# Criteria on Energy Efficiency and Initial Cost

# of HVAC Equipment for Public Buildings in Korea

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**ABSTRACT**
This study is part of the development for the remodeling support tool that will be show remodeling alternatives and the necessary budget for the HVAC system in public buildings. The purpose of this paper is to clarify the initial cost and the energy performance to determine the main instrument of the HVAC system. As the result, the energy performance and initial cost of HVAC equipment are possible to set criteria was confirmed.

**KEYWORDS**
HAVC equipment, Energy efficiency, Unit price, Remodeling, Installation cost

## 1. INTRODUCTION

HVAC systems, which directly consume 70% of the energy in a building, are composed of a combination of various types of equipment. The energy performance of an HVAC system changes depending on the system configuration and operation conditions. Furthermore, there are no quantized standards for the energy consumption and cost of HVAC systems.

This study is a part of the development of the remodeling support tool that was proposed the remodeling alternatives and the necessary budget for the HVAC system for public buildings. The purpose of this paper is to clarify the initial cost and the energy performance to determine the main instrument of the HVAC system. Because of these, the quantized proposed of the HVAC system is difficult in the remodeling planning stage.

## 2. Classification and investigation methods for HVAC equipment

The HVAC systems can be classified into 960 compositions of combinations

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according to reference (5). In addition, if the building size is increased, it is a plurality system instead of a single-type HVAC system and the system in the actual building, so the energy consumption characteristics are more complex.

First, the classification of the main equipment for the composition of the HVAC system should be arranged. The classifications of equipment are shown in Table 1. The equipment in a building HVAC system is classified as follows: heat source, transport system, air conditioning, and ventilation system. The equipment in a building HVAC system can be classified into 48 types considering the building code and design conditions for public buildings. The energy performance and cost of the HVAC equipment were investigated through a product catalog, a technology information package, information on commodity prices, the price information of the Korea ON-Line E-procurement System, and the quoted prices from the supplier of each type of equipment.

**Table 1.** *Classifications of equipment*

| Heat source | | Air-conditioning · ventilation | | Transport system |
|---|---|---|---|---|
| 1.Cooling tower (direct contact) | 11.Ice storage tank | 21.Humidifier | 31.FCU | 40.Measuring instrument |
| 2.Cooling tower (closed) | 12.Water heat storage tank | 22.AHU | 32.Fan terminal unit | 41.Valve (combination) |
| 3.Chiller (screw, air-cooled) | 13.Heat pump (gas-engine) | 23.AHU (direct expansion) | 33.Filter(air) | 42.VAV diffuser |
| 4.Chiller (screw, water-cooled) | 14.Heat pump (air) | 24.Damper(IAQ) | 34.Thermo-hygrostat (air-cooled) | 43.Fan |
| 5.Chiller (water-cooled, turbo) | 15.Heat pump (water) | 25.Air tower | 35.Thermo-hygrostat (water-cooled) | 44.Fan (air current circulation) |
| 6.Chiller(driving hot water, absorption) | 16.Heat pump (geo thermal) | 26.Heat exchanger (electric heat) | 36.Fume hood | 45.Heat exchanger (water-water) |
| 7.Chiller (absorption) | 17.Unit cooler | 27.Heat exchanger (sensible heat) | 37.Convector | 46.Constant air volume unit |
| 8.Hot and chilled water generator (absorption) | 18.Electric heater | 28.Heat exchanger (ventilation unit) | 38.Radiant panel | 47.Compact unit |
| 9.Boiler (hot water) | 19.Solar hot water supply | 29.Dehumidifier | 39.Chilled beam | 48.Pump |
| 10.Ice storage system | 20.Boiler(steam) | 30.Dehumidification wheel(passive) | - | - |

Second, the energy consumption performance of each type of equipment was analyzed based on equipment capacity. Additionally, the construction costs of pipes, ducts, and automatic control for HVAC installation were determined by referring to the costs of the Public Procurement Service (PPS) from 2004 (reference (1)). The PPS was classified depending on the building type and scale.

