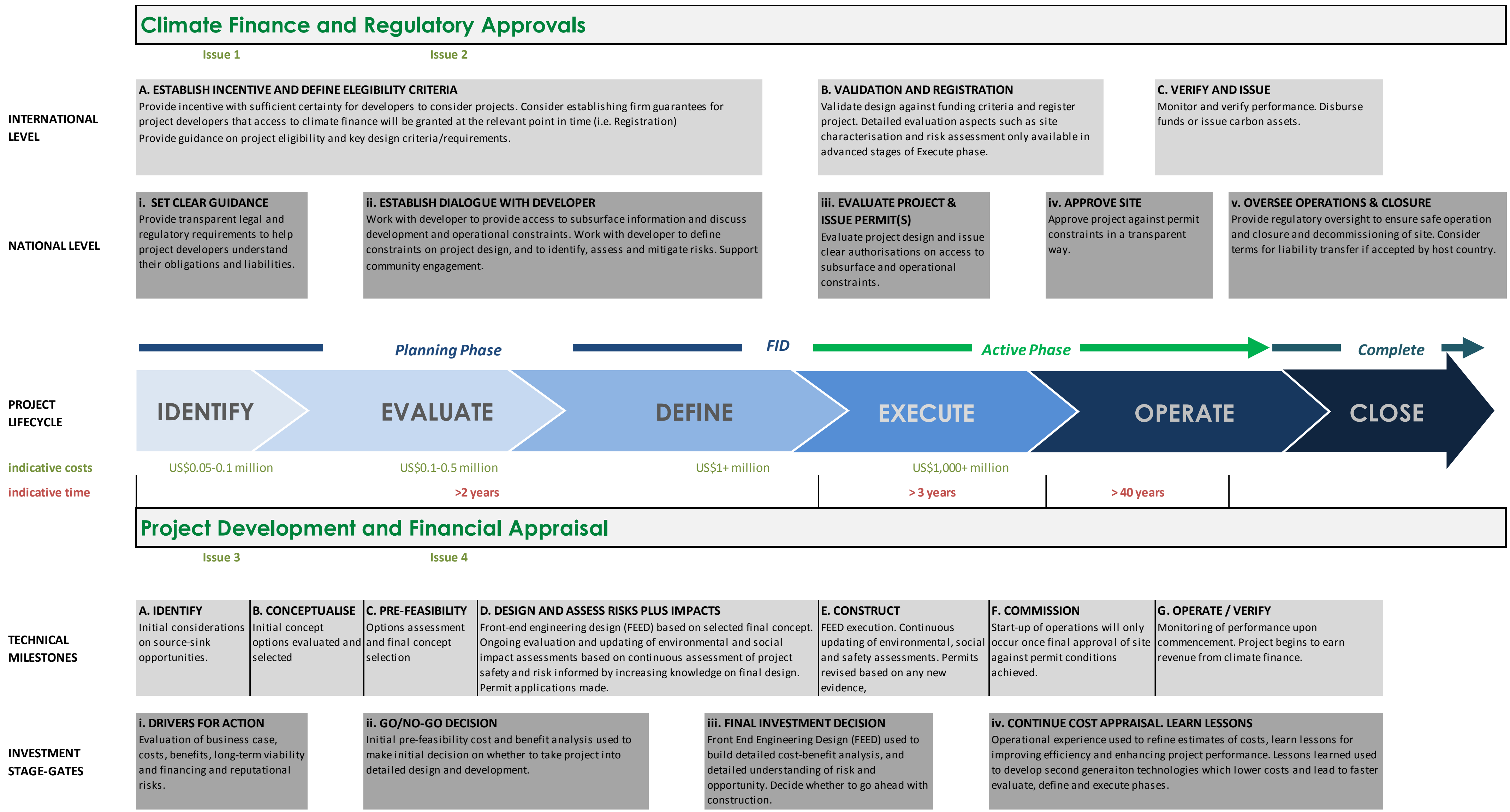
Because of the stringent technical and methodological requirements being suggested in the draft modalities and procedures for CCS,[24] meeting project validation and registration requirements for a project under the CDM will involve detailed and costly work through the *evaluate phase* of a project. As described previously, projects will only pass the FID and begin this work if there is a degree of certainty with the proponent that their CCS project abatement claims can be justly considered eligible under the CDM at the time of application for registration. Given that a significant level of investment could have already occurred, there is a risk that claims over *additionality* may be questioned by the EB during registration, especially if co-benefits are included (such as EOR). This is a potential gap that needs to be addressed (see also Section 4.4. below).

A revised form of the current *Prior Consideration of CDM application* could be used as a means to provide assurances to developers over such matters. This could prove essential to build investor confidence at the early stages of project conceptualisation. Furthermore, where projects are to be developed using a portion of debt finance, this type of assurance will be essential in acting as collateral for potential lenders and CER off-takers (see Chapter 5 below).

[24] UNFCCC, document FCCC/SBSTA/2011/4

Figure 4.1

Key milestones for CCS project development under the CDM



4.3 Regulatory issues

CCS project development poses several regulatory considerations, covering matters such as site selection, risk assessments, impact assessments, oversight of operations, and long-term stewardship for the geological storage site. Within this framework, there is a need to balance those aspects that can be addressed at an international level (e.g. through modalities and procedures for CCS and via approved methodologies developed there under), and local level regulations (e.g. through oversight of development and operation of a project by national regulators). The nature of concerns raised by Parties during considerations for CCS under the CDM over the past five years has led to requests for detailed guidance on a range of issues to be included within modalities and procedures for CCS.[25] These include:

1. site characterisation and selection;
2. socio-environmental assessment;
3. risk assessment;
4. monitoring plan design; and
5. approaches to long-term liability.

In part, the modalities and procedures for CCS as drafted address these issues through fairly detailed guidance on aspects that must be taken into consideration. Further, following agreement of the modalities and procedures for CCS, detailed approaches that take account of the rules will need to be developed in approved methodologies for CCS under the CDM. The procedural parts of the CDM can also provide quasi-regulatory oversight via the validation, registration, verification and certification steps (and also the review process). However, these aspects can only apply when a CCS project is in advanced stages of the Execute phase, when sufficient information will be available to demonstrate compliance with such requirements (see Figure 4.1). As a consequence, explicit legal and regulatory requirements and transparent permitting of projects by national regulators will also be needed to support projects during early stage planning. This will allow project proponents to demonstrate that the project is compliant with national laws at the time of the submission of CDM documentation (e.g. via the Letter of Approval from the host country Party designated national authority; DNA).

Project permitting at a national level

The need for clear guidance on regulatory requirements in early stages of project development will necessitate the development of national regulations in host countries in order to provide assurances for project proponents regarding their regulatory obligations. Moreover, since the host country Party will likely be expected to share part of the risk associated with the CCS project, particularly for stewardship of the storage site over the long-term, national regulators will likely wish to be involved in setting technical and operational constraints on projects. Furthermore, national laws will also be necessary in order to establish rights of access to the pore space in the subsurface in which CO_2 will be stored, which in most countries is under state ownership.

Any requirements set at the national level should be developed consistent with the requirements set out in the modalities and procedures for CCS (and potentially other future forms of climate finance). This will ensure that the results of work undertaken for national requirements can also be used for the purposes of CDM applications at the point of validation and registration, thus avoiding any duplication in effort.

[25] Based on UNFCCC, decision 7/CMP.6 (2010). It is important to note that the requirements imposed under the CDM would not apply to projects in developing countries established outside of the CDM framework.

Recognising this need, such requirements have been included as Participation Requirements within the draft modalities and procedures for CCS. These set out obligations for Parties wishing to host CCS projects under the CDM to establish national laws or regulations which:

- set licensing procedures that include provisions for the appropriate selection, characterisation and development of geological storage sites in accordance with specific requirements set out in the technical guidance in the modalities and procedures;
- define means by which rights to store carbon dioxide in, and gain access to, subsurface pore space can be conferred to project proponents;
- provide for timely and effective redress for affected entities, individuals and communities for any significant damages, such as environmental damage, including damage to ecosystems, other material damages or personal injury caused by the project activity, including in the post-closure phase;
- provide for timely and effective remedial measures to stop or control any unintended physical leakage or seepage of carbon dioxide, to restore the integrity of a defective geological storage site, and to restore long-term environmental quality significantly affected by a CCS project activity; and
- establish means for addressing liability arrangements for carbon dioxide geological storage sites.

In practice, achieving these obligations will likely involve modification of existing laws, such as those applicable to mining, oil and gas extraction, environmental permitting laws, as well as the creation of new laws to accommodate any additional requirements falling outside the scope of these regulations. In some cases, however, particularly for projects undertaken in the oil and gas sector (either involving EOR or CO_2 captured from natural gas processing; see Chapter 3) it may be possible to accommodate the requirements within existing laws for oil and gas extraction. For example, the In Salah Gas CCS project in Algeria is accommodated within the existing terms of the hydrocarbon lease for the Krechba field.

Host country Parties will need to identify relevant national authorities with sufficient competence to work with project developers to meet permitting requirements. This is likely to draw on agencies responsible for regulating hydrocarbon development, perhaps with support from national oil companies. In all cases, a close cooperation will be essential in order that all parties involved can build trust and learn lessons during project development. In many developing countries, it is likely that capacity building efforts will be needed to support the development of national laws and regulations to accommodate CCS. Further, it will be essential that host country Party DNAs have a good understanding of the requirements for CCS projects; in this context, it is advisable that the modalities and procedures for CCS be discussed in the DNA Forum soon after they are agreed by Parties at the CMP.

