ESTIMATION AND EVALUATION OF BUILDING CO2 EMISSIONAT KYUSHU UNIVERSITY, NEW CAMPUS

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ABSTRACT

This study has dealt with the energy and CO2 management at the new Kyushu University campus. The new campus named Ito Campus is located west of Fukuoka city, JAPAN, and opened on October 1st, 2005. In this paper, we estimated the CO2 emissions of new buildings at the Ito Campus by using simulated data and construction data, as the first step to develop an energy and environmental management system. In the evaluation, we compared the CO2 emission at the Ito Campus with the existing buildings at the old Hakozaki Campus. In addition, we also compared its air-conditioning systems with other ones.

KEYWORDS

University campus, Building CO2 emission, Energy management, Estimation and evaluation

INTRODUCTION

The Ito Campus of Kyushu University was founded on October 1st, 2005. As buildings create a living environment and provide a platform for economy and society, they consume many limited resources including energy and natural resources and release greenhouse gases into the natural surroundings and the metropolitan environment. So it is essential to create a sustainable building system of reuse and recycle associated with procuring and producing construction material. Especially, when considering the influence of Kyushu University on society at home and abroad, it is an important to show appropriate approaches to solving global environmental problems or energy problems and to put them into action.

In this paper, the building CO2 emission at the Ito Campus of Kyushu University was estimated and evaluated using the simulated data and construction data, as the first step to obtain basic data for the building environmental and energy management system. In the evaluation, we compared the CO2 emission at the Ito Campus with the existing buildings at the old Hakozaki Campus. In addition, we also compared its air-conditioning systems with other ones.

CONDITION FOR THE ESTIMATE OF CO2 EMISSION

The outlines of targeted buildings are shown in Table 1, and the photographs of the targeted buildings are shown in Figure 1, and the typical floor plan of building complex at the Ito Campus is shown in Figure 2.

In the estimate, we used the Input-Output Analysis and used the specific CO2 consumption rates based on the Inter-industrial relationship in 1990 [1]. Capital formation is excluded. Japan depends to a high degree on imports of iron ore, coal, crude oil, liquefied natural gas and primary aluminum, and the CO2 emissions from mining, refining and carrying these resources from oversea are included in the CO2 emissions calculations. In building lifecycle, we took into account only 4 phases in our estimate including design management, construction works, oparation (electricity consumption and gas consumption), and maintenance. We limited the operation phases to 50 years.

In the Ito Campus, it is difficult to estimate the CO2 emission based on the actual consumption data due to shortage of data presently. Therefore, the CO2 emission from the maintenance is estimated by using the maintenance cost per unit area in 1990 [1], and the CO2 emissions from the electricity and gas consumption are estimated by using Case 0 in the simulation as described later.

At the Hakozaki Campus, the buildings are very old and have been expanded and renovated numerous times. It is difficult to estimate the CO2 emission in Hakozaki Campus due to the shortage of construction data. Therefore, the CO2 emissions from the design management and the construction works are estimated by using the respective costs of the building work, the equipment work and the electricity work per unit area in 1990 [1].

The summary of values used in the estimate of the CO2 emission in each phase of each campus is shown in Table 2.

CONDITION FOR THE SIMULATION

In the energy consumption simulation for the Ito Campus, it was difficult to use the real plans of buildings directly, so we created a model of West 4. The typical plan for simulation is shown in Figure 3, and the outlines of the model for the targeted buildings are shown in Table 3. The total floor area of the model is the sum of areas of air-conditioned rooms but un-air-conditioned areas are excluded.

In air-conditioning simulations, we looked at 11 cases including gas package air-conditionings introduced in the Ito Campus, and they are shown in Table 5. In our simulation, cooling was used in summer (from June to September), and heating used in winter (from December to March). Indoor temperature was set at 26 degrees C in summer, and 22 degrees C in winter. Air-conditioners were operated only when someone was present in the rooms.

The number of hours a room was used, head-count in rooms, heat from lighting and equipment in detail according to each type of room was set and decided beforehand. We calculated the electricity consumption of lighting and equipment based on this setting. The summary of settings is shown in Table 6.

