Smart water pressure and quantity management plan for carbon neutrality in local water supply facilities

By

OH, Sewon

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

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Executive summary

Recently, it has set goals to reduce greenhouse gases worldwide to prevent climate change caused by abnormal temperature phenomena. And each country is implementing various policies to reduce carbon. The Ministry of Environment, which oversees Korea's water management policy, announced in its 2021 work plan that it will push for a "carbon neutral promotion in the water management sector" policy as one of the six major policies to promote water management. In particular, water supply facilities are one of the facilities that use a lot of energy in the water intake, water purification, and water transmission processes, and carbon emissions from local waterworks are much higher than wide-area water supply. Accordingly, this study reviewed ways to reduce the amount of leakage that can fundamentally reduce production to reduce energy use and ways to produce eco-friendly energy using the energy of water. Leakage reduction was derived using a smart meter installed at the consumer and a small flow rate and water pressure monitoring system installed at the inlet point of the small area. In addition, by finding the point where unnecessary chickenpox is generated in the pipeline flowing into the local water supply reservoir in Boryeong Metropolitan Water Supply, a plan to introduce small hydroelectric power using falling water was reviewed and power generation was calculated. In addition, we looked for areas where decompression valves were installed due to excessive pressure at the inflow point of the block unit of the local waterworks. Among them, the amount of eco-friendly energy that can be produced was calculated by calculating the amount of power generation for decompression valves of a certain size or more. Although it is the amount of leakage and small hydropower generation in some regions, if this concept is advanced and applied to workplaces across the country, carbon neutrality of domestic local waterworks is not expected to be difficult. In addition, active control of small pressurization plants that use a lot of energy in local waterworks and establishing a system to reduce water use at each consumer can be an efficient carbon reduction method, so it was suggested as a future task.

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1.1 Background

1.1.1 Global warming and natural disasters due to climate change

We are now living in an era of climate crisis amid global warming caused by climate change. Even after 2020, not only Korea but also the world has experienced various and severe weather disasters. In France, Europe, the average temperature in July 2020 was +0.9°C compared to the past, the highest ever since 1900 observations, and the highest daily temperature on July 30 was 41.9°C, the highest ever. Even Russia's Berghoyansk region, adjacent to the Arctic, recorded its highest temperature (38°C) since the 1885 observation on June 20, 2020. Meanwhile, Egypt experienced abnormal low temperatures and heavy snow in January 2020. Snow was observed in Alexandria, Egypt, especially for the first time in 100 years, and in Cairo for the first time in 110 years (Ministry of Public Administration and Security, 2020).

[Figure 1-1] Cases of damage caused by abnormal weather around the world

In particular, just looking at the abnormal climate phenomenon that has recently occurred in Korea, it has made us more aware of climate change. In March 2022, a sustained drought caused a huge forest fire in the East Coast area. Hwama, which swallowed numerous forests in 213 hours, burned about 23,000 forests (29,23ha) in soccer fields and damaged 700 private facilities such as houses and public facilities, causing about 300 victims. The forest fire was recorded as the second-largest forest fire with damage area after the east coast forest fire in April 2020, and the longestlasting forest fire in Korean history. On the other hand, in the summer of the same year, two days of water bombs turned the central region into a sea of water. From August 8 to 10, heavy rains of 141.5mm (maximum 24 hours of rainfall) were poured into the south of the Han River in Seoul and the central region of Gyeonggi Province and Chungcheong Province. According to the Korea Meteorological Administration (KMA), the torrential rain renewed its highest rainfall in 115 years.(CCTV News, 2022)

[Figure 1-2] Cases of damage caused by abnormal weather in Korea

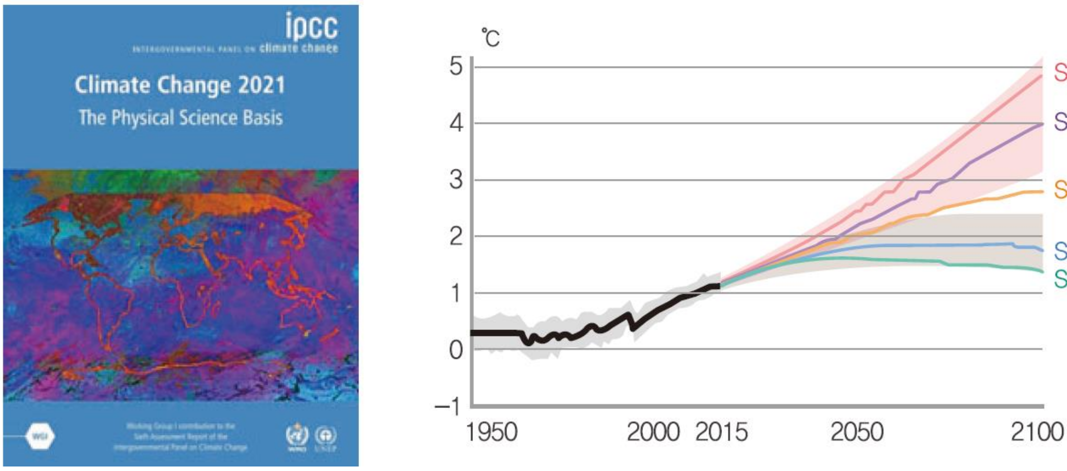
Floor View of Juam Dam Due to Drought

Flooding of rivers in downtown Busan due to flooding

According to the "Disaster Annual Report" released by the Ministry of Public Administration and Security, the damage caused by natural disasters in Korea has continued to increase over the past five years (2016-2020). The number of deaths from natural disasters increased from 7 in 2016 to 75 in 2020, and property damage also quadrupled from 288.4 billion won in 2016 to 1.3182 trillion won in 2020.(Ministry of Public Administration and Security, 2021) Over the past 10 years (2011-2020), about 300 people have been killed and about 16 trillion won has been lost in the economy, and the damage caused by climate change is expected to increase further (Ministry of Public Administration and Security, 2020).

The pace of climate change is getting faster. The International Panel on Climate Change (IPCC) analyzed that the global average temperature increased by about 1℃ in 2017 compared to before industrialization, and that it will increase by 1.5℃ from 2030 to 2050. (IPCC, 2018). In 2021, it predicted a 1.5℃ rise compared to pre-industrial times to 2021-2040, about 10 years earlier than the time analyzed in the previous report, calling for a more preemptive response from the international community..(IPCC, 2021)

[Figure 1-3] IPCC AR6 1st Working Group Report Cover (left) and future trend of global average temperature change (right)



※ IPCC 6th Evaluation Report 1st Working Group Report (2021)

1.1.2 Trends in carbon neutrality at home and abroad

To prevent such climate change, various policies are being implemented to reduce greenhouse gases worldwide. 195 countries around the world, including Korea, have adopted the Paris Agreement and are striving to respond to climate change. According to the agreement, each party must set its own greenhouse gas reduction target (NDC) and submit it every five years, and its implementation status must be checked. The Paris Agreement was adopted by the parties at the plenary session of the 21st United Nations Convention on Climate Change (COP21) in Paris on December 12, 2015, and calls for countries around the world to resolve global warming and gradually reduce greenhouse gas emissions. (Ministry of Foreign Affairs and Trade, 2015).

This year, the 27th General Assembly of the Parties to the UN Framework Convention on Climate Change (COP27) was held in Sharm el Sheikh, Egypt, from November 6 to 18 to discuss climate change. 198 parties participated in the meeting to share each country's strategy to achieve the goal of "limiting the global temperature increase within 1.5℃," which was proposed through the 2015 Paris Agreement. In particular, for the first time in the draft COP27 resolution, "Matters concerning financing for compensation for losses and damages" were adopted as the official agenda. Loss and damage refer to economic and non-economic losses caused by climate change. Loss refers to the loss of life, livelihood, culture, etc., and damage refers to the loss of infrastructure and ecosystem (Ministry of Foreign Affairs and Communications, 2022).

A key issue about losses and damage is that developed countries should take responsibility and urge compensation for developing countries (developing countries) that are less responsible for causing climate change but are suffering significantly. In response, some countries, including the United States and Europe, have promised to provide funds such as fair energy conversion and loss and damage funds (Ministry of Foreign Affairs and Trade, 2022). However, an agreement is needed as developing and developed countries are divided on the issue of raising funds for losses and damage, the method and size of support.

