Examination of "Net Zero Water Building" Evaluation Method in Japan

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Abstract

Water Environment Management Committee of the Architectural Institute of Japan has developed the results of the activities of the Subcommittee on the quantitative evaluation of resources and energy saving in the water environment, which was active from FY 2015 to FY 2018. We will establish the "Zero Water Evaluation Methodology Subcommittee" with a plan for four years and examine the applicability of Net Zero Water Building promoted by the US Department of Energy in Japan.

This study reports the results of the previous subcommittee and discusses the issues to be considered for the "Net Zero Water Building" evaluation method that will lead in the future. The US Net Zero Water Building Strategy consists of water conservation and efficiency improvement, alternative water (rainwater and reclaimed) use, water returned (treated wastewater on-site returned to original water source, and stormwater infiltrated to the original water source through green infrastructure).

In Japan, too, these factors are being promoted as elements, and while laws are being developed, there are fundamental restrictions on the use of alternative water and the infiltration of on-site drainage. On the other hand, in addition to very severe conditions such as typhoons, heavy rains, snowfalls and intense heat in weather conditions, geotechnical disasters such as earthquakes and eruptions are often encountered, and there is a high possibility that water supply and sewerage as infrastructure will cease for a long time. In such an emergency, it is necessary to secure water at the building or district level, and it is also necessary to evaluate the system that can cope with these.

In order to consider these methods, it is necessary to consider from both aspects of performance evaluation such as ZEB (Net Zero Water Building) defined by the Society of Air Conditioning and Sanitary Engineering of Japan parallel with the arrangement and scoring of the conditions found in LEED in the United States. These problems are shown in this study.

Keywords

Net Zero Water Building, SDGs, BCP, ZEB

1. Introduction

Japan has a lot of rainfall, and there are many storms and floods such as typhoons, floods and storm surges. In addition, the spread of water infrastructure has reached almost 100%, and since there is less need to secure water sources on their own, citizens are strongly aware that water is abundant.

On the other hand, the amount of existing water resources relative to precipitation is small due to the steep topography of the riverbed, urbanization, and the increase in abandoned land for forest management, and the amount of water resources per capita is considered to be the smallest in the world. In addition, due to natural disasters, there is a high risk of disruption of water and sewer infrastructure.

About 25 typhoons occur annually and land several times a year. Recently, the risk of torrential rain has increased further due to the occurrence of linear precipitation zones. Coupled with the occurrence of "guerrilla thunderstorms" accompanying the rise in the temperature of the ground surface such as heat island, the risk of infrastructure disruption, such as power outages and overflowing sewers, is increasing.

Furthermore, earthquakes are occurring throughout Japan. In addition to the effects of seismic waves, there is a possibility of disruption of water and sewage infrastructure due to the occurrence of tsunamis in coastal areas and landslides in mountainous areas. Therefore, there is a risk that these facilities cannot be operated.

In this way, Japan has been required to secure independent resources and energy from the viewpoint of BCP and LCP. In addition, the SDGs (Sustainable Development Goals) adopted by the United Nations in 2015 require the strengthening of infrastructure and simultaneous resolution of climate change. Against this background, we thought that securing resources and energy at the time of disaster should be considered from the viewpoint of the water environment as well as saving resources and energy in normal times.

In the United States, the Ministry of Energy has established "Net Zero Water Building Strategy". When this concept was applied to Japan, we decided to consider what viewpoints should be considered.

This study is based on the results of the "Subcommittee on Quantitative Evaluation Methods for Resource and Energy Conservation in the Water Environment of the Architectural Institute of Japan" that was active from FY 2015 to FY 2018, and it includes the contents being examined by the "Zero Water Evaluation Method Study Subcommittee of the Architectural Institute of Japan".

2. Methodology

In addition to ascertaining the status of disaster risk in Japan through literature surveys, the current status of Net Zero Water Buildings by the US Department of Energy will be assessed through information from public institutions and literature surveys. We will also consider what elements need to be incorporated when the water use program devised in the research submitted to the CIB W062 International Symposium in 2017 is applied in an emergency.

3. Trends in disaster risk and resource / energy conservation in Japan

3.1 Precipitation and flood damage

Japan is a country located at 20-45 degrees north latitude, and the capital Tokyo is located at 35 degrees north latitude. The average annual rainfall in Tokyo from 1981 to 2010 is 1528.8mm, and the maximum daily precipitation over the last 30 years is 259.5mm on September 22, 1996 (Figure 1). There are about 25 typhoons on average from 1981 to 2010, and they develop and approach Japan or land. Also, a heavy rain occurs due to the occurrence of a front due to the typhoon (Figure 2).