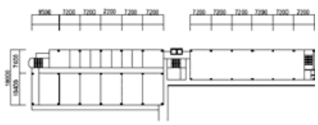
AIR-CONDITIONING SIMULATION (PACKAGE SYSTEM)

In a package air-conditioning system, each indoor AC unit is start and stop individually, and a detailed zoning is generally more convenient. Therefore we set equipment capacities depending on the type of rooms and categorized the whole building as 65 zones. Every zone has a system with one outdoor AC unit and at least 1 or more indoor AC unit per room. We added up the max loads of each room in each zone and selected appropriate AC units in each zone based on this total. The summary of AC units in each zone of each case is shown in Table 7. A package air-conditioning system differs from chilled or heated water circulating air-conditioning systems. Refrigerants go to each indoor AC unit and exchange heat with air taken from each room at a cooling or heating coil in indoor AC unit. Several indoor AC units are connected to 1 outdoor AC unit. This makes it difficult to determine the behavior of a refrigerant, so the surface heat transfer coefficient inside coils, the refrigerant's condensing temperature, the its evaporating temperature, and so on are unknown. Therefore it is very difficult to calculate those details individually. So we created a suitable model for the package air-conditioning system. It was an overall system integrating outdoor AC unit and indoor AC units. Between outdoor AC unit capacity and sum of indoor AC unit capacity, the lower decide whole system capacity.

Table 1 Outlines of targeted buildings

	Ito Campus	Hakozaki Campus
Names of targeted buildings	The education and research building, West 3 and West 4 in Engineering Zone in Ito Campus of Kyushu University	The Engineering Departments of Mechanics, Aeronautics and Material science in Hakozaki Campus of Kyushu University
Location	West ward in Fukuoka, JAPAN	East ward in Fukuoka, JAPAN
Total floor area	55,462[m2]	37,169[m2] (the total of 3 departments)
Floor number	9 stories above the ground and 1 underground floor	
Structure	Reinforced Concrete	

Figure 1 Photographs of targeted buildings (Left: Ito Campus, Right: Hakozaki Campus)



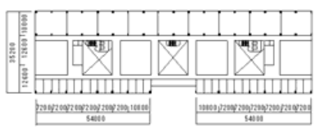


Figure 3 Typical floor plan for simulation

Figure 2 Typical floor plan in the Ito Campus

Table 3 Outlines of the model for targeted buildings

Total floor area	32,741[m2]
Floor number	9 [stories]
Building height	42.4[m]
Ratio of window area	26.3[%]

Table 2 Summary of values used in the estimate of CO2 emission

		Ito Campus	Hakozaki Campus
Design management		The construction workforce [head-count] * The term of works [a day] * The specific consumption rate 39.538[kg-CO2/(head-count*a day)] (The term of works should be 20 days per month.)	The estimated total construction cost [a thousand yen] * 3 [%] * The specific consumption rate 13.191 [kg-CO2/a thousand yen] (The term of works should be 20 days per month.)
Construction Works		Building material use [kg] * A specific consumption rate [kg-CO2/kg]	The estimated total construction cost [a thousand yen] * The specific consumption rate 2.474 [kg-CO2/a thousand yen]
		Building material unit cost [a thousand yen] / The construction cost deflator [-] * A specific consumption rate [kg-CO2/a thousand yen]	
Maintenance		The estimated maintenance cost [a thousand yen/a year] * The specific consumption rate 0.584 [kg-CO2/a thousand yen]	An actual maintenance cost in 2004 [a thousand yen/a year] / A corporate service price index [-] * The specific consumption rate 0.584 [kg-CO2/a thousand yen]
Operation	Electricity consumption	The simulated consumption [kWh/a year] * The specific consumption rate 0.477 [kg-CO2/kWh]	The actual consumption in 2004 [kWh/a year] * The specific consumption rate 0.477 [kg-CO2/kWh]
	Gas consumption	The simulated consumption [Nm3/a year] * The corresponding value 46.047 [MJ/Nm3] * The specific consumption rate 0.043 [kg-CO2/MJ]	The actual consumption in 2004 [Nm3/a year] * The corresponding value 46.047 [MJ/Nm3] * The specific consumption rate 0.043 [kg-CO2/MJ]

