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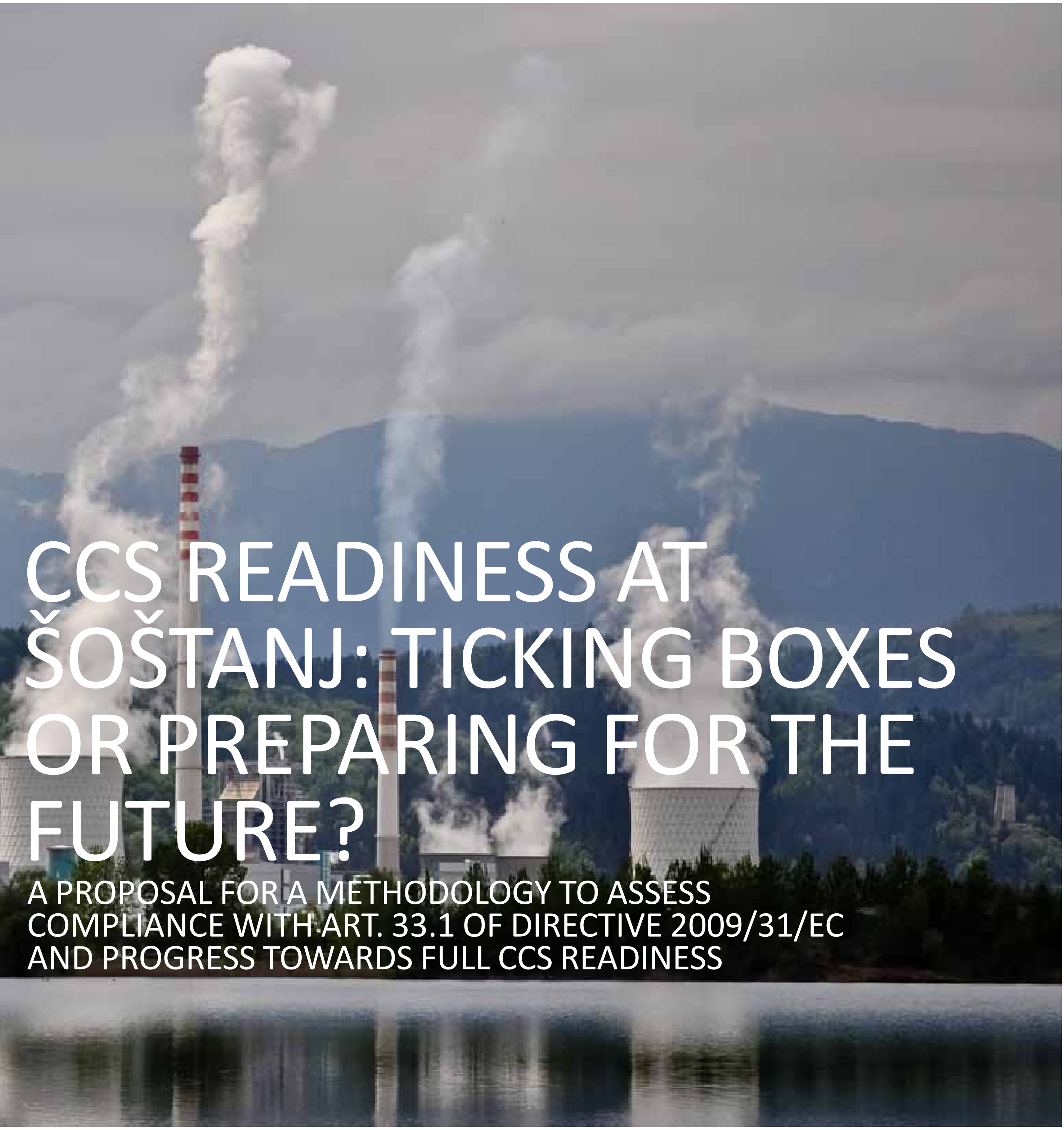

CCS READINESS AT ŠOŠTANJ: TICKING BOXES OR PREPARING FOR THE FUTURE?

A PROPOSAL FOR A METHODOLOGY TO ASSESS COMPLIANCE WITH ART. 33.1 OF DIRECTIVE 2009/31/EC AND PROGRESS TOWARDS FULL CCS READINESS

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Acknowledgements and legal disclaimer

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EXECUTIVE SUMMARY

↘Article 33.1 of directive 2009/31/EC ('the Directive') obliges Member States to ensure that applicants for new thermal power stations above 300 megawatt electric capacity (MWe) carry out an assessment of whether suitable CO_2 storage sites are available as well as of the technical and economic feasibility of CO_2 transport and retrofitting CO_2 capture technology, prior to the issuing of a construction permit for the power plant.

There is no commonly agreed standard for these assessments, although a number of organisations have suggested what the more comprehensive concept of CCS readiness should entail. This report draws on CCS readiness definitions to identify which questions can reasonably be addressed – at low cost – already prior to permitting of a power plant, in order to answer the questions of art. 33.1 of the Directive. In particular, this report sets out key project-specific information that needs to be provided in order to assess technical and economic feasibility. Some of the information will necessarily be highly uncertain at present, given the lack of experience with full-scale CCS at power plants.

The report then applies this methodology to the documents provided under art. 33.1 of the Directive by the project sponsor for a new unit 6 at the Šoštanj thermal power station in Slovenia.

Our evaluation shows that the submitted documents fail to comply with article 33.1 of the Directive because of:

- the absence of project-specific assumptions concerning economic feasibility, including lack of evaluation of economic feasibility of the capture, transport (in particular by sea) and storage;
- the lack of consideration of local geographical conditions' impact on technical feasibility, in particular for building pipelines;
- the absence of any information beyond already available data from GeoCapacity on suitability of storage sites;
- the lack of consideration of the impact of protected areas and NATURA 2000 areas on transport and storage locations.

In sum, the information contained within the documents does not exhaust what can reasonably be expected under article 33.1 of the Directive. It does not allow for the assessment of the feasibility of the project – neither technical nor economic feasibility, nor the availability of suitable storage sites.

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I. PURPOSE

This document's aims are:

» To propose a methodology firstly for assessing thermal power generation projects for compliance with art. 33.1 of directive 2009/31/EC and secondly for assessing power plants in their progress towards what we believe full CCS readiness should entail. Evaluation criteria have been defined for all parts of the value chain – capture, transport and storage.

» To apply this assessment methodology to the power plant construction project in Šoštanj, Slovenia.

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 (OJ L 140, 5.6.2009, p. 114)) (henceforth 'the Directive') entered into force 25 June 2009, and Member States had until 25 June 2011 to implement it. Article 33 added a new article 9a to the LCP (Large Combustion Plants) Directive,[1] requiring new thermal power generation installations with an electric capacity above 300 MWe to 1) assess the feasibility of CO_2 capture, transport and storage, and if this feasibility is established, to 2) set aside sufficient space for capture and compression of CO_2 from the plant. The article reads as follows:

Article 33

1. Member States shall ensure that operators of all combustion plants with a rated electrical output of 300 megawatts or more for which the original construction licence or, in the absence of such a procedure, the original operating licence is granted after the entry into force of Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide, have assessed whether the following conditions are met:

- suitable storage sites are available,

- transport facilities are technically and economically feasible,

- it is technically and economically feasible to retrofit for CO_2 capture.

2. If the conditions in paragraph 1 are met, the competent authority shall ensure that suitable space on the installation site for the equipment necessary to capture and compress CO_2 is set aside. The competent authority shall determine whether the conditions are met on the basis of the assessment referred to in paragraph 1 and other available information, particularly concerning the protection of the environment and human health.

In other words, Article 33 of the Directive requires applicants for new thermal power stations to carry out an assessment of whether suitable storage is available as well as of the technical and economic feasibility of CO_2 transport and retrofitting CO_2 capture technology. The introductory wording 'Member States shall ensure (...)' of article 33 also requires Member States to 1) judge the assessment presented by the project company and 2) require further assessments if the original assessments are not deemed sufficient, before issuing a permit for the power plant unit. *The present document*

1 The LCP directive was in 2010 're-cast' along with other EU legislation related to industrial emissions to form a consolidated directive on industrial emissions. Art. 33 of directive 2009/31/EC can now be retrieved as article 36 of directive 2010/75/EU of the European Parliament and of the Council on industrial emissions.

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seeks to assist Member States in interpreting this provision.

Article 33.2 requires appropriate space to be set aside to accommodate CO_2 capture technology only if assessments show that CCS is feasible (see Annex IV for further details). However, if CCS appears to be unfeasible, no requirements related to CCS are imposed on the project. This is why article 33 has a legal meaning only insofar as its paragraph 1 imposes obligations for assessing the feasibility of CCS. These conclusions remain unchanged by the recital 47 of the Directive,[2] related to CCS readiness.

