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Submission by Hungary and the European Commission on behalf of the European Union and its Member States

This submission is supported by Albania, Bosnia and Herzegovina, Croatia, the Former Yugoslav Republic of Macedonia, Montenegro, Serbia and Turkey.

Budapest, 15 February 2011

Subject: **Carbon dioxide capture and storage in geological formations as clean development mechanism project activities (SBSTA)**

Submission from Parties - on views on how different issues can be addressed in modalities and procedures

1. At COP/MOP 6 in Cancun, draft Decision -/CMP.6 invited Parties to make submissions to the secretariat, by 21 February 2011, on views on how different issues (referred in paragraph 3 of this decision) regarding carbon dioxide capture and storage (CCS) in geological formations as clean development mechanism (CDM) project activities can be addressed in modalities and procedures. The EU welcomes the opportunity to submit its views on this important issue and looks forward to discussions at SBSTA 34 and COP/MOP 7.

2. This submission should be considered in conjunction with our previous submissions, most recently that of March 2010.

3. The CCS in CDM should not serve as an incentive to increase the share of fossil fuel power plants in the host countries. Its development should not lead to a reduction of efforts to support energy saving policies, renewable energies and other safe and sustainable low carbon technologies, both in research and financial terms. In particular, as CCS is an end-of-pipe technology, it should ensure that downstream technologies (eg: boilers) are applying the best technologies available or at least that the crediting baselines are set at this BAT level. Any risk for the human health and the environment resulting from CCS should be avoided.

4. As the EU places high priority on environmental integrity and safety the assessment of CCS in CDM project activities should be done in a conservative manner, reflecting the specificities of such activities. The following sections elaborate the basis of a set of comprehensive and stringent modalities and procedures against which the Executive Board (EB) assesses that proposals for CDM project activities involving CCS adequately address specific issues referred in draft Decision -/CMP.6.

5. A suitable national obligatory and regulatory framework for the environmentally safe capture, transport and geological storage of CO2 should be established before the CCS project can be implemented in the host country. The purpose of environmentally safe geological storage of CO2 is permanent containment of CO2 to prevent and, where this is not possible, eliminate as far as possible negative effects and any risk to the environment and human health. The obligatory and regulatory framework needs to contain a permitting system for storage site operators. It should be ensured that no site is operated without such permit and there is only one operator for each storage site. Such permit should at least contain the name and address of the operator, proof of the technical competence of the potential operator, the precise location and delimitation of the storage site and storage complex, the requirements for storage operation, the total quantity of CO2 authorised to be geologically stored, the reservoir pressure limits, and the maximum injection rates and pressures, the requirements for the composition of the CO2 stream, the approved monitoring plan, the requirement to notify the competent authority in the event of leakages or significant irregularities, the approved corrective measures plan and the obligation to implement the corrective measures plan in the event of leakages or significant irregularities, the conditions for closure, any provisions on changes, review, updating and withdrawal of the storage permit, the requirement to establish and maintain the financial security.

6. Terminology throughout the submission is contained in Annex III "Definitions".

I. Selection of the storage site

7. This section addresses the issues raised in point (a) paragraph 3 of draft Decision -/CMP.6.

8. The secretariat should, drawing on external technical expertise as needed, elaborate draft criteria on site selection which will need to be met by national obligatory and regulatory frameworks before projects are approved. This should have regard to the issues discussed in paragraphs 9 to13.

9. A DOE with appropriate expertise should independently assess each project to verify both that regulations which meet the criteria referred to above are in place and that the project meets these regulations.

10. CO_2 storage in the water column, including storage on the sea ground, should be explicitly excluded from the scope. The suitability of a geological formation for use as a storage site under the CDM shall be determined through a characterisation and assessment of the potential storage complex and surrounding area pursuant to the criteria specified in Annex I. The selection of the appropriate storage site is crucial to ensure that the stored CO2 will be completely and permanently contained.

11. A geological formation shall only be selected as a storage site under the CDM, if under any conditions of use there is no significant risk of leakage, and if in any case no significant environmental or health risks exist.

12. Injection of CO2 streams for storage purposes into geological formations, which are not permanently unsuitable for other purposes shall be prohibited. This means that the storage of CO2 in freshwater aquifers or potential underground sources of drinking water shall be prohibited.

