A7 - Quantitative Evaluation Method of Resource and Energy Conservation in a Water Supply and Drainage System

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Abstract

This paper is the activity report organized as subcommittee of Architectural Institute of Japan (AIJ). The mechanism to estimate overall about resource and energy conservation in a building have been made from the time when United Nations Framework Convention on Climate Change is proclaimed in 1994 and the Kyoto Protocol is adopted in 1997. And the middle target reduced 26.0 % in fiscal year 2030 by the ratio in fiscal year 2013 is set by the Paris agreement settled on in COP21, 2015 at present [1]. Moreover "ZEB road map" aiming at achieving ZEB (net zero energy building) for an average of new public buildings by 2020 and for an average of new buildings by 2030 was published by Japanese Government in 2015 [2]. Energy conservation-ization in the water supply and drainage system is a pressing problem introduction of high-efficient hot-water supply. However, the contribution is small more than the other elements for the element about the water supply and drainage system and the water environment in Japan. For example, it's estimated as individual effort, but behavior such as water conservation fittings, rainwater use system and drainage reuse system aren't estimated at the inside through infrastructure from water intake to effluent treatment, and it isn't done clearly how effective its effect is to society and the environment. So, the evaluation and indication method in a quantitative way is developed that how much each effort of the resource and energy conservation about a water supply and drainage system and water environment will be in this paper. By the former activity of this sub-committee, collection of evaluation methods of resource and energy conservation, case collection of resource and energy conservation

architectures and examination of a structure of evaluation were cleared. The current state of study and future's task will be reported in this paper.

Keywords

Water conservation, energy conservation, simple evaluation system,

1 Introduction

In the plumbing system field of Japan, water conservation and energy saving about water are performed each element of water supply, hot water supply and plumbing fixtures and t and the study which includes the whole isn't enough. For example, even if reduction in washing quantity of water of the plumbing fixtures is developed, the thing can't be reflected about laying of the pipes and a design of equipment.

When it's possible to know how much water resource saving of the amount and energy saving are planned for as the whole when water conservation and energy saving were formed out of equipment, an incentive to introduction will function and be promotion of the spread. When it's possible to make the simple tool the way of calculation tends to understand, it'll be promotion to consideration to water environment by the level of the architect and the client and I can think it can also be utilized as educational consideration.

So, the evaluation and indication method in a quantitative way is developed that how much each effort of the resource and energy conservation about a water supply and drainage system and water environment will be in this paper. Moreover, this paper is the activity report organized as subcommittee of Architectural Institute of Japan (AIJ).

2 Methods

First, it's surveyed the evaluation of water supply and drainage system about environmental performance evaluation tool CASBEE [3] developed in Japan, similar tool LEED v4 BD+C [4] in the United States and building energy simulation tool the BEST Program [5] developed in Japan. The evaluation factor of Net Zero Water Building Strategies [6] settled on by American Department of Energy is checked.

The basic unit for these water resources and the energy (here, the carbon dioxide amount of emission) is set as a process to the source of water supply, water supply, hot water supply, drainage and water processing while referring to a document about these evaluation technique and basic unit. And the worksheet which calculates water resources the energy consumption in a building are made.

At the end, water resources and the energy consumption are calculated as a test using this worksheet. A change in the consumption of the water resources and the energy by introduction of water conservation equipment, water conservation behavior, introduction of renewable energy in hot water supply and introduction of non-potable water use is considered.

3 Evaluation Tools of Water Resources and Energy

3.1 CASBEE

CASBEE (Comprehensive Assessment System for Built Environment Efficiency) is developed in Japan and is the environmental in building total performance evaluation system which is widely used. Evaluation is formed out of BEE (Built Environment Efficiency) = Q (Quality) / L (Load) in CASBEE It'll be high evaluation so that building environmental performance is high and that building environmental load will be low.

It's explained about the item about the field related to the water supply and drainage system. There are preservation and creation of the renewal necessary time of the air conditioning and the water supply and drainage laying of the pipes, the reliability of the water supply and drainage, the renewal performance of a pipe for water supply and drainage, and creature of the biotic environment on the outside environment (biotope) about Q (building environmental performance). The energy saving and high efficiency-ization of hot water equipment and high efficiency operation, the rainwater use and non-portable water use which use efficiently and contributes to reduction in water supply consumption as water resource conservation and rainwater outflow restraint as consideration the area environment are incorporated about L (building environmental load). But these items are a partial one, and relationship of infrastructure and each item isn't considered.