Long-term liability

One of the most challenging aspects of CCS projects is the residual liabilities associated with the indefinite storage of CO_2 in the subsurface. In the case of the CDM, this presents issues relating to the permanence of the emission reductions achieved by the activity, and the role of the developing country government in potentially taking on such liability. It also presents the host country Party with potential obligations relating to any local impacts and damages that could occur as a result of seepage of CO_2 from the storage site.

As developing countries have successfully argued that the overriding objectives of economic development and poverty alleviation constrain their obligations to limit emissions, a transfer of liability for the stored CO_2 to a host country Party would, for the first time, place them under direct obligations to restrict and potentially compensate for greenhouse gas emissions occurring within their territory, albeit from only one source and only if seepage from a storage site were to occur in the future. This approach is widely referred to as a 'host liability' approach. The responsibility to compensate in the event of seepage, and the fact that the CDM acts as an offset mechanism with benefits also accruing to Annex I Parties (see Chapter 1), has meant that the concept of host country liability has been unpopular in some quarters. An alternative approach would involve attaching medium and long-term liability to the CERs generated by the CCS project activity, therefore transferring this obligation compensate in the event of seepage to the buyer ('buyer liability'). This would involve either making CERs temporary – meaning that they would expire over time and require replacement – or flagging CERs generated by CCS projects so that in the event of future seepage, the CERs could be cancelled in the holding Party's registry account, placing them under obligation to replace the cancelled units with alternative units.[26] Such an approach, however, is also mired in challenges because in the event of seepage it would likely prove extremely difficult to trace CERs created by a leaking project where they have been used for compliance many years previously.

These complications have meant that long and protracted discussions have taken place regarding the most appropriate approach to managing permanence in the CDM over the medium and long-term.[27] The issue is critical: the creation of fungible carbon assets that link to structured approaches to the stewardship of stored CO_2 over the long-term will be essential to build investor confidence sufficiently to bring projects through FID. The experiences with tCERs and lCERs for afforestation and reforestation CDM project activities has demonstrated that buyer liability approaches are not attractive to CER offtakers; the need to replace the credits sometime in the future essentially means that they have to pay twice for the same achievement. As a result, tCERs and lCERs have attracted much lower prices than for other types of CERs, and are prohibited for compliance in some Annex I Party jurisdictions (e.g. the European Union), significantly eroding demand hence the price effects (see Chapter 5).

Mindful of the experiences for afforestation and reforestation projects under the CDM, there has been a willingness by many Parties supportive of CCS to avoid a buyer liability approach for the technology. On the other hand, many developing country Parties have argued that all liabilities associated with CCS must be vested in Annex I Parties, essentially suggesting an objection to any approach other than a buyer liability type model.

As a consequence and reflecting a spirit of compromise, the draft modalities and procedures for CCS have outlined a flexible approach. They propose to separate liability for any local impacts arising from seepage – which, as drafted, revert from project proponent to the host country Party after a given period of time in all cases – from that of the 'climate' liabilities associated with the permanence of CCS.[28] For the latter, the

[26] Since the holding Party would have used the flagged CERs for compliance with a QELRO, cancelling the units would result in them breaching this obligation, hence the need to replace the units.

[27] In the short-term, during the operational phase, any release of CO_2 to the atmosphere can be attributed to the project activity as project emissions, and therefore netted out from the amount of CERs to be issued (see Figure 2.1)

[28] Referred to as a 'net reversal of storage' in the draft modalities and procedures for CCS, which occurs where there is a negative balance of emission reductions calculated in a given period (i.e. project emissions exceed baseline emissions, and includes where seepage occurs after cessation of CO_2 injection).

proposal is that, initially, all liabilities are allocated to the project proponent during the operational phase and for a period following closure, and thereafter two routes are available to host country Parties to address and allocate long-term liability:

- **Option 1** - for host country Parties prepared to take on long-term liability, which they must indicate at the time of project validation and registration via their *Letter of Approval*, a structured approach may be taken to transferring long-term liability in agreement with the project proponent. This must be carried out in accordance with the *Participation Requirements* outlined above. In the event that seepage occurs after a transfer of liability, responsibility for replacing cancelled CERs due to net reversal of storage shall reside with the host country Party, which will involve them acquiring and surrendering carbon 'credits' equal to the amount of seepage determined to have occurred.
- **Option 2** – for those host country Parties unwilling to take in this obligation, the liability will continue to reside with the project proponent indefinitely. In the event that seepage occurs over the short-, medium- and longer-term, the project proponent will be responsible for replacing cancelled CERs equal to the level of the net reversal of storage. Where they do not fulfil this obligation, the Annex I Party(ies) holding CERs generated by the project must act as the backstop, and are obliged to replace the cancelled CERs.

The approach provides flexibility amongst developing country Parties by allowing them to take into account their national priorities and circumstances when considering the type of support they wish to provide to CCS deployment within their jurisdiction. In practice, host country Parties unwilling to take on long-term liabilities are unlikely to attract investment into CCS projects compared to countries that are willing to accept such obligations. Further, the proposal also allows host country Parties to tailor approaches to specific projects according to assessed and/or perceived risk of a particular project proposal; where it considers the project (or project proponent) too risky it can elect to not accept liability, whilst for others where greater assurances are in place, it can elect to accept liability. Theoretically, this flexibility should link to risk assessments carried out for a particular project, as described further below.

Given historically entrenched positions amongst Parties both for and against 'buyer' or 'host' liability, the approach proposed in the draft modalities and procedures for CCS is considered to be an effective way of addressing these differing concerns. Whether the proposed approach can be agreed in Durban is a matter for debate, and only time will tell whether such an 'options based' method will be deemed acceptable by all Parties. If it is not, then it seems unlikely that a firm agreement on modalities and procedures will be reached at the Durban CMP.

Financial provision

The proposed approach to liability in the draft modalities and procedures for CCS means that host country Parties must take on long-term obligations for any local impacts arising from seepage. The approach has been taken as it is difficult to envisage alternative means by which liability for such impacts could be allocated to other entities; it is seemingly infeasible to consider that an Annex I Party could be held responsible for the restoration of the environment and compensation to local communities in a developing country for a specific CCS project; this obligation would likely impose on a country's sovereign rights, hence the proposed approach in the draft modalities and procedures for CCS.

However, recognising the potential burden faced by developing country Parties in taking on such obligations – and also recognising the potential need to continue intermittent storage site monitoring over the longer-term – the draft modalities and procedures for CCS include the requirement for a project proponent to establish and maintain a financial provision. The provision, which must be transferable to the host country Party at the point of liability transfer, offers a means by which, firstly, moral hazard[29] is diminished for the project proponent. Second, the provision means that funds are made available to the host country to undertake monitoring, remediation and compensation due to seepage over the long-term. In addition, obligations to compensate for any net reversal of storage occurring in the future also fall within the scope of the financial provision, although further clarification of how this will link to the proposed 'credit reserve'[30] also need to be further worked through in the negotiations to avoid double regulation.

Presently there is limited experience with establishing such financial provisions for CCS in any part of the world. The EU CCS Directive imposes similar obligations for operators, although it has yet to be fully demonstrated by CCS project developers in Europe. As such, there is considerable uncertainty on how it will evolve in practice; it could simply consist of the paying of royalties or tax to the host country government for example utilisation of the subsurface, or more dedicated approaches involving escrow accounts, insurance or a combination of various approaches. Further, the exact scope of coverage (i.e. a clear definition of the full range of potential impacts that the provision(s) should be taken out to cover) and triggers for releasing the provision (i.e. the types of events that could allow for the drawing on a particular provision or a portion thereof) remain to be fully worked through. As experience evolves with establishing such products, greater clarity can be expected.

During 2011, a developing country Party proposed the option of a 'compensation fund' for CCS under the CDM. Such a fund, which could be raised via contributions from all CCS projects developed under the CDM, could act as a risk sharing facility/insurance pool across all projects, operating in a similar way to that of the International Oil Pollution Compensation Funds (IOPC Funds). In the event of seepage, the fund could be called on to provide finance resources to support remediation and compensation as required. To date, the concept has been dropped from the consideration of draft modalities and procedures for CCS due to the lack of clarity about its precise scope and operation. However, it is conceivable that interest in such an approach could be rekindled at a later date, as further consideration by the CMP takes place after agreement of the modalities and procedures for CCS.

4.4 Technical and methodological issues

Whilst the modalities and procedures for CCS set the broader framework within which CCS projects will need to be developed to be eligible under the CDM, the rules set out therein will need to be applied in an approved methodology document (or multiple methodologies) specific to CCS.

To date, three CDM methodologies for CCS have been proposed following the 'standard' modalities and procedures for the CDM. In reviewing two of the proposed new

[29] Moral hazard occurs where a party is only partially exposed to the full risk of its actions, leading it to behave differently than it if were fully exposed. For CCS, this could mean lack of due diligence in site selection and operation as the entity would be insulated from the long-term implications of such actions. A requirement to hold a financial provision can help to close this gap.

[30] The draft modalities and procedures for CCS, in paragraph 21(b) of the annex, refer to the forwarding of [5] per cent of issued CERs to a reserve account in the registry system, which can be called upon for the purposes of compensation in the event of a "net reversal of storage". The CERs in the reserve account are released to the project proponent upon the termination of monitoring, conditions for which are also set out in the draft modalities and procedures.

methodologies – NM0167 and NM0168 – in 2005/06, the EB concluded at its 26th meeting that: “the submitted methodologies do not address the methodological and accounting issues in an appropriate and adequate fashion” and questioned “whether some issues can be resolved without further guidance from COP/MOP and/or a technical body on CCS”. This conclusion provided the trigger for the UNFCCC negotiations on the subject to date as described previously (Section 2.2). More recently (and responding to the mandate set at CMP6 in Nairobi[31]), a CDM methodology was prepared by the In Salah Gas partners for the In Salah CCS project in Algeria and submitted for review in September 2009. At that time and irrespective of the mandate, the EB responded by suggesting that they were unable to accept the documentation as further guidance had not been provided by the CMP.