13. Storage reservoirs should not affect the development of renewable sources of energy and have to consider other energy-related options for the use of a potential storage site, including options which are strategic for the security of the host State’s energy supply.

II. Stringent monitoring plan

(a) Monitoring

14. This section addresses the issues raised in points (b), (g) and (i) paragraph 3 of draft Decision -/CMP.6.

15. The monitoring shall be based on a monitoring plan designed by the project operator. This will need to meet criteria to be elaborated by secretariat which should have regard to the requirements laid down in Annex II and the issues raised in paragraphs 16 to 31.

16. Attention must be given to potential seepage during the pre-injection (CO_2 capture and transportation), injection, and post-injection (operation, closure, post-closure) phases of a CCS project. All those operational phases should be monitored appropriately. Monitoring of injection facilities is done for the purpose of comparison between the actual and modelled behaviour of CO_2 and formation water, in the storage site, detecting significant irregularities, detecting migration of CO_2, detecting leakage of CO_2, detecting significant adverse effects for the surrounding environment, including in particular on drinking water, for human populations, or for users of the surrounding biosphere, updating the assessment of the safety and integrity of the storage complex in the short and long term.

17. The plan should be submitted to and approved by a DOE with appropriate expertise to verify both that the monitoring plan meets the criteria referred to above and that the plan is being adhered to.

18. The plan shall be updated pursuant to the requirements laid down in Annex II and in any case every five years to take account of changes to the assessed risk of leakage, changes to the assessed risks to the environment and human health, new scientific knowledge, and improvements in best available technology. Updated plans shall be re-submitted for approval to a DOE.

19. In the case of geological storage under the seabed, monitoring shall further be adapted to the specific conditions for the management of CCS in the marine environment. Operational procedures and monitoring methodologies shall be determined in accordance with industry best practice and the recommendations of the IPCC.

20. Monitoring of the sealing performance of wells is necessary after storage operations are completed.

21. Appropriate quality control and quality assurance regulations are fundamental to ensure sustainable operation of storage sites without setting the environment and human health at risk.

22. A CO_2 stream shall consist overwhelmingly of carbon dioxide. To this end, no waste or other matter may be added for the purpose of disposing of that waste or other matter. However, a CO_2 stream may contain incidental associated substances from the source, capture or injection process and trace substances added to assist in monitoring and verifying CO_2 migration. Concentrations of all incidental and added substances shall be below levels that would: (a) adversely affect the integrity of the storage site or the relevant transport infrastructure; (b) pose a significant risk to the environment or human health; or (c) breach the requirements of applicable national legislation.

23. A DOE shall verify that the operator: (a) has carried out an analysis of the composition of the CO_2 streams (including corrosive substances) and the risk and safety assessment, and if the risk and safety assessment has shown that the contamination levels are in line with the conditions; (b) keeps a register of the quantities and properties of the CO_2 streams delivered and injected, including the composition of those streams.

24. A DOE shall verify that the project operator carries out monitoring of the injection facilities, the storage complex (including the CO_2 plume), and the surrounding environment for the purpose of: (a) comparison between the actual and modelled behaviour of CO_2 and formation water, in the storage site; (b) detecting significant irregularities; (c) detecting migration of CO_2; (d) detecting leakage of CO_2; (e) detecting significant adverse effects for the surrounding environment, including in particular on drinking water, for human populations, or for users of the surrounding biosphere; (f) updating the assessment of the safety and integrity of the storage complex in the short and long term, including the assessment of whether the stored CO_2 will be completely and permanently contained.

25. Before authorizing any CCS CDM project activity, the EB should develop specific criteria tailored for accreditation of DOEs that will guarantee a high level of expertise, competencies and independency of the DOE. The accreditation of a DOE expires automatically after 3 years and can be renewed. All DOEs responsible for validation and verification of CCS project activities shall have all proper experiences relevant to CCS.

(b) Reporting by the project operator

26. At least once a year, the monitoring report shall contain (1) all results of the monitoring in the reporting period, including information on the monitoring technology employed; (2) the quantities and properties of the CO_2 streams delivered and injected, including composition of those streams, in the reporting period; (3) proof of the putting in place and maintenance of the financial security; (4) any other information a DOE considers relevant for the purposes of assessing compliance with storage requirements and increasing the knowledge of CO_2 behaviour in the storage site.