3.2 The BEST Program

The BEST Program is able to do the simulation which coupled all equipment in a building. And it is able to simulate in detail using a weather data and the load pattern with the feature. In the water supply and drainage system, there are three programs: water supply, hot water supply and rainwater use. A simulation is possible by the condition of the default simply, and when customizing the condition, an in-depth simulation is possible. But it's difficult to grasp resource and energy conservation in water supply and drainage system.

3.3 LEED

Then a water relation system takes up LEED v4 BD+C (renewed on July 1, 2015) as integrated process first. It's written clearly to contribute to load reduction in water and sewage by reduction in the inside or outside demand of water and the grade of the supplier's provision of non-drinking water here. Outflow restraint of rainwater by maintenance of green infrastructure is written clearly in storm water management of SS credit in a site.

More use of water conservation equipment in the indoor water consumption reduction, measurement of a water meter and reduction in watering in the reduction by which it's the watering amount whether it's unnecessary and which are watering in the outdoor water consumption reduction in efficient use of water (WE) are written clearly.

But, point system is taken for LEED, and it isn't certain how much effect these restraints bring specifically.

3.4 Net Zero Water Building

In the “Net Zero Water Building Strategy”, to verify that the building is operating at net zero, annual water use data for each water flow is collected.
- Potable water use
- Non-potable water use (from freshwater sources)
- Alternative water use
- Treated wastewater on-site returned to original water source
- Storm water infiltrated to the original water source through green infrastructure.

When there is a destination of sewage and a branch at a Japanese city, underground penetration is prohibited. But for the underground penetration system to be used, when there were no destinations, I decided to make the model who can calculate based on this concept by this study.

4. Program for Water Resources and Energy Evaluation

4.1 Purpose

For the purpose of development of the program is that a building designer and a client can put in the water and energy conservation can consider each other, when, even a learner, for example a college student can use easily. And it was considered in order to subdivide various water use.

4.2 Calculation Method

Water use was shared with 17 according to the use and available discharge per each once was presumed from a reference [7]. And the use number of times per day per person and number of users is inputted, and the annual use number of days is crossed and annual water consumption in each water use is calculated.
Water resources are classified into 5 stages of the water sources, water supply, water heating or cooling, water discharge or recharge and the water processing, and volume of water consumption and the energy amount (here, the amount of CO_2 emission) according to each use are totaled. The CO_2 emissions per unit in each use is being presumed based on a reference [8] - [12]. Further, the use volume of hot water was calculated as a test as 50% of volume of water consumption of each use.
The condition can change the basic unit. It'll be necessary to be setting standard value from now on.

4.3 Trial Calculation

A case is set up as a trial about housing of family number of people 3 people, 100 m^2 of roof area, 1300 mm of annual amount of rainfall and 50 % of rainwater collection rate by this research. It was analyzed by 7 cases: use only of potable water (rainwater recharge), introduction of water conservation equipment, reduction in bathtub bathing number of times, introduction of a solar heat hot water supply system, introduction of rainwater use, introduction of drainage reuse and septic tank drainage recharge by this study. Table-1 shows a default case

(Case 1) and a worksheet. Table-2 shows each case or parameters. From Figure-1 to Figure-4 show diagrams of each water system.

Figure-5 and Figure-6 show some comparisons between calculated water consumption and CO_2 emissions using some indices. The model outline is shown on the table.

This test shows that volume of water consumption is decreased at most 20 % by introduction of water conservation equipment and decrease of the bathtub bathing. I find out that amount of CO_2 emission is reduced at most 49 % by introducing a solar heat hot water system and a rainwater utilization system as well as these systems and a service.

Each reduction in water resources and energy by introduction of the system and load reduction to infrastructure become possible to estimate the various situations relatively by use of this program. The throughput of the non-potable water and the amount of consumption decrease by introduction of water conservation equipment by the test calculation which assumed detached house, and a desirable thing finds out that rainwater use is introduced.

