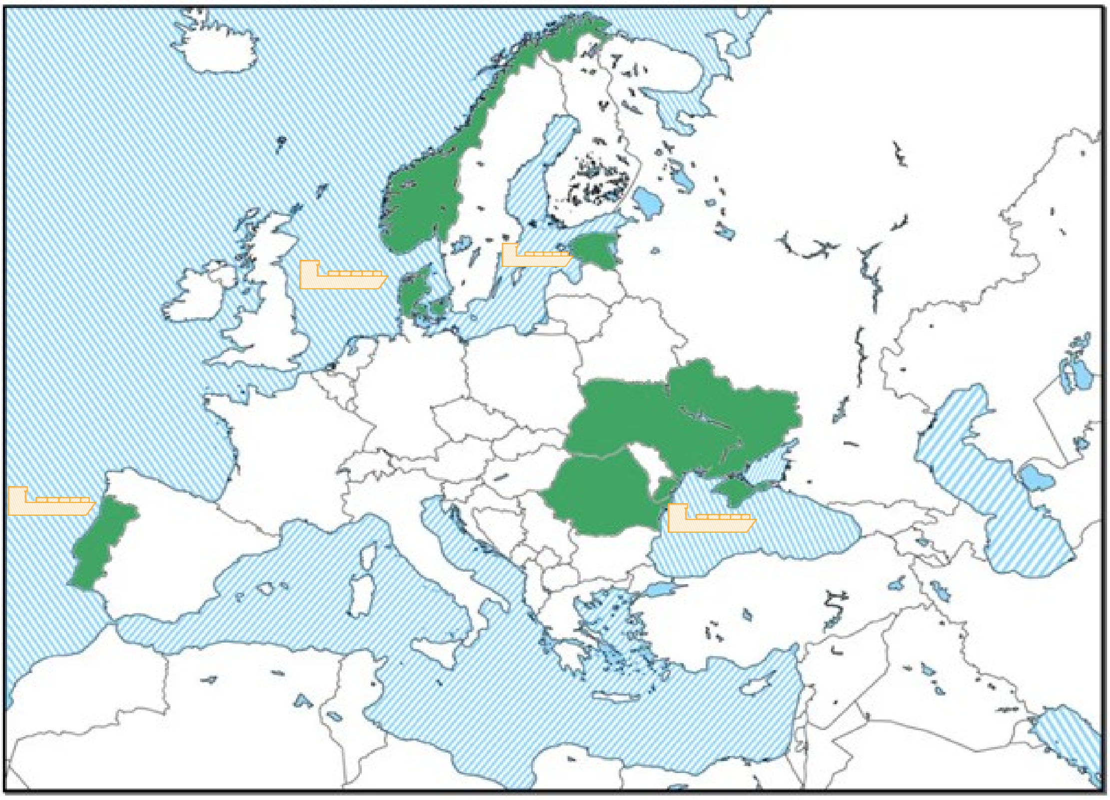
CO_2 Transport and Storage directly from a ship: flexible and cost-effective solutions for European offshore storage

Deliverable 1.1

Report on applicability criteria



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Introduction

In order to close the value chain with storage – direct ship injection components it is important to determine selection criteria for storage sites and emission points that could benefit the most from the application of the technology.

The discussion around the criteria selection has started during the first team workshop in Brussels in February 2022 and continued in Q1-Q3 2024 .

The goal of this activity is to develop criteria generally applicable to selecting optimal candidates for creating value chains based on the direct ship injection approach. It is also important to state that the project is not a regional optimization study looking for optimal selection of emission and storage sites. Having said that, the peculiarities of the region scenarios also need to be taken into account:

- In Portugal Atlantic coast the scenario has been created during Strategy CCUS project[1] and further developed in Pilot Strategy[2]. The scenario is therefore well defined, screening exercise is less of a relevance, criteria developed can help to identify potential alternative emission sources.
- In Black Sea the Romanian Strategy CCUS scenario[1] will be updated in accordance with criteria developed. It will also be extended with Ukrainian stakeholders (both emissions and storage sites) making the screening criteria important and relevant[3].
- In Baltics (Estonia, Latvia and Lithuania) the offshore storage site is predefined as a large number of previous studies[4,5] narrowed down to the particular structure. Selection of the emission points and the best positioned ports is, however, relevant.
- In the North Sea selection of storage sites is a relevant task for both storage and capture sites. For North Sea Scenarios base case will not necessarily go as far as individual emitters and may rather focus on large ports in Northern Europe as a starting point of the value chain.

