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## Synthesis of views on modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities

### Note by the secretariat

*Summary*

This note contains a synthesis of views submitted by Parties and admitted observer organizations on modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities. It has been prepared with a view to facilitate the conduct of a technical workshop and the drafting by the secretariat of modalities and procedures for consideration by the Subsidiary Body for Scientific and Technological Advice at its thirty-fifth session.

* Exact dates within the sessional period are subject to confirmation.

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# I. Introduction

## A. Background and mandate

1. The Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP), by its decision 7/CMP.6, decided that carbon dioxide ($CO_2$) capture and storage (CCS) in geological formations is eligible as project activities under the clean development mechanism (CDM), provided that the issues identified in decision 2/CMP.5 are addressed and resolved in a satisfactory manner.[1, 2]

2. Decision 7/CMP.6 also requested the Subsidiary Body for Scientific and Technological Advice (SBSTA), at its thirty-fifth session, to elaborate modalities and procedures for the inclusion of CCS as project activities under the CDM, with a view to recommending a decision to the CMP at its seventh session. This decision continued in its paragraph 3 by outlining a specific list of issues to be addressed in the modalities and procedures that could serve to resolve the issues raised in decision 2/CMP.5.

3. Parties and admitted observer organizations were invited by decision 7/CMP.6 to submit to the secretariat, by 21 February 2011, their views on how the issues referred to in paragraph 3 of the decision can be addressed in the modalities and procedures and requested the secretariat to prepare a synthesis report based on the submissions.[3]

4. Decision 7/CMP.6 further requested the secretariat to conduct a technical workshop with technical and legal experts, after the thirty-fourth session but prior to the thirty-fifth session of the SBSTA, to consider the submissions and this synthesis report, and to discuss how the issues referred to in decision 7/CMP.6, paragraph 3, can be addressed in modalities and procedures.

5. In addition, decision 7/CMP.6 requested the secretariat to prepare draft modalities and procedures, based on the submissions and the technical workshop. These draft modalities and procedures are to be prepared by the secretariat after the technical workshop, for consideration by the SBSTA at its thirty-fifth session.

## B. Scope of the note

6. This note presents a synthesis of the views submitted by Parties and admitted observer organizations in response to the invitation contained in decision 7/CMP.6 regarding how the issues referred to in paragraph 3 of that decision can be addressed in modalities and procedures for the inclusion of CCS under the CDM. In the interest of

[1] For the purpose of this document, all references to CCS shall refer to carbon dioxide ($CO_2$) storage in geological formations.

[2] Decision 2/CMP.5, paragraph 29, specified the following issues: 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.

[3] The submissions by Parties are contained in document FCCC/SBSTA/2011/MISC.10. A list of the admitted observer organizations that made submissions is contained in document FCCC/SBSTA/2011/MISC.11 and the submissions themselves are published on the UNFCCC website (those of intergovernmental and non-governmental organizations are available at: <http://unfccc.int/parties_observers/igo/submissions/items/3714.php> and those of non-governmental organizations may be found on <http://unfccc.int/parties_observers/ngo/submissions/items/3689.php>.

presenting a comprehensive document to support the work of Parties, some information has been drawn from earlier submissions and synthesis reports on this issue.[4]

# II. Synthesis approach

7. Whereas decision 2/CMP.5 sets out the issues that need to be resolved, the more specific issues outlined in decision 7/CMP.6 may be interpreted as requirements that must be met in order to resolve the issues that were raised in decision 2/CMP.5 in a satisfactory way. This approach is consistent with the need, when addressing any policy issue, to first identify which issues need to be considered and subsequently to determine what should constitute an acceptable standard to be reached. Such requirements may then guide the elaboration of specific regulations, in this case the modalities and procedures for the inclusion of CCS under the CDM.

8. While they are broadly consistent with each other, the lists of issues provided by these two decisions are structured differently and are not easily mapped together. However, the following six groupings of technical and legal issues may be identified from the lists and from the views contained in the submissions, and have been used to structure this synthesis report:

(a) **Site selection**. Approaches to site selection in designing CCS projects, steps and criteria for site selection, and the role of modelling in site selection;

(b) **Project boundaries and accounting for greenhouse gas emissions**. Approaches to defining project boundaries, including the role of modelling in setting project boundaries in the subsurface, and methodological aspects of robust emissions accounting inside and outside of the defined project boundaries;

(c) **Transboundary issues**. Approaches for addressing the movement of $CO_2$ from one jurisdiction to another or its transfer across multiple jurisdictions;

(d) **Risk, safety and socio-environmental assessment**. Approaches for assessing and addressing risk in CCS projects;

(e) **Monitoring**. Approaches for monitoring the design of monitoring plans and techniques that can be used to monitor storage sites, the interaction between modelling and monitoring, and the way in which the criteria for monitoring plans may be set;

(f) **Permanence and liability**. Approaches for managing the permanence of the stored $CO_2$ and for determining liability in cases of non-permanence or seepage over the short, medium and long term.

9. Annex I indicates the way in which issues from decision 2/CMP.5 and requirements from decision 7/CMP.6 may be mapped against the six groupings of technical and legal issues listed in paragraph 8 above. This annex, therefore, acts as a guide as to how the issues and requirements have been organized within the structure of this synthesis. In particular, chapter III addresses the views contained in the submissions on each of the technical and legal issues, as well as the possible approaches proposed for their resolution, in the order given in paragraph 8 above.

10. Chapter IV contains views from the submissions on how these technical and legal approaches may be translated into modalities and procedures. Many submissions suggest that the existing CDM modalities and procedures, as contained in decision 3/CMP.1, should apply as much as possible to CCS projects, with changes or additions only being made

[4] See in particular the following documents: FCCC/SBSTA/2008/INF.1 and FCCC/SBSTA/2008/INF.3.

where necessary (a mutatis mutandis approach). Consistent with these views, the structure of chapter IV follows the existing CDM modalities and procedures. At this stage, the views contained in the submissions do not necessarily cover all approaches to technical and legal issues. Nevertheless, the possible structure of future modalities and procedures on this issue is already starting to become apparent.

11. The nature of the concerns regarding CCS under the CDM, as reflected in decisions 2/CMP.5 and 7/CMP.6, is complex, with the issues involved being interlinked. The same is true for any modalities and procedures that are to satisfactorily resolve the wide range of issues raised. In considering this synthesis, it is worthwhile noting that technical and legal issues will typically need to be addressed through a range of possible provisions in multiple areas of the modalities and procedures. This may be illustrated by the following examples of concerns expressed in the submissions as needing to be addressed:

(a) **Concerns relating to the management of permanence and liability**. The risk that stored $CO_2$ may leak and re-enter the atmosphere may be addressed through provisions relating to, inter alia, site selection, project boundaries and accounting, monitoring, the use of models, risk assessment, and the allocation of liability;

(b) **Concerns relating to "perverse outcomes"**. This term covers a number of issues mentioned in submissions in relation to CCS under the CDM, including increases in emissions from the energy needed to capture $CO_2$ or from any increases or changes in the consumption of hydrocarbons as a result of using $CO_2$ for enhanced oil recovery ($CO_2$-EOR); possible long-term impacts on building a sustainable energy infrastructure; reducing requirements on Parties included in Annex I (Annex I Parties) to reduce emissions domestically; and any "crowding out" of other CDM project types by CCS projects. These concerns may be addressed through provisions relating to, inter alia, project boundaries, baseline methodologies, minimum standards for project types, or restrictions on the use of certified emission reductions (CERs) for compliance;

(c) **Concerns relating to national processes and institutional capacity**. Many submissions raised the need for national processes and capacity regarding various aspects of the CCS project cycle, such as regulating site selection, risk assessment, monitoring and liability. These concerns may be addressed through, inter alia, setting requirements that Parties must meet before hosting CCS projects, in particular the passing of appropriate national legislation. More generally, this raises an issue of the appropriate balance between setting requirements at the international level, in particular through the CMP, versus setting them at the national level.

12. Many references to external publications are provided in the submissions. These have been compiled in annex II and arranged in order of the technical and legal issues outlined in paragraph 8 above.

# III. Approaches to technical and legal issues

## A. Site selection

13. Various submissions characterize the objective of site selection to be the process of determining the suitability of a geological formation for use as a storage reservoir. On this basis, many Parties and observers agree that site selection and site characterization are critical for ensuring safe and secure long-term storage of $CO_2$. Submissions suggest that well selected, designed and managed storage sites can minimize the risk of seepage and support the long-term permanence of $CO_2$ storage.

14. Accordingly, there is broad agreement in the submissions that stringent and robust **site selection criteria** need to be developed. Submissions generally support the requirement set out in decision 7/CMP.6, paragraph 3(d), that such criteria need to be decided upon by the CMP, drawing on relevant guidelines by international bodies such as the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (2006 IPCC Guidelines).

15. The site selection criteria would guide the site selection and characterization for $CO_2$ storage under the CDM. The criteria would also provide the basis on which the various institutions involved in assessing and approving projects would function (see chapter IV).

16. Many submissions contain criteria of a technical nature that may be condensed as follows:

(a) *Cap rock/seal*: The presence of a high integrity sealing cap rock and confining unit that will not facture under the proposed conditions of use (e.g. based on estimated reservoir pressure during operation);

(b) *Capacity/volume and injectivity*: The presence of adequate capacity/volume and injectivity within the storage reservoir (e.g. based on the expected total volume of $CO_2$ to be stored across the whole life of the project (capacity/volume) and the rate at which the $CO_2$ will be delivered on an hourly/daily basis (injectivity));

(c) *Potential seepage pathways*: The presence of potential seepage pathways such as wells (existing or abandoned), mineshafts, boreholes, and faults and fissures;

(d) *Geological stability*: The existence of a sufficiently stable geological environment to avoid compromising the integrity of storage (e.g. based on historic data on seismic activity in the proposed storage region);

(e) *Environmental and economic factors*: The presence of potable water sources that could potentially be contaminated by $CO_2$ seepage, and/or the presence of valuable resources that could be utilized in the future which could potentially compromise storage integrity.

17. A number of submissions build upon such technical criteria by calling for site selection criteria of a more policy-oriented nature, in particular that:

(a) All available evidence (e.g. data and analysis) should indicate that the $CO_2$ in question will be completely and permanently stored such that, under the proposed conditions of use, no significant risk of either seepage or risk to human health and contamination of the environment exists (in this context, one submission suggests that “significant risk” requires definition);

(b) Storage sites should not be located in international waters;

(c) Storage sites that are suitable for other purposes (e.g. potable water supply) should not be selected;

(d) Storage sites should not affect the development of renewable energy sources.

18. One submission suggests that a geopolitical analysis should be included to assess the potential for political unrest to disrupt the project activities and compromise the storage integrity.

19. Several submissions suggest the need for flexibility in developing site selection criteria in order to accommodate a variety of site conditions. Some submissions suggest that the criteria should be performance-based such that they require certain outcomes and allow for these to be achieved through a range of technical methods. This would allow for specific technical approaches to be tailored on a site-by-site basis. Several submissions suggest that criteria adopted by the CMP should form the basis for standards to be set in

national legal and regulatory frameworks for CCS in host countries or that specific requirements should be approved by designated national authorities (DNAs).