Because the bathtub bathing is performed daily in Japan, reduction in hot water supply amount and introduction of a solar heat hot water supply system are very effective in reduction in CO_2 emission.

5 Conclusion

This study was made the fact purpose of comparing and examining a resource saving and energy saving in water environment and developing the simple program with which introduction of environment consideration equipment and a system is supported. A program using a spread sheet was developed and 7 cases were calculated as a test calculation while surveying an environment evaluation system in a building of existence.

The next can be named as future's problem.

1. Collection of the appropriate basic unit according to the building use and the scale and consideration of its validity (based on the primary energy)
2. Consideration of groundwater use in the water source
3. Consideration of an energy consumption of a pump in a watering system in the building
4. Consideration of a cooling tower make-up water in a building for business use
5. The information collection to raise a generality and renewal of a program

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7 Presentation of Author

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Table-1 Worksheet of Default Case (Case 1)

Water		
Item	Element	
Water Source	City Potable Water	
	Rainwater+Gray Water	
Water supply	Potable Water	
	Non-Potable Water	
Water Heating & Cooling	Hot Water Supply	
	Cold Water Supply	
	Regional Heat Supply	
Water Discharge or Recharge	Black Water	
	Gray Water	
	Recharge Water	
Water Treatment	Sewage System	
	Septic System	
	Water Treatment	

Buildings	
Item	Element
Type	House
Person(s)	3
Roof Area [m^2]	100
Rainwater [mm/year]	1300

CO_2 Emission	
Energy	CO_2 Emission [kg-CO_2/m^3]
Potable Water	0.251
Non-Potable Water	0.063
Hot Water Supply	4.8
Sewage System	0.439
Septic System	1
Water Treatment	0.6

Household	
Persons	Water Consumption [m^3/year]
1	98.4
2	190.8
3	244.8
4	291.6
5	342

Others	
Hot Water Use Ratio	0.5
Rate of Water collection	0.5

No.	Water Use	Unit of Water Consumption [L/times]	Times [times/day]	Person(s) or Times	Number of Days Used	Annual Water Consumption [m^3/year]	Percentage of Water Consumption	Water Source	Water Supply	Water Heating or Cooling	Water Discharge or Recharge	Water Treatment	Unit of CO_2 Emission from Water Supply [kg-CO_2/m^3]	Unit of CO_2 Emission from Water Heating or Cooling [kg-CO_2/m^3]	Unit of CO_2 Emission from Water Treatment [kg-CO_2/m^3]	CO_2 Emission from Water Supply [kg-CO_2/year]	CO_2 Emission from Water Heating of Cooling [kg-CO_2/year]	CO_2 Emission from Water Treatment [kg-CO_2/year]	Annual CO_2 Emission [kg-CO_2/year]	Percentage of CO_2 Emission
1	Kitchen Cooking & Washing	13	3	3	365	43	17%	City Potable Water	Potable Water	Hot Water Supply	Black Water	Sewage System	0.25	4.80	0.44	10.79	103.20	18.88	133	23%
2	Hand & Face Washing	1.5	7	3	365	11	4%	City Potable Water	Potable Water	Hot Water Supply	Black Water	Sewage System	0.25	4.80	0.44	2.76	26.40	4.83	34	6%
3	Bathtub	200	1	1	365	73	29%	City Potable Water	Potable Water	Hot Water Supply	Black Water	Sewage System	0.25	4.80	0.44	18.32	175.20	32.05	226	39%
4	Bathroom Shower	35	1	3	365	38	15%	City Potable Water	Potable Water	Hot Water Supply	Black Water	Sewage System	0.25	4.80	0.44	9.54	91.20	16.68	117	20%
5	Bidet	0.2	3	3	365	1	0%	City Potable Water	Potable Water	Hot Water Supply	Black Water	Sewage System	0.25	4.80	0.44	0.25	2.40	0.44	3	1%
6	Washing Machine	40	1	3	300	36	14%	City Potable Water	Potable Water		Black Water	Sewage System	0.25	0.00	0.44	9.04	0.00	15.80	25	4%
7	Dishwasher												0.00	0.00	0.00	0.00	0.00	0.00	0	0%
8	Humidifying	1	1	1	100	0	0%	City Potable Water	Potable Water				0.25	0.00	0.00	0.00	0.00	0.00	0	0%
9	Evaporative Cooling												0.00	0.00	0.00	0.00	0.00	0.00	0	0%
10	Steam Heating												0.00	0.00	0.00	0.00	0.00	0.00	0	0%
11	Cleaning	5	1	3	180	3	1%	City Potable Water	Potable Water		Black Water	Sewage System	0.25	0.00	0.44	0.75	0.00	1.32	2	0%
12	Plumbing Fixtures	9	5	3	365	49	19%	City Potable Water	Potable Water		Black Water	Sewage System	0.25	0.00	0.44	12.30	0.00	21.51	34	6%
13	Fire Fighting												0.00	0.00	0.00	0.00	0.00	0.00	0	0%
14	Thawing												0.00	0.00	0.00	0.00	0.00	0.00	0	0%
15	Vehicle Washing												0.00	0.00	0.00	0.00	0.00	0.00	0	0%
16	Irrigation	20	1	1	100	2	1%	City Potable Water	Potable Water				0.25	0.00	0.00	0.50	0.00	0.00	1	0%
17	Landscape												0.00	0.00	0.00	0.00	0.00	0.00	0	0%
18	Overflow of Gray Water					0	0					Sewage System			-0.15	0.00	0.00	0.00	0	0%
19	Rainwater	130000				65	0	Rainwater			Recharge Water		65							
		Rainwater Fall				Rainwater Recharge	Rainwater Use						Rainwater Catchment							

