NewTap
Network on Water Technology in Asia and Pacific

Kawai Water Purification Plant
Yokohama, Japan

1. Renovation of Kawai Water Purification Plant

The Yokohama Waterworks Bureau is the second largest water utility in Japan, serving 3.7 million people on a land area of 438 km2 (Figure 1). As the birthplace of the country's first pressurized water distribution system in 1887, the city has long been providing quality drinking water and reliable water service to the customer using its most advanced yet highly environment-conscious water supply system.

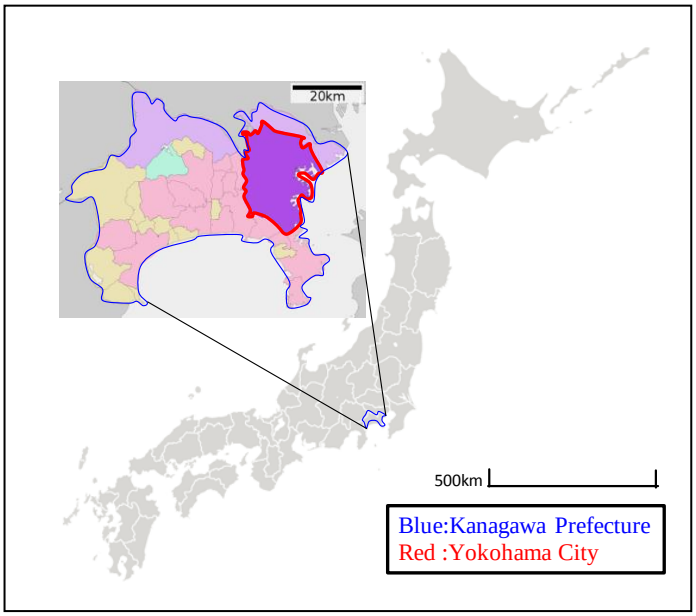

Figure 1 | Yokohama in Japan

Always keen to make less environmental footprint in their service management and operation, Yokohama has renovated recently the city's oldest water purification plant, Kawai, with an eco-friendly intake and treatment system.

The renovation project was launched in 2009. Kawai had been in service since 1901 and their newest facilities had been almost 50 years old. The city sought to renew the plant's aging facilities and reinforce the seismic resilience of its major components, including the sedimentation basin, filtration basin and the distribution reservoir. In renovating the plant, Yokohama replaced the rapid filtration process (106,400m3/d) with a gravity-fed ceramic membrane filtration capable of 172,800 m3/d water treatment. This decision was based on that membrane filtration would not only enable the use of natural energy of 35-meter gravity flow, thus entailing smaller energy consumption, but also it would be most suitable to the clean source water taken from Doshi river. Table 1 shows the plant's technical information after the renovation was completed.

Table 1 | Technical information of Kawai water purification plant

	Number of customers	About 310,000
Membrane filtration facility specifications	Filtration method	Dead end filtration
	Membrane surface area	57,600㎡
	Design treatment capacity	172,800㎥/d
	Membrane filtration flux	3.6m³m/m²/d
	Components	10elements/module × 10modules × 24units

Membrane specifications	Membrane material	Ceramic
	Membrane shape	Monolithic
	Diameter	0.1μm
	Outer diameter and length	180mm / 1,500mm
	Inside diameter of membrane filtration cell	About 2.5mm
	Membrane surface area/element	24㎡
	Membrane surface area of module	240㎡/module (24㎡/element × 10elements/module)

For an efficient project implementation, the city saw it important to utilize private-sector vitality and know-how. Upon considering various forms of public-private partnership, they decided to use a PFI (Public Finance initiative) scheme of BTO (Build-Transfer-Operate) type. The PFI was contracted for the renovation itself and for the management of the whole plant for 20 years from 2014 to 2034. Extensive use of private funds helped Yokohama to reduce burden on public finances, and in April 2014, Kawai resumed operation after going through a number of refurbishments. This project marks the first example in Japan to have used PFI for the renovation, operation and maintenance of an entire water purification plant. With its value for money estimated at 7.0%, the project is expected to promote public-private partnerships throughout the country.

The PFI scheme was undertaken by Water Next Yokohama, a special purpose company that is comprised of Metawater, Tsukishima Kikai, Tokyo Power Technology, and Tokyo Electric Power Company.

2. Ceramic Membrane Filtration Powered by Natural Energy

Membrane filtration generally requires a large amount of energy for pumps to apply differential pressures to the membrane. At Kawai, the city decided to utilize the potential energy due to the elevation difference between the intake point and the plant, generated as the 30 km transmission main carries source water, by gravity, down to the plant situated 35 meters below.