(c) DOE inspections

27. DOEs shall organize in cooperation a system of routine and non-routine inspections of all storage complexes for the purposes of checking and promoting compliance with the requirements and of monitoring the effects on the environment and on human health.

28. Inspections should include activities such as visits of the surface installations, including the injection facilities, assessing the injection and monitoring operations carried out by the operator, and checking all relevant records kept by the operator.

29. Routine inspections shall be carried out at least once a year until three years after closure and every five years until transfer of responsibility to the competent authority of the host country has occurred. They shall examine the relevant injection and monitoring facilities as well as the full range of relevant effects from the storage complex on the environment and on human health.

30. Non-routine inspections shall be carried out: (a) if one DOE has been notified or made aware of leakages; (b) to investigate complaints related to the environment or human health; (c) in other situations where any DOE or the EB considers this appropriate.

31. Following each inspection, a DOE shall prepare a report on the results of the inspection. The report shall evaluate compliance with the requirements and indicate whether or not further action is necessary. The report shall be communicated to the project operator concerned and shall be publicly available within two months of the inspection.

III. Risk and safety assessment

32. This section addresses the issues raised in points (j), (k) and (l) paragraph 3 of draft Decision -/CMP.6.

33. The secretariat should elaborate on a risk and safety methodology in the modalities and procedures having regard to the issues raised in paragraphs 34 to 44.

34. At a minimum, the risk and safety assessment shall comprise the elements specified in Step 3.3 of the Annex I.

35. The risk and safety assessment shall address the potential for leakage during operations as well as over the long term (i.e. after closure of the storage site).

36. The development and implementation of a risk and safety management and risk and safety communication plan shall be included in the risk and safety assessment.

37. The risk and safety assessment should help identify priority locations and approaches for enhanced monitoring activities.

38. The risk and safety assessment should provide the basis for mitigation/ remediation /corrective measures plans for response to unexpected events; such plans should be developed and submitted to the DOE in support of the proposed monitoring plan.

39. The risk and safety assessment should determine relevant operational data, including setting an appropriate injection pressure that will not compromise the integrity of the confining storage complex.

40. Periodic updates to the risk and safety assessment every 3 years shall be conducted throughout the project life cycle based on updated monitoring data and revised models and simulations, as well as knowledge gained from ongoing research and operation of other storage sites.

41. The risk and safety assessment should include site-specific information, such as the terrain, potential receptors, proximity of drinking water resources, faults, and the potential for unidentified borehole locations within the project extend.

42. The risk and safety assessment should include non-spatial elements or non-geologic factors (such as population, land use, or critical habitat) that should be considered in evaluating a specific site.

43. Pipelines located in vulnerable areas (populated or ecologically sensitive, areas) require extra due diligence by project operators to ensure safe pipeline operations. Options for increasing due diligence include among other things: decreased spacing of mainline valves, greater depths of burial, increased frequency of pipeline integrity assessments and monitoring for leaks.

44. The risk and safety assessment and all essential information shall be made public in order to guarantee a broad public participation in the decision making process.

IV. Socio-environmental impacts assessment

45. This section addresses the issues raised in points (j) and (l) paragraph 3 of draft Decision -/CMP.6.

46. The secretariat should elaborate on criteria for this socio-environmental impact assessment having regard to the issues raised in paragraphs 47 to 52.

47. Full socio-environmental impact assessment in accordance with relevant regional and international legal instruments as applicable shall be carried out for CO2 capture installations, CO2 storage sites and CO2 transport pipelines.

48. A DOE with appropriate expertise should undertake an assessment of each project based on the criteria referred to in paragraph 46 and provide a report to the EB.

49. For CO2 capture plants, as a minimum, the comprehensive socio-environmental impacts assessment shall analyze thoroughly and exhaustively air emissions (NOx, SOx, dust, Hg, PAHs, etc.), solid waste generation, and water use associated with current CO2 capture technologies.

50. In all cases, the socio-environmental impact assessment shall ensure that best available techniques are well applied and achieve a high level of protection for the environment as a whole.

51. The socio-environmental impact assessment shall include at least a comprehensive analysis of impacts on peoples living conditions in the possibly affected area, regardless of any boarders or other administrative frontiers.

52. In order to guarantee a broad public participation, project operators have to ensure that all relevant information is made available to the public and to stakeholders and that they are extensively involved in the decision making process, in line with relevant regional and international legal instruments as applicable,.