Finally, transport is a special case in CTS project:

- The transport from the emitters to the ports would be largely based on the existing scenarios. Otherwise, different options (pipelines, rail) may be evaluated using Strategy CCUS tool.
- Transport from the hubs (ports) to the injection site is the design parameter for the ships with direct injection capacity.

Therefore, selection criteria is developed for capture and storage sites. It is quite obvious that the storage and capture sites are also interlinked (for example a process with cheaper capture technology may be located further away from the storage site and be more profitable), however,

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[1] https://strategyccus.brgm.fr/
[2] https://pilotstrategy.eu/
[3] Virshylo, I., et.al. 2024 AAPG European Regional conference. Krakow. Carbon Transport Ship (CTS) Project – Baltic and Black Sea Scenarios
[4] Shogenova, A.; Shogenov, K.; Sliaupa, S.; Sliaupiene, R. (2023). The Role of CCUS Clusters and Hubs in Reaching Carbon Neutrality: Case Study from the Baltic Sea Region. Chemical Engineering Transactions, 105, 169−174. DOI: 10.3303/CET23105029
[5] Shogenov, K.; Forlin, E.; Shogenova, A. (2017). 3D geological and petrophysical numerical models of E6 structure for CO2 storage in the Baltic Sea. Energy Procedia, 114: GHGT-13, Lausanne, Switzerland, 14-18 November 2016. The Netherlands: Elsevier, 3564−3571. DOI: 10.1016/j.egypro.2017.03.1486.

since optimisation study is not intended and considering the peculiarities of the local scenarios presented above those at least as an initial approach, can be developed separately.

Criteria development

Several projects, such as Strategy CCUS[1] has recently looked at and developed criteria for selection of emission and storage actors for the value chain. Below we have made an attempt to improve the structure of the criteria in order to see their interplay along the value chain and highlight those specific for each individual type of actors. This more systemized approach should not only help in the selection, but also later in TEA / LCA and comparison between the regions.

In looking across the value chain a number of parameters would be common for all of the actors across it, while others would be specific to each industrial activity such as emitters, transportation and storage ones.

Common parameters may be divided into several large categories as shown in Figure 1.

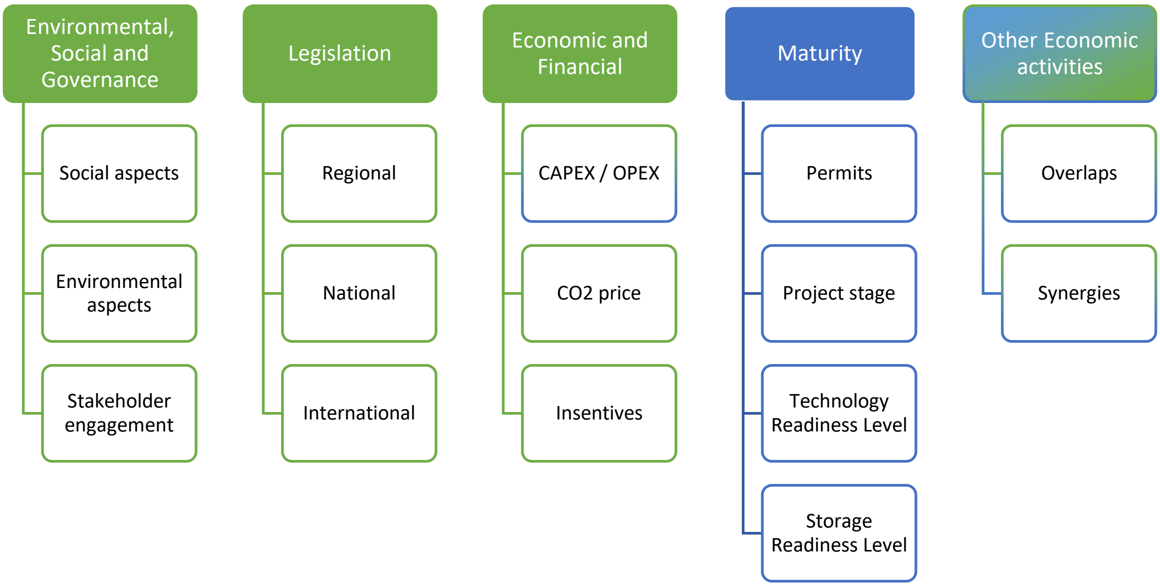

Figure 1. Example of common parameters for the value chain.

