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

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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. 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.
- 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 it can also be utilized as educational consideration.
- 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 study.

Methods

1. Surveyed the evaluation of water supply and drainage system about environmental performance evaluation tool “CASBEE”, “the BEST Program”, “LEED” and “Net Zero Water Building”.
2. The basic unit for these water resources and the energy (here, the carbon dioxide amount of emission) is set as each process while referring to a document. And the worksheet which calculates water and energy consumption in a building are made.
3. Water resources and the energy consumption are calculated as a test using this worksheet.

Evaluation Tools of Water Resources and Energy [1. CASBEE (Japan)]

- Evaluation is formed out of BEE (Built Environment Efficiency) = Q (Quality) / L (Load).
- Q (building environmental performance) has 4 items.
  1. Preservation and creation of the renewal necessary time of laying of the pipes
  2. Reliability of the water supply and drainage
  3. Renewal performance of a pipe for water supply and drainage
  4. Creature of the biotic environment on the outside environment
- L (building environmental load) has 4 items
  1. Energy saving and high efficiency-ization of hot water equipment and high efficiency operation
  2. Water conservation
  3. Rainwater use and non-portable water use
  4. Rainwater outflow restraint as consideration the area environment
- These items are a partial one, and the relationship of infrastructure is not considered.

Evaluation Tools of Water Resources and Energy [2. the BEST Program (Japan)]

- "The BEST Program" has 3 programs about plumbing system,
  1. Water supply
  2. Hot water supply
  3. Rainwater use
- Simulation is possible by the condition of the default simply, and when customizing the condition, an in-depth simulation is possible.
- Difficult to grasp resource and energy conservation in water supply and drainage system

Evaluation Tools of Water Resources and Energy [3. LEED (USA)]

- Water-Rerated System in the “Credit: integrative process”
  - Reduction potable water loads in the building
  - Estimation the project’s potential nonpotable water supply sources and water demand volumes
- SS (Sustainable Sites) Credit : Rainwater Management
  - To reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site, based on historical conditions and undeveloped ecosystems in the region
- WE (Water Efficiency) Prerequisite or Credit
  - Reduced Irrigation for the outdoor water use reduction
  - Reduce aggregate water consumption by 20% from the baseline for the indoor water use reduction
  - Install permanent water meters that measure the total potable water use for the building
- Point system is taken for LEED, and it is not certain how much effect these restraints bring specifically.

Evaluation Tools of Water Resources and Energy [4. Net Zero Water Building (USA)]

- Annual water use data for each water flow is collected,
  1. Potable water use
  2. Non-potable water use (from freshwater sources)
  3. Alternative water use
  4. Treated wastewater on-site returned to original water source
  5. Storm water infiltrated to the original water source through green infrastructure
- In this study the evaluation model is based on this concept.

Program for Water Resources and Energy Evaluation (Purpose and Calculation Method)

- Purpose
  - 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.
  - Considered in order to subdivide various water use
- Calculation Method
  - Divided 17 water use according to the use and available discharge per each once was presumed
  - Input use number of times per day per person, number of users and annual use number of days
  - Calculated annual water consumption in each water use by the cross of them
  - 5 stages of water resources : water sources, water supply, water heating or cooling, water discharge or recharge and the water processing
  - Totaled volume of water consumption and the energy amount (the amount of CO_2 emission) according to each use
  - 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.

Program for Water Resources and Energy Evaluation (Trial Calculation)

Table-1 Worksheet of Default Case (Case 1)

Precondition

1. Detached house 3 people live
2. 100 m^2 of roof area
3. 1,300 mm of annual amount of rainfall
4. 50 % of rainwater collection rate

Water Use Case

Water	
Item	Element
Water Source	City Potable Water
	Rainwater+Gray Water
	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

Precondition

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

CO_2 Emission Per Unit

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

Water Consumption per household

17 Water Use

Changeable Parameter

Changeable Water Use Case

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	4.81	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	16.66	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%
	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								