V. Short-, medium- and long-term liability

(a) General considerations

53. This section addresses the issues raised in points (m), (n) and (o) paragraph 3 of draft Decision -/CMP.6.

54. An effective national obligatory and regulatory framework has to be developed and implemented which covers liability before the CCS project can be authorised in the host country.

55. The secretariat should elaborate criteria on liability which will need to be consistent with national obligatory and regulatory frameworks before projects are approved. This should have regard to the issues discussed in paragraphs 56-73.

56. A DOE with appropriate expertise should assess each project to verify both that regulations are in place which meet the criteria referred to paragraph 55 and that the project is consistent with these regulations.

57. A general subsidiary responsibility and liability for the CCS complex lies with the host country. Before a transfer of responsibility each storage site should at all times be under the responsibility of only one entity (project operator or competent authority of the host country) for monitoring, preparedness, response, and remediation measures.

58. In cases of transboundary transport of CO2, transboundary storage sites or transboundary storage complexes, the project is only eligible as long as there is clear assignment of responsibilities and liabilities, and effectual accounting for emission reductions and any seepage according to solutions for reporting of cross border CCS projects put forward in the 2006 IPCC Guidelines; notwithstanding that the objective should be to avoid any seepage.

59. Before authorizing the CCS CDM project in the host country, the national obligatory and regulatory framework needs to contain closure and post-closure obligations, including provisions as mentioned in paragraphs 60-63.

60. A storage site shall be closed: (a) if the essential conditions stated in the permit have been met; (b) at the substantiated request of the operator, after authorisation of the competent authority of the host country; or (c) if the competent authority of the host country so decides after the withdrawal of a storage permit.

61. After a storage site has been closed pursuant to points (a) or (b) of paragraph 60, the project operator remains responsible for monitoring, reporting and corrective measures, and for all obligations relating to the accounting of emission reductions in case of leakages until the responsibility for the storage site is transferred to the competent authority of the host country. The project operator shall also be responsible for sealing the storage site and removing the injection facilities.

62. The obligations referred to in paragraph 61 shall be fulfilled on the basis of a post-closure plan designed by the operator based on best practice and in accordance with the requirements laid down in Annex II.

63. After a storage site has been closed pursuant to point (c) of the paragraph 60, the competent authority of the host country shall be responsible for monitoring and corrective measures, and for all obligations relating to the accounting of emission reductions in case of leakages. The post-closure requirements shall be fulfilled by the competent authority of the host country on the basis of the post-closure plan referred to in paragraph 62, which shall be updated as necessary.

64. Before authorizing the CCS CDM project in the host country, the national obligatory and regulatory framework in place has to demonstrate that there are adequate provisions guaranteeing in the long-term a means of redress for Parties, communities, private-sector entities and individuals affected by the release of injected CO2 or any other adverse health and environmental impact from the CCS project, including restoration of damaged ecosystems and full compensation for affected communities.

65. Storage sites, CO2 pipelines and potential seepage locations which cross national borders will potentially have additional legal implications and might be a source of dispute between States. A cooperation mechanism between countries together with an international organism to solve potential disputes might be created in the framework of the UNFCCC and/or international jurisdiction.

(b) Transfer of responsibility

66. Project Design Document (PDD) and monitoring plan should include clear and explicit assignment of long-term liability for monitoring and site-management, including remediation; they should clearly specify details of any transfer of liabilities, including evidence of agreements on such transfers; PDD and Monitoring Reports/Verification Reports should also include clear evidences of the compliance with financial and organizational provisions to ensure the continuing viability of the storage operation and monitoring beyond the crediting period.

67. Before authorizing the CCS CDM project in the host country, the national obligatory and regulatory framework in place has to demonstrate that there are adequate provisions guaranteeing that after closing the storage site, all legal obligations relating to monitoring and accounting of emissions in the event of leakages, have been transferred to the competent authority of the host country on its own initiative or upon request from the project operator.