Table 5 Summary of eleven air-conditioning systems

	Heat sources	Primary pumps	Secondary pumps	Fans	Total heat exchangers	Outdoor air cooling
Case 0	A gas package air-conditioning system					
Case 1	A electric package air-conditioning system					
Case 2	Quantity control	Constant flow and quantity control	Constant flow	Constant air volume	x	x
Case 3	Quantity control	Constant flow and quantity control	2-way valve control	Constant air volume	x	x
Case 4	Quantity control	Constant flow and quantity control	Inverter control	Constant air volume	x	x
Case 5	Quantity control	Constant flow and quantity control	Inverter control	Damper control	x	x
Case 6	Quantity control	Constant flow and quantity control	Inverter control	Inverter control	x	x
Case 7	Quantity control	Constant flow and quantity control	Inverter control	Inverter control	o	x
Case 8	Quantity control	Constant flow and quantity control	Inverter control	Inverter control	o	o
Case 9	Inverter and quantity control	Inverter and quantity control	Inverter control	Inverter control	o	o
Case 10	Gas system	Constant flow and quantity control	Inverter control	Inverter control	o	o

x = without
o = with

Table 6 Summary of settings

	Type of room	Floor area [m2]	Number of rooms [-]	Calculation formulas [W]	Total [kW]
Lighting	Lecture room	144	12	20[W/m2]*144[m2]*12[-]	34.56
	Office room	144	8	20[W/m2]*144[m2]*8[-]	23.04
	Laboratory	222	28	20[W/m2]*222[m2]*28[-]	124.32
	Test room	144	73	20[W/m2]*144[m2]*73[-]	210.24
	Professor's room	22	210	20[W/m2]*22[m2]*210[-]	92.40
	Lecture room	144	12	20[W]*12[-]	2.40
Equipment	Office room	144	8	Personal computer: 200[W/quantity]*0.15[head-count/m2] *1[quantity/head-count]*144[m2]*8[-] Printer: 50[W/quantity] *1[quantity]*8[-] Copier: 300[W/quantity] *1[quantity]*8[-]	37.36
	Laboratory	222	28	Personal computer: 200[W/quantity]*0.15[head-count/m2] *1[quantity/head-count]*222[m2]*28[-] Printer: 50[W/quantity] *1[quantity]*28[-] Copier: 300[W/quantity] *1[quantity]*28[-]	196.28
	Test room	144	73	Labware: 5,000[W/quantity] *1[quantity]*73[-]	365.00
	Professor's room	22	210	Personal computer: 200[W/quantity]* 1[quantity/head-count]*144[m2]*210[-] Printer: 50[W/quantity] *1[quantity]*210[-]	52.50

However in this modeling, the sum of indoor AC unit capacity is always lower.

AIR-CONDITIONING SIMULATION (CENTRAL SYSTEM)ESTIMATION WAYS

In the air-conditioning simulation with the building model, we required each room temperature and humidity of heat balance by inputting response coefficients of thermal storage and virtual air-conditioning loads calculated by HASP/ACLD/8501 [2]. We made separate models of subsystems that constituted air-conditioning systems and the models exchange heat data with each other to simulate total energy consumption. They are calculated at 10-minute intervals, and when air-conditioning is operated, the necessary fresh air, 25 [m3/ (head-count * hour)] are supplied constantly. Temperature rise by heat from equipment and thermal loss in pipe laying are excluded.

The air-conditioning system is shown in Figure 4. There is a bypass between a supply header and a return header, and water goes through a bypass when surplus water flow in primary pumps is different from one in secondary pumps. We decided operating unit counts of heat sources would be controlled by input water temperature. The number of primary pumps in operation should always be the same as the number of heat sources in operation. In this regard, however at least 1 primary pump should be always operated to circulate water when an air-conditioning system is operated.

Because each air-conditioned floor is large in a central system, we divided each floor into 4 areas and there is one-by-one air-conditioning equipment in every area. It should be a single duct system. Concerning air-conditioning zoning, we divided the building into 36 zones depending on each zones aspects, the operational time of air-conditioning, and the property of the indoor heat. From the 3rd to the 8th floor have the same typical floor plans and same max load [3]. A summary of air-conditioning systems in each zone is shown in Table 8 and a summary of heat sources and pumps is shown in Table 9.

