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# A Study on the Power Consumption Patterns of General Hospital Buildings

Park Jong Cheon[1a], Lee Kang-Guk [3c], Hong Won Hwa[2,b]

[1]School of architectural& civil engineering, Kyungpook National University, 713 702, Daegu, Korea

[2]School of architectural& civil engineering, Kyungpook National University, 713 702, Daegu, Korea

[3]School of architectural& civil engineering, Kyungpook National University, 713 702, Daegu, Korea

[a]ace7007@nate.com, [b]ggyi@naver.com [c]hongwh@knu.ac.kr

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**Abstract.** The most important part of energy use in hospital buildings is to identify its usage patterns and maintain power supply even in blackout situations, rather than to save energy. This paper presents the power energy usage patterns of general hospitals as basic data for the establishment of countermeasures in blackout situations.

## Introduction

The global primary energy supply is expected to increase steadily with economic growth. The International Energy Agency (IEA) predicts that the global primary energy demand in 2030 will be around 15.27 billion TOE (66% higher than that in 2000)[1]. By region, the annual growth rate between 2000 and 2030 in advanced nations will be only 1.0%, whereas the annual growth rate in developing nations around Asia will be 2.9%, almost triple the former. By energy source, natural gas is expected to show the highest growth of 2.4% per year on the average for 30 years in the future. However, the growth of coals and nuclear power demand are expected to be low[2].

Many governments, public organizations, and the private sector are making efforts to reduce energy usage. However, even in this situation, there are organizations that must not reduce their energy usage, such as hospitals that save people's lives. Therefore, hospitals and other critical facilities have standby power devices to prepare them for risks in the event of sudden blackouts. Even under emergencies, critical buildings such as hospitals must maintain their functions.

This paper presents the power energy usage of general hospitals in ordinary times as basic data for the establishment of countermeasures in blackout situations.

## Electricity Pricing System of South Korea

The electricity pricing system of South Korea has six categories: houses, general, education, industries, agriculture, and streetlamps. The six-step progressive pricing system is used. In other words, to promote energy savings in non-productive sectors, high prices are charged for the general and house categories, and low prices are charged for industries and agriculture to enhance industrial competitiveness and support agricultural and fishing villages.

As of 2010, the selling price of general houses, which are the highest-priced, was 103.38 won/kWh, whereas the selling price for agriculture was 42.54 won/kWh. For housing electricity prices, the progressive system (six steps from March 2004) is applied to charge higher prices for houses with high power consumption. Furthermore, higher prices are applied to electricity for general use to promote savings in energy consumption. In contrast, the production and education sectors are supported by low prices. Furthermore, to rationalize resource usage through demand management, higher prices are applied in summer, when the demand is the largest in the year, and to the hours when power demand is concentrated[3].

The general hospital under study has a site area of 37,226.36 $m^2$, a gross floor area of 88,187.25 $m^2$, and a floor area ratio of 236.9%. The electricity pricing system that corresponds to general electricity B (300 Kw or more contract electricity), or High-Voltage A Choice II pricing system is being applied to general hospitals. The pricing system contract can be changed yearly[3].

**Table 1.** High Voltage A electricity pricing system

| Division | | Base Rate | Watt-Hour Rate (Won/KWh) | | | |
|---|---|---|---|---|---|---|
| | | | **Hours** | **Summer (Jun-Aug)** | **Spring & Fall (Mar-May, Sept-Oct)** | **Winter (Nov-Dec)** |
| High-Voltage A | Choice I | 7,220 | Light load | 61.6 | 61.6 | 68.6 |
| | | 7,220 | Medium load | 114.5 | 84.1 | 114.7 |
| | | 7,220 | Maximum load | 196.6 | 114.8 | 172.2 |
| | Choice II | 8,320 | Light load | 56.1 | 56.1 | 63.1 |
| | | 8,320 | Medium load | 109.0 | 78.6 | 109.2 |
| | | 8,320 | Maximum load | 191.1 | 109.3 | 166.7 |
| | Choice III | 9,810 | Light load | 55.2 | 55.2 | 62.5 |
| | | 9,810 | Medium load | 109.4 | 77.3 | 108.6 |
| | | 9,810 | Maximum load | 178.7 | 101.0 | 155.5 |

As shown in Table 2, the High-Voltage A pricing system is divided into Choice I, Choice II, and Choice III. For each of these, the base rate, light load, medium load, and maximum load are applied. Thus, it is very difficult to choose which pricing system to use.are to be listed at the end of the contribution under a heading *References*, see our example below.

