RATINGPRACTICE OF DISTRICT HEATING & COOLING FACILITIES WITH HEAT PUMP USING HEAT OF STREAM WATER

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Abstract : The district heating & cooling (DHC) facilities at Hakozaki use the heat pump using the heat of the river. This was a case with the first, real river heat use in Japan, and operation started in 1990. At that time, The river mixed living drainage and garbage and was dirty. In addition, seawater flowed in the getting water point by the tide, too. The getting water system examined to correspond to such a water quality, and was constructed. This getting water system became the standard with a district heating & cooling facilities in Japan that used the stream water or seawater afterwards. This time, it reports on three themes of the following.

1. Role of composition part of getting water system that solves problem caused when stream water is taken.
2. Operation condition and maintenance situation of the getting water system. obtained through operation for 21 years
3. Device and ratingpractice in system operation.

Key words: heat pump, river heat use, DHC, ratingpractice

1 INTRODUCTION

The Hakozaki district heat supply center is DHC facilities with the heat pump where the river heat was used for the first time in full scale in our country. And, TOKYO TOSHI SERVICE COMPANY is doing operation and management. 21 years have passed since the heat supply by the river heat began, and the update time is faced now. On this occasion, it reports on the operation condition of the river heat use system.

2 EQUIPMENT OUTLINE

2.1 Outline OF DHC

This facilities began the heat supply in April, 1989 and started operation that used the river heat in 1990. The area of the heat service is 25.4ha. The heat supply at first destination was only large-scale office building (About 135,000m^2) and a housing complex. Afterwards, the heat supply destination increases as the redevelopment of this district concerned advances, and heat is being supplied to 11 places now. (Figure 1).

Figure 2 and Figure 3 show an appearance that is externals of the position in which the stream water is taken and under construction.

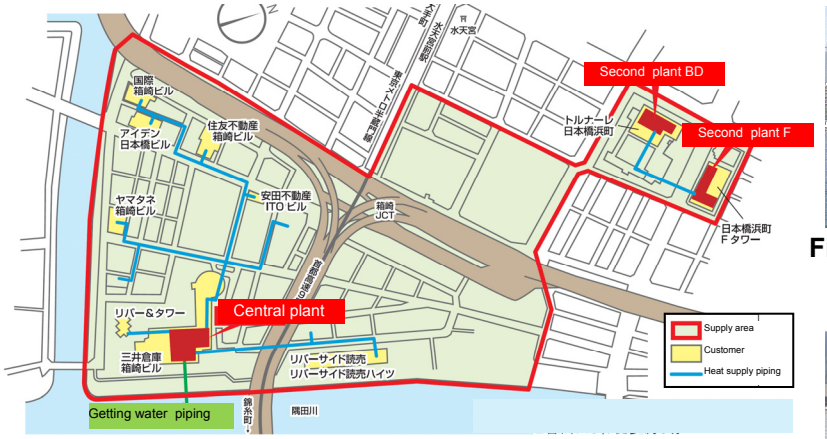

Figure 1 Heat supply area

Figure 2 Embankment in getting water part

Figure 3 Under construction

2.2 Outline of Stream Water Use Heat Source

A central plant supplies cold water and the hot water for air-conditioning. In addition, hot water supply to the housing complex is supplied. Here, it introduces the specification and the system of major items of equipment of the stream water use heat source that supplies the cool & hot water. The stream water use heat pump used a heating tower combinedly as a backup when the stream water was not able to be used due to some troubles.

Table 1 Specification of river heat use heat source

Sign	Heat source equipment	Ability	The number
RHP1,2	Stream water use heat pump Heat recovery type Type of heating tower using combinedly	Cooling 1,600RT Heating 14GJ/h	2
RTR	Stream water use refrigerator	Cooling 1,600RT	1
ST	Water thermal storage tank	4,980m^3	