Member States are free, however, to implement article 33 more expansively. In the 'Carbon Capture Readiness (CCR) A guidance note for Section 36 Electricity Act 1989 consent applications' issued by the Department of Energy and Climate Change in November 2009, the UK government set out its requirement for proposed power stations that they be granted the development consent only if they are assessed positively against the Article 33 criteria. This was done in order to support its commitment to new power stations at or over 300 MWe (and of a type covered by the LCP Directive) being built CCR.[3]

This report argues what CCS readiness (CCSR) should mean, building both on the Directive and existing literature. CCSR is understood as the end goal of a process. We break this process into two phases: In the first phase, prior to permitting of the plant, key information must be sought and evaluations need to be carried out. *This amounts to the feasibility and suitability evaluations required by article 33.1 of the Directive.* The second phase runs from permitting to the final investment decision to retrofit CCS on the plant. The criteria to fulfil in the second phase do not need to be fulfilled under the Directive but are important to map out in order to understand what is needed in the first phase, in order to give normative meaning to article 33.1.

This document is structured as follows: The next part (section II) proposes a CCSR assessment methodology. Our process approach to CCSR is first explained in general terms (section II.A), then CCSR assessment methodology is explained with a focus on phase 1 of building CCSR (II.B).

The last part of the document (section III) applies this assessment methodology – criteria by criteria – to the Šoštanj project based on the CCS feasibility studies provided by the project (section III).

2 Recital 47: 'The transition to low-carbon power generation requires that, in the case of fossil fuel power generation, new investments be made in such a way as to facilitate substantial reductions in emissions. To this end, Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants (OJ L 309, 27.11.2001,

3 ://decc.gov.uk/en/content/cms/what_we_do/uk_supply/consents_planning/guidance/guidance.aspx

II. CCS READINESS DEFINITION

II.A. CCS READINESS AS A PROCESS

In this document, we use an expansive understanding of CCSR, which includes the whole range of technical, commercial, legal and economic requirements that such a major project would need to fulfill in order for a final investment decision to be taken by the project company.

CCSR should thus be understood as a process of gradually increasing readiness, towards the final investment decision. As an example, acquisition of the land chosen for pipeline infrastructure investment may take up to 10 years in many countries. Therefore, in order to be prepared for the investment, the land acquisition process should be started 10 years prior to the planned introduction of CCS. CCSR thus requires prior definition of a process to reach the state of 100% readiness for the final investment decision moment.

This CCSR plan should consist of a) definition of the tasks and activities required prior to the investment along with an indicative task realization schedule and b) specifying of the conditions that need to be fulfilled but may be beyond the project company's influence (e.g. fuel cost, EUA price or pipeline access) for a final investment decision.

The company and other investors will make the final investment decision. This will depend mainly on two types of factors: Firstly, the net present value of the project, and secondly action by government (e.g. adoption of proper legislation, carrying out geological research). In addition, a lack of local support around potential storage sites could well be a show-stopper even if both the economics look attractive and government has assumed its responsibilities. Subjective assessments of both upward and downward risks for all these factors will be important for the foreseeable future.

II.B. ESTABLISHING CCSR CRITERIA

As mentioned above, we distinguish between two sets of CCSR criteria:

- Phase 1: Requirements under article 33.1 of the Directive, applicable to all permits for new power plant units above 300MWe ('CCS feasibility')
- Phase 2: Criteria recommended to be fulfilled prior to a final investment decision for retrofitting CCS to the plant (CCSR)

In this section, Phase 1 is analysed.

For CCSR, some crucial tasks can only be fulfilled by government, not the investor. Some of these tasks are listed in Annex V, but fall outside the scope of art. 33.1 of the Directive, as they concern 'full' CCSR.


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↘II.B.1. CCS FEASIBILITY

Article 33.1 requires assessments of ‘technical and economic feasibility’ of capture and transport of CO_2, whilst for storage the assessment should be about availability of ‘suitable storage sites’. The reason for the different wordings is presumably the greater local site specificity for storage. If there is no site with the required characteristics for permanently storing future captured CO_2, this is a geological reality that technical prowess or money can do little about. But this takes us to the term ‘available’, which brings us back to economic feasibility: The further away a suitable storage site, the more expensive the transport will be. Thus, in reality, similar standards for issues to address should be applied to both capture, transport and storage when evaluating assessments carried out for article 33.1 compliance.

‘Technically and economically feasible’

Article 33.1 of the Directive requires the ‘technical and economic feasibility’ of transport and of retrofitting the installation for capture of CO_2 to be assessed. Feasibility assessments should be carried out in a systematic manner and be based on reliable and objective methodology. However, the Directive does not give any guidelines for technical and economic feasibility assessments. A publication prepared by the European Commission – ‘Guide to Cost Benefit Analysis of Investment Projects’ - from July 2008, can be considered as a best practice example of how to approach feasibility assessments and is one source of criteria in this report.[1]

‘Economically feasible’ means that, during the operating life of the plant, there is a probability that a plant if retrofitted and operated with CCS can earn a reasonable rate of return on investment. The plant’s total cost for capture, transport, and storage would include planning, construction capital, and operating costs, including the time value of money.

The term ‘technically feasible’ is defined in point 2.4.b Annex I to directive 2003/87/EC[2], as *technical resources capable of meeting the needs of a proposed system can be acquired by the operator in the required time.*

‘Technically feasible’ or ‘technically capable’ can also be interpreted as meaning that technologies exist that can be applied to capture and transport and store a significant portion of the CO_2 emitted from the plant, while substantially preserving the original functionality of the plant.

The present document uses the outline for pre-feasibility studies[3] by P.M. Hawranek in *‘Manual for the preparation of industrial feasibility studies’* as the main reference to define the terms ‘technically and economically feasible’ that are used in the Directive. The outline for a pre-feasibility study can be found in Annex III. It must include a detailed assessment that takes local conditions into account.

For instance, if the operator decides to use an existing transport network, the availability and capacity assessment of this infrastructure must be made in the pre-feasibility study. If, because of the lack of connections or lack of transport facilities that match

1 http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf
2 http://eurlex.europa.eu/Notice.do?mode=dbl&lang=en&ihmlang=en&lng1=en,pl&lng2=bg,cs,da,de,el,en,es,et,fi,fr,hu,it,lt,lv,mt,nl,pl,pt,ro,sk,sl,sv,&val=454769:cs&page=
3 Manual for the preparation of industrial feasibility studies; W. Behrens, P. M. Hawranek, United Nations Industrial Development Organization, 2009

CO_2 transport criteria, the operator decides to build the network and facility, a pre-feasibility study for this must be prepared.

'Suitable storage sites are available'

A suitable storage site must have a reasonable chance of complying with the requirements of the Directive (a list of these criteria can be found in its annex I). It means that sites that are explicitly (under article 2 'Scope and Prohibitions') or implicitly (by national or regional law, as onshore storage sites in the UK) excluded from use as CO_2 storage sites are irrelevant to an assessment of suitability.

A third party should be commissioned (by the project company or the authorities) to carry out an evaluation of the most promising storage sites within a reasonable radius (which could be in the range 300-500 km, depending on the economics of a 'best-guess' future CCS project). The achievable level of detail – and probability – is driven by the data availability and the maturity of previous CO_2 storage assessments in the study area. An important part of a geological, technical and economic assessment is uncertainty and sensitivity evaluations. These should include stochastic modeling. A higher degree of uncertainty should entail that a larger number of potential storage sites are evaluated, and vice versa for low uncertainty, but in no case should less than two potential storage sites be evaluated.

The evaluation should at least address the parameters identified in Guidance Document 2 'Characterisation of the Storage Complex, CO_2 Stream Composition, Monitoring and Corrective Measures' to the Directive:

'The assessment will aim to identify and prioritize the most likely areas to continue future assessment activities. In performing this screening and ranking of regions or basins, a set of selection criteria with appropriate cut-off limits will be required on which the assessment can be made, e.g. basin depth, structural deformation, porosity, permeability, seal and reservoir quality and effectiveness. For each region or basin, the criteria may be adjusted to match the local issues in terms of criteria that reflect the scale and complexity of the storage needs such as distance to source, CO_2 supply volumes, injectivity rate etc. It is often quite important to adequately document the failure cases, so as to alert potential later attempts to re-assess such areas, and to make it apparent as to why they have been dismissed'.

Storage sites should be assessed within the jurisdictions of European Economic Area (EEA) countries, as CO_2 storage outside the EEA does not qualify as emission reduction under the EU Emission Trading System and thus will be economically more challenging. If economic feasibility depends on storage outside the EEA (e.g. for use in Enhanced Oil Recovery), they should be assessed against the requirements of the Directive, including the ability of the country of storage to fulfil the legal and administrative requirements of the Directive.

II.B.2. CCS FEASIBILITY CRITERIA

In the matrices below follows consolidated lists of criteria that this report argues need to be verified to assess the CCS feasibility of projects, and thus are required for compliance with article 33 of the Directive. It should be emphasized that this list is not closed and can be supplemented with additional, project-specific criteria. In the resulting matrices, CCS feasibility criteria are listed according to a number of variables:

Source of criteria

The criteria for assessing feasibility of capture, transport and storage build on the following sources:

- the Directive[4] (in Annex I to this report, general criteria for compliance with the Directive are listed that are particularly relevant for assessing the feasibility of CCS).
- Guidance documents for the interpretation of the Directive given by the European Commission[5]
- Recommendations on CCSR by the ICF[6]
- 'Definition of Carbon Capture and Storage Ready (CCSR)' by the Global CCS Institute, the International Energy Agency and the Carbon Sequestration Leadership Forum
- Global CCS Institute (see Annex II)
- UK Carbon Capture Readiness guidelines[7]
- Hawranek, P.M. (1991)
- Bellona's own analysis

It should be stressed that the sources generally link their criteria to other purposes than compliance with art. 33.1 of the Directive (CCSR, compliance with the Directive overall, etc.). The links to art. 33.1 of the criteria express the views of the authors only.

