Introduction of Energy Saving System in Water Supply Stations

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Abstract

Transmitted water from purification plants is stored in distribution reservoir at water supply stations and distributed by pressing with pumps. During that process, the pressure to send water from water purification plants is released in distribution reservoir, with the energy lost (excess pressure of drawing) in water supply stations, which are located between purification plants and water supply stations. Therefore Tokyo Waterworks has made efforts of improving energy efficiency, installing small hydraulic power generators and directly-connected water distribution pumps as standalone machineries, to utilize excess pressure of drawing. We are going to further promote the streamlining by installing the combined system of small hydraulic power generator and directly-connected water distribution pump in newly built or reinforced water supply stations. After evaluating various matters, the introduction of this system in Kohoku Water Supply Station is in the final phase in preparation for the completion in FY2018.

Keywords

small hydraulic power generation, directly-connected water distribution pump, energy saving, water supply station

1 Introduction

Tokyo Waterworks has the water purification capacity of 6.86 million m3/day to supply 13 million people and the service area of 1,239 km2, supporting the citizens' life and urban activities.
Tokyo Waterworks annually uses about 0.8 billion kWh of electricity, accounting for approx. 1% of the total power consumption in Tokyo. Therefore, being an organization consuming large amount of energy, we need to steadily progress the streamlining of energy consumed in water utility. Consequently we have already introduced solar photovoltaic generation, and cogeneration, which utilizes the waste heat produced during power generation. This is to say, we have actively promoted various other measures for energy saving and environment.
On the other hand, most of water purification plants intake water at low altitude location due to the geographical constraints on the location of water intake points, we need to pump water up to water supply stations located at high altitude. For these reasons, approx. 60 % of the electric power is consumed by water distribution, so we see the reduction of the usage as a critical issue.

2 Effort of Energy Saving

2.1 Effort in Water Supply Station

Transmitted water from purification plants is stored in distribution reservoir at water supply stations, and distributed by pressing with pumps. In the case, purification transmitted water to water supply station as shown in Figure 1 , the pressure to draw water into Water Supply Station B was not used

but released into distribution reservoirs of Water Supply Station B.
Accordingly, we work on reducing the power consumption by making effective use of excess pressure as much as possible. In concrete terms, small hydraulic power generators and directly-connected water distribution pumps were installed as standalone machineries. We are going to install a combined system of small hydraulic power generators and directly-connected water distribution pumps when a water supply station is newly built or reinforced. (refer to Figure 2)

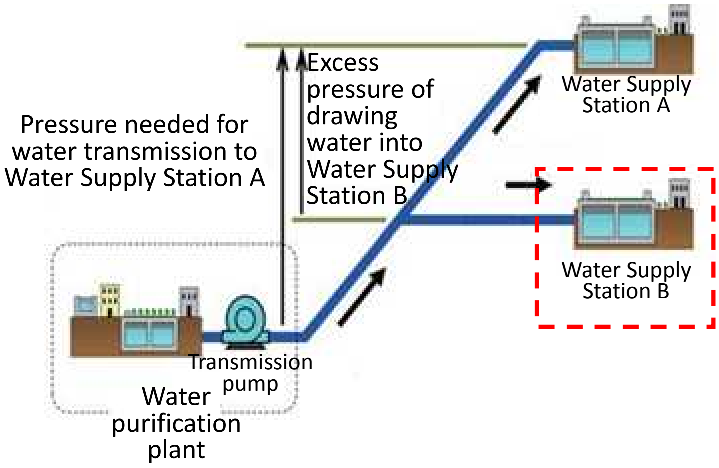

Figure 1: Excessive drawing pressure at Water Supply Station

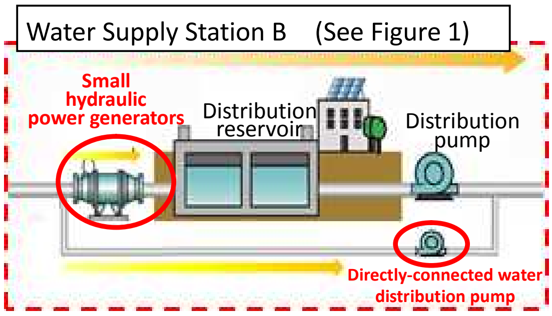

Figure 2: Energy saving equipment utilizing excessive drawing pressure at Water Supply Station

Outline of the energy-saving facility utilizing excessive drawing pressure at water supply stations is as follows:

・<u>Small Hydraulic Power Generator</u>

A small hydraulic power generator is installed in the upstream of the distribution reservoir at the water supply station. The excess pressure is retrieved as electric energy by generating power with the drawing water.
In this instance, the energy is lost in two places, the small hydraulic power generator and the distribution pump, in the route where the water is carried through distribution reservoir and pressed by a distribution pump, with electricity generated with a small hydraulic power generator.