Water Consumption Results

	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

Total Water Consumption Results

CO_2 Emission Results

[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%		

Total CO_2 Emission Results

Table-2 Parameters of Each Case

1. Use only of potable water

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 Reduce of Days Used Bathtub	Heat Pump Water Heater	25	6	250	4.8
Case 4	City Potable Water	Potable Water	Black Water	Sewage System	Recharge Water	Bathroom Shower and Plumbing Fixtures Reduce of Days Used Bathtub	Heat Pump Water Heater + Solar Water Heater	25	6	250	2.4
Case 5	City Potable Water / Rainwater	Potable Water / Non-Potable Water	Black Water	Sewage System	Recharge Water	Bathroom Shower and Plumbing Fixtures Reduce of Days Used Bathtub	Heat Pump Water Heater + Solar Water Heater	25	6	250	2.4
Case 6	City Potable Water / Rainwater+Glaywater	Potable Water / Non-Potable Water	Black Water / Gray Water	Sewage System / Water Treatment	Recharge Water	Bathroom Shower and Plumbing Fixtures Reduce of Days Used Bathtub	Heat Pump Water Heater + Solar Water Heater	25	6	250	2.4
Case 7	City Potable Water / Rainwater+Glaywater	Potable Water / Non-Potable Water	Recharge Water / Gray Water	Septic System / Water Treatment	Recharge Water	Bathroom Shower and Plumbing Fixtures Reduce of Days Used Bathtub	Heat Pump Water Heater + Solar Water Heater	25	6	250	2.4

Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7

2. Introduction of Water Conservation Equipment

3. Reduction in Bathtub Bathing Number of Times

4. Introduction of a Solar Heat Hot Water Supply System

5. Introduction of Rainwater Use

6. Introduction of Drainage Reuse

7. Septic Tank Drainage Recharge

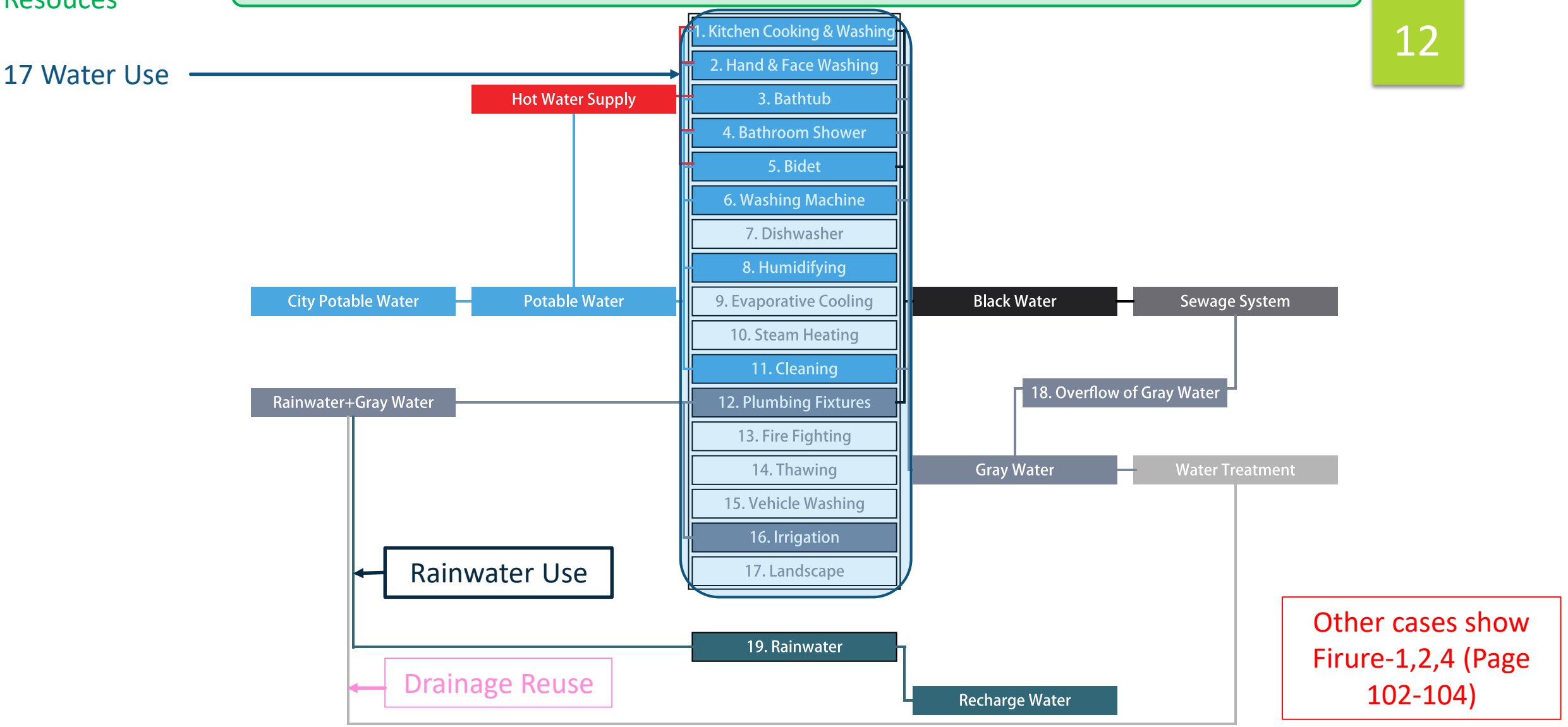
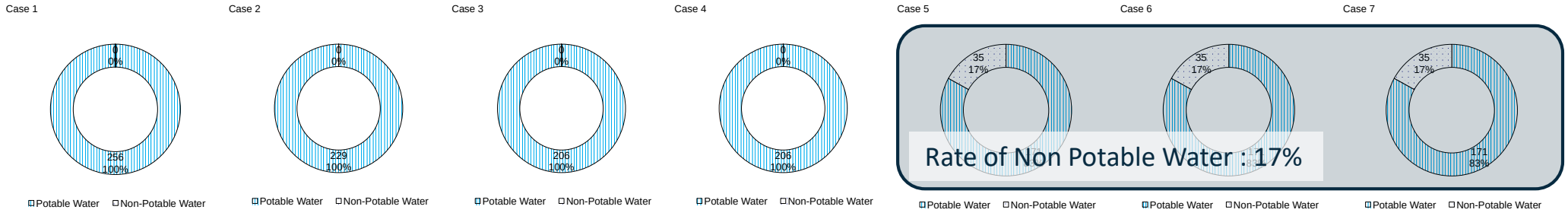
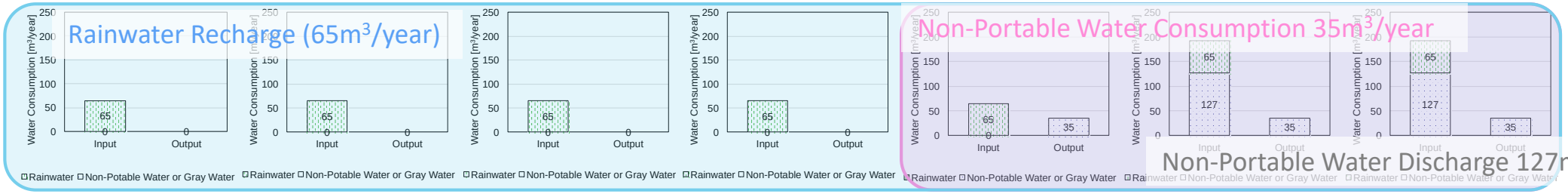


