A Study on the Optimal Model for the Expansion of Integrated Supply System of Customized Industrial Water to Strengthen Corporate Competitiveness

By

RO, Kyung Yool

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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Table of Contents

1. Executive Summary

Looking at the domestic industrial water supply system, a water service provider (local government or K-water) supplies only general-purpose industrial water (raw water, purified water, and settled water), and the consumer uses the water provided by the water service provider after additional water purification to suit its application (e.g., cooling water, boiler feed water, washing water, etc.) and water quality. Therefore, companies that require high-purity industrial water such as semiconductor, display, petrochemical, and precision machinery industries directly install and operate additional water treatment facilities at their own expenditure to supply customized industrial water (pure water, ultrapure water) required for product production.

Even though there are professional water supply companies that supply industrial water, high purity industrial water that requires additional water treatment is produced and managed by the manufacturer itself, raising product costs and production risks and weakening corporate competitiveness.

In particular, when a large amount of industrial water is required for product production, the supply of industrial water in a stable and affordable manner through improvement of the industrial water supply system is a very important factor in enhancing production efficiency and corporate competitiveness because the cost of the water has a large effect on the product cost.

Taking this study as an opportunity, if a specialized water service provider expands the introduction of a system that integrates and supplies customized industrial water required by manufacturing companies, it will be possible to prevent duplicate investment in facilities and to supply industrial water efficiently at a relatively low unit price. It could lead to an improvement in the competitiveness of companies.

For example, in 2011, quantitative results were also proven through the successful operation of a customized integrated industrial water supply facility (K-water Daesan Industrial Water Center) installed in the Daesan Petrochemical Complex for the first time in Korea. However, since then, the spread of the integrated industrial water supply system has been sluggish.

Therefore, in this study, through a feasibility analysis of project expansion and a review of the project implementation method, an optimal business model and implementation plan were suggested, and efforts were made to secure new driving forces.

The conclusions drawn through this study are summarized as follows:

From a locational perspective, it was judged that the existing national industrial complex, where demanding companies were concentrated, was suitable as a business target in many aspects, such as securing stable demand and linking with government policies (regeneration of aging industrial complexes).

From an economic perspective, there is a difference depending on the availability of financial support, fluctuations in benefits and total project costs, and the quality of water required by customers, but it turns out that it is possible to secure stable economic feasibility when the scale capacity of the integrated supply facility is 50,000 ㎥/day or more.

From a policy perspective, this project is in line with the policy direction of the country that wants to secure its own technology for high-purity industrial water treatment, and the willingness of the government and K-water to pursue the project is clear, so it is possible to secure sufficient feasibility if uncertainties are resolved through thorough preparation and the customized industrial water integrated supply plan is reflected in the relevant high-level plan (2040 national waterworks maintenance basic plan, etc.).

In addition, as a result of comparing the strengths and weaknesses of various business methods including the national finance project, it is judged that the promotion in the form of government fiscal projects led by the government and K-water will be the most advantageous in many aspects (e.g., deciding on flexible rates in consideration of acceptability, enhancing project execution power, achieving effective business goals, etc.).

Now is the time for K-water, a state-owned enterprise specializing in the water sector, to actively strive to enhance the execution power of the project by reflecting the plan to expand the introduction of Integrated Supply System for Customized Industrial Water in government policies and inducing financial and institutional support.

2. Introduction

According to UN Report (2020), “Global water use has increased by a factor of six over the past 100 years and continues to grow steadily at a rate of about 1%p per year as a result of increasing population, economic development and shifting consumption patterns” (p.1).

Thus, the global water market is expected to grow gradually with the increase in water consumption. GWI (international water industry research organization) Report (2017) states that the global water market is expected to grow from about 870 trillion won in 2017 in terms of investment (i.e., capital expenditure, operating expenditure) to about 1,068 trillion won in 2022. Of these, the industrial water market (the third largest after water supply and sewerage) is expected to grow by about 25% to 162 trillion won in 2022. This trend differs only in the size of the market, but the same is true for the domestic water market*.

* (total market) 16→17 trillion won (2016 to 2020), (industrial) 2.2→2.6 trillion won (2016 to 2020)

As such, the future market for industrial water is promising. So what is industrial water? Let's start with the definition. According to the United States Geological Survey(USGS), industrial water refers to “water used for the purposes of fabricating, processing, washing, diluting, cooling, or transporting a product; incorporating water into a product; or for sanitation needs within the manufacturing facility”. Probably every manufactured product uses water during some part of the production process. Some industries that use large amounts of water produce such commodities as food, paper, semiconductors, displays, refined petroleum, or primary metals. Also, unlike potable water, industrial water has the characteristics that the required water quality and usage are different depending on what industry and for what purpose.

For example, from widely used industrial water with low purity used in product cleaning or beverage production to high purity water (i.e., pure/ultra-pure water) removed from ion substances used as semiconductor wafer process water, the water quality required to obtain the quality product varies.

That is why customized industrial water that has undergone additional water treatment from normal industrial water must be provided for the consumer enterprises.

In that context, according to K-water report (2010), "Water that creates new added value as water used by reprocessing conventional industrial water such as raw water, settled water, purified water according to the needs of the consumer"(p.8) is defined as customized industrial water.

In conclusion, customized industrial water (i.e., water with higher purity than conventional industrial water) is an indispensable utility for manufacturing companies leading the Korean economy, especially for those that produce high value-added, cutting-edge products such as semiconductors, displays, petrochemicals and other electronics.

However, the current industrial water supply system has the following structural problems: Domestic water service provider (local government or K-water) supplies only conventional industrial water, and the consumer uses the water provided by the water service provider after additional water treatment to suit its use (e.g., cooling water, boiler feed water, washing water, etc.) and water quality.

Therefore, companies that require high-purity industrial water (pure water, ultrapure water) directly construct and operate additional water treatment facilities at their own expenditure to supply customized industrial water required for product production.

Even though there are professional water supply companies that supply industrial water, high purity industrial water that requires additional water treatment is produced and managed by the manufacturer itself, raising product costs and production risks and weakening corporate competitiveness. In particular, when a large amount of industrial water is required for product production, the supply of industrial water in a stable and affordable manner through improvement of the industrial water supply system is a very important factor in enhancing production efficiency and corporate competitiveness because the cost of the water has a large effect on the product cost.

In this research, focusing on customized industrial water, the author tries to analyze and improve the problems of the current industrial water supply system from various perspectives and aspects.

That process is like finding answers to the following two main research questions. The first is "Is there a business feasibility of introducing an integrated supply system for customized industrial water?" The second is "How can we expand the introduction of this?"

Based on these two questions, detailed research scope and items are as follows:

A. Integrated supply system

B. Feasibility of Introducing Integrated Industrial Water Supply System

   - Economic / Policy / Locational perspective

C. An optimal model to expand the introduction of an integrated supply system

Through this research, the feasibility of the introduction of the integrated supply system for customized industrial water will be reviewed from various aspects as well as the advantages / disadvantages and tangible / intangible expected effects, etc. Effective measures and action plans for expanding integrated supply system, as well as suggestions for inducing the government's policy and financial support is also included.

Concept Definition

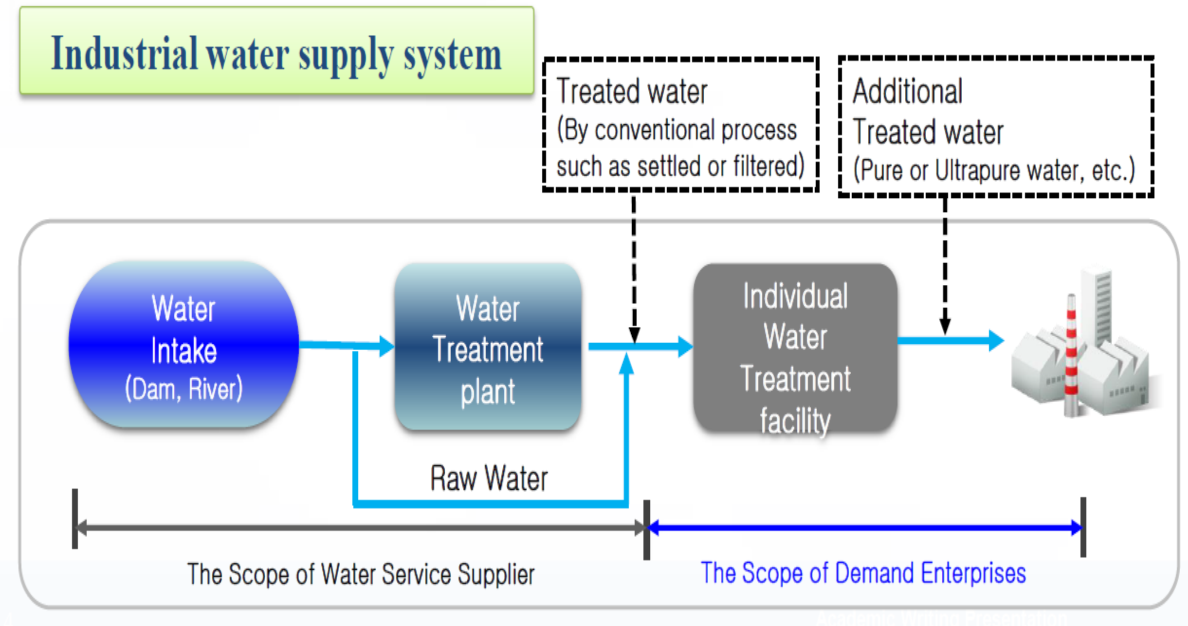
Pure water: Water consisting only of H_2O without impurities (specific resistance of 0.01~1㏁·cm). Pure water used in industrial field refers to water that has undergone simple pre-treatment and passed through distillation or reverse osmosis (RO) devices to remove impurities and increase electrical resistance.