Summary of each case

Case 2 has constant water flow and constant air flow operation. So it cannot control indoor temperature on the secondary side exactly because water flow and constant air flow in air-conditioning equipment are only rating on-off controlled. Secondary pumps have valuable water flow operation in Case 3 and Case 4, and water flows in pumps are changed to follow indoor loads so they can keep indoor temperature near preset values. Case 5 and above have valuable water flow and valuable air flow operations. And the speed of the air flow is determined by measuring supply air temperature and indoor temperature. Preset supply air temperature is always 18 degrees C in summer and 32 degrees C in winter. In this regard, however air flow is always faster than the necessary fresh air, 25 [m3/ (head-count * hour)]. Then, water flow from air-conditioning equipment is changed in order that indoor temperature matches the preset temperature according to the decided air flow and the heat balance in coil simulation model. Case 7 is exactly like case 6 except a total heat exchanger is introduced. It should not operate when outdoor temperature is lower than indoor temperature in summer or when it is higher in winter to prevent extra heat from entering or exiting from rooms through a total heat exchanger. Case 8 is the same as Case 7 except outdoor air cooling is introduced. It reduces indoor loads with outdoor air when outdoor temperature is lower than indoor temperature when cooling. In the simulation, April, May,

Table 7 Summary of AC units

Case	Zone	Quantity (in/out)	Cooling capacity [kW]	Heating capacity [kW]	Cooling input [kW]	Heating input [kW]
Case 0 (gas)	Lecture room zone	3	16.0	19.0	0.29	0.29
		1	56.0	67.0	(46.7) 1.75	(45.4)
	Office room and Test room zone	6	9.0	10.6	0.20	1.32
		1	56.0	67.0	(46.7) 1.75	0.20
	Professor's room zone	15	2.8	3.4	0.08	(45.4)
		1	45.0	53.0	(37.2) 1.30	1.32
	Lab zone	4	14.0	17.0	0.29	0.08
		1	56.0	67.0	(46.7) 1.75	(36.2) 1.32
	Test room zone	5	11.2	13.2	0.20	0.29
		1	56.0	67.0	(46.7) 1.75	(45.4) 1.32
	Test room zone	4	11.2	13.2	0.20	0.20
		1	45.0	53.0	(37.2) 1.30	(36.2) 1.32
Case 1 (electricity)	Lecture room zone	3	16.0	18.0	0.188	0.20
		1	56.0	63.0	19.0	20.1
	Office room and Test room zone	6	9.0	10.0	0.101	0.083
		1	56.0	63.0	19.0	20.1
	Professor's room zone	15	2.8	3.2	0.046	0.032
		1	45.0	50.0	14.6	16.0
	Lab zone	4	14.0	16.0	0.132	0.138
		1	56.0	63.0	19.0	20.1
	Test room zone	5	11.2	12.5	0.096	0.103
		1	56.0	63.0	19.0	20.1
	Test room zone	4	11.2	12.5	0.096	0.103
		1	45.0	50.0	14.6	16.0

The values in brackets ( ) are input by gas.

and October, when outdoor air is lower than the preset temperature 18 degrees C air output from air-conditioning equipment, outdoor air should supply rooms directly without passing through coils. And when outdoor air is lower than indoor temperature but higher than 18 degrees C, outdoor air should not be mixed with return air from rooms and should pass coils. Heat sources have inverter controls in Case 9. Primary pumps also have inverter control. In this simulation, inverter control should be used only during cooling time when it has high part-load efficiency. Heat sources run on gas in Case 10. In summer, a cooling tower should be operated.

ESTIMATED RESULTS

Table 10 and Figure 5 show the total CO2 emissions for the next 50 years use of the targeted buildings. CO2emissions from the electricity and gas consumption are estimated by using Case 0 in the simulation. Estimated CO2 emission of the buildings at the Ito Campus is 279,988[t-CO2] and the annual average is 5,600 [t-CO2]. Estimated CO2 emission of the buildings in Hakozaki Campus is 212,149 [t-CO2] and the annual average is 4,243 [t-CO2]. About 78% of CO2 emission originates from the operation phase at the Ito Campus and about 87% of CO2 emission originates from the operation phase at the Hakozaki Campus. Energy conservation on an operation phase is essential for reducing environmental loads in a building life cycle.