20. Several submissions highlight the **steps necessary to assess performance against site selection criteria**. Some submissions refer to the detailed approaches to site selection under existing legislation, in particular the approaches under the European Union (EU) CCS directive[5] and the United States of America (US) Safe Drinking Water Act.[6] The information in these submissions, taken collectively, suggests the following sequence of steps could be followed to determine whether a location meets the site selection criteria:

(a) *Step 1: Data and information collection, compilation and evaluation.* This step would collect sufficient data to characterize the reservoir and determine potential seepage pathways. Data at this stage also needs to be evaluated to make a preliminary assessment of the site's storage capacity and to assess the viability of monitoring. One submission highlights that the data would need to be evaluated for its quality and any gaps identified in it in order to recommend where new data acquisition is required;

(b) *Step 2: Characterization of the reservoir architecture and surrounding domains*. This step would include the assessment of known and inferred structures within the reservoir and cap rock that would act as barriers to or facilitators of the migration of injected $CO_2$. It is also likely to involve further analysis of active seismic data and evaluation of changes in the reservoir that have accompanied previous production of hydrocarbons from the reservoir, if applicable. Both the US EPA Final Rule and the EU CCS directive specify the building of computational three-dimensional static earth model(s) at this step, which may be used to determine the structure of the geological trap, various geological properties of the reservoir, cap rock and overburden, the fracture system, the areal and vertical extent of the storage "complex" or "area of review" (i.e. storage formation, cap rock formation, overburden , secondary containment zones, and surrounding domains), pore space volume, baseline fluid distribution and other relevant characteristics. It would be necessary at this step to assess the uncertainty associated with key parameters used to build the model;

(c) *Step 3: Characterization of dynamic behaviour, sensitivity characterization and risk assessment.* This step would include the assessment of how the injected $CO_2$ can be expected to behave within the reservoir architecture and surrounding domains, with a particular focus on the risk of seepage. The EU CCS directive and US EPA Final Rule foresee this step as being heavily dependent on dynamic modelling to assess coupled processes (i.e. interaction between each single process in the model); reactive processes (i.e. interaction of injected $CO_2$ with in situ minerals in the model); the reservoir simulator used, and short and long-term simulations. Such modelling provides insight into the pressure and extent of $CO_2$ in the formation over time, the risk of fracturing the cap rock, and the risk of seepage. It would also be necessary at this stage to conduct multiple simulations to identify the sensitivity of the assessments to assumptions and to conduct a rigorous risk and safety assessment;

(d) *Step 4: Site management plan.* Several submissions note the importance of establishing a site management plan in conjunction with the site selection process. In this context, it is noted that good site management is integral to the permanence of storage. The

[5] Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 (EU).

[6] United States Environmental Protection Agency. 2010. Federal Requirements under the Underground Injection Control (UIC) Program for Carbon Dioxide ($CO_2$) Geologic Sequestration (GS) Wells, Final Rule, 75 Fed. Reg. 77230 (10 December 2010) (US EPA Final Rule).

plan would need to address, inter alia, preparation of the site, well construction (e.g. materials used, and the location, trajectory and depth of the well), operating and maintenance programmes, monitoring, and the timing and management of the end of storage project (including site closure and post-closure activities).

21. A wide range of data and information would need to be collected as part of step 1, as outlined above, and utilized at each further step. Such data and information would include:

(a) *Geological information*. The compilation of information covering, inter alia, descriptions of the geological units above and within the reservoir, locations of mapped faults, location of existing wells and wellbore trajectories, and information about regional tectonics including the stress field and historical seismic activity;

(b) *Geophysical information*. The compilation of information covering, inter alia, the thickness and lateral extent of cap rock, existence of faults, and reservoir heterogeneity. Sources of data include well logs, sonic logs and three-dimensional seismic surveys;

(c) *Geomechanical information*. The compilation of information covering, inter alia, the stress state within the reservoir and the cap rock, as well as the rock fracture pressure in both the cap rock and reservoir. Sources of data include borehole data, such as breakouts inferred from caliper and televiewer logs, minifrac results, information about anisotropy within the reservoir, and mud loss events;

(d) *Geochemical information*. The compilation of information covering, inter alia, information on rock and fluid properties. Rock properties include permeability, porosity and mineralogy, which are important in determining reservoir injectivity and cap rock containment capacity. Fluid properties such as brine salinity should also be used to determine dissolution trapping rates;

(e) *Hydrogeologic information*. The compilation of information covering, inter alia, aquifer characteristics and aquifer flow direction and rates.

22. The **role of modelling** is identified in many submissions as important, or even essential, in assessing potential sites and predicting the behaviour of $CO_2$ injection, storage, plume movement and trapping. These submissions view modelling as playing a key role in assessing the capacity of a geological formation to meet the required criteria. Some submissions raise a general concern about the limitations of modelling, but it is noted that this is expressed in the context of monitoring where it is seen as necessary to ensure that direct measurement has a primary place in the monitoring of emission reductions and seepage.

23. Some submissions suggest that models involved in site selection should build on experience from the petroleum industry and other industries. One submission notes the need for models to be continuously improved, and suggests that the sharing of lessons between projects should be encouraged. It is also mentioned in various submissions that a CCS project developer should be required to demonstrate that he or she has taken into account available “good practices” in site selection.

24. Several submissions note the importance of making information on projects available to the public and stakeholders, and ensuring their involvement in the decision-making process, including local communities and indigenous people.

## B. Project boundaries and greenhouse gas emission accounting

25. There is broad agreement within the submissions that project boundaries are important in determining the emission sources that need to be monitored and accounted for within a CCS project under the CDM, in the same way as they are for other CDM project

types. In addressing the **elements of CCS projects that would need to be included** within a project boundary, the submissions generally reiterate the requirement set out in decision 7/CMP.6 that CCS project boundaries should include all above-ground and underground installations and storage sites, as well as all potential sources of $CO_2$ that can be released into the atmosphere. The submissions note that boundaries should include the full chain of CCS activities, covering capture, treatment, transport, injection and storage of $CO_2$.

26. Several submissions provide additional detail on the components that would need to be included within a project boundary for a CCS project under the CDM, including:[7]

(a) *Above-ground components*. This would include the installation where the $CO_2$ is generated, the capture facility, any additional $CO_2$ treatment facilities, the compression facility, the transportation equipment and booster stations along a pipeline or offloading facilities in the case of transportation by ship, any reception facilities or holding tanks at the injection site, and the injection facility. It is suggested in several submissions that these components present similar technical elements to any other CDM project activity, meaning that emissions from these components can be calculated using similar techniques and approaches as applied in other CDM project activities;

(b) *The $CO_2$ storage formation*. Site characterization and storage performance assessment studies carried out in advance of $CO_2$ injection operations should define the boundary for the storage site. It is highlighted in one submission that the boundaries for this component are subject to temporal changes as injection continues and that the $CO_2$ plume in the subsurface migrates and increases in volume. It is also noted that this could include several plumes if multiple injection wells are located within one project;

(c) *Subsurface components and all other potential direct pathways that may lead to seepage or physical leakage*. This would include injection wells, observation and abandoned wells, mineshafts and boreholes. These potential seepage pathways would need to be monitored as part of the overall project monitoring plan. It is also noted in several submissions that pathways for seepage would need to include dissolution in underground water and “other fluids”;

(d) *The geology surrounding the storage site*. This would include cap rock or spill points at the lateral edges of a geological structural trap. In this context, it is noted that the subsurface boundary would need to be larger than the volume of the storage reservoir to include potential secondary containment features and potential migration and seepage pathways from the storage site.

27. Many submissions suggest that the project boundary can be determined from the site characterization and risk and safety assessment (see chapters III.A and III.D, respectively). It is also noted that the project boundary plays an important role in establishing the scope of the monitoring plan. In this context, one submission suggests that, in the event of $CO_2$ moving outside of the predefined project boundary, the monitoring plan and risk and safety assessment would need to be reviewed.

28. Additional points raised in submissions in relation to project boundaries include:

(a) The above-ground emission sources may not be included in the project boundary once the capture and injection components of the project cease;

(b) There may be a need to establish temporal boundaries.

29. One submission suggests that the CMP should set appropriate criteria and a definition for the project boundary. Several submissions suggest that criteria for evaluating

[7] The list below includes previous views of Parties and observers, as outlined in document FCCC/SBSTA/2008/INF.1, paragraph 45.

whether an accurate physical boundary has been established for a project should be developed and updated over time.

30. Some submissions express views regarding the **role of modelling** in determining the boundaries for the subsurface components of a project boundary, with one submission specifically referring to the role of spatial and temporal computational assessment in determining the $CO_2$ plume boundary based on the use of reservoir simulation models.[8] On this point, several submissions suggest that there is some inherent uncertainty in the modelling techniques used to delimit a project boundary, with some submissions highlighting that flexibility in boundary setting would be necessary due to the uncertain nature of potential $CO_2$ migration pathways and the need to accommodate a range of storage types and different geological conditions. In this context, many submissions express support for a dynamic process of project boundary setting.

31. With regard to the **accounting of emissions** in relation to CCS projects, submissions note that the project accounting should take into account:

(a) Fugitive emissions (e.g. leaks from pipelines or releases during ship loading and unloading);

(b) Emissions resulting from the direct and/or indirect use of electricity and other energy sources required for the project, also taking account of the increased energy use (or "energy penalty") associated with capturing $CO_2$;

(c) Potential seepage.

32. One submission went further by suggesting that such emissions should be accounted for and subtracted from the amount of $CO_2$ stored. Another mentions that a decision will need to be made regarding accounting for the life cycle emissions for a CCS project including, for example, upstream greenhouse gas emissions associated with mining and transporting coal and other inputs into the industrial site, with one submission proposing that these should be included within the accounting method for CCS projects. It is also mentioned in several submissions that the 2006 IPCC Guidelines provide a comprehensive approach to accounting for project emissions from CCS activities.[9]

33. In the context of potential perverse outcomes, some submissions suggest that emissions associated with $CO_2$-EOR should be included in the accounting of emissions. This would relate to any increase in emissions from the combustion of the additional hydrocarbons brought to the surface, any breakthrough of injected anthropogenic $CO_2$ at extraction wells and additional energy used in the hydrocarbon recovery operation.

34. One submission notes that the capture, transport and storage of $CO_2$ may result in less energy being available for consumption than if a non-CCS technology were used, and as such suggests that project proponents should implement renewable energy or energy efficiency measures to compensate for the additional energy needed. The submission holds that this would also counter a tendency in CCS projects to increase the dependency on fossil fuels in the power generation mix. Such a requirement would need to be accounted for in any methodological approaches adopted, with the renewable energy or energy efficiency measures also being potentially included within the project boundary. On a similar note, and building on the potentially perverse outcome of incentivising less efficient

[8] The US EPA Final Rule on Class VI injection wells refers to an "area of review" which in essence is the same as a project boundary. It requires the use of modelling during site characterization to determine the initial area of review.