The parameters marked in green in Figure 1 are external parameters, while maturity is an internal one. Several of the parameters, however, can be classified as both external and internal. Overlap with other economic activities might be both external, i.e. other activities and / or operators in the area as well as an internal parameter, such as plans for CO_2 utilisation. CAPEX and OPEX are also covers both areas where costs of components, minimal wages are external factors, while cost optimisation is controlled by the project. Environmental, Social and Governance (ESG) factors are also both external such as, for example, general attitude to CCS in the society, but also internal one where individual participants or value chain in general may (and should) address the existing issues.

Each of parameters in Figure 1 have different overall effect on the value chain, however it doesn't seem to make sense to "weight" or prioritise one or several most critical factors, since each of them can quickly became a critical bottleneck for an individual case. I.e. most techno-economical case with fantastic synergy can still have a no go if regulatory regime is unfavourable or social aspects are not addressed.

Finally, it is also important to highlight that relative weight of criteria in relation to each other changes as project matures. Simultaneously their overall effect on the value chain decreases together with overall risk reduction as project matures. Let us use UNECE UNFC Documents – "Supplementary Specifications for the application of the United Nations Framework Classification for Resources (Update 2019)[6] to Injection Projects for the Purpose of Geological Storage Project lifetime" to define maturation stages:

- The Preparation phase involves site selection, exploration and appraisal data gathering activities, geological assessments, environmental impact assessments and risk assessments, permit requests, financing and establishing the general feasibility of the entire project. When the technical, economic and environmental feasibility is established, and regulatory permits and funding have been secured and agreed upon, this is followed by a construction phase where all remaining project facilities are constructed including wells.
- The Operational phase describes the period when fluids are actively injected into the geologic formation and/or extracted (cyclic storage) for use.
- The Closure Phase includes the plugging and abandonment of the project injection wells (or their conversion to monitoring wells) and the termination of extraction activities (in the case of temporary storage). Typically, the project site is closed for operations and prepared for long-term monitoring in the case of long-term storage. This closure may warrant a certificate issued by the government or government designee based on regulations governing the project.
- Post-Closure Phase: This phase begins after the closure certificate of the site is issued and injection and withdrawal operations cease. The applicable regulations will require a period of monitoring and potential interventions to ensure that the stored fluids remain safely contained and that there are no leakages or other adverse events from the project.

We can illustrate the expected behaviour of the criteria as shown in Figure 2. Please note that while overall importance declines monotonically as project matures, relative importance of criteria in relation to each other changes.

[6] Supplementary Specifications for the application of the United Nations Framework Classification for Resources (Update 2019) to Injection Projects for the Purpose of Geological Storage. UNECE Sustainable Energy Division. Sustainable Resource Management Unit, Geneva, Accessed 26 April 2024.

