

FUEL CELL DEVELOPMENT AND COMMERCIALIZATION BY FUJI ELECTRIC

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1. FOREWORD

Fuji Electric commenced the development of phosphoric acid fuel cell (PAFC) in 1973 and have since supplied 43 PAFC demonstration plants from 1982 to the first quarter of 1992. Support from the government (MITI), NEDO, electric utilities, gas utilities and others made this all possible.

Key technologies such as high performance cells and compact reformer have been developed for on-site applications. Together with the three gas utilities: Tokyo Gas, Osaka Gas and Toho Gas, reliable commercial 50 kW and 100 kW PAFC power plants are expected to be completed within two years.

Successful commercialization of the relatively high cost early commercial units requires the close cooperation of the government, customers such as the utilities, and the manufacturers.

2. DEVELOPMENT OF MAJOR COMPONENTS

2.1 Fuel cell development

Fuel cell development primarily focuses on two major areas: increasing power density and extending life. We have thus far developed a 0.2 W/cm^2 high performance cell which can achieve a life target of 40,000 hours (at less than 10% voltage drop). Further effort shall be expended towards the confirmation and improvement of cell performance.

Comparing to a decade ago, Fuji Electric has been able to improve the cell power density threefold. This technical achievement not only resulted in significant performance improvement at the gas/catalyst/liquid interface, but also leads to further cell stack cost reduction. Cell power density enormously influences the manufacturing cost of PAFC. Figure 1 shows the cell performance trend achieved.

2.2 Development of reformers for on-site fuel cell power plants

For on-site PAFC units in capacity of 50 kW, 100 kW and 500 kW, we have incorporated the highly efficient reformer technology developed internally at Fuji Electric. The reformer is of the mono-tube design and is compact.

Fig. 1 The cell performance trend

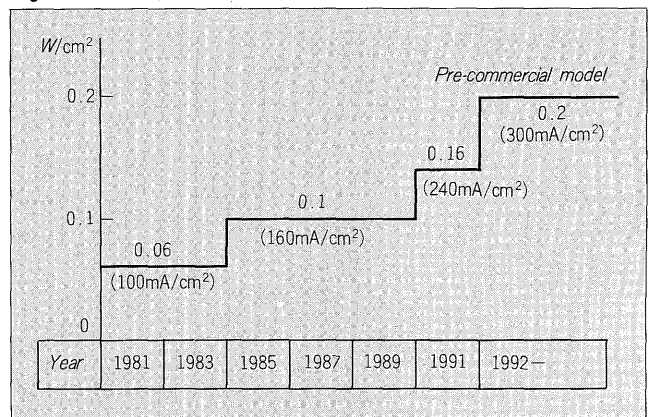


Table 1 Fuji's PAFC activities

Purpose	Capacity	Type	Fuel
On-site fuel cell	50 kW × 29	Water-cooled Amb. press.	Natural gas
	20, 50 kW	Water-cooled Amb. press.	Naphtha
	100 kW	Water-cooled Amb. press.	Natural gas
Power plant for electric utilities (incl. NEDO)	30 kW	Air-cooled Amb. press.	Natural gas
	50 kW	Water-cooled Pressurized	Natural gas
	1 MW	Water-cooled Pressurized	Natural gas
	200 kW	Water-cooled Amb. press.	Methanol
Vehicular power system. Others	25 kW	Liquid-cooled Amb. press.	Methanol
	4 kW × 6	Air-cooled Amb. press.	Methanol

Total 43 units 2,949 kW installed

3. DEVELOPMENT OF PAFC POWER PLANTS

Fuji's development focuses on three primary applications: on-site cogeneration power plant, large scale power plant suitable for electric utilities, and vehicular power system. To-date we have installed 43 PAFC demonstration units ranging from 4 kW to 1 MW. The 50 kW and 100 kW on-site power plants currently under demonstration test have been developed together with Tokyo Gas, Osaka Gas