Ultrapure water: High-purity water based on theoretical purity (specific resistance of 10.0㏁·cm or higher) by suppressing electrical conductivity, particulate number, and viable cell count to extremely low levels.

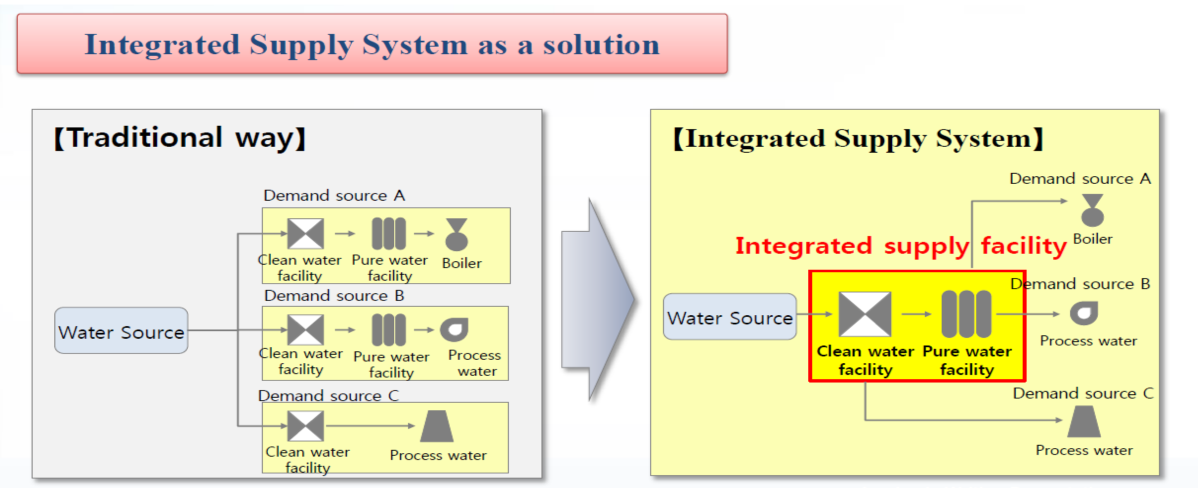
* (Main use) Used to improve yields in advanced manufacturing processes such as semiconductors and displays

Sortation	River Water	Settled Water	Low-pure Water	High-purity Industrial Water	
				Pure Water	Ultrapure Water
Applied Field	·Raw water	·General -purpose industrial water	·Product processing water ·For beverage production ·boiler feed water (low pressure)	·Semiconductor component cleaning water ·Distilled water for injection ·Camera lens cleaning water ·boiler feed water (high pressure)	·Integrated Circuit Manufacturing ·Magnetic disc cleaning water for computers ·Nuclear boiler water
Specific Resistance (㏁·cm)	0.001~ 0.01	0.001~ 0.01	0.01~0.1	0.1～1	10～18.25
Electrical Conductivity (㎲/㎝)	1000～100	1000～100	100～10	10～1	0.1～0.055
Organic Matter (ppm)	15 >	1~15	1~5	< 0.1	< 0.01

Current Industrial Water Supply System VS Integrated Industrial Water Supply System



Currently, the domestic industrial water supply system is divided into the domain of water service providers (suppliers) and individual demand (consumer) enterprises, so operated and managed separately. In other words, in the domestic industrial water supply system, a water service provider (local government or K-water) supplies only general-purpose industrial water (raw water, purified water, and settled water), and the consumer uses the water provided by the water service provider after additional water purification to suit its use (e.g., cooling water, boiler feed water, washing water, etc.) and water quality. Consequently, the final industrial water used must be produced and managed by the manufacturers themselves, resulting in national inefficiency, overlapping investment and weakening corporate competitiveness.



As shown in the figure above, the integrated supply system for industrial water supply is a system that integrates water treatment facilities of individual companies that are distributed unlike the existing supply system and provides them in a centralized manner. In other words, by installing integrated supply facilities, it refers to a system operated and managed by a professional waterworks corporate (operator) on behalf of the customized industrial water production and supply that has been in charge of individual companies. Through this, we can prevent overlapping investments in facilities and supply industrial water efficiently at an affordable unit price, and ultimately expect to improve the competitiveness of the enterprises.

Expected Effects of Introduction of Integrated Supply System

National Perspective

1. Reduce manufacturing cost and enhance industrial (company) competitiveness by preventing duplicate investment in water treatment facilities, improving operational management efficiency, and improving the utilization of factory sites, etc.

* In particular, as Korea is an export-led economy, it is highly dependent on trade, so the impact of exports of key industries (semiconductors, displays, petrochemicals, steel, etc.) on the national economy is significant.

e.g., Exports accounted for about 60-70% of GDP over the past 10 years, more than twice that of Japan

2. In connection with the introduction of the integrated industrial water supply system, the industry, academia, and research clusters are formed in the industrial complex and used as test-beds and educational facilities, thereby strengthening the capabilities of all related technologies (design, material, construction, operation, etc.) for supplying high-purity industrial water in the long term. And laying the groundwork to escape the high dependence on tech for specific country (Japan)

3. Creation of new jobs in areas related to the supply of high-purity industrial water, which is expected to increase in future demand

K-water (supplier) perspective

1. Diversification of the K-water business portfolio and fostering new growth engine businesses by expanding the introduction of an integrated high-value-added, high-purity customized industrial water supply business in the face of limitations in securing new water demand

2. Securing technical skills and O&M performance in the customized industrial water field
3. Fostering small and medium-sized enterprises by establishing a win-win cooperation system with domestic companies and inducing shared growth with SME (small-to-medium enterprise)
  * Private companies are specialized in design, manufacturing, construction, and K-water is specialized in operation and management, accumulating know-how in their respective fields

Demand company (consumer) perspective

1. Enhancement of reliability of process water supply and minimization of related risks through consignment of external specialized agencies
2. Quality improvement and production efficiency improvement by focusing on the core process of product production
3. Reduced production cost as installation and operation of individual water treatment facilities are unnecessary
4. Enhancement of personnel management efficiency by rearrangement of industrial water management personnel
5. Appropriate use of individual water treatment facility sites for other purposes

3. Literature Review and Case Study

There have been various efforts to expand the integrated supply of customized industrial water. In particular, K-water has conducted research on developing customized process design and standard financial models, establishing a pilot project to establish a customized central supply system for industrial water in Gumi, analyzing the customized industrial water market, and efficient supply. In this chapter, we will look at the performance and limitations of existing research results and then derive implications and future challenges related to this study.

Literature Review

Development of Customized Industrial Water Process Design and Standard Financial Model (2019.4, K-water)

The purpose of this study is to establish an industrial water process design and business plan according to the water quality of the water source and present a standard financial model for the smooth implementation of customized industrial water projects. To this end, pure and ultra-pure processes were selected based on basic status surveys, raw water quality analysis, and water treatment process status surveys, and standard financial models were developed and financial feasibility was analyzed by project type.

 # Main research contents and results

Classification	Main Contents	Research Results
· Basic investigation	· Raw water quality analysis of five industrial complexes in Korea · Selection of 5 to 10 water quality items with high sensitivity to process selection ·Analysis of the water quality characteristics of the project site(including seawater) through the utilization or direct analysis of existing data	· 4 water quality surveys of 9 water sources in 6 industrial complexes · Selection of water quality items necessary for ultra-pure water treatment TDS, TOC, DOC, B, Silica · Analysis of existing water purification facility operation data for the past three years and reflection of seawater quality measurement results for one year
· Process design	·Review the pre-treatment, main treatment, and wastewater treatment processes suitable for raw water and target water quality, and present guidelines for composition of processes by raw water quality. · Establish at least 20 processes by raw water quality	· Process review for three pre-treatment, three pure water, one ultrapure water, two wastewater treatment facilities, and suggest process design standards for each raw water quality · Create 89 mass balances by raw water quality and capacity
· Schematic Project cost	· Calculation of project cost (CAPEX, OPEX) by batch process, unit process, and facility size · Establish a model so that the approximate project cost for each capacity can be calculated based on Excel according to the selected process	· Users can calculate project cost by attaching an estimate for each unit process and capacity · Excel-based outline project cost can be reviewed by applying a cost function equation to the construction cost by capacity for a unit process
· Financial model	· Modified the existing K-water industrial water financial model to suit user convenience · Develop a standard financial model according to business type (water quality, scale, finance, etc.)	· Modified the existing financial model to suit the user's convenience by applying the 2017 unit price (Excel-based) · Appropriate supply unit price can be calculated by entering maintenance costs such as construction cost, electricity cost, and chemical cost for each type

National industrial complex high-purity industrial water central supply system establishment research service (2017, Gumi-si, Gyeongsangbuk-do)

(1) Business background

· The size of the global industrial water market is estimated to increase by more than 32.8%p from $24.4 billion in 2013 to $27.1 billion in 2020.

· Multinational water companies are expanding their scope across the water circulation system based on technology integration and specialization and preoccupying customized industrial water overseas markets.

· Countries that create high added value through the water industry are commonly developing the water industry centering on the water industry cluster, and the competitiveness of the water industry is strengthened through network establishment and joint cooperation system of universities, research institutes, and companies within the cluster.

(2) Concept of high purity cluster

· The Gumi high-purity cluster is a central supply facility that supplies high-purity industrial water, a promotion facility for supporting related technology development and commercialization, a facility for demonstrating the developed technology (test bed), etc. It can be defined as an accumulation complex in which related organizations cooperate.

(3) Purpose of high purity cluster formation

· Securing customized industrial water performance and entering the overseas customized industrial water market through technology development in the domestic market.

· Localization of related technologies such as materials and parts through operation of a full-scale test bed and connection with national R&D projects.

· Improved operation and maintenance capabilities through feed-back with actual consumers.

· Reinforcing the competitiveness of demanding companies (Small and Medium Businesses) and create jobs by reducing costs and improving efficiency through economies of scale through the central industrial water supply facility.