Categories of criteria

Criteria for readiness of capture, transport and storage are divided into:

- Commercial (contractual)
- Economic
- Environmental
- Gelogical
- Legal
- Technical
- Public awareness
- Organisation

Impact

The relative magnitude of potential impact on CCS retrofitting if a criterion is not fulfilled, is assessed.

Risk assessment

If a criterion is not fulfilled, it entails some risk to the investment, which is described in some detail for certain criteria.

Risk management

How risks can be managed and mitigated is here described for some of the criteria.

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4 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, EC 2009, (open), http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF

5 Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Guidance Document 1, CO_2 Storage Life Cycle Risk Management Framework, EC 2011 (open), http://ec.europa.eu/clima/policies/lowcarbon/docs/gd1_en.pdf, Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Guidance Document 2, Characterisation of the Storage Complex, CO_2 Stream Composition, Monitoring and Corrective Measures, EC 2011 (open), http://ec.europa.eu/clima/policies/lowcarbon/docs/gd2_en.pdf
Questions and Answers on the directive on the geological storage of carbon dioxide, http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/798&format=HTML&aged=0&language=

6 CCS Ready Policy: Considerations and Recommended Practices for Policymakers, GCCSI 2010, (open), http://www.cslforum.org/publications/documents/CCS_Ready_Policy_Considerations.pdf: The report includes three levels of ambition, This document has retained all maximum (level 3) requirements, as well as some minimum (level 1) requirements.

7 Carbon Capture Readiness (CCR), A guidance note for Section 36 Electricity Act 1989 consent applications, Department of Energy and Climate Change, UK 2009, (open), http://www.decc.gov.uk/publications/

↘ PROPOSED CRITERIA FOR CCS FEASIBILITY ASSESSMENTS
CAPTURE

No	Source of criteria	Category	Criteria	Impact	Risk	Risk management
1	ICF	Economic	Project-specific preliminary economic analysis of capture facilities prepared	High		
2	ICF	Economic	Economic and technical pre-feasibility study made	Medium		
3	Bellona	Organisation	Conditions for triggering final investment decision for CCS retrofit are described (EUA price, fuel cost…)	High	Operational costs, ETS income and financial costs are incorrectly projected	Plan trigger mechanism
4	Hawranek, P.M. (1991)	Organisation	Indicative schedule for preparing and undertaking CCS retrofit is made	High		
5	Bellona	Public awareness	Participation of the public in the project preparation has been planned, including assessment of costs of the participation.	High		
6	Bellona	Technology	Location and land footprint of capture plant, compression equipment, chemical storage facilities and exit point are planned.	High	The land space reserved is not sufficient	Carefully assess space needs, investigate alternative capture technology
7	ICF	Technology	Preferred capture technologies identified	High	Integration difficulties with existing plant, higher capital costs than expected, high risk novel technology, possible technological lock-in	Asses all available technology prior to vendor and technology commitment
8	ICF	Technology	Preliminary design for capture facilities and their integration into the plant prepared	Medium	Improper assessment of the space needed.	Prepare preliminary design
9	ICF	Technology	List of companies which can supply construction and operation services for capture facilities compiled	Medium		

PROPOSED CRITERIA FOR CCS FEASIBILITY ASSESSMENTS
TRANSPORT

No	Source of criteria	Category	Criteria	Impact	Risk	Risk management
1	Bellona	Commercial	Rights of way to access the pipeline corridor or shipping route identified and evaluated	High		
2	ICF	Economic	Economic and technical pre-feasibility study made.	High	Transport facilities are not technical and economical feasible	Prepare economic and technical feasibility
3	Hawranek, P.M. (1991)	Economic	Total transportation demands prepared	Medium	Transportation needs may not be satisfied	Prepare demand forecast for each transportation network
4	Hawranek, P.M. (1991)	Economic	Investment and operational costs assessed			
5	Bellona	Environment	Compatibility with environmentally sensitive or protected areas, especially NATURA 2000 areas, identified	Medium	Building permission would be suspended or rejected due to environmental conflicts	Identify NATURA 2000 areas, and list potential environmental concerns
6	Dir, Art.3, par.22	Law	Preferred transport infrastructure defined (pipelines, booster stations, port facilities etc.). Feasible pipelines and/or shipping routes identified. Health and safety evaluation of transportation system done.	Low	Delay in forming required regulation and permits necessary for CO_2 transport	
7	Hawranek, P.M. (1991)	Organisation	Timeline for CCS transportation system permitting and construction prepared	Medium	Delays due to cost rises, material and expertise availability.	Planning projections along with information and understanding of transportation network construction industry
8	Bellona	Public awareness	Participation of the public in the project preparation has been planned, including assessment of costs of the participation.	High		Puublic can stop or delay investment process
9	ICF	Technology	One or more feasible pipelines and/or shipping routes identified	High		Feasibility of the whole project can be jeopardised
10	ICF	Technology	Compile a list of companies capable of providing equipment, materials and services, required for construction and operation of a CO_2 transportation network.	Low		

↘ PROPOSED CRITERIA FOR CCS FEASIBILITY ASSESSMENTS
STORAGE

No	Source of criteria	Category	Criteria	Impact	Risk	Risk management
1	CSLF/ Directive/ Guidance Document 2/ Bellona	Geology	A qualified 3rd party has been commissioned to assess within a radius of 500km from the CO_2 source the most promising (two or more) storage sites, addressing: 1) Overall technical and geological capacity of storing CO_2 (incl. basin depth, structural deformation, porosity, permeability, seal and reservoir quality and effectiveness), 2) Storage capacity (incl. porosity of the storage formation, fracture density and orientation of the storage formation, the composition and/or compressibility of the pore fluid in the storage formation, migration pathways, the volume of closures and acceptable pressure build-up), 3) Monitorability of storage, and 4) Net costs (incl. capital, operation and maintenance costs; for non-EEA sites: non-ETS revenues;). This includes evaluation of uncertainties and sensitivities of key parameters.	High	Possible conflict of interest; economic influences and previous industry relationships may lead to sub-optimal storage site selection.	Results supervised and verified by relevant competent authority
2	Dir, Art. 4, par. 1	Legal	Surveyed potential storage sites are not a priori excluded from CO_2 storage by the authorities	High	A potential storage country may reject CO_2 storage on part or entire territory	Check the position of the Member States (relating to the storage site). Get official statement from the relevant Competent Authority.
3	ICF	Ongoing activities	Preliminary schedule for confirming storage site (seismic, drilling) is prepared	Medium	Changes to regulations and the progress of storage facility will influence investment and operational costs	Plan and evaluate trigger mechanism
4	Bellona	Public awareness	Participation of the public in the project preparation has been planned, including assessment of costs of the participation.			

III. READY OR NOT? APPLYING THE METH-ODOLOGY TO ŠOŠTANJ UNIT 6

In May 2010, a study called ***'CO2 Capture Readiness of Unit 6 in Thermal Power Plant Šoštanj'*** (Paper no. 2034) was prepared by the Milan Vidmar Electric Power Institute. Emphasis was placed on CO_2 capture and storage legal requirements as well as CO_2 capture technology. The study compares the technical characteristics with requirements necessary to retrofit CCS to Unit 6 of the pulverized coal combustion power plant. The study also analyses the possibilities of transporting and storing captured carbon dioxide as well as environmental impacts of potential investment. The study claims that CCS is technically and economically feasible for Unit 6 of Thermal Power Plant Šoštanj.

In September 2010, an addition to the study was prepared by the Milan Vidmar Electric Power Institute: ***'Capture Readiness of Unit 6 in Thermal Power Plant Šoštanj, Addition.'***[1] It analyses the availability of CO_2 storage sites in Slovenia, the nearby countries as well as North Sea sites in greater detail. Their availability and appropriate capacity are a condition for retrofitting CCS. The 'Addition' also sets out economic parameters for retrofitting CO_2 capture and storage technology to Unit 6. Investment costs, operational and maintenance costs and transport and storage costs are evaluated. Costs originating from loss of power production are also considered. The document claims that *'all of them are expressed in Euros per unit of generated electricity (€/MWh). On this evaluation is based economic feasibility of retrofitting CCS.'*

MAIN CONCLUSIONS

The lack of experience with full-scale CCS at power plants means that assessments of CCS retrofit feasibility will contain large uncertainties. However, assessments still need to investigate project-specific variables to the extent possible. We therefore find that the documents prepared by the Milan Vidmar Electric Power Institute fail to comply with article 33.1 of the Directive because of:

- the absence of project specific assumptions concerning economic feasibility, including lack of evaluation of economic feasibility of the capture, transport (in particular by sea) and storage;
- the lack of consideration of local geographical conditions' impact on technical feasibility, in particular for building pipelines;
- the absence of any information beyond already available data from GeoCapacity on suitability of storage sites;
- the lack of consideration of the impact of protected areas and NATURA 2000 areas on transport and storage locations.

In sum, the information contained within the documents does not allow for the assessment of the feasibility of the project (neither technical nor economic feasibility, incl. suitability of storage sites).