		1	City Potable Water	Potable Water	Hot Water Supply	Black Water	Sewage System
		2	Rainwater +Gray Water	Non-Potable Water	Cold Water Supply	Gray Water	Septic System
		3	Rainwater		Regional Heat Supply	Recharge Water	Water Treatment
Water Consumption	Total [m^3/year] 256	1	256	256	166	254	254
	Total [L/day,person] 234	2	0	0	0	0	0
		3	65		0	65	0
		Total	321	256	166	319	254
		Rate	25%		65%	99%	99%
			Zero Water Building		Water Heating or Cooling	Rate of Water Discharge	Rate of Water Treatment

[kg-CO2/year]		Water Supply	Water Heating or Cooling	Water Treatment	Total	Rate
CO_2 Emission	from Infrastructures	64	0	112	176	31%
	From a Building	0	398	0	398	69%
	Total	64	398	112	574	
	Rate	11%	69%	19%		

Table-2 Parameters of Each Case

Case	Wter Source	Water Supply	Water Discharge or Recharge	Water Treatment	Rainwater	Water Conservation Equipment	Water Heating or Cooling	Unit of Water Consumption [L/times] of Bathroom Shower	Unit of Water Consumption [L/times] of Plumbing Fixtures	Number of Days Used of Bathtub	Unit of CO_2 Emission from Water Heating or Cooling [kg-CO_2/m^3]
Case 1	City Potable Water	Potable Water	Black Water	Sewage System	Recharge Water	None	Heat Pump Water Heater	35	9	365	4.8
Case 2	City Potable Water	Potable Water	Black Water	Sewage System	Recharge Water	Bathroom Shower and Plumbing Fixtures	Heat Pump Water Heater	25	6	365	4.8
Case 3	City Potable Water	Potable Water	Black Water	Sewage System	Recharge Water	Bathroom Shower and Plumbing Fixtures	Heat Pump Water Heater	25	6	250	4.8
						Reduce of Days Used Bathtub					
Case 4	City Potable Water	Potable Water	Black Water	Sewage System	Recharge Water	Bathroom Shower and Plumbing Fixtures	Heat Pump Water Heater +	25	6	250	2.4
						Reduce of Days Used Bathtub	Solar Water Heater				
Case 5	City Potable Water	Potable Water	Black Water	Sewage System	Recharge Water	Bathroom Shower and Plumbing Fixtures	Heat Pump Water Heater +	25	6	250	2.4
	Rainwater	Non-Potable Water				Reduce of Days Used Bathtub	Solar Water Heater				
Case 6	City Potable Water	Potable Water	Black Water	Sewage System	Recharge Water	Bathroom Shower and Plumbing Fixtures	Heat Pump Water Heater +	25	6	250	2.4
	Rainwater+Glaywater	Non-Potable Water	Gray Water	Water Treatment		Reduce of Days Used Bathtub	Solar Water Heater				
Case 7	City Potable Water	Potable Water	Recharge Water	Septic System		Bathroom Shower and Plumbing Fixtures	Heat Pump Water Heater +	25	6	250	2.4
	Rainwater+Glaywater	Non-Potable Water	Gray Water	Water Treatment	Recharge Water	Reduce of Days Used Bathtub	Solar Water Heater				