(4) Business effect

· It is possible to internalize the technology knowledge cluster and strengthen corporate competency by promoting win-win development among related companies through a cluster that activates the interaction between innovation actors, and jointly conducting mid- to long-term projects in the central and regional areas within the cluster.

· It is possible to create a technology innovation mecca for the whole period of the water industry that can commercialize strategic core technologies in the national water industry through development and demonstration tests

· Building a complex to support high-purity industrial water plant-related companies' market entry and technology development.

· Establishing a foundation to create continuous added value in the water industry by fostering small and medium-sized venture companies specializing in the water industry with global competitiveness

Table. Economic benefits for R&D investments

Unit: million won

Year	Cost				Benefit		
	Facility	Labor	R&D	Total	Waterworks Industry	All Industry	Total
2019	688			688	710	573	1,283
2020	14,382			14,382	14,833	11,969	26,802
2021	14,382			14,382	14,833	11,969	26,802
2022~2066		855	805	1,660	1,712	1,381	3,093
Total	29,452	38,475	36,225	104,152	107,416	86,656	194,072

(5) Prediction of pure and ultra-pure demand

A. Market research result of this time

The results of this market survey on pure and ultra-pure demand are as follows:

In the case of SK Hynix, M16 plant is scheduled to be completed in 2020, and it plans to invest 120 trillion won over 10 years with a plan to establish a Yong-in semiconductor cluster after 2022. (Feb 2019, Kyunghyang Shinmun et al.)

The quantity that SK Hynix is planning to use in 2020 is equivalent to M16. In the case of the M16 plant, it will cover the supply volume by increasing the reuse capacity at Icheon Campus without increasing the water supply, which should be reflected in the demand for ultra-pure water, but it is expected that there will be no increase in raw water.

Samsung Electronics is planning to install NAND Flash plants in Pyeong-taek plant, and Samsung Display is also planning to invest 14 trillion won in Cheon-an plant to expand OLED plant and continue to invest in semiconductor field.

Samsung Electronics is investing a total of 20.4 trillion won in NAND lines, etc. in the Pyeong-taek factory, and Samsung Display is also planning to invest in the semiconductor and display sectors by investing 14 trillion won in the Cheon-an factory to expand the OLED factory (Feb 2018, Seoul Economic Daily)

LG Display is promoting to expand its plant by investing 1.5 trillion won in Gumi plant, which is expected to increase demand for pure and ultra-pure water.

Domestic demand for pure and ultra-pure water is expected to increase as shown in the table below, and Samsung Electronics (Godeok) is included in the 2025 water maintenance master plan. In the case of LG Display, etc., it is judged that it is not included in the 2025 water maintenance master plan, so it shall be calculated by including it in the estimation of industrial water demand.

However, since the ultra-pure water sector has a large demand (more than 50,000㎥/day) from individual companies, it is reasonable to exclude it from the application of the customized integrated supply method of industrial water. In addition, it will be necessary for K-water to pursue a strategy to accumulate operational experience in ultra-pure facilities by acting on behalf of its operations management tasks.

B. Estimation of demand for industrial water

· The ratio of industrial water use is applied by dividing into ultra-high purity, high purity, and settled water by field such as semiconductor, LCD, and solar.

· As for the ratio of use, the ratio by use of 40 individual companies surveyed during the "K-water Industrial Water Market Analysis and Efficient Supply Plan (2010)" service, and the ratio by use of 44 plants surveyed on-site in this service are comprehensively considered.

· The semiconductor and LCD industries have a high proportion of high-purity industrial water.

Classification		Key use	Field				
			Semi conductor	LCD	Solar	Electronics	Other
Usage Ratio	Ultra-pure	Production process	40%	40%	29%	5%	-
	High purity	Boiler water supply	10%	10%	10%	10%	10%
	Settled water	Cooling water etc.	50%	50%	61%	86%	90%

Market Analysis and Efficient Supply of Industrial Water (2010, K-water)

A. Industrial water M/P establishment background

- High value-added market with continuous growth potential at home and abroad
- Systematic access to the domestic industrial water market with high barriers to entry into the market is required
- Strategic and specific approach is required as one of the new growth engines

B. Market conditions and problems

- Market operation status

  Most individual companies supply water after water treatment by themselves

  Some large corporations are operating water treatment facilities by entrusting them to specialized water institutions.

- Market problems

  It is difficult to enter because it is a closed market in the form of direct operations

  High-cost market formation due to high barriers to market entry

C. Selection of project targets

(1) Selection criteria

Out of 505 industrial complexes and 75,947 individual companies, marketability, business feasibility (1 trillion won in sales), market size (10,000㎥/day of use), and business evaluation are carried out and selected.

(2) How the project is carried out

Table. How the project is carried out

Classification	Investment Business	Operation Service Business
Selection Criteria	Pre-investment or customized integrated supply business	Asset acquisition or operational service business
Business Method	Supply after installation of new facilities	Operation entrustment by contract
Scope of Business	Investment + Operation + Maintenance +Facility Improvement	Operation + Maintenance + Facility Improvement

(2) Business Model

Table. Business Model

Classification	Main Contents
Integrated Service Model	A business that realize savings in supply prices due to economies of scale
Cost advantage model	A business that offers a competitive price lower than the general industrial water price range.
Tech. advantage model	A project that provides technical skills covering surface and alternative water resources

(3) Project Target: 11 industrial complexes and 11 individual enterprises

Table. Content of Business

Business Model	Business Method	strategic project implementation target
Integrated Service(5)	Investment Business	5 Daesan Corporation, Daesan (Daehoji), Daesan (2, 3) / Yeosu / Onsan Industrial Complex
Cost Advantage (7)	Operating Service	Hyundai Steel, GS Caltex, Honam Petrochemical, SK Energy, S-OIL, Samsung Precision Chemical Co., Ltd. Moorim P&P
Tech. Advantage (10)	Investment Business	POSCO (Gwangyang), Samsung Electronics (Godeok)
	Operating Service	Samsung Electronics (Cheonan, Hwaseong), Cheonan 3 Industrial Complex (Reuse), Northern BIT (Reuse), Asan Tangjeong (reuse), Gwangyang Industrial Complex (reuse), Yeosu Industrial Complex (reuse), Pohang Industrial Complex (Reuse)

Strategic project sites were selected for industrial complex tenants and individual companies (more than 10,000 m^3/day of facility size), but reliability is low due to insufficient economic and financial feasibility analysis in the process of selecting project performance methods, promotion models, and project targets. In addition, it is necessary to re-establish the project site in consideration of changes in conditions as the ten years have passed since the service was performed.

Case Study

K-water investigated the cases of customized industrial water integrated supply project in the Daesan Petrochemical Complex for the first time in Korea and drew implications.

(1) Purpose of business

The purpose of the project is to contribute to reducing costs and strengthening corporate competitiveness through integrated supply of high-quality industrial water in the Daesan Maritime Industrial Zone, and to develop the national water industry by securing global competitiveness by accumulating know-how in design, construction, and operation of advanced water treatment facilities.

< Status of Daesan Petrochemical Complex >

£ Location: Dokgot-ri, Daesan-eup, Seosan-si, Chungcheongnam-do

£ Area: 15,610,000m^2 (4.73 million pyeong)

£ Major Enterprises: Hanwha Total (Samsung Total), Hyundai Oilbank, Lotte Chemical (Honam Petrochemical), LG Chem, KCC and 60 others

£ Total sales: KRW 21 trillion (3.25 trillion in national tax, KRW 17.7 billion in local tax)

£ Employees: approximately 11.5 million (7,500 including partner companies)

(2) Overview of the integrated supply project of customized industrial water

£ Project Name: Integrated supply of customized industrial water for Daesan Maritime Industrial Zone

£ Project target area: Daesan Maritime Industrial Zone, Daesan-eup, Seosan-si, Chungcheongnam-do

£ Supply target: 5 Daesan companies (Hyundai Oilbank, Hanwha Total, Lotte Chemical, LG Chem, KCC)

Sortation	Hanwha Total	Hyundai Oilbank	Lotte Chemical	LG Chem	KCC
Area (pyeong)	950,000	820,000	350,000	360,000	640,000
Sales (KRW)	3.7 trillion	9.5 trillion	3.0 trillion	3.4 trillion	2.1 trillion

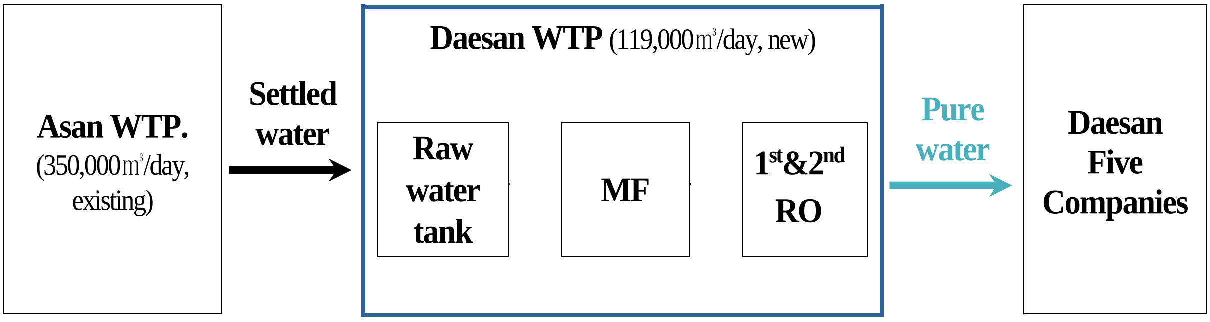
Workers	1,000	1,660	600	740	4,450
Products	Ethylene, propylene, etc.	Gasoline, diesel, lead, etc.	Polypropylene, polyethylene, etc.	Ethylene, propylene, etc.	Gypsum board, silicon, etc.