68. When the competent authority of the host country endorses this responsibility, it shall notify it to the EB.

69. After the transfer of responsibility, DOE inspections can cease and monitoring may be reduced to a level which allows for detection of leakages or significant irregularities which imply the risk of leakage if the following conditions are met: (a) all available evidence indicates that the stored CO_2 will be completely and permanently contained; (b) a minimum period since the closure, to be determined by the competent authority of the host country, has elapsed. This minimum period shall be no shorter than 20 years, unless the competent authority and the DOE are convinced that the criterion referred to in point (a) is complied with before the end of that period; (c) the operator has paid a financial contribution to cover possible cost resulting from the transfer of responsibility (incl. corrective measures), at least the costs for monitoring for 30 years; (d) the site has been sealed and the injection facilities have been removed. If any leakages or significant irregularities which imply the risk of leakage are detected, the competent authority of the host country shall notify it to the EB and monitoring shall be intensified as required to assess the scale of the problem and the effectiveness of corrective measures.

(c) Measures in case of leakages or significant irregularities which imply the risk of leakage

70. At any time in the short-, medium- and long-term, in cases of leakages and significant irregularities which imply the risk of leakage, the entity responsible (i.e. project operator or competent authority of the host country) shall notify the EB and take the necessary corrective measures, including measures related to the protection of human health. Moreover, the entity responsible has to verify and notify to the EB the amount of CO_2 still stored safely in the relevant reservoir.

71. Before authorizing any CCS CDM project activity, the CMP/EB shall elaborate provisions to guarantee that leakage of any ton of CO_2 in the atmosphere is compensated, including through the removal of the same amount of credits from the market and/or by remediation.

(d) Financial security

72. The project operator must demonstrate a financial security or any other equivalent in order to ensure that all obligations during project operation as well as closure and post-closure requirements can be met. This financial security shall be valid and effective before the registration of the CCS CDM project.

73. The regulatory framework for the financial security shall be periodically adjusted by the EB to take account of changes in the assessed risk of leakage and the estimated costs of all obligations.

74. The financial security or any other equivalent shall remain valid and effective after a storage site has been closed, until the responsibility for the storage site is transferred to the competent authority of the host country.

ANNEX I: CRITERIA FOR THE CHARACTERISATION AND ASSESSMENT OF THE POTENTIAL STORAGE COMPLEX AND SURROUNDING AREA

The characterisation and assessment of the potential storage complex and surrounding area shall be carried out in three steps according to best practices at the time of the assessment and to the following criteria. Derogations from one or more of these criteria may be permitted by the DOE provided the project operator has demonstrated that the capacity of the characterisation and assessment to enable the determinations is not affected.

Step 1: Data collection

Sufficient data shall be accumulated to construct a volumetric and three-dimensional static (3-D)-earth model for the storage site and storage complex, including the caprock, and the surrounding area, including the hydraulically connected areas. This data shall cover at least the following intrinsic characteristics of the storage complex:

(a) geology and geophysics;

(b) hydrogeology (in particular existence of ground water intended for consumption);

(c) reservoir engineering (including volumetric calculations of pore volume for CO2 injection and ultimate storage capacity);

(d) geochemistry (dissolution rates, mineralisation rates);

(e) geomechanics (permeability, fracture pressure);

(f) seismicity;

(g) presence and condition of natural and man-made pathways, including wells and boreholes which could provide leakage pathways.

The following characteristics of the complex vicinity shall be documented:

(h) domains surrounding the storage complex that may be affected by the storage of CO_2 in the storage site;

(i) population distribution in the region overlying the storage site;

(j) proximity to valuable natural resources;

(k) activities around the storage complex and possible interactions with these activities (for example, exploration, production and storage of hydrocarbons, geothermal use of aquifers and use of underground water reserves);

(l) proximity to the potential CO_2 source(s) (including estimates of the total potential mass of CO_2 economically available for storage) and adequate transport networks.

Step 2: Building the three-dimensional static geological earth model

Using the data collected in Step 1, a three-dimensional static geological earth model, or a set of such models, of the candidate storage complex, including the caprock and the hydraulically connected areas and fluids shall be built using computer reservoir simulators. The static geological earth model(s) shall characterise the complex in terms of:

(a) geological structure of the physical trap;

(b) geomechanical, geochemical and flow properties of the reservoir overburden (caprock, seals, porous and permeable horizons) and surrounding formations;

(c) fracture system characterisation and presence of any human-made pathways;

(d) areal and vertical extent of the storage complex;

(e) pore space volume (including porosity distribution);

(f) baseline fluid distribution;

(g) any other relevant characteristics.

The uncertainty associated with each of the parameters used to build the model shall be assessed by developing a range of scenarios for each parameter and calculating the appropriate confidence limits. Any uncertainty associated with the model itself shall also be assessed.