The estimated results of CO2 emissions per unit area are shown in Figure 6. In total, CO2 emission of the buildings at the Ito Campus increased by about 32% compared to Hakozaki Campus, but in per unit area, it is reduced by about 12%. It is 5,048 [kg-CO2/m2] for the Ito Campus and it is 5,708 [kg-CO2/m2] for the Hakozaki Campus. Because the buildings face south, have the well-insulated walls and windows and this contributes to air-conditioning loads. The CO2 emission from the gas consumption in Ito Campus has higher rate than one in Hakozaki Campus because gas package air-conditionings are mainly used.

Meanwhile, low CO2 emission from the maintenance is included as the main characteristic in Hakozaki Campus. The specific buildings under Enactment of the Waste Management and Public Cleanliness Law are few in the Hakozaki Campus, so the maintenance level in Hakozaki Campus is lower than the setting of the buildings at the Ito Campus.

CO2 emission per unit area at the Ito Campus, as already stated, the reduction remains about 12% compared to

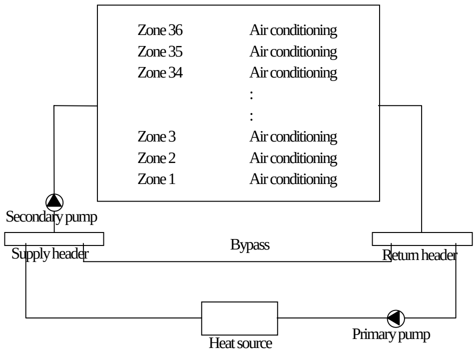


Figure 4 Air-conditioning system

Table 8 Summary of air-conditioning systems for central

Zone	Performance of cooling coil: Air flow [m³/h]	Capacity [kW]	Water flow [l/min]	Fun [kW]	Application
ZONE 1	9,720	96.0	275	5.5	Lecture room
ZONE 2	9,720	96.0	275	5.5	Lecture room
ZONE 3	13,200	92.6	266	5.5	Test room
ZONE 4	10,550	72.8	209	5.5	Office room
ZONE 5	9,720	96.0	275	5.5	Lecture room
ZONE 6	9,720	96.0	275	5.5	Lecture room
ZONE 7	13,200	92.6	266	5.5	Test room
ZONE 8	10,550	72.8	209	5.5	Office room
ZONE 9	5,110	36.1	104	2.2	Professor’s room
ZONE 10	5,110	36.1	104	2.2	Professor’s room
ZONE 11	19,150	132.0	379	7.5	Laboratory
ZONE 12	21,950	150.1	431	11.0	Laboratory
ZONE 13	6,640	47.3	136	3.7	Professor’s room
ZONE 14	6,640	47.3	136	3.7	Professor’s room
ZONE 15	22,750	150.1	431	11.0	Laboratory

Table 9 Summary of heat sources and pumps

		Except Case 10	Case 10
Heat sources	Type	Air cooled screw tiller	Hot-and-chilled water generator by gas
	Capacity	Cooling 600*6 [kW]	Cooling 738*5 [kW]
		Heating 560*6 [kW]	Heating 665*5 [kW]
	Input	Cooling 203*6 [kW]	Cooling 50.3*5 [Nm3]
		Heating 174*6 [kW]	Heating 60.2*5 [Nm3]
Primary pumps	Flow	2.0 [m3/min]	2.8 [m3/min]
	Input	30*6 [kW]	45*5 [kW]
	Lifting range	60.8 [m] (2 columns)	60.8 [m] (2 columns)
Secondary pumps	Flow	1.6 [m3/min]	1.6 [m3/min]
	Input	75*6 [kW]	75*6 [kW]
	Lifting range	104 (2 columns)	104 [m] (2 columns)
Cooling water pump	Flow	-	3.15[m3/min]
	Input		55*5 [kW]
	Lifting range		67.5 [m] (2 columns)
Refrigerant pump	Input	-	0.3 [kW]
Solution pump	Input	-	2.2+0.75 [kW]
Cooling tower	Capacity	-	569*2 [m3/h]
	Fun		5.5*4 [kW]

Hakozaki Campus, but we should keep in mind that they cannot be compared on a like-for-like basis. This is because the operation phase, we use a simulated calculation for Ito Campus actual data for Hakozaki Campus. It is no wonder that the actual indoor condition including temperature, moisture and air quality in Hakozaki Campus is much lower than the supposed one in Ito campus. If the same indoor condition rose to the same level as Ito Campus, CO2 emission would be terribly increased at the Hakozaki Campus. So 12%, the rate of the CO2 emission reduction per unit area is underestimated.

