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Asset management system for business management of water suppliers

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Abstract

Many water suppliers in Japan are required to renew aged waterworks facilities systematically in spite of the decline in revenues due to the decrease in the population. Moreover, they are needed to build waterworks facilities with high earthquake resistance. Therefore, it is necessary for water suppliers to manage waterworks effectively and efficiently in order to build sustainable waterworks. In this paper, to support sound business management, a method of water asset management is arranged systematically. And also an actual example with this systematic method in a water supplier is introduced in which reduction of renewal costs by optimization of ability of the waterworks facilities and setting renewal cycle standards is explained. Furthermore, a perspective of renewal costs taking into account the acceleration of earthquake-resistance strengthening plan and equalization of renewal demands is shown.

Key words: earthquake resistance strengthening, equalization of renewal costs, renewal cycle standards, renewal of aged waterworks facilities, water asset management system

INTRODUCTION

Total asset values of waterworks in Japan are estimated to be about 40 trillion yen. Most of them were installed during the period of high economic growth from the 1960s to 1970s. Judging from the useful life designated by law regarding pipelines and concrete structures, it is considered that many facilities will have to be renewed and the amount requiring renewal will reach its peak during the period from the 2020s to 2030s. Furthermore, Japan has suffered from frequent earthquakes since the beginning of recorded history. Many waterworks facilities were damaged by the Hanshin-Awaji Earthquake of 1995 and the Great East Japan Earthquake of 2011. Therefore, water suppliers are required to build facilities with high earthquake resistance.

The population of Japan continues to decrease. National Institute of Population and Social Security Research forecasted that it would reach about 8.7 million in 2060. Because of this situation, it will be harder to secure a revenue source for water suppliers. In order to renew many aged facilities and accelerate the earthquake resistance strengthening of waterworks facilities, considerable investment is needed in spite of the decline in revenues caused by the decrease in the population and the spread of water saving devices.

Waterworks management is based on beneficiary-pays principle. Therefore, it is necessary for water suppliers to manage waterworks with comprehension from customers. And also, it is necessary for water suppliers to conduct their various projects effectively and efficiently.

To develop a sustainable business management system, we arranged a method of water asset management based on our consultants' experience and knowledge together with information from Japanese Ministries and Government Offices and research institutions.

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OUTLINE OF WATER ASSET MANAGEMENT SYSTEM

An outline of the water asset management system is shown below in Figure 1. According to this system, comprehensive asset management is conducted.

These details are explained below.

