

STUDY on ENERGY SYSTEM of “ NEXT 21” FUTURE HOUSING

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ABSTRACT NEXT 21 is the experimental residential building ,completed in October 1993 at Osaka. Main theme of this project is to create comfortable housing for early 21th century life without the increase of stress to urban environment. For this purpose many experimental design ,such as, earth covered roof , ecological garden, greenery for wild birds and many efficient mechanical systems were applied to this building. Fuel cell was installed at basement as cogeneration system for its high efficiency and cleanness, further more each house has passive and active solar systems and HVAC systems for indoor environment .This paper presents the performance of this new energy systems and thermal environment created by ecological design.

1. INTRODUCTION

NEXT21 is 6 storied residential building which has 18 houses(3-6F) ,small office rooms , a hall (1-2F), and machine room(BF) as shown by Photo-1. The courtyard called “ecological garden “ and roof garden are designed as habitat for wild birds and insects to create natural environment in the center of city ,Osaka. The energy system ,fuel cell ,supplies whole demand of electricity of this building and its waste heat is used for heating ,cooling and hot water supply.



Photo-1 NEXT21
Total Floor Area 4577 M²
Dwellings 18

2. ECOLOGICAL DESIGN AND THERMAL ENVIRONMENT

Before the construction 2 years of observation study has been done about wild birds ,insects and trees around the building site. At NEXT21 roof garden ,green balconies and ecological garden were designed mainly for wild birds and insects ,not for habitant according to the design concepts, creating natural environment in the urban site. Actually these study and design was done in corporation with Japan Wild bird Association. It is reported that after construction number of wild birds coming across is increasing almost 4 times by the expansion of greenery area.

Besides the creation of natural environment, trees and soil at roof garden, ecological garden are effective for thermal environment of building. Fig-1 , temperature gradient of the roof in summer , shows that the soil is good insulation material .Fig-2 is the hourly change of air temperature around the building(ecological garden, south road and north road) . Fig-2 shows that temperature of ecological garden is always cooler than other 2 places by the shading effect of trees. This helps to keep indoor environment comfortable. it is realized by thermograph that surface temperature around NEXT21 is always cooler than other buildings near by.