## 3. Energy performance and cost of HVAC equipments

Fig. 1 and Fig. 2 show the relations between power consumption and the efficiency of the HVAC equipment. The power consumption of equipment, increased linearly with equipment capacity. Therefore, the power consumption per unit capacity of each type of equipment was constant, because the efficiency of the equipment changed in a narrow range. That is, it was possible to determine the energy consumption of the equipment by calculating its constant efficiency value.
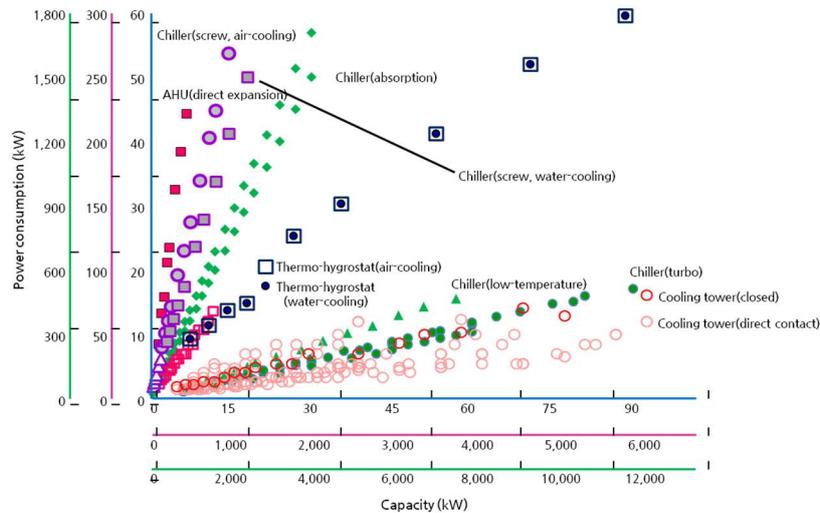


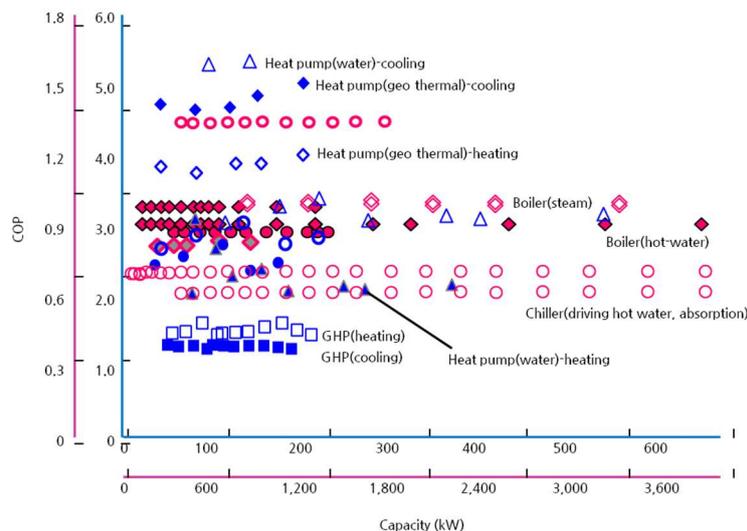*Figure 1*. Power consumption-Capacity



*Figure 2*. COP-Capacity

As shown in Figs. 3 and 4, the unit price of each type of equipment changed by the downward-sloping curve according to the increase in equipment capacity (size).

As a result, it was confirmed that the energy performance and unit price of the 48 types of HVAC equipment, follow certain rules.
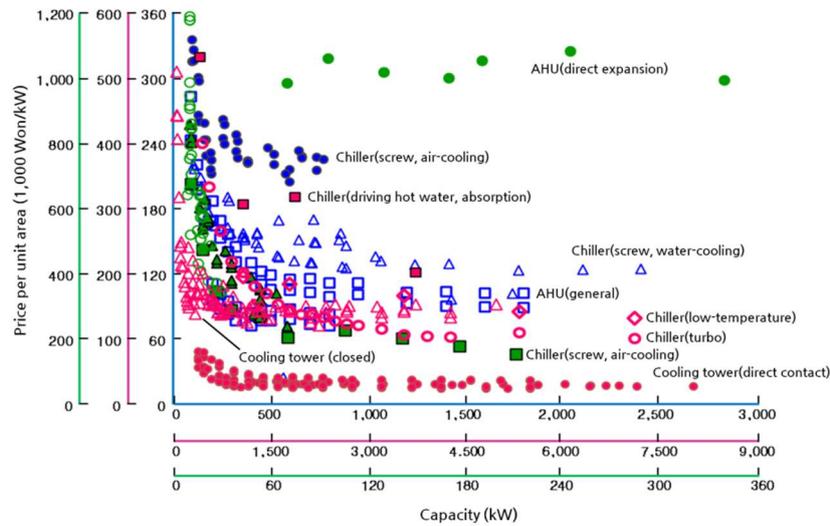