Figure-3 Diagram of Water System in Case 6 (Introduction of Gray Water Use System)

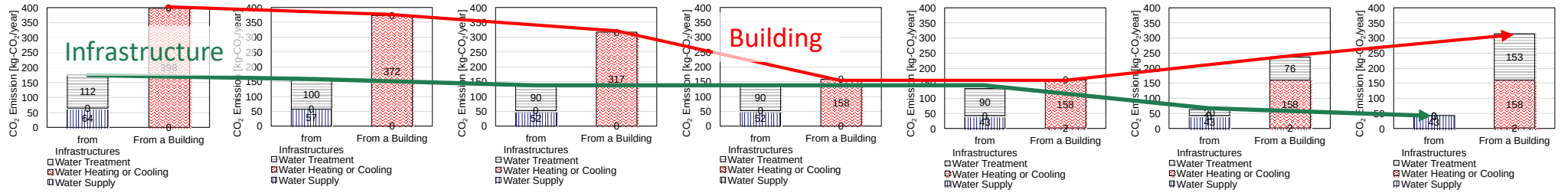
Case 1 Case 2 Case 3 Case 4 Case 5 Case 6 Case 7



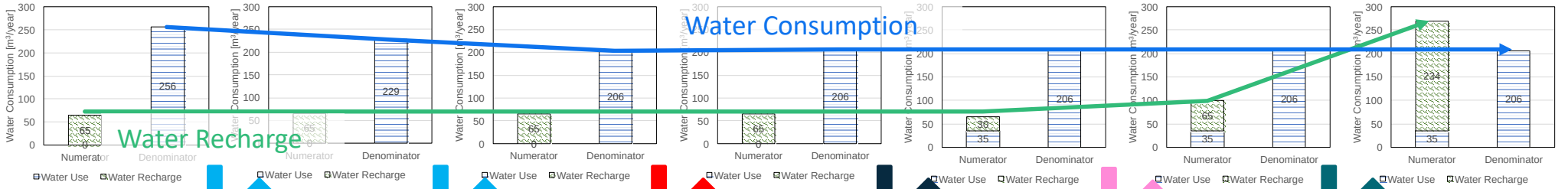
<- Rate of Non-Potable Water



<- Water Balance of Non-Potable Water



<- CO_2 Emission from Infrastructures or a Building



<- Net Zero Water Index

Water Conservation

Solar heat hot water supply system

Rainwater use

Drainage reuse

Septic tank drainage recharge

Figure-5 Results of Test Calculation

2. Introduction of Water Conservation Equipment

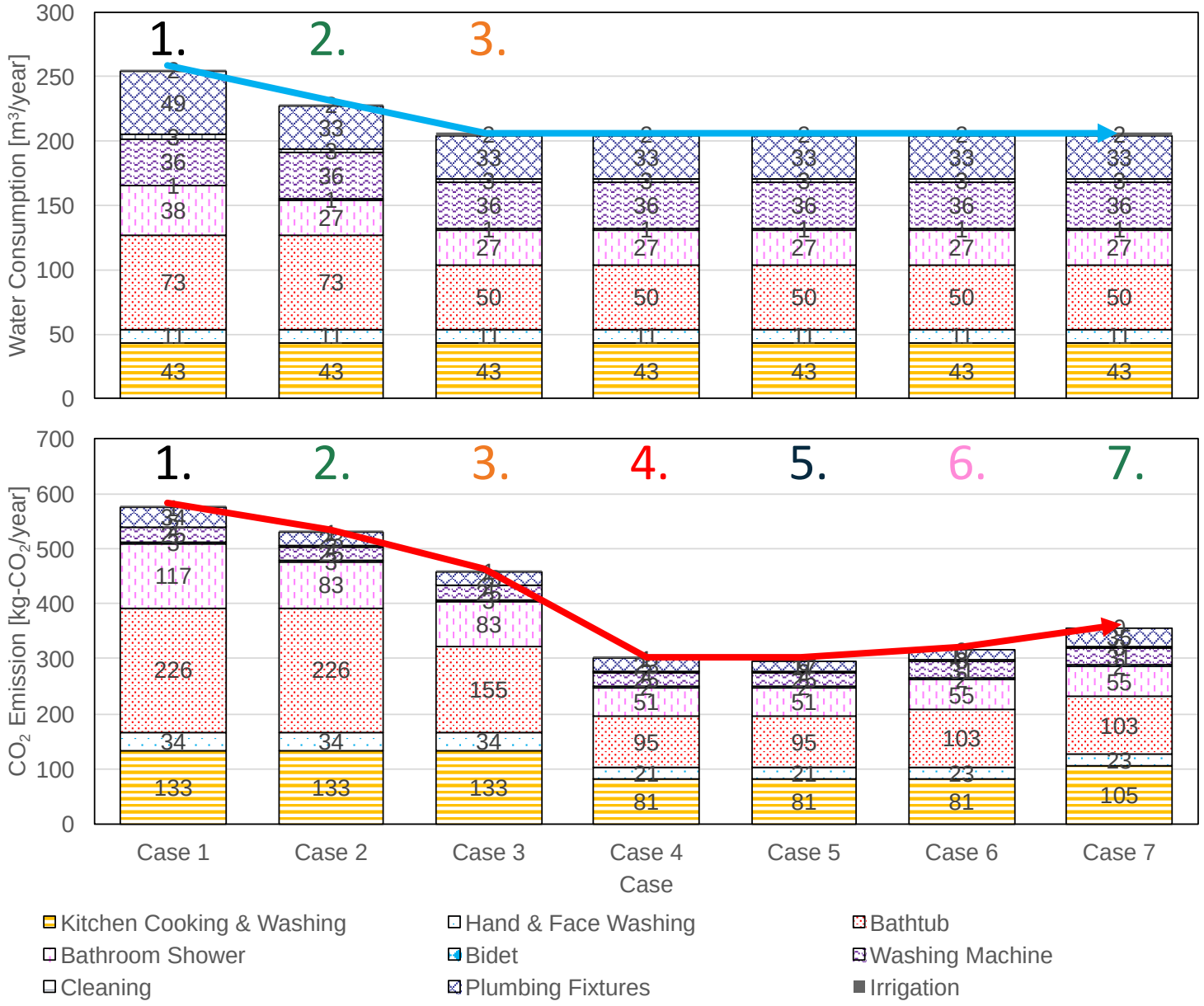
3. Reduction in Bathtub Bathing Number of Times

4. Introduction of a Solar Heat Hot Water Supply System

5. Introduction of Rainwater Use

6. Introduction of Drainage Reuse

7. Septic Tank Drainage Recharge



<- Total Water Consumption

<- Total CO_2 Emission

Figure-6 Results of Test Calculation

Consideration of Trial Calculation

- Volume of water consumption is decreased at most 20 % by introduction of water conservation equipment and decrease of the bathtub bathing.
- Amount of CO_2 emission is reduced at most 49 % by introducing a solar heat hot water system and a rainwater utilization system.
- 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.

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