Korea also declared carbon neutrality through the president's speech at the National Assembly on October 28, 2020. Subsequently, the 2050 carbon neutral promotion strategy was announced and the carbon neutral scenario was announced in October of the following year. In the scenario, technology development and one while making the most of the existing system and structure?A plan considering the conversion of fuel was proposed. In addition, two plans were proposed to reduce fossil fuels and further reduce greenhouse gases through lifestyle changes, and three plans to drastically reduce fossil fuels and convert all hydrogen supply to green hydrogen. (MOT Consultant, 2021).

In addition, the National Determined Contribution (NDC) set by the previous government at the COP27 is a high goal in the reality of the Korean economy based on manufacturing, but it has decided to maintain its existing goal to contribute to climate response and keep its promise with the international community. It also announced that it will strive to achieve the reduction target through a feasible energy mix based on science and innovation such as renewable and nuclear power. In addition, the government said it would push for carbon-neutral green growth based on responsible implementation, orderly transition, and innovation under the carbon-neutral green growth strategy proposed by the carbon-neutral green growth committee (joint with relevant ministries, 2022).

However, the international community's assessment of Korea's response to climate change is not very good, compared to its announcement that it will strive for climate change. According to the 2023 Climate Change Performance Index (CCPI) released by German Watch, a private climate evaluation agency, and the New Climate Research Institute, Korea ranked 53rd among the 63 countries surveyed.

[Figure 1-4] Climate Change Performance Index 2023

※ ZDNET Korea

The CCPI cited poor renewable energy supply as the reason for Korea's low performance in responding to climate change. Specifically, it is good that the government raised the NDC from 26.3% to 40% in 2018, but the target for the proportion of renewable energy generation is still low. Experts point out that the current government should pay more attention to carbon neutrality and change the direction of climate change policy to reduce investment in fossil fuel businesses and increase renewable energy to meet carbon neutral goals. (Im Hae-won, 2022).

1.1.3 Status of the government's promotion of carbon neutrality in the water management sector

The Ministry of Environment, which oversees Korea's water management policy, announced in its 2021 work plan that it will push for a "carbon neutral promotion in the water management sector" policy as one of the six major policies to promote water management. As a strategy for these measures, it was announced as detailed measures such as water conservation and revitalization of water reuse, carbon reduction in the entire water flow process, fostering new and renewable energy related to water, and carbon offset (Ministry of Environment, 2021).

Water conservation and water reuse activation reduce energy by reducing water use and achieve adaptation to the climate crisis at the same time. In addition, reducing carbon in the entire water flow process means reducing leaks generated in the water supply process and minimizing energy use in the supply and treatment processes. In addition, the sector that fosters renewable energy and offsets carbon means that it will replace the supply of energy that is inevitable to use with eco-friendly renewable energy and offset emissions (Ministry of Environment, 2021).

In the first category, water demand system, integrated water supply and supply management, rainwater and runoff groundwater reuse activation system, carbon reduction in the entire water flow process, and waterfront eco-belt development in the third category.

1.2 Problem statement

1.2.1 Status of carbon emissions from local water supply

Water supply facilities are one of the facilities that use a lot of energy in the water intake, water purification, and water transmission processes, but have the production potential to produce abundant renewable energy depending on the production and transportation process of water supply and the characteristics of the facility. In particular, carbon emissions from local waterworks are much higher than that of metropolitan waterworks. The total number of local waterworks is 6,779, with 473 water purification facilities (21,081,000 m^3/day), 473 water intake facilities (18,946,000 m^3/day), and 5,833 pressurization facilities in operation. In particular, the number of pressurized facilities to supply tap water to mountainous areas and villages far from intake and water purification facilities was found to be higher than that of intake and water transmission facilities (Korea Water Resources Corporation, 2020). The operation status of the water purification facility is 13,325,000 m^3/day, 63.2% of the average daily operation rate, the maximum daily production is 15,931,000m^3/day, and 75.5% of the maximum operation rate, and the annual power use is 963,627MWh, emitting 443,000tCO2 greenhouse gases. The operation status of the water intake facility is 10,244,000//day, 54.1% average operation rate, 11,822,000 m^3/day maximum operation rate, and 62.4% maximum operation rate, and annual power use is 712,997MWh, emitting 328,000tCO2 greenhouse gases (Korea Water Resources Corporation, 2020).

1.2.2 Carbon reduction efforts and limitations centered on local water supply sites

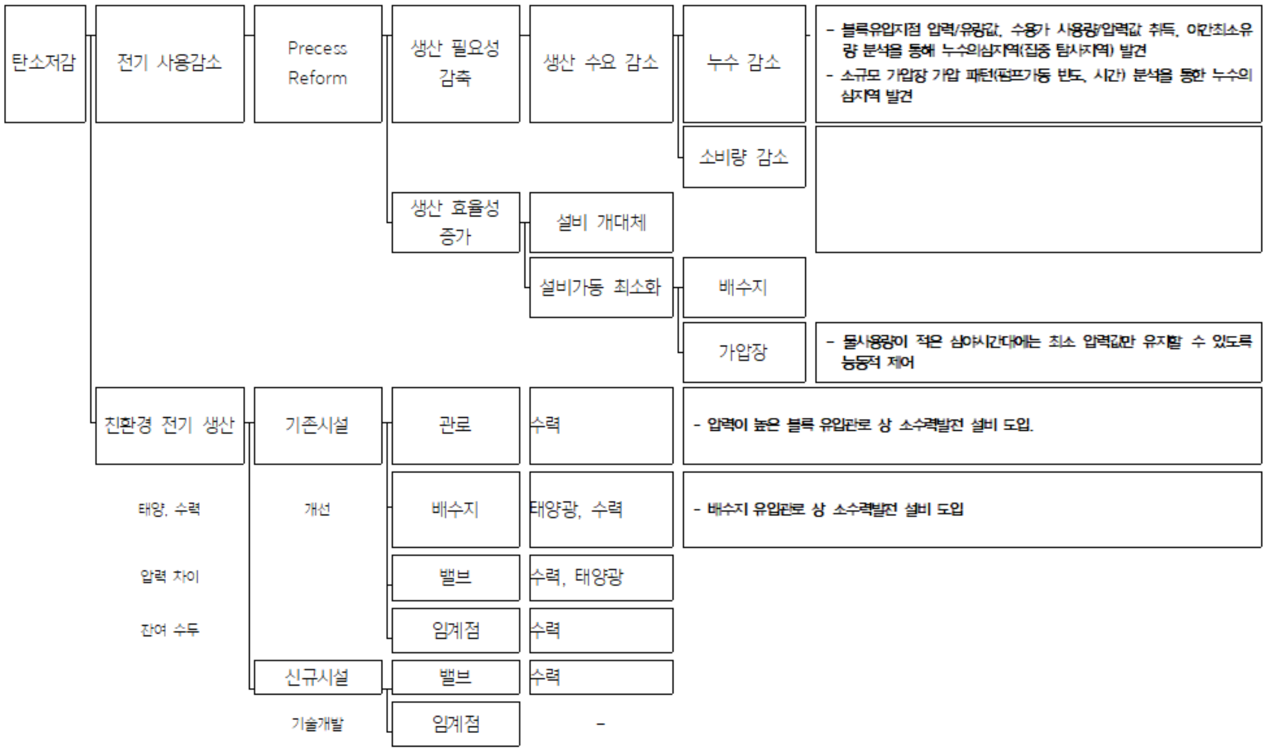
Due to the poor financial and manpower conditions of local waterworks, carbon reduction measures at the level of metropolitan waterworks are not being promoted. In addition, 161 metropolitan and local governments operate most of the water facilities individually, and the energy management system varies depending on the financial and manpower conditions of the operator, unnecessary carbon emissions are increasing, and the energy independence rate is low. Therefore, production of low-carbon tap water by improving energy efficiency and actively introducing renewable energy?It is urgent to establish a supply base.

Accordingly, the Ministry of Environment ordered a "service for establishing a basic plan for carbon neutrality of local water supply" for local water intake plants and water purification plants nationwide. Survey on greenhouse gas emissions and renewable energy production at local waterworks?After the analysis, greenhouse gas reduction measures such as the introduction of high-efficiency facilities and renewable energy installation plans such as solar, hydrothermal, and small hydroelectric power were derived. In addition, a basic plan for carbon neutrality of local water supply was established, such as setting goals for carbon neutrality of local water supply, preparing procedures for project promotion, and selecting pilot and expansion projects. It will also present a standard model of carbon neutrality for local water supply and push for guidelines for promoting carbon neutrality by 2050.