[9] Significantly more detail on the types and sources of greenhouse gas emissions from CCS projects, with reference to the 2006 IPCC Guidelines, are included in previous synthesis reports, in particular document FCCC/SBSTA/2008/INF.1, paragraph 13, 15, and 47–52.

plants to capture $CO_2$, one submission suggests that only the most efficient plants should be used for CCS.

## C. Transboundary issues

35. Many submissions refer to the 2006 IPCC Guidelines as a key source to use when identifying the types of **transboundary scenarios** that could occur in CCS projects involving more than one country. Based on this, and the views expressed in submissions, three types of transboundary scenarios can be identified and summarized as follows:[10]

(a) The possibility of transporting $CO_2$ that is captured in one country to another for storage;

(b) The possibility of migration or seepage of the injected $CO_2$ into the underground or the atmosphere of another country;

(c) The sharing of a storage reservoir located within more than one country.

36. The **consequences of such scenarios** relate to, inter alia, potential violation of international law, the potential for cross-border disputes, the attribution of liability for any seepage emissions that might occur, and longer-term liability for abandoned storage reservoirs. These issues should also be considered alongside views on the criteria for site selection, as highlighted above (e.g. regarding projects in international waters).

37. In terms of **approaches to managing transboundary issues under the CDM**, a range of views are expressed in submissions. The majority of submissions suggest that they either do not have any specific objections to transboundary projects per se and/or indicated that they considered that transboundary projects should be allowed within the CDM. However, the submissions highlight that such projects should only be allowed subject to a range of governance needs being agreed between all Parties involved prior to project initiation. Some submissions also state that, in practice, there may be relatively few transboundary projects because of their belief that most CCS projects will be contained well within the national borders of one host Party.

38. The governance needs raised in submissions for transboundary projects include:

(a) That joint approval of the project boundary has been reached, typically involving the DNAs of the respective Parties;

(b) That the host Parties have established measures to identify and address any potential seepage pathways;

(c) That legal and regulatory regimes have been put in place by all host Parties involved;

(d) That effective accounting for any seepage emissions is established (many submissions suggest this should follow approaches outlined in the 2006 IPCC Guidelines) and the allocation of any liabilities in the post-closure, post-crediting period of the project (see chapter III.F) has been determined;

(e) That procedures for verification of the amount of $CO_2$ stored, as well as remediation, are established;

(f) That the application to register the project under the CDM should be required to include a clearly defined and agreed liability between the involved host Parties.

[10] See also: views outlined the previous synthesis report(s) on this matter, in particular FCCC/SBSTA/2008/INF.1, paragraph 64.

39. On the question of whether to include transboundary projects within the CDM immediately, submissions express varying opinions:

(a) One submission disagrees with the immediate inclusion of transboundary projects within the CDM, suggesting that these should only be allowed after more experience is gained with CCS projects and that, in the early phases of projects, project proponents should demonstrate that there are no transboundary effects associated with their project. Another submission suggests that, while it has no objections to transboundary projects, it would be preferable that priority be given to projects that fall under a single national border;

(b) Alternatively, one submission notes that similar provisions concerning transboundary projects are included under the EU CCS directive and have been proposed under the *London Protocol: Risk Assessment and Management Framework for $CO_2$ Sequestration in the Subsea Bed and the Related Injection Guidelines* (London Protocol: Risk Assessment and Management Framework Guidelines) and suggests their use as models, while another submission suggests that transboundary CCS projects should be accepted in a manner which is consistent with existing CDM rules and practices;

(c) Another submission suggests the importance of an enabling environment to be put in place for bilateral and multilateral cooperation to commence across boundaries, as it notes that it would take some time before domestic regulators would become interested in and capable of collaborating on a CCS project.

40. On the issue of transboundary transport of $CO_2$, one submission notes that international law frameworks are often in place in developing countries in relation to, inter alia, waste transport and management, marine pollution, liability for transboundary impacts and nature conservation, and that projects would need to be consistent with both domestic legislation and relevant international law applicable in those jurisdictions.

## D. Risk, safety and environmental impacts, and socio-environmental assessment

41. The main types of risk, safety and environmental impacts of CCS projects, as identified in submissions, include:

(a) Damage to the environment and ecosystem health due to, inter alia:

(i) Emissions to the air and associated pollution (e.g. sulphur oxides, nitrogen oxides, dust and mercury);

(ii) Solid waste generation;

(iii) Water consumption;

(iv) Noise and vibration;

(b) Specific risks associated with $CO_2$ containment failure resulting in leaks from both above-ground and subsurface installations;

(i) Contamination of underground sources of drinking water;

(ii) Affects on the chemical properties of seawater;

(iii) Human health and safety and ecosystem damage associated with accumulations of $CO_2$ at dangerous levels in non-turbulent air.

42. The risk of continuous slow seepage or sudden mass release of $CO_2$ from storage sites can arise as a result of the buoyancy and pressure associated with injected $CO_2$.

Submissions highlight a number of scenarios that could arise, drawing on the *2005 IPCC Special Report on Carbon Dioxide Capture and Storage*,[11] including:[12]

(a) Seepage along injection well(s) or an abandoned well(s);

(b) Seepage along a fault or fracture;

(c) Seepage along storage formation stratum;

(d) Seepage through the caprock.

43. Other types of risk identified in submissions include risks associated with potential leaks from $CO_2$ pipelines located in densely populated and/or ecologically sensitive areas and risks to the integrity of measurement, verification and reporting.

44. Views in the submissions differ on the viability of assessing and managing all the risks associated with CCS projects. The majority of submissions suggest that the risks and safety concerns posed by CCS can be addressed. One submission cites the *2005 IPCC Special Report on Carbon Dioxide Capture and Storage*, which states that: "Observations from engineered and natural analogues as well as models suggest that the fraction [of stored $CO_2$] retained in appropriately selected and managed geological reservoirs is very likely [90–99 per cent] to exceed 99% over 100 years and is likely [66–90 per cent] to exceed 99% over 1,000 years".[13] One submission notes that general experience with underground injection of $CO_2$ for EOR indicates that the operational risks of worker exposure to $CO_2$ can be managed with existing industry best practice for workplace safety, although it also notes that health and safety over the long term must also be considered. Other submissions highlight that there are international standards such as ISO 31000 that can be followed for conducting risk assessments.

45. Other submissions raise concerns about whether the risk and safety challenges posed by CCS can be met, adding that there are no reliable precedents for environmental impact assessment on the full cycle of a CCS project in developing countries and suggesting that it would be very challenging to undertake such an assessment. One submission suggests that there are unresolved issues related to, for example, the absence of host country regulation and capabilities to implement CCS, the lack of experience with environmental impacts of $CO_2$ seepage, the long timescale after which the impact could arise, and the absence of recognized international guidelines on how the assessment is to be carried out.[14]

46. A wide range of **specific objectives and components of risk assessment and management** are highlighted in submissions, including that risk and safety assessments should:

(a) Cover the full CCS chain and its environs;

(b) Provide assurance of safe operational integrity and the containment of $CO_2$, based on site-specific information about the reservoir, potential seepage pathways, and secondary effects of storing $CO_2$ (e.g. brine migration);

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[11] 2005 IPCC SRCCS. Metz, B, Davidson, O, de Coninck, HC, Loos, M, and Meyer, LA (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.

[12] A range of potential seepage pathways has been highlighted previously by Parties and Observers as outlined in document FCCC/SBSTA/2008/INF.1, paragraphs 13–16.

[13] See also: document FCCC/SBSTA/2008/INF.1, paragraphs 88–92, and document FCCC/SBSTA/2008/INF.3, paragraphs 61–64.

[14] Specific risks regarding seepage are outlined in document FCCC/SBSTA/2008/INF.3, paragraphs 14–15.

(c) Be fully integrated with selection procedures for storage sites, proposed site management, and monitoring;

(d) Be used to determine operational data, such as to set the appropriate injection pressure that will not compromise the confining geological units (e.g. the cap rock and the "storage complex");

(e) Take account of the effects of potential induced seismicity, or geological and any other potential consequences for the environment (both local ecosystems and the global climate), on property, public health or global effects to the climate directly attributable to the CDM project activity during and beyond the crediting period;

(f) Be used to help prioritize locations and approaches for enhanced monitoring activities;

(g) Provide a basis for remediation and corrective measures, including plans for responses that can stop or control any unintended $CO_2$ release if unexpected events occur. Such measures and plans should accompany monitoring plans (see chapter III.E);

(h) Include modelling of potential climatic impacts from the massive and catastrophic release of $CO_2$;

(i) Take account of impacts on people's living conditions in the potentially affected areas, regardless of any administrative frontiers;

(j) Include the performance of dynamic risk management and mitigation procedures;

(k) Include a quantitative approach to assessing uncertainty (quantitative risk assessment);

(l) Include a communication plan.

47. One submission, drawing on the EU CCS directive, highlights that a **sequence of steps in risk and safety assessment** could be built around the following:

(a) *Step 1: Hazard characterization.* This should include: potential seepage pathways; the potential magnitude of leaks for identified pathways; critical parameters affecting potential leakage such as the maximums of reservoir pressure, injection rates and temperature; the sensitivity to various assumptions made during modelling; and any other factors which could pose a hazard to human health and the environment;

(b) *Step 2: Exposure assessment.* This should be based on the characteristics of surrounding populations and ecosystems, and the potential fate and behaviour of any seeped $CO_2$, and other factors;

(c) *Step 3: Effects assessment.* This should be based on the sensitivity of species, communities or habitats linked to potential seepage events identified during the hazard characterization (e.g. effects of elevated $CO_2$ concentrations on the biosphere and effects on seawater chemistry);

(d) *Step 4: Risk characterization.* This should comprise an assessment of the safety and integrity of the storage site in the short and long term, including an assessment of the risk of seepage under the proposed conditions of use.

48. With regard to risks associated with pipelines, one submission suggests that possible risk mitigation measures include the decreased spacing of main line valves, greater depths of burial, and increased frequency of pipeline integrity assessments and monitoring for leaks.

49. One submission suggests that risk and safety assessments should be updated periodically every three years throughout the project life cycle, based on an updated monitoring plan and revised models and simulations (see paras. 60 and 65), and taking into account knowledge and research gathered from other operating storage sites. Another submission suggests that, during the closure phase of a project, a final risk assessment should be carried out to establish that the risk levels are acceptable before responsibility for the storage site is transferred to the host country.

50. A number of submissions suggest that all relevant information in the risk and safety assessment and the socio-economic impact assessment should be made public to enable public participation in the decision-making process. In addition, some submissions indicate that risk assessment should be an ongoing activity, and should be reported on regularly.

51. Recognizing the requirement set out in decision 7/CMP.6, paragraph 3(j), a range of views are expressed in submissions regarding the integration of appropriate risk management approaches with the CDM. Views expressed include the following:

(a) That risk and safety assessment should be part of the Environmental Impact Assessment (EIA), which is already required by the CDM modalities and procedures. Some submissions also suggest that because EIAs should be performed on a case-by-case basis, it would not be necessary to provide methodological guidance;

(b) That a risk and safety assessment should be part of a socio-environmental impact assessment;

(c) That it is not necessary for the risk, safety, environmental and/or social impact assessment to be undertaken by an independent entity;

(d) That any CCS risk and safety assessments should be carried out by independent assessors with sufficient expertise in that field.