Therefore, at the current time, and as a consequence of the most recent requirement for new specific modalities and procedures for CCS, no approved methodologies applicable to the technology exist. Therefore, in order to actually get a CCS project to the registration stage of the CDM cycle, it will first require a new methodology for CCS to be proposed by a project proponent. A new methodology will need to be developed in accordance with the finalised version of the modalities and procedures for CCS, and following the standardised approaches for developing new methodologies as required by the CDM EB. This means that it must be:

- compiled in accordance with the guidance and templates issued by the EB (Table 4.1);[32]
- applied to an actual project, with its application demonstrated in an accompanying draft project design document (PDD[33], Table 4.1);
- submitted by a designated operational entity (DOE) or an applicant entity (AE); and
- reviewed and assessed by the CDM EB and its supporting bodies (this can be a lengthy exercise usually involving external expertise).

Once a methodology has been approved, its application involves the compilation of the project-specific data into a standardised CDM PDD template. Taking into account the additional requirements for information disclosure imposed by the draft modalities and procedures for CCS (such as for site selection and characterisation) it is likely that a new PDD template will also need to be developed to accommodate these specific new elements associated with CCS. The present draft modalities and procedures for CCS do not include any proposals for specific modifications to the PDD template, although they do make it incumbent on the CDM EB to prepare such a document in the future (in paragraph 4(a)).

It is important to note that, notwithstanding the requirement to develop specific methodologies, the detailed nature of the draft modalities and procedures for CCS also means that much of the technical requirements in relation to matters such as site selection, risk and safety assessment and monitoring will likely be already quite clearly

[31] UNFCCC, decision 1/CMP.2 (2006). This decision also requested the EB “to continue to consider proposals for new methodologies, including the project design documents for carbon dioxide capture and storage in geological formations as clean development mechanism project activities, with a view to gaining further knowledge and understanding of matters related to the clean development mechanism”.

[32] Methodological guidance for large-scale CDM projects, including the new methodology template form, is available at: http://cdm.unfccc.int/Projects/pac/howto/CDMProjectActivity/NewMethodology/index.html

[33] The PDD is the main document used in a CDM application for the purposes of applying for validation and registration of a specific CDM project activity. The CDM EB has agreed a standardised template for PDDs which must be used in all CDM request for registrationUNFCCC, project design document v.3.0. Available at: http://cdm.unfccc.int/Reference/PDDs_Forms/PDDs/index.html

prescribed. This could, in theory, reduce the level of effort needed in preparing a new methodology for CCS project activities.

Table 4.1

Structure of CDM methodologies and PDDs and new elements for CCS

<table>
<tr><th><u>New Methodology (template, v.3.1)</u></th><th><u>Project design document (template, v.03)</u></th></tr>
<tr><td>
Section A – Recommendation by the Meth Panel
Section B – Summary and applicability
Section C – Proposed new baseline and monitoring methodology
I. Source, Definitions and Applicability
- Sources (proponents are required to explain which tools are used in the methodology)
- Approach to baseline determination (under the modalities and procedures)
- Definitions (as used in the methodology)
- Applicability conditions (under which the methodology can be applied)
II. Baseline methodology procedure
- Project boundary (what is included for the project type)
- Identification of the baseline scenario (steps to determine the counterfactual scenarios)
- Additionality (explain how the project scenario is not the baseline and therefore additional)
- Baseline emissions (explain how these are calculated)
- Project emissions (explain how these are calculated)
- Leakage emissions (explain how these are calculated)
- Emission reductions (explain how these are calculated)
- Data and parameters not monitored (outline any parameters which remain constant through the project)
III. Monitoring methodology
(outline the parameters to be monitored in accordance with the matrix template provided)
IV. References and any other information
Section D – Explanations/justifications to the proposed new baseline and monitoring methodology
(detailed explanations for the approach proposed for each part of sections I-III)

<u>In an approved methodology, only sections I-III are included.</u>
</td><td>
Section A – General description of project activity
- Title, - Description, - Project participants
- Technical description (including items such as location, technology to be employed, contribution to sustainable development, summary of ex ante estimated emission reductions)
Section B – Application of baseline and monitoring methodology
- Title and reference of approved methodology (as employed for the specific project)
- Justification for choice of approved methodology
- Description of sources and gases included in the project boundary
- Description of how the baseline scenario is indentified and a description of the identified baseline scenario (developed in accordance with the AM)
- Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (“additionality”)
- Emission reductions (sets out the methodological choices, the data and parameters available at validation, and the ex ante calculation of emission reductions)
- Application of the monitoring methodology (details of the specific parameters to be monitored such as the source of the data used to collect the parameter, location, QA/QC etc.)
Section C – Duration of the project activity
(Start date, operational lifetime, crediting period etc).
Section D – Environmental impacts
(Summarise environmental impacts and provide references to relevant documentation where a full EIA has been carried out).
Section E – Stakeholder’s comments
(Brief description of comments received and how they were taken account of.).
Annexes (Contact details, public funding, baseline and monitoring information)
</td></tr>
<tr><td colspan="2">
Potential new elements for CCS
Taking account of the templates outlined above, the draft modalities and procedures for CCS suggest the following additions may be needed in new methodologies and PDDs for CCS project activities under the CDM.
</td></tr>
<tr><td>
New sections in the NM/AM template will be required in which methodological steps and procedures, and related guidance can be outlined for the following items:
• Site selection and characterisation
• Risk and safety assessment
• Monitoring (including a base-level survey)
</td><td>
The PDD template will need to incorporate of the following additional aspects for a CCS project:
• Legal title to the land and subsurface pore space in which CO_2 is to be stored (see Section 4.3)
• Approach to managing long-term responsibility for a net carbon reversal (see Section 4.3)
• Financial provision (see Section 4.3)
• Additional sections in which to set out the implementation of the methodological items described in the adjacent column
</td></tr>
</table>

A summary of the main documentation and the sections and subsections therein required for the preparation of a new methodology and a CDM PDD is highlighted in Table 4.1. For most aspects of a CCS project, the existing documentation templates and approaches can be applied to CCS project activities, a view reflected in the 'mutatis mutandis' approach proposed in many parts of the draft modalities and procedures for CCS. However, some of the CCS-specific additional requirements suggest that new elements in the documentation will be required. Suggestions for these have been added at the bottom of Table 4.1, highlighting additions for site selection and characterisation, risk assessment and additional monitoring provisions in both approved methodologies and PDDs. Two of the new sections in the PDD document template may also be required to accommodate host country national regulatory approvals/confirmations, as shown in Table 4.1.

Taking into account the content of Table 4.1, the following sections discuss potential approaches to compiling several of the more challenging issues posed for developing a new methodology and associated PDD template for CCS projects are outlined below.

Project boundary

Project boundaries[34] for CCS projects has been raised as an issue by the EB and CMP on several occasions in the past, including in the Cancun CMP decision on CCS modalities and procedures. In addressing these concerns, the draft modalities and procedures for CCS suggest the following elements are to be included within the project boundary for a CCS project under the CDM:

- the installation where the carbon dioxide is captured;
- any treatment facilities;
- transportation equipment and booster stations along a pipeline, or offloading facilities in the case of transportation by ship, rail or road tanker;
- any reception facilities or holding tanks at the injection site;
- the injection facility; and
- subsurface components, including the geological storage site and all potential sources of seepage, as determined during the characterisation and selection of the geological storage site.

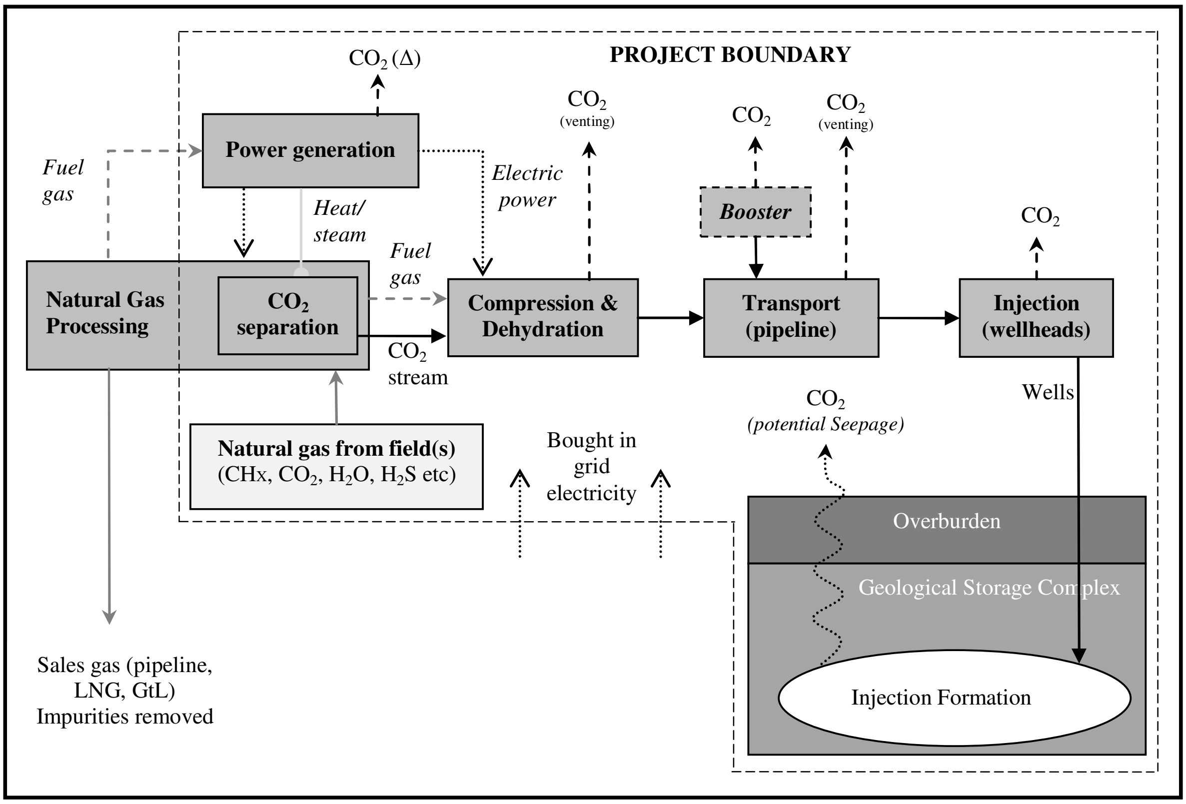
It also notes that the project boundary should also encompass the vertical and lateral limits of the storage site that are expected when the CO_2 plume stabilises over the long term during the closure phase and the post-closure phase.