£ Business method: Investment and operation of the Korea Water Resources Corporation

£ Facility size: Industrial water pure 119,000㎥/d (reverse osmosis), waste water 11,000㎥/d

£ Project period: 27 years (construction '10~'11, operation '12~'36)

£ Total project cost: KRW 82.2 billion



(3) Implications

As the only case of converting to a customized integrated supply method of industrial water, K-water implemented a project to integrate and supply customized industrial water to Daesan Petrochemical Complex, and signed a mutual agreement to recover investment costs at a consultation rate with demand companies (See figure above). In order to reduce transportation energy and minimize pollution in pipes, the shortest-distance facility location and the existing industrial water supply pipeline were planned to be utilized as much as possible (See figure below).

Given its operational performance, it is necessary to expand its introduction nationwide in the future as it has been shown to have an economic effect (cost reduction, etc.) of KRW 92 billion on the introduction of the integrated supply system. (Below Table)

※ Economic Effects of Integrated Supply of Customized Industrial Water

Classification		Individual supply facility (A) (50,000m^3/d*4ea)	Integrated supply facility (B) (200,000m^3/d*1ea)	Economic Effects (B)-(A)
Water production (m^3/d)		200,000	200,000	
Constant Value	Facility Investment costs (million won)	203,151	132,371	△70,780
	O&M costs (million won)	369,915	307,820	△62,095
	Total Cost (million won)	**573,066**	**440,191**	**△132,875**
Operation Period (Including construction 2years)		22 years		
Present Value	Facility Investment costs (million won)	169,196	110,194	△59,002
	O&M costs (million won)	196,996	164,020	△32,976
	Total Cost (million won)	**366,192**	**274,214**	**△91,977**
Production Unit price	Annual operating costs (won/㎥)	251	209	△42.5
	Facility Investment costs (won/㎥)	216	141	△75.3
	Unit Price (won/㎥)	**464**	**347**	**△117.35**

* Source: K-water Research Institute for Policy Economics (2012)

Although there have been steady efforts to investigate the basic research, develop technology, and spread the introduction of customized industrial water integrated supply systems, it has been sluggish to push for additional projects since K-water's Daesan Industrial Water Center.

The main reasons will be uncertainty in demand and controversy over business feasibility, lack of government attention and support, and lack of specific implementation strategies of K-water.

This study intends to recover from the sluggishness by reviewing the feasibility of the project, the method of implementation, etc. and drawing up the optimal business model and implementation plan by reflecting the changed economic, social, and political conditions.

4. Research Methodology

£ ***Basic direction***

『Related Acts and subordinate statutes and guidelines』

In order to establish a budget plan for large-scale new projects (total project cost of 50 billion won or more, national financial support of 30 billion won or more), a preliminary feasibility study should be conducted by the Minister of Strategy and Finance.

[Article 38 of the National Finance Act (Preliminary Feasibility Study), Article 13 of the Enforcement Decree of the same Act, Article 2 of the Ministry of Economy and Finance's preliminary feasibility study operation guidelines (Define of preliminary feasibility study)]

The preliminary feasibility study aims to prevent budget waste and contribute to the efficiency of financial operations by making new investments in financial projects transparent and fair based on priorities through objective and neutral investigation of the feasibility of large-scale financial projects.

[(Article 4 (Purpose of Preliminary Feasibility Study)]

In this study, we will analyze the economic and policy feasibility of implementing a customized integrated supply of industrial water from a national perspective by utilizing a preliminary feasibility study methodology that corresponds to a preliminary procedure for determining whether to invest in government finances.

The purpose of the customized integrated supply of industrial water is to enhance corporate competitiveness through efficient supply of industrial water, and in order to achieve this, the key is to secure acceptability of charges, namely to determine the appropriate supply unit price that can be accommodated by companies.

Companies will try to achieve maximum effect at minimum cost, and they will be able to supply water at the cheapest price when implemented in the form of national financial projects, such as the wide-area water supply project in charge of K-water.

On the other hand, business methods through private investment have limitations in lowering fees, considering the high financing costs compared to financial projects implemented by SOEs (K-water), and it is difficult to achieve unless stable investment recovery (business feasibility) is secured.

In addition, in April 2018, the project to supply pure-grade customized industrial water to the petrochemical complex in Daesan (Daesan-eup, Seosan-si, Chungnam) through the seawater desalination facility passed a preliminary feasibility study. For the first time in the K-water industrial water supply project, it succeeded in receiving the government's financial support (30% government subsidy) for the construction project cost. Therefore, for customized integrated supply projects with similar business characteristics, we will first review the feasibility of implementing financial projects, which are advantageous in increasing acceptance by lowering the fee burden.

* Under Article 75 of the Waterworks Act (National Treasury Assistance, etc.), the State may subsidize or lend waterworks service providers expenses incurred in waterworks service.

In this study, among the three assessment frameworks of preliminary feasibility studies, the feasibility of customized integrated supply of industrial water will be analyzed based on economic analysis (cost-benefit analysis) and policy analysis (consistency and willingness of policy and risk factors for project implementation). In addition, for private investment (PF) or consignment business methods, the pros and cons of each business method will be compared in various respects to draw conclusions. For reference, the actual preliminary feasibility study also examines the possibility of implementing private investment projects to determine whether to implement financial projects only if private investment projects are not appropriate.

Overview of economic analysis.

Cost-benefit analysis is a key research process that analyzes the expected national economic ripple effects and suitability of investments when carrying out the target project, and uses cost-benefit analysis as a basic methodology. The economic analysis of preliminary feasibility studies requires the general guidelines and sector-specific standard guidelines to be applied to ensure consistency of assessment with other projects. In this study, the analysis is conducted by referring to the existing preliminary feasibility study guidelines and the case of the Daesan seawater desalination project.

* A preliminary feasibility study was passed in 2018 as a project to supply customized industrial water to demand companies by desalinating seawater.

A. Cost estimation

This economic analysis calculates appropriate costs based on objective data such as research reports, existing waterworks construction cost calculation standards, and estimates, and estimates total project cost and economic analysis data.

B. Estimating demand and benefits

In this study, it is intended to estimate water demand based on the literature, research data, and water usage performance, and to calculate economic benefits based on the industrial water supply benefits generated through the supply of industrial water.

C. Economic feasibility

Economic feasibility is evaluated by calculating the cost-benefit ratio (B/C), net present value (NPV), and internal rate of return based on quantified costs and benefits. On the other hand, since this project is a water resource business, the analysis is conducted by applying the economic analysis period and social discount rate (4.5%), project cost estimation method according to the relevant research and guidelines.

* "Complementary Research on General Guidelines for Conducting a Preliminary Feasibility Study (Stage 5) (KDI PIMAC, 2008)" and "General guidelines for conducting preliminary feasibility studies (Ministry of Economy and Finance, 2017)", "Complementary Research on the Standard Guidelines for Preliminary Feasibility Study of Water Resources Projects (4th Edition) (KDI PIMAC, 2008)"

Policy Analysis Overview

The policy analysis does not include economic analysis, but quantitatively or qualitatively analyzes the assessment items that are important in assessing the feasibility of carrying out the project. This study referred to the "General Guidelines for Preliminary Feasibility Study (5th Edition)" and conducted a narrow-line policy analysis, such as policy consistency, willingness to implement, risk factors for project implementation, and excluded regional balanced development analysis (regional backwardness, the ripple effect of the local economy, etc.).

Comprehensive evaluation and policy suggestions

In the government's preliminary feasibility study, the “Financial Project Evaluation Advisory Committee” uses the Analytic Hierarchy Process (AHP) to derive the adequacy of project implementation into quantified values. However, in this study, the comprehensive evaluation using the AHP method is not conducted due to the limitations of time and cost, and difficulty in recruiting experts.

Based on the results of economic and policy analysis according to the methodology presented above, the feasibility of the project will be comprehensively evaluated, and the limitations of this study and additional research tasks to overcome them will be suggested.

※ Attachment: Flow chart of preliminary feasibility study for large-scale construction projects

5. Analysis and Findings

Prior to the feasibility analysis of the customized integrated supply of industrial water, the project sites suitable for the implementation of the integrated supply project were selected in consideration of the essential prerequisites. As a result, five project sites were derived and economic and policy feasibility analyses were conducted for each candidate site as follows:

< Major prerequisites for selecting a candidate site for the project >

A. Stable demand secured

Areas where demand for pure water (before and after 1MΩ•cm of water quality) is more than 30,000㎥ /day, and where continuous water use is expected in the future;

Minimize facility investment costs and maximize economic feasibility by selecting complexes that are concentrated in semiconductors, displays, steel, and petrochemical industries with high pure water usage among national industrial complexes.

* Restrictions on the size and type of facilities (excluding ultra-pure numbers with limited demand) to ensure minimum economic feasibility.

** Excludes new national industrial complexes (Seokmun, Daegu, Light Green, Blue Valley, etc.) whose future demand is uncertain due to low sales rates.

B. Water Supply Infrastructure Conditions

Areas where reliable water supply is available using existing pipe networks

→ Reduce the cost of installing new water intake facilities

* National Industrial Complex can provide stable water supply by utilizing the wide-area water supply network operated and managed by K-water.

** For your information, K-water has operated and managed a nationwide water supply network (35 wide-area waterworks and 13 industrial water facilities) starting with the acquisition of Ulsan industrial water facilities in 1979, and is providing industrial water to major industrial complexes in Korea (Gumi, Yeosu, Ulsan, Mipo/Onsan, Changwon, Sihwa)

D. Regions without restrictions on K-water project execution)

K-water is designated as an industrial water supply business operator in accordance with the relevant statutes and guidelines (such as the “Water Act" and the "Operation Guidelines for Industrial Complex Support"). K-water is the operator of the water supply project of the National industrial complex.