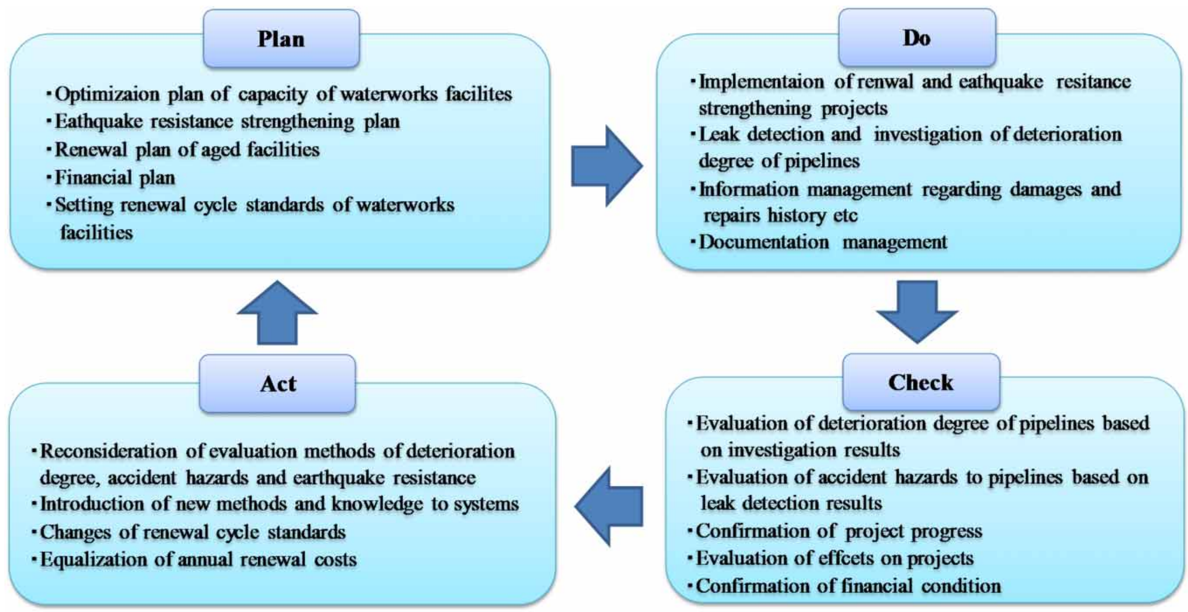

Figure 1 | Outline of the methodology of the water asset management system.

Contents of plan

Optimization plan of capacity of waterworks facilities. Because of the decrease in population, the amount of water supply declines. Therefore, it is necessary for water suppliers to reconsider and optimize capacities of waterworks facilities in order to reduce investments in renewal of aged facilities.

Earthquake resistance strengthening plan. It is important to make earthquake resistance strengthening plan effectively. As one way for that, some methods developed by the Japan Water Research Center or other research institutions in which earthquake damages to pipelines are estimated based on parameters such as material type, diameter, earthquake resistant joints and geological classifications. The results of the estimation are utilized to prioritize an earthquake resistance strengthening plan.

Making renewal cycle standards of waterworks facilities. Renewal cycle standards of waterworks facilities are estimated based on *a* history of damages and repairs and statistical data of life time of them.

Renewal plan of aged pipelines. It is necessary for water supplies not to cause water suspension due to damages and breakdowns of waterworks facilities as possible as they can. Therefore, it is required to renew aged facilities systematically. As one way for that, some methods developed by the Japan Water Research Center and other research institutions in which accident risks of pipelines are estimated based on some factors such as year placed, material type, diameter, type of earthquake resistant joints and geological classification. The renewal plans for aged pipelines are prioritized based on the results of these analyses.

Financial plan. Based on above plans, a long-term financial plan is made taking into account the transition of capital revenue and expenditure, operating revenue and expenditure, unit price and cost of water supply and review of water service charge levels.

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Leak detection and investigation of deterioration degree of pipelines. Water leak investigations such as measuring sound pressure of pipelines and catching water leak sound with some tools are conducted to grasp characteristics and tendency of water leak of pipelines. For the purpose of evaluations of deterioration degree of pipelines, the thickness of aged pipelines are measured and compared with the designed thickness.

Information management. Histories of damages and repairs of waterworks facilities are recorded as fundamental information to make new renewal cycle standards.

Contents of check

Confirmation of projects progress. Performance indicator such as aseismic rate of waterworks facilities and renewal rate of aged facilities in Waterworks Guideline (JWWA Q 100) established as Japan Water Works Association Standard are utilized to confirm projects progress.

Confirmation of financial condition. In order to confirm financial condition of waterworks management comparing with other water suppliers, Management Indicators related to efficiency of waterworks facilities and projects management calculated by Ministry of International Affairs and Communications are utilized.

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Introduction of new methods and knowledge to systems. New methods and knowledge on management of waterworks are developed continuously. Therefore, in accordance with changes of social situation, it is required for water suppliers to keep watching on new information and improve the management system adequately.

Changes of renewal cycle standards. Based on results of investigations and analysis of histories of damages and repairs on waterworks facilities and new knowledge and methods regarding waterworks management, renewal cycle standards of aged waterworks facilities should be reviewed and revised.