1.3 Project objectives by smart water management technology

To reduce carbon, or carbon neutrality, in local waterworks, we can think of ways to reduce the use of electricity used in facilities that produce tap water and to produce eco-friendly energy using the characteristics of waterworks. First, it can be divided into a radical method of reducing tap water production and a method of increasing the efficiency of production facilities as a way to reduce electricity use. On the other hand, even in the process of producing eco-friendly energy, it can be divided into a method of installing sunlight using a drainage site and a method of using residual water head in the jurisdiction. In this study, we would like to review ways to reduce the amount of leakage that can fundamentally reduce production to reduce energy use and ways to produce eco-friendly energy using the energy of water.

[Table 1-1] Causal Map for deriving carbon reduction measures for local waterworks



2. 2. Methodology

2.1 Derivation of suspected leakage areas in small blocks

In order to reduce tap water production with the aim of reducing energy use at local waterworks, the fundamental measure would be to reduce the amount of leakage flowing into the ground above all else. It is a method of managing demand in terms of supply that can be implemented by water service providers, and it can be said to be a priority measure in terms of efficiency. If the leakage volume decreases, excessive investment can be prevented by not having to build large water purification facilities, and tap water production costs are reduced by reducing the leakage volume. In particular, by reducing power and drug costs, greenhouse gas reduction effects are also seen, and this reduction in production costs improves the local water supply management balance and converts the water supply business into a virtuous cycle structure to prevent leakage.

The International Water Association (IWA) classifies water losses as nominal and real losses, and except for general errors, methods to reduce water losses are largely summarized as leakage exploration and recovery, water pressure management, old irrigation, meter error improvement, and illegal use improvement. Through the recently implemented "Local Water Supply Modernization Project" and "Local Water Supply Smart Network Management Infrastructure Construction Project," this study focused on ways to more efficiently and actively promote leakage detection and recovery in the field.

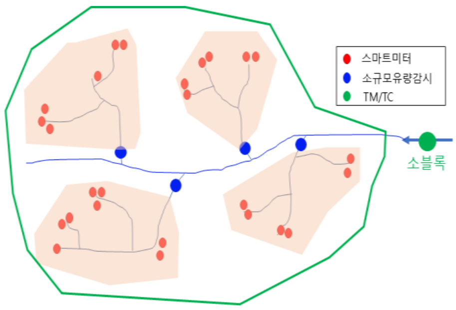
[Table 2-1] Overview of Local Water Supply Modernization projects and SWM project

Modernization project	SWM project
- Business period: 2020 to 2024 - Total project cost: KRW 12,535 million - Business goal: 85% target flow rate - Details of the project: Maintenance of old pipes, building block systems, and establishing maintenance systems	- Business period: 2020 to 2023 - Total project cost: KRW 1.2 trillion - Business target : 161 a water supplier - Purpose: Establish a tap water monitoring system to prevent accidents and respond quickly to accidents

2.1.1 Installation of water pressure sensing system and smart meter in small blocks

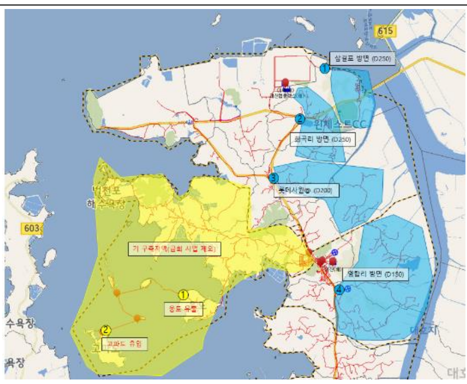
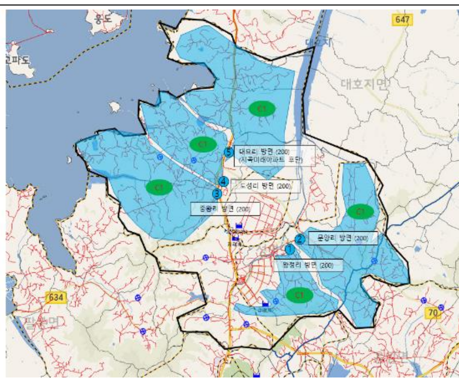
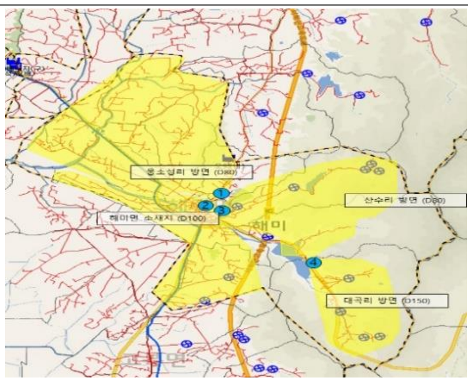
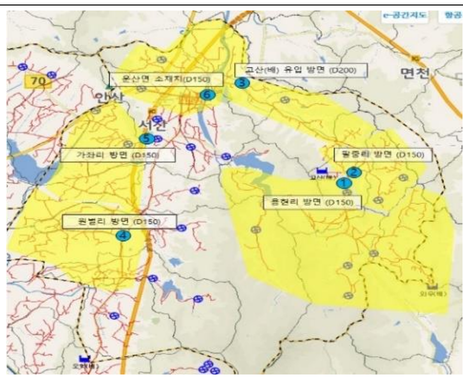
Currently, most local waterworks have installed smart meters around old or large-diameter meters and customers of the vulnerable, and small-scale flow rate and water pressure reduction systems have been installed around simple water supply or high-use areas. However, these installation standards are bound to be limited to the level of utilizing the simple functions of each technology. Despite the fact that smart technologies were applied to the field with a large budget and manpower, the flow rate of the middle block area has no choice but to be calculated only monthly. Accordingly, small areas should be selected first, focusing on areas where water pressure is relatively high, where many old pipes are distributed, and areas where it is difficult to meter. Furthermore, by replacing all existing mechanical meters with smart meters and installing a small flow rate and water pressure monitoring system at the inlet of the small area, it is necessary to find areas with low flow rates in the middle block and analyze flow rate data in real time.

[Table 2-2] Conceptual diagram of smart meter and small flow rate and water pressure monitoring system

# Linkage with consignment and consignment projects, modernization projects, etc - Block System Flowmeter Complementation, Segmentation # Establishment of a foundation for automation facility operation system - Establishment of real-time water flow rate management system # Increase maintainability - Sustainable Leakage Management System	

Seosan-si introduced smart technology by utilizing smart projects in rural island areas in 2019 and smart pipe network management infrastructure construction projects and modernization projects in 2020. Typically, all smart meters were replaced and installed in small areas, centering on the Daesan Water Supply Zone, the Chari Water Supply Zone, and the Ohak Water Supply Zone. In addition, a small flow rate and water pressure sensing system was introduced at tap water inflow points in small areas where all smart meters were introduced (K-water, 2020).

[Figure 2-1] Status of smart meter and small flow rate and water pressure monitoring system

< D-B BLOCK >	< P-A BLOCK >
	
< O-A BLOCK >	< O-B BLOCK >
	

In this study, real-time water flow rate observation data were collected around the DB-5 small area of the Daesan Water Supply Zone and the P-A small area of the Chari Water Supply Zone, where the meter reading system through smart metering is stabilized. The DB-5 block is a block containing a representative island area, and a small flow rate and water pressure monitoring system was installed at the point of inflow from Daesan Reservoir to the DB-5 block to monitor the flow rate by separating the entire DB-5 and the island area (Ungdo rear). In addition, the P-A block was divided into four small areas, and a small flow rate and water pressure sensing system were installed at the inflow point of each small area.