The figure below shows a proposed approach to determining the project boundary for a CCS project involving capture and storage of reservoir CO_2 produced during natural gas processing (Figure 4.2).

[34] Under the CDM "The project boundary shall encompass all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the CDM project activity". Decision 3/CMP.1

Figure 4.2

Example of a proposed project boundary for a CCS project in the CDM



Source: *Capture, transport and long-term storage in Geological Formations of carbon dioxide from natural gas processing operations.* Proposed CDM new methodology for CCS by the In Salah Gas partners.

For the subsurface components, it will be important that a flexible approach is taken to delineation of the subsurface boundary because of inherent uncertainties involved in ex ante estimates of the vertical and lateral extent, covering both data gathered during geological surveys, and the computer simulation software used to create a model of the subsurface. For this reason, it may be necessary to allow the project boundary to be periodically updated through the project lifecycle.

Baseline and additionality

As outlined in Chapter 2, the CDM is based upon the generation of CERs that are aligned to quantified estimates of the reduction of GHG emissions below those that would have occurred in the absence of the CDM project activity (see Figure 2.2). To generate such estimates, the development of a baseline scenario (and the quantification of baseline emissions under that scenario) and also the demonstration of how the project results in a reduction of emissions against this baseline – known as 'additionality' – is required. These are two key principles underpinning the CDM, and will likely be equally applicable to other potential carbon finance mechanisms that could emerge post-2012.

Both aspects raise several considerations for the different types of CCS projects that could be developed under the CDM. The need to establish a baseline raises different sets of issues for both project-based approaches, as applied in the CDM, and also sectoral-based approaches including sectoral baselines that could potentially be developed in the CDM, or under a broader sector-based mechanism that could be developed for the post-2012 period. Some of the different factors to consider in this context are summarised in Table 4.2 for the main CCS candidate sectors.

Most estimates of CCS potential are based on either 'captured CO_2' or 'avoided CO_2' emissions, which are calculated by using a comparison with an equivalent plant with the same output but not using CCS. However, under the CDM and other climate finance mechanisms, alternative approaches may be used to calculate the emissions baseline against which emission reductions are calculated and carbon credits earned. This could in practice result in significantly less carbon credits (e.g. CERs) being generated. For example, emissions baselines under existing CDM approved methodologies for new-build power generation projects may be calculated according to approaches other than an equivalent non-CCS plant, in order to demonstrate conservativeness given the uncertainty around the counterfactual scenario.[35] Depending upon the baseline calculation, which could vary considerably by region, only a limited share of the 'captured' or 'avoided' emissions might therefore be eligible to generate CERs.

There are other features of the CDM which must be carefully considered when assessing potential approaches to baseline calculations for CCS. For example, in the case of CCS retrofitted to existing power generation or industrial facilities, it is not clear which baseline might apply (for example, whether historical emissions or an alternative approach such as product benchmarks would be used). This factor could, in theory, penalise against some new build CCS projects. Baseline approaches – to be developed in new methodologies – will therefore likely be a key factor in determining CER revenues.

Table 4.2

Project- and sector-based climate finance issues for CCS

Sector	**Project-based mechanisms** (e.g. CDM; reformed CDM)	**Sector-based mechanisms** (e.g. sectoral crediting; NAMAs)
Power	Baselines for new-build CCS projects are likely to be determined using similar approach to existing CDM methodologies e.g. calculation of baseline grid emissions using combined margin (CM). In some cases, this may result in a significantly reduction in CERs generated for fossil-fuel projects compared to estimates of CCS project abatement potential. The possible use of historical emissions as baseline methodology to retrofit projects could perversely penalise against new build projects.	CCS could play an important role in generating carbon credits within power sector mitigation agreements. Likely to be most applicable to countries with power grids with high carbon intensity, dominated by coal-fired power (e.g. China, India, South Africa, Botswana). The development of appropriate crediting baseline(s) likely to be subject to similar methodological considerations to CDM (e.g. combined margin approach). Use of sector-wide crediting baseline(s) may erode potential for carbon asset generation (under e.g. 'no lose' type sectoral approaches).
Industry	Potentially suitable, depending upon sector/product factors. Baseline determination for new builds may make use of benchmarks (e.g. tCO_2 per t output). The possible use of a benchmark-based baseline methodology (as opposed to historical emissions) to retrofit projects would be unlikely to perversely penalise against new builds.	Standardised baselines (e.g. tCO_2 per t output) may be applicable to relatively homogenous industrial process sectors such as cement, iron and steel and some chemicals processes. The use of sector-wide crediting baseline(s) may erode potential for carbon asset generation (under e.g. 'no lose' type sectoral approaches).
Upstream	Typically single-operator projects e.g. isolated natural gas field developments - well suited to project-based approaches. Clusters of high-CO_2 gas fields with single storage could potentially be developed under programmatic CDM, or similar type of mechanism.	For natural gas processing CCS projects, the heterogeneity of CO_2 content within natural gas reservoirs means that it is not possible to develop credible sectoral baselines. Unlike more homogenous industrial processes, the 'counterfactual case' is highly case-specific (i.e. the natural gas reservoir).

Source: Zakkour et al, 2011, *op. cit.*

[35] For example, using grid emission factors based on the 'combined margin' (CM) approach, intended to reflect the carbon intensity of existing regional or local electricity grids adjusted for new units likely to be added over time. The CM comprises of an operating margin (OM) and a build margin (BM), as described in the latest version of the CDM Methodological Tool: *Tool to calculate the emission factor for an electricity system*; see http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v2.pdf

A key part of demonstrating additionality for a project involves showing that the CDM and the associated revenues from CER sales was instrumental in passing FID, and that in the absence of the CER revenue an alternative option would have been implemented – the counterfactual that sets the basis for the baseline scenario. A large amount of upfront spending without ample evidence that the CDM was taken into account could jeopardise the chances of a project being considered additional, especially if there are other co-benefits involved such as EOR which create other financial drivers for investment. On the other hand, it is likely that 'first-of-a-kind' additionality considerations would apply in at least the short- to medium-term. In most cases other than where storage is combined with CO_2-EOR, demonstrating that a CCS project achieves additionality is likely to pose few difficulties as the technology will be undertaken purely for the purposes of GHG emissions reduction at considerable additional cost.

Site selection and characterisation

There is broad agreement amongst most experts that site selection and characterisation is critical for safe and secure geological storage of CO_2 over the long-term. Mindful of this, the draft modalities and procedures for CCS propose prescriptive approaches to this aspect of project design, and specific methodological approaches will need to build on these to create a comprehensive guidance document for selecting and characterising storage sites.

Recognising this potential requirement, the proposed CDM methodology for CCS from the In Salah Gas Partners set out a comprehensive annex with detailed procedures that could be developed to be compliant with requirements set out in the draft modalities and procedures for CCS. The methodological guidance and reporting template proposed therein included the following aspects for site selection: (1) introduction, (2) screening and selection, and (3) characterisation (see Box 4.1).

Box 4.1

An approach to site screening, selection and characterisation under the CDM

Annex A of the proposed In Salah Gas CCS CDM methodology set out the following template for reporting of site screening, selection and characterisation studies. A condensed version of the main parts is outlined below.

I. INTRODUCTION

II GEOLOGICAL STORAGE COMPLEX SCREENING AND SELECTION

Section B.1 Options identification

A range of options for reducing emissions via CCS should be considered at a high-level in this section.

Section B.2 Options evaluation and selection

Options identified in B.1 should be evaluated against a set of criteria to test for their suitability for CO_2 capture, transport and storage. Criteria include geology; technology; legal and regulatory considerations; economic considerations; and environmental, health and safety considerations.

III. GEOLOGICAL STORAGE COMPLEX CHARACTERISATION

Selected option(s) from the high-level screening exercise should be taken forward for further characterisation and analysis. The following steps are proposed by the In Salah Gas Partners: (1) storage characterisation; (2) performance assessment; (3) sensitivity analysis.

Section C.1 Storage Characterisation

Sources of data for storage characterisation – including data acquisition activities – should be documented in this section.