On the other hand, at the Ito Campus, the gas package air-conditioning almost fills the air-conditioning system. They don't use an inverter control that makes a best contribution to energy conservation and leaves the decision of operation up to individual users. They also have the risk of increasing waste energy consumption, if we let it continue unchecked. In addition, the resulting increase by 32% in the total is a real and substantive problem even if the floor areas at the Hakozaki Campus are smaller than those at the Ito Campus. It is essential to build a practical management system for the highest energy conservation and the highest CO2 reducing emission by constantly analyzing and re-evaluating the actual data on the building environment and the energy consumption in Ito Campus.

The results of the simulated annual energy consumption in each case is shown in Table 11, and CO2 emission in each case is shown in Table 12 and Figure 7.The lowest, Case 1 that used an electric package air-conditioning system is 3,670[t-CO2]. It reduced emissions by about 13% compared to the gas package air-conditioning system. That is the reason why electric package air-conditionings have higher part-load efficiency by inverter control. And in case where a central system is used, the case with the lowest emissions, Case 9, has emissions of 3,776[t-CO2]. Case 9 has energy conservation technology introduced into its pumps and fans. However, as for case 2 that has the highest emissions, it does not have any energy conservations system installed and emissions are at 5,355[t-CO2].

Many people use the lecture room at the same time, so the energy consumption for carrying outside fresh air has a high rate of the total. In other words introducing energy conservation technology including inverter control into pumps and fans produces a big effect. This study has dealt with very primitive energy conservation technology in central system. If advanced technologies including heat storage system, high-efficiency inverter refrigerator, and cogeneration system are introduced, more energy conservation can be expected. On the other side, individual air-conditioning systems can hardly ask for more energy conservation because it depends largely on stand-alone energy conservation efficiency. There isn't so much of a difference between Case 1 and Case 9 in energy consumption, but the central system has an advantage in capability and certainty of energy conservation due to the risk of leaving the decision of operation up to individual users. Meanwhile, the individual system has a higher degree of freedom for individual operation in laboratories and professor's rooms that are used at random times.

Table 10 Total CO2 emissions

	Total CO2 emission for the next 50 years of use [t-CO2]		Total CO2 emission for the next 50 years of use per unit area [t-CO2]	
	Ito Campus	Hakozaki Campus	Ito Campus	Hakozaki Campus
Design management	1,132	353	20	9
Construction works	58,893	27,006	1,062	727
Maintenance	9,636	335	174	9
Electricity consumption	173,556	178,566	3,129	4,804
Gas consumption	36,771	8,890	663	158
Total	279,988	212,149	5,048	5,708
Annual average	5,600	4,243	101	114

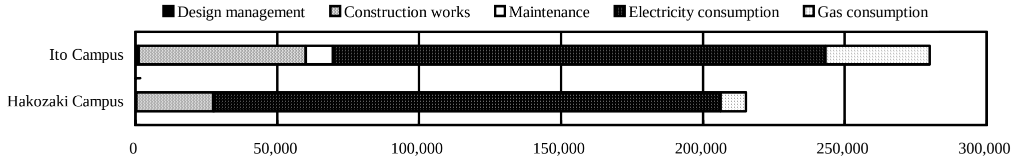


Figure 5 Total CO2 emission for the next 50 years use [t-CO2]

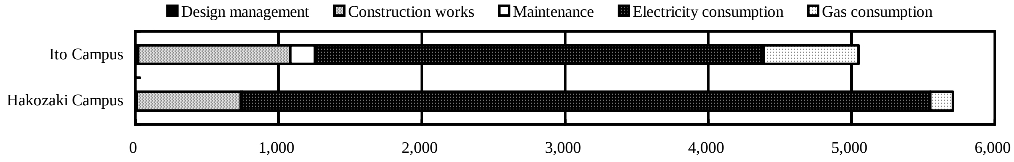


Figure 6 Total CO2 emission for the next 50 years use per unit area [kg-CO2/m2]

By rights, CO2 emission from design management, construction, and maintenance changes when air-conditioning system changes. It has a special impact on construction and maintenance, for example, it can be said that an individual system's maintenance cost is higher than central system's one because indoor equipment must be installed in every room. Besides, in an individual system, a gas package air-conditioning systems one is higher than an electricity package air-conditioning system's one. We haven't dealt with the detailed calculations of CO2 emissions in when considering these factors. It needs further study.