Given the failures to comply with article 33.1 of the Directive, it is hardly surprising that no operational schedule exists for making the plant fully CCS ready.

The documents' description of the feasibility and readiness of capture, transport and storage is assessed in the following sections against the methodology presented in section II:

1) compliance of the Šoštanj project with article 33.1 of the Directive, and

2) the project's fulfilment of criteria for full CCS readiness.

1 Available on http://www.focus.si/files/programi/energija/CCS_Readiness_Study_TES_Sostanj_1.pdf

↘ AVAILABLE SPACE FOR RETROFITTING UNIT 6 OF SOSTANJ TPP WITH CAPTURE TECHNOLOGY

SOURCE: WWW.MG.GOV.SI/FILEADMIN/MG.GOV.SI/PAGEUPLOADS/ENERGETIKA/POROCILA/TES_6_NIP4.PDF, PAGE 72.

III.A. CAPTURE

↘ III.A.1. ARTICLE 33.1 COMPLIANCE

Assessing the technical and economic feasibility of capture for a project requires a number of components to be assessed. A general level description of what a pre-feasibility study should include is found in Annex III. Below is a list of the most important capture-related items for a project such as that at Šoštanj.

1. Project-specific preliminary economic analysis of capture facilities prepared

Assessment (not passed): Project specific financial and economic information is not provided, so it is impossible to assess economic feasibility

Recommendations: Provide proper financial information, show numbers and discuss economic feasibility

2. Economic and technical pre-feasibility study made

Assessment (not passed): Feasibility of the project not assessed

Recommendations: Assess feasibility of the project (economic and technical)

3. Conditions for triggering final investment decision for CCS retrofit are described (EUA price, fuel cost…)

Assesment (not passed): information about conditions for taking decision about retrofitting (trigger mechanism) has not been provided. Without information about triggering conditions it is impossible to assess technical and economic feasibility of the planned investment.

Recommendations: Describe conditions for taking CCS retrofit investment (for example price of CO_2, cost of investment, risk perception, geological research completion).

4. Indicative schedule for preparing and undertaking CCS retrofit is prepared

Assesment (not passed): no CCS retrofitting schedule was presented. Without presenting schedule for preparation of CCS readiness, the technical and economic feasibility cannot be assessed properly.

Recommendations: Show steps and indicative dates for major CCS readiness criteria fulfilment. Harmonise planned activities with transport and storage investments.

5. Participation of the public in the project preparation has been planned, including assessment of costs of the participation.

Assesment (not passed): No information about public awareness activities provided

Recommendations: Plan public awareness activities.

6. Location and land footprint of capture plant, compression equipment, chemical storage facilities and exit point are planned.

Assesment (not passed): location of the storage site is provided in the form of a map:

The need for space is not elaborated in the document. The author provided map with the space reserved for CCS, but it is impossible to conclude if reserved space suffices the needs. There is no information provided on the area of the reserved surface.

Recommendations: Provide details and compare the technological needs for reserved surface.

7. Preferred capture technologies identified

Assessment (passed): Preferred technology is clearly identified: post combustion amine absorption.

8. Preliminary design for capture facilities and their integration into the plant prepared

Assessment (not passed/partly passed): the preliminary design for the capture facility is depicted, although on a very general level. Understanding and assessment of material and energy flow is impossible.

Recommendations: Provide details needed to understand the process.

9. List of companies which can supply construction and operation services for capture facilities compiled

Assessment (not passed): Technology providers are not listed.

Recommendations: List potential technology providers and vendors.

III.A.2. FULL CCSR

In addition to the above criteria, the following criteria will need to be fulfilled for a final investment decision prior to a retrofit of the unit with CCS to be undertaken:

Economics

- Economic feasibility study based on technical feasibility study, with information provided by the design basis memorandum, is prepared prepared.
- Financing plan of investment is made.

Environment

- Environmental impact assessment is undertaken.

Law

- Permit for capture plant installation obtained.
- Approvals for retrofitting obtained.
- Suitable space on the installation site for the equipment necessary to capture and compress CO_2 is set aside.

Public awareness

- The public is notified of the proposed capture facility retrofit.
- The public is engaged and informed in planning of the capture plant and has an opportunity to take part in the permitting process.

Technology

- Technical feasibility study for capture facilities and their integration prepared.
- Companies contacted and nonbinding letters of intent to bid on project negotiated.
- Material inputs (approximate input requirements, their present and potential supply positions, and a rough estimate of annual costs of local and foreign material inputs) are assessed.

III.B. TRANSPORT

III.B.1. ARTICLE 33.1 COMPLIANCE

Assessing the technical and economic feasibility of transport for a project requires a number of components to be assessed. A general level description of what a pre-feasibility study should include is found in Annex III. Below is a list of the most important transport-related items for a project such as that at Šoštanj.

1. Rights of way to access the pipeline corridor or shipping route identified and evaluated

Assesment (not passed): Commercial accessibility was not evaluated. No land ownership information is available.

Recommendations: Evaluate commercial accessibility of the selected transportation routes.

2. Economic and technical pre-feasibility study made

Assesment (not passed): Feasibility of the project not assessed

Recommendations: Assess feasibility of the project (economic and technical)

3. Total transportation demands prepared

Assesment (passed): Page 16 of 'Addition' states that from the costs point of view it is recommended that the storage site is as close as possible to the source of CO_2. In the frame of the Geocapacity Project it was discovered that Slovenia has sufficient capacity to store captured CO_2 from Unit 6 of Šoštanj Power plant. Expected quantities of CO_2 captured from Unit 6 in the period 2020 - 2054 amounts in the range from 70.2 to 76.2 Mio.t; the representative value is 73,6 Mio.t. Conservative estimates of storage capacity in Slovenian aquifers is 92 Mio.t CO_2.'

Recommendations: Specify capacity of each pipeline (leading to each location).

4. Investment and operational costs assessed

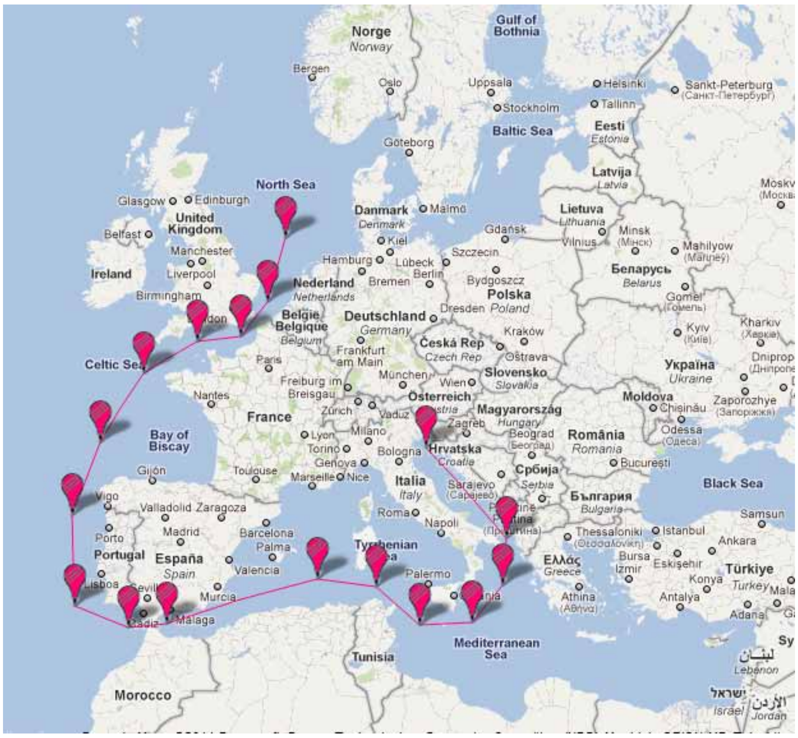
Assesment (not passed): No information provided about specific investment and operational costs. Transportation costs are provided in an imprecise and ambiguous way.

'The representative cost of transport to the storage sites 250 km from Unit 6 of Thermal power plant Šoštanj in Croatia or Italy that does not include the cost of loss of electricity production because of carbon capture operation is 1.8 €/MWh. The expected cost range is from 1.7 to 1.9 €/MWh. The representative transport cost to the storage sites 250 km from Unit 6 of Thermal power plant Šoštanj in Croatia or Italy that include cost of loss of electricity production is 2.2 €/MWh. The expected cost range is from 2.1 to 2.3 €/MWh. The cost of transport to Italian offshore location is higher. The most expensive is the combination of pipeline transport from Unit 6 to port Koper and then by ship to the North Sea.' (page 19 of 'Addition')

Comment: Italian offshore and North Sea (via Koper) routes calculations are not provided. A North Sea location probably is not feasible due to too excessive transportation costs.

