

Recent tendency of accidents in building facilities and risk of fatal accidents by heatstroke in construction industry

Li Jingye and Takehiro Tanaka

School of Architecture, Toyo University, 2100 Kujirai, Kawagoe-shi, Saitama 350-8585, Japan;
riseiyatoyo@gmail.com; tanaka@toyo.jp

Abstract

The present study concerns Smart Building Continuity Management (SBCM) and District Heating and Cooling in Japan, through an analysis of smart building projects implemented in Japan and their prospects.

Today many companies and organizations prepare a business continuity plan (BCP) so that they can continue or resume business operations following the outbreak of unexpected incidents, but the SBCM function can be further optimized to be implemented not only in a company or building but throughout a city. Under SBCM, the safety of the city will be more secured, practical convenience in the city will be improved and value added.

The strategic local lifestyle in a low-carbon society is described here as a smart community. In the smart community, a community/cluster energy management system (CEMS) that exercises optimal energy management with various mechanisms is developed. CEMS is expected as its goal to be a new information and communication applied technology that connects Business Energy Management Systems (BEMS), Home Energy Management Systems (HEMS), electric vehicles (EV) and dispersed power sources including renewable energy and smart cities.

District Heating and Cooling (DHC) is the system for supplying cold and hot water with equipment set in one place, energy being used more efficiently and saving space. With the collaboration of BEMS and DHC, the smart center works more efficiently; by supplying reliable energy and the service range is also enlarged. It can be realized that the energy of the area will be efficiency used, and the function of BCP is also fulfilled.

In the future, the smart center can be made to work more efficiently, by supplying reliable energy, enlarging the service range and fulfilling the function of BCP through introducing DHC and BEMS to the Smart City. The city will then function much better by using overall energy efficiently.

Introduction

The growth of smart cities has been remarkable throughout the world. The concept of a smart city as a new type of urban lifestyle has been receiving much attention worldwide. This research study investigated smart city & district cooling and heating in Japan, it will introduce the smart city projects implemented in Japan and discuss their future prospects.

Business Continuity Plan (BCP) and Business Continuity Management (BCM)

Business continuity management (BCM) is a series of strategic operation processes, which include formulation, implementation and review of BCP. In the process of BCP formulation, a business impact analysis (BIA) is conducted in the first place, where targets, activities and impacts related to business continuity are clarified and subsequent risks are identified. Then, systems and facilities on which priorities of restoration should be placed are selected and restoration procedures are designed.

The BCP create guidelines explains that a long business suspension not only puts a company's trade connection to trouble but incurs the risk of losing its confidence and that the preparation of plans for such occasions is a strategic issue for the business protection. The guidelines were revised to the 2nd edition of Business Continuity Guidelines in November, 2009, and the 3rd edition of Business Continuity Guidelines in August, 2013. In the 3rd edition of Business Continuity Guidelines, attention is called to the preparation for a wide range of potential risks to deal with unforeseen incidents by thinking back on such disasters as the Great East Japan Earthquake and the Thai flood. Based on the experience of supply chain interruption, the guidelines mention alternative strategies and counter measures, accentuating the importance of various linkages between business partners, trade organizations and local interested parties

Smart City

Meaning of Smart City

In English, “smart” means agile, nimble, intellectual, intelligent, brilliant and so forth. As the term “smart city” implies, “smart xxx” gives us an impression of secure independence. The concept “smart” originated in the US, when the electricity market was liberalized in 1992 and unbundling of the electricity sector led to inefficiency of infrastructural management. As a result, electric facilities were superannuated, frequently causing blackouts on a broad scale.

To address these problems from the viewpoint of economic efficiency in management, smart grids were developed. Electric meters equipped with transmitters were installed in places of power networks to monitor and control fragile power collection systems for the purpose of preventing them from incurring overload and accidents, and transmitting stable power from different systems. The concept of “smart system” deriving its origin from power infrastructure as one of urban structures has expanded into various fields, communities and cities. Because of its rapid development and infiltration, the definition of “smart city” has yet to be specified both in Japan and abroad. The Ministry of Economy, Trade and Industry expresses a general view that the smart city has the capacity for efficiently managing basic urban infrastructure with the help of the information and communication technology (ICT) to improve social daily life more comfortably and conveniently.