CONCLUSIONS

In this paper, the CO2 emissions of buildings at the Ito Campus of Kyushu University was estimated and evaluated to obtain basic data for the building environmental and energy management system. In the evaluation, we compared building CO2 emission at the Ito Campus with ones at the old Hakozaki campus and ones when the other air-conditioning systems are introduced into Ito Campus.

As a result, total CO2 emission of the buildings at the Ito Campus increased by about 32% compared to Hakozaki Campus. It is a real and substantive problem even if the floor areas and the quality of the indoor condition at the Hakozaki Campus are different from those at the Ito Campus.

The gas package air-conditioning system introduced into Ito Campus is comparatively good for energy conservation and low environment loads, and has a high degree of freedom for individual operation in laboratories and professor's rooms. However, it leaves the decision of operation up to individual.

It is essential to build up a practical management system for CO2 reducing emission by analyzing and re-evaluating data of the building environment and the energy consumption constantly. In particular, the students, faculty, and employees of Kyushu University as a whole have to make efforts to improve balancing comfort with energy conservation.

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Table 11 Results of the simulated energy consumption in each case

		West 4	West 3	Total
Floor area [m2]		24,228	8,513	32,741
Annual electricity consumption [kWh/a year]	Case 0	5,384,885	1,892,089	7,276,974
	Case 1	5,693,885	2,000,662	7,694,548
	Case 2	8,307,885	2,919,144	11,227,030
	Case 3	7,794,885	2,738,891	10,533,777
	Case 4	6,886,885	2,419,847	9,306,733
	Case 5	6,618,885	2,325,680	8,944,565
	Case 6	6,283,885	2,207,971	8,491,856
	Case 7	6,028,885	2,118,371	8,147,257
	Case 8	5,959,885	2,094,127	8,054,012
	Case 9	5,857,885	2,058,287	7,916,172
	Case 10	5,671,885	1,992,932	7,664,818
Annual gas consumption	Case 0	276,779	97,252	374,031
	Case 10	[illegible]	[illegible]	[illegible]

Table 12 CO2 emissions in each case [t-CO2]

	Case 0	Case 1	Case 2	Case 3
Electricity consumption	3,471	3,670	5,355	5,025
Gas consumption	735	0	0	0
Total	4,207	3,670	5,355	5,025

	Case 4	Case 5	Case 6	Case 7
Electricity consumption	4,439	4,267	4,051	3,886
Gas consumption	0	0	0	0
Total	4,439	4,267	4,051	3,886

	Case 8	Case 9	Case 10
Electricity consumption	3,842	3,776	3,656
Gas consumption	0	0	342
Total	3,842	3,776	3,998

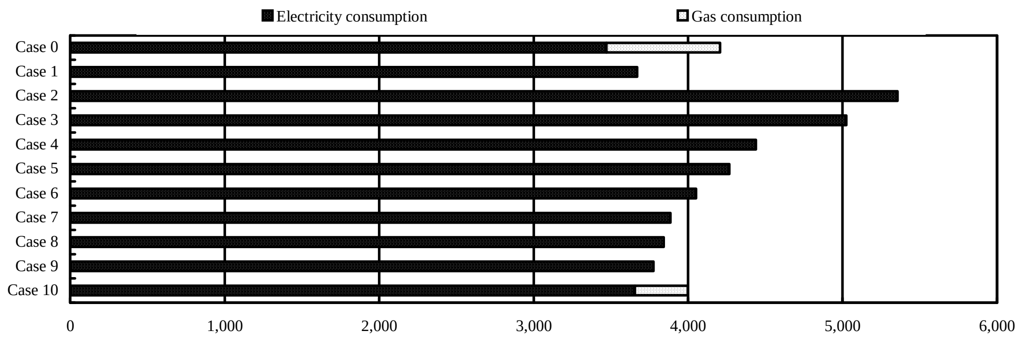

Figure 7 CO2 emissions in each case [t-CO2]