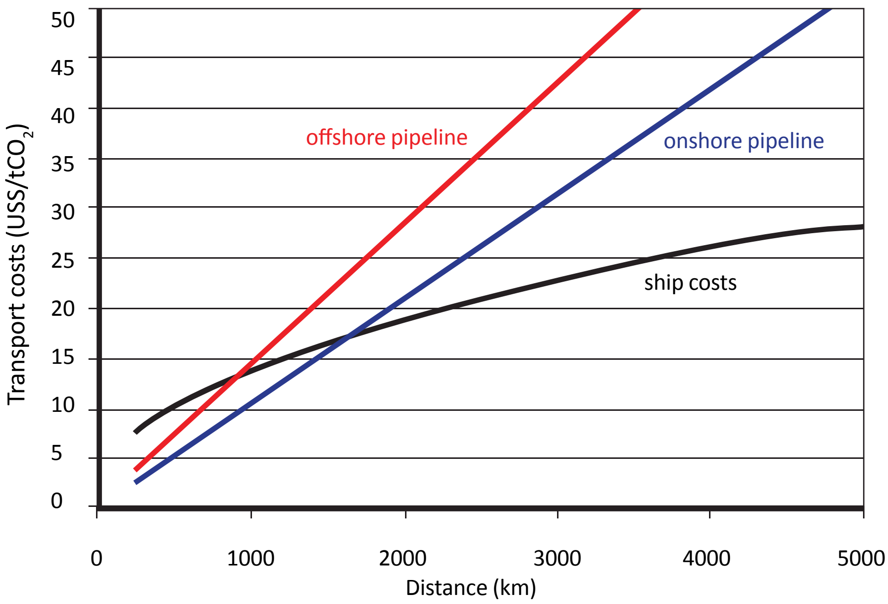
Distance from Koper to the North Sea is about 6200 km. Unit ship transportation price is about 0.004 EUR/(Km*ton), which equates

↘ ROUTE FROM KOPER PORT TO THE NORTH SEA



SOURCE: BELLONA, USING GOOGLE MAPS

↘ CHANGE OF THE TRANSPORTATION COST AS A FUNCTION OF DISTANCE



Costs, plotted as transportation costs in USS/tCO_2 against distance, for onshore and offshore pipelines, and ship transport. The costs include intermediate storage facilities, harbour feets, fuel costs and loading/unloading activities. Costs also include additional costs for liqefaction compared to compression. There is a capital charge factor of 11% for all transport options.

SOURCE: HTTP://WWW.POWERPLANTCCS.COM/CCS/TRA/TRA_SHIP_COST.HTML).

PHOTO KALE

to of approximately 25 EUR/(km*ton). Costs of 25-30 EUR/km are most likely prohibitive. The cost has a negative impact on economic feasibility for the entire project. The costs of North Sea transportation have not yet been discussed.

Building pipelines via Austria and Germany will likely be a more feasible and a cost effective solution.

In the document, it was stated: *'In the context of long distance movement of large quantities of carbon dioxide, pipeline transport is part of current practice. Pipelines routinely carry large volumes of different gases and liquids over distances of thousands of kilometers, both on land and in the sea.*

The costs of pipelines can be categorized into three items:

- construction costs: aterial/equipment costs (pipe, pipe coating, cathodic protection, telecommunication equipment; possible booster stations);

- installation costs (labor);

- operation and maintenance costs: monitoring costs, maintenance costs, possible) energy costs;

- other costs (design, project management, regulatory filing fees, insurances costs, right-of-way

costs, contingencies allowances).

Apart from the categories listed, cost is affected by the type of terrain, as well . Onshore pipeline costs may increase by 50 to 100%, or more, when the pipeline route is congested and heavily populated. Costs are also increased in mountainous 'territory, in nature reserve areas, in areas with obstacles such as rivers and freeways, and in heavily urbanized areas because of accessibility to construction and additional required safety measures. Offshore pipelines generally operate at higher pressures and lower temperatures than onshore pipelines, and are often, though not always, 40 to 70% more expensive.' (page 17)

There is no information about technology, for instance: limitations of pipeline system constructed in the vicinity of existing natural gas networks, pressure, need of compression, any other specific requirements.

Recommendations: Provide information about costs (CAPEX and OPEX).

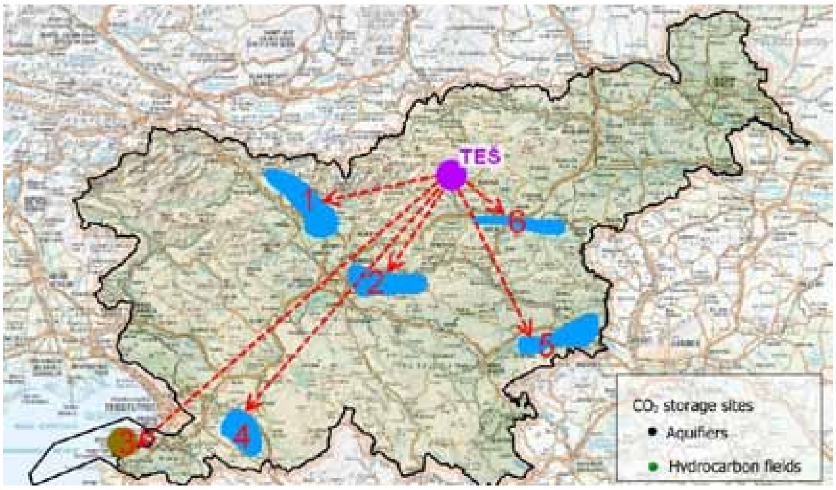
5. Compatibility with environmentally sensitive or protected areas, especially NATURA 2000 areas, identified

Assesment (not passed): The following information is provided about location of the transportation network: 'The transmission network, designed to transport carbon dioxide, shall most probably run in the vicinity of the existing gas pipeline.' (page 18 of 'Addition')

Although the pipeline network project may come across numerous impediments connected with the environmental pro-

↘ THE PIPELINE NETWORK AND CO_2 EMISSION SOURCES SUITABLE FOR RETROFITTING WITH CCS TECHNOLOGY

↘ FIGURE8: LOCATIONS OF STORAGE SITES (1, 2, 4, 5, 6) IN SLOVENIA AND LOCATION OF PORT KOPER(3)



tection, none of the possible impediments has yet been evaluated.

Recommendations: Evaluate possible environmental impediments, especially those related to NATURA 2000, and national parks.

Examples of information which should be evaluated in the context of pipeline network construction:

a) NATURA 2000 areas

b) National protected areas, NATURA 2000 areas, Valuable Natural Features, Ecologically Important Areas, Zonation (protected areas)

6. Preferred transport infrastructure defined (pipelines, booster stations, port facilities etc.). Feasible pipelines and/or shipping routes identified. Health and safety evaluation of transportation system done.

Assesment (not passed): Information about pipeline infrastructure is very general, information about necessary booster stations and other necessary facilities is not provided. However, page 18 of the 'Addition' document includes a map of potential storage sites and says the following:

'In case of transportation to locations out of Slovenia transport will be done by onshore and in some cases in combination with offshore pipelines. The possibility is also pipeline transport to port Koper and from there by ships to storage site in North Sea or elsewhere. The pipeline to port Koper is approximately 150 km long. The location of Koper port is shown on figure 8.'

Costs of North Sea transportation are very high, and there is no information about financial feasibility of this route. No information is provided about income for location outside of the EU/EEA.

Recommendations: Prepare technical information pertaining to transport facilities. The information should be used for technical and economic prefeasibility analysis.

7. Timeline for CCS transportation system permitting and construction prepared

Assesment (not passed): No information provided

Recommendations: Prepare indicative timeline for transport system construction. The information should be used to defend technical and economic feasibility of the project.

8. Participation of the public in the project preparation has been planned, including assessment of costs of the participation.

Assesment (not passed): No information about public awareness activities provided

Recommendations: Plan public awareness activities.

9. Any conflicting land use, activity as well as feasibility of land/port access assessed

Assesment (not passed): No evaluation done.
Recommendations: Evaluate conflicting land use.

10. Compile a list of companies capable of providing equipment, materials and services, required for construction and operation of a CO_2 transportation network.

Assesment (not passed): No evaluation done.
Recommendations: Prepare the list of technology supplies.

III.B.2. FULL CCSR

In addition to the above criteria, the following criteria will need to be satisfied for a final investment decision to retrofit the unit with CCS:

Commercial
- Rights of way to access the pipeline corridor or shipping route obtained.

Economics
- Financial analysis of investment completed.

Environment
- Environmental impact assessment made according to directive 85/337/EEC.

Law
- Permits/approvals obtained for transport infrastructure.