Geological Storage Complex geology, geophysics and geochemistry

Data and information on intrinsic geological and geophysical criteria and underlying properties in the storage site and overburden (where applicable), including: regional geology; geophysics, geomechanics and geochemistry; formation fluids and hydrogeology

Containment and Features identification

Information should be provided on identified features in the geological storage site (e.g. existing and future wells etc; caprock/seal and, seismicity). Identified features must be documented in a risk register as described in Section IV - Risk Assessment.

Surrounding domains

Various aspects of the areas surrounding the storage site must be documented, including environment, human populations, and other economic activity.

Section C.2 Performance assessment

Characterisation studies undertaken in section C.1 should be used to compile an assessment of storage performance based on evaluation of the injection formation, geological analysis, and reservoir engineering and modelling assessments of containment performance etc.

Storage capacity estimation

Numerical computer simulation should be undertaken which can facilitate estimations of the volumetric capacity of the selected injection formation and the results documented.

CO_2 Migration analysis

This stage involves dynamic numerical modelling of CO_2 injection in the selected storage site. Detailed guidance is outlined on the objectives and approaches to modelling.

Features and processes analysis

This stage involves an assessment of the safety of different features such as the caprock, wells, faults etc. The results should be used to determine safe operating pressures for the storage site.

Section C.3 Sensitivity analysis

Multiple simulations should be undertaken using uncertainty assessments of key parameters, and the results evaluated. Any significant sensitivity should be taken into account and incorporated in Section IV - Risk Assessment.

Source: Summarised from: *Capture, transport and long-term storage in Geological Formations of carbon dioxide from natural gas processing operations.* Proposed CDM new methodology for CCS by the In Salah Gas partners, Annex A.

Risk assessment

As for site selection and characterisation, the draft modalities and procedures for CCS include fairly prescriptive requirements for assessing the risk of CCS projects under the CDM. These draw on Parties views as submitted in March 2011 and as summarised in the synthesis of views.[36] They are broadly reflective of approaches adopted in CCS-specific regulations in several parts of the world such as in the EU CCS Directive.

In terms of converting these requirements into the methodological approaches under the CDM, the best available example is again the proposal from the In Salah Gas partners, as outlined in Box 4.2 below.

[36] UNFCCC, document FCCC/SBSTA/2011/INF.7

Box 4.2

An approach to risk assessment under the CDM

Annex A of the proposed In Salah Gas CCS CDM methodology set out the following template for compiling a risk assessment for a CCS project under the CDM (condensed from the proposed methodology).

IV. RISK ASSESSMENT

An introduction to the concepts involved in risk assessment is outlined, covering: (1) hazard characterisation, (2) scenarios and sensitivities (based on expert judgement of the likelihood of certain events occurring) (3) consequence analysis (4) risk management approaches.

The methodology proposes that the results of this analysis should be compiled into an *Initial Risk Register*, summarizing the features/hazards identified under Section III (Box 4.1), the events (scenarios) which could trigger their activation, and the potential consequences.

Section D.1 Scenario's and sensitivities

This part involves the description of various events and/or processes that could lead to irregularities in operations such as migration outside the boundary or seepage at the surface. Numerical simulation of such scenarios is required where possible in order to determine the potential magnitude of such events.

Section D.2 Consequence analysis

The results of scenario analysis should be used to support the development of an impact assessment for the proposed CCS project activity, based on the sensitivity of potential receptors in surrounding domains including within the hydrosphere, biosphere and atmosphere. Exposure and effects assessment for seepage scenarios should be included based on human populations and the flora and fauna in the surrounding domains.

Section D.3 Risk management

Approaches to risk management should be documented, covering (1) avoidance (to ensure sufficient spatial separation between risk factors is achieved) (2) management (safe operation of the site such as appropriate injection strategies) (3) monitoring (to detect early signs of irregularities) (4) secondary containment (to act as enhanced barriers to migration and seepage).

A template for the initial risk register is proposed in the document.

Source: Summarised from: *Capture, transport and long-term storage in Geological Formations of carbon dioxide from natural gas processing operations.* Proposed CDM new methodology for CCS by the In Salah Gas partners, Annex A.

Environmental, social, and health and safety impact assessment

The draft modalities and procedures for CCS propose that environmental and socio-economic impact assessments for all CCS projects under the CDM must be carried out, and these must be undertaken by independent entities. Other than recognising the link between the impact assessments and the risk assessment, and suggestions that a detailed description of monitoring and remedial measures must be carried out for indentified impacts, no other guidance on how these shall be compiled is included.

However, this lack of guidance is not unexpected; whilst the modalities and procedures for the CDM (including modalities and procedures for afforestation and reforestation projects under the CDM) also require that an environmental impact assessment (and for forestry projects, a social impact assessment) be carried out, they do not provide prescriptive approaches on how these must be undertaken. Consequently, it is extremely unlikely that prescriptive guidance will be provided by the CDM EB on how to undertake such assessments. In the main, environmental and social impact assessments are considered to fall within the scope of national regulations rather than the CDM.

To date, there is limited experience in developing environmental and socio-economic impact assessments for CCS projects, particularly in developing countries. For the most part, it can be assumed that they will need to be compliant with existing requirements present in the host country for environmental impact assessment as applied to large industrial projects such as oil and gas field developments. In order to ensure good practice, it will also likely be necessary for approaches to draw on international standards such as those issued by the International Finance Corporation[37] and other CCS specific proposals such as those prepared for the Gorgon CCS project in Australia.[38]

Requirements for environmental and socio-economic impact assessments should be considered as good practice by any CCS project developer, and should not be considered as an unnecessary burden on project development. As such, this aspect is unlikely to present a significant barrier to the development of CCS projects under the CDM in coming years.

Developing a monitoring plan

The modalities and procedures for the CDM contain detailed guidance on monitoring requirements for CDM project activities. These requirements are focussed on establishing robust requirements in approved methodologies for determining a projects baseline emissions, project emissions and leakage emissions (see Figure 2.1).

In addition to these requirements, monitoring for a CCS project is required to meet other objectives, described in the draft modalities and procedures for CCS as:

- to provide assurance of the environmental integrity and safety of the geological storage site;
- to confirm that injected carbon dioxide is permanently stored within the geological storage site and within the project boundary;
- to ensure that good site management is taking place, taking account of the proposed conditions of use set out in the site development and management plan
- to detect any seepage or contamination, as well as to assess impacts on human health and the surrounding environment; and
- to determine whether timely and appropriate remedial measures have been carried out in the event of seepage.

As such, the draft modalities and procedures for CCS significantly expand on the monitoring requirements currently applied under the CDM. Furthermore, unlike conventional CDM projects, monitoring of CCS projects is required to continue beyond the end of the crediting period to ensure that the objectives outlined above continue to be met, and that assurances over the permanence of emission reductions can be maintained.

As a result of these additional requirements, new methodologies proposed for CCS project activities will need to be developed that can take account of these additional requirements. In attempting to address these concerns, the proposed new methodology from the In

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[37] IFC Environmental, Health and Safety Guidelines and related documentation such as the Performance Standards. Available at: http://www.ifc.org/ifcext/sustainability.nsf/Content/EHSGuidelines

[38] Further information is available at: http://www.chevronaustralia.com/ourbusinesses/gorgon/environmentalresponsibility/environmentalapprovals.aspx Information on the geological storage site impact assessment can be found at: http://www.chevronaustralia.com/Libraries/Chevron_Documents/Rev_O_ch13_23Aug05.pdf.sflb.ashx

Salah Gas partners included guidance on the design of a monitoring plan as described below (Box 4.3).

Box 4.3

An approach to monitoring plan design under the CDM

Annex B of the proposed In Salah Gas CCS CDM methodology set out the following template for compiling a monitoring plan for a CCS project under the CDM (condensed from the proposed methodology).

I. INTRODUCTION

Section A.1 Name of the selected Geological Storage Complex

Section A.2 Brief description of the monitoring plan

II. MONITORING PLAN DESIGN AND IMPLEMENTATION

The purpose of the monitoring plan is introduced, highlighting the main aspects to selecting: various monitoring techniques, their locations for application, and frequencies of application. It is highlighted that these should link to the risk assessment (see Box 4.2). Techniques employed should be able to detect presence of CO_2 and parameters which support monitoring of the following: (1) CO_2 migration; (2) features (3) modes of operation; and (4) surrounding domains.

Section B.1 Technique selection

Guidance is set out on how to select and present the techniques to be used, including (1) the rationale for technique selection (2) the locations for monitoring for each technique (3) the frequency at which they will be applied; and (4) what information from a base-level survey is required to calibrate specific monitoring results.

A matrix for compilation of the monitoring plan is set out based on the objectives described. The methodology also suggests that the subsurface monitoring techniques to be employed should be cross-checked against the *initial risk register* compiled in the risk assessment.

Section B.2. Base-level survey

The nature of different techniques used in subsurface monitoring means that data collected prior to the project development are often required to calibrate monitoring results (for example background measurements of soil gas CO_2 concentration and diurnal, seasonal and annual variations). As such, the development of a monitoring plan must be accompanied by a base-level survey so that such data exists and can be used during the operational and closure phases.

In some cases it may be supported by existing datasets from site characterisation or require additional data collection activities. Data may also be available from broader environmental impact assessment activities, although EIA procedures cannot be relied on to gain suitable data for base level data needs.

Key data needs for base-level survey may include inter alia: (1) subsurface data (e.g. data on brine aquifer characteristics; wells; gravity surveys; seismicity data; topographic/relief data) (2) surface and near-surface data such as soil gas and potable aquifers; (3) data from the surrounding domains such as ecosystem survey data.

