Energy Consumption Pattern in Commercial Buildings to Be Used for Assessing Various Community Energy Systems

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ABSTRACT
It is believed that one method of making effective use of energy is the sharing of hydrogen energy or heat and electricity produced by cogeneration systems at multiple facilities in the community. In this regard, temporal changes in energy demand at various facilities in the community greatly influence the efficiency of such systems. Therefore, the actual conditions of heat demand as well as electricity demand of different types of buildings were summarized.

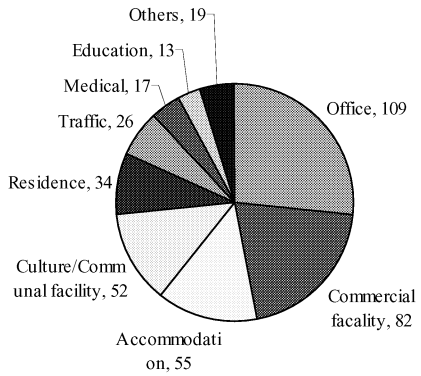


Figure 3. The number of districts for each consumer type of heat supply in Japan.

1. Heat Demand

1.1 District Heating and Cooling in Japan

1.1.1 Recipients of Heat Supply

In the Heat Supply Handbook of The Japan Heat Service Utilities Association, statistics for the number of consumers is listed, including nearly 45000 residential consumers and about 1500 commercial consumers. While the number of residential customers has been declining in the recent years, the gross floor area of heat supply is on the rise. Therefore, it is clear that large-scale industrial usage is expanding.

1.1.2 Changes in the Amount of Heat Supply

Regarding heat supply for residential consumers, the sales in heating energy show a minimal growth while hot water supply demonstrates an upward trend, even though not much change has been seen since several years ago. Although supply of cooling energy is scarce, its gradual increase is noticeable.

In regards to commercial consumption which greatly differs from its residential counterpart, the usage of cooling energy clearly occupies a large percentage. The increase in cooling energy consumption is particularly prominent after the burst of the bubble economy, yet it seems to be stable in recent years. The balance

of heat quantities sold for commercial and residential usages shows that commercial usage occupies most of it. As well, it is discernible that the quantity sold for commercial usage is on the rise, while that of residential usage is declining.

1.2 Daily Variations in Heat Demand

An examination was performed using the data on daily variations in the amount of heat usage, which was obtained in the form of district heat supply, for the buildings in Table 1.

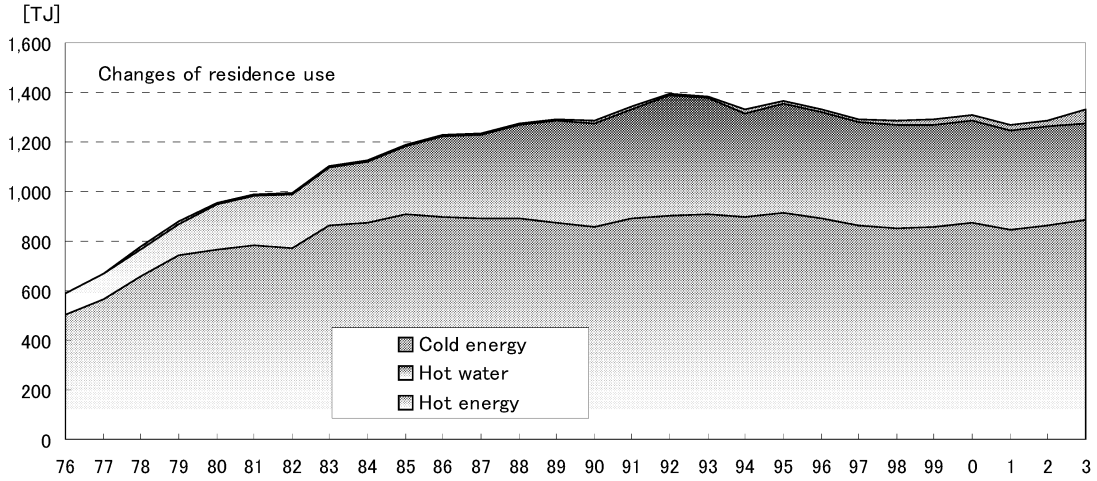


Figure 1. Changes in the amount of heat supply for residential usage in Japan.