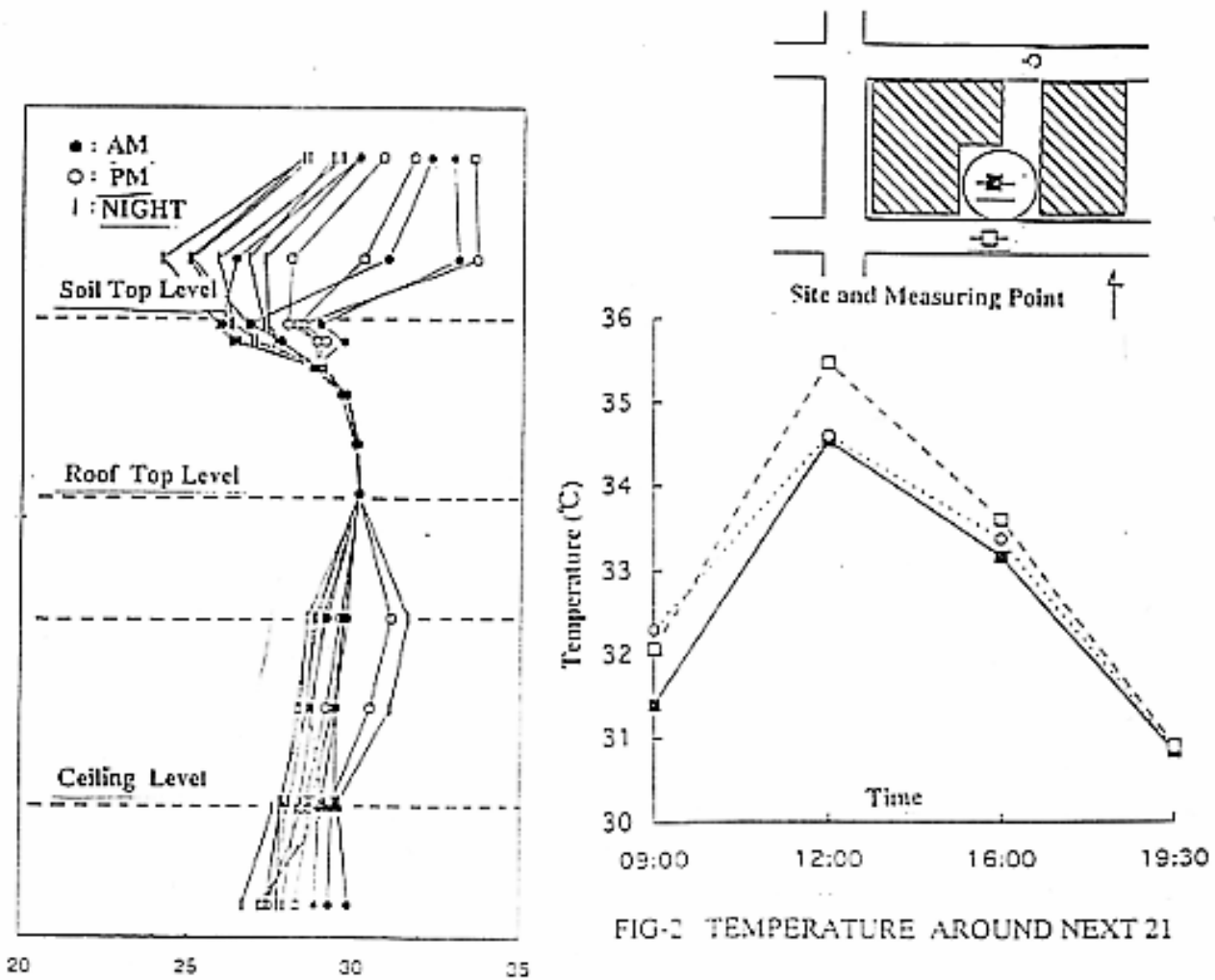


FIG-1 TEMPERATURE GRADIENT OF ROOF

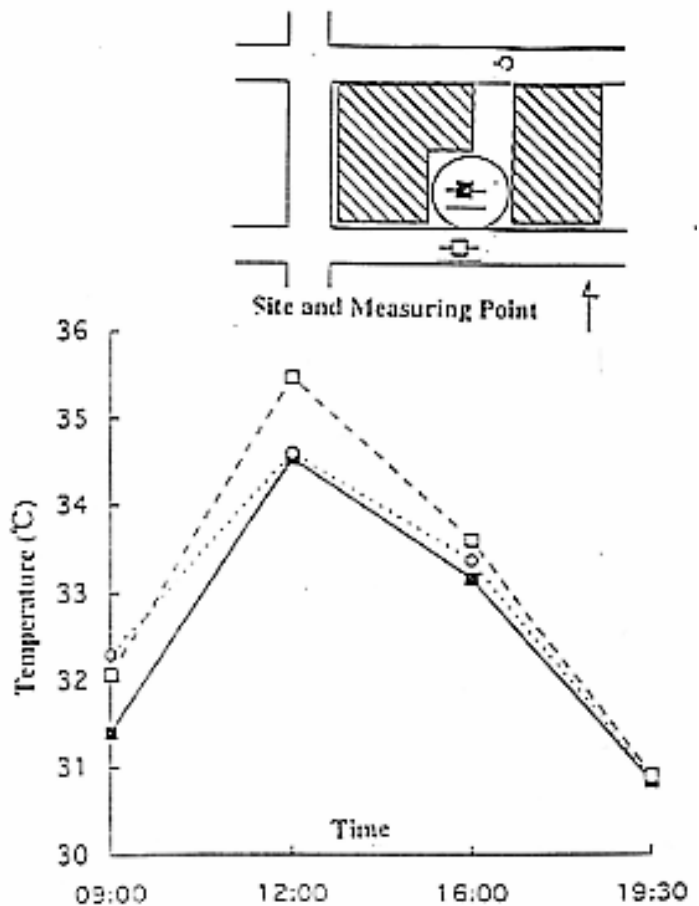
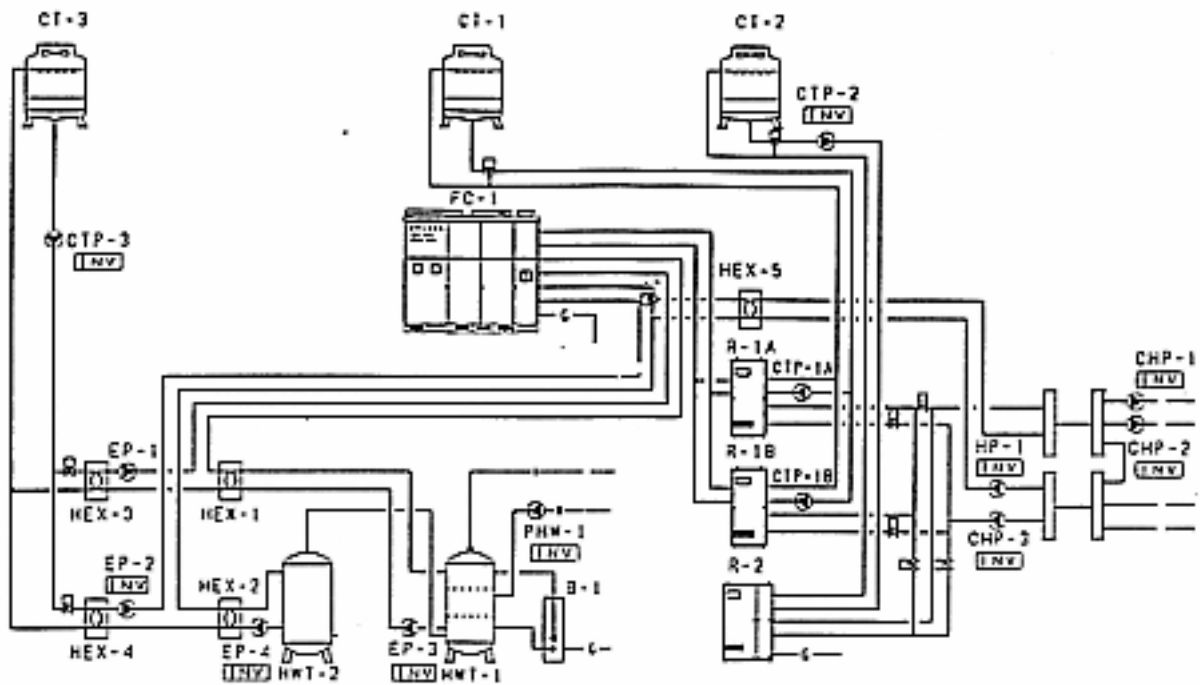


FIG-2 TEMPERATURE AROUND NEXT 21

3. DESCRIPTION OF ENERGY SYSTEM

In this building all the electricity, hot and chilled water for air conditioning ,hot water supply comes from energy system installed at basement. Fig-3 shows simplified diagram of energy system, which has 100kw phosphoric acid fuel cell, 2units of R-1 steam driven absorption chiller (7RT)and R-2 gas fired chiller heater(30RT) as auxiliary heat source. The high temperature waste heat from fuel cell is used to drive R-1 absorption chiller for cooling in summer, used for heating in winter and for hot water supply through the year. In addition low temperature waste heat (55)is used for preheating hot water supply. All the electricity comes from this fuel cell and photovoltaic roof array (7.5kw),except in case of system trouble ,backup by electricity from power company. All the energy system(fuel cell ,solar cell, batteries) and HVAC system are operated at optimal performance by ESC (energy system controller). This means that ESC controls always performance of fuel cell and battery to meet electricity demand of building . And also to meet thermal demand ESC controls the operation of R-2 gas fired chiller heater.