In addition, in the case of large-scale individual factories (more than 300,000㎡), K-water can be implemented in accordance with Article 48 of the Waterworks Act (industrial water installed by the state).

E. Linking with Government Policy

The government's policy to strengthen competitiveness and revitalize remodeling of old industrial complexes (2014~17), promote industrial complex regeneration projects (announcement of industrial complex big renovation plan, 19 November), and support policies for old factory remodeling in industrial complexes (2020).

* Industrial complexes in Gumi, Yeosu, and Ulsan were selected as the target complexes for the old industrial complex competitiveness enhancement project.

Considering the above prerequisites, four existing national industrial complexes and Daesan Maritime Industrial Zone were selected as candidates for customized integrated supply projects, and new national industrial complexes were excluded from the project because conditions were not mature.

* Sale rate (2017): Seokmun (17%), Daegu (53.1%), Light Green (4.1%), Pohang Blue Valley (10.3%), etc.

※ Selection of the target site for the integrated supply of customized industrial water (draft)

Demand area	Consumer	Demand (10,000㎥/d)	Type of water	Remark
Sum		27.2		
Yeosu National Industrial Complex	Lotte Chemical, Hanwha Chemical, LG Chemical, etc.	6.2	Pure water	Conversion Demand
Ulsan Mipo National Industrial Complex	SK energy, SK chemicals, etc.	5.0	Pure water	Conversion Demand
Gumi National Industrial Complex	High Tech Valley	3.0	Pure water	New Demand
Onsan National Industrial Complex	S-oil, Korea Zinc, etc.	3.0	Pure water	Conversion Demand

Daesan Petrochemical Complex	Hyundai Oilbank, Hanwha Total, etc.	10.0	Pure water	New Demand

Assumption of Economic Analysis

Economic analysis is a process of identifying the economic and financial feasibility of a business through calculations of benefit/cost ratio (B/C Ratio), net present value (NPV) and internal rate of return (IRR) and performing sensitivity analysis to the effects of changes in key variables on economic feasibility to compensate for errors in estimates.

This study adopts Cost-benefit Analysis as the basic methodology for economic analysis, and, in accordance with the “Preliminary Feasibility Study and Economic Analysis Guidelines(MOEF, KDI)”, the following conditions are assumed:

First, all costs and benefits of an economic analysis were calculated at an unchanged price as of 2018.

Second, the period of generation of benefits shall be 30 years after completion of facility investment . The preliminary feasibility study (2017-2018) of the Daesan Industrial Waterworks (Seawater Desalination) project, which has similar business characteristics, was referred to.

Third, the current price was applied to project costs and benefits as of 2018, and because of the nature of the construction project, the benefits are initially concentrated while the benefits are generated for a long time after construction, the social discount rate was applied to the expected costs and benefits.

* For your information, both costs and benefits in economic analysis mean 'social costs and benefits'. Therefore, the analysis includes not only this direct cost of the project but also all explicit and implicit costs to the government and private sector to generate estimated benefits.

Cost estimate: Total project cost + O&M cost

- **Total project cost**: Integrated supply facilities (water treatment plant, pipeline, etc.) construction cost, compensation cost, survey design cost, construction management cost and reserve cost

* Water intake facilities and pre-processing facilities: Basis for rough estimation of waterworks facility operation and construction costs (2016, Ministry of Environment)

* Pure water production facilities: Civil engineering and building (construction standard market unit price applied to construction, 2018 Ministry of Land, Infrastructure and Transport), electricity generation and measurement (Basis for rough estimation of waterworks facility operation and construction costs)

* Wastewater treatment facility: Wastewater generated from the integrated supply plant is linked to a nearby wastewater treatment facility

* Pipeline facilities: Waterworks Operation and Construction Cost Estimation Criteria (2016, ME) and Gumi National Industrial Complex High purity Industrial Water Supply System (2017, K-water)

- Operation and management expenditures : labor costs, expenses, chemical costs, water supply, electricity cost, repair and maintenance cost, sludge treatment cost, general management cost, etc.

* Referred to the research report on the operation performance of the existing Daesan Industrial Water Center and the development of customized industrial water process design and standard financial model.

Benefit estimate

1) Estimation of industrial water supply benefits:

In this study, estimation of the supply benefits of industrial water (pure water) can be considered in two main ways. There may be ways to consider the various economic values obtained by supplying industrial water and to calculate the benefits of reducing the own water treatment facilities and operating expenses of individual enterprises by installing integrated supply facilities. In other words, the cost of water treatment for individual enterprises that is reduced when pure water is supplied from an integrated industrial water treatment plant is converted into benefits.

However, even if the benefits are calculated in the above manner, there is a limit to reflect all benefits. In the case of the former, the water quality produced and supplied through customized integrated supply facilities is better than the purified water on provided in the KDI's "Guidelines for Calculating Industrial Water Supply Benefits (2009)", so it has a problem of underestimating benefits.

In the latter case, it is very difficult to obtain accurate data because the facility investment and operating expenditures of individual companies' water treatment facilities correspond to business secrets. In addition, there is a problem that the reliability of benefit estimation is reduced when the cost and benefits of individual companies that differ in facility size and water treatment process are calculated based on the Daesan Industrial Water Center operated by K-water or related research data.

Nevertheless, the most reasonable measure applicable in this study is to follow the case of calculating the benefits of the preliminary feasibility study of the Daesan Industrial Waterworks (Seawater Desalination) project with similar business characteristics. Therefore, the marginal production value of purified water produced in customized industrial water integrated supply facilities shall be applied as a parameter for calculating the benefits by applying the “Industrial Water Supply Benefits Guidelines (KDI, 2011)”.

2) Estimation of industrial water supply benefits:

Benefits of supplying industrial water = Demand for new customized industrial water (㎥) * Economic value of industrial water (won/㎥)

The industrial water supply benefit is calculated by estimating the new industrial water demand at the project site and multiplying it by 365 days per year to calculate the annual water supply. Then, the water supply is multiplied by the economic value of industrial water to finally calculate the benefit.

However, as mentioned above, the quality of industrial water supplied to this project site is of pure water quality that is better than the purified water suggested in the KDI guidelines. Therefore, it seems that the possibility that the benefits may be underestimated by far exceeding the quality of industrial water (settled water, purified water) suggested in the guideline cannot be excluded.

Since the economic value for calculating the industrial water supply benefit is the value in 2009, the economic value was derived by considering the timing of the benefit occurrence. To this end, the Bank of Korea's producer price index (total index) is applied and corrected. The producer price index of the Bank of Korea is shown in Table 1 below, and the economic value of each water quality in 2019, corrected by the price index, is shown in Table 2.

Table.1 Producer Price Index

Account Item Code	**2009**	2010	2011	2012	2013	2014	2015	2016	2017	2018	**2019**
Total Index (2015=100)	**95.42**	99.06	105.71	106.44	104.74	104.18	100.00	98.18	101.57	103.48	**103.50**

* Source: Bank of Korea producer price survey

Table2. Economic value for calculating industrial water benefits (2018)

Sortation		Purified water	Settled water	Raw water
Economic Value (Won/㎥)	2009	1,129.6	855.2	610.7
	2018	1,225.0	927.4	662.3

※ Guidelines for Calculating the Benefits of Supply of Industrial Water (KDI, 2011.3)

Sortation	Purified water	Settled water	Raw water
Economic Value(Won/㎥)	1,129.6	855.2	610.7

Estimation of demand: Demand for customized industrial water (pure water)

Securing demand should be a prerequisite for the introduction of an integrated supply system for customized industrial water. Here, demand is divided into demand (conversion demand) that is converted from existing industrial water supplies to integrated supply and demand (new demand) that is supplied to new demand sources.

Of the two, demand that meets the conditions for selecting a project site is conversion demand. The demand was estimated by calculating the amount of water that needs to be supplied with pure water among the amount of industrial water used in the existing national industrial complex selected as the project site, and the conversion rate of pure water of the existing industrial water usage was calculated by applying 10% according to the research results.

* Assume that the total supply of industrial water has been approximately 10% recently (2019)]

Sortation		Where to use	Percentage of usage by sector				
			Semiconductor	LCD	Solar	Electronic	Etc.
High-purity	Ultrapure Water	Production Process	40%	40%	29%	5%	-
	Pure water	**Boiler feed water**	**10%**	**10%**	**10%**	**10%**	**10%**
Normal	Settled water	Coolant, etc.	50%	50%	61%	86%	90%

* Source: K-water internal report (2010)

However, the project sites (Gumi, Daesan) where the demand for pure water was presented in the recent survey and research data were applied with the values.

Economic Analysis Results

Sortation	Scale of customized industrial water supply facilities		
	10,000㎥/day	30,000㎥/day	50,000㎥/day
PV of total benefit	66,709 (66,709)	200,170 (200,170)	333,632 (333,632)
PV of total cost	109,030 (92,263)	219,557 (191,622)	333,692 (289,916)
NPV	-42,321 (-25,554)	-19,387 (8,548)	-60 (43,716)
Benefit-Cost Ratio	0.61 (0.72)	0.91 (1.04)	1.00 (1.15)

Note 1) (): Assuming 30% government subsidy
Note 2) When introducing a low-purity pure water treatment process, B/C increases by about 15% due to cost reduction.

※ **Conditions for economic analysis review:**
► Scale of facility: Integrated WTP 1/3 / 50,000㎥/day, water y pipeline about 5km
► Treatment process: pure production (UF + 2RO + EDI: high purity)

Water Quality	Pretreatment	Pure water treatment process
1㏁•㎝ or less (low purity)	UF/Coagulation+ Sedimentation+ filtration	2-stage RO / 2B3T
1㏁•㎝ or more (high purity)		2-stage RO+EDI / 2B3T+1-stage RO+MB

* source: Customized industrial water process design and standard financial model development research report

► Analysis period: 3 years of construction and 30 years of operation (Considering the useful life of waterworks under the Local Public Enterprises Act)
► Social discount rate: 4.5% (General guidelines for conducting preliminary feasibility studies by the MOEF, September 2017)
► All costs and benefits are calculated at an unchanged price as of 2018

As a result of economic feasibility analysis, it is difficult to secure economic feasibility because the economic feasibility of the facility size of 10 to 30,000㎥/day is less than 1.0 with B/C 0.61 to 0.91, and economic feasibility can be secured with B/C 1.0 only if the facility size is 50,000㎥/day or more. .