In 2018, the largest flood damage occurred in the last 30 years, which was called "The Heavy Rain Event of July 2018". Damages such as floods and landslides occurred in various places, resulting in 224 deaths. Disruptions in water and sewage infrastructure due to floods also occurred in various places (Figure 3).

Also, in Japan, septic tanks for merging treatment are installed in each house and village in places where sewerage is not widespread, but if it goes down, wastewater is not purified, and water pollution occurs.

Furthermore, due to the occurrence of the heat island phenomenon accompanying urbanization, there are frequent showers and thunderstorms, and it is called "guerrilla heavy rain". These may cause inundation, causing inundation damage such as inundation of buildings and underground submergence in urban areas (Figure 4).

3.2 Disaster caused by earthquake

Japan is at risk of earthquakes across the country. The probability of an earthquake has been announced, and in Tokyo, the probability of being affected by a shake with a seismic intensity of less than 6 is over 26% in the next 30 years (Figure 5). The Great East Japan Earthquake that occurred in 2011 was M9.0, the largest earthquake in Japan's observation history, and the coastal area from Tohoku to Kanto was devastated by the tsunami. In other areas, it was difficult to return home, planned blackouts, long-term stays at evacuation shelters, long-term residences for temporary housing, etc. in various parts of eastern Japan. Recently, large-scale earthquakes such as the 2016 Kumamoto earthquake have occurred frequently (Figure 6).

In Japan, securing 3L a day of drinking water for 3 days (1 week recommended) is shown as a guideline for stockpiled items (Figure 7). However, there are problems related to non-potable water and drainage, such as inadequate evacuation toilet environment and inability to drain the building infrastructure.

We think that there is a possibility that the problem can be solved if the self-sustained building can be considered by utilizing the evaluation of the Net Zero Water Building.

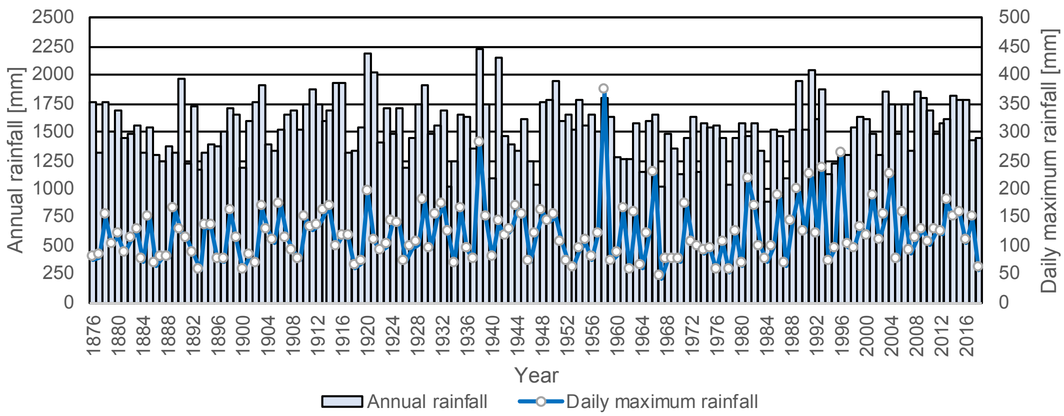


Figure 1 – Annual and daily maximum rainfall in Tokyo (1876-2018) from 1)

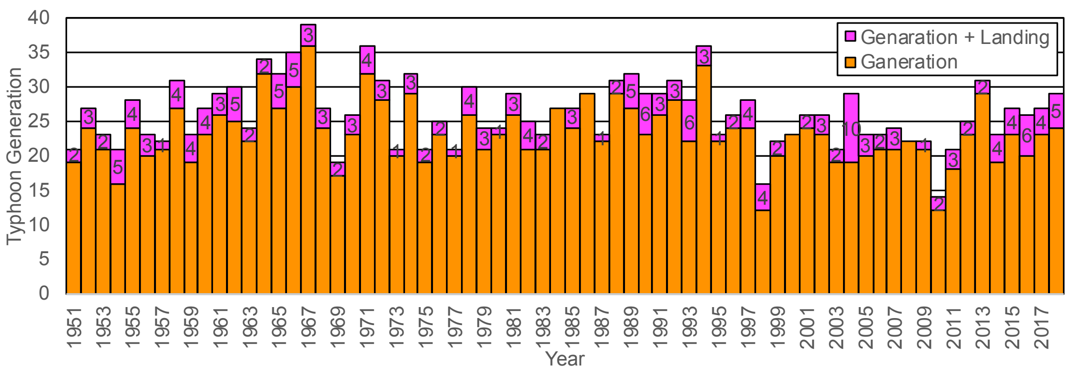


Figure 2 – Typhoon generation and landing in Japan (1951-2018) from 2),3)

