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Global District Energy Climate Awards Submittal

System: Dubai Healthcare City Treated Sewage Effluent-Reverse Osmosis Plant

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Conversion of Dubai Healthcare City District Cooling plant from the use of conventional domestic water to treated sewage effluent.

Executive Summary

The major challenges that face any district cooling provider are to operate the chiller systems with the highest achievable efficiency, minimize water wastage and reduce the cost of operation.

This documentation was prepared to demonstrate how the conversion from the usage of potable or domestic water in district cooling plants into alternative water sources (specifically Treated Sewage Effluent) can be achieved and showcases this accomplishment with the integration of reverse osmosis technology. The financial savings incurred from this approach are also demonstrated.

It is important to define that "domestic water" is the potable water produced by the local governmental utility DEWA (Dubai Electricity and water authority) using the process of sea water desalination. This water is distributed throughout the city of Dubai for the domestic use. On the other hand, "TSE", treated sewage effluent is the sewage water recycled by the local Municipality DM (Dubai Municipality) through a Sewage Treatment Plant. TSE water is primarily used by the local municipality for irrigation.

The key concern involving the use of alternative water sources other than domestic water such as grey water or treated sewage effluent is that it is not advised to be used directly in the District Cooling System unless it is treated due to the high risk associated with using it in the raw form. The risk arises from the fact that this type of water contains high concentration of contaminants and high biological fouling potential which would degrade the performance of the heat exchange equipment.

Several simulation calculations were done to provide a range of alternatives to the use of domestic water in the cooling towers of a district cooling plant. These calculations helped to narrow down the options and provided a guide to select the optimum combination of Treated sewage effluent water mixed with treated TSE through reverse osmosis technology.

As a result of this analysis, the optimum approach was chosen which uses the permeate water from the reverse osmosis plant and blended it with enough quantity of pre-filtered treated sewage effluent to make it equivalent to domestic water in chemical properties. By following this approach, several goals were achieved.

- Eliminated the use of valuable domestic water from the district cooling plant.
- Reduced the risk potential of the treated sewage effluent.
- Implemented an economically viable solution.

Innovation

The main objective of this project was to reduce the operation expenses by converting the District Cooling plants from using the municipal domestic water, as a make up to the cooling towers, to Treated Sewage Effluent without risking the environment or the cooling plants' integrity. This goal was never achieved successfully in the history of the district cooling industry in the United Arab Emirates or the Gulf region before.

To accomplish this goal, several scenarios were prepared showing all possibilities of using alternative water sources through different mixing percentages (Chart -1).

The existing scenario was the use of 100% domestic water. The first set of introduced options were to partially blend TSE with domestic water without any capital investment; however, due to the high risks associated with directly using TSE water ranging from corrosion to fouling of the system, these options were not considered.

The option to make a capital investment in reverse osmosis technology was chosen in order to use the pure water as a make-up to the Cooling Towers. However; the permeate water produced by the reverse osmosis plant has its drawbacks in terms of high corrosivity. Therefore, the high quality permeate of the reverse osmosis was blended with ultra-filtered TSE water of higher TDS to make it an equivalent to domestic water in terms of chemical properties and then the mix was used as a cooling tower make up without altering the chemical treatment program on the plant. The system has been running since February 2011.

Improvements / Benefits

It is evident from the data summarized in Table-1 that TSE water has higher TDS than domestic water. So the cooling system using raw TSE water will run on lower cycles of concentration as opposed to using domestic water. This will result in increasing the cooling tower blowdown quantities in order to maintain the water quality and hence the integrity of the DC plant.

On the other hand, using the permeate water of a reverse osmosis plant which is purifying TSE water, will produce water with low TDS and has a high corrosion potential.

Although the permeate has lower TDS than the raw TSE water, the cycle of concentration achievable on the cooling towers is limited due to several factors such as high holding time of the cooling towers and high turbidity due to the weather conditions in the Gulf Region.

From an environmental perspective, using raw TSE or RO permeate would involve the usage of special chemical treatment plans on the cooling towers that would require the inclusion of toxic metals in the corrosion inhibition program (Zinc, Molybdate).

Based on this, a water blend consisting of 80% RO permeate and 20% of TSE water which is filtered by Ultrafiltration was selected. This option fulfilled the following objectives:

a. Eliminated the use of valuable potable water.
b. Reduced Blowdown quantities.
c. No introduction of hazardous chemicals.
d. No risk of increased corrosion.
e. Economically viable solution.
f. No need to modify the chemical treatment on the cooling towers.

Financial Advantages

The cost of raw TSE water is ten times (x10) less than the cost of domestic water in the city of Dubai. It is evident that using TSE water through any of the given options will involve a significant savings and reduction on the cost of operation of the cooling system (Chart-2). However, since the cost difference is minimal between the TSE options themselves, it was crucial to look at other factors, such as the need to use specialty chemicals (hazardous in some cases), the risks associated by following each option and the impact on the operational side of the cooling system. The most viable option from Table-1 was the use of 80% RO water blended with 20% of TSE water.