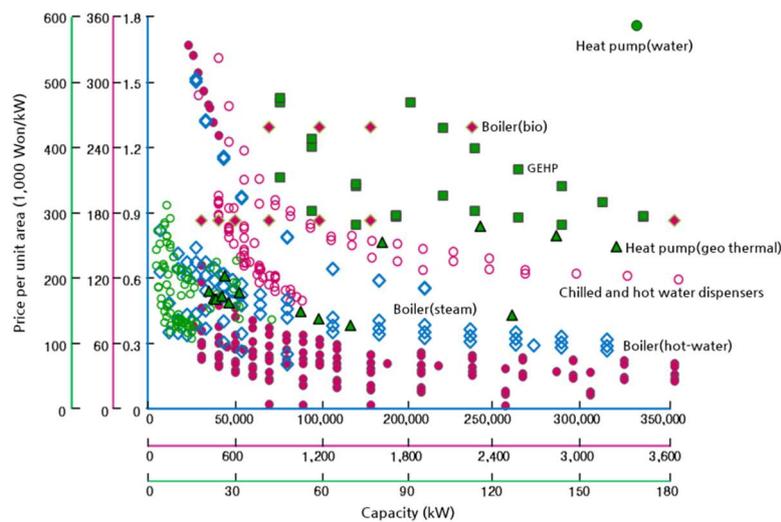***Figure 3***. *Unit price-Capacity (1)*



***Figure 4***. *Unit price-Capacity (2)*

## *4. Installation cost of HVAC equipment*

The installation cost of HVAC equipment is an important elemen. in order to calculate the initial cost of the HVAC system as well as the unit price of the HVAC equipment in Section 3.

Fig. 5 shows the installation cost per unit area of pipes, ducts, and automatic control. As can be seen from Fig. 5, the scale and unit cost for each project differed, because the data was insufficient. However, if the public building projects assume that there is consistency, this analysis data is useful as a reference for the degree of investment in building scale in the first stages of a

remodeling for public buildings. Furthermore, if the data is updated every year continuously, the reliability of the data will be gradually increased. In fact, the difference in the installation cost of the HVAC system combination should be supplemented by the actual design methodology.
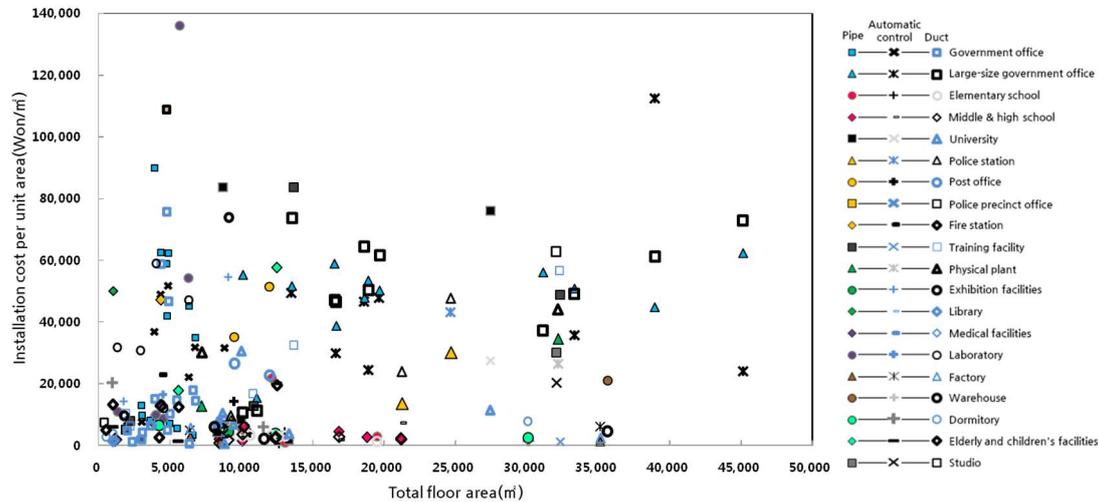


*Figure 1. Installation cost per area*

## 5. Conclusion

In this study, the establishment of criteria for the energy performance and initial cost of HVAC equipment was clarified to be applied to domestic public facilities. The results can be summarized as follows:

(1) The equipment in a building HVAC system can be classified into 48 types considering the building code and design conditions for public buildings.

(2) The 48 types of HVAC equipment, follow certain rules regarding energy performance and price.

(3) The energy consumption performance of each type of equipment was analyzed based on equipment capacity. Additionally, the construction costs of pipes, ducts, and automatic control for HVAC installation were determined by the cost of the PPS from 2004.

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