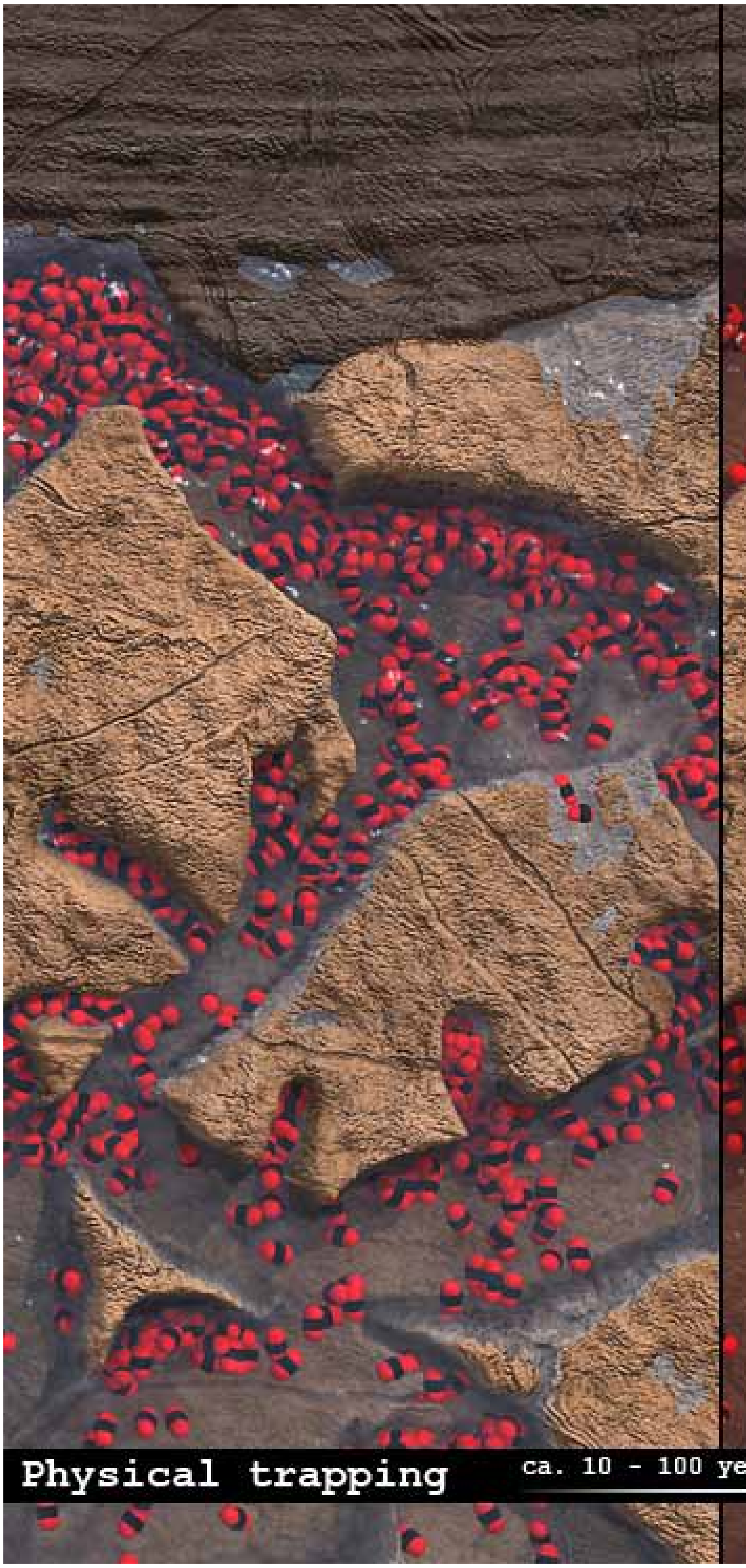
Public awareness
- The public is engaged in planning of transport infrastructure and has an opportunity to take part in the permitting process.

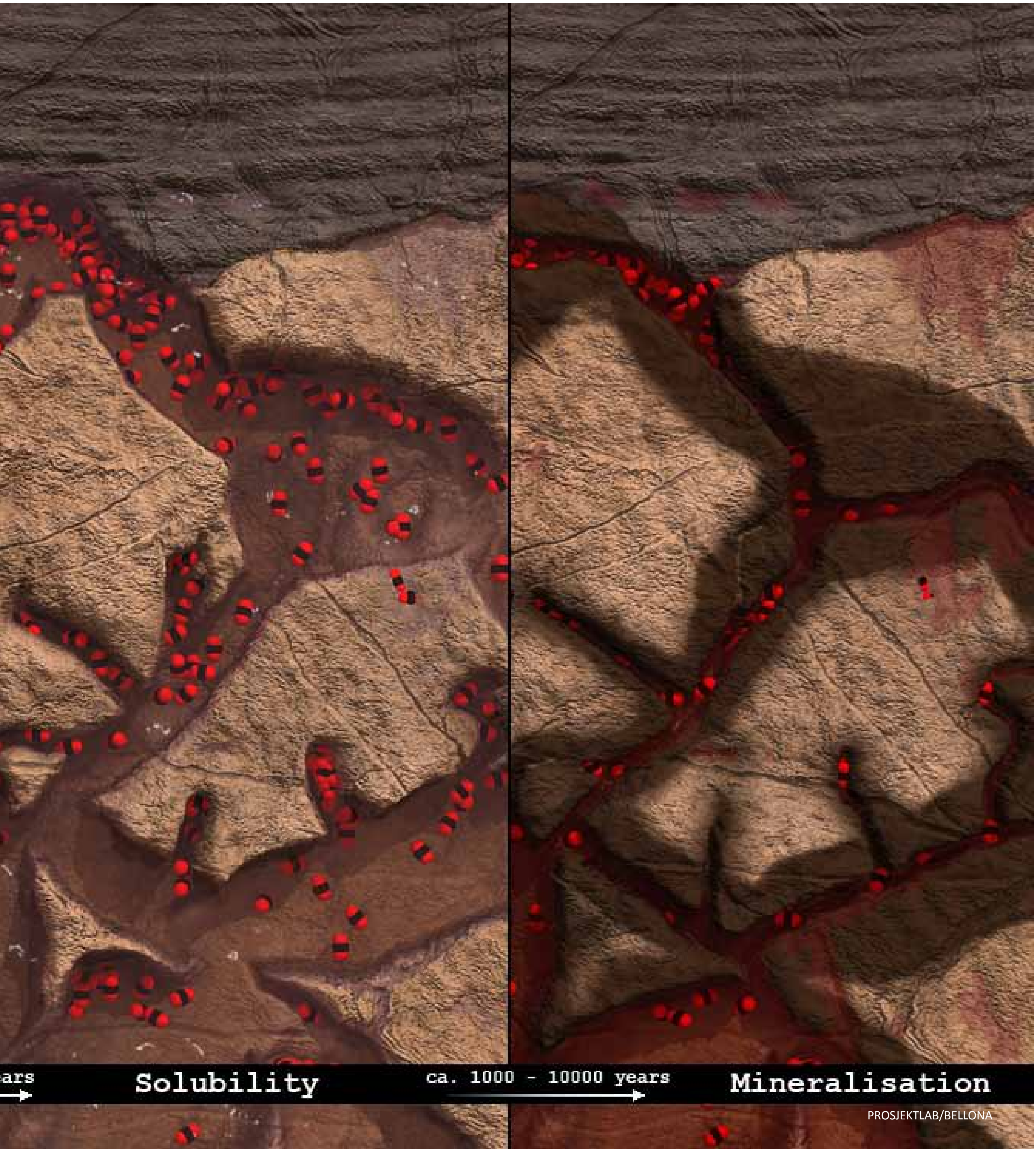
Technology
- Approximate material input requirements, at both present and future supply positions. Additionally the annual costs of local and foreign material inputs are to be projected.
- One or more potential transport method(s) identified and selected.
- Any issues connected with conflicting surface and sub-surface uses, and land/port access resolved.
- Contacts with companies made and nonbinding letters of intent to bid on project signed.
- The availability of the required transport capacity for the needs of the project.

III.C. STORAGE

III.C.1. ARTICLE 33.1 COMPLIANCE

As described in section II.B.1, assessing the 'availability of suitable storage sites' requires technical and economic feasibility studies, as for capture and transport. This requires a number of components to be assessed. A general level description of what a pre-feasibility study should include is found in Annex III. Below is a list of the most important storage-related items for a project such as that at Šoštanj.





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1. A qualified 3rd party has been commissioned to assess within a radius of 500km from the CO_2 source the most promising (two or more) torage sites:

Addressing:

1) Overall technical and geological capacity of CO_2 storage potential incl. basin depth, structural deformation, porosity, permeability, reservoir quality, seal and effectiveness.

2) Storage capacity, incl. porosity of the storage formation, fracture density and orientation of the storage formation, the composition and/or compressibility of the pore fluid in the storage formation, migration pathways, the volume of closures and acceptable pressure build-up.

3) Monitorability of storage.

4) Net costs, incl. capital, operation and maintenance costs; for non-EEA sites: with non-ETS revenues. This includes evaluation of uncertainties and sensitivities of key parameters.

Assesment (not passed): No information provided. Evaluation of feasibility may be impossible.

Rough information about geological formation is provided in the GeoCapacity project, which is insufficient.[2]

Recommendations: A third party to be commissioned to select sites for evaluation and uncertainty analysis.

2. Surveyed potential storage sites are not a priority excluded from CO_2 storage by the authorities

Assesment (passed): There is no indication that potential storage sites will be excluded by any government

3. Preliminary schedule for confirming storage site (seismic, drilling) is prepared

Assesment (not passed): There is no information regarding storage site schedule.

Recommendations: Schedule activities, plan trigger mechanism (incl. economic evaluation).

4. Participation of the public in the project preparation has been planned, including assessment of costs of the participation.

Assesment (not passed): No information about public awareness activities provided

Recommendations: Plan public awareness activities.

III.C.2. FULL CCSR

In addition to the above criteria, the following criteria will need to be satisfied for a final investment decision to retrofit the unit with CCS:

Commercial
- One or more storage sites are contractually secured.

Environment
- Selected storage site(s) demonstrate storage security, covering environmental and health risk assessments.

Geology
- The suitability of a geological formation for use as a storage site determined through a characterisation and assessment of the potential storage complex and surrounding area pursuant to the criteria specified in Annex I.