Necessity of Smart BCM (SBCM)

‘S’ in SBCM stands for “smart” and SBCM is the business continuity management that is made smart. “Making a system smart” generally means that information processing technologies and management functions are integrated into the system by taking advantage of IT. That is to say, SBCM aims to enhance the efficiency of business continuity by applying IT to business operation.

Currently, BCM is reinforced for individual structures or organizations separately, and holistic plans or operations for the functionality of an entire city have yet to be established. Nevertheless, if the business continuity function is managed under SBCM, business continuity can be further optimized; information can be sorted effectively; damage in case of emergency can be minimized; and restoration time shortened. When SBCM is

implemented throughout a city, its safety will be more secured. In addition, practical convenience of the city will be improved and, as a result value will be added to the city. Thus, SBCM is essential for the future urban functionality.

Smart City

Efforts are exerted in various fields to make their systems smarter. To facilitate the successful implementation of SBCM, the concept of the smart city can be specially referred to. As Table 1 shows, the smart city is interpreted differently by various organizations and its definition is yet to be established. Generally, the smart city is considered to

be a city which develops, by efficiently using energy

Table 1 Different Interpretations of the Smart City

Japan Smart City Portal (JSCP)	A new style of city providing sustainable growth and designed to encourage healthy economic activities that reduce the burden on the environment while improving quality of life (QOL).
Ministry of Economy, Trade and Industry	A system that uses local energies effectively through the network between households, buildings and transportation systems.
Toshiba Corporation	A community that seeks to develop "smart" solutions for the community as a whole, by using information and communications technology (ICT). A smart community also promotes the use of renewable energies, integrated management, and optimized controls for infrastructure. This includes electric power, heat, water, traffic, healthcare, and lifestyle information.
Hitachi, Ltd.	An environmentally conscious city that uses information technology (IT) to manage energy and other resources efficiently.

and infrastructure while pursuing environmentally-friendly solutions with the help of information and communication technology (ICT). As for regional examples in Japan, a number of projects for realizing the efficient use of local energies have been carried out in four cities of Yokohama, Toyota, Keihanna, and Kitakyushu. Also on a

world scale, more than 400 projects are currently under way.

Under a building energy management system (BEMS) and a home energy management system (HEMS), varying quantities of energy demand and supply among buildings and houses are controlled by ICT to make good and stable use of electric power. The introduction of BEMS and HEMS allows energy management to be carried out in the entire community.

District Heating and Cooling in Japan

Number of Service Districts

District Heating and Cooling (DHC) is the system by supply cold and hot water, this equipment is set in one place, it can use the energy efficiently and save more space. By the collaboration of BEMS and DHC, the smarter center works more efficiency; by supplying reliable energy, the service range is also enlarged. It can be realized that the energy of the area will be efficiency used, and the function of BCP can be expected, too.

The construction of the first district heating and cooling system is in 1970 at the Senri Chuo Area in Osaka. The history of district heating and cooling in Japan comes from Senri of Osaka, 1970, in the current heat is being supplied to 154 districts of the whole country. The following figure shows the development history of DHC.

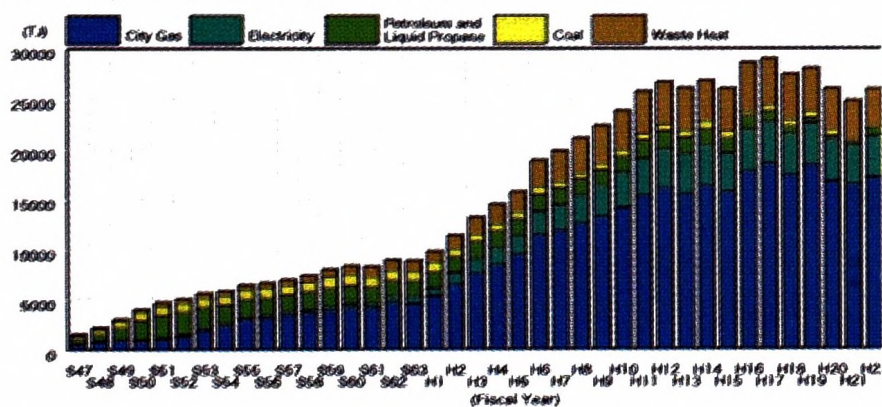


Figure 1 Changes in Energy Supply System

Standard System

Design Considerations for Standard System

The following items must be considered when devising a district heating and cooling system.

The selection of a heat production system appropriate for the heat medium and energy source. The selection of a heat supply system appropriate for the heat medium, demand and the geographical conditions.