Fig. 2 Program of PAFC development

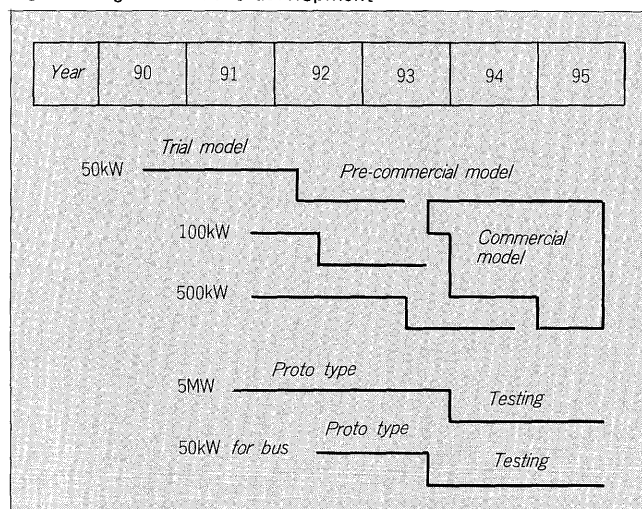
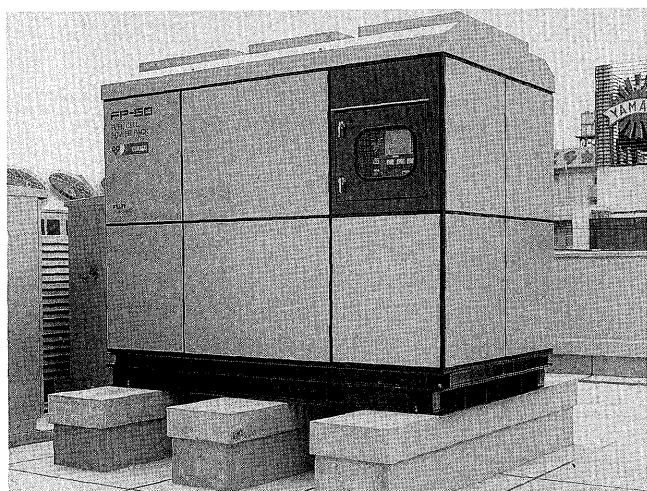


Fig. 3 50 kW power plant



and Toho Gas. We are expected to field test about 35 pre-commercial on-site PAFC plants during 1992 and 1993. Table 1 shows Fuji's PAFC activities and Fig. 2 shows PAFC development program. Figure 3 shows a 50 kW plant installed at Fuji's Osaka building by Osaka Gas.

In cooperation with Osaka Gas, we are currently developing a 500 kW on-site PAFC plant. The first prototype is targeted to be completed in September of 1992. This will be followed by two pre-commercial units to be installed at customer sites for field testing. The 500 kW PAFC plant consists of three packages for ease of transportation and installation. To minimize the footprint, one 500 kW fuel cell stack with 1m² cell size and one 500 kW compact reformer shall be adopted.

Figure 4 shows the outer view of a 500 kW power plant.

We at Fuji Electric, based on many years of experience in supplying power plants to various customers, continue to emphasize the importance of high reliability and ease of

maintenance for all commercial plants. In addition to the fuel cell stack and reformer, the reliability of auxiliary equipments and the overall layout of all components internal to the PAFC package have been meticulously considered.

Based on the successful experience with the 1 MW PAFC plant supported by NEDO, we have embarked on the design of a 5 MW pressurized PAFC plant under the direction of NEDO/PAFC Technology Research Association. The 5 MW plant is planned to be completed in 1993 and installed at Kansai Electric Co..

The 5 MW demonstration co-generation plant is intended to be located in an urban area serving as an energy center. The exhaust heat will be partially utilized for air conditioning of an office and an experimental farm. Experience gained from this 5 MW plant will serve as the basis for the design and manufacturing of a more compact MW class power plant for commercial installation in buildings.

Fuji Electric has been developing liquid-cooled PAFC for vehicles. A 25 kW brassboard power system manufactured under the Phase 1 bus contract of US DOE also proved its successful operation in the USA. The project is entering into the next phase under which three sets of 50 kW PAFC plants will be on board of the three demonstration buses.

4. ISSUES: FUEL CELL INTRODUCTION TO THE MARKET

It is envisioned that several years (from first commercialization of fuel cells) will be required to truly achieve the necessary volume (orders from prospective customers) to effect cost reduction for PAFC.

To accelerate the commercialization process, strong incentives from the government and other sectors are absolutely essential.