ACTUAL EXAMPLE OF WATER SUPPLY MANAGEMENT WITH THIS SYSTEM

An outline of waterworks in K city

Waterworks in K city was started in 1956. K city is dependent on groundwater and receiving of water from bulk water supplier. The total length of the pipelines has extended to about 310 km. Most of the facilities were installed in the 1970s and about 26 billion yen values of the waterworks facilities have exceeded statutory useful life. Therefore, it is required for the water supplier to renew aged waterworks facilities systematically.

Population in K city continues to decrease. Figure 2 shows changes in water supply. According to the decrease in population, the maximum daily supply decreased from 15,900 m^3/day in 2004 to 14,900 m^3/day in 2014. The maximum water supply is predicted to decrease down to 13,800 m^3/day in 2024. Current design water supply is 15,000 m^3/day which is 75% of previous design value (Table 1). Therefore, there are surplus of capacities in the waterworks facilities.

Optimization of capacity of waterworks facilities

Based on the decline in water supply, reorganization of distribution area, changes of distribution system and downsizing of capacity of the waterworks facilities were conducted. As a result, renewal costs were cut by 1.3 billion yen (Table 2).

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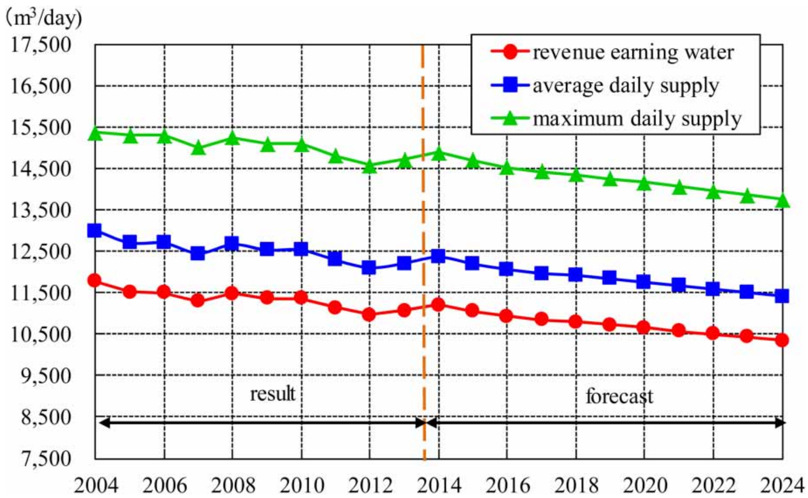

Figure 2 | Changes in water supply.

Table 1 | Design value

	Unit	Previous	Current
Design population served	Person	37,000	34,500
Design water supply	m^3/day	20,000	15,000

Table 2 | Reduction of renewal costs by optimization

Categorization	Renewal cost in current ability (billion yen)	Renewal cost after optimization (billion yen)
Pipelines	15.1	14.2
Civil engineering structures and equipment	3.6	3.2
Total cost	18.7	17.4

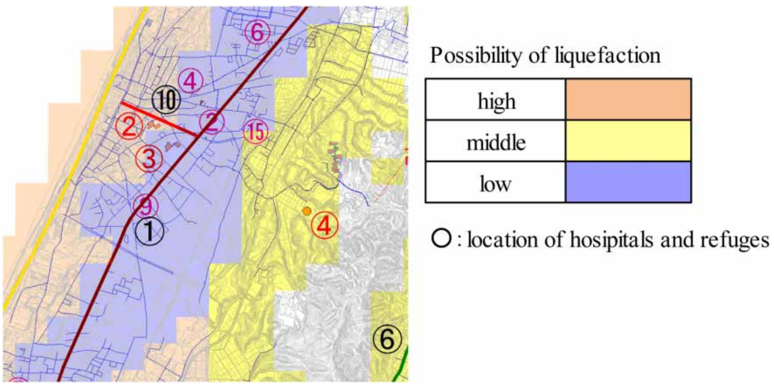

Figure 3 | Distribution map of possibility of liquefaction.