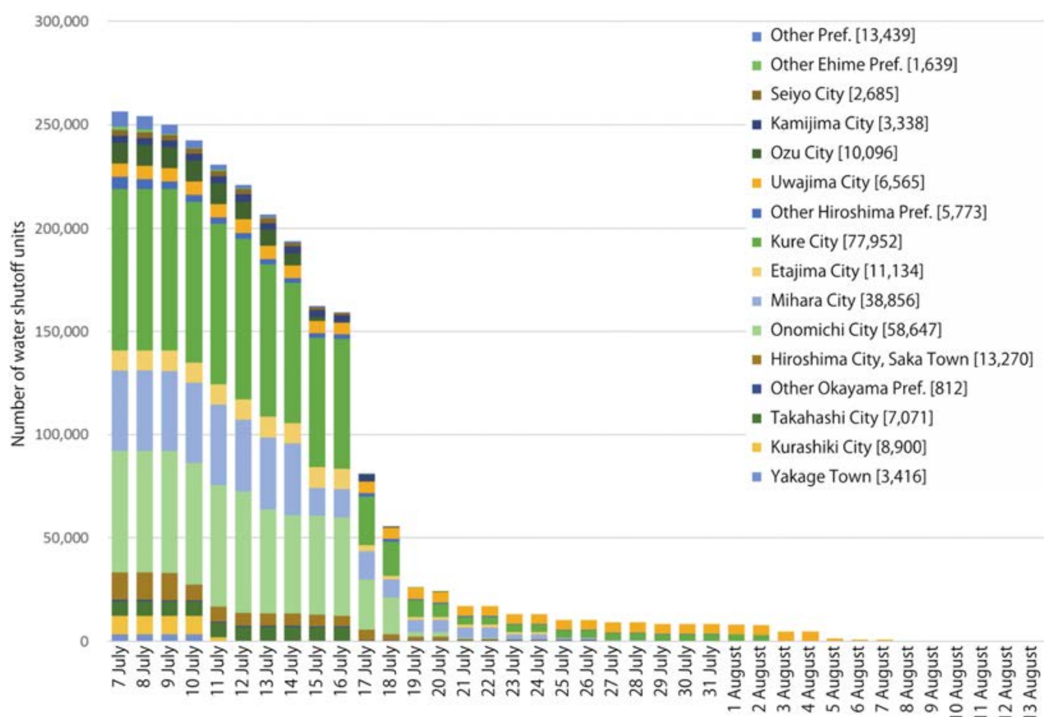


Figure 3 - Recovery status of water supply due to heavy rain in July 2018 from 4)

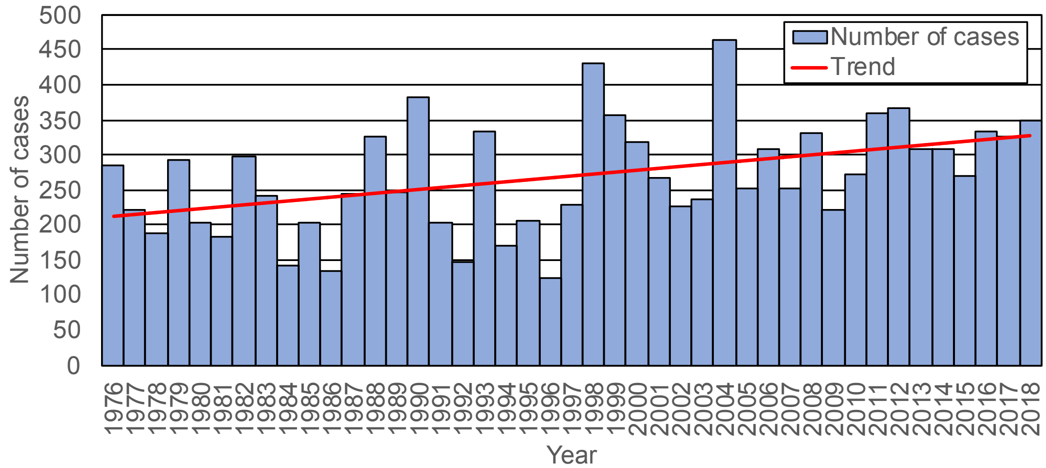


Figure 4 - Number of annual occurrences of hourly precipitation over 50mm in Japan (1976-2018) from 5)

