Carbon dioxide Capture and Sequestration System for Natural Gas Supply System

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Among fossil fuels, natural gas has the lowest CO_2 emission intensity. Further, switching fuel from coal or oil to natural gas leads to reductions in CO_2 emissions. However, in the long term, if the carbon dioxide capture and sequestration (CCS) method is employed for coal, and further, oil is used only as a raw material, natural gas could have a higher CO_2 emission intensity than coal or oil, especially if CCS is not employed for natural gas. This report presents a CCS system for natural gas supply system and introduces the technologies of micro-bubbling CO_2 injection and a high-efficiency co-generation with CO_2 capture for realizing the CCS system.

Figure 1 shows the current natural gas supply system. Natural gas is produced from natural gas reservoirs, transported by pipelines or as liquefied natural gas (LNG), and consumed at the natural gas consumers. At the natural gas reservoir side, CO_2 is generated as an associated gas. Further, at the natural gas consumer side, CO_2 is generated when it reacts with oxygen. In many cases, the CO_2 generation reaction is air combustion. Today, most of the generated CO_2 is emitted to the atmosphere. CO_2 is also generated during transportation because pipeline transportation requires energy for compression while LNG transportation requires energy for liquefaction and shipping. However, the amount of CO_2 generated from transportation is much smaller than that from the natural gas consumers and reservoirs, and hence, CO_2 emission by natural gas transportation can be considered to be negligible.

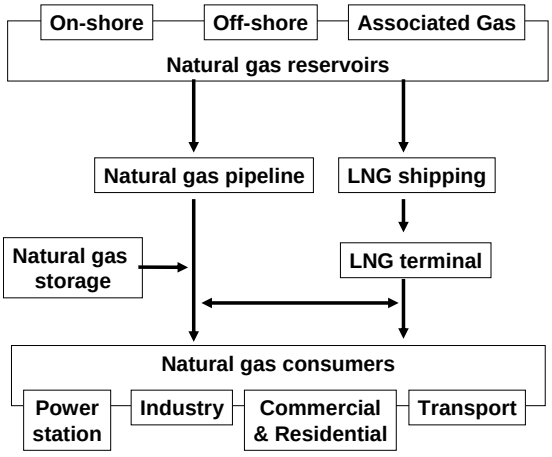

Figure 1 Natural gas supply system

Figure 2 shows the CCS system for natural gas supply system. CO_2 generated at the reservoirs and natural gas consumers is captured, transported by pipelines or as liquid CO_2 (LCO_2), and sequestrated from the atmosphere. When the financial penalty for CO_2 emissions to the

atmosphere is small, it is important to develop CO_2 sequestration technologies that can generate revenue. CO_2-enhanced oil recovery (CO_2-EOR) and the usage of CO_2 as raw materials are considered as examples of such a technology. When the financial penalty for CO_2 emissions becomes sufficiently large, commercial CO_2 underground storage will become prevalent.

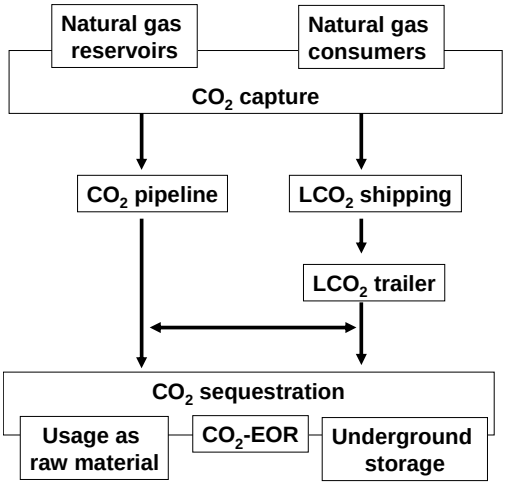

Figure 2 CCS system for natural gas supply system

Tokyo Gas is developing a micro-bubbling CO_2 underground injection system in collaboration with the Research Institute of Innovative Technology for the Earth (RITE) and Kyoto University. By using this technology, CO_2 will dissolve in water or oil more easily than current injection technologies. Moreover, this technology will increase the possible number of CO_2-EOR sites and CO_2 underground storages to aquifers.

Table 1 shows the performance of co-generation systems with and without CO_2 capture. The current technology comprises 5-MW and 8-MW gas engines (GE) without CO_2 capture, while 3-MW molten carbonate fuel cells (MCFCs) with CO_2 capture represents the future technology. Tokyo Gas is developing a CO_2 capturing technology for MCFCs. 8-MW GE + FC represents a combination system of 5-MW GE without CO_2 capture and 3-MW MCFC with CO_2 capture.

Table 1 Co-generation systems with and without CO_2 capture

	5MW GE	8MW GE	3MW MCFC	8MW GE+FC*
CO_2 Capture	without	without	with	partially with
Electric output (kW)	5,200	7,800	3,000	8,200
Electric efficiency (%)	48.5	48.5	51.5	50.8
Steam efficiency (%)	14.8	14.8	7.0	12.2
Hot water efficiency (%)	21.6	21.6	0.0	14.0
Total efficiency (%)	84.9	84.9	58.5	77.1
CO_2 emission intensity ($kg-CO_2/kWh$)	0.41	0.41	0.01	0.21

* 8MW GE+FC is combination of 5MW GE and 3MW MCFC with CO_2 capture. For 8,000h operatic
MCFC operates 8,000h as base load and GE operates 4,800h as adjusting load.

In this paper, we will discuss the value-chain assessment of CCS system for natural gas supply system and provide further information on the two technologies introduced here.