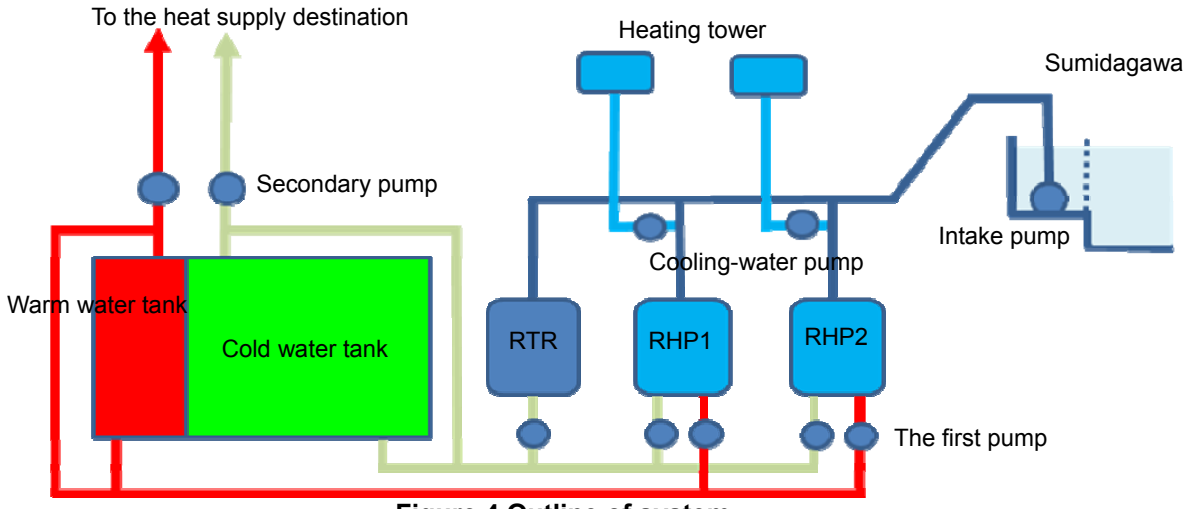

Figure 4 Outline of system

2.3 Situation of River

The position in which the water of Sumidagawa is taken is the vicinity of the mouth of a river of Tokyo Bay. Therefore, the flowing direction of the river reverses by the tide and the stream water mixes it with seawater. The ratio of seawater is 80% at the flood tide roughly. The average of the temperature of the stream water according to the month is lower than the mean maximum temperature at summer and the intermediate season, and it is higher than the on the average lowest temperature in winter. Therefore, the effect of energy conservation can be expected more than the atmosphere is assumed to be a heat source. It was the highest, and in the water temperature for the operation period, it was 28.9℃, and the lowest was 10.1℃.

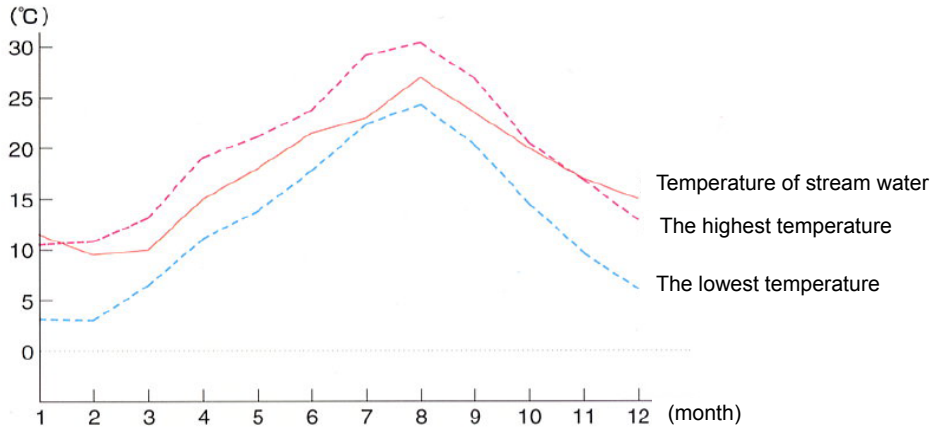

Figure 4 Degree of water temperature of river and temperature according to the month

As for the water quality of the river when the heat supply began, the causticity was high and there were a lot of floats. Afterwards, the environmental reform by the administration advances, and the water quality has been improved greatly. However, the water quality item concerning causticities such as the chloride ions and the sulphuric acid ions has not changed basically.