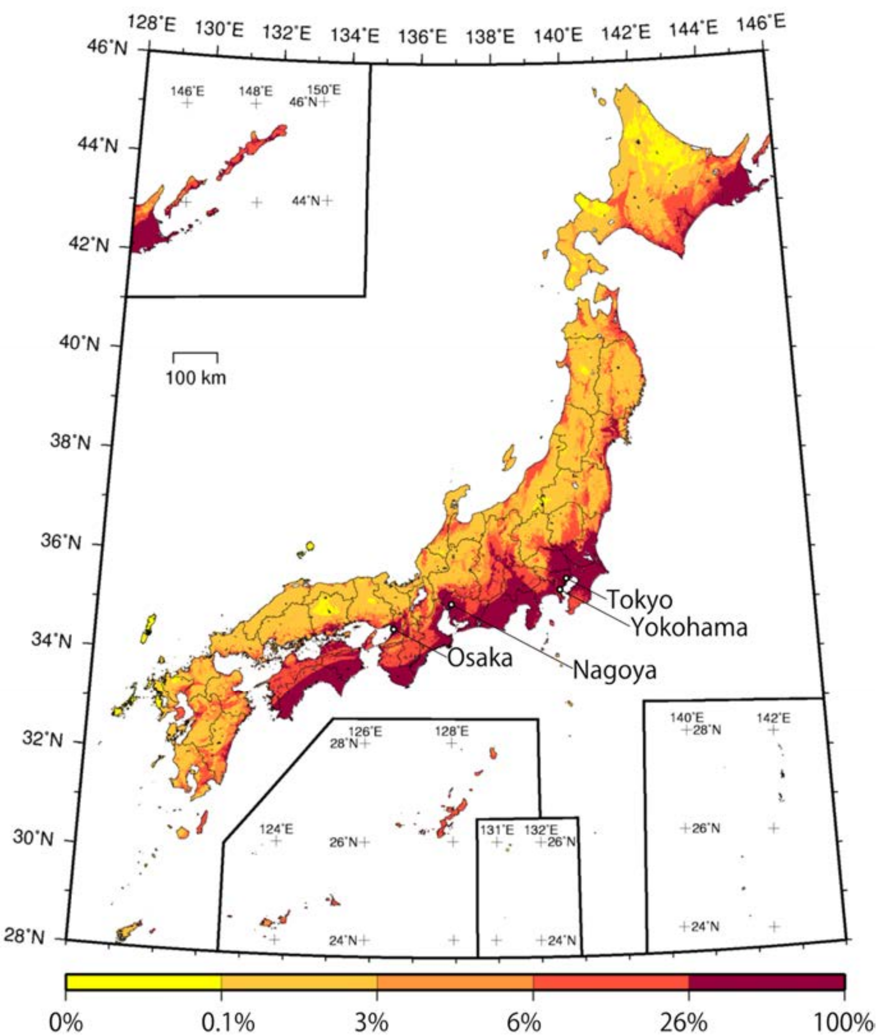


Figure 5 - Probability of experiencing seismic intensity of less than 6 in the next 30 years (2018) from 6)