Step 3: Characterisation of the storage dynamic behaviour, sensitivity characterisation, risk and safety assessment

The characterisations and assessment shall be based on dynamic modelling, comprising a variety of time-step simulations of CO2 injection into the storage site using the three-dimensional static geological earth model(s) in the computerised storage complex simulator constructed under Step 2.

Step 3.1: Characterisation of the storage dynamic behaviour

At least the following factors shall be considered:

(a) possible injection rates and CO2 stream properties;

(b) the efficacy of coupled process modelling (that is, the way various single effects in the simulator(s) interact);

(c) reactive processes (that is, the way reactions of the injected CO2 with in situ minerals feedback in the model);

(d) the reservoir simulator used (multiple simulations may be required in order to validate certain findings);

(e) short and long-term simulations (to establish CO2 fate and behaviour over decades and millennia, including the rate of dissolution of CO2 in water).

The dynamic modelling shall provide insight into:

(f) pressure and temperature of the storage formation as a function of injection rate and accumulative injection amount over time;

(g) areal and vertical extent of CO_2 vs time;

(h) the nature of CO_2 flow in the reservoir, including phase behaviour;

(i) CO_2 trapping mechanisms and rates (including spill points and lateral and vertical seals);

(j) secondary containment systems in the overall storage complex;

(k) storage capacity and pressure gradients in the storage site;

(l) the risk of fracturing the storage formation(s) and caprock;

(m) the risk of CO_2 entry into the caprock;

(n) the risk of leakage from the storage site (for example, through abandoned or inadequately sealed wells);

(o) the rate of migration (in open-ended reservoirs);

(p) fracture sealing rates;

(q) changes in formation(s) fluid chemistry and subsequent reactions (for example, pH change, mineral formation) and inclusion of reactive modelling to assess affects;

(r) displacement of formation fluids;

(s) increased seismicity and elevation at surface level.

Step 3.2: Sensitivity characterisation

Multiple simulations shall be undertaken to identify the sensitivity of the assessment to assumptions made about particular parameters. The simulations shall be based on altering parameters in the static geological earth model(s), and changing rate functions and assumptions in the dynamic modelling exercise. Any significant sensitivity shall be taken into account in the risk and safety assessment.

Step 3.3: Risk and safety assessment

The risk and safety assessment shall comprise, inter alia, the following:

3.3.1. Hazard characterisation

Hazard characterisation shall be undertaken by characterising the potential for leakage from the storage complex, as established through dynamic modelling and security characterisation described above. This shall include consideration of, inter alia:

(a) potential leakage pathways;

(b) potential magnitude of leakage events for identified leakage pathways (flux rates);

(c) critical parameters affecting potential leakage (for example maximum reservoir pressure, maximum injection rate, temperature, sensitivity to various assumptions in the static geological Earth model(s));

(d) secondary effects of storage of CO_2, including displaced formation fluids and new substances created by the storing of CO_2;

(e) any other factors which could pose a hazard to human health or the environment (for example physical structures associated with the project).

The hazard characterisation shall cover the full range of potential operating conditions to test the security of the storage complex.

3.3.2. Exposure assessment — based on the characteristics of the environment and the distribution and activities of the human population above the storage complex, and the potential behaviour and fate of leaking CO_2 from potential pathways identified under Step 3.3.1.

3.3.3. Effects assessment — based on the sensitivity of particular species, communities or habitats linked to potential leakage events identified under Step 3.3.1. Where relevant it shall include effects of exposure to elevated CO_2 concentrations in the biosphere (including soils, marine sediments and benthic waters (asphyxiation; hypercapnia) and reduced pH in those environments as a consequence of leaking CO_2). It shall also include an assessment of the effects of other substances that may be present in leaking CO_2 streams (either impurities present in the injection stream or new substances formed through storage of CO_2). These effects shall be considered at a range of temporal and spatial scales, and linked to a range of different magnitudes of leakage events.

3.3.4. Risk characterisation — this shall comprise an assessment of the safety and integrity of the site in the short and long term, including an assessment of the risk of leakage under the proposed conditions of use, and of the worst-case environment and health impacts. The risk characterisation shall be conducted based on the hazard, exposure and effects assessment. It shall include an assessment of the sources of uncertainty identified during the steps of characterisation and assessment of storage site and when feasible, a description of the possibilities to reduce uncertainty.