Law
- All required environmental, safety, and other approvals for storage site have been obtained.
- For non-Member States storage locations: Compliance of the storage country regulations with the EU regulations and requirements.
- Storage country has undertaken or commissioned an assessment of the storage capacity

Public awareness
- The public is engaged in the planning stage of a proposed storage site and has an opportunity to take part in the permitting process.

Technical
- One or more storage sites have been identified with the geological storage capability for industrial volumes of captured CO_2
- Sources for equipment,[3] materials, and services for future injection and storage operations have been identified.

2 The detailed objectives of the project are:
- Inventory and mapping of major CO_2 emission point sources in 13 European countries (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Italy, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Spain), and review of 4 neighbouring states: Albania, Macedonia (FYROM), Bosnia-Hercegovina, Luxemburg) as well as updates for 5 other countries (Germany, Denmark, UK, France, Greece). See TABLE 1 below.
- Conduct assessment of regional and local potential for geological storage of CO_2 for each of the involved countries.
- Carry out analyses of source-transport-sink scenarios and conduct economical evaluations of these scenarios.
- Provide consistent and clear guidelines for assessment of geological capacity in Europe and elsewhere.

3
- Further develop mapping and analysis methodologies (i.e. GIS and DSS).
- Develop technical site selection criteria.
- Initiate international collaborative activities with the P.R. China, a CSLF member, with a view to further and closer joint activities.

The project will build upon the basic work and results generated by the GESTCO project which pioneered the development of carbon dioxide emissions and geological storage mapping in Europe, and which has served as an international example.


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OTHER LINKS/READING

↘ FEASIBILITY STUDY

Checklists

http://www.epa.gov/chp/documents/level_2_studies_september9.pdf

http://www.sa.gov.au/upload/franchise/Business,%20industry%20and%20trade/Feasibility%20study/Conducting_Feasibility_checklist.pdf

http://www.freetutes.com/systemanalysis/sa3-technical-economic-operational-legal.html

http://www.greenempowerment.org/attachments/SiteSelectionandTechnicalFeasibilityGuide.pdf

Examples

http://www.teqs.net/DEFRAPFSresponse.pdf

http://www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf

http://www.nr.gov.nl.ca/nr/publications/energy/pipeline.pdf

ANNEX I KEY CRITERIA FOR ANY SUITABLE STORAGE SITE TO COMPLY WITH THE DIRECTIVE

Storage site shall be defined by: a) volume area, b) definition geological formation used for geological storage, c) associated surface and injection facilities

Legal basis:

Art. 3, par. 3. - '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; art. 3, par. 4. - 'geological formation' means a lithostratigraphical subdivision within which distinct rock layers can be found and mapped;

Suitable storage site cannot be in an area explicitly excluded by relevant authorities for CO_2 storage

Legal basis:

Art. 4, par. 1. - Member States shall retain the right to determine the areas from which storage sites may be selected pursuant to the requirements of this Directive. This includes the right of Member States not to allow for any storage in parts or in the whole of their territory.

English example (exclusion of the onshore storage)

The Government has made it clear in its response to the 'Towards Carbon Capture and Storage' consultation that only offshore storage areas in the UK are currently considered by the Government as suitable for CO_2 storage. Therefore applicants must identify an offshore CO_2 storage area in their CCR storage assessment.

Carbon Capture Readiness (CCR) A guidance note for Section 36 Electricity Act 1989 consent applications, UK 2009, Par. 33 page 15

Member State shall make sure an assessment of the storage capacity is undertaken

Legal basis:

Art. 4, par. 2. Member States which intend to allow geological storage of CO_2 in their territory shall undertake an assessment of the storage capacity available in parts or in the whole of their territory, including by allowing exploration pursuant to Article 5.

The suitability of any geological formation for use as a storage site shall be determined through a characterisation and assessment of the potential storage complex and surrounding area pursuant to the criteria specified in Annex I of the Directive

Legal basis (identical wording):

Art. 4, par. 3: The suitability of a geological formation for use as a storage site shall be determined through a characterisation and assessment of the potential storage complex and surrounding area pursuant to the criteria specified in Annex I.

For geological formation, selected as a storage site, environmental and health risk analysis shall be carried out

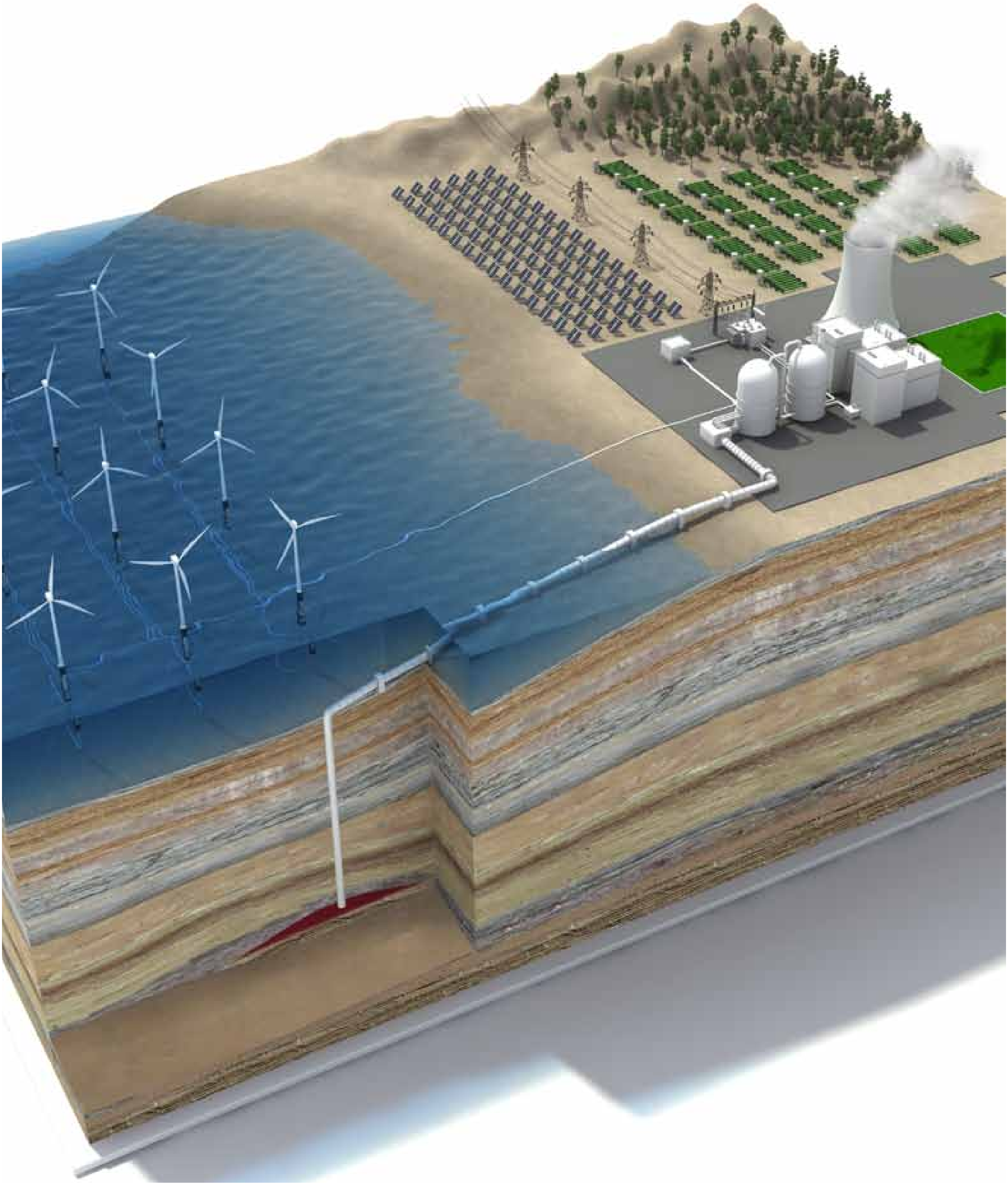
Legal basis (identical wording):

Art. 4, par. 4: A geological formation shall only be selected as a storage site, if under the proposed conditions of use there is no significant risk of leakage, and if no significant environmental or health risks exist.

Suitable storage site should be evaluated for conflict uses

Legal basis (identical wording):

Art. 6, par. 1: Member States shall ensure that no storage site is operated without a storage permit, that there shall be only one operator for each storage site, and that no conflicting uses are permitted on the site.



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ANNEX II DEFINITION OF CARBON CAPTURE AND STORAGE READY (CCSR)[1]

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

ESSENTIAL REQUIREMENTS OF A CCSR FACILITY

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

- Carry out a site-specific study in sufficient engineering detail to ensure the facility is technically capable of being fully retrofitted for CO_2 capture, using one or more choices of technology which are proven or whose performance can be reliably estimated as being suitable.
- Demonstrate that retrofitted capture equipment can be connected to the existing equipment effectively and without an excessive outage period and that there will be sufficient space available to construct and safely operate additional capture and compression facilities.
- Identify realistic pipeline or other route(s) to storage of CO_2.
- Identify one or more potential storage areas which have been appropriately assessed and found likely to be suitable for safe geological storage of projected full lifetime volumes and rates of captured CO_2.
- Identify other known factors, including any additional water requirements that could prevent installation and operation of CO2 capture, transport and storage, and identify credible ways in which they could be overcome.
- Estimate the likely costs of retrofitting capture, transport and storage.
- Engage in appropriate public engagement and consideration of health, safety and environmental issues.
- Review CCSR status and report on it periodically.