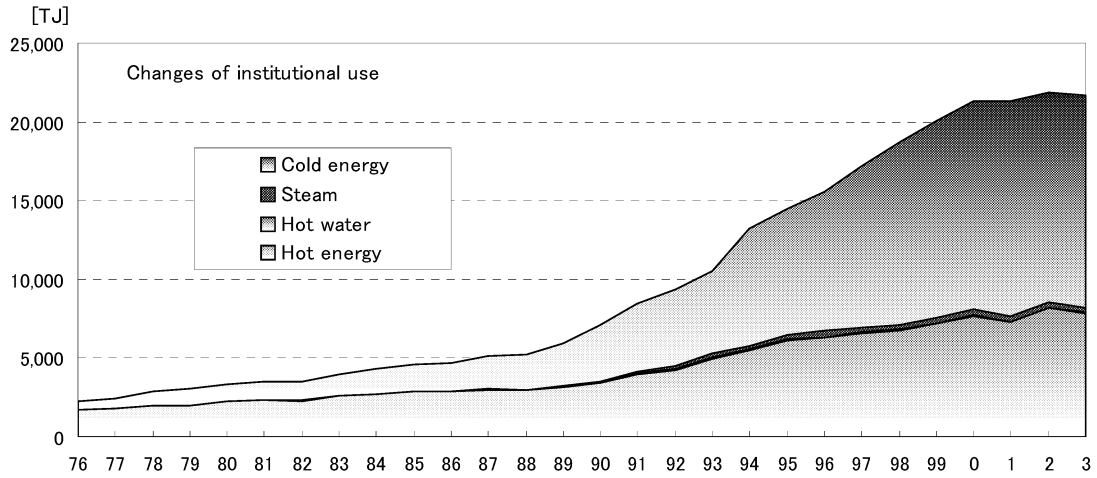


Figure 2. Changes in the amount of heat supply for commercial usage in Japan.

Table 1. The number of cases for the target buildings.

	Floor Area				Total
	1000-5000m^2	5000-20000m^2	20000-50000m^2	50000m^2-	
Office	6	3	5	19	33
Commercial facility	1	2	4		7
Accommodation	1		1	5	7
Medical facility		1			1
Government facilities, Hall, Station	2	2	1		5
Total	10	8	11	24	53