Table 2 Water quality item comparison that plans and is present

Water quality item	At plan (Sept. , 1987)		Present (Oct. , 2010)	
	At the flood tide	At the ebb tide	At the flood tide	At the ebb tide
PH （—）	7.2	7.2	7.6	7.6
Suspended substance （mg/l）	8.5	7.2	Less than 10	Less than 10
Specific electric conductivity （mS/m）	3,910	1,620	3,390	3,130
Chloride ion （mg/l）	14,200	5,240	13,000	12,200
Sulphuric acid ion （mg/l）	1,930	759	1,860	1,770
Total nitrogen （mg/l）	2.8	6.5	2.2	2.6
All phosphoruss （mg/l）	0.3	0.53	0.16	0.16
Dissolved oxygen （mg/l）	2.6	1.6	2.5	2.4

3 ROLE OF GETTING WATER SYSTEM AND EACH PART

The problem of the getting water system was extracted from the characteristic of the stream water of the mouth of a river of Sumidagawa and the getting water system was composed. The composition of this getting water system was established as the standard of the heat source using the stream water and seawater of our country afterwards.

Table 3 Feared problem when stream water is used and the correspondence system

Feared trouble	Correspondence system
Short circuit by reversal of direction of flow	・System that exchanges positions of draining water off
Change of stream water side level by tide	・Pump pit method
Inflow of floatage garbage such as vinyl bags and hairs	・Bar screen of 50mm pitch in getting water part ・Auto strainer
Blockage of piping with oceanic product such as mussel	・Marine growth preventing equipment with silver ion
Decrease in heat exchange efficiency because of adhesion	・Brush type tube washing device
Corrosion of piping with stream water with high causticity etc.	・The heat exchanger of the freezer is a titanium tube. ・The getting water tube is the glass epoxy lining steel pipe. ・The sacrifice anode is set up in each place of the system.
Inflow of stream water to plant by siphon	・ Emergency shut-off valve