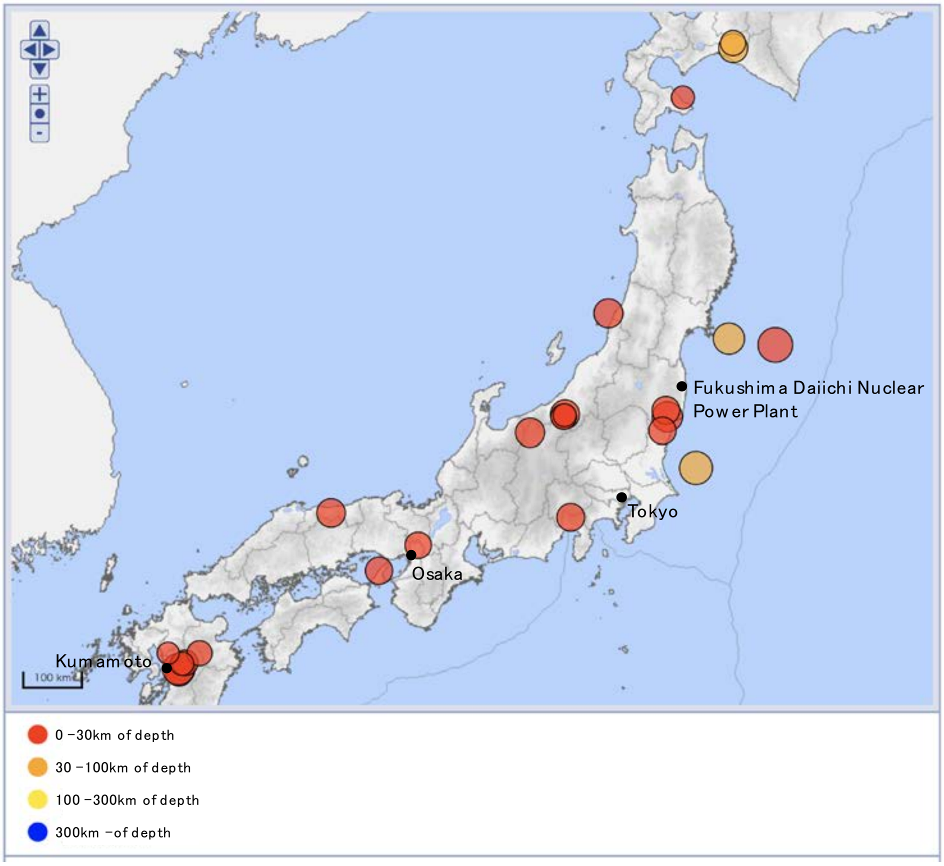


Figure 6 - Epicenter distribution of earthquakes with seismic intensity of less than 6 in Japan over the past 10 years (26 earthquakes, 18 August 2009-17 August 2019)
from 7)

Figure 7 – Video about disaster preparation by Government of Japan [8)]

3.3 Trends in resource and energy conservation

Two-thirds water use of Japan is agricultural water, less than 20% is domestic water, and over 10% is industrial water. Domestic water consumption per person has been decreasing since 2000 (Figure 8), and in office buildings, water supply unit will be changed from the past 60 - 100 L [10)] to 40 - 60 L.

On the other hand, toilet flushing, washing machine and cooking water are generally on the water-saving trend, but in Japan there is a custom of bathing in the bath, so the proportion of water used for bathing tends to increase. As a result, water consumption is higher than in other countries (Figure 9). But used bathtub water is reused as cloth washing for washing machines at home.

Concerning energy saving of energy related to water, for example, pump design in buildings is said to be in a situation where energy saving is not achieved due to the situation where many safety factors are estimated. [12)]

The energy around the water is increasing in households where hot water is used, such as the spread of the domestic hot water supply system and a bidet toilet seat. Also, in these devices, energy saving is progressing in each device such as a high-efficiency water heater, solar water heater, and a bidet toilet seat with instant water heating systems (Figure 10).

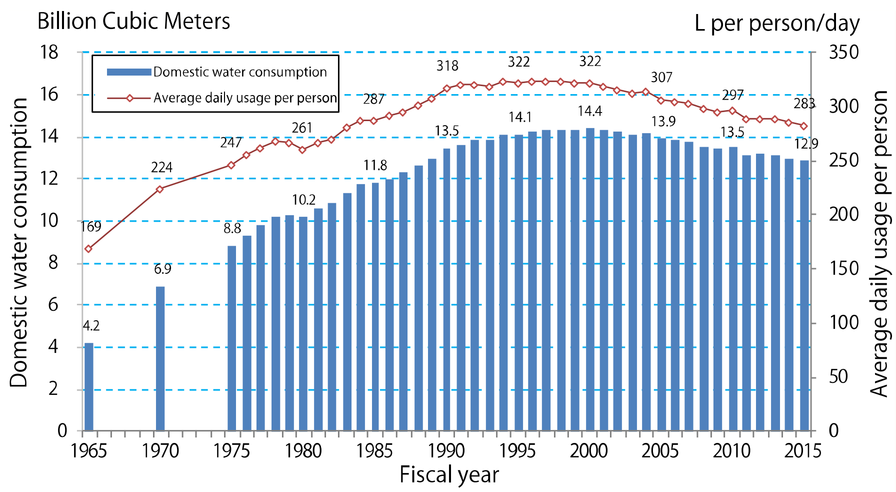


Figure 8 - Trends in domestic water usage in Japan [from 9)]

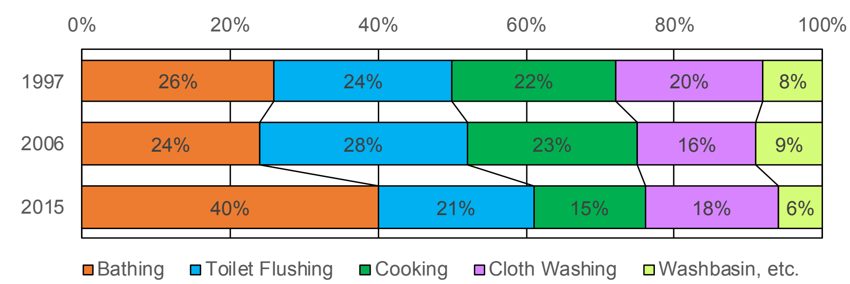


Figure 9 - Water consumption rate at home [from 11), etc.]