ANNEX II: CRITERIA FOR ESTABLISHING AND UPDATING THE MONITORING PLAN AND FOR POST-CLOSURE MONITORING

1. Establishing and updating the monitoring plan

The monitoring plan shall be established according to the risk and safety assessment analysis carried out in Step 3 of Annex I, and updated with the purpose of meeting the monitoring requirements according to the following criteria:

1.1. Establishing the plan

The monitoring plan shall provide details of the monitoring to be deployed at the main stages of the project, including baseline, operational and post-closure monitoring. The following shall be specified for each phase:

(a) parameters monitored;

(b) monitoring technology employed and justification for technology choice;

(c) monitoring locations and spatial sampling rationale;

(d) frequency of application and temporal sampling rationale.

The parameters to be monitored are identified so as to fulfil the purposes of monitoring. However, the plan shall in any case include continuous or intermittent monitoring of the following items:

(e) fugitive emissions of CO2 at the injection facility;

(f) CO2 volumetric flow at injection wellheads;

(g) CO2 pressure and temperature at injection wellheads (to determine mass flow);

(h) chemical analysis of the injected material;

(i) reservoir temperature and pressure (to determine CO2 phase behaviour and state).

The choice of monitoring technology shall be based on best practice available at the time of design. The following options shall be considered and used as appropriate:

(j) technologies that can detect the presence, location and migration paths of CO2 in the subsurface and at surface;

(k) technologies that provide information about pressure-volume behaviour and areal/vertical distribution of CO2-plume to refine numerical 3-D simulation to the 3-D-geological models of the storage formation;

(l) technologies that can provide a wide areal spread in order to capture information on any previously undetected potential leakage pathways across the areal dimensions of the complete storage complex and beyond, in the event of significant irregularities or migration of CO2 out of the storage complex.

1.2. Updating the plan

The data collected from the monitoring shall be collated and interpreted. The observed results shall be compared with the behaviour predicted in dynamic simulation of the 3-D-pressure-volume and saturation behaviour undertaken in the context of the security characterisation pursuant to Annex I Step 3.

Where there is a significant deviation between the observed and the predicted behaviour, the 3-D model shall be recalibrated to reflect the observed behaviour. The recalibration shall be based on the data observations from the monitoring plan, and where necessary to provide confidence in the recalibration assumptions, additional data shall be obtained.

Steps 2 and 3 of Annex I shall be repeated using the recalibrated 3-D model(s) so as to generate new hazard scenarios and flux rates and to revise and update the risk and safety assessment.

Where new CO2 sources, pathways and flux rates or observed significant deviations from previous assessments are identified as a result of history matching and model recalibration, the monitoring plan shall be updated accordingly.

2. Post-closure monitoring

Post-closure monitoring shall be based on the information collected and modelled during the implementation of the monitoring plan.

ANNEX III: DEFINITIONS

1. "geological storage of CO_2" means injection accompanied by storage of CO_2 streams in underground geological formations;

2. "storage site" means a defined volume area within a geological formation used for the geological storage of CO_2 and associated surface and injection facilities;

3. "geological formation" means a lithostratigraphical subdivision within which distinct rock layers can be found and mapped;

4. "leakage" means any release of CO_2 from the storage complex;

5. "storage complex" means the storage site and surrounding geological domain which can have an effect on overall storage integrity and security; that is, secondary containment formations;

6. "CO_2 stream" means a flow of substances that results from CO_2 capture processes;

7. "CO_2 plume" means the dispersing volume of CO_2 in the geological formation;

8. "migration" means the movement of CO_2 within the storage complex;

9. "significant irregularity" means any irregularity in the injection or storage operations or in the condition of the storage complex itself, which implies the risk of a leakage or risk to the environment or human health;

10. "significant risk" means a combination of a probability of occurrence of damage and a magnitude of damage that cannot be disregarded without calling into question the purpose of this Directive for the storage site concerned;

11. "corrective measures" means any measures taken to correct significant irregularities or to close leakages in order to prevent or stop the release of CO_2 from the storage complex;

12. "closure" of a storage site means the definitive cessation of CO_2 injection into that storage site;

13. “post-closure" means the period after the closure of a storage site, including the period after the transfer of responsibility to the competent authority.