2.1.2 Analysis of real-time inflow and usage measurement data

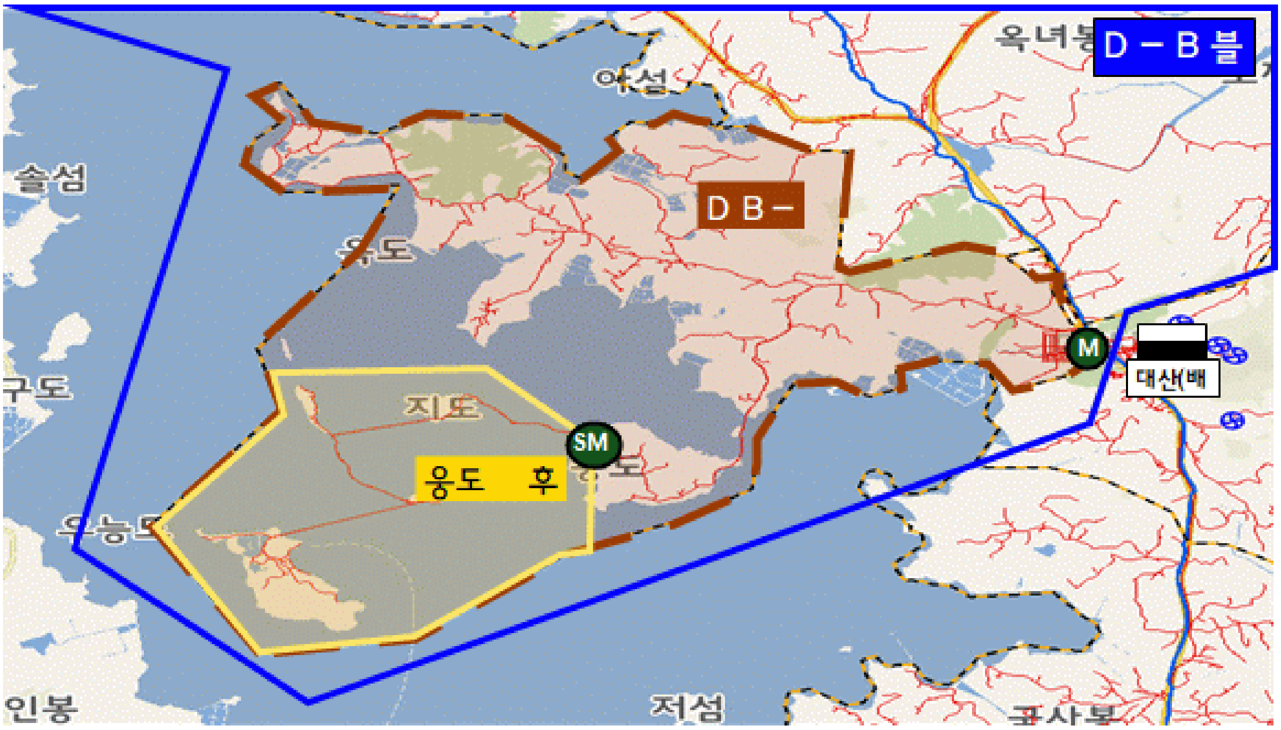
The analysis target area was the entire DB-5, DB-Ungdo rear area, and P-A area of the Chari water supply area, which are island areas of the Daesan water supply area. In addition, the analysis period was set from August 16 to September 15, 2022, and the flow rate data according to daily and day-to-day usage were analyzed for 31 days.

[Table 2-3] Current status of water flow rate analysis targets by small area

Middle block	Small block	water flow rate (Sep)	Small flow monitoring (number)	Average Daily Supply (m^3/day)	Average Daily Usage (m^3/day)	Number of meters
Chari(Drainage)	P-A	73.1	5	1,349	987	2,075
Deasan(Drainage)	DB-5	82.5	2	1,139	940	2,429

DB-5 Block is an area that supplies water to farming and fishing villages, including the island area among Daesan-eup, Seosan-si. In particular, the island area supplies wide-area water supply by closing the existing water supply and installing a pipeline connecting the island and the island. However, the overall water flow rate of the DB block is 90%, which is a relatively high area. Therefore, it is an area that has been excluded from the area subject to intensive management and only conducts leakage management based on resident reports.

[Figure 2-2] DB-5 Block Location Map

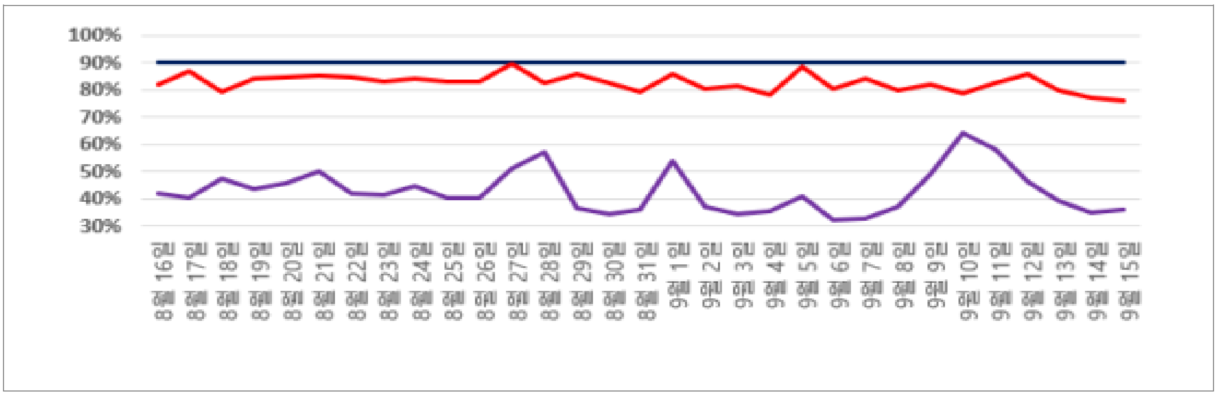


However, as a result of monitoring small areas by introducing smart meters and small flow and water pressure monitoring systems, it was confirmed that the DB-5 area had a very low flow rate of about 82% among the DB blocks, especially the DB-Ungdo rear area had a very low flow rate of 43%, and serious leaks were occurring. In addition, when the oil flow rate was calculated through daily use and supply, the oil flow rate was measured relatively high on days of high use and low on days of low use. When the usage is low, it is confirmed that the leakage amount increases along with the increase in the pressure in the jurisdiction, indicating that it is urgent to investigate the leakage through step tests in the DB-Ungdo rear area.

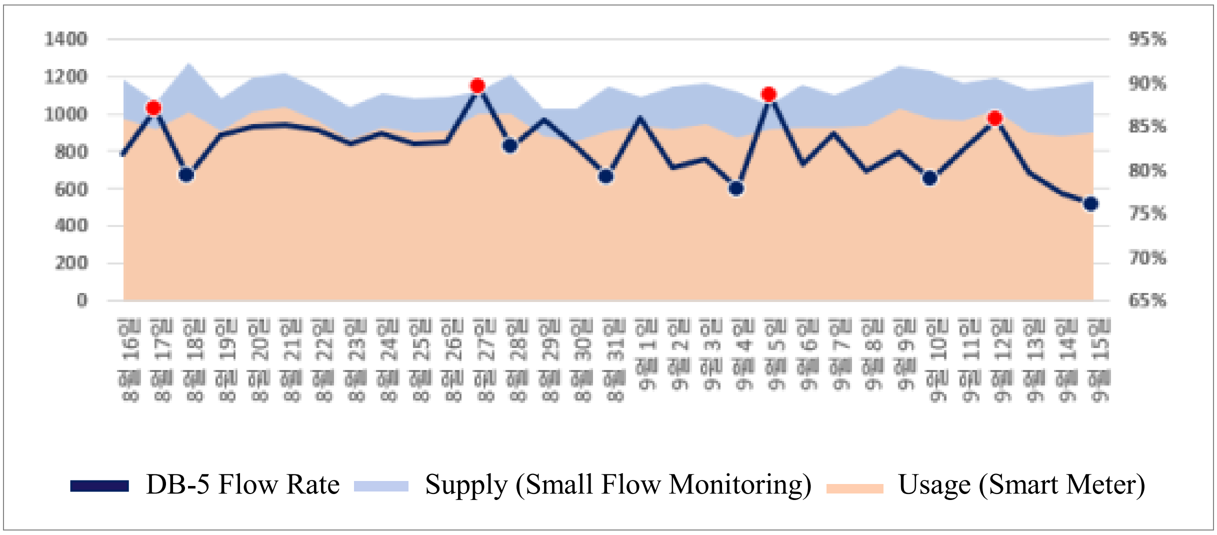
[Table 2-4] DB Block Oil Flow Rate Data Analysis Results

area	water flow rate (%)	Supply water consumption (m^3)	Used water consumption (m^3)	non-revenue water (m^3)	Number of meters
Whole D-B	90.0	129,000	116,000	13,000	2,714
DB-5	82.5	35,000	29,000	6,000	2,680
Island (Ungdo rear area)	43.7	1900	800	1,000	2,429