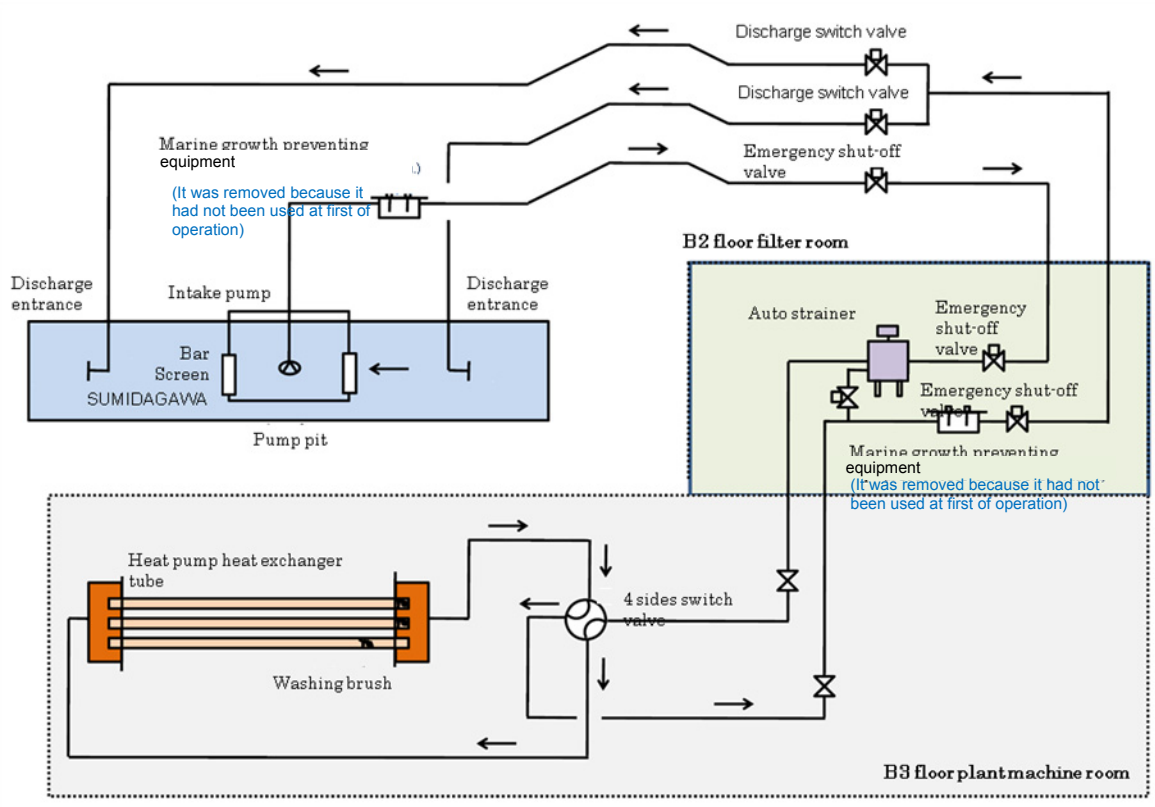

Figure 5 Composition of getting water system

4 RATINGPRACTICE OF HEAT SOURCE

4.1 Supply Calorie in Each Fiscal Year According to The Month

In five recent years, the amount of the cold water supply became the maximum in 2007 and, minimum in 2009. Figure 6 shows cold water supply in these two years according to the month and the supply of the hot water. The cold water supply is 8～10 times the hot water supply. The stream water has been used throughout the year because it is not only a cold water demand period of summer and the intermediate season but also effective at the hot water demand period in winter.

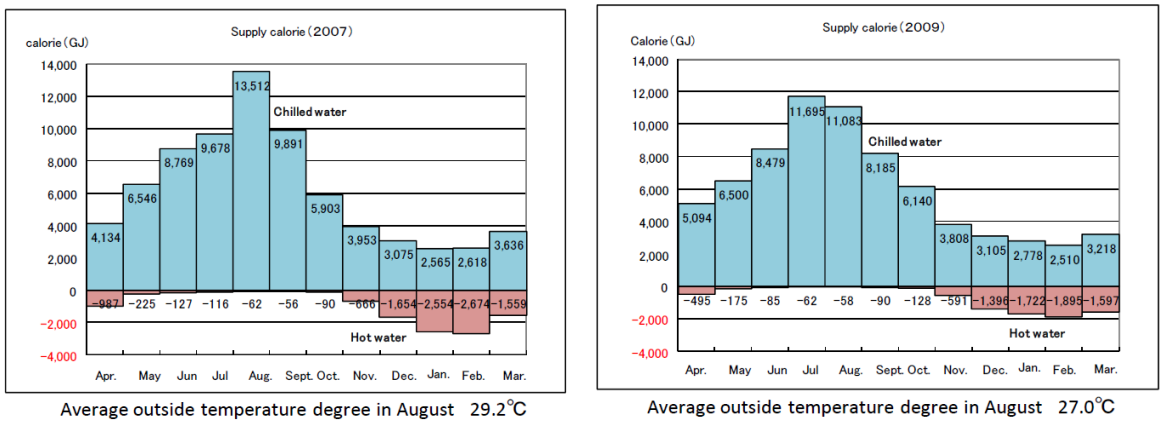

Figure 6 Supply calorie results according to the month

4.2 Effect of Energy Conservation of River Heat Use

It drives because of the taking out heat from three heat pumps and the cold water thermal storage tanks on the cold water peak day. When it is possible to drive in electric powers few between from 13:00 to 16:00 in the afternoon when the power demand becomes a peak, the electricity cost is discounted great. It drives because of the taking out heat from two heat pumps and the cold water thermal storage tanks at this time zone that this fee system is applied. The heat recovery driving goes once a week, and meets the hot water demand in summer.

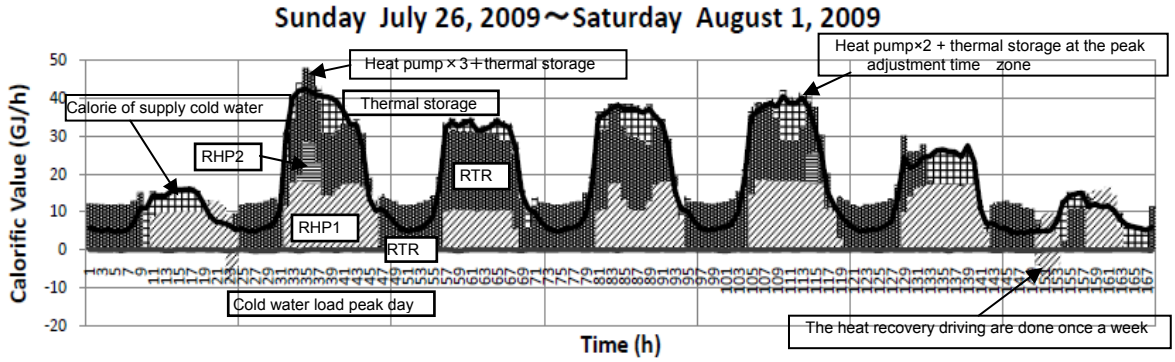

Figure 7 Supply calorie results of one week according to time and Driving pattern of heat source

When the hot water is supplied, the cold water supply calorie and the hot water supply calorie alternately exceed it according to time. For this case, driving only for the hot water,

the heat recovery driving of the heat pump, and the combination driving by the taking out heat from the hot water thermal storage tank are done.