Earthquake resistance strengthening of pipelines

Distribution map of possibility of liquefaction examined by local government was utilized to grasp the area which was subject to damage from earthquake. Moreover, pipelines routes leading to hospitals

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and refuges were selected to supply water to them absolutely in time of disaster (Figure 3). Based on these basic information, the priority order in selecting routes of installation of earthquake-resistant pipelines were created.

Setting of renewal cycle standards of waterworks facilities

In order to set renewal cycle standards, histories of damages and repairs of waterworks facilities and results of various investigations on leak detection of pipelines and deterioration degree of facilities is utilized as basic information. But information about them was not adequate to grasp tendencies of damages and breakdown of aged facilities. Therefore, samples of renewal cycle suggested by Ministry of Health, Labor and Welfare based on results of renewal of waterworks facilities were utilized as reference. Table 3 shows standards of civil engineering structures and mechanical and electric equipment. Table 4 shows standards of distribution pipes for each material.

Table 3 | Renewal cycle standards of structures and equipment

Categorization	Statutory useful life (year)	Renewal cycle standard (year)
Civil engineering structures	60	75
Mechanical equipment	15	24
Electric equipment	10–15	20

Table 4 | Renewal cycle standards of distribution pipes

Categorization	Statutory useful life (year)	Renewal cycle standard (year)
Ductile cast-iron pipe (main pipe)	40	60
Ductile cast-iron pipe (not main pipe)	40	75
Steel pipe	40	40
Hard impact resistant poly Vinyl chloride pipe	40	40

Calculation of renewal costs of waterworks facilities

The following two scenarios were prepared to calculate renewal demands in the future.

Scenario1 Renewal of waterworks facilities by statutory useful life
Scenario2 Renewal of waterworks facilities by renewal cycle standards

Renewal costs in scenario1 and scenario 2 are shown below Figures 4 and 5 respectively. In scenario 1, assets of 4.5 billion yen have exceeded the statutory useful life in 2014. Renewal demands will reach its peak during the period from 2016 to 2020, which will be about 8.0 billion yen. In scenario 2, renewal demands will reach its peak during the period from 2031 to 2035, which will be about 4.5 billion yen. In renewal by renewal cycle standards, renewal demands will reduce from 21.4 billion yen to 11.1 yen billion yen until 2050 (Table 5).

In any case, renewal demands will be concentrated on a fixed term. Therefore, it is required to equalize investments for renewal in order to conduct various projects appropriately. Renewal costs after equalization of investments taking into account the acceleration of earthquake-resistant plan is shown below Figure 6. As a result, renewal demands during the period from 2031 to 2035 in scenario 2 are front-loaded.

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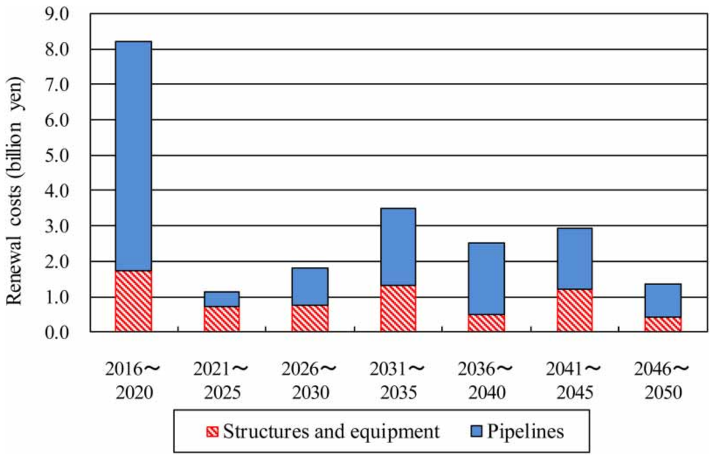

Figure 4 | Renewal cost by statutory useful life.