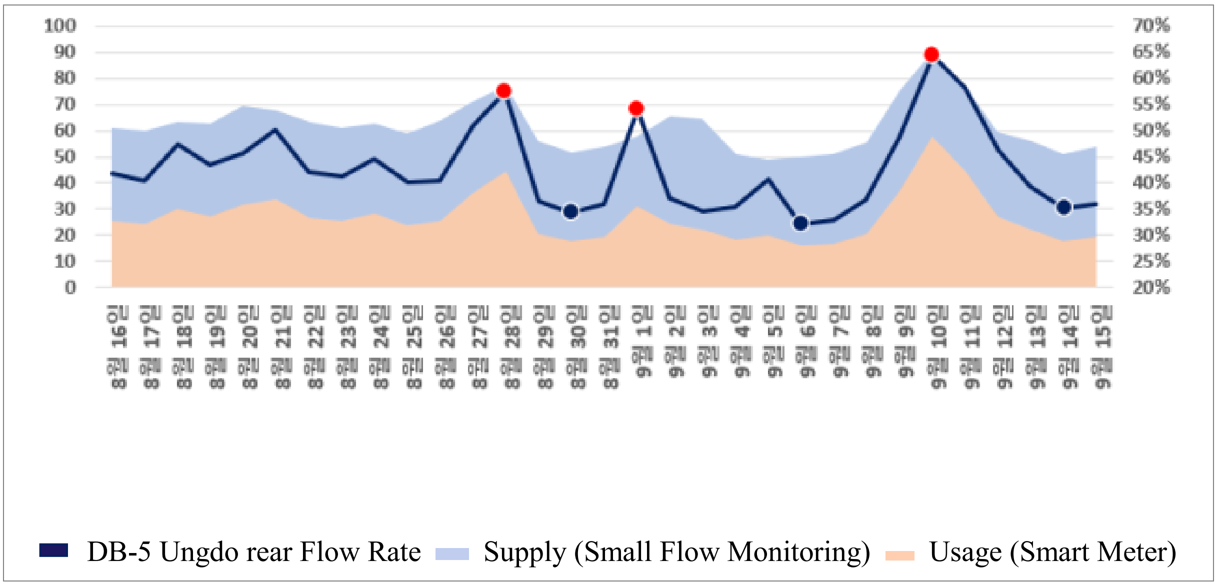
[Figure 2-3] DB Block Oil Flow Rate Data Analysis Results



[Figure 2-4] DB-5 Supply, usage, and flow rate

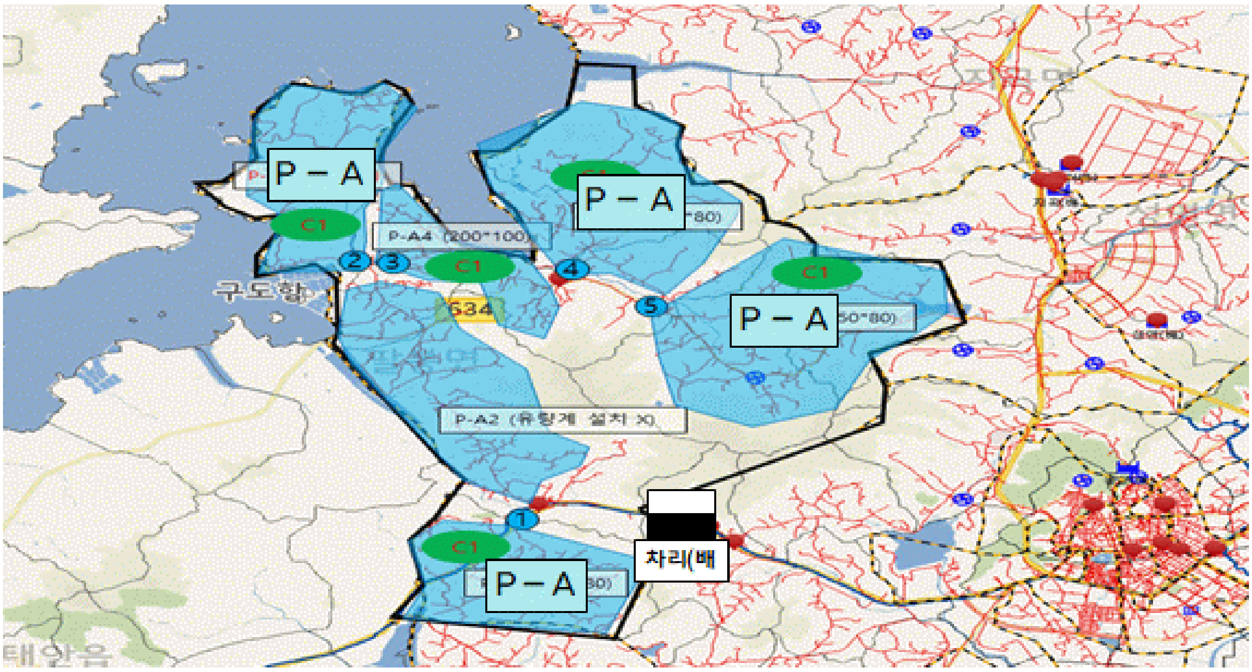


[Figure 2-5] DB-Ungdo rear end supply, usage, and flow rate



The P-A block is a mountainous area that supplies water from the Chari drainage basin, and shows a relatively low water flow rate (73%) compared to the total water flow rate (84%) in Seosan-si. In addition, managers know that it is an area with a lot of leaks because there are many old pipes buried, but it is difficult to find a leak point, so they have no choice but to manually manage the leak by relying on resident reports.

[Figure 2-6] Location map of P-A block

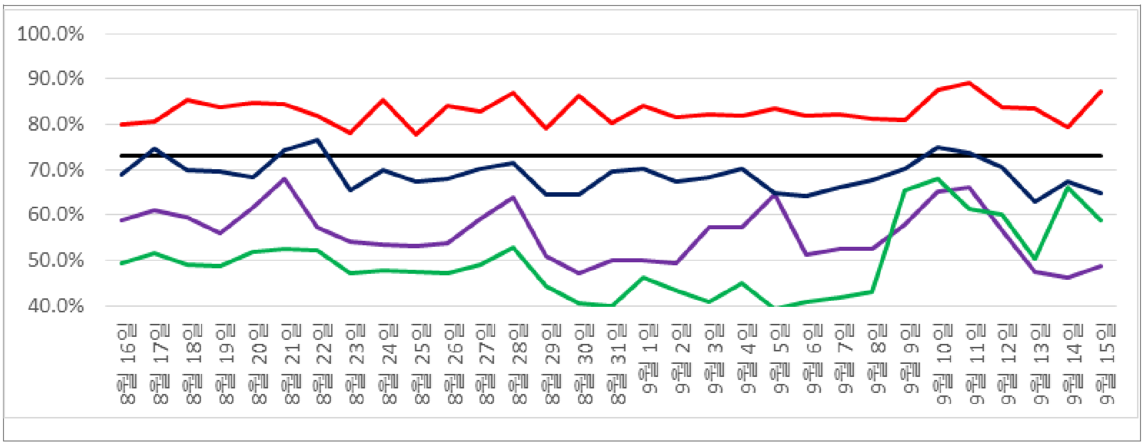


Among the P-A blocks, the P-A2 block was 56% and the P-A3 block was 49% with a relatively low flow rate, and in particular, the P-A2 block was analyzed to have a relatively large leakage despite its short pipe length.