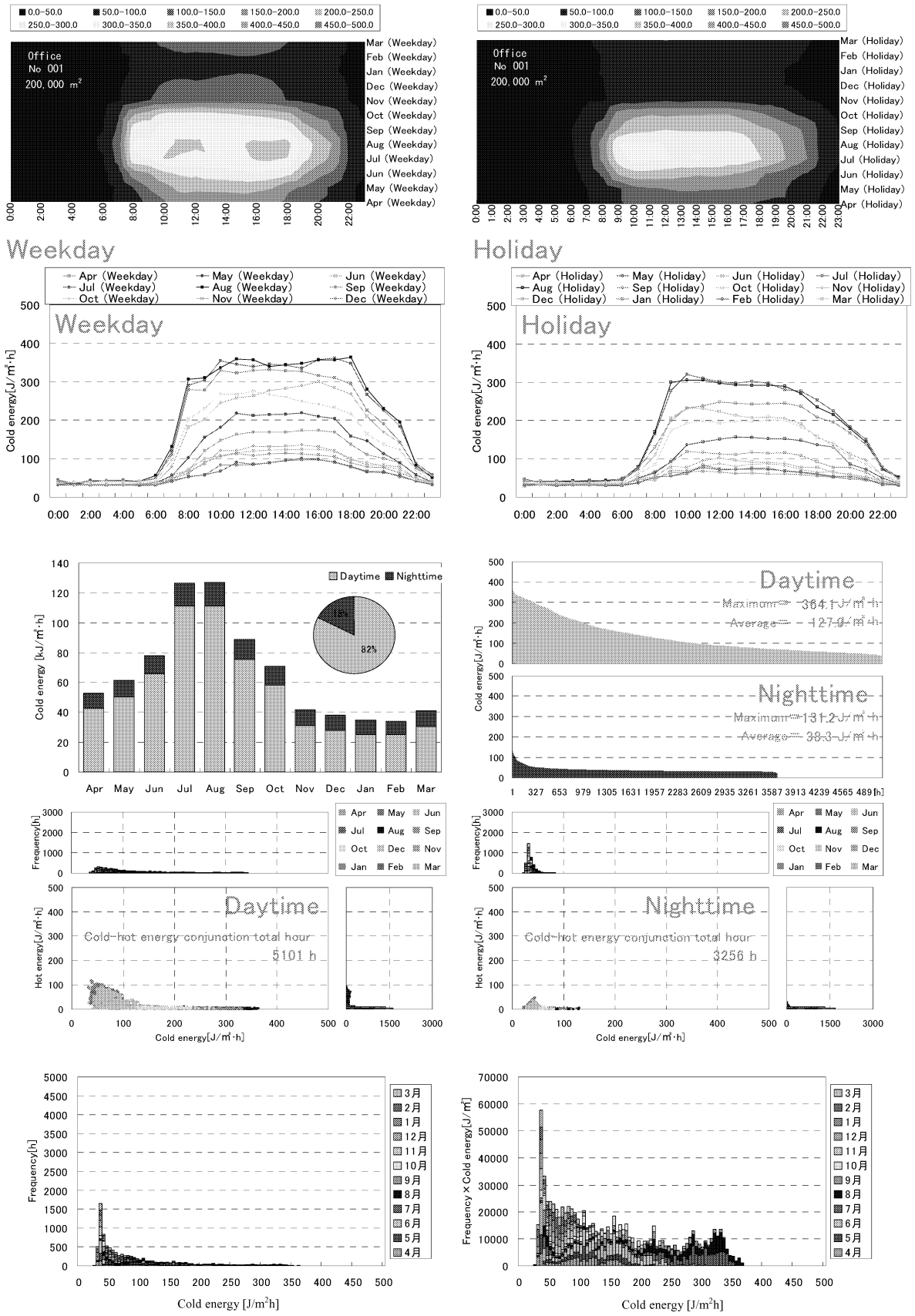


Figure 4. An example of cooling energy demand patterns (Office, approximately 200,000m^2).

Table 2 Summary for the targets of investigation.

Application	Complex (retailers, restaurants, accommodation)		Medical Facility
Location	Tokyo		Tokyo
Date built	Sep. 1984		Sep. 2005
Renewal	Jul. 2004		----
Floor area	Supermarket (1)	: ca 2,800m^2	27,400m^2
	Shops, restaurants (115)	: ca 17,400m^2	(320 beds)
	Accommodation （197 rooms）	: ca 10,400m^2	
Avg. floor area	4,300m^2		----
Number of floors	Above grade 9 floors Below grade 1 floor		Above grade 9 floors Below grade 1 floor Penthouse 1 floor
Data	1-7 Apr., 1-7 May., 1-7 Jun., 1-7 Jul., 1-7 Aug., 1-7 Sep., 1-7 Oct., 1-7 Nov., 1-7 Dec. 2005, 16-22 Jan., 1-7 Feb., 1-7 Mar. 2006		1 Jan. -31 Dec. 2005

The main constituent of the medical facility is the division of cardiovascular disease, and it also has operating rooms.

In Figures 4, example of analysis for the target data are shown. The graphs represented in contour show the day of each month in which the maximum load occurred.

The following are what can be identified from the contour graphs of the offices.

1) Presence or absence of load at night (12:00 am – 7:00 am, constant) (1 case/23 cases)

2) Presence or absence of load during non-operating hours (until 12:00 am) (11 cases/23 cases)

3) Presence or absence of load at night of a particular month (2 cases/23 cases)

4) Presence or absence of load on non-business days (21 cases/23 cases)

5) Presence or absence of load during winter (6 cases/23 cases)

All of the above are attributable to the utilization of the buildings which also characterizes each of them. Thus for a detailed examination, it is necessary to make a supposition of the utilization of each building for it governs its energy usage.

2. Electricity Demand (Excluding Air-conditioning Usage)

2.1 Targets of Investigation

Our targets included 2 properties, one being a complex facility with a supermarket, other shops, restaurants and a accommodation, and another being a medical facility as shown in Table 2. The data recorded in each of BEMS (Building Energy Management System) was obtained, followed by the examination of electricity demand excluding that of heat source using the aforementioned data.

2.2 Electricity Consumption

Hereinafter, “electrical lighting” refers to the consumption of electricity by lights as well as other devices through outlets, whereas “motive energy” refers to conveying equipments such as elevator as well as pumps for heat source.

2.2.1 Monthly Integrated Values

In Figures 5 and 6, monthly integrated values for electricity consumption are presented for each building application. Regarding the overall consumption, all application types display the largest values in the summer. However, consumption of electrical lighting shows little fluctuation throughout the year.

