A methodology for CO_2 storage leakage remediation techniques performance assessment and portfolio optimisation

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Abstract

In an EU Seventh Framework Program-funded MiReCOL (Mitigation and Remediation of CO_2 Leakage) project, a toolbox of leakage remediation techniques have been assessed in order to develop corrective measures plans (Neele *et al.*, 2014), and build confidence in the safety of subsurface CO_2 storage. The corrective measures investigated in the MiReCOL project broadly fall under three categories: (a) techniques relevant to controlling CO_2 migration within the reservoir, such as flow diversion and pressure management; (b) techniques relevant to fault-related migration, such as flow diversion, use of sealants, hydraulic barriers; and (c) techniques relevant to wellbore-related leakage mitigation, such as the use of gels, smart cements. The decision to implement a corrective measure, however, depends on the change between the 'unmitigated/unremediated' and 'mitigated/remediated' levels of risk, referred to as an outcome, associated with an observed irregularity.

The overall objective of the research described in this paper was to synthesise the results of leakage remediation modelling scenarios carried out within the scope of the MiReCOL project and develop a remediation portfolio optimisation strategy. In order to evaluate the performance of leakage remediation techniques considered as either threat barriers for potential leakage risk reduction, or recovery and preparedness measures for leakage consequence reduction, a methodology has been developed to quantify the effectiveness of CO_2 storage leakage remediation techniques in a manner which allows for a comparison of the indicative performance metrics, based on the results of the scenarios that were investigated. The overall performance characterisation was based on five dimensions, namely: likelihood of success, spatial extent, longevity, response speed, cost efficiency. In particular, the quantification of effectiveness of a technique is generally based on either: (a) the delay achieved in the arrival time of the CO_2 plume at the location of a potential threat, e.g. leaky faults or fractures; (b) the reduction in amount of CO_2 that could migrate beyond the reservoir spill point; (c) the reduction in amount of CO_2 that may leak through sub-seismic fractures in the caprock into a shallower formation; (d) the reduction in the reservoir pressure which could potentially induce or exacerbate leakage; or (e) the enhancement of the dissolution of injected CO_2 in the reservoir brine to either reduce the local pressure or the amount of CO_2 that may leak.

The spider chart outputs prepared were then used to standardise the performance scales in different dimensions in order to ensure that this is indicative of the overall merit of a given technique, and also allowing for a comparison between the leakage remediation techniques. Two examples of success

probability charts and spider diagrams prepared from each modelled scenario for Polymer-gel injection for CO_2 plume diversion within the reservoir and/or Sealing fracture/fault leakage above the caprock and Brine/water injection for CO_2 plume diversion within the reservoir are given in Figures 1 and 2.

Research in MiReCOL also recognised that the assessment lacks value for consequence reduction, unless it is complemented with an effective framework which allows for the optimal allocation of resources for remediation technology implementation, considering the uncertainty with regards to their outcome, i.e. success or failure. Therefore, a remediation portfolio optimisation methodology was developed based on the concept of decision trees, which are probabilistic models for structured decision making comprising of a sequence of one or more decisions and their respective possible outcomes, characterised by probability distributions, with the aim of maximising/minimising the expected value of a user-defined utility/cost function (Fraser and Jewkes). The success probability plots and spider chart visualisations referred to above were utilised and interpreted as a qualitative ranking system for the development and implementation of the remediation portfolio optimisation methodology using decision trees.

References

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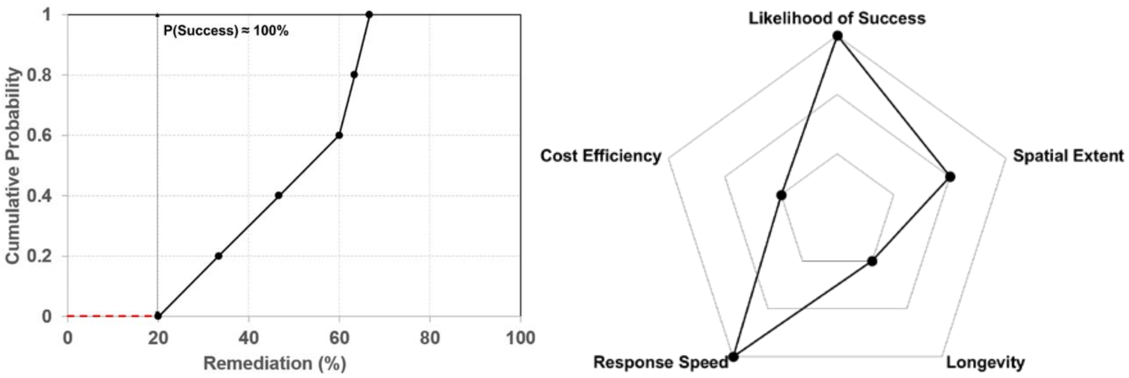
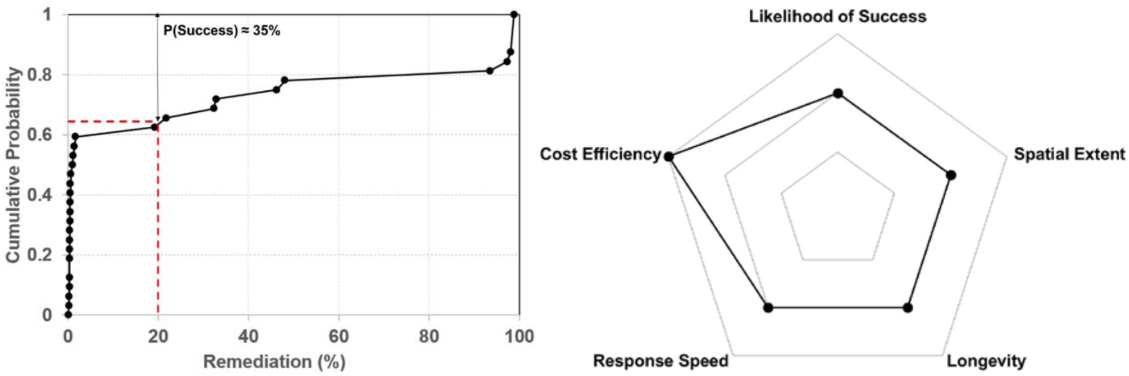
Neele, F., Grimstad, A.A., Fleury, M., Liebscher, A., Korre, A. and Wilkinson, M., 2014. MiReCOL: Developing Corrective Measures for CO_2 Storage. Energy Procedia, 63, pp. 4658-4665.



(a) (b)

Figure 1. Polymer-gel injection technique: (a) success probability; (b) spider chart.



(a) (b)

Figure 2. Brine/water injection technique: (a) success probability; (b) spider chart