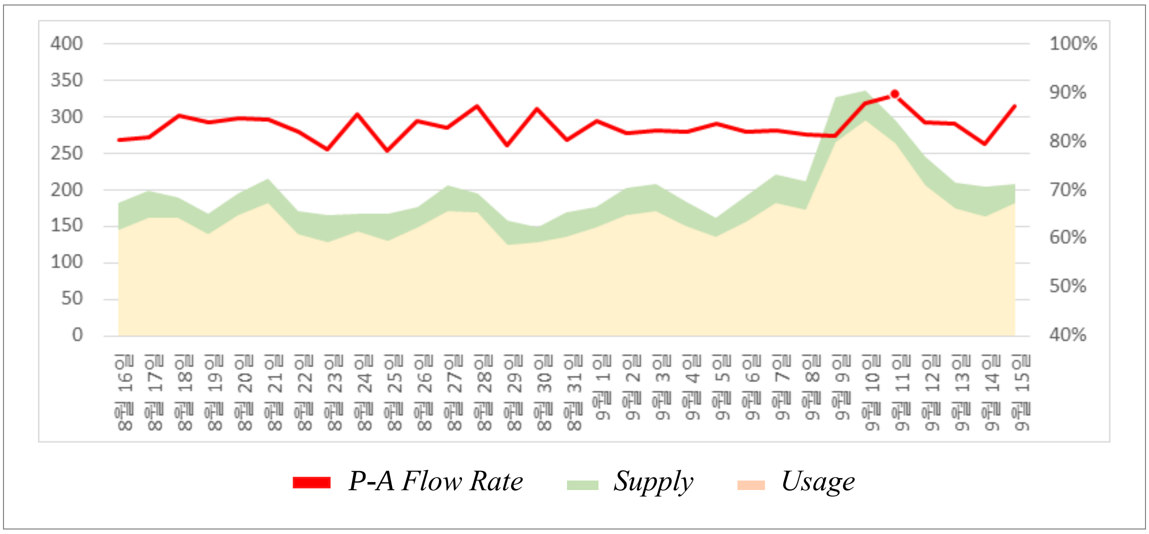
[Table 2-5] Current status of P-A block oil flow rate

section	water flow rate (%)	Supply water consumption (m^3)	Used water consumption (m^3)	non-revenue water (m^3)	Number of meters	Length of Pipe (km)
Whole P-A	73.1	41.8	30.6	11	2,714	2,714
P-A1	83.2	6.2	5.2	1.0	367	29.5
P-A2	56.5	9.0	5.1	3.9	342	21.0
P-A3	49.5	5.5	2.7	2.8	218	42.9
P-A4	69.3	4.6	3.2	3.2	311	29.6

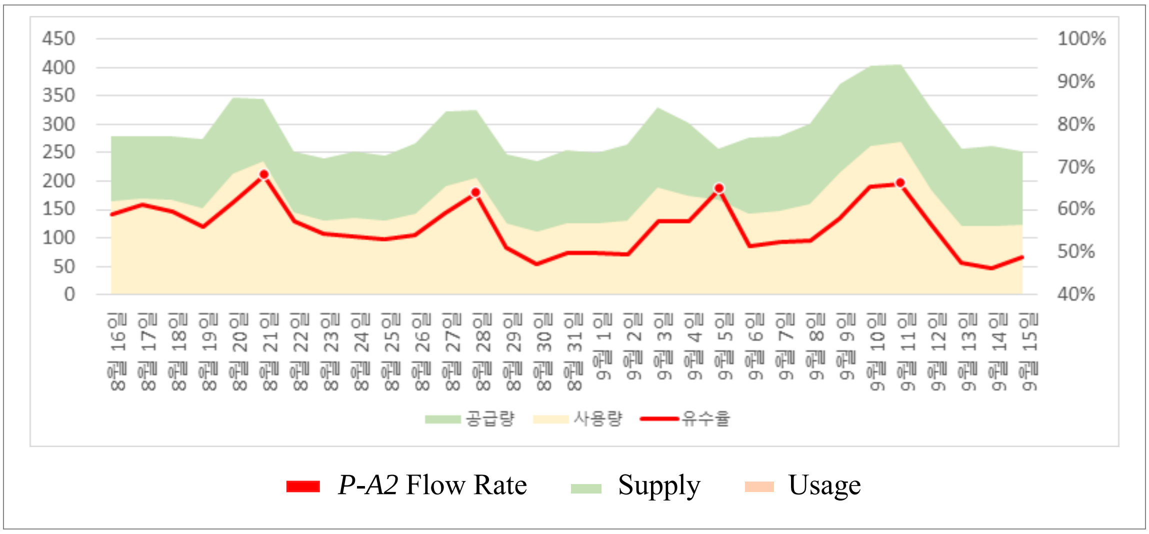
[Figure 2-7] P-A Block Oil Flow Rate Data Analysis Results



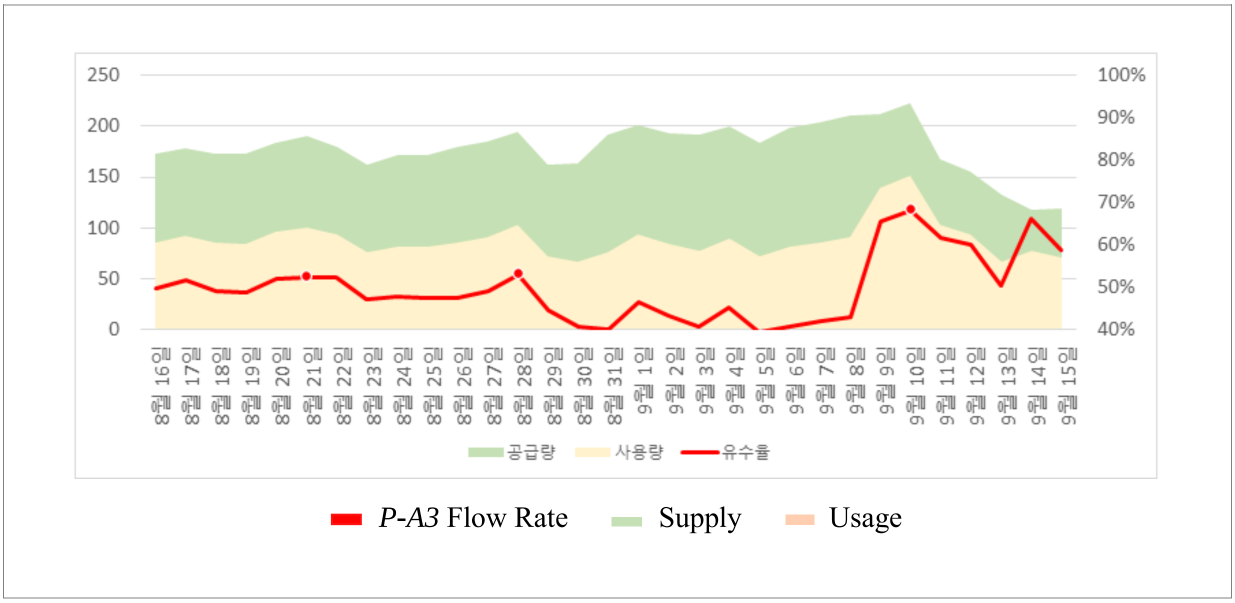
[Figure 2-8] P-A1 supply, usage, and Flow Rate



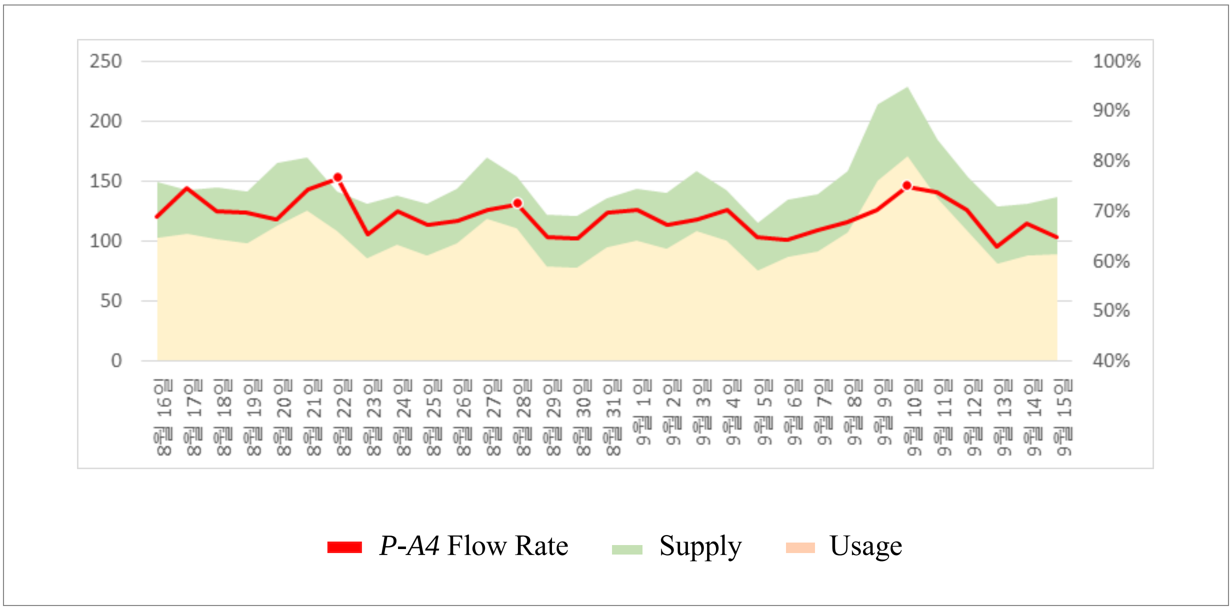
[Figure 2-9] P-A2 supply, usage, and Flow Rate