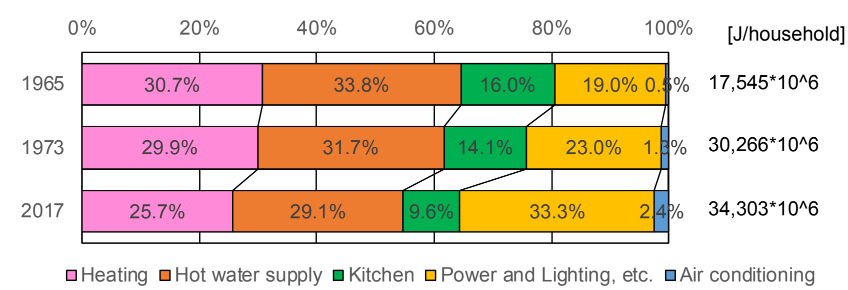


Figure 10 - Trends in energy consumption per household and energy consumption by application [from 13)]

4. Evaluation of "Net Zero Water"

4.1 "Net Zero Water Building Strategy" and examples in the United States

"Net Zero Water Building Strategy" by the US Department of Energy includes four concepts: water saving and water efficiency, rainwater and alternative water use, on-site drainage penetration, and green infrastructure. As an ideal form, it is supposed to fulfill the water circulation within the site. This is thought to be due to the fact that in the western part of the United States, there is not enough precipitation, it is in an arid region, and there is a lack of green space (Figure 11).

Microsoft Silicon Valley Campus has obtained zero water building certification. This is the first time for the company. This means that 100 percent of the building's non□potable water will come from rainwater or recycled water. Beyond drinking fountains and sinks and showers, not a drop will come from municipal reservoirs. This involves a lot of work – from design and construction to the actual operation of a wastewater treatment facility on site. [16)]

The Bullitt Center is a tenant building in Seattle. In this building, water from sinks and showers is stored in a greywater tank and cleaned in a constructed wetland, which can filter about 1900L per day. And clean greywater is infiltrated back into the soil to recharge the local aquifer. The building will restore the historical relationship of water to the land by collecting rain, returning it to the earth and the atmosphere. And 61% of the water in a Douglas fir forest evaporates or infiltrates into the ground, similar to the grey-water treatment in the Bullitt Center. [17)]

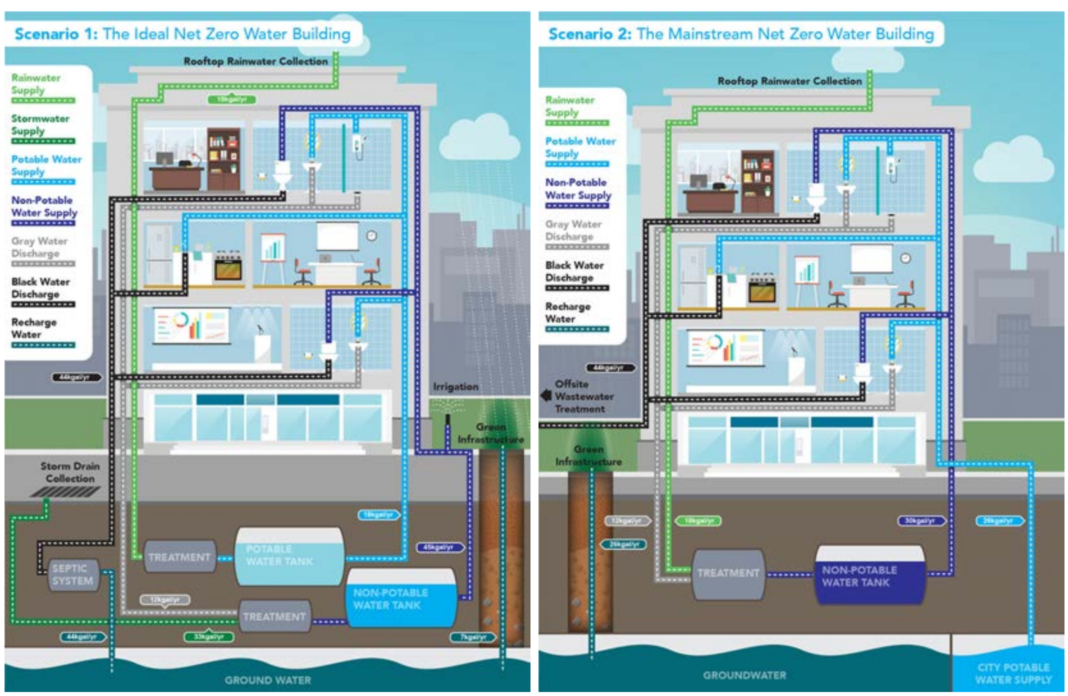


Figure 11 – Net Zero Water Building strategy by US government [14), 15)]
(Left) Scenario 1: The Ideal Net Zero Water Building
(Right) Scenario 2: The Mainstream Net Zero Water Building

4.2 Net Zero Water Building Framework in Japan

Net Zero Water Building in Japan extends the concept of Net Zero Water Building from the viewpoint of water conservation in the event of disasters, in addition to water saving and energy saving, rainwater and reclaimed water use, and construction of green infrastructure. As a result, it is thought that the water supply and drainage can be secured in an emergency, and the interest in the in-building water environment system can be raised for citizens, businesses and government.

