An Analysis of Korean District Heating System's Heat Supply Load by Building Usages

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***Abstract*—Many countries around the world have been executing district heating system projects to promote the efficient use of energy and boost the reduction of greenhouse gas emissions. Unlike Japan and European countries where the district heating system projects have been successfully implemented, Korea has difficulties in executing the projects because of supply heavily relying on new housing sites; fuel costs of energy and supplying market prices; and conflicts over interests between government-owned agencies and suppliers, thereby producing low profitability and accordingly low feasibility and distribution rate. Still, the stakeholders are only focusing on policy discussion to find out ways to solve the current problems, and the local governments that have adopted the system have yet to settle the system taking into account heat density and heat distribution ratios among heat source, heat transport, and heat using facilities, as was established for housing site planning. This research selected an area where the district heating system was adopted as a research subject, analyzed energy heat load characteristics for building usages by dividing the subject area into residential and non-residential areas, and identified energy load ratios by building usages against the supply scale of the heat source facility**

***Index Terms*—district heating energy system, IEB (Integrated Energy Business), Heat supply load ratio, CHP (Combined Heat & Power), PLB (Peak Load Boiler)**

I. INTRODUCTION

District heating system that supplies heat or heat and electricity to multiple users can be an alternative for efficient energy use. The energy efficiency of the district heating system that uses cogeneration system reaches 80% while that of general power generation type is approximately 30-40% [1]. Advanced countries already adopted 'expansion and distribution of cogeneration systems' as a national energy policy and are promoting the policy [2], and the system use rate is higher than 50% [3]. In Korea, where population density and urban concentration are high, district heating system is good for solving the problem of heat demand density efficiently [4]. The system is also an effective option to raise energy independence in response to an emergency like major blackout caused by energy concentration [5]. However, system providers are suffering difficulties because in 2012, the distribution rate of district heating system in Korea is only 14% but the prices of LNG to produce heat are high and system use fees are relatively low, resulting in low profitability. Fortunately, various policies are being established to adopt and settle efficient systems and academia has been conducting studies to set up the best operating methods for proper supply of the system [6].

Studies on district heating system's optimum modeling and performance optimization and best operating methods for efficient heat supply and distribution have been conducted, but in the field, various factors occur and it is hard to estimate whether or not the heat source facility's supply capacity calculated in the planning phase can cover the area [7].

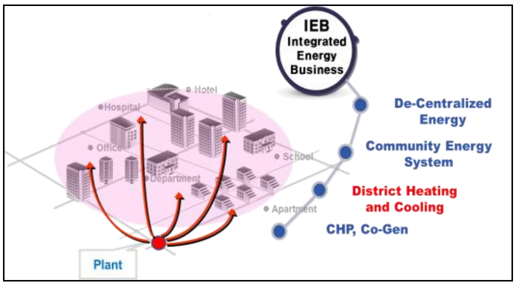

Figure 1. Concept map of IEB projects

Fig. 1 shows the concept of IEB projects. IEB is a distributed power type contrary to centralized energy supply. There are other names for IEB depending on size and energy users. In general, integrated energy facilities are defined as ones aimed at comprehensively supplying multiple sources of energy (mainly heat and electricity) produced from at least one energy production facility such as cogeneration power plant, heat-only boiler or resource recovery facilities to multiple users in residential, commercial or industrial complexes.

When laying heat pipes to transport heat from the district heating system, in fact, the shorter distance from the heat source facility is better [8], [9]. Since the bend part of heat pipes is weak, it should be considered, but in reality, where is long distant from the supplying area, where civil complaints are less likely raised, and where is easy to purchase are more likely to be selected. To develop basic design for setting the locations of heat source facilities and laying heat pipes, data and materials on general building composition ratio, supply scale, and operating status of various buildings using district heating system currently being operated [10], [11].

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This research selected a building using the district heating system(included in IEB projects) largely divided into residential area and non-residential area by characteristics of the facilities and more specifically classified into 9 use purposes in order to analyze heat load properties and energy load ratio depending on the composition ratio of different facility.

II. Selection and Overview of Research Subject Area

First of all, prior research was on the current status of the District heating by classifying the capacity of heat and electricity supplied. Generally, the standard of such classification is 3 parts based on the law of Integrated Energy Supply Act are allowed to supply the maximum power load of 150MW and more than 30Gcal/h of heat density; industrial complex integrated-energy providers can supply electricity and heat of less than 250MW and more than 60Gcal/h in permitted districts; Community energy supply businesses are allowed to supply less than 35MW of electricity and 5Gcal/h of heat [12].