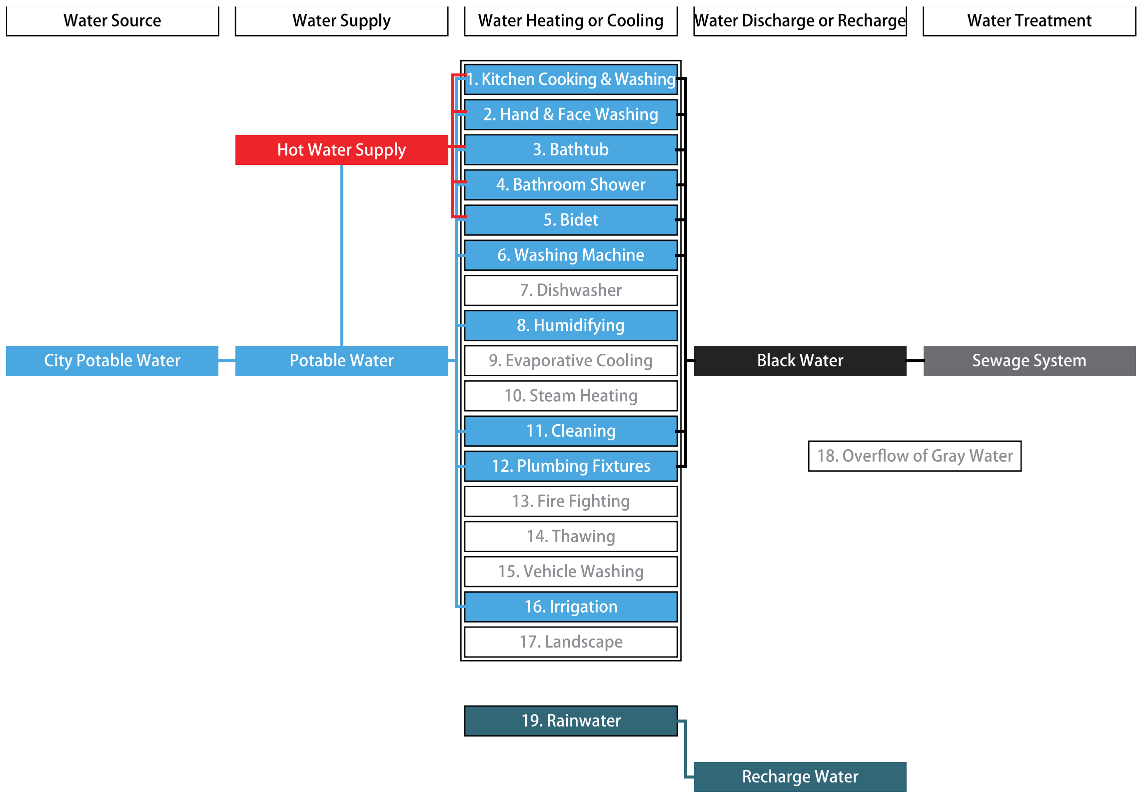

Figure-1 Diagram of Water System in Case 1,2,3,4 (Default Case)