**Table 2.** Pricing by hours

| **Division** | **Summer (Jun-Aug)** | **Spring & Fall (Mar-May, Sept-Oct)** | **Winter (Nov-Dec)** |
|---|---|---|---|
| Light load | 23:00-09:00 | 23:00-09:00 | 23:00-09:00 |
| Medium load | 09:00-10:00<br>12:00-13:00<br>17:00-23:00 | 09:00-10:00<br>12:00-13:00<br>17:00-23:00 | 09:00-10:00<br>12:00-17:00<br>20:00-22:00 |
| Maximum load | 10:00-12:00<br>13:00-17:00 | 10:00-12:00<br>13:00-17:00 | 10:00-12:00<br>17:00-20:00<br>22:00-23:00 |

As shown in Table 3, the number of hours for light loads, medium loads, and maximum loads are identical in summer, spring, and fall; but in winter, there is a slight difference between the medium load and the maximum load.

## Power Usage of Hospital Buildings

The annual power usage from 2008 to 2012 was lowest in 2009 and highest in 2010, after which it has been decreasing. According to the monthly electricity usage from 2008 to 2012, the highest was in August 2010 and the lowest, in November 2008. Electricity consumption generally significantly increased in summer due to the cooling load. In winter, the load for heating showed a slight growth, which indicates that the heating of the hospital under study depended on city gas.

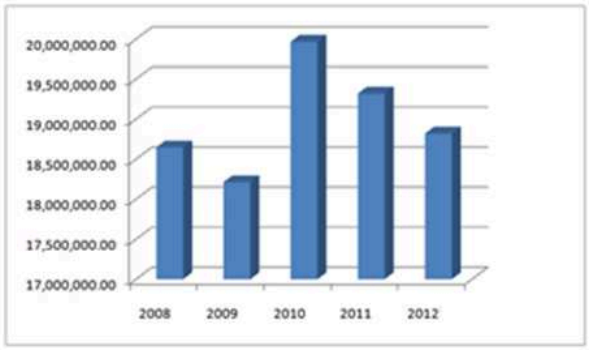


**Figure 1.** Annual electricity usage between 2008 and 2012

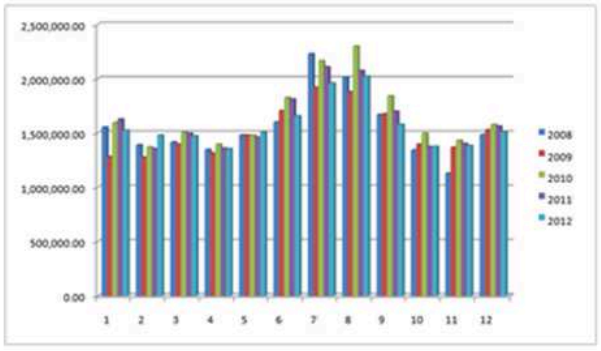


**Figure 2.** Monthly electricity usage between 2008-2012

## Price Change Simulation of the Selective Pricing System by Load Rate

The simulations of the price changes in the selective pricing system by load rate showed almost identical patterns each year between 2008 and 2012. Thus, with the most recent data (2012), the annual and monthly rates were compared with the base rate, light load, medium load, and maximum load for Choice I, Choice II, and Choice III.