In particular, facilities below 10,000㎥/day are B/C of 0.61, making it impossible to pass the preliminary feasibility study, which is a prerequisite for the implementation of national financial projects, regardless of the state financial support. Here, national financial support is based on 30% of government subsidies by referring to the Daesan seawater desalination (industrial water supply) project.

In the case of a 30,000㎥/day facility, B/C of 0.91 is expected to be close to B/C 1 depending on whether financial support is provided, total project cost decreases or benefits increase, but considering the potential risks, it is uncertain whether or not the financial project will be implemented.

In the past, there were cases in which B/C 0.8 to 1 projects were pushed ahead as financial projects by securing feasibility (AHP>0.5) as a comprehensive feasibility assessment, but usually B/C should be more than 1 considering the proportion (40-50%) of economic feasibility.

** AHP (Analytic Hierarchy Process) A method for comprehensively evaluating various feasibility assessment indicators, such as economic, policy, and balanced regional development, according to their weights*

In conclusion, the facility capacity (demand) 30,000㎥/day (Gumi, Onsan) cannot be optimistic about the implementation of the financial project, and those more than 50,000㎥/day (Yeosu, Ulsan, Daesan) are expected to be implemented as a financial project by passing a preliminary feasibility study.

For reference, this is the result of review based on pure water with high purity (1㏁•cm) or higher. Therefore, in the case of applying a low-purity pure water treatment process (less than 1㏁•cm), B/C is expected to increase by about 15%p, and it is expected to be more advantageous in securing economic feasibility.

Sensitivity analysis

In consideration of potential risks due to changes in social, economic, and technological conditions, a sensitivity analysis was conducted on the increase or decrease in social discount rate, total project cost and benefits.

- Social discount rate fluctuation factors: economy (economic situation), interest rate and inflation
- Sensitivity according to the factors of increase or decrease in total project cost: increase or decrease in construction cost, compensation cost, design cost according to changes in site conditions
- Benefits increase/decrease factors: fluctuations in demand, recalculation of existing benefits, and discovery of new benefits

※ Sensitivity analysis result by facility capacity

<Facility capacity 10,000㎥/day>

► Analysis according to discount rate

(Unit: KRW 1 million)

Social Discount rate	PV of Total benefit	PV of Total cost	NPV	B/C Ratio
2.5%	89,093	136,042	46,949	0.65
3.5%	76,787	121,173	44,386	0.63
4.5%	66,709	109,030	42,321	0.61
5.5%	58,402	99,036	40,634	0.59
6.5%	51,478	90,773	39,295	0.57

► Analysis according to Total Project Cost Variation

(Unit: KRW 1 million)

Total project cost change rate	PV of Total benefit	PV of Total cost	NPV	B/C Ratio
-20%	66,709	98,088	31,379	0.68
-10%	66,709	103,575	36,866	0.64
0	66,709	109,030	42,321	0.61
10%	66,709	114,455	47,746	0.58
20%	66,709	119,855	53,146	0.56

► Analysis according to Benefit Increase and Decrease

(Unit: KRW 1 million)

Benefit Change rate	PV of Total benefit	PV of Total cost	NPV	B/C Ratio
-20%	53,374	109,030	55,656	0.49
-10%	60,040	109,030	48,990	0.55
0	66,709	109,030	42,321	0.61
10%	73,388	109,030	35,642	0.67
20%	80,060	109,030	28,970	0.73

<Facility capacity 30,000㎥/day>

► Analysis according to discount rate

(Unit: KRW 1 million)

Social Discount rate	PV of Total benefit	PV of Total cost	NPV	B/C Ratio
2.5%	267,341	263,816	3,525	1.01
3.5%	230,403	239,726	9,323	0.96
4.5%	200,170	219,557	19,387	0.91
5.5%	175,251	202,485	27,234	0.87
6.5%	154,475	188,077	33,602	0.82

► Analysis according to Total Project Cost Variation

(Unit: KRW 1 million)

Total project cost change rate	PV of Total benefit	PV of Total cost	NPV	B/C Ratio
-20%	200,170	196,481	3,689	1.02
-10%	200,170	208,050	7,880	0.96
0	200,170	219,557	19,387	0.91
10%	200,170	231,003	30,833	0.87
20%	200,170	242,387	42,217	0.83

► Analysis according to Benefit Increase and Decrease

(Unit: KRW 1 million)

Benefit Change rate	PV of Total benefit	PV of Total cost	NPV	B/C Ratio
-20%	160,136	219,557	59,421	0.73
-10%	180,151	219,557	39,406	0.82
0	200,170	219,557	19,387	0.91
10%	220,190	219,557	633	1.00
20%	240,211	219,557	20,654	1.09

<Facility capacity 50,000㎥/day>

► Analysis according to discount rate

(Unit: KRW 1 million)

Social Discount rate	PV of Total benefit	PV of Total cost	NPV	B/C Ratio
2.5%	445,581	399,642	45,939	1.11
3.5%	384,028	363,765	20,263	1.06
4.5%	333,632	333,692	- 60	1.00
5.5%	292,098	308,217	- 16,119	0.95
6.5%	257,473	286,702	- 29,229	0.90

► Analysis according to Total Project Cost Variation

(Unit: KRW 1 million)

Total project cost change rate	PV of Total benefit	PV of Total cost	NPV	B/C Ratio
-20%	333,632	297,894	35,738	1.12
-10%	333,632	315,844	17,788	1.06
0	333,632	333,692	- 60	1.00
10%	333,632	351,440	- 17,808	0.95
20%	333,632	369,087	- 35,455	0.90

► Analysis according to Benefit Increase and Decrease

(Unit: KRW 1 million)

Benefit Change rate	PV of Total benefit	PV of Total cost	NPV	B/C Ratio
-20%	266,910	333,692	66,782	0.80
-10%	300,265	333,692	33,427	0.90
0	333,632	333,692	60	1.00
10%	367,004	333,692	33,312	1.10
20%	400,373	333,692	66,681	1.20

Comparative analysis of the strengths and weaknesses of the project implementation

(1) Government financial projects

◦ Concept: A comparative analysis of the strengths and weaknesses of the government's financial support (investment, etc.) and K-water consciousness

◦ Basis for implementation: Article 3 of the Waterworks Act (Industrial Waterworks), Article 9 of the Water Resources Corporation Act (Project)

◦ Facility characteristics: public facilities

◦ Mode of implementation: Application for preliminary feasibility study by the government

◦ Advantages:

① According to Article 75 of the Waterworks Act, financial support for the expenses necessary for the water supply business can be provided through the government subsidy method, and through this, it is possible to ease the financial burden of K-water.

② It is possible to reduce the cost of industrial water customers (company) due to the decrease in production cost compared to private investment projects (PF, BTO, etc.).

③ As K-water is a public corporation, it is possible to judge profitability and publicity in a balanced manner, so it is advantageous in securing rate acceptance and enhancing business execution power by easing tap water rates compared to private investment projects.

◦ Disadvantages:

① In order to newly install and add pure water species to the current conventional water supply system (raw water, purified water, sedimentary water), revisions to the legal system such as “Water Supply Regulations” and “Guidelines for Calculating Tap Water Charges (Ministry of Land, Infrastructure and Transport, 2013)” is necessary, and in this process, it is necessary to determine a reasonable fee level that the customer can accommodate and recover the minimum production cost (fixed cost). If the rate realization rate is lowered in order to secure rate acceptance, the resulting loss could be returned to K-water's burden.

② Since all or part of the construction cost of industrial water has been supported by government investment, sufficient consultation with government ministries (MOEF, ME) is necessary for financial subsidies and subsidy ratios.

* Strategic response is needed by referring to the first case of government subsidy (30%) for industrial water supply (Daesan Industrial Project, 2019).

(2) Private Project Financing

◦ Concept: Establish a separate corporation (SPC) based solely on private sector investment, and recover investment after project implementation through financing through project financing

◦ Basis for implementation: Article 3 of the Waterworks Act (Industrial Waterworks), Article 9 of the Water Resources Corporation Act (Project)

◦ Facility characteristics: private facilities

◦ Implementation type: Implementation through concession agreements with construction companies, operators, and financial investment companies (FI)

◦ Advantages:

① It relieves the government's fiscal burden by revitalizing private investment using excess circulating funds in the market and helps in revitalizing the economy.

② It is possible to apply the unit price of the agreement by consulting with the customer without improving the legal system for the establishment of pure water fee.

◦ Disadvantages:

① If the gap between production cost and supply unit price is excessive, it is difficult to carry out the project.

* When supply unit price rises, demand deviates, and when supply unit price decreases, investor recruitment is limited.

② There is concern about an increase in the supply unit price due to the higher production cost compared to the financial business.

* (Factor of production cost increase) High financial costs, VAT imposed, etc.

③ In order for K-water to secure a certain stake (more than 30%) as an operating company, it is necessary to conduct a preliminary feasibility study for public institutions and consult with government ministries (ME, MOEF) before establishing an investment company.

* (Relevant Basis) Article 18 of the Guidelines on Management and Innovation of Public Enterprises, Article 50 of the Act on the Operation of Public Institutions

④ When K-water participates 100% of the operation, there is a risk of increased loss compared to the financial business due to the risk of demand and operation costs (restrictions on internal decision-making for participation in the project if the management burden is excessive)

⑤ Financial support from the government is not possible.