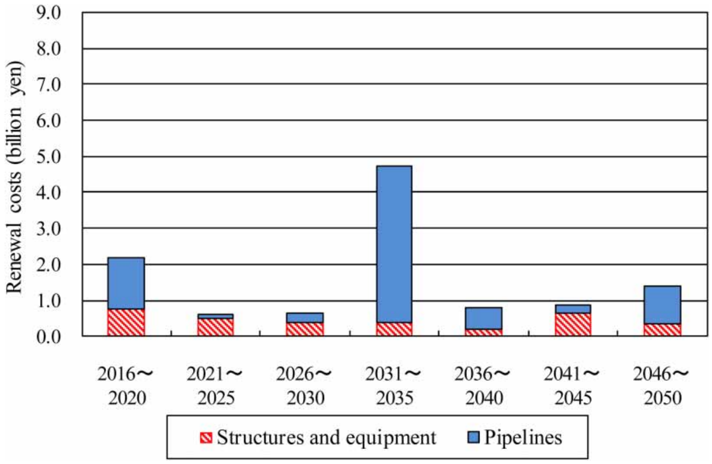

Figure 5 | Renewal cost by renewal cycle standard.

Table 5 | Renewal costs in each case

Categorization	Statutory useful life (billion yen)	Renewal cycle standard (billion yen)
Civil engineering structures	2.4	0.8
Mechanical equipment	1.2	0.4
Electric equipment	3.0	1.9
Pipelines	14.8	8.0
Total cost	21.4	11.1

Financial plan

Based on renewal costs with equalization, a long-term financial plan was drawn up. Changes of water supply cost, unit price of water supply and recovery percentage are shown below Figure 7. According to enforcement of renewal projects, depreciation cost will increase. Furthermore, together with reduction of revenue on water supply by decease in water consumption, recovery percentage will decline. Because of them, it will be required to revise the water service charges three times until 2035.

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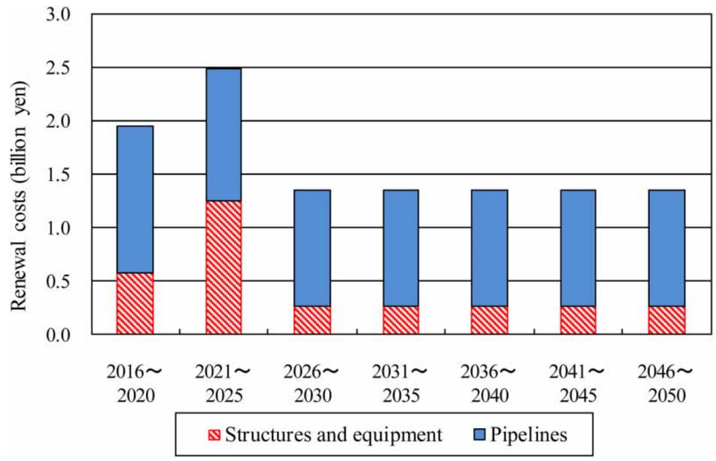

Figure 6 | Renewal costs by equalization.