TABLE I. The Distribution State of IEB (District Heating)

	Energy supply capacity		Amount of production	
	Thermal (Gcal/h)	Electricity (MW)	Thermal (Gcal)	Electricity (MWh)
A (55)	16,335	3,524	21,751,144	17,227,801
B (27)	9,509	1,871	45,135,678	16,772,112
C (3)	839	133	2,147,837	393,621

Table I shows the current status of the heat and electric energy supplied compared with the scale and fuel cost of current Integrated Energy Supply Business in Korea. As of 2013, integrated energy suppliers numbered 88 in total, among which district heating and cooling suppliers numbered 55, industrial complex energy suppliers numbered 27, and energy suppliers with both district and industrial complex types numbered 3.

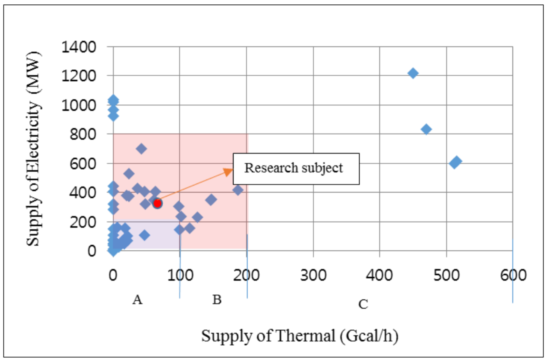

Figure 2. Heat load for heating area of residential area

Fig. 2 shows the distribution of Korean' integrated energy supply based on the capacity of heat and electric energy supply facilities. It was divided by scale in the scope of businesses implemented in compliance with the Integrated Energy Supply Act excluding small cogeneration system and micro CHP. Largely, the district heating provided for household and commercial use was divided into Group A, B, C; Group A (200MW or less, 100Gcal or less), Group B (800MW, 200Gcal), and Group C (1200MW, 500Gcal)..

This research subject is on B Group which takes the largest part of the distribution mostly maintained its energy production and consumption rate at and appropriate level.

Table II shows the research subject area including 102,000 households, and general buildings in Seongseo, Daegok, Yongsan, and Janggi areas, to which Daegu branch of Korea District Heating Corp. supply heat [13].

TABLE II. Types of the Facilities Using the District Heating System in the Subject Area

Building types			Number of buildings	Heating area (1,000 m²)	%
Residential buildings		A	113	7,455	91
Non-Residential buildings	Educational facilities	B	42	179	3.4
	Public agencies	C	18	69	2.7
	Office buildings	D	4	13	0.2
	Commercial Facilities	E	2	17	0.4
	Sauna buildings	F	5	4	0.6
	Hotels	G	3	11	0.2
	Hospital	H	4	34	1.0
	Religious facilities	I	2	4	0.1
	Total		80	331	9.0

The number of buildings that are provided with heat in the subject area is 193, out of which residential buildings are 113 and educational facilities, public agencies, and commercial facilities are 80 [14]. The numbers of residential buildings and non-residential buildings are not significantly different. In the non-residential area, educational facilities like schools and kindergartens are the most.

Figure 3. Research subject area

The site selected as a research subject is an area using the district heating system, where ratio of residential area to non-residential area is 9:1. A total capacity of the heat source facilities installed is 396.5Gcal/h, among which heat load of residential part is 249Gcal/h and that of non-residential part is 14Gcal/h, accounting for 62.8% and 3.6%, respectively.

Generation plant for district heating is located in the outskirts of the area, which is indicated as P point in Fig. 3. In Korea, large-scale heat source facilities like CHP and PLB are installed in the proximity of the supply area and mainly the heat supply ratio of the residence area is high.

III. Heat Supply Status by Building Usages in the Subject Area

A. *Scale of Heat Source Facilities*

Table III shows the heat source facilities for the subject area. The facilities include CHP, PLB and incinerator that absorbs the incineration heat. Among those facilities, PLB has the largest capacity for heat generation at 272Gcal/h followed by CHP at 97.5Gcal/h and incinerator at 27Gcal/h.

TABLE III. Capacity of the Heat Source Facilities in the Subject Area

Facilities		Heat Capacity (Gcal/h)
CHP	CHP1 * 1 CHP2 * 1	85.5 12
PLB	PLB1 * 2 PLB2 * 2	204 68
Incinerator	Incinerator * 3	27
Total		396.5

B. *Analysis on Heat Load Characteristics by Heating Area and Unit*

Facilities that use the district heating system in the subject area were grouped into 9 types according to heat consumption characteristics of residential and non-residential buildings, and data and materials on heat consumption, building locations, and heating area.

The subject area consisted of 90% of residential area and the rest was mostly educational area, so it fell under a general big city.

