Chapter 4
Installation Plan of a Fuel Cell Cogeneration System

ABSTRACT
This chapter consists of two sections, ‘Installation Plan of a Fuel Cell Microgrid System Optimized by Maximizing Power Generation Efficiency’ and ‘Fuel Cell Network with Water Electrolysis for Improving Partial Load Efficiency of a Residential Cogeneration System.’ A microgrid that use PEFC may significantly reduce the environmental impact when compared with traditional power plants. The 1st section investigates what occurs when a set of PEFCs and a natural gas reformer are connected to the microgrid in an urban area. In the 2nd section, a fuel cell energy network which connects hydrogen and oxygen gas pipes, electric power lines and exhaust heat output lines of the PEFC cogeneration for individual houses is analyzed.

GENERAL INTRODUCTION
The summary of the 1st section is as follows. If energy-supplying microgrids can be arranged to operate with maximal efficiency, this will have a significant influence on the generation efficiency of the grid and will reduce greenhouse gas production. A means of optimizing the microgrid needs to be developed. Moreover, microgrids that use PEFC may significantly reduce the environmental impact when compared with traditional power plants. The amount of power supplied to the grid divided by the heating value of the fuel is defined as the system generation efficiency. The authors find that when a set of PEFCs and a natural gas reformer are connected to the microgrid in an urban area, the annual generation efficiency of the system slightly exceeds 20%. When a PEFC follows the electricity demand pattern of a house, it operates at a partial load most of the time, resulting in a low efficiency of the microgrid. A method of improving the generation efficiency of a fuel cell

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Microgrid is proposed, where a supply system of power and heat with a high energy efficiency are constructed. In this study, a method of installing two or more microgrids is proposed (known as the partition cooperation system). The grids can be connected in an urban area to maximize generation efficiency. Numerical analysis shows that the system proposed in this study (which has an annual generation efficiency of 24.6 to 27.6%) has a higher generation efficiency than conventional PEFC systems (central generating systems have annual generation efficiencies of 20.6 to 24.8%).

The summary of the 2nd section is as follows. A fuel cell energy network which connects hydrogen and oxygen gas pipes, electric power lines and exhaust heat output lines of the fuel cell cogeneration for individual houses, respectively, is analyzed. As an analysis case, the energy demand patterns of individual houses in Tokyo are used, and the analysis method for minimization of the operational cost using a genetic algorithm is described. The fuel cell network system of an analysis example assumed connecting the fuel cell co-generation of five houses. If energy is supplied to the five houses using the fuel cell energy network proposed in this study, 9% of city gas consumption will be reduced by the maximum from the results of analysis. 2% included to 9% is an effect of introducing water electrolysis operation of the fuel cells, corresponding to partial load operation of fuel cell co-generation.

INSTALLATION PLAN OF A FUEL CELL MICROGRID SYSTEM OPTIMIZED BY MAXIMIZING POWER GENERATION EFFICIENCY

Introduction

Microgrid systems used in urban areas have several notable characteristics (Robert et al., 2004; Carlos 2005; Takuma & Goda, 2005). (a) The distance between the heat-supply and heat-demand sites is small, making it possible for exhaust heat to be used in the process. (b) The systems can also be linked with existing large-sized electric power facilities to perform load-leveling. A proton-exchange membrane fuel cell (PEFC) may extend as a power plant. These fuel cells have the advantage that they are highly efficient and have little environmental impact. However, the electrode material (especially the catalyst material and the solid polymer membrane) of the PEFC is expensive, and its system is complex. It may be possible to reduce the number of expensive fuel cells that need to be installed by connecting the PEFC to a microgrid and supplying power to two or more buildings. If the energy of the overall grid is supplied by one set of fuel cells (central system), the facility costs will be reduced considerably. Past work has examined the method of supplying power to a water electrolyzer and hydrogen and oxygen fuel storage methods (Obara & Kudo, 2005a). Another study looked at controlling the number of units that divide a fuel cell and a reformer, finding that the system efficiency falls when operated at partial load (Obara. & Kudo, 2005b). In addition, energy storage methods, such as batteries and flywheels, have been considered, though this equipment is not introduced in this chapter. Energy storage methods must consider power fluctuations in the microgrid affecting how the fuel cell is controlled. Although this is an important topic, for simplicity, this chapter focuses on other issues related to microgrids. There are no examples of the effect of the power demand pattern of buildings linked to a microgrid on the generation efficiency of a fuel cell system. This chapter will examine how the overall generation efficiency is affected by connecting a building to another grid. In this chapter, the fuel cell microgrid (FC microgrid) is installed in an urban area and divided into multiple grids. The system efficiency is improved over the case where each grid is connected independently (partition cooperation system). By dividing the
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