FC: Fuel Cell R-1 : Absorption Chiller (30RT) R-2 : Gas Fired Absorption Chiller(30RT)
 CT: Cooling Tower Hwt-1,2 : Hot Water Tank Hex : Heat Exchanger

Fig-3 Energy System Diagram

4. SYSTEM PERFORMANCE AND EVALUATION

Since April, 1994 all the energy systems and indoor environment has been monitored by ESC. Fig-4 is graph of monthly power output of fuel cell. It is realized by Fig-5 that high temperature waste heat from fuel cell utilized as a steam to drive R-1 absorption chiller in summer and for heating as hot water in winter. Fig-6 shows monthly output of photovoltaic array. The consumption of electricity rises at summer and winter ,depending on the operation of HVAC system ,such as

chiller, cooling tower, pump, fans and boiler. Fig-7 shows monthly demand of electricity, heating, cooling, hot water supply and monthly energy consumption of energy system to meet the demand. From this graph the maximum energy consumption of the building happens in summer, this trend in energy consumption is almost the same at residential part of building as shown by Fig-8. To compare the other residential building we separate the demand of dwelling area and public area where ordinary residential building don't have.

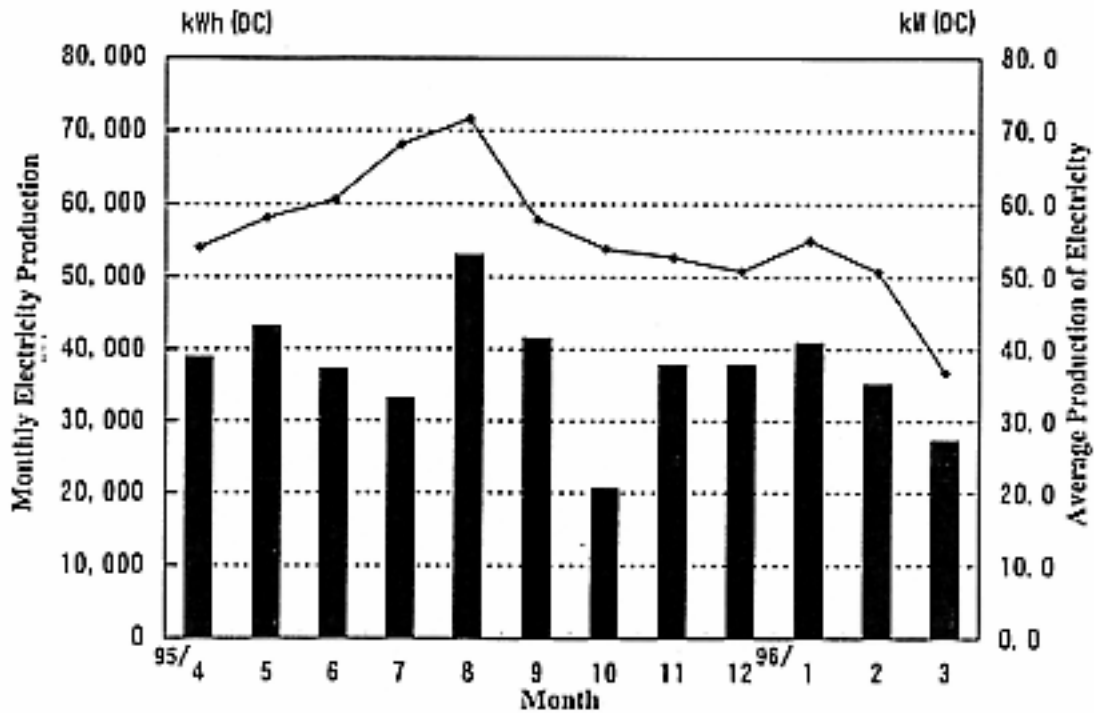


Fig-4 Monthly Electricity Production by Fuel Cell

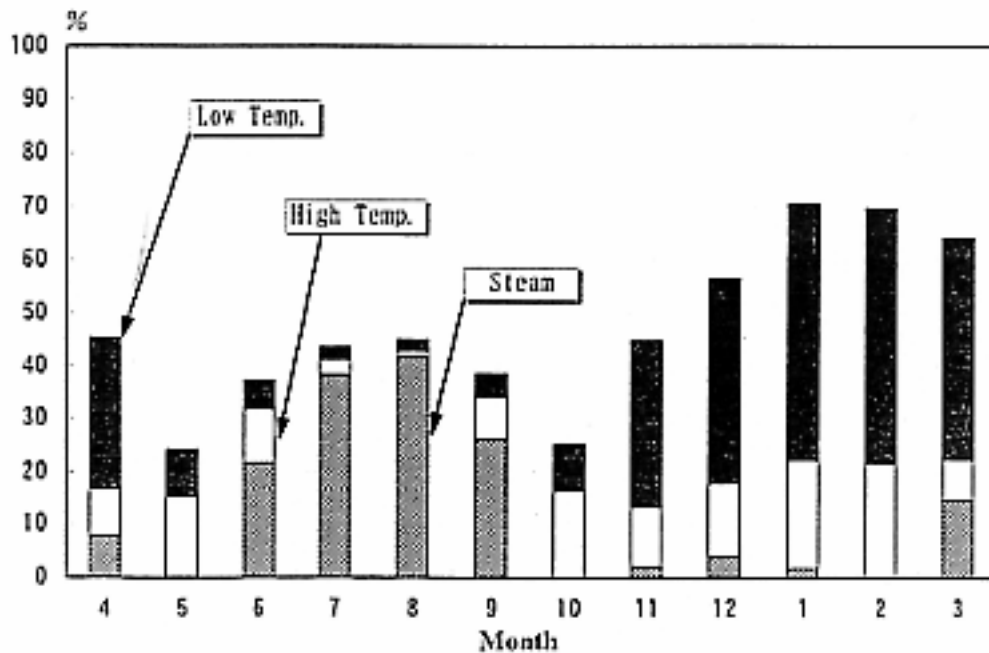


Fig-5 Fuel Cell Waste Heat Utilization Ratio(%)
(Total Waste Heat=100%)