A matrix for compilation of the base-level survey data is set out in the proposed methodology, and linkages to the monitoring plan are described as set out above.

Source: Summarised from: *Capture, transport and long-term storage in Geological Formations of carbon dioxide from natural gas processing operations.* Proposed CDM new methodology for CCS by the In Salah Gas partners, Annex B.

4.5 Review of key CDM documentation

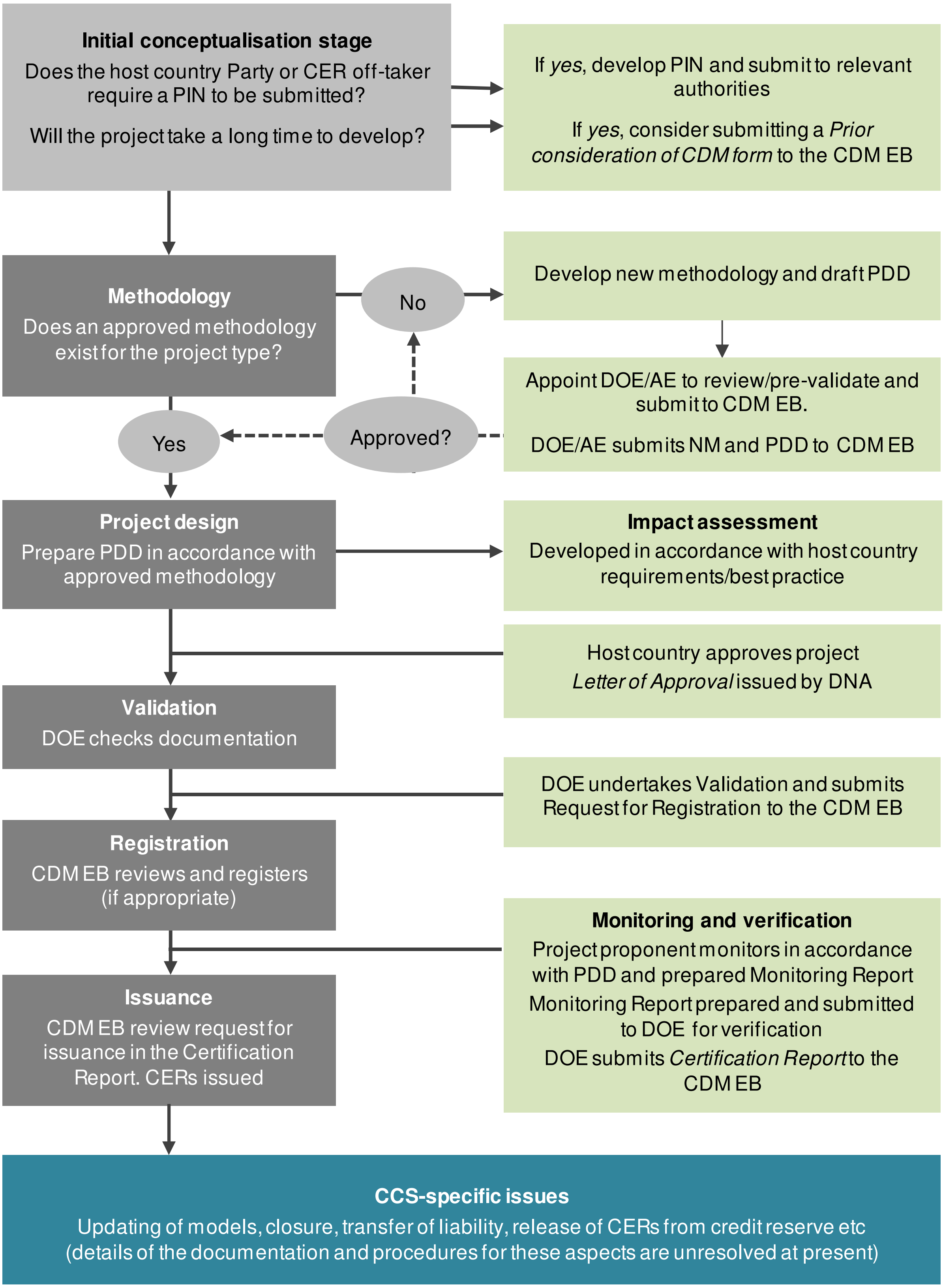
Previous sections have outlined some of the issues that will need to be addressed in developing a CCS project under the CDM. They also included mention of some of the key documentation and approvals involved in the project cycle under the CDM. To recap, the key documentation involved in the CDM includes:

- **Approved methodology –** this sets out the accounting approach that must be applied to the particular CDM project activity. Where an appropriate approved methodology does not exist (as is the case for all CCS projects), a new methodology must be developed and submitted for approval by the EB prior to it being applied to a project activity. An application for a new methodology must be developed in accordance with relevant EB guidance and template (Table 4.1).
- **Project design document** – this is the key document used for filing a CDM application with the EB. It must be developed in accordance with an approved methodology applicable to the project activity. It must be prepared using the template issued by the EB (Table 4.1).
- **Host country letter of approval** – host country DNA must review a project and issue a letter of approval confirming its compliance with host country sustainable development objectives. Under the draft modalities and procedures for CCS, the requirements for host country approval will be increased for CCS projects, covering aspects such as compliance of the project with national laws, and confirmation of the approach to be taken managing long-term liability.
- **Monitoring report** – a monitoring report must be prepared for a registered CDM project activity to obtain CERs. The monitoring report, which must be verified by a DOE, forms the basis for requesting the issuance of CERs from the EB.
- **Certification report** – the certification report is prepared by the DOE based on the verification of the monitoring report. When submitted to the EB, it constitutes a request for issuance of CERS from the EB to the project proponent;
- **Other components** – a range of other forms are also sometimes needed under the CDM for specific circumstances, such as Prior consideration of CDM form and documentation associated with Reviews.
- **CCS-specific components** – the closure of a CCS project activity is likely to trigger new requirements for information disclosure history-matching and updating of monitoring plans, such as a site closure report (although this could in principle be wrapped up into the final verification report for a CCS project activity). According to the model adopted, arrangements and procedures for long-term liability will also need to be developed (e.g. release of CERs from credit reserve). The precise scope and procedures for these various aspects are difficult to predict at the current time and only likely to be clearer through practical implementation.

The main procedures and documentation is summarised graphically below (Figure 4.3).

Figure 4.3

Main steps in CDM project development cycle

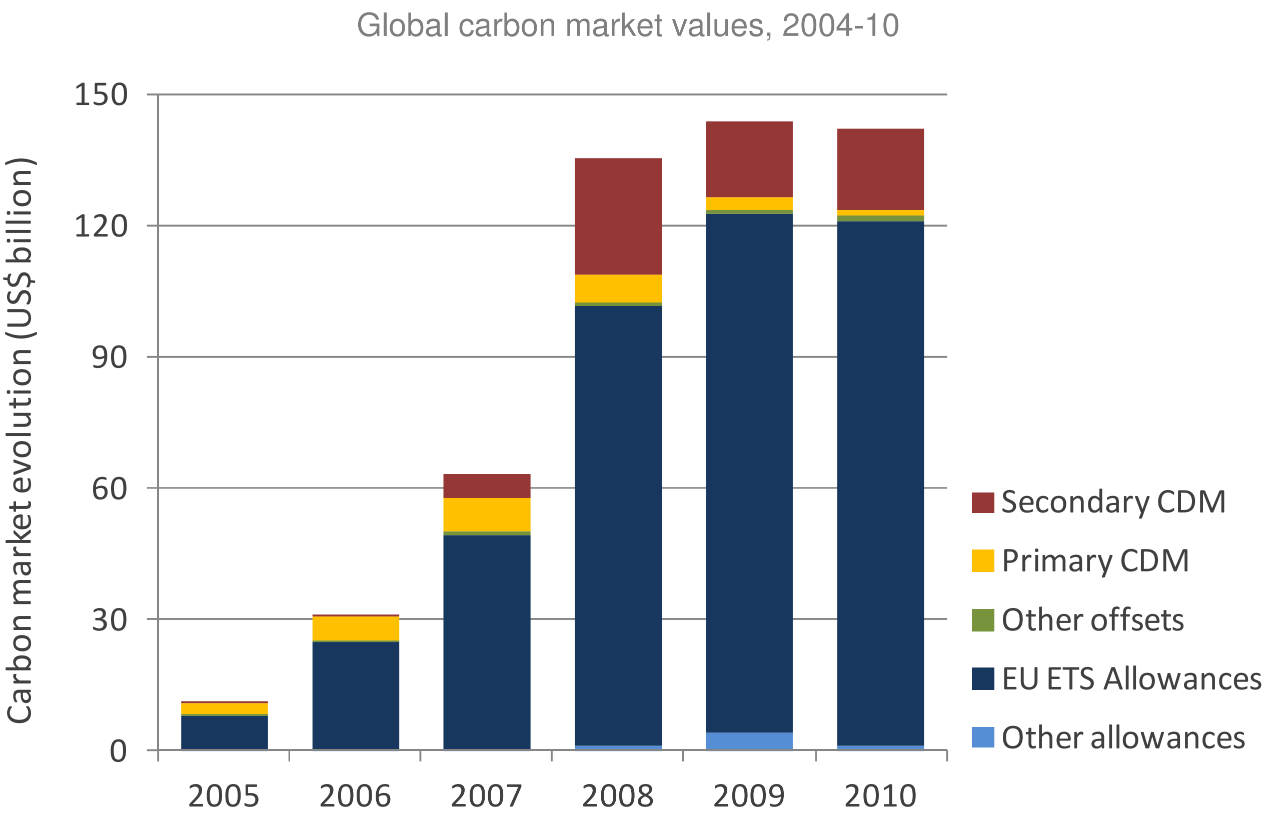


5. ACCESSING THE CARBON MARKET

5.1 The CDM and the global carbon market

CERs generated under the CDM represent an important share of the global carbon market. The demand for CERs is driven by Annex I country Party QELROs and also the rules of regional-level GHG reduction schemes which make use of CDM offsets (see Chapter 2). By far the most important of these, in terms of overall offset demand, is the EU ETS which allows companies within the scheme to surrender a certain share of their compliance with annual levels of regulated emissions in the form of CERs.[39] According to *State and Trends of the Carbon Market 2011*, the World Bank's annual survey of the global carbon market, the total value of the market in 2010 was around US$142 billion, of which CDM transactions accounted for around US$20 billion, or 14 per cent of the total (Figure 5.1).