The framework under consideration is shown in the form added to the flow diagram of the water calculation program created in 2017 [18] (Figure 12). When considering as an evaluation method, it is possible to express the numerical value that Net Zero Water Building can be achieved when the necessary facilities are secured by calculating the water usage situation when the water source and drainage destination is disrupted according to a unified standard. In this way, it is desirable to be able to utilize BCP and LCP.

However, the current water calculation program calculates the annual water consumption assuming normal times. In an emergency, for example, it is necessary to re-evaluate the evaluation in a week or in a form that restricts the use of water.

In addition, even if the infrastructure is disrupted, it is assumed that the building is functioning. However, there are various disaster cases, and the power level in the premises cannot be secured, or the pipeline is damaged. Therefore, it may be necessary to consider the level that cannot be used. Considering everything, the condition becomes complicated, so it may be necessary to consider a few limited cases.

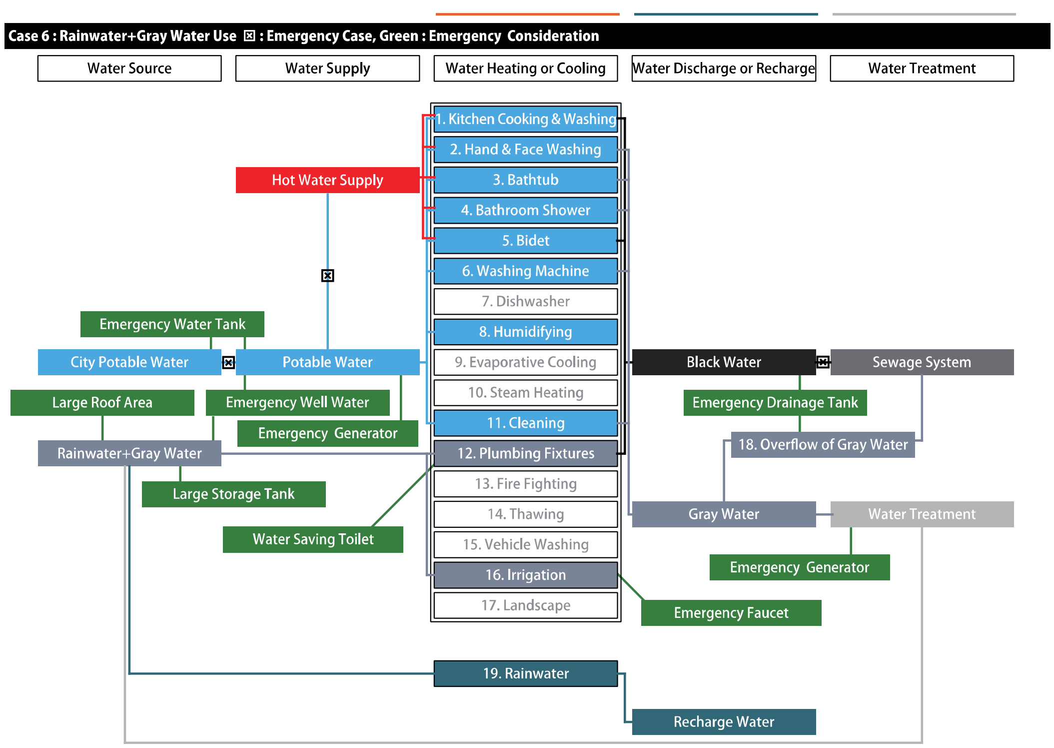
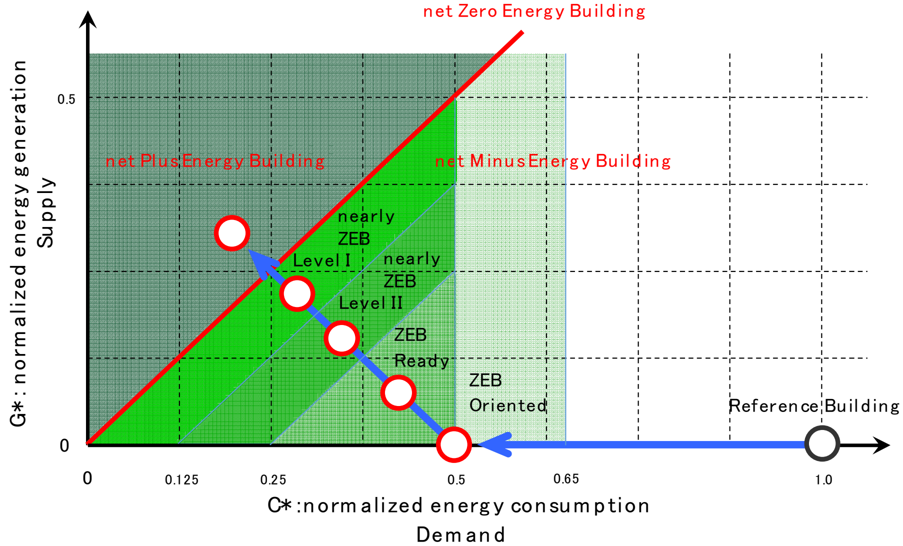