## E. Monitoring

52. There is broad agreement among the views submitted that all operational phases of a CCS project must be monitored for potential seepage. This would include above-ground activities ($CO_2$ capture and transportation) and injection activities. It would extend throughout the project life cycle and through the post-closure phase, including after the crediting period under the CDM has ended. Some submissions suggest further that the requirement for monitoring could cease when evidence demonstrates that the site has achieved long-term stability (see chapter III.F).

53. The **objectives of monitoring** outlined in submissions, in particular for subsurface monitoring, would include:

(a) To provide assurance over the environmental integrity and safety of CCS;

(b) To measure emissions associated with the capture and transport of $CO_2$;

(c) To confirm that $CO_2$ stored underground is permanently stored within the geological formation of the agreed site and within the agreed project boundary;

(d) To ensure good site management is taking place;

(e) To detect any seepage or contamination, as well as impacts on surrounding populations and ecosystems;

(f) To estimate the flux of $CO_2$ released to the atmosphere or hydrosphere in the event of a release being detected.

54. There is broad agreement in the submissions generally that storage operations need to be continually monitored against the site management plan for the duration of the CCS project activity. Several submissions make reference to different phases of monitoring of the subsurface covering: pre-injection monitoring, monitoring during operations, and post-injection monitoring.

55. **Aspects that should be monitored**, as highlighted in submissions, include:

(a) The $CO_2$ stream composition, including impurities;

(b) The quantity of the $CO_2$ stream delivered and injected;

(c) Temperature and pressure at the top and bottom of the injection well(s);

(d) Various geological, geochemical and geomechanical aspects (e.g. fluid pressures, displaced fluid characteristics, fluxes, and the microseismicity of the site);

(e) Surface monitoring of $CO_2$ concentrations in the air;

(f) All potential seepage pathways;

(g) Detection of corrosion or degradation of the injection facilities;

(h) The effectiveness of any corrective measures taken.

56. Other items raised in submissions regarding the design of monitoring plans include:

(a) It should encompass and incorporate all the site specific issues identified during site selection, and risk and safety assessment;

(b) A baseline measurement of the reservoir should be carried out before any $CO_2$ is injected;

(c) Numerical modelling must be applied against which monitoring data can be compared during project implementation.

57. A number of submissions highlight that, because of the variety of potential geological storage reservoirs, monitoring plans and techniques will most likely need to vary across CCS projects, such that a prescriptive approach to monitoring should be discouraged. Building on this view, the majority of submissions highlight that a range of different **monitoring techniques** will be required according to the type of reservoir being used to store $CO_2$. For example, monitoring under the seabed requires different techniques than the monitoring of onshore geological storage. The types of subsurface monitoring techniques that may be applied to CCS projects, as outlined in submissions, include:

(a) Active seismic measurements ranging from cross-well, to vertical seismic profiling, to four-dimensional surface seismics;

(b) Passive seismic measurements, including measurements that rely on induced seismicity;

(c) Geodetic measurements, including data from existing or newly deployed Global Positioning System stations and Interferometric Synthetic Aperture Radar surveys;

(d) Time-lapse microgravity and/or gradiometry measurements;

(e) Electrical resistance tomography.

58. In terms of the **design of a monitoring plan**, several submissions highlight that it should include details of the parameters to be monitored and data to be collected, recorded and reported; the monitoring techniques to be employed; the frequency of the monitoring; and it should take account of transparency and security of the monitoring data. Many of the submissions also recommend that decisions on the appropriate monitoring methods should

be integrated with the storage site selection and site management plan. Several submissions refer to the approach to design of a monitoring plan outlined in the EU CCS directive, annex II. This covers several steps including:

(a) *Step 1: Establishing the plan.* This should include parameters monitored, techniques employed, locations and spatial sampling rationale, the frequency of application, and a range of other criteria;

(b) *Step 2: Updating the plan.* This should include aspects described in paragraphs 60 and 65 below.

59. Several submissions suggest it would be useful to allow or require project proponents to adapt their site management and monitoring plans in response to the observed behaviour of the stored $CO_2$, as determined through monitoring (as per step 2 in para. 58(b) above).

60. Several views are put forward in the submissions regarding the **frequency** with which monitoring plans should be updated (as per step 2 in para. 58(b) above), ranging from yearly to at least every three or five years, but not less frequently than every ten years. It is suggested that updates also need to incorporate changes to the assessed risk of seepage, changes to the assessed risk to human health and the environment, new scientific knowledge, and improvements in best available technology.

61. Many submissions highlight that this type of approach is consistent with that outlined in the 2006 IPPC Guidelines, the US EPA Final Rule, the EU CCS directive, and industry best practice.[15] Another highlights the difficulty of applying tier 3 methodologies to CCS as outlined in the 2006 IPCC Guidelines.

62. In considering the way in which criteria for monitoring plan design might be set down, the following views are expressed:

(a) Several submissions suggest that monitoring and modelling practices are compatible with the current modalities and procedures for the CDM;

(b) Other submissions suggest that monitoring plans should be designed using the criteria elaborated by the UNFCCC secretariat or the CMP. One submission suggests that criteria should be performance-based rather than being prescriptive of specific methods. Several submissions also mention the need for criteria to be established by the CMP regarding the point at which monitoring of a specific project could cease;

(c) One submission suggests that monitoring plans should be approved by the DNAs, and that these national plans could include additional criteria added to a set of criteria at the international level, and that a designated operational entity (DOE) with appropriate expertise could assess such plans to ensure that any international criteria were met.

63. Submissions highlight that monitoring methods already partially exist in industrial practices, as well as in the 2006 IPCC Guidelines and the London Protocol: Risk Assessment and Management Framework Guidelines.

64. Regarding the **role of modelling**, it is highlighted in many of the views put forward that this is closely interrelated with the performance monitoring of CCS projects. One submission holds that models can be used to simulate the expected behaviour of $CO_2$ in an underground reservoir but cannot make perfect predictions as they simplify the characteristics of the reservoir. On the other hand, as suggested by the submission,

[15] Both the US EPA Final Rule and the EU CCS Directive, mentioned in various submissions, require updates to be no less than every five years.

monitoring gives real information about the behaviour of the $CO_2$ in the reservoir during injection but has no predictive power.

65. Therefore, based on this approach, most submissions recommend using monitoring results to calibrate models of the subsurface, and use the results to update the models. This can help achieve various aspects of good project management, including assessing the suitability of modelling work undertaken previously and adjusting models in the event of large deviations. As highlighted in one submission, this allows the model to reflect not just predictions, but also the real behaviour of the $CO_2$ in the geological formation at that given time.

66. In this context, there is broad agreement across the submissions that modelling should not be used as a tool to calculate emission reductions arising from CCS projects, and should not replace measurement and monitoring as a means of estimating emission reductions from CCS projects, but that modelling may be used in a supplemental manner to support the monitoring. One submission states clearly that modelling should not be used as the primary or only means of quantifying emission reductions or seepage.

67. Different views are submitted regarding the sophistication and utility of models – while some submissions suggest that there are uncertainties with models, others point out that there is extensive experience in industry with such models. One submission suggests that there are likely to be low capabilities in many developing countries to handle complex dynamic geological models.

## F. Permanence and liability

68. Permanence in the context of CCS relates to the ability of geological storage reservoirs to retain the injected $CO_2$ for very long periods of time, or in perpetuity. Non-permanence relates to the possibility that a reversal of the $CO_2$ emission reductions achieved could occur due to seepage sometime after injection has taken place (a “carbon reversal”), perhaps due to risks as described in chapter III.D.

69. In terms of managing permanence and reducing the risk of non-permanence, many submissions emphasize the importance of site selection, risk and environmental impact assessment, and a risk mitigation and remediation plan to manage permanence over the short, medium, and long term, with specific mention made of a need for a long term monitoring plan and long term stewardship.[16, 17] Many submissions highlight that well selected and well managed storage sites should retain injected fluids for very long periods of time.[18] They also highlight various potential factors that could lead to non-permanence, as described in chapter III.D in the context of seepage risk.

70. Seepage, whether it occurs in the short, medium or long term, presents a **range of risks** which, as outlined in various submissions, can be categorized as:

(a) *Local risks.* These relate to any impacts on and damage to the immediate surroundings, including the local environment, human health and/or property and other economic resources;

[16] Several submissions appear to imply that short-term liability relates to the operational or injection phase of a CCS project; medium-term liability relates to the period beginning with the closure of the formation while the $CO_2$ plume is still stabilizing; and long-term liability relates to the continuation of the post-closure phase to perpetuity.

[17] Similar views on managing “permanence” were expressed previously and are summarized in document FCCC/SBSTA/2008/INF.3, paragraphs 62–63.

[18] Similar views were expressed previously and are summarized in document FCCC/SBSTA/2008/INF.1, paragraphs 88–89.

(b) *Global climate risks.* These relate to the release of $CO_2$ back into the atmosphere.

71. The issue of liability is intrinsically linked to the issue of permanence, because in either category of risk outlined, there is a need to attach responsibility to specific entity(ies) to remediate, compensate and/or make good the effects of seepage. In the case of local risks, this could cover restoration of damaged ecosystems or compensation for property damage or bodily injury. In the case of global climate risks, non-permanence would compromise the ability of CCS technologies to mitigate climate change and also impact on the environmental integrity of the CDM and carbon markets by rewarding emissions abatement that was not permanently achieved.

72. All submissions agree that it is critical for issues of permanence and liability for the residual and actual risks associated with stored $CO_2$ – at both local and global levels – to be clearly defined in the short, medium and the long term. One submission suggests that, at any point in time, the liability should be with only one entity, although this should also be considered in the context of multiple project participants and approaches to transboundary projects outlined previously (chapter III.C).

73. In terms of **general approaches to managing liabilities** associated with seepage and non-permanence, the following views are given:

(a) All short-term liability should rest with the project participants during the operational phase and during the post-closure phase of a CCS project;

(b) Long-term liability should be transferred to the host country, either through national regulation or a negotiated agreement specific to the project and this should be finalized during the project permitting stage;

(c) A "financial provision" should be established in order to cover any costs of remediation and/or compensation in the event of seepage, with one submission suggesting that a reasonable capped contribution for monitoring costs for liability transfer can be provided by the project proponent to the host government;

(d) A transfer of liability for the storage site in the post-closure phase (from the medium to long term) from project proponent to host country could or should occur after a defined period of time and/or in accordance with an agreed set of criteria, with one submission suggesting that private entities developing projects will find it difficult to assume liabilities for periods of hundreds of years, but also suggests that the "current institutional structure" also does not provide for long-term liability for the host country.[19]

(e) Liability needs to be placed in the context of benefits accruing to Annex I Parties, and therefore any liabilities arising should be vested in the Annex I Party investing in such projects. It is suggested that further discussion is needed regarding appropriate placement and channelling of liability to private and public actors in the event of seepage or accidental release, responsibility for remediation in the event of seepage or accidental release in the pre- and post-closure phases, and responsibility for site closure, and post-closure monitoring and releases;

(f) Procedures should be established for ensuring that post-closure stewardship and liability be managed by a competent institution over the long term (e.g. by the operator, the government or another authority);

[19] This can be assumed to refer to the lack of quantified emission limitation and reduction targets in non-Annex I countries, which would mean that there is no liability on the government, per se, to stop and remediate seepage.