Selection of the optimum heat medium, taking into consideration the type of demand for thermal energy within the district and the geographical conditions.

Selection of an energy source suitable for supplying heat.

Types of Systems

- Steam boiler plus steam absorption chiller
- Steam boiler plus steam turbine-driven turbo chiller
- Heat-collecting heat pump plus heat storage tank
- Air-cooled heat pump plus heat storage tank
- Electric turbo chiller (heat storage tank) plus steam boiler
- System utilizing river water or seawater plus absorption heat pump
- System utilizing waste heat from waste plus hot water boiler
- Heat pump utilizing seawater plus heat storage tank and steam absorption chiller
- Cogeneration plus waste heat driven absorption water heater and water heater
- Cogeneration plus steam boiler, steam absorption chiller and turbo chiller

Effective Usage of Unutilized Energy

By recovering urban waste heat and using it to heat and cool buildings throughout the district, for example, DHC systems can utilize untapped energy sources to help decrease our dependence on fossil fuels. For this reason district heating and cooling has been identified as a key component of the urban infrastructure for the new century, one that is both effective and friendly to the global environment. District heating and cooling systems make use of the following unutilized energy resources: cogeneration systems, energy generated from wastewater temperature differential, energy derived from solid waste, energy derived from waste (refuse derived fuel, or RDF), heat energy from seawater.

Widespread Problems of DHC in Japan

Average Energy Efficiency of DHC

Based on measurement data from an investigation "Actual situation and direction for the next generation about regional usage of unused energy (2008.3)" of the Ministry of Economy, Trade and Industry Agency for Natural Resources and Energy, the average energy efficiency of DHC has been verified. As seen in Table 2, the average total

energy efficiency for all valid data in district heating system is high (0.749), the localised boilers system is 0.675.

Although it has high energy utilization, the penetration rate in Japan is still only 5%. The rate in developed countries in Europe is high: Denmark 60%, Sweden 47%, and the rate of Korea is 15% (Source: Euroheat & Power "DHC Country by Country 2013").

Table 2. Average Value of Total Energy Utilization between DHC and Localised Boilers System

Type of Energy Source System		DHC	Localised Boilers System
Absorption Refrigerator	Normal*	0.636	0.569
	CGS recycled heat used	0.699	0.606
	Usage of unused energy	0.916	—
	Average	0.688	0.570
Electric Refrigeration	Normal*	0.954	0.694
	Usage of unused energy	1.019	—
	Cold water supply only	—	1.143
	Average	0.977	0.694
Absorption • Electric Refrigerator	Normal*	0.753	0.690
	CGS recycled heat used	0.772	0.696
	Usage of unused energy	0.798	—
	Average	0.768	0.693
Average of all	Normal*	0.750	—
	CGS recycled heat used	0.724	—
	Usage of unused energy	0.850	—
	Average	0.749	0.675

*Normal = No recycled heat used

Because air-conditioning and hot water supply needs for a high proportion of the residential sector, with the spread of DHC to households in residential areas in Japan, it will be possible to significantly increase the energy utilization rate of the entire nation.

Current Situation of Sector Energy Use

According to the statistical study “Energy Annual report in 2015 (Energy White Paper 2015)” by the Ministry of Economy, Trade and Industry Agency for Natural Resources and Energy, household energy consumption can be classified into five major areas: power cooling, heating, hot water supply, kitchens, lighting and other (use of

consumer electronics equipment, etc.). The usage in 1965 was hot water supply (33.8 percent), heating (30.7%), power and lighting, etc. (19.0%), kitchens (16.0%), cooling (0.5%), but along with the spread and increase in number, size and lifestyle changes in home appliances, the share for power and lighting and others has increased. Furthermore, due to the spread of air conditioning, relatively for use and hot water for heating, kitchens share has been reduced. As a result, the share in year 2013 came to: power and lighting, etc. (37.8%), hot water supply (27.8%), heating (23.1%), kitchens (8.7%), cooling (2.6%).

Moreover, the highest household power consumption is air-conditioning equipment, such as air conditioning. If we reduce the use of air source heat pumps and spread DHC to households, the contribution to reduction of power and lighting would be significant.