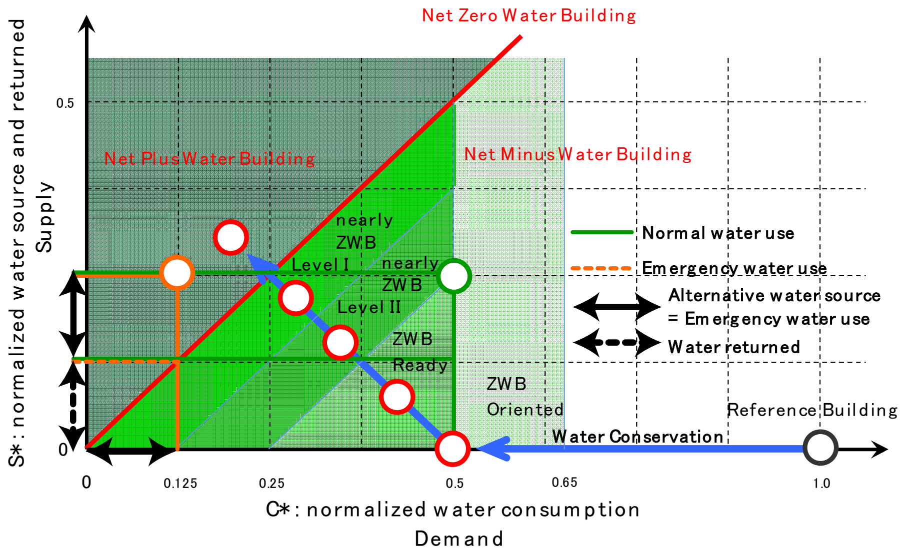
Figure 12 - Flow diagram of the water calculation program 2017 with an emergency consideration (green boxes) from 18)



G*: normalized energy generation = $\dfrac{\text{energy generation of the building to be evaluated}}{\text{energy consumption of the reference building}}$

C*: normalized energy consumption = $\dfrac{\text{energy consumption of the building to be evaluated}}{\text{energy consumption of the reference building}}$

Figure 13 - Staged evaluation of ZEB (Net Zero Energy Building) from 19)



S*: normalized water source and returned = $\dfrac{\text{water source and returned of the building to be evaluated}}{\text{water consumption of the reference building}}$

C*: normalized water consumption = $\dfrac{\text{water consumption of the building to be evaluated}}{\text{water consumption of the reference building}}$

Figure 14 – Evaluation of Net Zero Energy Building (proposal)

4.3 Considering the evaluation of zero water building from the evaluation method of ZEB in Japan

Japanese Basic Energy Plan plans to convert new public buildings into ZEBs by 2020 and average all new buildings by 2030. In Japan, the concept of ZEB is organized and shown. The energy saving rate for the standard energy consumption is at least 50%, and ZEB is defined by these XY judgment lines based on the energy created by renewable energy such as solar power generation (Figure 13).

When this definition is applied in consideration of the definition of Zero Water Building in the United States, the water conservation rate relative to the water consumption of the standard building is on the X axis, and the sum of alternative water use (rainwater and reclaimed water) and recharge water is on the Y axis. Furthermore, it is necessary to evaluate the Net Zero Water in the building from various perspectives by calculating considering both normal water use and emergency water use (Figure 14). For the evaluation of Net Zero Energy related to water, the same evaluation method as that for Net Zero Energy Buildings in Japan can be applied.

5. Conclusion

In this study, we conducted a basic study on the evaluation method of net water buildings in Japan and could sort out the evaluation method from the viewpoint of securing water supply and drainage at the time of disaster and saving resources and energy.

In the future, we would like to show this idea with easy-to-understand charts in the three-year committee activities and improve the calculation program to continue the activities with the aim of putting the evaluation method into practical use.

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7. Presentation of Author

Hiroyuki Kose is the Professor at Toyo University, Faculty of Information sciences and arts from 2009. Special fields of study are plumbing engineering, water environment, reproduction of the agricultural and forestry industries by collaboration of citizens and an organization and community design for regional vitalization.