・<u>Directly-connected Water Distribution Pump</u>

This is the method in which the drawing water containing excess pressure is carried without flowing through a distribution reservoir. It suppresses the energy applied uses directly-connected water distribution pump by utilizing the excess pressure.
The energy is lost only in this pump when using this route.

It is shown that the power saving effect is larger in the route using a directly-connected water distribution pump, also by the operation data of water supply stations where standalone small hydraulic power generators and directly-connected distribution pumps are installed. (refer to Figure 3)

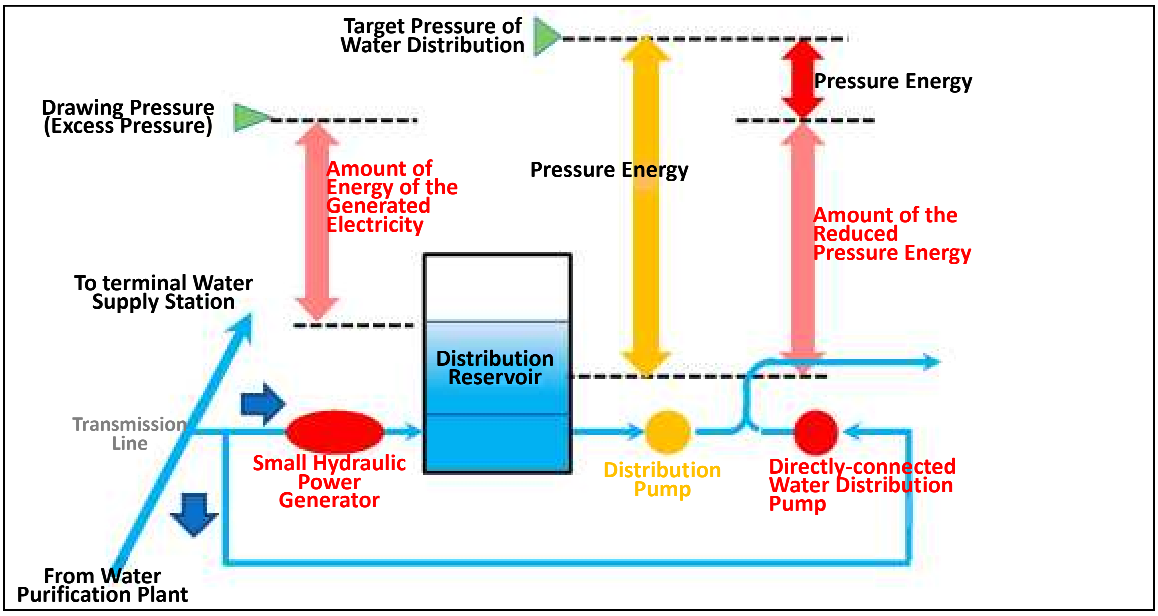

Figure 3: Energy-saving Effect (Image)

2.2 Effect and Operation Procedure which Discussed from the Simulation Result

Energy-saving effect has been evaluated with the simulation assuming water operation in implementing this system (combination of small hydraulic power generator and directly-connected water distribution pump).

In concrete terms, it is evaluated from the aspect of small hydraulic power generator and directly-connected water distribution pump, considering the characteristics and restriction (*) in the operation of distribution reservoir.

According to the simulation, power saving was the maximum when the directly-connected water distribution pump, which is superior in efficiency to the small hydraulic power generator, is operated during the time when water supply quantity is high, and the small hydraulic power generator is operated mostly during around midnight, when water supply quantity is small.

Therefore we consider the operation scheduling in which the directly-connected water distribution pump is used while the water supply is much and small hydraulic power generator is used during midnight, etc, when water supply is low, in the actual operation. (refer to Figure 4)

(*) Taking account of the following three points, a certain limit needs to be set to the quantity of the water distributed by the directly-connected water distribution pump and it needs to operate in parallel with the distribution pump supplying water through a distribution reservoir.