[Figure 2-10] P-A3 Supply, usage, and Flow Rate



[Figure 2-11] P-A4 supply, usage, and Flow Rate



2.2 Analyzing the pressure values of wide and local water supply and deriving excess water head points

K-water or a water purification plant operated by each local government supplies stable water to each local government's drainage system through a water transmission pipe. Water must be sent with sufficient energy (pressure) in order to supply water to the highland drainage or wide-area water supply pipes until the end. In the process, water flows into the drainage basin with more energy (pressure) than necessary in the drainage basin located in a relatively low area or an area close to the water flows into the drainage basin. In addition, a pressure relief valve is installed to reduce very large pipeline energy in the wide-area direct connection section that supplies water directly to the customer through the wide-area water supply without going through the drainage basin. Even if water is supplied through the drainage resin, a decompression valve is also installed in a section where more pipe pressure is formed than necessary. Carbon reduction is expected to be realized in local waterworks by investigating the section where more pressure is generated inside the pipeline and converting the pressure inside the pipeline into energy and using it for various facility operations. In this study, we would like to investigate the pressure status of the pipeline at the inflow of the drainage resin and review eco-friendly energy production methods through residual water heads.

2.2.1 Analysis of pressure values at the end of a wide-area water supply pipe (water drain inlet)

The water supply of Boryeong is BoryeongRaw water is taken from Daesang Dam and purified water is produced at Boryeong Water Purification Plant. The produced purified water is supplied to Seocheon through the Seocheon system. In addition, water is supplied to Hongseong, Cheongyang, and Boryeong in the direction of the Hongseong system, and it is pressurized at the Hongseong pressurization plant to supply water to Seosan and Hongseong. Again, water is supplied to Dangjin and Taean through additional pressurization at Seosan Press, and the total pipeline is about 181km and the pipe diameter ranges from 300mm to 1,650mm. Water produced at the water purification plant is fed at a pressure of 9.1 kg/cm. In this review, it was analyzed for the Hongseong system and the Seosan system, which are sections with a somewhat large difference in the level of drainage compared to the Dongsudu of the pipeline.

[Table 2-6] P-A4 supply, usage, and yield

Area	Drainage Name	Capacity (m3)	Usage (m3/일)	water level (m)	Dynamic water head (m)	Potential head (m)	Pressure head (m)
Hongsung	Ungcheon	900	6,200	72	90	19	71
Hongsung	Changdong	8,700	21,434	80	84	49	35
Hongsung	Deachoen	3,200	14,860	45	80	6	74
Hongsung	Goanchang	4,970	2,915	70	77	8	70
Hongsung	Sinboryung	40,000	5,000	12	76	12	63
Hongsung	Cheongso	2,500	3,701	60	70	7	63
Hongsung	Goangcheon	3,200	3,365	50	65	2	63
Hongsung	GangcheonKim	300	404	55	63	15	48
Seosan	Kyulsung	1,100	2,354	83	116	26	90
Seosan	Guhang	160	460	87	115	35	81
Seosan	Galsan	430	572	67	112	14	98
Seosan	Galsan Nong	480	988	79	107	26	81
Seosan	Gobuk	직결	1,578	27	103	27	77
Seosan	Ohhank	4,100	0	86	99	28	71
Seosan	Susuk	26,120	29,528	99	94	30	63

2.2.2 Analysis of Pressure Relief Valve Installation Status and Pressure Values

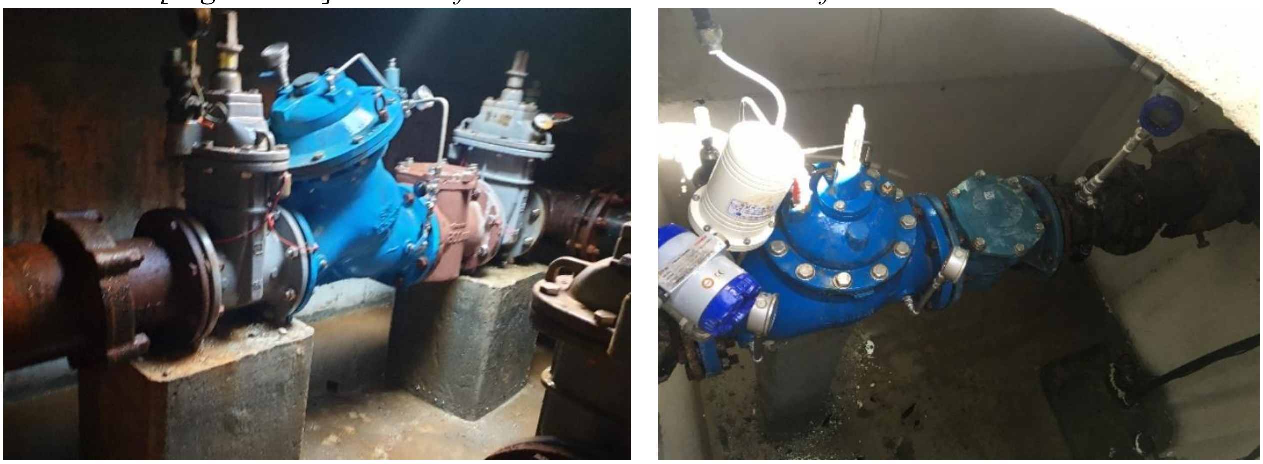
In general, local water supply is supplied with wide-area water supply through a drainage system. However, considering geographical conditions, there are areas where wide-area water supply is inevitably supplied directly. In the case of local waterworks in Seosan-si, water is supplied to Gobuk-myeon by directly branching the Boryeong Metropolitan Water Supply. However, since the pressure inside the wide-area water supply pipeline is very high, a decompression valve must be installed to supply water. According to the data from the wide-area water pipe network, the pressure at the branch point is about 10kg/cm2, and a facility (pressure reduction valve) that lowers the supply pressure of general local water to about 4kg/cmcm2 is installed and in operation. It has been confirmed that a very large energy loss is occurring in this process, and a pressure loss of about 6kg/cm2 is generated through the pressure reduction valve installed in the Gobuk direct connection area.

Among the areas where tap water is supplied from the drainage basin as well as the pressure relief valve according to the direct supply of wide-area water supply, there are areas with excessive pressure in the jurisdiction depending on the relatively low terrain. Even when supplying water to the area, a decompression valve is often installed at the inlet of the block to lower it to an appropriate water pressure. Seosan-si's local water supply business manages 69 pressure relief valves, including two direct pressure relief valves in the Gobuk water supply area. Among them, data on 15 places that can secure pressure data on the inflow side and outflow side were obtained and analyzed. In particular, the pressure reduction valve of the O-A block inflow pipeline located in Unsan-myeon, Seosan-si, measured 9kg/cm2 and physically caused a pressure loss of 4.3kg/cm2 to lower the pressure suitable for supplying to the customer.