Figure 5.1



Sources: World Bank, Thomson Reuters Point Carbon, Bloomberg New Energy Finance and Ecosystem Marketplace

[39] Offsets generated under the Joint Implementation (JI) Kyoto mechanism can also be used. The JI is also a project-based mechanism in which credits are generated by emissions reduction projects located in Annex I countries. The credits generated are known as Emissions Reduction Units (ERUs).

The CDM market is divided into primary CER (pCER) and secondary CER (sCER) transactions, and buyers can chose to invest in either. Primary CERs are those transacted between the original owner of the offsets (usually the project proponent) and the buyer, whereas secondary CERs involve one or more secondary sellers in the transaction (for example, traders and brokers). Because they are generated and issued on an annual basis, primary CERs come with a 'delivery risk', which is typically not present in secondary CERs transactions, as these have already been generated and issued by the CDM EB (see Section 2), although hybrid transactions do exist. This risk factor is reflected in their relative price, with pCERs typically traded at around 75 to 85 per cent of the sCER price.[40]

A further important division for the primary CDM market is between *pre-2013* and *post-2012* pCERs, i.e. those delivered before and after the end of the first Kyoto Protocol commitment period (2008-2012). This is an important factor influencing the demand for offsets, given the need for Annex I countries to meet their existing Kyoto QELRO commitments and also the uncertainties regarding a post-2012 international agreement. The World Bank reports that in 2010, prices for *pre-2013* pCERs averaged €8-10 for most regions and sectors, with *post-2012* pCER prices falling in the €6-8 range. As shown in Figure 5.1, primary CER transactions, which once represented a large share of the global carbon market, now account for only around 1 per cent. Secondary CER transactions now account for the majority of CER transactions, equal to around 13 per cent of the total global carbon market. This suggests a clear buyer preference in the current market for risk-free offsets.

5.2 Understanding the market for CERs – who are the buyers?

The CDM market contains many different categories of CER buyers. These include those seeking to buy offsets for compliance with the EU ETS and other regional schemes ('compliance buyers') as well as Annex I Parties directly acquiring CERs to meet their QELRO commitments under the Kyoto Protocol ('sovereign buyers'). In addition, various organisations within the financial sector (traders, brokers, private and commercial banks, funds) purchase CERs in order to speculate in the market and develop carbon asset portfolios ('speculators'). Buyers have different preferences, including their appetite for risks such as CER 'delivery risk', and may be constrained by various rules and restrictions regarding both the CDM project type and its details (see below).

These factors will likely determine the most appropriate buyer for CERs generated by CCS projects, and also the price and conditions upon which the CERs are transacted. The creditworthiness of project proponents, their track record in developing complex infrastructure projects, sovereign risk in the host country Party, and host country Party approaches to managing long-term liability will all potentially affect the price of CERs generated by CCS projects. CCS projects also create a dilemma for CER off-takers: the potentially large volumes of CERs that could be generated by a single project is attractive to buyers in terms of reduced complexity and transaction costs on a unit basis, but on the other hand, reliance on a single project for a large volume of CERs also presents inherent risks in the event of project failure (a matter enhanced for novel technologies such as CCS), driving buyers to consider creating more diversified portfolios and creating syndicated buying pools.

[40] The rate at which pCERs sell below the price of sCERs (or the 'price spread') can vary between project types and CDM host countries, reflecting the perceived delivery risk from offset buyers.

European Union Emissions Trading Scheme (EU ETS)[41]

As shown in Figure 5.1, EU ETS allowances (European Union Allowances, EUAs) accounted for the majority of global carbon market value in 2010, at around 84 per cent. Companies with installations included in the EU ETS – often acting as both compliance buyers and speculators – can internally reduce their emissions, purchase EUAs from the market and/or acquire CERs (and ERUs) to surrender for compliance obligations. Because the cost of reducing emissions is typically lower in CDM host countries, many European operators included within the scheme seek to use offsets to help reduce their overall cost of compliance. These include power generators, international oil and gas companies and industrial producers, some of which originate their own projects through their non-European operations and partner organisations. The EU ETS therefore represents the principal demand in the market for CERs: with the value of the secondary CDM transactions taken into account, the share of the carbon market primarily driven by the EU ETS represented around 97 per cent of the total global carbon market in 2010 (World Bank, 2011). When surrendered for compliance under the EU ETS, Member States in the EU can include the CERs to meet their compliance obligations with QELROs under the Kyoto Protocol.

Under Phase I (2005-2008) and Phase II (2008-2012) of the EU ETS, CERs have been eligible for direct use by operators, subject to some restrictions around eligible project types and the overall contribution to Member State and EU QELROs that could be met using international offsets. For example, CERs derived from hydropower projects greater than 20 MW have been subject to strict requirements, and the use of tCERs and lCERs from afforestation and reforestation project activities under the CDM have been excluded[42].

Another important development under the new rules is that offsets issued from projects registered after 2012 will only be eligible to be used if sourced from a least developed country (LDC)[43]. This may serve to restrict the opportunities for developing economically-viable projects with sufficiently creditworthy project sponsors and low risk profiles to attract investment. According to the UNEP Risoe database of CDM projects[44], this group of countries accounts for less than one per cent of the total CERs issued to date. There may also be restrictions in respect of certain CCS projects undertaken.[45] For example, where host country Parties do not accept long-term liability for a ‘net carbon reversal of storage’ (see Section 4), there may be restrictions regarding the use of the associated CERs for compliance in certain regional GHG compliance schemes such as the EU ETS; the EU has consistently stated its support for a host country liability model for CCS under the CDM in submissions to the UNFCCC on the matter over the last few years.

The outlook for CER demand from the EU ETS is subject to a large number of unknown factors. Some commentators suggest that additional demand could come from power generators that start to hedge their future exposure in Phase III of the scheme as a result

[41] Note also that some other existing and emerging regional GHG trading schemes may make use of CCS-derived CERs, subject to ongoing international discussions and the domestic policy developments.

[42] The European Commission has also proposed that CERs from HFC-23 and N_2O adipic acid projects will also be excluded from the EU ETS from April 2013 onwards.

[43] Article 11a (4) of the Revised EU ETS Directive; for the list of LDCs see: http://www.un.org/special-rep/ohrlls/ldc/list.htm

[44] See: http://cdmpipeline.org/

[45] Note that at the current time, CCS has not been excluded from the eligibility criteria described for the use of international offsets in any known existing or proposed GHG trading schemes.

of tighter caps and increased auctioning. Increases in global energy prices could also drive compliance demand from the power sector. These factors are important because the power sector accounts for around one half of the emissions covered under the EU ETS. The aviation sector will face auctioning in their first year of the EU ETS, leading to an expected shortfall of allowances, which they will seek to meet through the use of offsets.

Sovereign buyers

Sovereign buyers of CERs have been an important factor driving the CDM market, particularly in its early years. A number of Annex I country Parties – notably Japan, Denmark and the Netherlands – have historically engaged in origination activities and promoted the CDM market in order to meet QELROs under the Kyoto Protocol fist commitment period. Although their presence in the carbon offset market remains important, some sovereign buyers have since shifted their focus towards the market for Assigned Amount Units (AAUs). AAUs are traded between Parties to the Kyoto Protocol in order to meet their emission reduction goals.

Sovereign buyers have also increasingly sought purchases through the secondary CER market (sCERS), seeking advantages of fast transactions, simple contractual processes, and predictable volumes ensured through delivery guarantee (World Bank, 2011).

Multilateral Development Banks and Carbon Funds

Climate finance is a priority area for the six major multilateral development banks (MDBs).[46] One form of MDB support takes the form of investment funding, including the use of carbon funds investing in, and generating CERs from, CDM projects developed across many developing country sectors and regions. Several of the MDBs have developed initiatives targeting sustainable energy, enabling them to combine climate finance (including the purchase of post-2012 CERs) with underlying project finance.