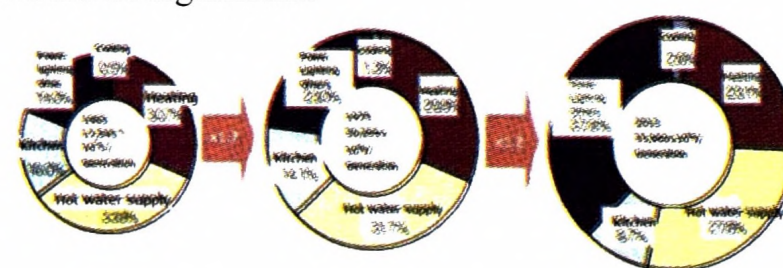


Fig. 2. Changes in Application-specific Energy Consumption per Household

Energy utilization of the DHC compared with traditional air conditioning is high, however usage of household DHC in Japan is still low, the number of district heating is especially extremely low. There has been no study on the disparity of costs between household DHC and household Air source heat pumps. In order to enlarge usage of DHC to home in the future, I will research the comparison of the annual fee in Japan between DHC and household Air source heat pumps.

Annual Cost Composition of Air Source Heat Pumps and DHC

With Europe being the birthplace of DHC, household penetration rate of District Heating (DH) in Iceland is 92%, Finland 50% and Denmark 61%¹. Sales volume of District Cooling (DC) (3TWh) is to occupy 1% of the cooling market (300TWh). Japan's housing sector to Europe is 0.1% of the total market in 2009². I will try to estimate the annual fee of household air-cooled heat pump and gas facilities. The configuration of the air-cooled heat pump charges, air conditioning costs, part of the public interest costs and rents. District heating fee is composed of pay-as-you-go and the basic charge.

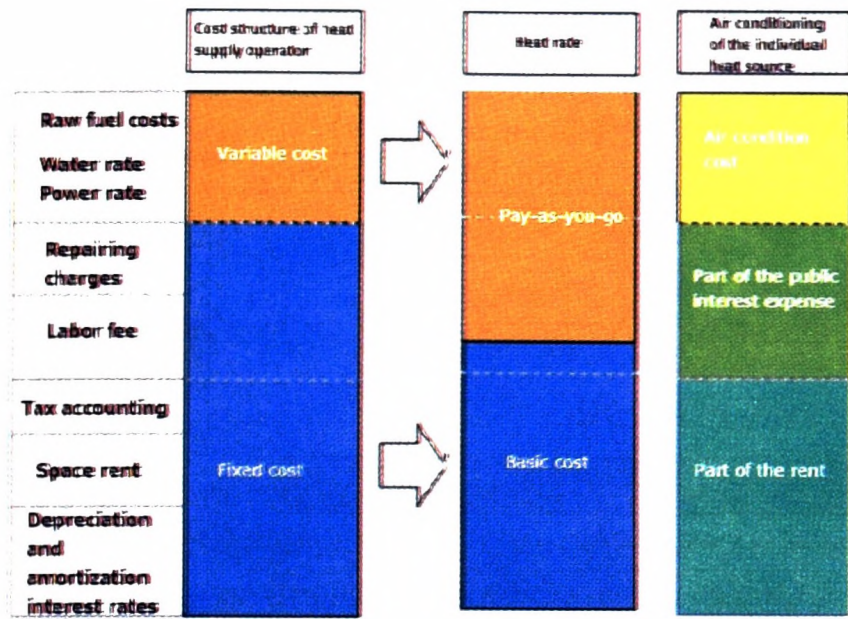


Fig. 3. Annual Cost Composition of Air Source Heat Pumps and DHC

Trial Calculation about Annual Cost of Air Source Heat Pumps and DHC

First of all, using the “General Energy Statistics” of the Japan Agency for Natural Resources and Energy, I investigated the price of Japan city gas.³ I then estimated annual cost of air source heat pump and DHC during a heating period of the model house, which was assumed as a general house of 75m². There is an average of 2.5 air conditioner units per household in Japan, three air source heat pumps were selected, indicating the equipment below.

Brand	Daikin Urusara 7 AN56SRP-W		
Cost	141,473Yen(2016.3.25,Now)		
Type	Wall hanging	Power Supply	100V
Cooling (Wooden Japanese-style House)	24m ²	Cooling (Rebar Western-style House)	24m ²
Heating (Wooden Japanese-style House)	37m ²	Heating (Rebar Western-style Guide)	29m ²
Cooling Capacity	5.6kW	Heating Capacity	6.8kW
Cooling Power Consumption	1,540W	Heating Power Consumption	1,500W
COP of Cooling	3.64	COP of Heating	4.53
Period Power Consumption	1,123kWh	1,093.5kWh(JIS C 9612:2013)	
Period Power Cost(tax included)	28,075Yen	27,337.5Yen	

Period of heating and cooling as per JIS C 9612_2013): 9h/day, 3.6month (6.2-9.21); 7h/day, 5.5month (10.28-4.14).