Favorable federal and local environmental regulations mandating the need of clean power generation alternatives such as fuel cell is another complementary incentive. In

Fig. 4 500 kW power plant

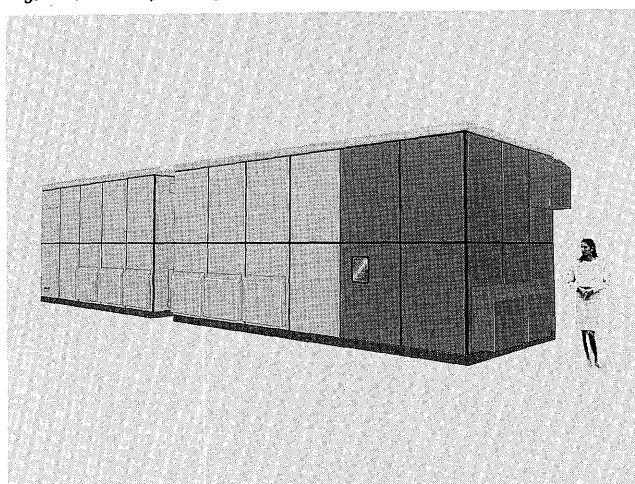
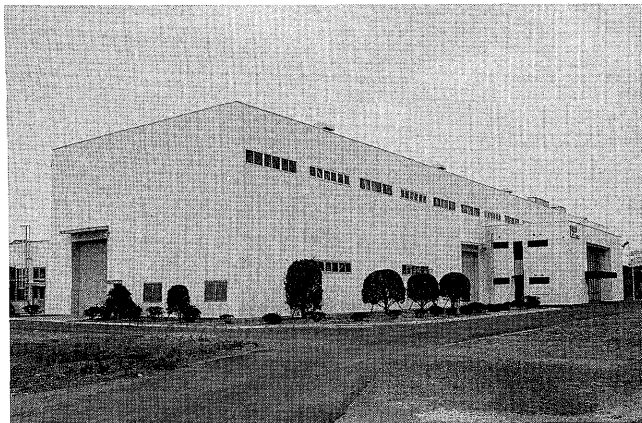


Fig. 5 Fuel cell factory



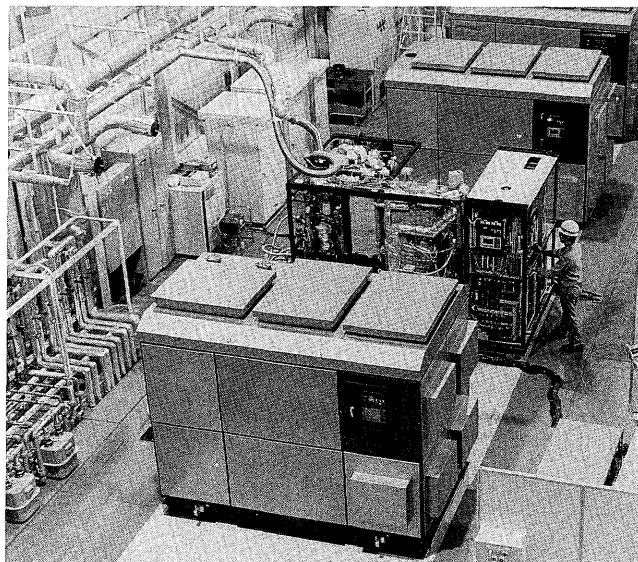
short, the successful introduction of fuel cells into the market place rests not only on the ability of the developers to achieve their technical targets, it requires an infrastructure capable of providing the proper momentum.

5. TARGETS: FUEL CELL INTRODUCTION TO THE MARKET

According to the "Long term energy supply and demand prospects" of MITI, 1,200 MW for on-site fuel cells and 1,050 MW for large dispersed power plants shall be introduced by year 2000. This plan provides tremendous stimulus to the fuel cell industry, particularly the manufacturers. Fuji Electric fully intends to contribute to this plan by adding necessary manufacturing facilities to meet future demand. Fuji Electric has built the fuel cell factory in Chiba. *Fig. 5* shows the fuel cell factory *Fig. 6* shows a testing shop of power plants in the factory.

A new technology such as PAFC must demonstrate to our customers confidently that it can operate reliably and successfully for more than 40,000 hours.

Fig. 6 Testing shop of fuel cell power plant



Production of pre-commercial PAFC plants for Japanese customers for evaluation will be commenced in 1992. Achieving the set technical targets will unquestionably accelerate this process. Further cost reduction will also be achieved via mass production.

6. CONCLUSION

Government, electric utilities, gas utilities in Japan have been instrumental in the development of PAFC. Their continuous support is essential and vital for furthering the commercialization of fuel cells. Future participation from various agencies (Environmental Agency) and sectors are encouraged. With your support, Fuji Electric is confident that PAFC can be a commercially viable power plant in the not too distant future.