Carbon funds and facilities active in the post-2012 CDM market include the following:

- **International Finance Corporation (IFC) Post-2012 Carbon Facility:** The IFC launched a Post-2012 Carbon Facility in February 2011 to forward purchase CERs from projects either directly financed by IFC or by local banks financed by IFC. See http://www.ifc.org
- **World Bank Carbon Partnership Facility (CPF):** The new facility, launched in December 2009, focuses on purchasing post-2012 offsets. See http://cpf.wbcarbonfinance.org/cpf/
- **Asian Development Bank (ADB) Carbon Market Program:** supports CDM projects through two carbon funds (the Asia Pacific Carbon Fund and Future Carbon Fund), a technical support facility, and a credit marketing facility. See http://www.adb.org/Clean-Energy/CEFPF.Asp.
- **European Investment Bank (EIB) Post-2012 Carbon Credit Fund:** focuses on purchasing CERs (and ERUs from JI projects) generated after 2012, potentially up to 2020, with funding from several public and private European Banks[47] See http://www.eib.org/projects/publications/post-2012-carbon-credit-fund.htm

[46] These include the African Development Bank (AfDB), Asian Development Bank (ADB), European Bank for Reconstruction and Development (EBRD), European Investment Bank (EIB), Inter-American Development Bank (IADB), and the World Bank Group (WBG)
[47] These include the European Investment Bank, Caisse des Depots, Instituto de Credito Oficial, KfW Bankengruppe, and Nordic Investment Bank

- **EBRD Post-2012 Fund, and EBRD Multilateral Carbon Credit Fund (MCCF):** the Multilateral Carbon Credit Fund (MCCF) is a post-2012 fund jointly developed by the EBRD and EIB. See http://www.ebrd.com/pages/sector/energyefficiency/sei/carbon/markets.shtml

Depending upon the specific policies of each fund and participating organisation, there may be restrictions on the type of projects which are supported and/or from which CERs are purchased. Certain funds will also have preferences for particular sectors and regions.

Private sector financial organisations such as commercial banks and traders are also important participants in the market for both primary and secondary CERs. Several banks have developed carbon asset portfolios (carbon funds) which include CERs, often working with the development banks and other public organisations. Participants in such funds may include private companies (especially compliance buyers), sovereign buyers or secondary traders and other banks. These funds seek partnerships with CDM project developers and their involvement may extend from providing up-front project finance through to the purchase of CERs generated during the operational phase of the project.

5.3 Strategies for trading

The CDM project proponent can seek to contract the CERs to a buyer (or buyers) at different stages of the CDM project cycle. There are likely to be different advantages to selling the CERs at the various stages, depending upon the details of the project, the project developer's appetite for risk and the commercial/finance strategy being pursued:

- **PIN/PDD stage.** The project developer may choose to seek a potential contractor for the CERs at the earliest stage of the CDM project cycle, in which the PDD, or even the PIN, is being developed. The advantages of this would be the use of the collateral provided by the contract to secure up-front finance to fund the required technology investments, develop the analysis and documentation required, the locking-in of project revenues, and where relevant, the possibility of the investor/financer helping to identify technology providers or other potential project partners. The resulting involvement from the buyer would however be reflected in the CER price negotiated under the transaction agreement, also taking account of the deferred term until tradeable assets would be realised.
- **CDM Registration stage.** Once verified by a DOE, the PDD is submitted to the CDM EB for registration (see Section 2). If successfully registered, the key risk of non-registration is overcome and is likely to be reflected by more favourable contractual terms to the buyer – although there is still risk of non-delivery which may limit the involvement of some potential buyers. Depending on when the project started, there may still be some potential for the buyer to assist in providing up-front, or early-stage project finance.
- **When CERs are issued ('unilateral CDM').** Transacting CERs once they are issued by the CDM EB overcomes CER delivery risk, an important factor determining contracted price. The seller can receive immediate payment from the buyer. However, the project proponent must generally take on all of the investment risk associated with developing the project.

Project developers can seek to identify a suitable buyer through several routes, including establishing direct contact through business events and trade fairs, enquiring through the offices of the host country's Designated National Authority (DNA) or contacting one or more of the climate funds in operation. In addition, many CDM project proponents may have compliance obligations through their operations in Annex I regions, including under the EU ETS (i.e. international companies with presence in both developed and developing markets). Government buyers can also be contacted, either through trade fairs or through the Annex I country Party's DNA. These can be found from the UNFCCC website. Finally, project developers may choose to transact through a trader or broker in order to gain access to a larger number of potential buyers and receive detailed guidance regarding the contractual processes – Including the appropriate contractual terms.

What is an Emissions Reduction Purchase Agreement (ERPA)?

The transaction of primary CERs between a buyer and seller is governed by an Emissions Reduction Purchase Agreement (ERPA; sERPA are typically used for sCERs). The ERPA contains the terms and conditions negotiated between the counterparties and, as with other commercial contracts, it reflects a balance struck between the risks and rewards perceived by both parties. The allocation of 'risk and reward' between the buyer and seller is partly driven by the prevailing level of demand for CERs in the market, and also expectations around its future direction. For example, where there is reduced demand from buyers, clauses agreed in ERPAs are likely to be more restrictive to sellers than when there is higher demand (and/or less supply).

Key aspects of an ERPA which need to be negotiated include:

- **Contracted prices:** ERPAs can be agreed based on either a fixed or variable CER price basis. Where variable prices are negotiated, the price typically comprises a fixed or floor component and a variable component defined in terms of shared upside gain between sellers and buyers (determined based on prevailing spot CER prices traded on exchanges, or indexed to EUA prices). The preference for buyers and sellers to enter into either fixed-price or variable price contracts depends upon the perceptions of the gains versus the risks. Where the risks are seen to be greater, sellers will generally have a preference for fixed-price contracts, as this allows them to lock-in a predictable revenue stream, which in turn can help to secure up-front project finance. Buyers however, may favour variable price arrangements, particularly given uncertainty in the post-2012 global carbon market and the non-guaranteed nature of volume flows.
- **Length of contracts:** Buyers typically prefer to sign ERPAs limited to the end of the project's first CDM crediting period (seven years before renewal). This is because projects must demonstrate their additionality after each crediting period in order to be eligible for CERs. Depending upon the buyer, additional timing considerations e.g. relating to the banking of EUAs under the EU ETS will also be important factors.
- **Eligibility and option clauses:** These are commonly included in ERPAs. In the first instance, ERPAs typically specify that CERs supplied must be eligible in the particular market at the time of delivery otherwise the buyer is under no obligation to offtake them; this basically allocates most of the risk to the CER seller. Also the buyer in an ERPA has an option or right of first refusal for either purchasing CERs in excess of any maximum delivery volume specified in the ERPA if any, or for periods beyond the agreed delivery period (e.g. post-2012 in the EU ETS context).

Although the specific circumstances of CDM projects will shape the form of the agreement reached between the contracting parties, market standards have been developed for ERPAs. Most carbon traders, and also independent specialist financial advisors and law firms are able to provide detailed advice on what to look out for and how best to negotiate a fair and reasonable agreement with a buyer.

6. REFERENCES AND RESOURCES

Carbon Sequestration Leadership Forum	www.cslforum.org
CCS Africa web pages	http://www.ccs-africa.org/
CO_2 Capture Project (industry-led CCS group)	http://www.co2captureproject.org
Global CCS Institute	www.globalccsinstitute.com
IEA Greenhouse Gas R&D Programme (IEAGHG)	www.ieaghg.org
IEAGHG – *CCS in the CDM reports*	http://www.co2captureandstorage.info/techworkshops/2007%20TR2CCS%20CDM%20methodology%20.pdf http://www.ieaghg.org/docs/general_publications/2008_13.pdf
IEA Model Regulatory Framework for CCS	http://www.iea.org/ccs/legal/model_framework.pdf
In Salah Gas CCS project (includes information on CDM methodology)	http://www.insalahco2.com
International Energy Agency (IEA) CCS pages, including *CCS Roadmap* and *Developing Country Roundtables*	http://www.iea.org/subjectqueries/cdcs.asp
International Performance Assessment Centre for CCS	www.ipac-co2.com
IPCC – *Special Report on CCS*	http://www.ipcc-wg3.de/publications/special-reports/special-report-on-carbon-dioxide-capture-and-storage
IPCC – 2006 *Guidelines for GHG Inventories*	www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
Masdar Carbon	http://www.masdar.ae/en/Menu/index.aspx?MenuID=48&CatID=13&mnu=Cat
Pontifícia Universidade do Rio Grande do Sul (CEPAC)	http://www.pucrs.br/cepac/index_e.php?p=sequestro_carbono
South African Centre for CCS (SACCS)	http://www.sacccs.org.za/
UK-China Near Zero Emissions Power Coal (NZEC) project	http://www.nzec.info/en/
UNEP Risoe CDM project database	http://cdmpipeline.org/

UNFCCC CDM web pages (contains detailed description of the CDM requirements, latest news and on-line database of projects and methodologies)	http://cdm.unfccc.int/
UNFCCC – *Draft Modalities and Procedures for CCS inclusion in the CDM*	http://unfccc.int/documentation/documents/advanced_search/items/3594.php?rec=j&priref=600006571&suchen=n
UNFCCC – *Synthesis of Party Views on Modalities and Procedures for CCS inclusion in the CDM*	http://unfccc.int/resource/docs/2011/sbsta/eng/inf07.pdf
UNIDO - *CCS Industrial Sector Roadmap for Developing Countries*	http://www.unido.org/index.php?id=1000821
White Tiger and Bintulu CDM submissions	https://cdm.unfccc.int/methodologies/PAmethodologies/pnm/byref/NM0167 https://cdm.unfccc.int/methodologies/PAmethodologies/pnm/byref/NM0168
World Bank – *State and Trends of the Carbon Market 2011*	http://siteresources.worldbank.org/INTCARBONFINANCE/Resources/StateAndTrend_LowRes.pdf
World Bank – Energy and CCS web-pages (information and reports relating to the World Bank CCS Programme and financing CCS deployment in developing countries)	http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTENERGY2/0,,contentMDK:22926556~pagePK:210058~piPK:210062~theSitePK:4114200,00.html