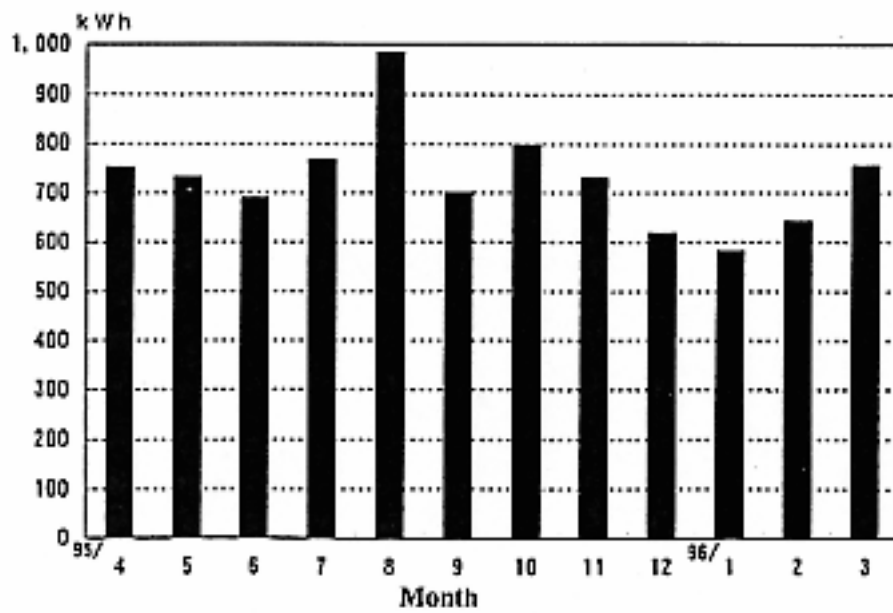


Fig-6 Monthly Electricity Production by Photovoltaic Array

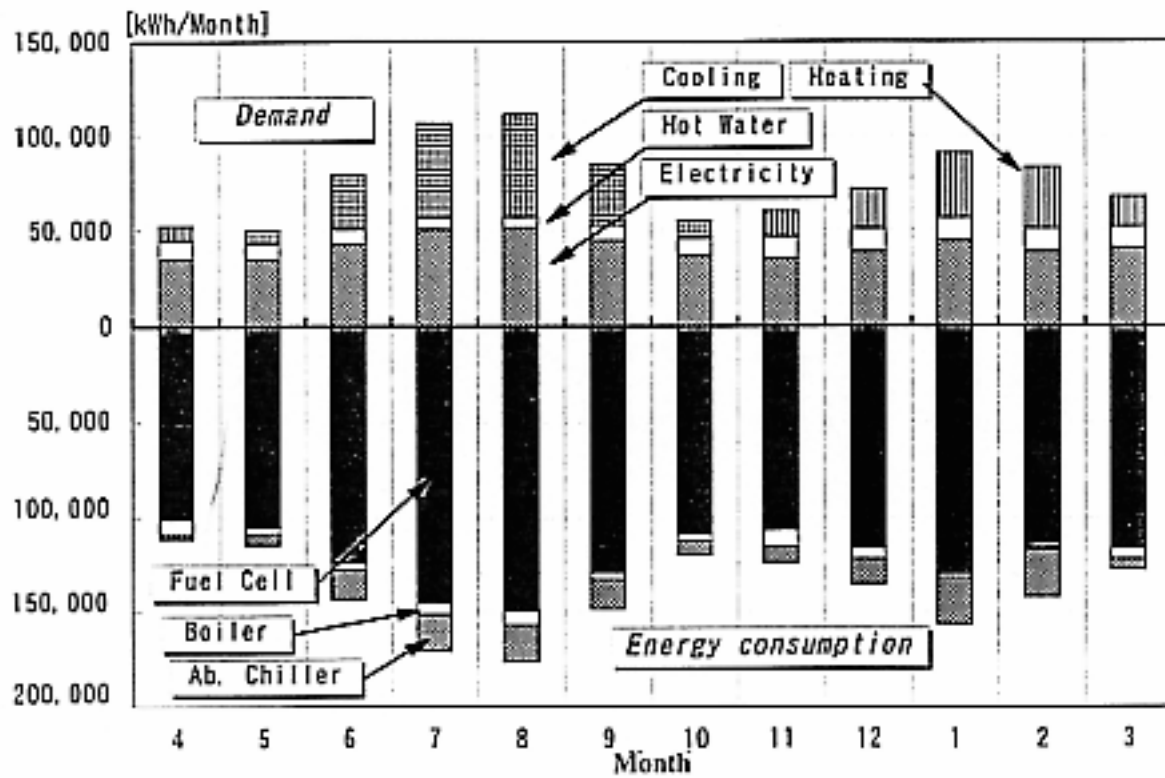


Fig-7 Monthly Demand and Energy Consumption

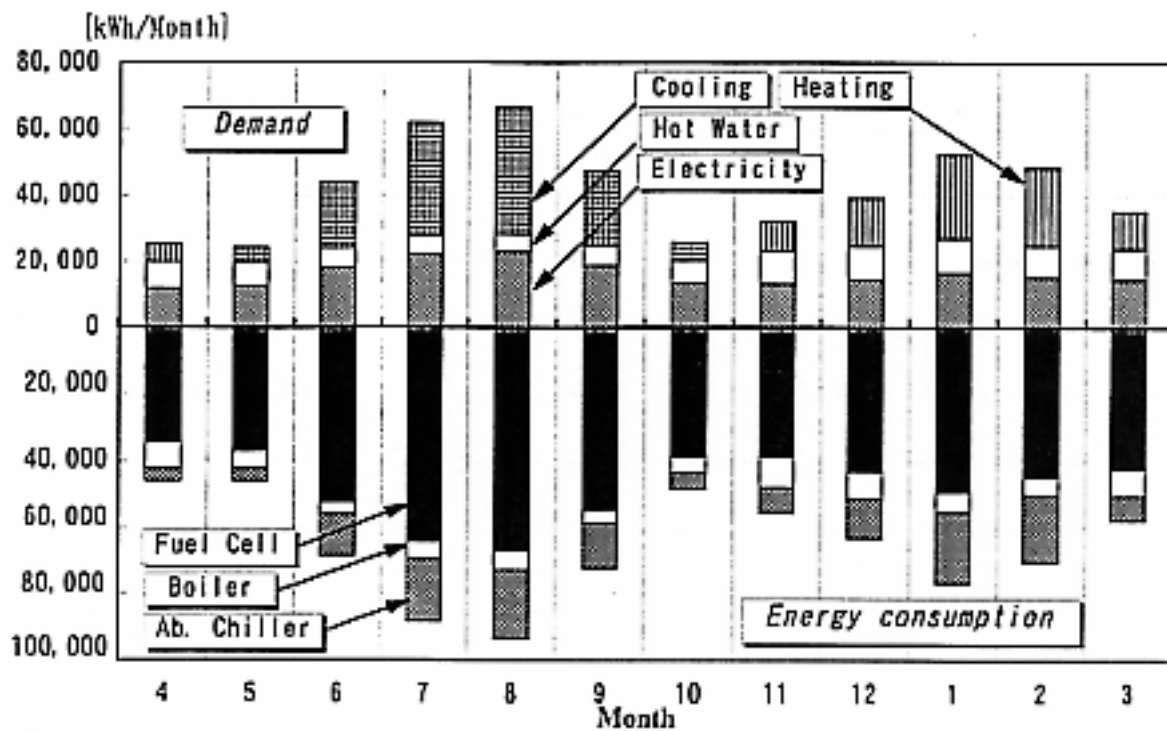


Fig-8 Monthly Demand and Energy Consumption (Residential Part of Building)

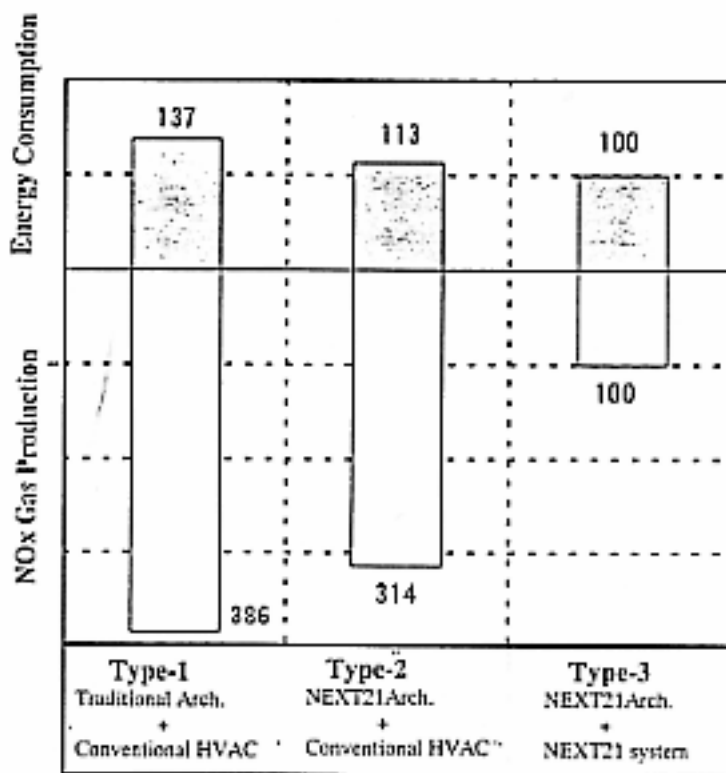


Fig-9 Energy Consumption and NOx Gas Production Ratio

On evaluating the energy system we tried to evaluate both of energy system and building shelter performance together , because our design goal is to reduce the environmental load of the construction. For evaluation 3 types of buildings, every one of them is architecturally same designed, were selected. Type 1 is ordinary insulated building with conventional HVAC system ,type 2 is well insulated as same as NEXT21, with conventional HVAC system and type 3 is NEXT21, with fuel cell energy system. Fig-9 shows 27% reduction of energy consumption was done by NEXT21 ,17% reduction comes from building insulation and 10% comes from energy system. About environmental evaluation 74% reduction of NOx gas production was done ,56% comes from energy system and 18% from building insulation.

CONCLUSION

From investigation of 2 years operation ,it is realized that the energy system of NEXT21 gives least environmental load to urban environment and works as energy conservation system for building. It is necessary for wide spread use of this system that we must prepare design method and technical data of fuel cell system. From environmental point of view ecological design is very effective not only for birds ,insects but for thermal environment .

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