- Securing the capability of distribution reservoirs to adjust flow rate automatically (the original function of distribution reservoir to adjusting the amount of water supply and water distribution)
- Maintaining the residual chlorine concentration in distribution reservoirs
- Considering the influence of the fluctuation of water supply pressure from the water purification plant

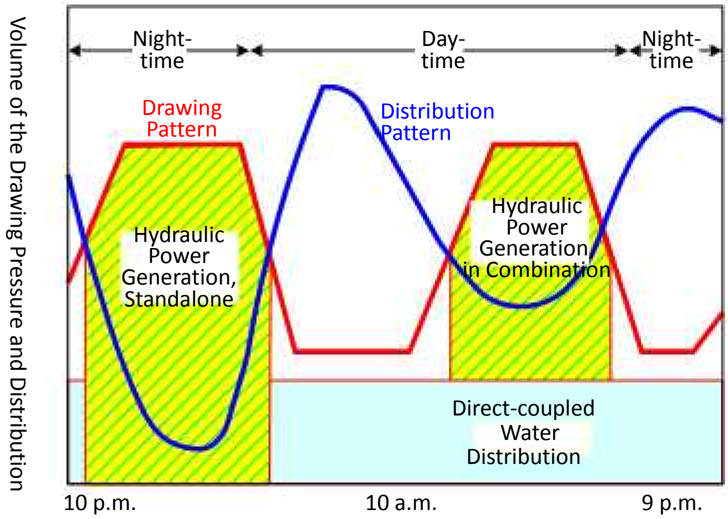

Figure 4: Image of the Operation Pattern

3 Current Status of Implementation

3.1 Schedule

Tokyo Waterworks is discussing implementation in other four facilities in introducing the system, as well as preparing in Kohoku Water Supply Station and Kamikitazawa Water supply Station (tentative name). (refer to Table 1)

Table 1: Schedule of Introduction

Name of facilities	Period of the plan
Kohoku Water Supply Station	To be completed in FY 2018
Kamikitazawa Water Supply Station (tentative name)	To be completed in FY 2019
Other 4 facilities (under consideration)	To be introduced

Kohoku Water Supply Station, where the construction is proceeding with a plan of action for the completion in FY 2018, is described below.

3.2 Current Status of Kohoku Water Supply Station

3.2.1 Simulation Result

In installing this system in Kohoku Water Supply Station, energy saving effect of the combination, in which multiple specifications were assigned to both the small hydraulic generator and directly-connected water distribution pump, were evaluated. As a result, we have obtained the data that power saving efficiency is reduced when the generation capacity is excessively large, because

there occur many periods when the flow rate is lower than the power generation flow rate range. After these evaluations, power reduction ratio in Kohoku Water Supply Station was computed approx. 25 % through a year from simulation. In addition, it has turned out that the system becomes highly economical by utilizing electric power under the feed-in tariff system. (refer to Table 2) Additionally, these trial calculation showed that small hydraulic power generator and directly-connected water distribution pump were expected to payback their initial implementation cost during their useful life. (refer to Table 3)
Moreover, the power saving described above is also expected to reduce approx.480 t-CO_2 /year.

Table 2: Simulation Result of Kohoku Water Supply Station

				Small hydraulic power generation and directly-connected water distribution pump	Remarks
Electric Energy	A	Power consumption by water distribution pump	kWh/day	6,645	Electric energy when distributing the entire water amount by watar distribution pumps = 10,637 kWh Reduction amount D= 10,637kWh-A-C+B
	B	Power generated by small hydraulic power generator	kWh/day	595	
	C	Power consumption by directly-connected water distribution pump	kWh/day	1,896	
	D	Reduction	kWh/day	2,691	
	Reduction ratio		%	**25%**	
Electric Charge	E	Total amount	JPY10,000/day	10.8	The electric charge assuming all water is distributed with the water distribution pump = 159,000 JPY E=(A+C)×15 JPY-B×34 JPY F=159,000 JPY -E
	F	Reduction amount	JPY10,000/day	5.1	
	Reduction ratio		%	**32%**	

・Electricity generated by small hydraulic generator is to be sold at JPY34/kWh (*1) (The unit price of hydraulic power of less than 200 kWh under the feed-in tariff system (*2).
・Amount of reduction when using the directly-connected water distributioon pump is calculated based on TEPCO'average electricity unite price of 15yen, because it means the reduction of the service station power cost.
*1: The purchase price has been unchanged since March of 2016 (the price JPY34 will remain unchanged during FY 2017-FY 2019).
*2: The system that electric companies purchase the electricity geenerated with renewable energies (solar, wind, hydraulic, geothermal, biomass).

