Enhanced CO₂ Geological Storage System using Gas Hydrates and Environmental Risk Assessment

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ABSTRACT
In this paper, we propose the framework of risk assessment system for CCS, carbon capture and storage, especially for enhanced recovery of gas, oil and gas hydrates. Based on the protocol proposed by US and European institutions, the framework of enhanced CCS has been modified to improve the functions of geological-based performance assessment. Some results on simulation of CO₂ migration and the estimation of the leakage of CO₂ in pathways are presented and discussed for the further development. In addition, the stimulation of gas hydrates using CO₂ would be possible CCS methods at offshore area. The original method of CO₂-CH₄ substitution in the production of gas hydrates is also introduced in the present study.

KEY WORDS: gas hydrates, enhanced recovery, carbon dioxide, geological storage, CCS, risk assessment.

INTRODUCTION
Both aspects of risk and benefit are very important in understanding the feasibility of CO₂ geological storage at specified situation. Various type of benefits of geological carbon storage, compared with ocean and atmospheric discharge, can be easily understood in the scientific aspect of global environment and the economical aspect of CDM. However, the assessment of risks caused by CCS would be hardly undertaken, because of difficulties to determine the end points and parameters for estimating ecological and human risks. In order to achieve transparent risk governance for any stakeholders who are involved in CCS project, it is necessary to develop the general and/or common framework, enable to be fully communicated within any party of concern.

In the present study, we propose the framework of risk assessment system for CCS, especially for enhanced recovery of gas, oil and gas hydrates. Based on the protocol proposed by US and European researchers, the framework of enhanced CCS has been modified to improve the functions of geological-based performance assessment. Analytical results on simulation of CO₂ migration and the estimation of the leakage of CO₂ in various pathways will be presented and discussed for the further development. In addition, the promotion of methane gas hydrates by the injection of CO₂ would be one of the geological storage at offshore area. The original method of CO₂-CH₄ substitution in the production of gas hydrates will be introduced in the presentation.

Finally the framework of risk assessment for these enhanced CCS system is discussed by means of a methodology of escape or leakage pathway analysis.

CO₂ GEOLOGICAL STRAGE AT OFFSHORE
Capture and storage of CO₂ in deep geological structure is one of the mitigation measures of carbon emission, regarding the issue of global climate change. The possible target of geological storage of CO₂ has shifted from areas at onshore to offshore. This change is considered to be the reason that risks caused by the injection of CO₂ at offshore area might be smaller than at onshore residential places. In terms of environmental risk assessment for CCS, there are typical endpoints of geological storage of CO₂, human and animals, ecological system, local and global environments. The offshore storage of CO₂ has a possibility to reduce risks for some endpoints, except for marine environment. The effects of retardation and attenuation of CO₂ emission would be expected through various media of escape pathways of CO₂ migration. IPCC report has stated the possibility of CCS would be in deeper geological structures. Major institutions of geological survey in the world have been investigating the possible places of offshore geological storage of CO₂.

In considering the feasibility of CO₂ geological storage, there are other aspects, such as environmental impacts, engineering problems and cost-effectiveness. Fig. 1 illustrates the features of CCS by means of various methods including gas hydrate and isolation processes.

Fig. 1 Environmental and economical aspects for CCS.