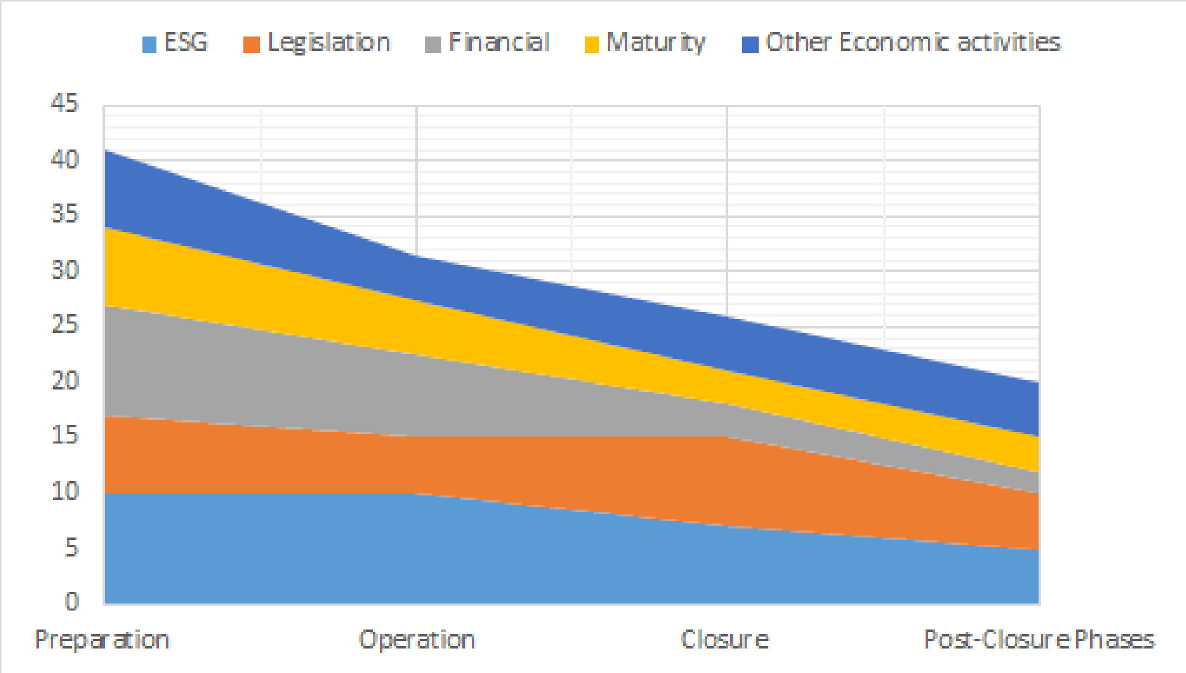

Figure 2. Importance of different criteria in relation to each other and change of overall importance during different maturation stages.

Finally, external parameters are not selection criteria as such but are used to characterize the value chain and its components and may be used in comparison of different regions or CTS scenarios created. Internal common parameters, together with individual ones are presented in Figure 3, in the form of criteria tree, are the ones that can be used in selection process.