(g) Sufficient flexibility is required in implementing the liability regimes in order to allow project proponents to be able to extend or share liabilities over dissimilar periods of time and according to specific project arrangements;

(h) Specifying liability arrangements may be accommodated alongside the CDM process, such as through the use of minimum standard setting in the environmental impact assessment or via the introduction of a new section in the CDM project documentation;

(i) Risks or liabilities can possibly be removed from host countries with the use of a broad range of options, for instance, the use of instruments such as long-term financial bonds or insurance or contractual arrangements with the project operator, and host Parties should be allowed to choose their liability transfer and funding mechanism.

74. Although most submissions agree with the view presented in paragraph 73(a) above, there are divergent views as to the way in which a financial provision could be established (not all submissions refer to a financial provision) and as to whether, when and under what conditions a transfer of liability could take place.

75. In the context of the financial provision, the range of views expressed in submissions include:

(a) The financial provision should be agreed bilaterally between the host country and the project participant or developer. In most cases, it is suggested that this would need to be in accordance with nationally implemented legislation in place in that country;

(b) The details of financial provision should be developed by the SBSTA, covering all aspects of the capture, transport and storage of $CO_2$;

(c) The financial provision should be reassessed and readjusted to take account of the changing risks posed by a storage site (e.g. through increased stability of the $CO_2$ plume after injection ceases);

(d) Some submissions suggest a financial provision that would only be required to cover local liabilities during the operational phase. Others suggest a wider scope covering global climate liabilities and ongoing costs of monitoring and remediation and/or compensation, if needed, in the event of seepage occurring in both the operational and post-closure phase and also after any transfer of short, medium or long term liability (see also paragraph 78);

(e) In the case of a transfer of liability, it is noted in submissions supporting such an approach that financial provisions would need to be transferable;

(f) Financial provision would only need to cover the operational phase of a project, while an international “compensation fund” should be established and held by the CDM Executive Board to cover a wide range of potential issues and risks, possibly focused on the post-closure phase, including ongoing monitoring of the storage site, remediation, compensation and replacement of CERs or similar units in the event of seepage. Some components would only be applicable to least developed countries. It also noted that further elaboration of this concept is required;

(g) The financial security instruments which host countries and project developers use in addressing liabilities and contingent liabilities arising from industrial activities should be developed and adapted for CCS projects in order to ensure that adequate funds are made available to cover the costs of meeting any liabilities.

76. In the context of a transfer of liability, the range of views expressed in submissions includes:

(a) Liability should be transferred from project participants to the host country after a post-closure period (i.e. the period after injection has ceased and the site has been sealed but while the $CO_2$ plume is still stabilizing, from the medium to the long term), which should be based on a set of criteria agreed between the project participants and the host country prior to project authorization. Criteria are suggested in several submissions, all of which are broadly consistent with the following requirements:

(i) All available evidence indicates that the stored $CO_2$ will be completely and permanently contained;

(ii) A minimum period since the closure, to be determined by the host country, has elapsed. This minimum period should be no shorter than 20 years, unless the host country and the DOE are convinced that the criterion referred to in point (i) is complied with before the end of that period;

(iii) The operator has paid a financial provision to cover possible costs resulting from the transfer of responsibility (including corrective measures), and to cover the costs for at least 30 years of monitoring;

(iv) The site has been sealed and the injection facilities have been removed;

(b) In the event of a transfer of liability, the host country would take on full liability for monitoring, remediation, compensation and replacement of CERs or similar units in the event of seepage, subject to the views on financial provisions described in paragraph 68 and specific views on managing “carbon reversal” as described in paragraph 78;

(c) Liability needs to be placed in the context of benefits accruing to Annex I Parties, and therefore any liabilities arising should be the responsibility of the Annex I Party investing in such projects, including the issues of liability allocation described in paragraph 68.

77. Irrespective of the proposed approach, most submissions agree that details of the liability arrangements would need to be set out in the project design document (PDD).

78. In the context of global climate risk and “carbon reversal”, submissions agree that remediation would be required in the event of seepage with approaches typically based on the acquisition and/or retirement of CERs or equivalent units equal to the amount of $CO_2$ estimated to have seeped. Building on the discussion presented in previous paragraphs, a range of views is expressed in submissions regarding **specific approaches to managing the risk of carbon reversal** in the short, medium and long term, including:

(a) In the short term (the operational phase of the project), any seepage emissions should be counted as project emissions and deducted from the total amount of CERs issued;

(b) In the medium term (the post-closure phase prior to any transfer of liability), liability for any seepage would still rest with the project participants and they would be required to remediate through the purchase of replacement CERs or equivalent units. Alternatively, and subject to the views presented in paragraphs 73–77, the financial provision or a compensation fund could be called on to cover the costs of “carbon reversal”;

(c) In the long term, possibly after liability has transferred from project proponent to host country, various approaches are proposed in submissions as means to remediate any damages arising due to seepage, including the allocating liability to the project proponent or, if a liability transfer takes place, the host country, and/or the use of a financial provision, or other approaches as described below.

79. Submissions include proposals covering the following options for managing the risk of non-permanence and carbon reversal:[20]

(a) The holder of liability could surrender CERs in the event of seepage. This could be the project participant or the host country if liability has been transferred. In the case of the latter, the financial provision held by the host country or the compensation fund held by the CDM Executive Board could be used to purchase CERs or equivalent units. This approach would equate to a "seller liability". Alternatively, the obligation could also reside with an Annex I Party buyer that used the CERs for compliance (a "buyer liability" approach);

(b) The use of cancellable or temporary credits such as temporary CERs (tCERs) or "long-term" CERs (lCERs), as applied in afforestation and reforestation project activities under the CDM. This would attach the liability to the buyer ("buyer liability");

(c) The introduction of a "discount factor", based on setting aside a percentage of the total CERs that would be issued, which could be applied at issuance so that a proportion of CERs are available for use to remediate against "carbon reversal" due to any future seepage. This could be implemented at the international level collectively for all CCS projects in the CDM, or by the host country on a project-by-project basis;

(d) A proportion of CERs could be surrendered to a "confidence buffer" that could be used to remediate for any future seepage. This also could be implemented at the international level collectively for all CCS projects in the CDM, or by the host country on a project-by-project basis.

80. In terms of support for various approaches for managing longer-term liability, a range of views are presented:

(a) The majority of submissions support the "seller liability" approach in combination with a transfer of liability to the host country on the grounds that it would create solid, fungible CERs that are equivalent to CERs from other CDM projects;

(b) The majority of submissions reject the use of cancellable or temporary CERs for several reasons, including that it would make it difficult to manage investment in projects and would discourage involvement in CCS projects;

(c) Several submissions express firm views regarding the need for any liability arising from CCS projects to be apportioned to the CER buyer (this could take the form of a "strict buyer liability" approach as outlined in para. 79(a) in the absence of any liability transfer or the use of cancellable or temporary CERs as outlined in para. 79(b));

(d) There are no strong views expressed in support of either a "discount factor" or "confidence buffer" approach;

(e) Several submissions suggest that all liability arrangements should be determined bilaterally between the project proponent and the host country, based potentially on national regulations set down for liability. These would set out the specific applicable approach to be taken for projects in that country, be it "strict buyer" or "seller" liability (i.e. a flexible approach determined on a country-by-country basis).

81. Given the complex nature of liability issues, several submissions suggest that international rules and laws may need to be developed to address the unique liability issues raised by the possible inclusion of CCS in the CDM. In particular, much of the complexity for the international accounting system stems from the possibility of $CO_2$ releases in host Parties that do not have emission reduction commitments and therefore do not fall under the

[20] A fuller set of information was submitted in earlier submissions and is synthesized in document FCCC/SBSTA/2008/INF.1, paragraph 68.

approach of fixed assigned amounts under the first commitment period of the Kyoto Protocol.

82. There is seemingly broad agreement, as reflected in the comments in a number of submissions, that addressing long-term permanence is a challenging subject and needs further discussion and deliberation. In approaching the subject, one submission cautions that liability provisions should not result in obstacles to CCS deployment under the CDM, especially those for which an EIA has been conducted.

# IV. Implications for modalities and procedures

83. Views on technical and legal issues have been highlighted in the previous section in the context of specific elements of CCS and CDM project design. This section builds on those views by outlining a synthesis of views in relation to CCS project approvals under the CDM that may need to be incorporated in new modalities and procedures, covering the procedural aspects and associated entities. It is organized around several of the major "building blocks" of the modalities and procedures for a CDM, although some of the topics have been clustered together as the submissions contain differing views around the division of different responsibilities.

84. In reviewing the remainder of this section, it may be useful to recall a view expressed in a submission that there is a need to develop a clear distinction between the roles and responsibilities of the host government, the DOE, the Executive Board of the CDM (CDM EB) and the project developer, which must be elaborated in order to determine a credible, robust and practical framework for CCS project development under the CDM.

## A. Definitions

85. Recognizing that the terms already included in annex A of the CDM modalities and procedures will apply for CCS project activities mutatis mutandis, some CCS-specific definitions are included in several submissions. These will likely need to be incorporated in new modalities and procedures for CCS to address CCS-specific technical and legal matters, as outlined throughout this report. One submission suggests that the term "significant risk" would require a definition, while another submission includes a list of definitions related to its submission. These can be used as the basis for developing new CCS specific definitions that will likely be needed in CDM modalities and procedures for CCS.

86. Additional sources which contain extensive definitions on this subject include the "Glossary, acronyms and abbreviations" included in annex II of the *2005 IPCC Special Report on Carbon Dioxide Capture and Storage*, the EU CCS directive, the US EPA Final Rule, *IEA CCS Model Legal and Regulatory Framework*, and the proposal for CDM new methodology made by the In Salah Gas Partners (see annex II of this report for full references).

## B. The role of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol and the Executive Board of the clean development mechanism

87. Recognizing the widely held view in submissions that the existing CDM modalities and procedures should be applied wherever possible mutatis mutandis, a range of additional activities are raised in submissions in relation to the role of the CMP and the CDM EB.

However, the nature of the views submitted means that further clarification of the precise roles and responsibilities of the bodies of the UNFCCC in relation to CCS will be required before a succinct view of specific changes that might be required for new modalities and procedures for CCS can be established. The remainder of this chapter outlines the range of proposals for action by the different bodies, as outlined in the submissions. It is important to note that some of the views presented relate more to one-off actions at the CMP level, rather than specific roles and responsibilities under new modalities and procedures for CCS.

