Economy and CO_2 Emission on Hydrogen Production via Both Coal Gasification and Steam Methane Reforming:
Importance of Securing CO_2 Storage Space Domestically

Summary

In hydrogen production processes by coal gasification and steam reforming (SMR) of natural gas, costs and CO_2 load emissions were studied when an amine absorption process was installed, and the CO_2 capture rate was varied in the range of 90 to 99.5%. Additionally, when ZC is achieved with DAC (Direct Air Capture) technologies combined, ZC hydrogen costs and required amounts of CO_2 storage have been calculated separately for an overseas plant location and a domestic plant location. When the overseas storage conditions can be applied to those of the domestic case without any changes, it has been found that ZC hydrogen costs for the domestic case become smaller than those for the overseas case. It is, therefore, important to establish technology and secure locations for domestic storage.

Proposals for Policy Development

- In order to realize a ZC society, the development of the DAC process is ultimately essential, but at the same time, if the site is domestic, it is necessary to implement CO_2 capture and storage in domestic location, and it is necessary to promote research and development to search for and secure storage sites as well as storage technology.

1. Processes of ZC hydrogen production

Energy consumption, equipment specifications, production costs, CO_2 loads and others were examined for each case of hydrogen production (Table 1). The block diagrams of the hydrogen production process by coal gasification and steam methane reforming (SMR) are shown in Fig. 1 and Fig. 2 [1-3]. Storage areas for captured CO_2 are assumed to be in the vicinity of production plants. In order to achieve ZC, the unabsorbed CO_2 in the amine unit as well as the CO_2 deriving from the production facility must be collected by applying the DAC process.

The hydrogen production was designed for 25.7 t/h (annual production scale of 200,000 tons).

Table 1 Descriptions of considered cases

	Raw material	Location condition of production plants
Case A	Coal	Overseas
Case B	Natural gas	Overseas
Case C	Coal	Domestic
Case D	Natural gas	Domestic