(3) Private proposal projects (BTO, BTL, etc.)

◦ Concept: Upon completion of the infrastructure, the ownership of the facility belongs to the state (or local government), and the facility operation and management rights are granted for a certain period of time.

◦ Basis for Promotion: Article 3 of the Waterworks Act (Industrial Waterworks), Articles 2, 9, and 10 of the Private Investment Act on Social Infrastructure

◦ Facility characteristics: public facilities

◦ Form of implementation: Implementation through concession agreements between competent authorities and private investment companies

◦ Advantages:

① It relieves the government's fiscal burden by revitalizing private investment using excess circulating funds in the market and helps in revitalizing the economy.

② It is possible to apply the unit price of the agreement by consulting with the customer without improving the legal system for the establishment of pure water fee.

③ In order to maintain the usage fee at an appropriate level, subsidies can be paid during the construction and operation period of the facility, so it is possible to reduce the burden of fees for demanding companies.

* (Relevant Basis) Article 53 of the Private Investment Act and Article 37 of the Enforcement Decree of the

same Act

◦ Disadvantages:

① Given the high production cost, there is a concern that the government's fiscal burden will increase as more subsidies are required compared to the government fiscal project in order to keep the usage fee at an appropriate level.

③ In order for K-water to secure a certain stake (more than 30%) as an operating company, it is necessary to conduct a preliminary feasibility study for public institutions and consult with government ministries (ME, MOEF) before establishing an investment company.

* (Relevant Basis) Article 18 of the Guidelines on Management and Innovation of Public Enterprises, Article 50 of the Act on the Operation of Public Institutions

④ When K-water participates 100% of the operation, there is a risk of increased losses compared to the financial business due to the risk of demand and operation costs (restrictions on internal decision-making for participation in the project when the management burden is excessive)

(4) Consignment business (dedicated industrial waterworks business)

◦ Concept: Construction and operation of a dedicated industrial waterworks facility is entrusted by a customer, and ownership of the facility is held by the tenant company, and service costs are collected and paid as commissioned fees.

* 시설투자비는 입주기업별 지분 출자

◦ Basis for implementation: Article 3 of the Waterworks Act (dedicated industrial waterworks), Article 9 of the Water Resources Corporation Act (projects)

◦ Facility characteristics: private facilities

◦ Form of implementation: Implemented through equity investment in tenant companies and individual agreements

◦ Advantages:

① It is possible to shorten the business period when making an early decision on equity investment through the agreement of the tenant company.

② As the tenant company pays the entire project cost, the financial burden of K-water is alleviated.

◦ Disadvantages:

① Discussion may be difficult due to differences in positions between tenant companies and the burden of equity investment.

② Financial support from the government is not possible.

Comprehensive review opinion on the business method

In the case of government fiscal projects, the government's preliminary feasibility study is passed, and in the case of private project financing, it is difficult to secure the acceptability of fees due to the inability to support the government finances, so the possibility of commercialization is low. In the case of private proposition projects (BTO, BTL, etc.), the will of the private business entity and the local government, which is the competent authority, is important, but motivation is not easy, and the consignment of exclusive industrial water supply is expected to be difficult to agree between the tenant companies (recipients) without government financial support.

In conclusion, as a result of a comparative review of various business models for the customized industrial water integrated supply project, it is judged that the government's fiscal business models will be advantageous in a number of ways, such as determining an acceptable rate, promoting a sense of speed, and achieving effective business objectives. Therefore, in the future, the customized integrated industrial water supply project will be pushed ahead by the government and K-water led by the national fiscal business method, but if there is a demand for the introduction of various business methods, it will be necessary to take this into account.

Policy feasibility Analysis Result

Policy analysis is not included in economic analysis, but includes evaluation factors that need to be considered in evaluating the feasibility of the project. Evaluation contents to be included in the policy analysis are divided into 'basic evaluation items' and 'project-specific evaluation items'.

According to the “Revised and Complementary Study on General Guidelines for Preliminary Practice (5th edition, KDI)”, “basic evaluation items” include consistency and willingness to implement, risk factors for project promotion, and employment effect analysis. In addition, 'project-specific evaluation items' are special evaluation items that should be considered particularly important in evaluating the project, and can be presented in various ways depending on the project content.

This study reviews only the consistency and will of policy among the 'basic evaluation items'. In detail, it evaluates the consistency with the related plans and policy directions, the will and preference of the relevant ministries to promote the project, and the degree of preparation for the project. Items that are difficult to quantify and require a lot of time, cost, and professional manpower (financial procurement possibility, environmental characteristics, employment effect analysis, etc.) were excluded.

(1) Consistency with related plans and policy directions

When the government establishes a major plan, not only the relevant laws and regulations, but also the relevance to the higher level plan must be reviewed with great importance. Most of the higher-level plans are long-term plans of about 20 years, and are established after a considerable period of review and expert opinion gathering by the authorities, and have a profound impact on the policy implementation of related plans and sub-plans over a long period of time in the future.

That is, by analyzing whether the project is reflected in the higher level or related plans, it is possible to determine whether the project has been promoted with policy consistency.

The customized industrial water integrated supply business aims to reduce product cost and enhance corporate competitiveness by supplying high-purity industrial water to domestic manufacturing companies more efficiently and economically. Related higher-level plans related to this project are 『The 5th Comprehensive National Territory Plan (2020-2040) (MOLIT, 2019)』, 『Long-term Comprehensive Water Resources Plan (2011-2020) (MOLIT, 2011)』, 『2025 National Waterworks Maintenance Basic Plan (MOLIT, 2015)』. As a result of examining the consistency with these plans, there is no particular mention of the integrated supply of high-purity industrial water. However, the advancement of water-related technologies among the goals of the Long-term Comprehensive Water Resources Plan seems to be in line with the purpose of this project.

Therefore, in order to push ahead national fiscal projects in the future, it is necessary to secure consistency with the higher national plans by including concrete business plans in the 『(tentative name) 2040 National Waterworks Maintenance Basic Plan』 currently being established by the Ministry of Environment.

Regarding the consistency of the national policy direction, it is judged to be in line with the policy direction in light of the recent government (MOLIT, MOTIE) policy as follows.

◦ Full-scale promotion of industrial complex regeneration (MOLIT, 2019~2020)

-The government is promoting manufacturing innovation through regeneration of deteriorated industrial complexes, such as announcing the plan for industrial complexes renovation (2019) and supporting project expenses for remodeling old factories in old industrial complexes (2020).

When implementing a project in connection with this, it is advantageous to improve execution power.

◦ Measures to strengthen competitiveness of material parts and equipment according to Japanese export regulations (MOTIE, 2019), 2.0 strategy for material parts and equipment (MOTIE, 2020)

-The government regards the materials, parts, and equipment industries as a key factor in the competitiveness of the manufacturing industry, and plans to build specialized complexes and support the establishment of infrastructure for water supply. It is expected to be able to contribute to the achievement of the policy through the integrated industrial water supply project.

(2) Willingness and preference to implement the project

In the case of public investment projects, it is necessary to consider the attitudes of local residents and other stakeholders toward the project from the project implementation stage with respect to the spatial location in which the project is implemented and the ripple effect. Even projects of interest in the region may have a low priority in terms of limited budget and national economy. Conversely, even projects required by the central government may be undesirable from the perspective of local residents.

Accordingly, based on the opinions of the Ministry of Environment, K-water, local governments (Ulsan, Gumi, Seosan, and Yeosu), and consumers, the will and preference for the project were identified.

Since the installation and operation of the Daesan Industrial Water Center, K-water has been conducting various researches* to develop customized industrial water processes and revitalize the business, and recently, jointly with the Ministry of Environment, it is discovering a national research project for localization of high-purity industrial water production technology development. Considering these points, the willingness to implement the project is strong. In preparation for the shortage of industrial water in the future, local governments and demanders prefer a customized integrated supply system that can provide a stable supply of high-quality industrial water provided only an affordable supply unit price is premised.

* Pure and ultrapure water technology research and analysis service (2011), High-purity industrial water pilot plant construction and process development (2016), Customized high-purity industrial water process design and standard financial model development (2019), etc.

(3) degree of business preparation

The degree of project preparation is determined by the degree of specific preparation of the project, such as the specificity of the project plan and the possibility of securing human resources and financial resources. The more concrete the project preparation, the more the project purpose is in line with the policy direction, and the more willingness to pursue the project can be evaluated.

Although a schematic basic plan for this project has been established, there are uncertain aspects related to water demand, supply targets, and supply unit prices that directly affect the feasibility. Therefore, it is necessary to closely review the feasibility of the project and further refine the business plan, so the level of project preparation is judged to be at a normal level.

6. Conclusions and Recommendations

The results of the feasibility analysis and review of the project implementation method for the customized integrated industrial water supply project are summarized as follows.

From a locational point of view, the existing national industrial complex, where demanding companies are concentrated, is likely to be the most suitable in many ways, such as securing stable demand, linking with government policies (regeneration of old industrial complexes), and ease of participation by K-water.

From an economic point of view, there is a difference depending on the state financial support, fluctuations in benefits and project costs, and the quality of water required by customers, but if the capacity of the integrated supply facility is 50,000 m3/day or more, it will be advantageous to secure a stable feasibility.

From a policy point of view, it conforms to the national policy direction to cultivate technology for high-purity water treatment processes, and the government and K-water have a clear will to implement the project. If the plan is reflected in the basic maintenance plan, etc.), there is sufficient validity.

From the perspective of business method, it is judged that the government's financial projects (Executioner: Government & K-water) will be most suitable in many aspects, such as determining acceptable rates, enhancing business execution power, and achieving effective business objectives.

Therefore, in the future, K-water, the only public company specializing in water sector in Korea, is expected to take an active role in establishing an action plan, proposing and consulting with the authorities so that the integrated supply of customized industrial water can be expanded. This is expected to ultimately contribute to strengthening corporate competitiveness and developing the national economy.