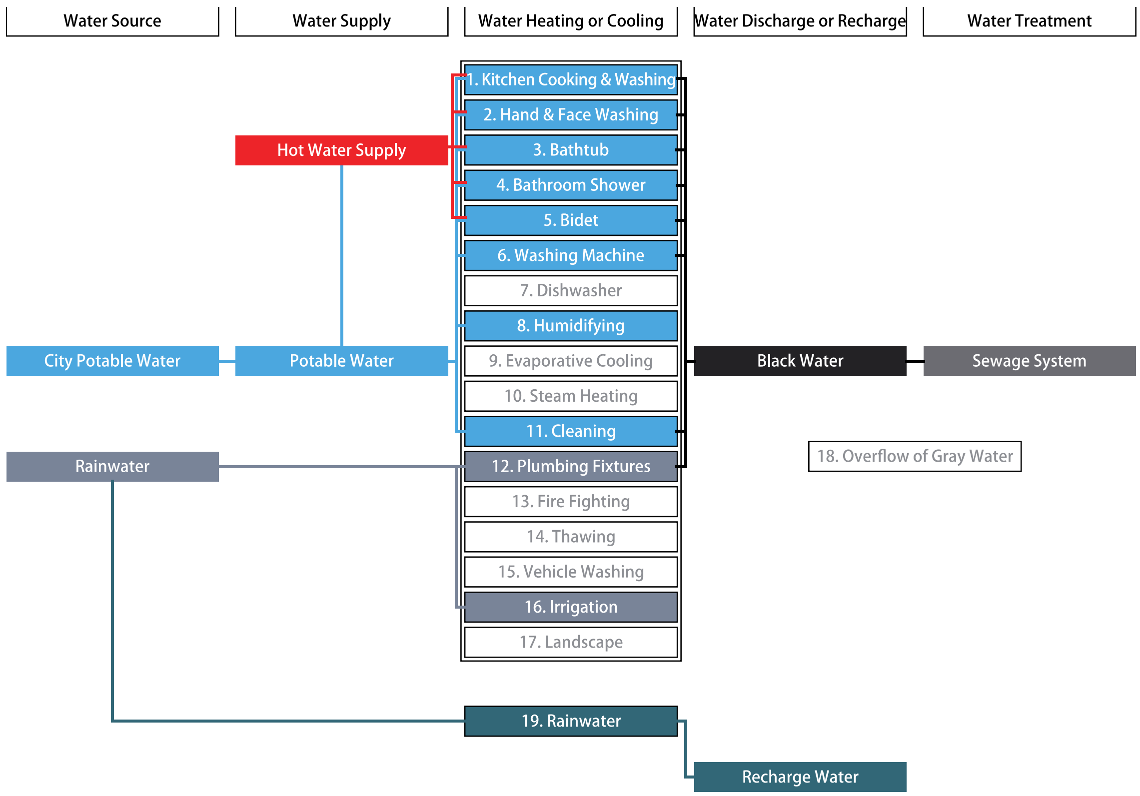

Figure-2 Diagram of Water System in Case 5 (Introduction of Rainwater Use System)

