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EMISSIONS OF PHOSPHORIC ACID FUEL CELL PLANTS

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1. FOREWORD

The emission level of the air pollutants of the phosphoric acid fuel cell was studied by comparing it to the emission value of the gas turbine and diesel engine. The effect of co-generation on CO_2 emission was also studied. The air pollutants discussed in this paper are nitrogen oxide (NOx), sulfur oxide (SOx), and carbon dioxide (CO_2). dioxide (CO_2).

2. EMISSION LEVEL

2.1 Nitrogen oxide (NOx)

Table 1 shows the measured exhaust NOx densities of fuel cell plants developed by Fuji Electric (at full load). *Table 2* compares the NOx densities of the gas turbine, diesel engine, gas engine, and fuel cell. These tables show that the NOx density of the phosphoric acid fuel cell is two or more digits lower than that of the diesel engine and one digit lower than that of the gas turbine. The major reason why the NOx density of the fuel cell is low is that the fuel cell generates power chemically and not through combustion. Only the low calorie fuel cell exhaust gas is combusted. Therefore, the combustion temperature is low and the thermal NOx generated is essentially zero. Furthermore, the fuel used does not contain nitrogen and fuel NOx is not generated.

2.2 Sulfur oxide (SOx)

Table 3 shows the exhaust SOx volumes for a 10MW fuel cell, a gas turbine, and a diesel generator. Usually, the volume of SOx emitted is determined by the amount of sulfur (S) in the fuel. However, for a fuel cell, a desulfurizer that uses the exhaust heat is installed so that the reformer catalyst is not poisoned by sulfur and, usually, no SOx is detected. Of course, even for a gas turbine and diesel generator, the SOx can be reduced by installing a desulfurizer, but this involves an additional cost. For a diesel engine, especially, since the fuel is a liquid, desulfurization at the fuel side is difficult and exhaust gas desulfurization must be performed.

2.3 Carbon dioxide (CO_2)

If CO_2 is not removed, all the carbon (C) in the fuel will change to CO_2, provided complete combustion is made a precondition. Therefore, the only methods of reducing

Table 1 Measured exhaust NOx densities from fuel cell plants developed by Fuji Electric (at full-load)

Customer	Output	Fuel	NOx(ppm)
NEDO-The Kansai Electric Power Co., Inc.	1,000	LNG	10
Tohoku Electric Power Co., Ltd.	50	LNG	4.5
Tokyo Gas Co., Ltd.	50	NG	2
Shikoku Electric Power Co., Ltd.	4	methanol	Not detectable
Power Pack for Forklift Ltd.	5	methanol	〃
NEDO-The Okinawa Electric Power Co., Ltd.	200	methanol	〃

(Note) (1) NOx densities are converted to states of residual O_2 = 7%
(2) NEDO = New Energy and Industrial Technology Development Organization
(3) LNG = Liquid natural gas
(4) NG = natural gas

Table 2 Comparison of exhaust NOx densities (at full-load)

Power system	Fuel	NOx (ppm)
Diesel engine	Oil	2,000~4,000
Gas engine	Gas	2,000~4,000
Gas turbine	Gas	200~600
Fuel cell	Gas	3~15

(Note) (1) NOx densities are converted to states of residual O_2 = 7%.

Table 3 Calculated exhaust SOx volumes from 10MW power sysrem

Power system	Fuel	Sulfur content (weight fraction)	SOx (Nm^3/h)
Diesel engine	Oil	0.1%	1.4
Gas turbine	Gas	6.5ppm	0.011
Fuel cell	Gas	6.5ppm	0.00007

(Note) (1) Calculated as SO_2
(2) In case of fuel cell, 99% desulfurizing rate is assumed on measured data.