Table 3: Payback Period in Years

	Useful life of the facility	Gain and investment				Payback period in years
		Reduced power consumption	Reduced electric charge	Implementation cost	Maintenance cost	
Small hydraulic power generation	22 years	217 thousand kWh/year	JPY7.38 million/year	JPY103 million	JPY1 million/year	16.7 years
Directly-connected water distribution pmup	30 - 45 years	765 thousand kWh/year	JPY11.47 million/year	JPY133 million	JPY1.6 million/year	13.7 years
Sum	—	980 thousand kWh/year	JPY18.85 million/year	JPY236 million	JPY2.6 million/year	14.9 years

3.2.2 Development of Kohoku Water Supply Station

3.2.2.1 Outline of Kohoku Water Supply Station

- Location: Kohoku 5, Adachi-ku, Tokyo
- Distribution Reservoir: 50,000 m^3 (25,000 m^3×2 reservoirs)
- Amount of the Water Distribution : 99,000 m^3/day (maximum)
- Water Distribution Area: Adachi area, where there are about 200 thousand users

3.2.2.2 Layout of the Facility

The pump building and distribution reservoirs, and others are built within the site of Tokyo Waterworks, of which a major road is located in the north, and an elementary school is located in the south.

The pump building on the north side is a building two-story on the ground and three-story basement, with electric room, generator room, and carry-in chamber, and others on the ground, and piping and pumps in the basement.

The distribution reservoir is an underground structure, whose upper space is under discussion for effective use (refer to Figure 5).

