



## Estimation of Carbon Dioxide Storage Capacity for Depleted Gas Reservoirs

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A depleted gas reservoir is one of the best options for CO<sub>2</sub> storage for many reasons. First of all, the storage safety or the caprock integrity has been proven because the natural gas was trapped in the formation for a very long period of time. Also the formation properties and fluid flow characteristics for the reservoir have been well studied since the discovery of the gas reservoir. Finally the surface constructions and facilities are very useful and relatively easy to convert for the use of CO<sub>2</sub> storage.

The purpose of this study was to apply an analytical approach to estimate CO<sub>2</sub> storage capacity in a depleted gas reservoir. The analytical method we used is the material balance equation (MBE), which have been widely used in natural gas storage.

We proposed a modified MBE for CO<sub>2</sub> storage in a depleted gas reservoir by introducing the z-factors of gas, CO<sub>2</sub> and the mixture of the two. The MBE can be derived to a linear relationship between the ratio of pressure to gas z-factor ( $p/z$ ) and the cumulative term ( $G_p - G_{inj}$ , where  $G_p$  is the cumulative gas production and  $G_{inj}$  is the cumulative CO<sub>2</sub> injection). The CO<sub>2</sub> storage capacity can be calculated when constraints of reservoir recovery pressure are adopted. The numerical simulation was also used for the validation of the theoretical estimation of CO<sub>2</sub> storage capacity from the MBE.

We found that the quantity of CO<sub>2</sub> stored is more than that of gas produced when the reservoir pressure is recovered from the abandon pressure to the initial pressure. This result was basically from the fact that the gas- CO<sub>2</sub> mixture z-factors are lower than the natural gas z-factors in reservoir conditions. We also established a useful  $p/z$  plot to easily observe the pressure behavior of CO<sub>2</sub> storage and efficiently calculate the CO<sub>2</sub> storage capacity. The application of the MBE we proposed was demonstrated by a case study of a depleted gas reservoir in northwestern Taiwan. The estimated CO<sub>2</sub> storage capacities from conducting reservoir simulation and using analytical equation were very consistent. The validation results showed that the modified MBE we proposed in this study can be efficiently used for the estimation of CO<sub>2</sub> storage capacity in a depleted gas reservoir.