**Table 3.** Simulation of price changes when the selective pricing system by load rate is selected in 2012

| Division | Power Usage (KWh) | General (B) High-Voltage A Choice II (A) | General (B) High-Voltage A Choice I (B) | General (B) High-Voltage A Choice III (C) | Price Change (B-A) | Price Change (C-A) |
|---|---|---|---|---|---|---|
| Base rate | 50,833 | 422,930,560 | 367,014,260 | 498,671,730 | -55,916,300 | 75,741,170 |
| Light load | 8,198,314.56 | 478,332,827 | 523,423,557 | 471,743,232 | 45,090,730 | -6,589,595 |
| Medium load | 6,388,211.52 | 624,885,816 | 660,020,979 | 619,398,306 | 35,135,163 | -5,487,511 |
| Maximum load | 4,231,787.04 | 640,409,797 | 663,684,626 | 596,344,364 | 23,274,829 | -44,065,433 |
| Total | 18,818,313.12 | 2,166,558,999 | 2,214,143,422 | 2,186,157,630 | 47,584,423 | 19,598,631 |

**Table 4.** Simulation of price changes when the selective pricing system by load rate is selected in July 2012

| Division | Power Usage (KWh) | General (B) High-Voltage A Choice II (A) | General (B) High-Voltage A Choice I (B) | General (B) High-Voltage A Choice III (C) | Price Change (B-A) | Price Change (C-A) |
|---|---|---|---|---|---|---|
| Base Rate | 4,267 | 35,501,440 | 30,807,740 | 41,859,270 | -4,693,700 | 6,357,830 |
| Light load | 819,642.24 | 45,981,930 | 50,489,962 | 45,244,252 | 4,508,032 | -737,678 |
| Medium load | 652,731.84 | 71,147,771 | 74,737,796 | 70,756,131 | 3,590,025 | -391,639 |
| Maximum load | 486,254.88 | 92,923,308 | 95,597,709 | 86,893,747 | 2,674,402 | -6,029,561 |
| Total | 1,958,628.96 | 245,554,447 | 251,633,207 | 244,753,400 | 6,078,760 | -801,047 |

**Table 5.** Simulation of price changes when the selective pricing system by load rate is selected in August 2012

| Division | Power Usage (KWh) | General (B) High-Voltage A Choice II (A) | General (B) High-Voltage A Choice I (B) | General (B) High-Voltage A Choice III (C) | Price Change (B-A) | Price Change (C-A) |
|---|---|---|---|---|---|---|
| Base Rate | 4,206 | 34,993,920 | 30,367,320 | 41,260,860 | -4,626,600 | 6,266,940 |
| Light load | 864,122.40 | 48,477,267 | 53,229,940 | 47,699,556 | 4,752,673 | -777,710 |
| Medium load | 660,385.44 | 71,982,013 | 75,614,133 | 71,585,782 | 3,632,120 | -396,231 |
| Maximum load | 497,508.48 | 95,073,871 | 97,810,167 | 88,904,765 | 2,736,297 | -6,169,105 |
| Total | 2,022,016.32 | 250,527,070 | 257,021,559 | 249,450,963 | 6,494,489 | -1,076,107 |

Based on the price change simulations for July and August when the power usage peaks, Choice I is advantageous in terms of the base rate, and Choice III is advantageous in each load compared to Choice II, which is identical to the overall trend in 2012. However, when the Choice III pricing system was chosen, the price savings were very high--about 800,000 won in July and about 1,080,000 won in August.

## Conclusions

1. The monthly power consumption of general hospitals increase the highest due to their cooling load in summer, whereas in winter, there is no particular increase in the load due to the nature of the buildings that use city gas for heating.
2. The annual energy usage of the general hospital under study steadily decreased after 2010, seemingly due to the installation of highly efficient energy-saving devices and energy-saving patrol activities.
3. If the monthly electricity pricing system can be changed, the general hospital under study can save electric charges if it chooses the General (B) High-Voltage A Choice II at ordinary times and the General (B) High-Voltage A Choice III in July and August.

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