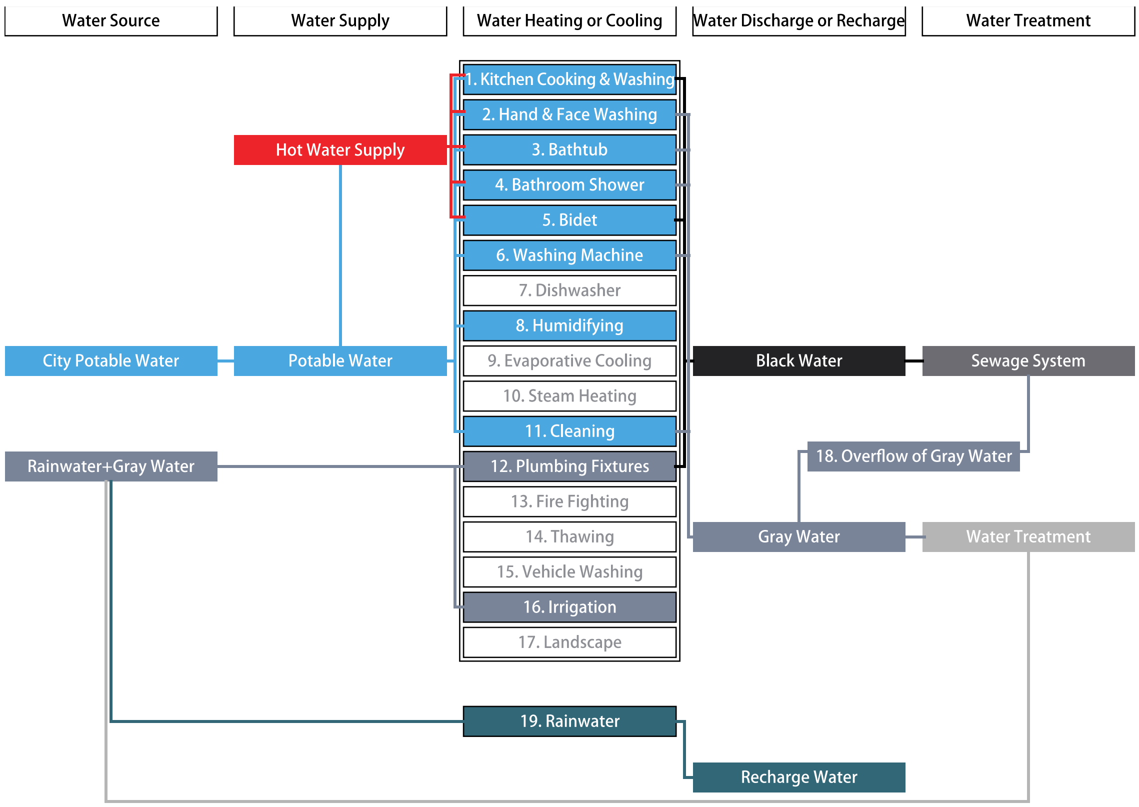

Figure-3 Diagram of Water System in Case 6 (Introduction of Gray Water Use System)

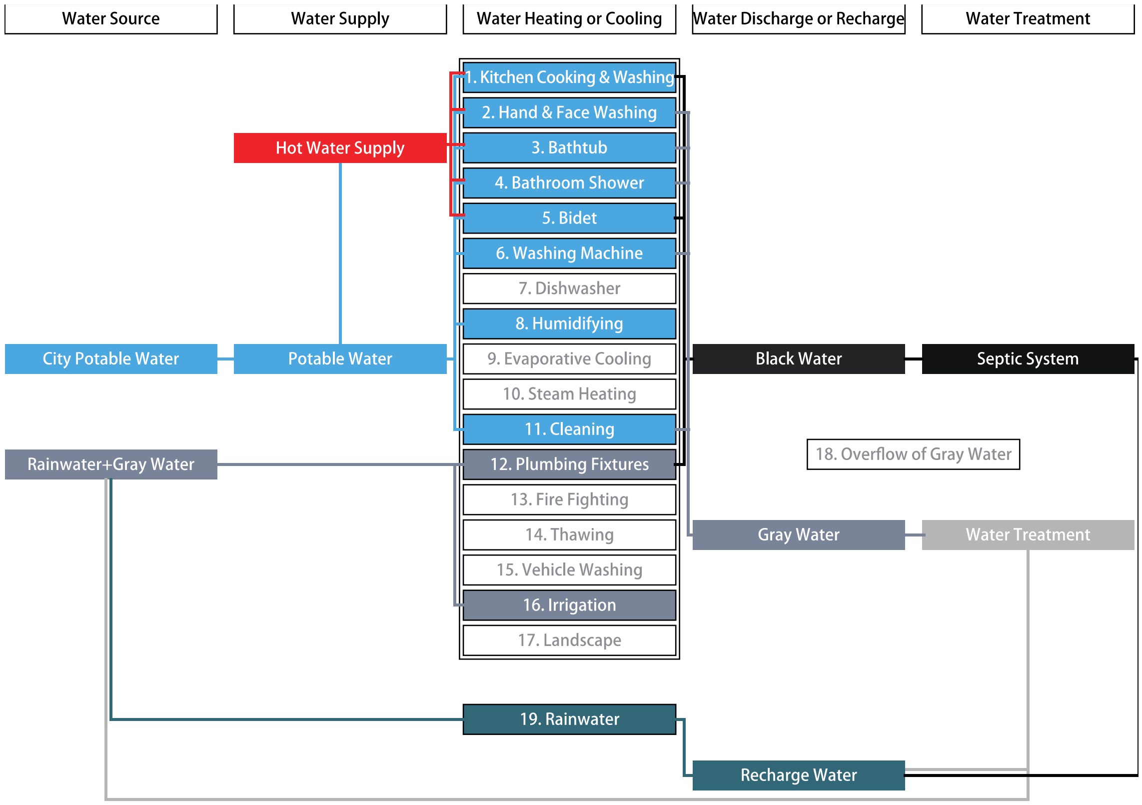

Figure-4 Diagram of Water system in Case 7
(Introduction of Septic Tank Drainage Recharge)