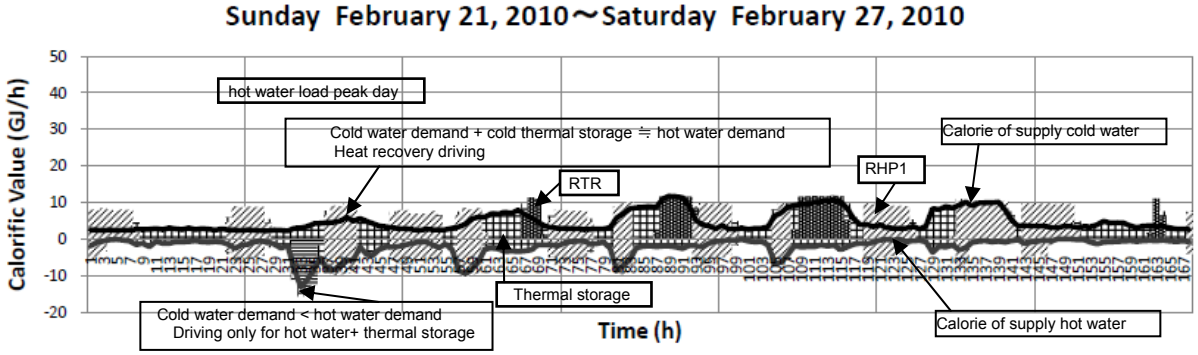

Figure 8 Supply calorie results of one week according to time and Driving pattern of heat source

4.3 Effect of Energy Conservation of River Heat Use

The heat source was driven by a heating tower without using the river heat in 1989. Driving the heat source using the river heat was started in 1990 next year. The consumption energy of the heat source was compared in August,1989 and July,1991 when the average outside temperature degree was almost equal. The effect of energy conservation of the river heat use was 18%. Moreover, the reduction of the make-up water of the cooling tower is a big effect of the saving resource.

Table 4 Comparison of driving by river heat with driving and heating tower (cooling tower)

	August, 1989	July, 1991
Average outside temperature degree（℃）	26.5	26.3
Degree of water temperature of average river（℃）	—	24.4
Total power (ratio)	100	82
Amount of make-up water（m3）	6480	0

The effect of energy conservation of the river heat use in year is about 16% according to the simulation case. Recently, the system efficiency by primary energy equivalent value in 2008 when the cooling load was the largest was 0.96.

5 RATINGPRACTICE OF HEAT SOURCE

The situation of the maintenance check of each composition part of the getting water system is shown.

5.1 Bar Screen

The bar screen was installed in the getting water part so that neither the vinyl bag nor the floating waste may enter in the pump pit as much as possible. When the width of the bar screen is too narrow, the getting water part is blockaded. The float was examined, and it set it by the width of 50mm not to be able to pass the tennis ball.This width was appropriate. The cleaning work was necessary two times though an oceanic living thing adhered to the bar screen during year.

5.2 Pump Pit

The water level of Sumidagawa changes regularly by the tide. The getting water part set up the intake pump as a pump pit so that the getting water system should not receive this influence. Three intake pumps were set up considering the partial load driving and the

backup. One was updated in ten years after it set it up, and other two removed an oceanic product with the check. Two pumps of the remainder are renewed in 21 years after it sets up.

5.3 Getting Water Piping

The getting water piping of 900φ removed an oceanic product and repaired the lining material in year fourth, year 12 and year 21. The obstacle is not caused in the getting water function though the getting water piping of 500φ has not been updated up to the present time.

Figure 9
Improving of intake pump

5.4 Marine Growth Preventing Equipment

It is a system that extracts the copper ion in piping, kills out an oceanic product, and prevents an oceanic product from adhering to the getting water piping. There are a lot of results in the getting water system of the ship. However, it was judged that there was a problem to kill out the living thing as environmental consideration, did not operate, and after several years completion, it was removed. It is possible to correspond to an oceanic product with other systems even if this system is not installed.