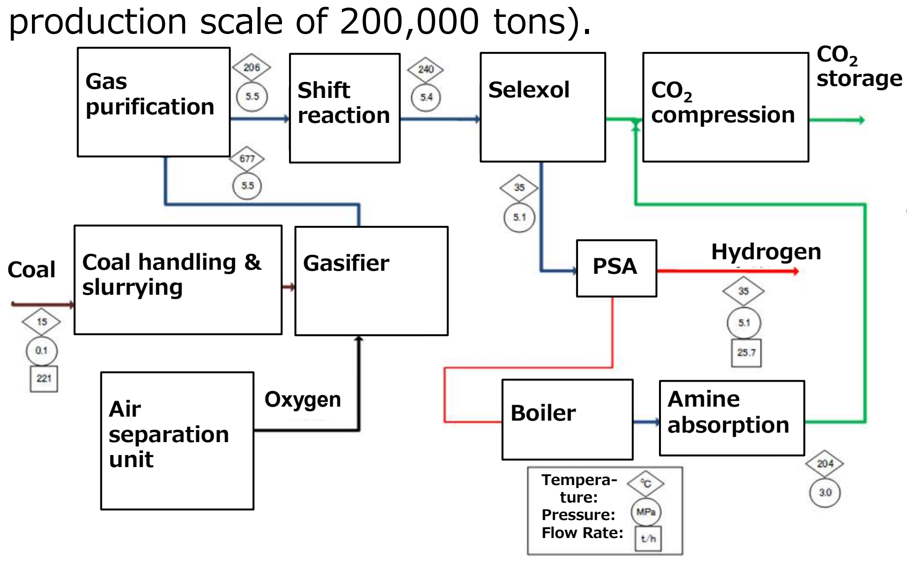

Fig. 1 Block diagram of hydrogen production process via coal gasification

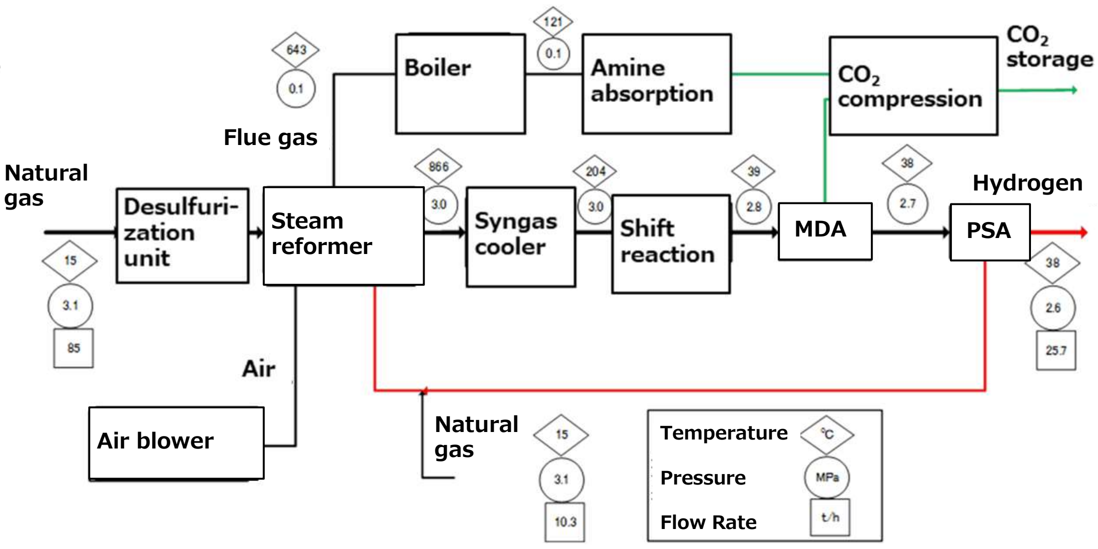

Fig. 2 Block diagram of hydrogen production process via steam methane reforming (SMR)

Table 2 Summary of results

Case	Raw Material	Location	CCS capture efficiency at the production plant (%)	Hydrogen production cost (JPY/MJ)	Transpor-tation cost (JPY/MJ)	DAC cost (JPY/MJ)	ZC hydrogen cost at domestic power station (JPY/MJ)	CCS storage amounts (Mt/y)	DACS storage amounts (kt/y)
A	Coal	Overseas	90～99.5	2.2～2.4	3.7	1.0～0.4	6.9～6.4	3.6～4.0	587～218
B	Natural gas	Overseas		1.2～1.3	3.7	0.7～0.4	5.6～5.3	1.8～2.0	399～214
C	Coal	Domestic		2.1～2.2	—	0.6～0.1	2.7～2.3	Same as A	407～38
D	Natural gas	Domestic		2.8～2.9	—	0.3～0.03	3.1～2.9	Same as B	210～23

2. Hydrogen production costs and CO_2 storage amounts for each case

Results of costs and CO_2 storage amounts for each case are shown in Table 2. The ZC hydrogen costs in domestic power stations of Cases C and D, where production plants and storage areas for captured CO_2 are domestically located with importing coal and natural gas as raw materials, are lower than those of Cases A and B with overseas plants and storage areas. However, the CCS storage amounts to be secured domestically for Cases A and B are equal to the “DACS storage amounts” in Table 2, and those for Cases C and D are equal to the sum of “CCS storage amounts” and ”DACS storage amounts.”

[1] LCS, Proposal Paper for Policy Making and Governmental Action toward Low Carbon Societies, “Economy of Hydrogen and Ammonia by Coal Gasification and CO_2 Emissions―A Comparative Consideration on “Economy of Production and Logistics Systems of Hydrogen and Ammonia via Coal Gasification (CCS included)―”, the Japan Science and Technology Agency, the Center for Low Carbon Society Strategy, February 2019.
[2] LCS, Proposal Paper for Policy Making and Governmental Action toward Low Carbon Societies, ”Overview and Outlook of CCS (Carbon Capture and Storage)―Assessment and Challenges on CO_2 Separation and Capture Technologies―”, March 2016.
[3] Assessment of Hydrogen Production with CO_2 Capture Volume 1: Baseline State-of-the-Art Plants”, August 30, 2010, DOE/NETL-2010/1434.