7. Limitations and Further Research

First, additional efforts are needed to improve the reliability of the business feasibility analysis. In this study, the feasibility was analyzed on the premise of several basic assumptions due to cost and time constraints, but in order to obtain a more objective and accurate analysis result, a review is needed based on the results of direct and in-depth demand surveys on individual companies.

* Obtaining more reliable basic data through interviews with individual demand companies in the “Industrial Water Market Research and Analysis Service (2020. 10 ~)” currently being conducted by K-water.

Second, it is necessary to discover and reflect costs and benefits from an environmental point of view. Efforts are needed to review and quantify the factors that increase or decrease the discharge of concentrated water that may occur in the customized industrial water treatment process and reflect it in the economic analysis.

Third, further research is needed on a plan to produce and supply high-purity industrial water by utilizing sewage reused water or seawater desalination. With the advancement of the industry, the demand for high-purity customized industrial water is increasing. However, it is necessary to gradually expand the reuse of sewage and seawater desalination through the advancement of the water treatment process, as there is a limit to satisfying the demand with only limited freshwater resources.

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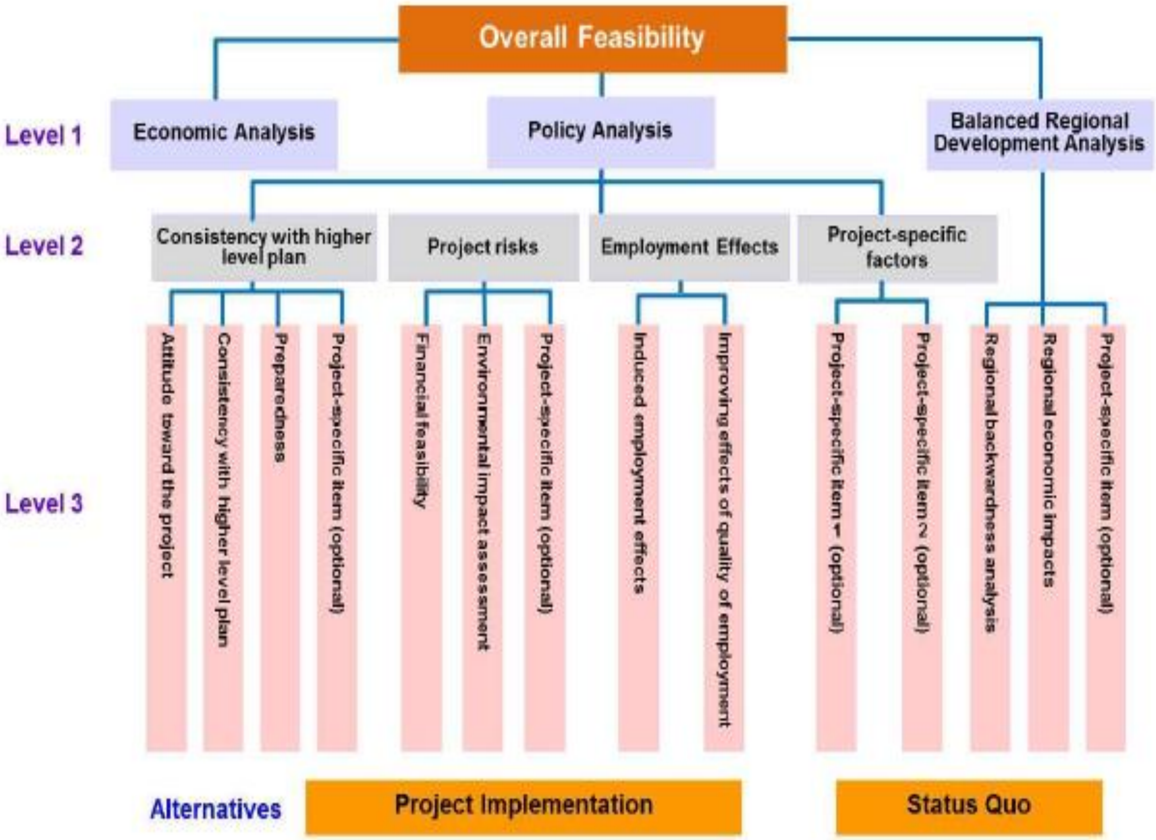
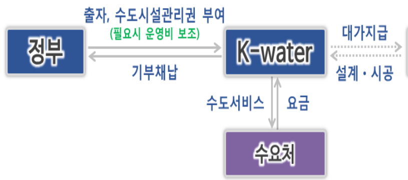
9. Appendix

Structure of the AHP in PFS



Source: KDI, General Guidelines for PFS 6th edition, 2018(forthcoming)

Comparison of implementation methods of customized industrial water integrated supply business

구 분	① 정부재정사업	② 민간자체투자 (PF)	③ 민간제안사업 (BTO, BTL 등)	④ 위수탁 사업 (전용공업용수도사업)
개 념	정부의 재정지원(출자 등) 및 K-water가 사업비를 부담하여 사업 시행 	민간부문이 출자하여 별도 법인(SPC)을 설립하고, 자금 조달을 통해 사업 시행 후 투자비 회수 	사회기반시설의 준공과 동시에 해당 시설의 소유권은 국가(또는 지자체)에 귀속하고, 일정기간 시설관리운영권을 인정 	전용공업용수도 시설을 위탁 받아 건설·운영 (소유권은 입주기업이 보유, 서비스 대가는 위탁수수료로 회수) 
추진근거	수도법 제3조(공업용수도), 수자원공사법 제9조(사업)	수도법 제3조(공업용수도), 수자원공사법 제9조(사업)	수도법 제3조(공업용수도), 사회기반시설에 대한 민간투자사업법 제2조, 제9조, 제10조	수도법 제3조(전용공업용수도), 수자원공사법 제9조
(시설성격)	공공시설	민간시설	공공시설	민간시설
추진형태	국고 보조방식으로 **예비타당성조사 신청** ☞ 출자 30% → 보조 30~50%	건설사, 금융투자사(FI)와 **실시협약**을 통한 시행	주무관청과 민간투자사업자간 **실시협약**을 통한 시행	**입주기업 지분출자** 및 **개별 협약**을 통한 시행
장 점	□광역(공업)용수도 보조 비율(30~50%) 범위 내에서 국가 재정지원 가능, **K-water 재무부담 완화** □민간투자방식(PF, BTO등) 대비 생산원가 하락으로 공업용수 수용가(기업) **요금부담 경감 가능**	□민간투자 활성화를 통한 **정부 재정부담 완화** □법/제도 개선없이 협약단가 적용 가능	□민간투자 활성화를 통한 **정부 재정부담 완화** □법/제도 개선없이 협약 단가 적용 가능 □시설의 건설 및 운영기간 중 보조금 지급 가능, 공업용수 수용가 (기업) **요금부담 경감 가능**	□입주기업 지분출자 조기 의사결정시 **사업기간 단축** □사업비 전액 입주기업 부담, **K-water 재무부담 완화**
단 점	□현행 단일 요금(원수, 침전수, 정수) 外 별도의 수종 신설 적용을 위해 **수돗물공급규정 등 개정** 필요 □그동안 건설비 전부 또는 일부를 출자방식으로 지원해 옴, **국고보조 방식** 및 **비율 변경에 대한 사전 협의** 필요	□생산원가와 공급단가 間 **Gap 과다 시 사업 무산** 우려 ☞ **(Trade off)** 공급단가 상승 時 수요 이탈, 공급단가 하락 時 투자자 모집에 한계 □재정사업 대비 **높은 생산원가로 공급단가 상승**, 민간참여(민영화) 거부감 ☞ **(생산원가 상승요인)** ① 높은 금융비용 ② 부가세 부과 등	□높은 생산원가 감안 시 사용료를 적정 수준으로 유지하기 위해서는 정부재정사업 대비 더 많은 보조금 지원이 필요, **정부 재정부담 가중** □공공부문 단독으로 사업제안 불가, 민관합동법인을 통해 간접 참여 (민간투자법 제2조 제7호, 제12호)	□입주기업의 **입장차** 및 **지분출자 부담**으로 인한 협의 난항 예상
		□일정지분 확보(30%이상)를 위해서는 **공공기관 예타 수행** 및 **출자회사 설립 前 사전 정부부처**(환경부, 기재부) **협의** 필요 □K-water가 100% 운영참여시 수요/운영비 Risk 전담으로 **재정사업 대비 손실 증가** 우려 □일정지분 확보(30%이상) 時 **출자회사 설립 前 정부부처 사전 협의 필요** (공기업 경영 및 혁신에 관한 지침 제18조) □**투자비 300억 이상시 공타 대상** (공공기관 운영에 관한 법률 제50조 제1항 제2호)		
재정지원	□수도사업에 필요한 비용을 **보조 가능** (수도법 제75조)	□정부의 **재정지원 불가**	□사용료를 적정 수준으로 유지하기 위하여 불가피한 경우 등 **시설의 건설 또는 운영기간 중** 예산의 범위에서 **보조금 지급이 가능** (민간투자법 제53조 및 동법 시행령 제37조 제1항 제2호)	□정부의 **재정지원 불가**
종합의견	□ ① **정부재정사업**의 경우 **정부 예비타당성조사를 거쳐 적정 공급 단가로 사업 추진 가능** ② **민간자체투자(PF)**의 경우 정부 재정지원 불가 및 사업성 확보가 곤란하여 사업화 가능성이 희박, ③ **민간제안사업**(BTO, BTL 등)은 추진절차 감안 時 사업착수 지연 및 재정사업 대비 공급 단가 高, ④ **전용공업용수도 수탁**은 정부 재정지원 없는 입주기업(수용가) 주도의 사업방식으로 시설투자에 대한 협의가 곤란			