5.5 Auto Strainer

It is a strainer that becomes guard final so that the foreign body should not enter the heat exchanger of the refrigerator. It devised it so that the hair etc. should not twine round a past bucket type strainer. That is, the hair etc. can be cut by dropping the garbage of the inner cylinder with the brush, and printing and matching the outer cylinder and the inner cylinder. The blow is automatically driven, and the schedule is in for five minutes every 40 minutes. The check is executed twice a year.

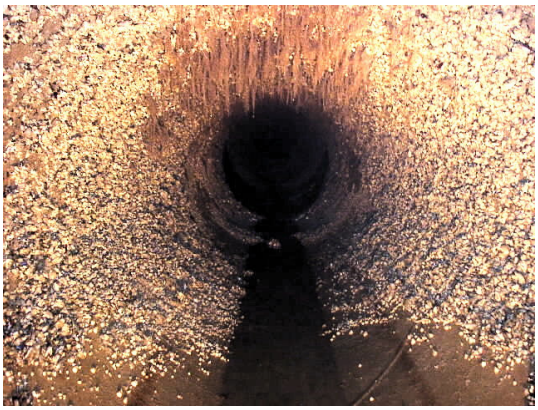

Figure 10
Oceanic product in getting water

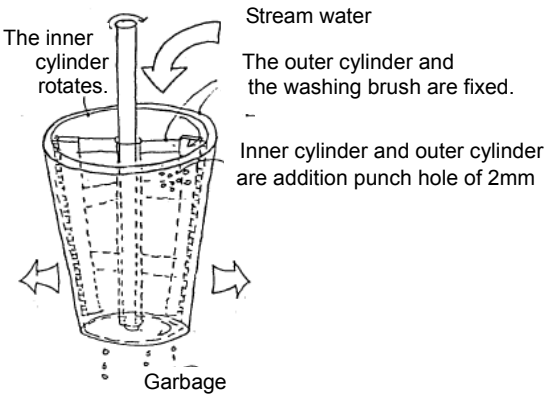

Figure 11 Mechanism of auto strainer

Figure 12 Inside of auto strainer

5.6 Titanium Tube of Heat Pump

Even if 21 years have passed since it set it up, the corrosion trend is not seen in the tube. The causticity doesn't change basically though the water quality of Sumidagawa is improved 21 years ago. The check of the Titanium tube of heat pump has been executed twice a year.

5.7 Brush Type Tube Washing Device

The heat exchange tube in the heat pump adheres internally the scum etc. and decreases the heat exchange efficiency. The brush was installed as the precaution in the tube. The direction of the flow of the stream water was changed at the start and each stop of the heat pump, the brush was moved, and it washed it in the tube. The troubles such as brushes deteriorated, caught with the passing age in the brush storage part in the tube were occasionally caused. The method to make the sponge ball circulate at random as other techniques with results in the tube was taken partially on the way. This method is unnecessary the tube water room major inspection, and judges the aspect of stable supply to be excellent.

5.8 Emergency Shut-off Valve

The plant position is below the surface of the water in the river. Therefore, the siphon phenomenon is caused by the trouble of the equipment, and the stream water might flow in in the plant. The emergency shut-off valve was installed as the measures. Of course, it doesn't cause it to say nothing of the situation that the system operates. To confirm driving the system, the annual operation examination is done. The malfunction of the emergency shut-off valve with an oceanic product has not been generated.

5.9 Other Correspondences

To expect the effect of disturbing the promotion of an oceanic product that adheres to the piping wall, and to throw the stream water at the maximum flow velocity, the intake pump is driven in the whole quantity for 30 minutes once a week. Moreover, the corrosion of the piping system is prevented from progressing by installing the sacrifice anode in piping, an auto strainer, and a header of the tube. Changing the anode executed when checking going twice a year about the equipment, and executed the piping part every ten years.

6 SUMMARY

When the plant is renewed, the heat source system that becomes further highly effective is scheduled to be introduced. The double-bundle type heat pump is introduced, and when the heat recovery is driven, the hot water is manufactured efficiently. Moreover, the highly effective turbo refrigerator only for cooling is introduced considering the cold water demand superior. The system efficiency of the heat source is expected to improve by these more than current states by 18%. Moreover, the getting water system of the stream water demonstrates the expected performance in the current state.

If this anecdotal report can even somewhat contribute to the development of seawater and the stream water use, it is great.