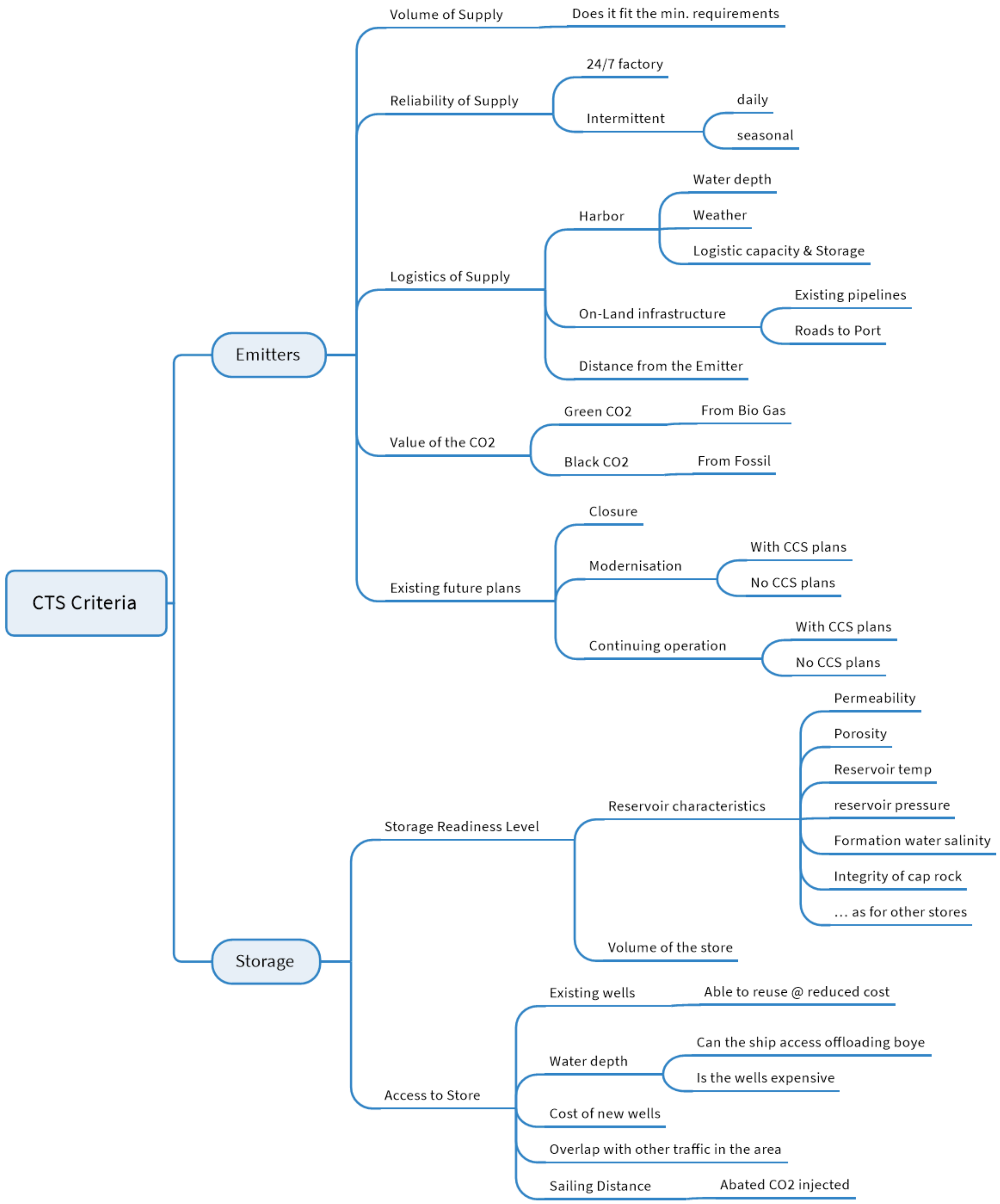

Figure 3. CTS criteria for Storage and Capture.

Selected Criteria emitters and storage sites

Since the purpose of the project is to look into tecno-economics of the direct ship injection the selection criteria should favour the applicability of the technology.

Selection criteria for capture side

- Logistics of supply: location withing 50km of the existing ports with good connectivity to it, or at least a clear possibility to establish one. The sailing distance between the port and the storage site is not a selection criterion as such, but a part of value chain optimization where injection, sailing and loading need to be balanced.
- Value of CO_2. An important criterion where negative emissions are preferred
- Future scenarios. An important criterion is to consider long term plans of the emitters and existence of CCS plans. Here facilities with long term sustainable operation plans are preferred.
- Reliability of supply and volume are not going to be used as a screening criterion. Here flexibility of the direct ship injection can benefit players that are often excluded from consideration. Supply volume may be later used in optimizing the value chain in the form of the cost of captured CO2. Again, flexibility of ship design could help to involve small emitters.

In the regions where large selection of potential emitters exist a spider diagram of the above-mentioned criteria may be applied in order to pre-screen and reduce the list of potential candidates for the scenario evaluation.

Selection criteria on the storage side

Storage readiness level[7] – a criterion encompassing both technical and permitting state of the storage site. SRL of at least 3 (screening identifying individual site and storage concept) are preferred.

Access to store – representing initial guesses of ease of access from the point of view of water depth, distance, existing infrastructure, preliminary assessment of costs.

Overlap with other economic activities which can constitute a part of access to store category including traffic and other economic activities.

Other factors including salinity, hydrate formation risks potentially other factors specific to given area of operation.

Individual factors in each criterion, for example, salinity and hydrate formation risks may be given different weight factors to be combined into overall factors score ranging from 0 to 1. Four categories (SRL, Access to store, overlap, other) may then be plotted together on spider diagram in order to select storage sites. Further selection may be done as a part of scenario assessment based on storage costs and balancing emissions with storage capacity.

[7] Akhurst, M., et.al. 2021. Storage Readiness Levels: communicating the maturity of site technical understanding, permitting and planning needed for storage operations using CO2. Int.J. of Greenhouse Gas Control. 110. 103402. https://doi.org/10.1016/j.ijggc.2021.103402