88. For the CDM EB and/or the CMP and/or the SBSTA, the following additional activities are suggested in submissions:

(a) On technical and legal issues described in chapter III:

(i) Establish procedures for site characterization, risk assessment and mitigation plans, drawing on the existing knowledge base (e.g. the EU CCS directive, $CO_2$QUALSTORE) and set minimum and/or "performance-based" criteria for $CO_2$ storage site selection (subject to a mandate set out in decision 7/CMP.6, para. 3(d), and resolution of the most appropriate means of setting such requirements as described in section chapter III.A) and establish criteria for the assessment of monitoring methodologies and plans (see para. 62);

(ii) Decide on an appropriate definition for the project boundary for CCS project activities under the CDM;

(iii) Establish a code of conduct for the operation and monitoring of reservoirs;

(iv) Ensure that the issue of liability is appropriately addressed in PDDs;

(b) On more general organizational and procedural issues related to CCS inclusion under the CDM:

(i) Establish and support a CCS Working Group working under the auspices of the CDM EB along similar lines to existing working groups such as the Afforestation and Reforestation Working Group, Small-Scale Working Group, etc.;

(ii) Establish and maintain a registry of the location of $CO_2$ storage sites and their project boundaries;

(iii) Establish, develop and maintain a compensation fund, covering accidents, seepage avoidance, monitoring and corrective actions for long-term risk mitigation and corrective actions in least developed countries (see para. 75(f)). The CMP should assist in establishing such a fund;

(iv) Include CCS as a new sectoral scope (scope 16) within the CDM, and develop criteria for operational entities applying for accreditation to this scope (see chapter IV.H);

(v) Support knowledge sharing by ensuring, for example, that risk assessment and mitigation measures, including emergency response plans, are not considered as proprietary or confidential;

(vi) Decide, with support from a CCS Working Group, on a maximum number of years of crediting for CCS projects;

(vii) Consider a mechanism for conflict resolution in the event that disputes arise due to movement of $CO_2$ across national borders;

(viii) In the case of carbon capture and utilization (CCUS) projects, develop requirements for a percentage of "breakthrough" $CO_2$ to be recovered and re-injected in the reservoir in addition to the $CO_2$ injected in the base case.

89. Given the wide range of roles suggested for the CMP, the SBSTA and the CDM EB across a broad range of activities, further discussion is warranted in order to clarify the envisaged scope of activities, roles and responsibilities of the different bodies of the UNFCCC, including which actions may involve one-off decisions of the CMP or the CDM EB, and which ones constitute new requirements that will need to be included in modalities and procedures for CCS.

## C. Accreditation and designation of operational entities

90. While a broad range of views are expressed in submissions regarding the roles and activities of DOEs, no specific issues are raised in submissions regarding these aspects of the CDM modalities and procedures (annex D of the CDM modalities and procedures). However, specific technical competencies relevant to CCS are highlighted in several submissions, which would need to be addressed in appendix A of the CDM modalities and procedures for CCS (see chapter IV.H). The existing CDM modalities and procedures will therefore likely apply for these aspects of CCS, mutatis mutandis.

## D. Designated operational entities and validation and registration

91. A range of additional activities are raised in submissions in relation to DOE validation requirements, and CDM EB considerations during registration. Taking into account the widely held view in submissions that the existing CDM modalities and procedures should be applied wherever possible mutatis mutandis, for the most part any new activities during verification and registration will likely involve modifications to annex G in the new CDM modalities and procedures for CCS ("Validation and registration"). However, it is also possible that some activities could involve modifications to annex E ("Designated operational entities"), although it seems more appropriate that the existing CDM modalities and procedures, annex E, should apply mutatis mutandis without any modification.

92. Additional activities raised in submissions include the following:

(a) In validating projects, the DOE should:

(i) Evaluate the PDD in relation to the appropriateness of the following:

- The procedure for selection of the geological formation as a $CO_2$ storage site covering for example site injectivity, cap rock suitability, seismic stability, etc.;
- The modelling technique used for site selection and field development and the operating plan;
- The monitoring plan;
- Any response and/or proposed remediation or contingency measures in the event of seepage.

(ii) Validate that regulations and/or criteria for site selection, as set out in a national and/or international regulatory framework(s) and/or as guided by criteria from the UNFCCC, have been met;

(iii) Assess whether the project boundary meets the criteria established under the modalities and procedures;

(iv) Assess and confirm whether the risk assessment and socio-environmental impact assessment have been carried out and approved by the DNA (see chapter IV.E);

(b) Registration by the CDM EB should be based on its assessment of the host Party's approval and the DOE's validation and assessment of whether the project demonstrates good/best practices at the time of application in relation to site selection, monitoring, modelling, etc.

93. Several submissions also note the role of stakeholders in approvals for site selection, including local communities and indigenous people.

94. The extent to which the range of activities highlighted present new and additional requirements beyond the scope of the existing CDM modalities and procedures should be considered in the future in order to clarify the exact nature of new requirements. Furthermore, many of the roles envisaged are dependent on the approach that will be taken to regulate CCS projects as this will, to a large extent, determine which entity undertakes what activity during approvals and verification. Presently, views outlined in submissions differ on this matter. Therefore, final agreement on the precise role of the DOE and CDM EB will not be possible until further clarity is achieved regarding the host country participation requirements, and the harmonization of requirements between internationally determined elements and those aspects that should reside within the capacity of national governments (as discussed further in chapter IV.E).

## E. Participation requirements (and the role of designated national authorities)

95. Recognizing the widely held view in submissions that the existing modalities and procedures for a CDM should be applied wherever possible mutatis mutandis, a range of additional activities are raised in submissions in relation to the host country participation requirements. Depending on the agreed approach to host country participation agreed between Parties, the issues outlined in this section would need to be addressed in the new CDM modalities and procedures for CCS by way of modifications to annex F of the existing CDM modalities and procedures; all other aspects of annex F would apply mutatis mutandis.

96. Several submissions suggest that national implementing agencies should be required to establish national laws and regulations covering various aspects of project development before a country could be eligible to host a CCS project that is recognized as a CDM project activity. Elements suggested for national laws and regulations included, inter alia, the following:

(a) Regulation of site selection;

(b) Setting requirements for carrying out risk assessment;

(c) Regulation of $CO_2$ storage site monitoring;

(d) Defining approaches to managing long-term liability in any country wishing to host CCS projects that are recognized as CDM project activities.

97. Other requirements for non-Annex I Parties wishing to host CCS projects under the CDM suggested in submissions included:

(a) The Party has designated areas as potential storage sites;

(b) The Party has undertaken a storage capacity assessment for its country;

(c) The Party has evaluated long-term liability and developed national regulations for managing long-term liability and/or has agreement(s) in place with project proponent/developer(s) regarding the managing of long-term liability. These should provide guarantees that all legal obligations relating to monitoring and reporting have been transferred to the host country Party, and requirements to notify the CDM EB as to when such a transfer has taken place;

(d) That there are effective resources employed in the country to promote compliance with the national regulatory framework.

98. Further, most submissions agree that design of legal and regulatory systems should be guided by criteria agreed at the UNFCCC level. On the other hand, several submissions suggest that new international law frameworks may be required for CCS, focused on addressing various aspects related to permanence and liability.

99. In terms of the various approaches to managing long-term liability, it is also noted in some submissions that where liability is transferred to the host Party, the following will need to apply between project developer and host Party government:

(a) A bilateral agreement setting out the terms of liability, covering its period, conditions, and any specific criteria under which liability may be transferred;

(b) If a financial provision is applied as part of liability provisions, this will need to be transferred to an authorized body designated by the host country after the end of the project developer's liability period.

100. For national approvals of project design, several submissions note that the host country should be required to approve a selected site prior to the project being able to apply for CDM registration (which would apply under the current modalities and procedures for CDM via its DNA). Views expressed on the role of host country authorities include:

(a) The host country authority(s) and/or the DNA should undertake the following:

(i) Approve the site selection and characterization procedures, monitoring plan, project boundaries, compliance with national laws and regulations, etc. including any additional requirements imposed by the host country in addition to any internationally-agreed approaches and standards. Any such additional requirements would need to be communicated in an explicit, clear and transparent way;

(ii) Approve the risk assessment, and socio-environmental impact assessment, covering its scope, objectives and methodology (the "terms of reference" or "workplan") that is to be carried out by a project developer or an appointed independent third-party on its behalf, and to approve the results of such analysis;[21]

(iii) Confirm the establishment of liability arrangements that cover the full life cycle of a CCS project, with clear assignment of liability and compensation arrangements in the event of seepage over the longer term, potentially after liability has transferred to the host Party;

(iv) Confirm approval by all DNAs involved in co-hosted transboundary projects, including the liability arrangements and the national greenhouse gas inventory reporting approach to be taken, recognizing the 2006 IPCC Guidelines recommended approach;

(v) Carry out routine and non-routine inspections (see paras. 106–108).

[21] There are divergent views on whether the entity carrying out such an assessment would need to be independent.

101. One submission highlights that CCS in its current state is only suitable for a few developing countries, and especially for those that have established legal and regulatory frameworks for CCS. They also suggest that significant know-how is required to accommodate all of the requirements of such a framework, which they suggest is a significant barrier to CCS in deployment in developing countries. Another submission highlights that national laws and regulations for CCS in developing country Parties should be as stringent as those applied in developed country Parties, and should be cognizant of international laws relating to CCS. It also suggests that an international law framework might be applied to managing potential emission from CCS projects over the long term, given the absence of developing country emission reduction targets.

102. One submission suggests that the inclusion of CCS in the CDM does not imply any obligation whatsoever to any developing country to deploy CCS, rather it only supplies a means to provide finance for countries wishing to develop such projects in accordance with their national circumstances.

103. Drawing on the views outlined, further discussion seems warranted to clarify the approach to establishing various requirements for CCS project design and development so as to establish appropriate arrangements that harmonize requirements between internationally-determined elements and those aspects that should reside within the capacity of national governments. In this context, it will be important to strike an appropriate balance between the two which all parties are comfortable with. Cognizant of the mandate set down in decision 7/CMP.6, aspects to take into account include:

(a) The type and level of detail required in the guidance for project design that could be developed at the UNFCCC level, either through a decision of the CMP, work of the CDM EB, and supported by any dedicated working groups thereunder, and through proposals for CDM new methodologies for CCS project activities relative to national laws and regulations. Areas of focus could include: site selection criteria, monitoring plan design criteria, risk assessment methodologies and the necessary provisions to be established internationally or in national law for managing long-term permanence and liability;

(b) Whether and how such guidance would need to be incorporated in national legal and regulatory systems of host Parties, and at what level of detail, and how these might be tailored to specific national circumstances. One submission notes that modalities and procedures for CCS projects under the CDM should not seek to replace or prescribe national law in developing country parties, and that host Parties should be able to determine the conditions under which projects may be developed;

(c) How checking and enforcement of national level regulations could be applied to ensure consistency with any requirements set down at an international level while at the same time balancing countries sovereign rights, if such checking is considered appropriate;

(d) The role of DNA in approving project design methods, and DOE in supporting these functions. The former could include the setting of additional criteria to those set at an international level that are specific to the host country Party’s requirements.

104. Several submissions note the important role that capacity-building can play in facilitating the design and implementation of national regulatory procedures.