Figure-5 Results of Test Calculation
(1. Rate of Non-Potable Water, 2. Water Balance of Non-Potable Water, 3. CO2 Emission from Infrastructures or a Building, 4. Net Zero Water Index)

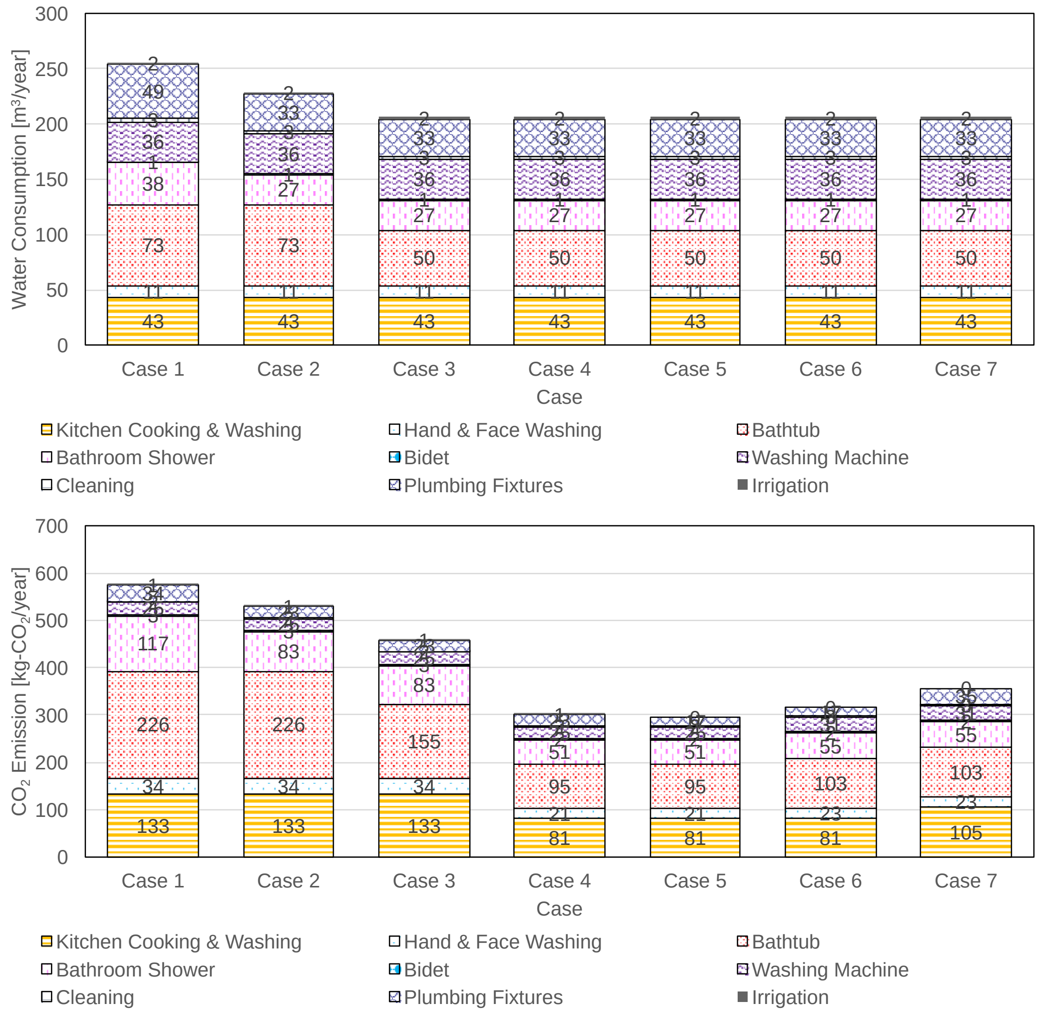

Figure-6 Results of Test Calculation
(5. Total Water Consumption and CO_2 Emission for Each Case)