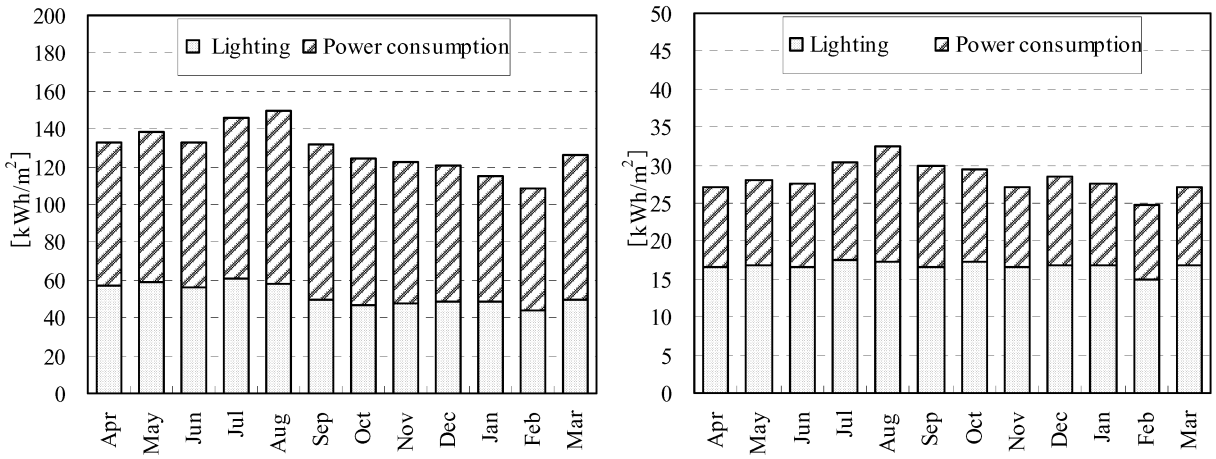


Figure 5. Monthly integrated values for electricity consumption

(Left : Supermarket, Right : Shops and Restaurants)

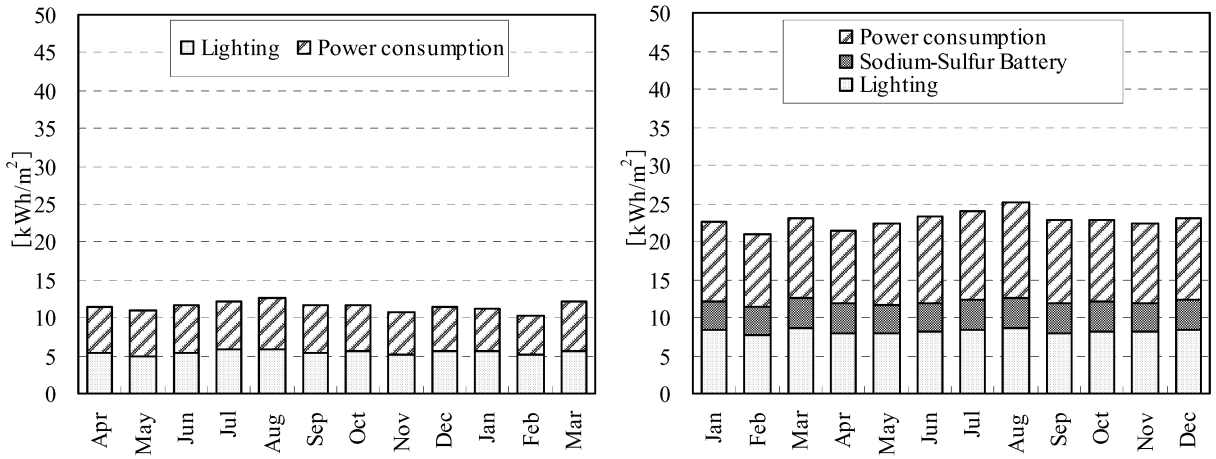


Figure 6. Monthly integrated values for electricity consumption

(Left : Accommodation, Right : Medical facility)