## F. Monitoring

105. Technical and legal issues and approaches related to monitoring of CCS projects are outlined in chapter III.E. In addition, procedural issues related to monitoring in the context of verification are outlined in chapter IV.G. These suggest that specific modifications may be necessary in new CDM modalities and procedures for CCS to take account of specific

requirements of the technology, as highlighted in submissions, for example, $CO_2$ stream composition in order to satisfy any international laws related to marine protection, or reservoir pressure to ensure safe operation.

106. Furthermore, several submissions refer to the need for both routine and non-routine checks and/or inspections of storage sites for compliance purposes, carried out by the CDM EB, host country, or an independent verifier on their behalf. This may require additional modifications of the existing CDM modalities and procedures to take account of this need. Views expressed in submissions regarding inspections suggest that they could include activities such as:

(a) Visits to the surface installations where injection takes place;

(b) Assessing the relevant results from injection and monitoring operations carried out, including information on the monitoring techniques employed, and the $CO_2$ stream composition;

(c) Checking for proof that any agreed financial provision is being maintained;

(d) Checking all relevant records kept by the project participant/project operator;

(e) Any other evidence the verifier considers relevant for the purposes of assessing compliance with the storage requirements and increasing knowledge about the subsurface.

107. In terms of the appropriate frequency of inspections/checks, views range from:

(a) **Routine inspections** – every year to at least every five years. It is suggested in one submission that they would require at least one calendar month's prior written notice to the project participant/project operator. In terms of the closure phase, some submissions suggest that a final risk and safety assessment would be required, and that routine inspections should continue for at least three years after closure, and then at least every five years until a transfer for liability has occurred;

(b) **Non-routine inspections –** these should be carried out at the discretion of CDM EB/host country, within the guidelines of reasonable frequency. One submission suggest that inspections should also be carried out in the event that a DOE has been made aware of seepage or where complaints about environmental or health impacts are occurring, or other situations where it is considered appropriate.

108. These submissions go on to suggest that following each inspection, the inspector should be required to prepare a report on the results of the inspection. The report should evaluate compliance with the requirements of the storage permit and the project parameters as established in the PDD, and indicate whether or not further action is necessary. The report must also be communicated to the project proponent/project operator concerned.

109. While several submissions refer to liability transfer, proposals regarding the procedure for liability transfer and the responsible entities for assessing the conditions under which liability transfer could occur are not clear from the submissions. Some suggest the DOE could be the approving authority, while another suggests that the host country's national authority would need to be involved. The latter would seem like the most likely course of action, given that the country would be taking on obligations relating to the long-term stewardship of the storage site. Clearer articulation of the potential modalities for liability transfer, if and where applicable, should be considered with respect to the drafting of modalities and procedures.

110. Based on the views expressed, it will be important to consider how compliance and enforcement could work under different arrangements for CCS project governance, taking into account that regulations could be set nationally and/or internationally (see chapter

IV.A), that host countries may impose differential requirements for CCS projects (see chapter IV.A), and on this basis, how best to separate and/or coordinate roles between DOEs and national level enforcement authorities.

111. Other aspects of the existing CDM modalities and procedures as outlined in annex H would likely apply, mutatis mutandis.

## G. Verification and certification

112. Recognizing the widely held view in submissions that the existing modalities and procedures for a CDM should be applied wherever possible mutatis mutandis, a range of additional activities are raised in submissions in relation to the verification of and issuance for CCS projects. These mainly cover the role of the DOE during verification, in that the DOE should:

(a) Review compliance with a monitoring plan and checks on data accuracy, trueness, etc. based on the existing principles for monitoring established in the modalities and procedures for the CDM;

(b) Verify the calculation of project emissions, leakage emissions and the level of additional energy use in a project activity;

(c) Review compliance with the site/field development plan in terms of, for example, injection pressure, reservoir pressure, etc.;

(d) Assess whether a project is conforming with its pre-injection estimate of the project boundary, and the appropriateness of the ongoing modelling techniques being used;

(e) Assess whether the operator has carried out analysis of the composition of the $CO_2$ stream, including whether contaminant levels are in line with the conditions of the risk and safety assessment, and a register is being kept of the $CO_2$ stream composition;

(f) Assess whether seepage could have occurred;

(g) Assess whether any modifications to the monitoring plan and/or project boundary may be required to improve the spatial coverage and/or resolution of subsurface monitoring;

(h) Assess whether any changes or updates to the risk assessment has been carried out, where appropriate, including the use of up-to-date modelling techniques and updated monitoring data.

113. A submission suggests that additional reporting obligations should be imposed on project developers for CCS projects, with requirements to submit reports to both the host country national authority and the CDM EB. A range of information to be contained in such reports is suggested, covering the types of data that may be subject to verification as described in paragraph 112, and also the type of information that could be subject to inspection as described in paragraph 106.

## H. Issuance of certified emission reductions

114. The existing CDM modalities and procedures would likely apply to issuance for CCS projects, mutatis mutandis. However, depending on the approaches taken to manage permanence and liability as described in chapter III.F, there may be additional requirements if an approach involving a “discount factor” or “confidence buffer” is taken. This may require a portion of CERs to be forwarded to an alternative registry account in order that they be available to act such a buffer (see paras. 79(c) and (d)). Also, if an international

"compensation fund" is to be established by the CMP, then there may also be a requirement for CERs to be forwarded to this account.

115. It is also highlighted in one submission that a CCS Working Group established under the CDM EB should assist the UNFCCC Registration and Issuance team during registration and issuance.

## I. Permanence

116. Annex K to decision 19/CP.9[22] set out specific provisions to address permanence issues associated with afforestation and reforestation projects under the CDM in the first commitment period. Subsequently, these provisions were included in annex J to decision 5/CMP.1 in relation to "Issuance of certified emission reductions". Subject to agreement on ways to address issues of permanence for CCS projects, specific elements may need to be included within modalities and procedures for CCS under a new section in a similar way as in decision 19/CP.9, drawing on the views outlined in paragraphs 78 and 79.

## J. Accreditation of designated operational entities (appendix A)

117. Many submissions note that, in order to fulfil the validation and verification roles envisaged, DOEs will need to have the appropriate expertise and experience at their disposal to validate, monitor and verify CCS project activities. Specific knowledge includes geological knowledge, modelling, risk assessment and health, safety environment and social impact assessment. Two submissions suggest defining CCS as a new sectoral scope (against which DOEs could be separately accredited).

118. Submissions suggest that the SBSTA or the EB should develop specific criteria for the accreditation for DOEs, and also suggest that requirements to fulfil these criteria require further consideration. One submission suggests that the accreditation of a DOE should expire automatically after three years, subject to renewal.

119. A submission highlights that capacity-building may be required to set such accreditation standards.

## K. Project design documents (appendix B)

120. Many submissions made suggestions on the type of information that would need to be outlined in PDDs that is relevant for any proposed CCS project activity, including inter alia:

(a) For site selection, the site characterization and selection procedures undertaken and the proposed site/field development plan, the type of computer model used in the analysis for site characterization and selection, techniques used to complement modelling in the site characterization and selection, the estimated likelihood of seepage, an indication of any transboundary issues, and information about the pre-injection condition of the reservoir;

(b) For a project boundary, this must be clearly defined in the PDD. Specific project accounting rules could be best determined through development of specific CDM methodologies for different applications of CCS;

[22] Decision 19/CP.9 "Modalities and procedures for afforestation and reforestation project activities under the clean development mechanism in the first commitment period of the Kyoto Protocol".

(c) For risk and socio-environmental assessment, some submissions express the view that this would need to go beyond existing EIA requirements under the CDM, while others suggest that this would not need to go beyond existing requirements;

(d) For monitoring plans, this would need to be included for the proposed CCS project activity, covering the greenhouse accounting procedures across all phases of capture and transportation, and specific plans for storage site monitoring;

(e) The approach to managing permanence and liability, including the transfer of liability and any related financial/compensation mechanisms (as described in para. 76).

### L. Terms of reference for establishing guidelines on baselines and monitoring methodologies (appendix C)

121. Additional terms of reference may be needed to address items such as the use of the most efficient plant, the use of an equivalent amount of renewable energy to the level equivalent to the energy penalty associated with CCS, and consideration of the life cycle emissions from CCS.

### M. Clean development mechanisms registry requirements (appendix D)

122. Additional requirements for the CDM registry may be needed depending on the approach taken to managing permanence and liability, taking into account the views outlined in paragraphs 78 and 79.

123. Furthermore, there may be a need to either modify the existing registry, or create a new registry, if a registry of the location of $CO_2$ storage sites and their project boundaries is agreed by Parties as requirement for CCS projects under the CDM (see para. 88(b)(ii)).

## V. Summary

124. On technical and legal issues outlined in chapter III, elements common to many submissions are that:

(a) **Site selection and characterization** is critical for ensuring safe and secure storage of $CO_2$, and that well selected, designed and managed storage sites can minimize the risk of seepage and support the long-term permanence of emission reductions, and a range of steps and criteria can be developed by the CMP and/or CDM EB to support this process;

(b) **Project boundaries** for a CCS project should include the full chain of CCS activities, covering capture, transport, injection and storage of $CO_2$, and would therefore support the text of decision 7/CMP.6, paragraph 3(e), and that modelling may be used to determine the boundary;

(c) **Greenhouse gas emissions accounting** should take into account fugitive emissions, emissions resulting from the direct and/or indirect use of electricity and other energy sources required for the project, and potential seepage. Methodological approaches may also be employed to restrict the possibility of perverse outcomes;

(d) **Transboundary issues** can be resolved through effective governance approaches;

(e) **Risk, safety and environmental impacts, and socio-environmental assessment** includes a wide range of potential impacts, including emissions to air and associated pollution; solid waste generation; water consumption; noise and vibration, and specific risks associated with $CO_2$ containment failure resulting in leaks from both above-ground and subsurface installations, including: contamination of underground sources of drinking water; affects on the chemical properties of seawater; and, human health and safety and ecosystem damage associated with accumulations of $CO_2$ to dangerous levels in non-turbulent air. Approaches can be taken to assess these risks and mitigate them;

(f) **Monitoring** to detect seepage must be undertaken across all operational phases of a CCS project, including above-ground activities ($CO_2$ capture and transportation) and injection activities, with it being potentially extended across the project life cycle and through the post-closure phase, including after the crediting under the CDM has ceased. Monitoring plans would need to be established and approved, and subsequently updated from at least every year, to every five years, but no less frequent than every ten years;

(g) **Permanence** is strongly linked to site selection, risk and environmental impact assessment, and application of risk mitigation and remediation measures to reduce the risk of non-permanence over the short, medium and long term;

(h) **Liability** issues need further discussion to decide upon the preferred approach to address the issue, with several submissions distinguishing between shorter and longer term liability issues, and calling in particular for a sufficiently robust yet flexible regime for determining long-term liability, including through the possible use of financial instruments to address and/or transfer liability.