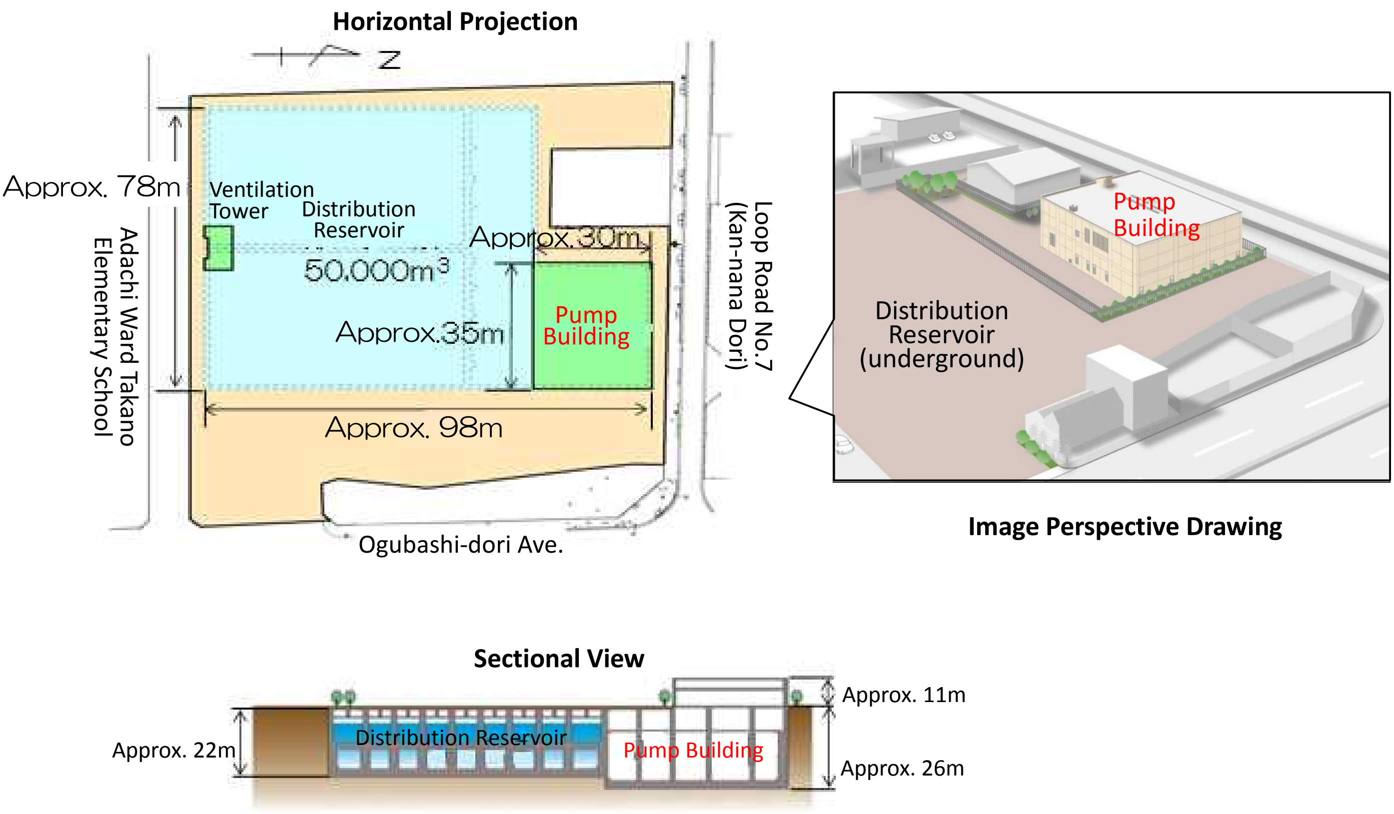

Figure 5: Layout of Kohoku Water Supply Station

3.2.2.3 Specification and Arrangement of the Facilities

Outline and arrangement of the water distribution pump and energy saving facility are as follows.

(refer to Figure 6)

- Distribution Pump(ϕ 600 mm) : 4 sets
  Horizontal Shaft Double-Suction Type Centrifugal Pump (pump discharge 46 m^3/minute (with lift 65 m))

- Flow Control Valve for Direct Connection and Flowmeter : 1 set each

- <u>Directly-connected Water Distribution Pump</u> (ϕ 300mm) : 2 sets
  Horizontal Shaft Double-Suction Type Centrifugal Pump (pump discharge 12m^3/minute (with lift 25m))