As shown in Figure 2, small hydraulic power generators are located along the way, but the residual pressure equivalent to a head of 11.5 meters still remains as the water reaches the plant. This remaining pressure is used for conducting ceramic membrane filtration and transferring the treated water into the distribution reservoir. In this way, Kawai has realized membrane filtration process that requires zero electricity.

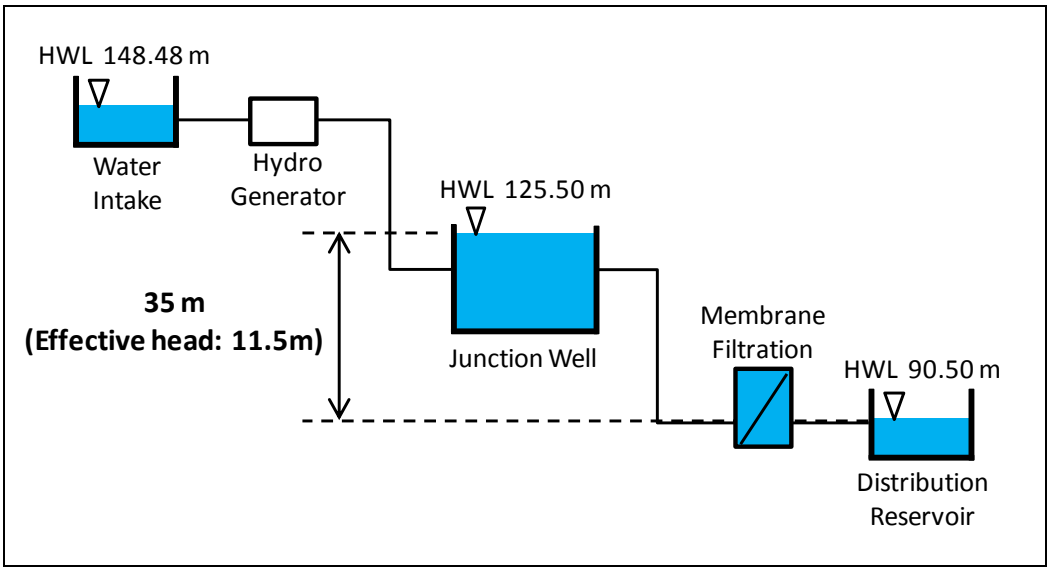

Figure 2 | Use of natural energy for membrane filtration

After membrane filtration, its wash water is sent to sludge treatment and the supernatant is returned to the beginning of the treatment process (Figure 3). Consequently, the plant achieves 99% water recovery rate, meaning 99% of the raw water is turned into drinking water and only 1% is discharged out of the system. This makes the whole treatment process highly eco-friendly.

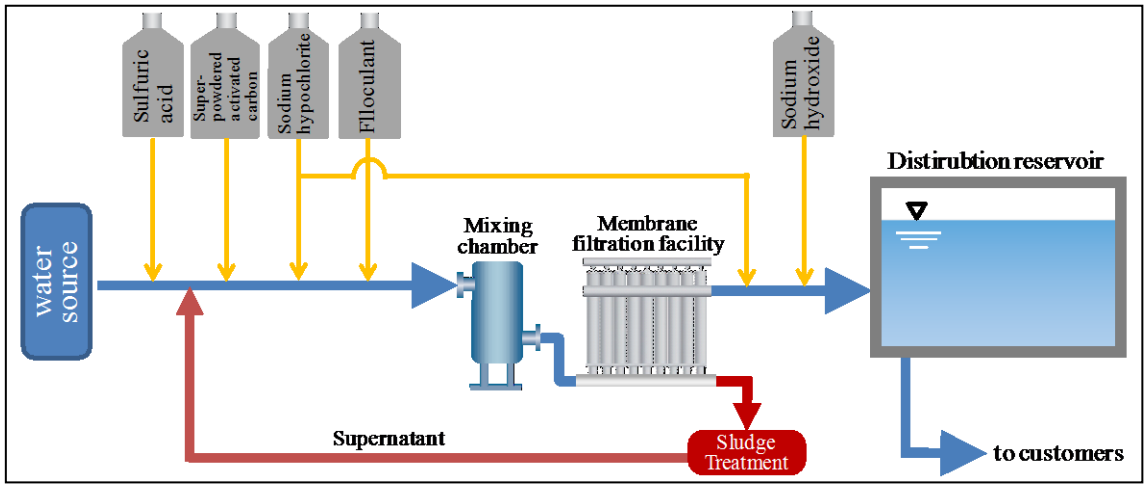

Figure 3 | Ceramic membrane facility at Kawai

To minimize the membrane fouling, pH is controlled by sulfuric acid injection, and the effectiveness of coagulation is boosted by the appropriate coagulant injection ratio, which is adjusted according to the raw water quality. For energy saving purposes, operators try to make the backwashing less frequent, conducting it every six hours where possible. The membrane also goes through chemical cleaning two times a year. Figure 4 shows the membrane filtration facility at Kawai.