125. Areas where a divergence of views exist or further clarification on technical and legal issues is required include:

(a) For **site selection**, it will be important to clarify the types of criteria that could be set by the CMP (e.g. "outcome-" or "performance-based");

(b) On **project boundaries and greenhouse gas emissions accounting**, further consideration of the scope of the emissions that need to be accounted for within a CCS project is required (e.g. life cycle emissions including emissions arising from extra oil produced due to $CO_2$-EOR);

(c) In terms of allowing **transboundary** projects under the CDM, some submissions consider that they should be allowed subject to establishing appropriate governance, while some consider that transboundary projects should be allowed only after more experience is gained with CCS projects, and that it would be preferable for priority to be given to projects that fall within a single host Party;

(d) On **risk, safety and socio-environmental assessments** within the CDM, some consider that a risk and safety assessment should be part of the EIA, which is already required by the CDM modalities and procedures, while others are critical of the current approach to EIAs. A divergence of views is apparent on whether a CCS risk, safety and socio-environmental assessment needs to be undertaken by an independent entity;

(e) For **monitoring** plan design, some suggest that monitoring and modelling practices are compatible with the current modalities and procedures for the CDM, while others suggest that monitoring plans should be designed against criteria elaborated by the UNFCCC secretariat or the CMP, and/or possibly including additional criteria selected by the host Party;

(f) On **permanence and liability**, further discussion regarding the various options is required in order to establish an approach which can be agreed on by all Parties.

126. Regarding the **implication for modalities and procedures** a wide range of views also exist. Key issues to resolve in the future include:

(a) The roles and responsibilities for different entities involved in establishing rules and approving projects including:

(i) The CMP, the SBSTA, the CDM EB and the UNFCCC secretariat;

(ii) DOEs;

(iii) The host country and DNA;

(iv) Other entities (e.g. a CCS Working Group under CDM EB);

(b) What host country participation requirements might be, taking into account:

(i) The type and level of detail in guidance for project design that could be developed at the UNFCCC level, either through a decision of the CMP, work of the CDM EB, and supported by any dedicated working groups thereunder, and through proposals for CDM new methodologies for CCS project activities relative to national laws and regulations;

(ii) Whether and how such guidance would need to be incorporated into national legal and regulatory systems of host Parties, and at what level of detail, and how these might be tailored to specific national circumstances;

(iii) How checking and enforcement of national level regulations could be applied;

(iv) The role of the DNA;

(c) What the structure and content for PDDs specific to CCS projects would need to contain.

# Annex I

## Relationship of technical and legal issues to decisions 2/CMP.5 and 7/CMP.6

Table 1
**Relationship of technical and legal issues to decisions 2/CMP.5 and 7/CMP.6**

| *Chapter of this document* | *Issues raised in decision 2/CMP.5, para. 29 (a)–(i)** | *Requirements and future work specified in decision 7/CMP.6, para. 3 (a)–(o)* |
|---|---|---|
| III.A. Site selection | (a) Non-permanence, including long-term permanence [partial coverage]<br><br>(h) Safety [partial coverage] | (a) The **selection of the storage site** for carbon dioxide capture and storage in geological formations shall be based on **stringent and robust criteria** in order to seek to ensure the long-term permanence of the storage of carbon dioxide and the long-term integrity of the storage site;<br>(c) Further consideration is required as regards the suitability of the use of **modelling**, taking into account the scientific uncertainties surrounding existing models, in meeting the stringency requirements of such monitoring plans, in particular taking into account the Intergovernmental Panel on Climate Change *2006 IPCC Guidelines for National Greenhouse Gas Inventories*;<br>(d) The **criteria for site selection** and monitoring plans shall be decided upon by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol and may draw upon relevant guidelines by international bodies, such as the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*; |
| III.B. Project boundaries and greenhouse gas emission accounting | (b) Measuring, reporting and verification<br><br>(d) Project activity boundaries;<br><br>(e) International law [partial coverage] | (c) Further consideration is required as regards the suitability of the use of **modelling**, taking into account the scientific uncertainties surrounding existing models, in meeting the stringency requirements of such monitoring plans, in particular taking into account the Intergovernmental Panel on Climate Change *2006 IPCC Guidelines for National Greenhouse Gas Inventories*;<br>(e) The **boundaries** of carbon dioxide capture and storage in geological formations shall include all above-ground and underground installations and storage sites, as well as all potential sources of carbon dioxide that can be released into the atmosphere, involved in the capture, treatment, transportation, injection and storage of carbon dioxide, and any potential migratory pathways of the carbon dioxide plume, including a pathway resulting from dissolution of the carbon dioxide in underground water;<br>(f) The **boundaries** referred to in paragraph 3(e) above shall be clearly identified;<br>(g) **Any release of carbon dioxide** from the boundaries referred to in paragraph 3(e) above must be **measured and accounted** for in the **monitoring plans** and the reservoir pressure shall be continuously measured and these data must be independently verifiable;<br>(i) Any **project emissions** associated with the deployment of carbon dioxide capture and storage in geological formations shall be accounted for as project or leakage emissions and shall be included in the monitoring plans, including an ex-ante estimation of project emissions; |

| *Chapter of this document* | *Issues raised in decision 2/CMP.5, para. 29 (a)–(i)** | *Requirements and future work specified in decision 7/CMP.6, para. 3 (a)–(o)* |
|---|---|---|
| III.C. Transboundary issues | (e) International law [partial coverage] | (h) The appropriateness of the development of **transboundary** carbon dioxide capture and storage project activities in geological formations and their implications shall be addressed; |
| III.D. Risk, safety and environmental impacts, and socio-environmental assessment | (c) Environmental impacts | (j) A thorough **risk and safety assessment** using a methodology specified in the modalities and procedures, as well as a comprehensive socio-environmental impacts assessment, shall be undertaken by (an) independent entity(ies) prior to the deployment of carbon dioxide capture and storage in geological formations;<br>(k) The **risk and safety assessment** referred to in paragraph 3(j) above shall include, inter alia, the assessment of risk and proposal of mitigation actions related to emissions from injection points, emissions from above-ground and underground installations and reservoirs, seepage, lateral flows, migrating plumes, including carbon dioxide dissolved in aqueous medium migrating outside the project boundary, massive and catastrophic release of stored carbon dioxide, and impacts on human health and ecosystems, as well as an assessment of the consequences of such a release for the climate;<br>(l) The results of the **risk and safety assessment**, as well as the socio-environmental impacts assessment, referred to in paragraph 3(j) and (k) above shall be considered when assessing the technical and environmental viability of carbon dioxide capture and storage in geological formations; |
| III.E. Monitoring | (b) Measuring, reporting and verification | (b) Stringent **monitoring plans** shall be in place and be applied during and beyond the crediting period in order to reduce the risk to the environmental integrity of carbon dioxide capture and storage in geological formations;<br>(c) Further consideration is required as regards the suitability of the use of **modelling**, taking into account the scientific uncertainties surrounding existing models, in meeting the stringency requirements of such monitoring plans, in particular taking into account the Intergovernmental Panel on Climate Change *2006 IPCC Guidelines for National Greenhouse Gas Inventories*;<br>(d) The **criteria for** site selection and **monitoring plans** shall be decided upon by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol and may draw upon relevant guidelines by international bodies, such as the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*;<br>(g) **Any release of carbon dioxide** from the boundaries referred to in paragraph 3(e) above must be **measured and accounted** for in the **monitoring plans** and the reservoir pressure shall be continuously measured and these data must be independently verifiable; |
| III.F. Permanence and liability | (a) Non-permanence, including long-term permanence;<br><br>(b) Measuring, reporting and verification<br><br>(f) Liability | (m) **Short-, medium- and long-term liability** for potential physical leakage or seepage of stored carbon dioxide, potential induced seismicity or geological instability or any other potential damage to the environment, property or public health attributable to the clean development mechanism project activity during and beyond the crediting period, including the clear identification of liable entities, shall:<br>(i) Be defined prior to the approval of carbon dioxide capture and storage in geological formations as clean development mechanism project activities;<br>(ii) Be applied during and beyond the crediting period;<br>(iii) Be consistent with the Kyoto Protocol; |

| *Chapter of this document* | *Issues raised in decision 2/CMP.5, para. 29 (a)–(i)** | *Requirements and future work specified in decision 7/CMP.6, para. 3 (a)–(o)* |
|---|---|---|
| | | (n) When determining the **liability provisions** referred to in paragraph 3(m) above, the following issues shall be considered: |
| | (g) The potential for perverse outcomes [partial coverage] | (i) A means of redress for Parties, communities, private-sector entities and individuals affected by the release of stored carbon dioxide from carbon dioxide capture and storage project activities under the clean development mechanism; |
| | | (ii) Provisions to allocate liability among entities that share the same reservoir, including if disagreements arise; |
| | (i) Insurance coverage and compensation for damages caused due to seepage or leakage | (iii) Possible transfer of liability at the end of the crediting period or at any other time;<br>(iv) State liability, recognizing the need to afford redress taking into account the longevity of liabilities surrounding potential physical leakage or seepage of stored carbon dioxide, potential induced seismicity or geological instability or any other potential damage to the environment, property or public health attributable to the clean development mechanism project activity during and beyond the crediting period; |
| | | (o) Adequate provision for **restoration of damaged ecosystems and full compensation** for affected communities in the event of a release of carbon dioxide from the deployment of carbon dioxide capture and storage in geological formations must be established prior to any deployment of related activities; |

# Annex II

## References and good practice documents

Table 2
**References and good practice documents**

| *Chapter of this document* | *Sources cited in submissions* |
|---|---|
| III.A. Site selection | Metz, B, Davidson, O, de Coninck, HC, Loos, M, and Meyer, LA (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. |
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| III.B. Project boundaries and greenhouse gas emission accounting | IPCC. 2006. *Guidelines for National Greenhouse Gas Inventories* (Volume 2, Chapter 5).<br><br>UNFCCC. 2009. *Implications of the Inclusion of Geological Carbon Dioxide Capture and Storage as CDM Project Activities – An Assessment*. A report to the UNFCCC. 50th Meeting of the UNFCCC CDM Executive Board (CDM-EB50), 2009 Annex 1.<br><br>In Salah Gas Partners. 2009. *Capture, Transport and Long-term Storage in Geological Formations of Carbon Dioxide from Natural Gas Processing Operations*. Proposal for a CDM New Methodology. Available at: <http://www.insalahco2.com/index.php/en/low-co2-gas-production/joint-venture.html#cdmMethodology>. |
| III.C. Transboundary issues | Metz, B, Davidson, O, de Coninck, HC, Loos, M, and Meyer, LA (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.<br><br>2006. IPCC. *Guidelines for National Greenhouse Gas Inventories* (Volume 2, Chapter 5).<br><br>UNFCCC. 2009. *Implications of the inclusion of Geological Carbon Dioxide Capture and Storage as CDM Project Activities – An Assessment*. A report to the UNFCCC. 50th Meeting of the UNFCCC CDM Executive Board (CDM-EB50), 2009 Annex 1.<br><br>IEA. 2010. *Carbon Capture and Storage, Model Regulatory Framework*. IEA Information Paper. Paris: IEA.<br><br>In Salah Gas Partners. 2009. *Capture, Transport and Long-term Storage in Geological Formations of Carbon Dioxide from Natural Gas Processing Operations*. Proposal for a CDM New Methodology. Available at: <http://www.insalahco2.com/index.php/en/low-co2-gas-production/joint-venture.html#cdmMethodology>. |
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