Fig. 4 and Fig. 5 include graphs that show building-specific heat load ratio against heating area.

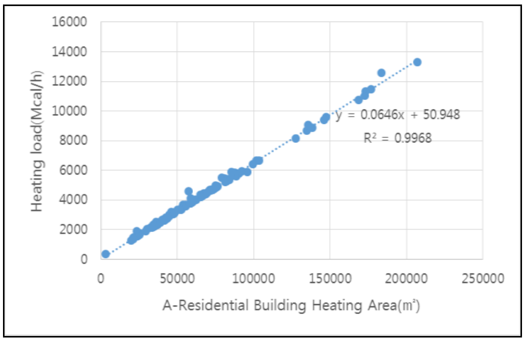

Figure 4. Heat load for heating area of residential area (A)

In terms of heating, housing area is 7,455,000 ㎡ while non-residential area is only 331,000 ㎡. Educational facilities and public agencies take up 179,000 ㎡ and 69,000 ㎡, respectively, and medical facilities are only 4 but their heating area is 34,000 ㎡, which is relatively large. The connected heat loads of houses and other buildings are 488gcal/h and 48Gcal/h, respectively. Out of the 48Gcal/h, the connected heat loads of educational facilities and public agencies are 18Gcal/h and 15Gcal/h, respectively.

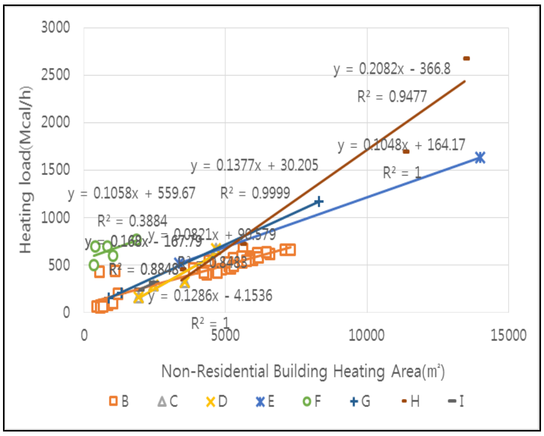

Figure 5. Heat load for heating area of non-residential area (B~I)

C. *Calculation of Basic Unit of Heat Load by Building Usage*

Basic unit of heat load is calculated by summing up the heat load and heating area of buildings were calculated by type, which is shown in Fig. 6.

Residential area (A) taking up the largest share has the lowest heat load which is calculated in 65.398 while baths and sauna (F), which use hot water, consumed the most heat.

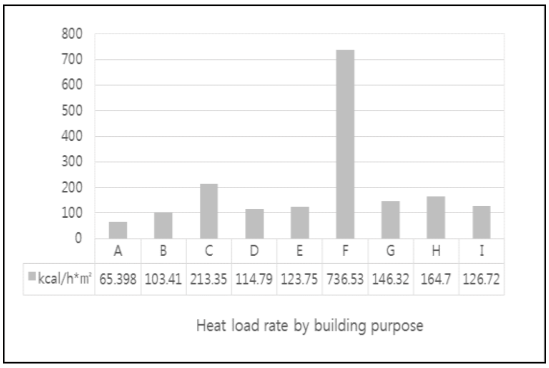

Figure 6. Heat load rate by building usage

IV. Result of Heat Load Ratio Calculation.

The result of research shows comparisons between the district heating system usage ratio and the heat load ratio against the capacity of heat source facility, in the residential area(A) and non-residential area(B~I).

Total heat load of the residential and non-residential areas is 263Gcal/h, out of which heat loads of residential area and non-residential area are 249Gcal/h (62.8%) and

14.3Gcal/h (3.6%), respectively. Among non-residential buildings, heat load of school facilities is the highest at 6.6Gcal/h, which accounts for 39.9%.

V. Conclusion

This research investigated the heat supply status of a certain area using Korean district heating system and classified the heat-supplied facilities by their size and purpose to calculate the heat load unit and analyze heat load ratio by building purpose against the scale of the existing heat source facility.

The site selected as a research subject is an area using the district heating system, where ratio of residential area to non-residential area is 9:1. A total capacity of the heat source facilities installed is 396.5Gcal/h, among which heat load of residential part is 249Gcal/h and that of non-residential part is 14Gcal/h, accounting for 62.8% and 3.6%, respectively.

This research can serve as valuable reference to develop new housing sites and house concentrated areas. It can also identify heat demand patterns for each building usages when planning heat supply for the development of housing sites and accordingly ensure well-balanced heat load, thereby, ultimately, contributing to revitalizing distribution of the co-generation-type district heating system.

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