Figure 4 | Membrane filtration facility at Kawai

3. Expanding Areas Supplied by Gravity Flow

The Kawai water purification plant lies at the highest elevation of all the water purification plants in Yokohama. This allows for gravity-fed water distribution to wide area. With the renovation of Kawai, Yokohama boosted its treatment capacity and expanded the number of households serviced by the plant from 190,000 to 310,000. As a result, the city was able to reduce the number of households serviced by other plants using pumps for distribution. Over the past five years from 2011 to 2015, based on its five-year management plan, the city has successfully increased the ratio of drinking water distributed via gravity flow to as much as 36%. It plans to augment this ratio even further over the next five-year period.

4. Solar and Hydropower Generation

As part of the renovation, a solar power generation system was newly installed on the rooftops of the distribution reservoir and other facilities (Figure 5). The huge roof space was put to effective use by the installation of 1,400 solar panels with a combined generation capacity of 336 kW. During the daytime in clear weather, this new energy source allows the whole plant to operate without additional power supply from the grid, and even produces surplus for sale.

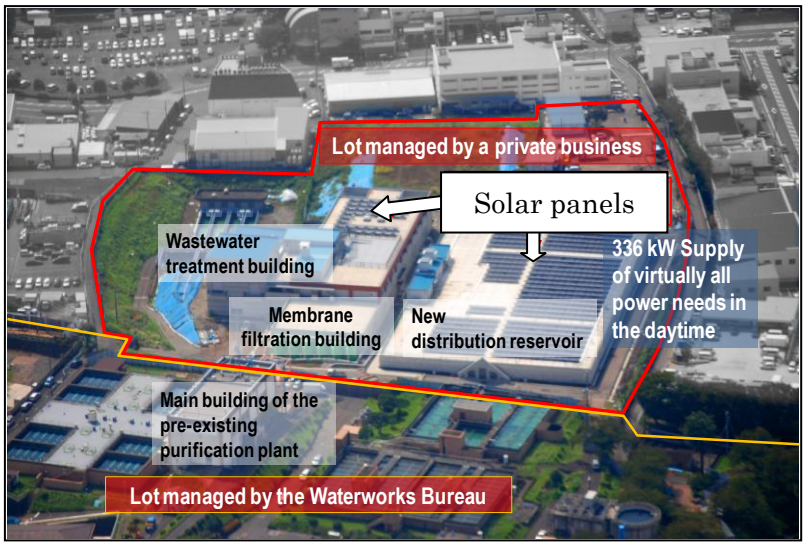

Figure 5 | Solar power system newly installed on reservoir and other facilities

During the FY2014, the hydropower generation at Kawai recorded 1.74 million kWh. The 90% of the produced electricity was used for running plant's facilities and outside pumping stations, excluding the membrane filtration facility (membrane filtration is gravity-powered and requires no electricity).

From 2011 to 2014, the city as a whole managed to grow its hydro and solar energy production from 1,745 kW to 2,226 kW, way over than 2,000 kW, which was originally set to be reached by 2015.

5. Use of Membrane Filtration in Japan

Membranes clearly represent an important area of development as far as water treatment is concerned. Raw water treated at membrane filtration facilities makes up about 1.4%[*1] of the total design treatment capacity of Japan's large water suppliers (serving > 5,000 people) and wholesale water suppliers. In addition, membrane filtered water accounts for around 6.2%[*2] of the annual volume of raw water treated for the country's small water supplies (serving 101–5,000 people).

In terms of membrane material, a survey by the Japan Water Research Center on the use of membrane filtration by large water suppliers, wholesale water suppliers and small water suppliers in Japan[*3] showed that there were 809 membrane filtration facilities in the country, of which 216 were equipped with organic microfiltration (MF) membranes, 160 with inorganic MF membranes and 433 with ultrafiltration (UF) membranes. It was also found that 57% of the membrane-filtered raw water came from groundwater, spring water and river-bed water while 43% came from surface water sources including rivers and lakes.

*1: 2011 Japanese Drinking Water Statistics (Japan Water Works Association)

*2: 2012 Japanese Drinking Water Statistics on Small Water Suppliers (Japan Small Scale Water Works Association)

*3: JWRC's survey result at March 2013

Note:
This report was prepared together by the Yokohama Waterwork Bureau and the Japan Water Research Center for the NewTap project, which is funded by JWRC. The report is provided solely for informational purposes. For details about the copyright, please refer to the site policy of the NewTap website.

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