[Table 2-7] P-A4 supply, usage, and yield

Area	Block name	Diameter	inflow pressure	outflow pressure	loss pressure
Umam	Y-A	150	5	2.8	2.2
Gobuk	G-A	50	9	6	3
Unsan	O-A	50	9	4.7	4.3
Unsan	O-A	100	8.4	5.5	2.9
Palbong	P-A	80	7.8	6.4	1.4
Palbong	P-A	80	6.3	5.3	1
Deasan	D-A	200	6	5	1
Upnea	Other than Block	100	7	4.8	2.2
Heami	O-B	100	5.1	3.9	1.2
Unsan	O-A	100	7	5	2
Gobuk	G-A	200	7.5	4	3.5
buk	G-A	200	7.5	4	3.5
Heami	O-B	80	5	3.5	1.5
Heami	O-B	150	5.2	4.3	0.9
Dongmun	SH-F1	150	8	6	2

[Figure 2-12] A View of Local Water Pressure Relief Valve in Seosan-si >



3. 3. Findings

3.1 Converting to production that can be saved by deriving leakage in blocks

Small-scale flow rate and water pressure monitoring systems were established at the inflows of some small areas of DB-5 and P-A blocks to monitor the usage of each consumer, thereby efficiently deriving suspected leakage areas. In addition to DB-5 and P-A blocks that previously calculated leakage, leakage was calculated and included in the analysis to O-A and O-B blocks, which are Ohak water supply areas where real-time flow rate monitoring systems were established through small flow rate monitoring systems and smart metering. Assuming that the leakage amount is reduced and the average water flow rate of the small block is reached through intensive leakage exploration of the small area of the block, tap water production can be reduced by the reduced leakage amount. According to the Ministry of Environment's Carbon Neutral Living Steels Guide (2021), it was calculated that the carbon emission coefficient per ton of tap water could reduce greenhouse gases by about 4773 kg CO2eq.

[Table 3-1] Status of greenhouse gas reduction using smart technology

Area	water flow rate (%)	Supply volume (m3)	Usage (m3)	Required supply amount (m3)	production savings (m3))	greenhouse gas reduction kgCO2eq
DB-5	82.5	35000	29000	34800	227.8	56
P-A	73.1	41800	30600	36700	5109.4	1262
O-A	70.6	57000	40200	48300	8748.2	2161
O-B	78.9	97100	76600	91900	5239.2	1294
sum					19,324.6	4773

* Basis for calculating greenhouse gas reduction: leakage reduction ()) × carbon emission coefficient per ton of tap water (kgCO2eq/m3)

* Carbon emission coefficient per ton of tap water: 0.247 (kgCO2eq/m3) applied (Source: Based on the Ministry of Environment's Carbon Neutral Living Practice Guide (2021)

Leakage reduction, such as the amount of greenhouse gas reduction according to the table above, is one of the reduction techniques with a large greenhouse gas reduction effect. If smart technologies installed on the site are used through various projects such as modernization projects and smart pipe network management infrastructure construction projects in the future, the leakage of water into the ground can be drastically reduced. If the oil flow rate improves in this way, the production of water purification decreases as the water leakage decreases, and the resulting power consumption decreases, which can be expected to suppress greenhouse gas emissions.

3.2 Conversion of excess water head value into power generation energy by wide area and local water pipe network

They found a section with a higher water level difference in the drainage compared to Dongsudu in the Boryeong Metropolitan Water Supply Pipeline and an area with high pressure inside the pipeline at the local water supply plant in Seosan-si. In addition, the amount of energy that can be produced when small hydroelectric power facilities are installed instead of facilities that physically reduce pressure by generating unnecessarily high pressure through the decompression valve was calculated. When calculating the capacity of power generation facilities, the aberration efficiency was 88% and the generator efficiency was 94, and the annual utilization rate of power generation facilities was calculated as 80%.

Among the pipelines flowing into the drainage basin from the Boryeong Metropolitan Water Supply Pipeline, it was calculated for a section with a flow rate of more than 1,000//day with a residual head of 10m or more, and in the case of Daecheon drainage, about 341MWh per year.

[Table 3-2] Energy of small hydroelectric generation by drainage area subject to review

Drainage Name	Capacity (m3)	Usage (m3/day)	water level (m)	Dynamic water head (m)	Pressure head (m)	Potential head (m)	Power generation (MWh/year)
Ungchan	900	6,200	72	90	71	18	10
Deacheon	3,200	14,860	45	80	74	35	49
Sinboryeong	40,000	5,000	12	76	63	64	30
Cheongso	2,500	3,701	60	70	63	10	3
Goangcheon	3,200	3,365	50	65	63	15	5
Gyeolsung	1,100	2,354	83	116	90	33	7
Gobuk	direct	1,578	27	103	77	76	11

In addition, it was calculated for a section of more than 200mm on the Seosan Regional Water Supply and Drainage Pipeline, and it was calculated that about 728MWh of power generation was possible per year.

[Table 3-3] Energy of small hydroelectric generation by decompression valve

Area	Block name	Diameter	inflow pressure	outflow pressure	loss pressure	Power generation (MWh/year)
Umam	Y-A	150	5	2.8	2.2	52
Gobuk	G-A	50	9	6	3	11
Unsan	O-A	50	9	4.7	4.3	15
Unsan	O-A	100	8.4	5.5	2.9	42
Palbong	P-A	80	7.8	6.4	1.4	14
Palbong	P-A	80	6.3	5.3	1	9
Deasan	D-A	200	6	5	1	56
Upnea	고블럭외	100	7	4.8	2.2	30
Heami	O-B	100	5.1	3.9	1.2	15
Unsan	O-A	100	7	5	2	28
Gobuk	G-A	200	7.5	4	3.5	175
buk	G-A	200	7.5	4	3.5	175
Heami	O-B	80	5	3.5	1.5	11
Heami	O-B	150	5.2	4.3	0.9	26
Dongmun	SH-F1	150	8	6	2	69

4. 4. Conclusion

4.1 Application of Field Application Smart Technology to Realize Carbon Reduction

In this study, leakage reduction was derived using a smart meter installed at the consumer and a small flow rate and water pressure monitoring system installed at the inflow point of the small area. Furthermore, if various technologies installed through the SWM project and the local water supply modernization project and technologies such as active pressure control systems are utilized and applied, carbon reduction methods at local water supply sites will be more diverse. It is expected that leakage exploration will be more efficient by remotely monitoring the flow rate and water pressure in small areas to reduce the suspected leakage area, and furthermore, it will greatly help reduce the leakage amount. Therefore, it is expected that sustainable local waterworks will be possible through the introduction of technologies that can create synergy effects of reducing leakage by linking the functions of each technology, even if it is a little less economical than the field application of uniform and theoretical smart technologies.

4.2 Expect to produce eco-friendly energy and reduce leakage through small hydropower generation on the pipe network where more pressure is generated than necessary

A plan to introduce small hydropower using falling water was reviewed by finding the point where unnecessary chickenpox was generated in the pipeline flowing into the local water supply reservoir in Boryeong Metropolitan Water Supply. Although there is not much power generation generated depending on the characteristics of local waterworks, the expected effect is expected to be very large if it targets numerous drainage systems across the country. In addition, the area where the decompression valve was installed due to excessive pressure at the inflow point of the block unit of the local water supply business was reviewed. Among them, power generation was calculated for decompression valves of a certain size or more, but if small hydroelectric power generation facilities using residual water in the jurisdiction are expanded to small pipelines, the power generation will be further expanded. In addition, eco-friendly energy can be produced through partial hydroelectric power generation by discovering the point where excessive chickenpox occurs for a certain period of time among sections without a pressure relief valve installed. At the same time, the increase in backwater leakage due to excessive pressure will be drastically reduced. This will naturally reduce tap water production and reduce carbon generation at local waterworks.

4.3 Follw up research

In this study, the method of reducing leakage using smart technology and the method of producing eco-friendly energy using residual pressure in the jurisdiction were reviewed. But there will be a variety of other ways to reduce carbon. Among them, I would like to propose topics that could not be reviewed in this study as future tasks. Local waterworks often install small pressurization plants to supply tap water to highlands. The pump at the pressurization plant is always operated, and there is a method of improving the pump's facilities to monitor the pressure generated in the container and to introduce a system in which the pump is actively controlled according to the pressure. In particular, when there is no water use at night, the pressure in the pipe increases, so the operating time of the pump will be reduced and the amount of electricity used will be reduced. Reducing the amount of water used by consumers who use tap water will be the most fundamental measure to reduce carbon. In fact, in California, the U.S., the first goal of each water service provider is to create and support various systems to save water. In Korea, where water conservation is not yet familiar, its effectiveness may be very low. However, considering the increasingly serious climate change, I would like to conclude this study by suggesting that efforts should be made to discover and make daily life a system for water conservation suitable for Korea's reality.

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