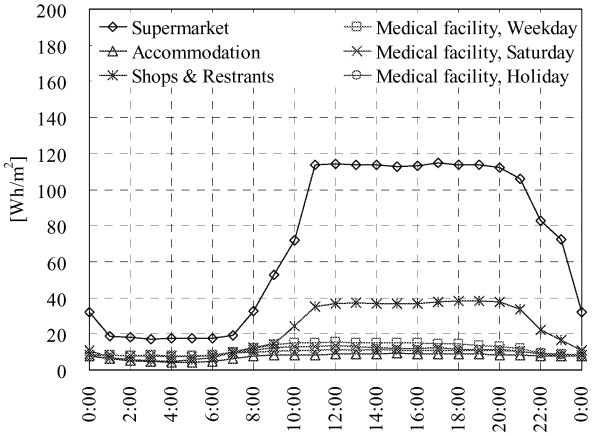
2.2.2 Temporal Changes in Electricity Consumption

In Figure 7 to 9, temporal changes in electricity consumption are shown for electrical lighting as well as motive energy for each building application. Hourly data fluctuations are large because of the inexact pulse count outputs by integrating watt meters. For this reason, smoothing was performed on temporal changes by calculating the hourly averages of each week. Moreover, regarding the medical facility, the data on electrical consumption of sodium-sulfur battery was excluded. At the same time, the data were separated into weekdays, Saturdays and Non-business days (Sundays and holidays) as

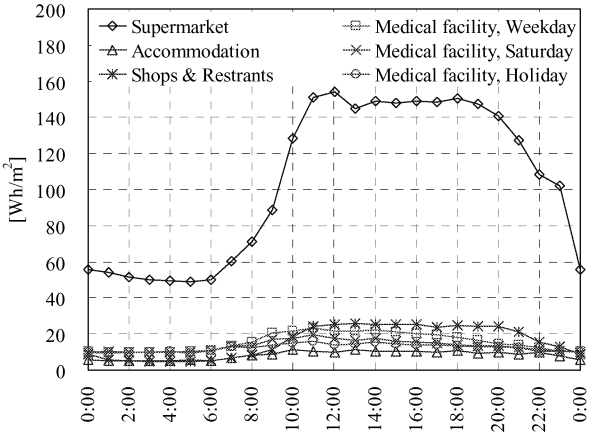
the data was obtained for all 365 days.

The load patterns of consumption in electrical lighting in day time are flat for the supermarket and other shops, restaurants while those of the accommodation and medical facility show curves with the peak of the accommodation occurring at a somewhat later time comparatively.

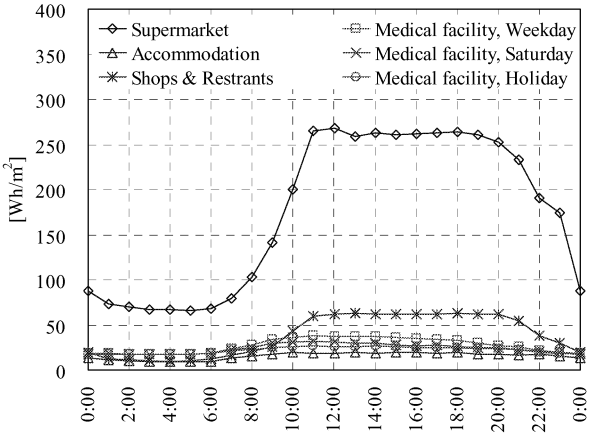
Consumption in regard to motive energy shows different hourly fluctuations for each month while at the same time displaying seasonal fluctuations. In addition, at the supermarket and other shops, restaurants, the peak occurs at around 10 o'clock in all months, and they are generally flat. Regarding the accommodation's, the data fluctuations are hard to discern even after performing smoothing as mentioned earlier, yet it appears to have a peak at around 10 o'clock as with other applications. The data pertaining to the medical facility also shows a peak at around 10 o'clock on weekdays and Saturdays, yet on non-business days, it shows a moderate curve with the center being approximately 2 pm.



Figre 7. Temporal changes in average electricity consumption (electrical lighting)



Figre 8. Temporal changes in average electricity consumption (motive energy)



Figre 9. Temporal changes in average electricity consumption (electrical lighting and motive energy)

3. CONCLUSIONS

In order to realize the effective utilization of energy by way of district-wide usage, the actual conditions of heat demand as well as electricity demand were summarized for different building types. Through employing these characteristics, it will be possible to explore the potentials for reducing energy consumption. However, only a small number of buildings were investigated in this study. Therefore, more data on demand must be collected in the future in order to improve reliability of data.

REFERENCES

http://www.jdhc.or.jp