Fig. 1 Fuel emission CO_2 volume per M-cal (HHV)

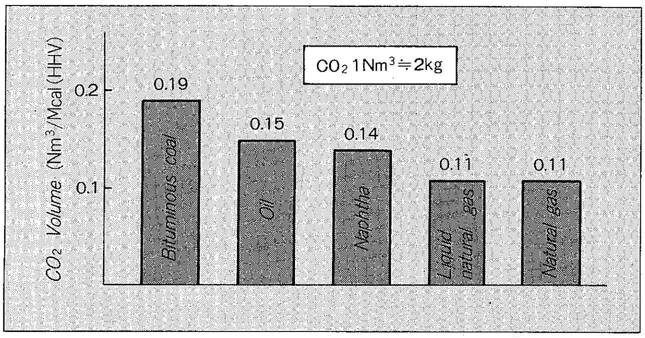


Fig. 2 Power system emission CO_2 volume per kWh (terminal base)

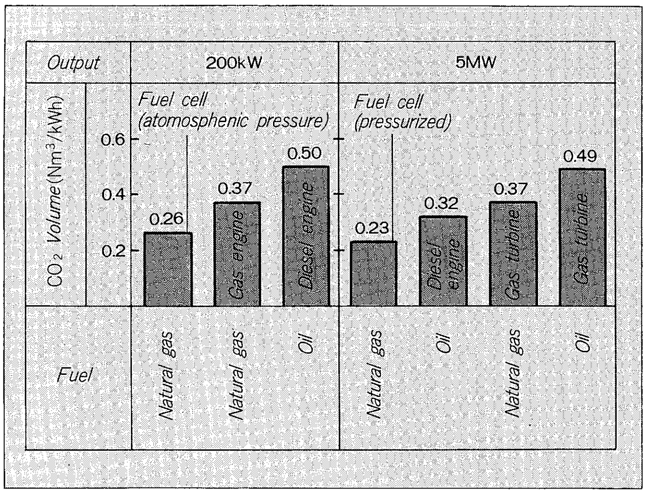
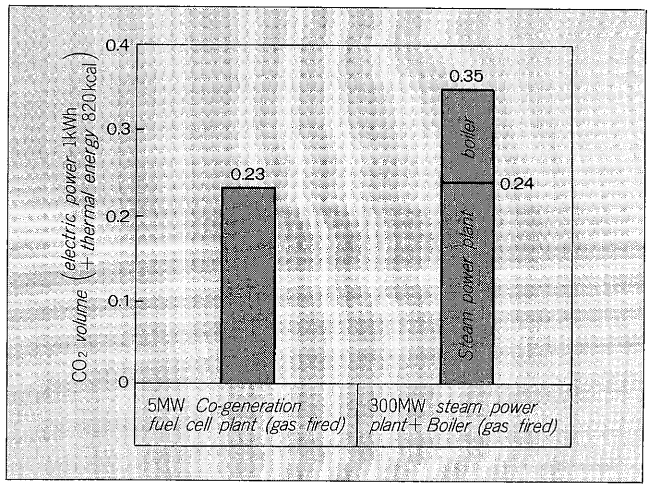


Fig. 3 Effect of co-generation



the volume of CO_2 emitted are:

(1) Using a fuel with a low volume of C per unit calorie
(2) Improving the generating efficiency
(3) Improving the energy efficiency including heat supply by co-generation

Figure 1 shows the fuel emission CO_2 volume per Mcal. *Figure 2* shows the calculated CO_2 emission volume for 200kW and 5MW outputs.

In both cases, other power systems emit about 1.4 times or more CO_2 than the fuel cell. This is because the fuel cell satisfies conditions (1) and (2) listed above. Conversely, the poor efficiency of the gas turbine and gas engine and the large amount of C in diesel engine fuel make their emission volumes high.

To confirm the validity of (3), the effect of on-site co-generation on emission CO_2 volume is shown in *Fig. 3*, If the overall efficiency of a 5MWFC plant is made 80%, heat of approximately 820kcal per 1kWH can be used in calculation without adding fuel. In *Figure 3*, the volume of CO_2 for generating these electric power and thermal energy emitted by a steam power plant and a boiler is compared with that by fuel cell plant. The latter emits about 1.5 times more CO_2 than a fuel cell.

3. CONCLUSION

The exhaust volumes of NOx, SOx, and CO_2 of a fuel cell were numerically compared with those of a diesel engine, gas turbine, and gas engine above. As a result, it was found that the characteristics of the fuel cell are overwhelmingly superior for all items. The fuel cell is expected to play a large role as one of counter-measures against the increasingly important environmental problems.