Table 3 Air Conditioner Model

The area of heating is a guideline. Data is affected depending on the conditions such as the structure or geographical location of the house. Electricity rates may vary depending on the electric power company, and the amount of electric power used.. I

calculated at 25 Yen per kWh (tax included) as a guide.

As a result annual cost composition of 3 Air source heat pumps is 166237.5Yen.

Estimates of Household Water Heater Annual Cost (2016.3.25, Now)

Table 4. Air Conditioner Model

Type of cost	Amount used of gas per month	Basic fare (Yen/month)	Pay-as-you-go fare			
			(average)	2016.2	2016.3	2016.4
A	0m ³ ~ 20m ³	745.20	142.66	143.53	141.78	139.07
B	20m ³ ~ 80m ³	1,036.80	128.08	128.95	127.20	124.49
C	80m ³ ~ 200m ³	1,209.60	125.92	126.79	125.04	122.33
D	200m ³ ~ 500m ³	1,857.60	122.68	123.55	121.80	119.09
E	500m ³ ~ 800m ³	6,177.60	114.04	114.91	113.16	110.45
F	>800m ³	1,225.60	106.48	107.35	105.60	102.89

The amount of the average gas usage of each household was estimated as 26.6m³ per month from the “Gas Business Production Survey (2015)” of *Trial Calculation about the Cost of DHC*

There is a difference in the DHC unit price depending on the heat supply area. The current data

the Japan Ministry of Economy, Trade and Industry Agency for Natural Resources and Energy

of Tokyo energy services Ebisu Garden Terrace Ichibankan Co., Ltd. was used in this research (<http://www.tokyo-energy-service.jp/customer/charge01.html>).

Table 5 Total Annual Cost of Household Gas and Air Source Heat Pumps

Item	Electric Bill/Gas Bill	Machine Cost	Repair, Cleaning	Air Conditioning Costs (summer& winter) / Public Interest Expense	Total
Air Source Heat Pumps	166,237.5Yen	14,147.0 Yen	5,000.0 Yen	18,000.0 Yen	359,858.5 Yen
Water Heater	40,633.4Yen	8,180.0 Yen		—	

Table 6 Unit Price of the DHC

Base Cost (2016.3.25, Now)	
Residential Forms	Cost(tax included)
A (50m ² -60m ²)	7,310Yen
B (60m ² -70m ²)	8,224 Yen
C (70m ² -80m ²)	9,149 Yen
D (80m ² -90m ²)	10,054 Yen
E (100m ² -110m ²)	11,883 Yen
F (110m ² -120m ²)	12,799 Yen
Pay-as-you-go Cost	
Warm Water(Per MJ)	2.355Yen
Cold Water(Per MJ)	3.336Yen

According to the "Gas business production survey", gas energy consumption of gas water heater per month is 2,996.67MJ, apply it to the C Type, the calculation results are as follows. The Table shows the calculated annual fee of DHC.

The cost of DHC was found to be higher than that of air source heat pumps. This is a problem to be solved in the future if the household DHC is to be spread to the smart city

Table 7 Cost of the DHC

Item	Pay-as-you-go Fare	Base Cost	Total
Cooling	84,685.9 Yen	109,788.0Yen	419,756.9 Yen
Bath Water Heater	99,294.3 Yen		
Heating	125,988.7 Yen		

Conclusion

The smart centre of the future can work more efficiently by supplying reliable energy, enlarging the service range and realizing the function of BCP. If we introduce District Heating and Cooling and BEMS to the Smart City, the city will be able to use overall energy more efficiently. For Japan, a high energy consumption nation, DHC is an efficient way to solve the energy consumption problem.

References

1. The project Renewable Smart Cooling for Urban Europe (RESCUE), *EU District Cooling Market and Trends*, 2013, p.9.
2. Mitsubishi Research Institute, *The DHC in Overseas*, 2011.6.20, p.5.
3. Japan Agency for Natural Resources and Energy, *Tendency of the Energy, Energy Annual Report in 2015 (Energy White Paper in 2015)*, 2016, p.154.