DEFINITION APPLICATION

These essential requirements represent the minimum criteria that should be met before a facility can be considered CCSR. However, a degree of flexibility in the way jurisdictions apply the definition will be required to respond to region- and site-specific issues and to take account of the rapidly changing technology, policy and regulatory background to CCS and CCSR, both globally and locally. More specific or stringent requirements could be appropriate, for instance, in jurisdictions where the CCSR regulator is working on the assumption that CCS will need to be retrofitted to a particular facility within a defined time frame.

1 Agreed by the Global CCS Institute, the International Energy Agency and the Carbon Sequestration Leadership Forum.


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ANNEX III OUTLINE OF PRE-FEASI-BILITY STUDY

Source: Manual for the preparation of Industrial Feasibility Studies; W. Berents, P.M. Hawranek, UNIDO 1991, page 352

- Executive summary—a synoptic review of all the essential findings of each chapter
- Project background and history
  - Project sponsors
  - Project history
  - Cost of studies and investigations already performed
- Market analysis and marketing concept:
  - Definition of the basic idea of the project, objectives and strategy
  - Demand and market
    - Structure and characteristics of the market
    - The estimated existing size and capacities of the industry (specifying market leaders), its past growth, estimated future growth (specifying major programmes of development), local dispersal of industry, major problems and prospects, general quality of goods
    - Past imports and their future trends, volume and prices
    - Role of the industry in the national economy and the national policies, priorities and targets related or assigned to the industry
    - Approximate present size of demand, its past growth, major determinants and indicators
  - Marketing concept, sales forecast and marketing budget
    - Description of the marketing concept, selected targets and strategies
    - Anticipated competition for the project from existing and potential local and
    - foreign producers and supplies
    - Localization of markets and product target group
    - Sales programme
    - Estimated annual sales revenues from products and by-products (local and foreign)
    - Estimated annual costs of sales promotion and marketing
  - Production programme required
    - Products
    - By-products
    - Wastes (estimated annual cost of waste disposal)
- Material inputs (approximate input requirements, their present and potential supply positions, and a rough estimate of annual costs of local and foreign material inputs):
  - Raw material
  - Processed industrial materials
  - Components
  - Factory supplies
    - Auxiliary materials, utilities (especially power and energy requirements)
- Location, site and environment:
  - Pre-selection, including, if appropriate, an estimate of the cost of land
  - Preliminary environmental impact assessment
- Project engineering:
  - Determination of plant capacity

- Feasible normal plant capacity
- Quantitative relationship between sales, plant capacity and material inputs
- Preliminary determination of scope of project
  - Technology and equipment
  - Technologies and processes that can be adopted, given in relation to capacity
  - Technology description and forecast
  - Environmental impacts of technologies
  - Rough estimate of costs of local and foreign technology
  - Rough layout of proposed equipment (major components)
    - Production equipment
    - Auxiliary equipment
    - Service equipment
- Spare parts, wear and tear parts, tools Rough estimate of investment cost of equipment (local and foreign), classified as above
- Civil engineering works
  - Rough layout of civil engineering works, arrangement of buildings, short description of construction materials to be used Site preparation and development Buildings and special civil works Outdoor works
  - Rough estimate of investment cost of civil engineering works (local and foreign), classified as above

Organization and overhead costs:
- Rough organizational layout
  - General management
  - Production
  - Sales
  - Administration
- Estimated overhead costs
  - Factory
  - Administrative
  - Financial

Human resources:
- Estimated human resource requirements, broken down into labour and staff and into major categories of skills (local/foreign)
- Estimated annual human resource costs, classified as above, including overheads on wages and salaries

Implementation scheduling:
- Proposed approximate implementation time schedule
- Estimated implementation costs

Financial analysis and investment:
- Total investment costs
  - Rough estimate of working capital requirements Estimated fixed assets
- Project financing
  - Proposed capital structure and proposed financing (local and foreign) Cost of finance
- Production cost (significantly large cost items to be classified by materials, personnel and overhead costs, as well as by fixed and variable costs)
- Financial evaluation based on the above-mentioned estimated values
  - Payback period Simple rate of return Break-even point
  - Internal rate of return
  - Sensitivity analysis
- National economic evaluation (economic cost-benefit analysis)
- Preliminary tests, for example, of Foreign exchange effects
  - Value-added generated
  - Absolute efficiency
  - Effective protection
  - Employment effects Determination of significant distortions of market prices (foreign exchange,
  - labour, capital)
  - Economic industrial diversification; estimate of employment-creation effect

ANNEX IV EXCERPTS FROM THE UK GUIDANCE NOTE ON SPACE RESERVATION FOR CAPTURE INSTALLATION

This Annex summarises space reservation requirements for capture installations under the guidance note on 'Carbon Capture Readiness'[1] issued by the UK Department for Energy and Climate Change and applicable to new installations covered by art. 33.1 of the Directive:

Plans and supporting documents should be prepared to demonstrate that the space for carbon capture equipment installation is sufficient. The potential amount of CO_2 emission to be captured by their proposed technology should be provided. Information and data given by the applicants should be sufficiently detailed so as to ensure the possibility of CO_2 capture and compression plant use and allow for its subsequent retrofitting. The proposed space allocation should be reasonably justified on the basis of the capture technology chosen. The amount of space allocated by applicants should accord with the figures provided in the IEA report 'CO_2 capture as a factor in power plant investment decisions'[2]. The report sets the approximate minimum land footprint for CO_2 capture installations for different types of gas and pulverized coal plant. These footprints are provided in the table below, where CCGT stands for combined cycle gas turbine, IGCC stands for integrated gasification combined cycle and USCPF stands for ultra-supercritical pulverized fuel.

It must be demonstrated that suitably located land is available for the use of the capture element of the CCS chain at the point of retrofit. The ownership of the land as well as ability to use the ancillary site for the time of CCS installations and, further, for CCS purposes must be ensured. Availability of the land should be assessed in accordance to each case's specific contractual arrangements. In order for the proposed space as well as development to be stated as Carbon Capture ready, detailed outline site plans should be provided by the operators. Those outline site plans should be very detailed in order to ensure the proposed plan layout suitability for the subsequent CCS installation. The site plans should be sufficiently detailed to precisely show:

- the footprint of the combustion plant,
- the location of the capture plant including any air separation units,
- the location of the CO_2 compression equipment,
- the location of any chemical storage facilities,
- the exit point for CO_2 pipelines from the site.

Calculations using the known volumes of CO_2, which will have to be processed, should be included in the space description so as to justify the size and type of the chosen equipment.

1 Carbon Capture Readiness (CCR), A guidance note for Section 36 Electricity Act 1989 consent applications, Department of Energy and Climate Change, UK, 2009, available at http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/development%20consents%20and%20planning%20reform/electricity/1_20091106164611_e_@@_ccrguidance.pdf

2 CO_2 capture as a factor in power plant investment decisions, report 2006/8, IEA GHG 2006

↘ MINIMUM LAND FOOTPRINT FOR CO_2 CAPTURE INSTALLATIONS

	CCGT with post-combustion capture	CCGT with pre-combustion capture	CCGT with oxy-combustion	USCPF with post-combustion capture	IGCC with capture	USCPF with oxy-combustion
Site dimension - generation equipment (m)	170x140	170 140	170x140	400x400	475x375	400x400
Site dimension - CO_2 generation equipment (m)	250x250	175x150	80x120	127x75	475x375	80x120
Total site footprint(m^2)	62,000	50,000	34,000	170,000	180,000	170,000

ANNEX V KEY RESPONSIBILITIES OF MEMBER STATES UNDER THE DIRECTIVE

Art. 2, par. 3: The storage of CO_2 in a storage site with a storage complex extending beyond the area referred to in paragraph 1 shall not be permitted.

Art.2 par. 4: The storage of CO_2 in the water column shall not be permitted.

Art. 4, par. 1. - Member States shall retain the right to determine the areas from which storage sites may be selected pursuant to the requirements of this Directive. This includes the right of Member States not to allow for any storage in parts or in the whole of their territory.

Art. 4, par. 2. Member States which intend to allow geological storage of CO_2 in their territory shall undertake an assessment of the storage capacity available in parts or in the whole of their territory, including by allowing exploration pursuant to Article 5.

Art. 4, par. 3: The suitability of a geological formation for use as a storage site shall be determined through a characterisation and assessment of the potential storage complex and surrounding area pursuant to the criteria specified in Annex I.

Art. 6, par. 1: Member States shall ensure that no storage site is operated without a storage permit, that there shall be only one operator for each storage site, and that no conflicting uses are permitted on the site.

Art. 21, par.1: Member States shall take the necessary measures to ensure that potential users are able to obtain access to transport networks and to storage sites for the purposes of geological storage of the produced and captured CO_2, in accordance with paragraphs 2, 3 and 4.

Art. 21, par. 4 Member States shall take the measures necessary to ensure that the operator refusing access on the grounds of lack of capacity or a lack of connection makes any necessary enhancements as far as it is economic to do so or when a potential customer is willing to pay for them, provided this would not negatively impact on the environmental security of transport and geological storage of CO_2 .

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