- Small Hydraulic Power Generator (about 50kw) : 1 set

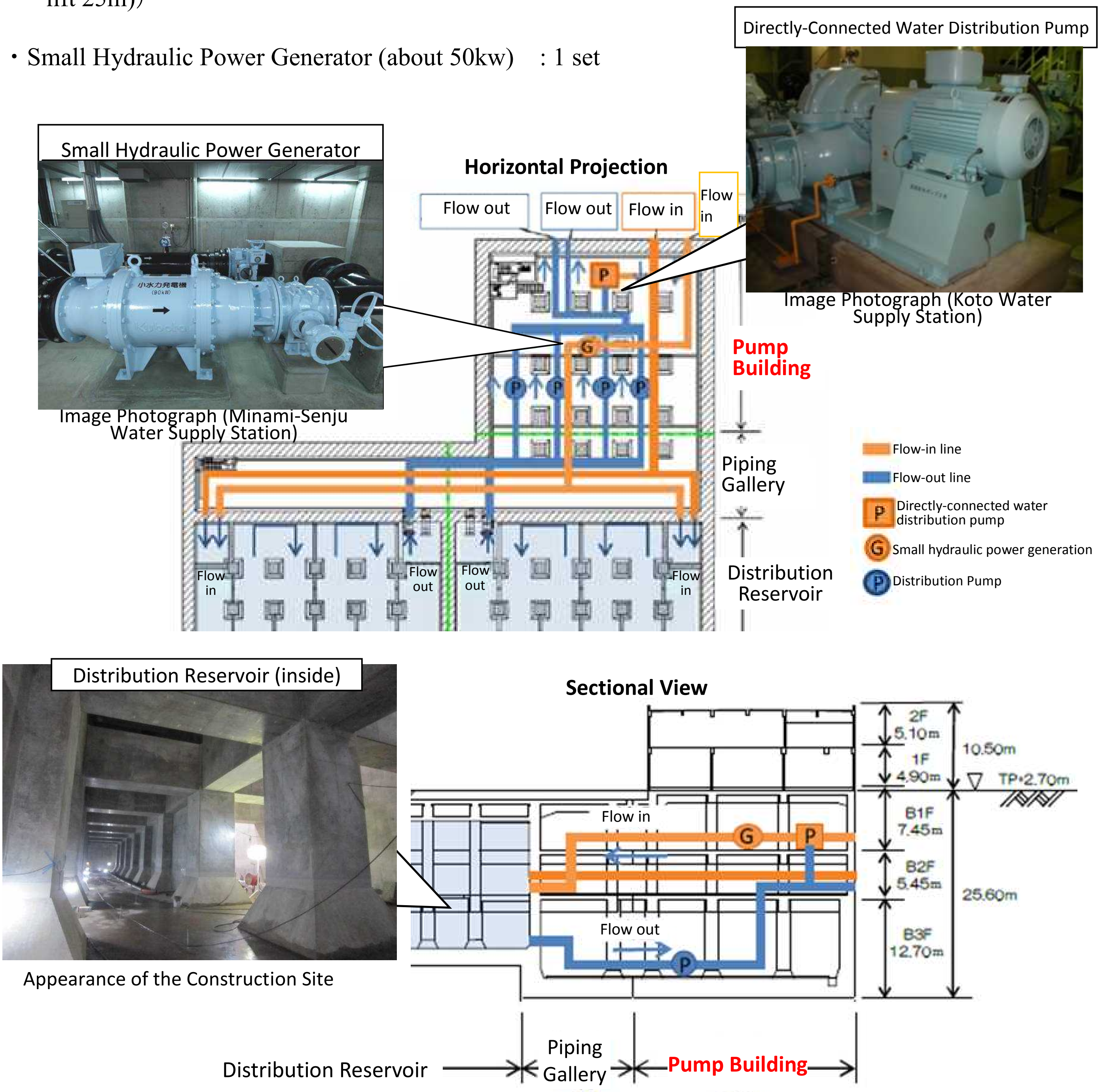

Figure 6: Deployment in the Pump Building

3.2.2.4 Preparation for Launching Operation

In this project of Kohoku Water Supply Station, we carry a plan forward by the following schedule and all works are going to be completed in FY 2018. (refer to Table 4)

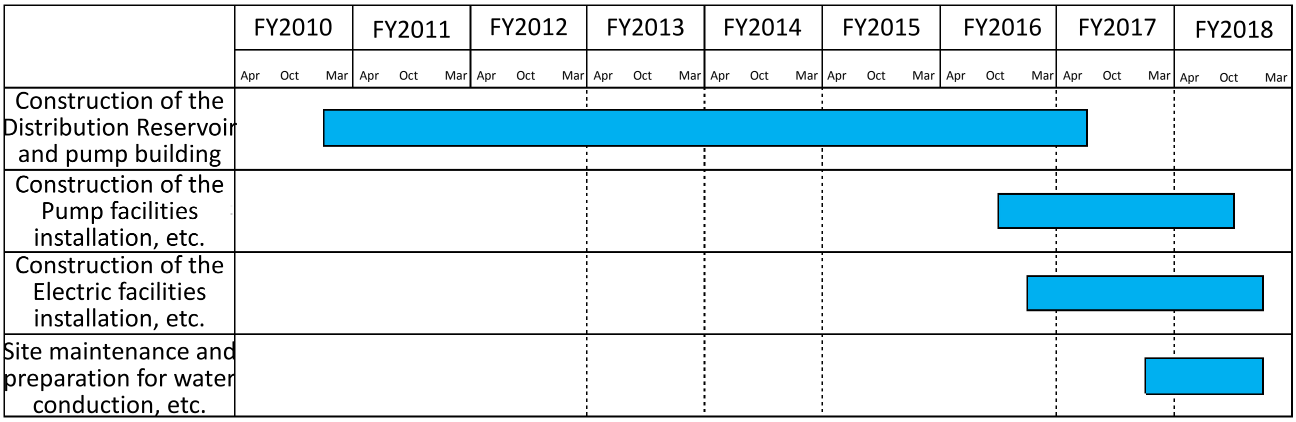

Table 4 Construction Schedule

4 Conclusion

Considering from the geographical conditions of facilities for Tokyo Waterworks, adoption of this system combining small hydraulic power generator and directly-connected water distribution pump is an effective measure in saving power consumption.

Construction projects are in progress, as described above, after evaluating various factors including consideration of environmental matters such as reducing CO_2 emission and payback period of the implementation cost of the facility, and others as well as the power saving effect.

We are going to perform the fundamental duty as the water utility of supplying safe and tasty water and continue to make efforts to save energy taking advantage of various opportunities.