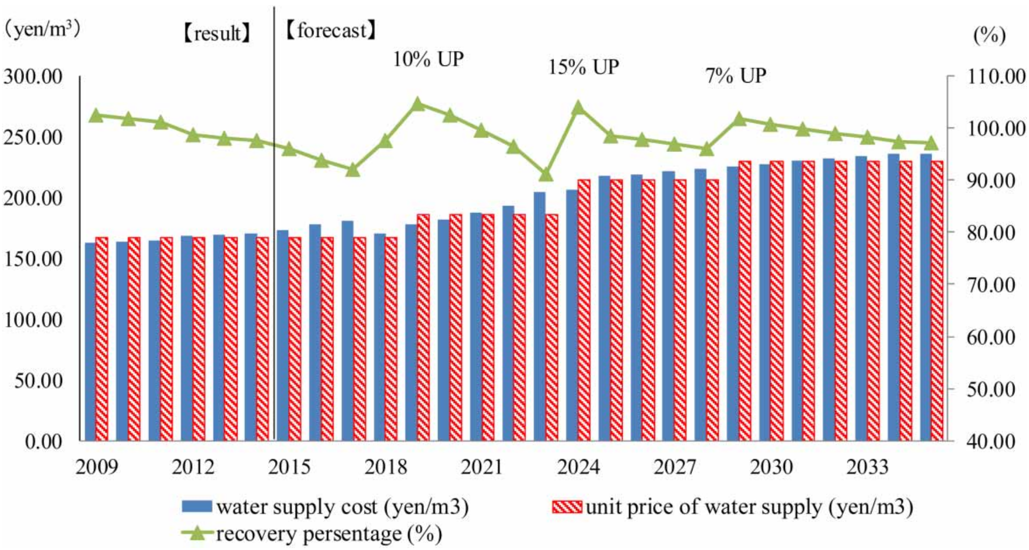

Figure 7 | Changes in water rate.

Confirmation of projects progress

Earthquake-resistant plans of water conveyance pipes, transmission pipes and distribution main pipes toward hospitals and refuges were planned. As one of indicators to confirm progress of projects, the rate of earthquake-resistant pipelines was calculated. Rate of earthquake-resistant main pipelines and all pipelines are shown below Figure 8. By conducting those plans, the rate of earthquake-resistant of main pipelines will be about 38% which is twice as much as current value.

CONCLUSION

To implement projects for renewal and earthquake resistance strengthening, many financial resources are needed. Depending on the financial situation, an increase in the water service charges may be necessary. Before increasing the water service charges, it is important to reduce annual renewal cost by reviewing capacity of waterworks facilities, extending useful life of them with appropriate maintenance and to equalize costs with the real useful life estimated based on the damages and

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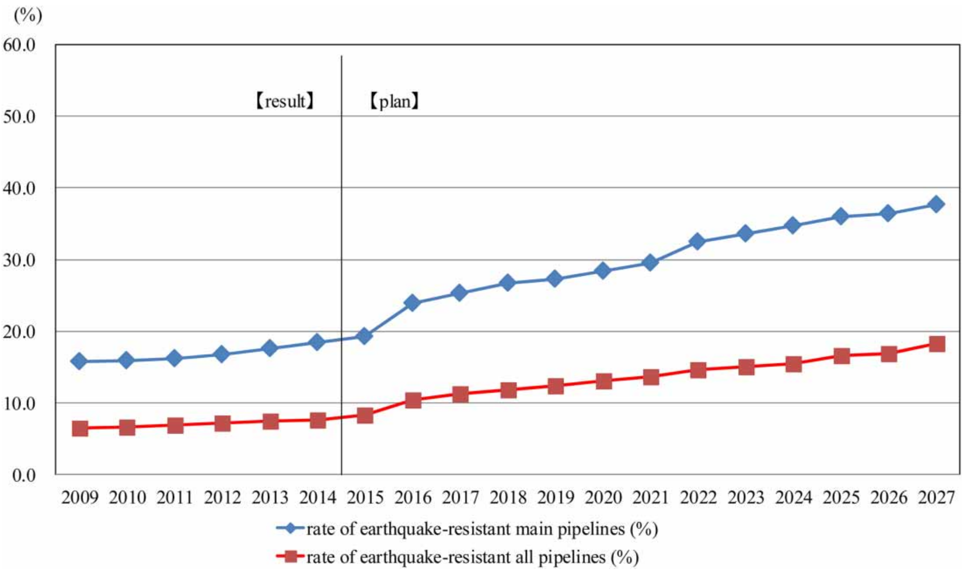

Figure 8 | Changes in rate of earthquake-resistant pipelines.

repairs histories. We expect that this method of water asset management will contribute to sound business management for the water suppliers. In the near future, public-private partnership of water business management such as concessions and private finance initiative will begin operating in Japan. Therefore, we also expect that this system will contribute to that progress.