Moving forward with this selection, the cost of water per Imperial Gallons was reduced by 85%. The figures used in the calculation are actual numbers extracted from the utility bills collected over the period of 2010 – 2011 for the operation of the Dubai HealthCare City plant. A capital investment was made to install a polishing plant utilizing reverse osmosis technology and the payback period of the plant was calculated to be around 4 years. The significant drop in the cost of water is clearly demonstrated in Chart-2.

Chart-2:

1- In 2010 – domestic water was used as cooling tower make up water.
2- In 2011 – domestic water was replaced with the TSE-RO blend.

Challenges

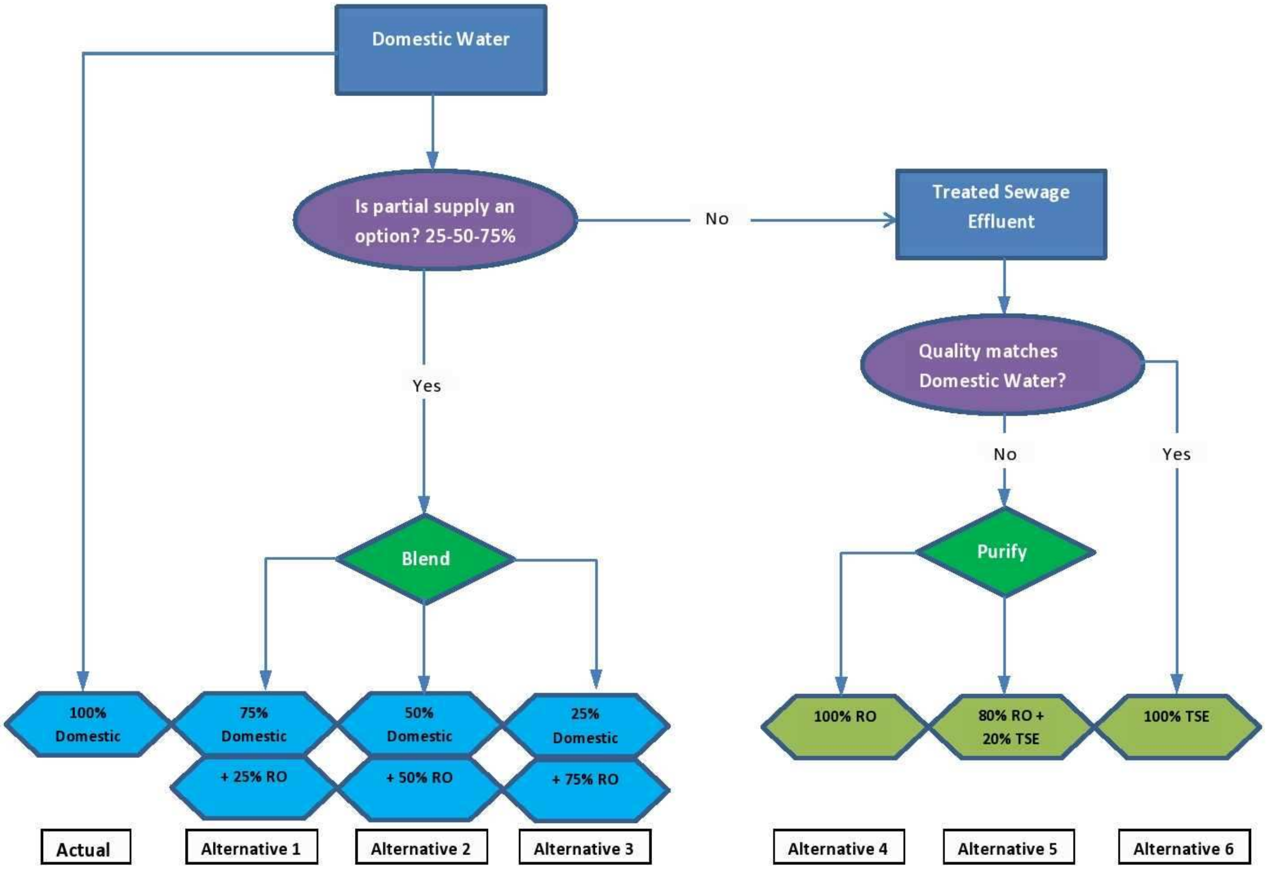
The key concern involving the use of treated sewage effluent water is its high bacterial count and high fouling potential whether it is to be used directly on the cooling towers, or stored in the premises of the district cooling plant for polishing and treatment. To overcome this challenge, a paneled type of storage tanks were installed with small holding times (15 – 20 min) to avoid storing the TSE water in the permanent concrete tanks and for long periods of time. However, the purified water was directed to the plant's tanks for storage and use.

Another challenge was the reverse osmosis plant discharge water quantity and quality. Normally, any DC plant drainage system is initially designed to accept cooling tower blowdown. The DC plant drainage network needs to be upgraded to accommodate the increased quantities of discharge from the reverse osmosis plant. Therefore, discharging reverse osmosis reject water quantity and quality needs to be discussed with the local authorities in order to define the proper ways to discharge this water.

Having proven its financial savings, the TSE-RO project has been included in the master plan of all future permanent plants for EMPOWER to utilize TSE water and replacing the domestic water.

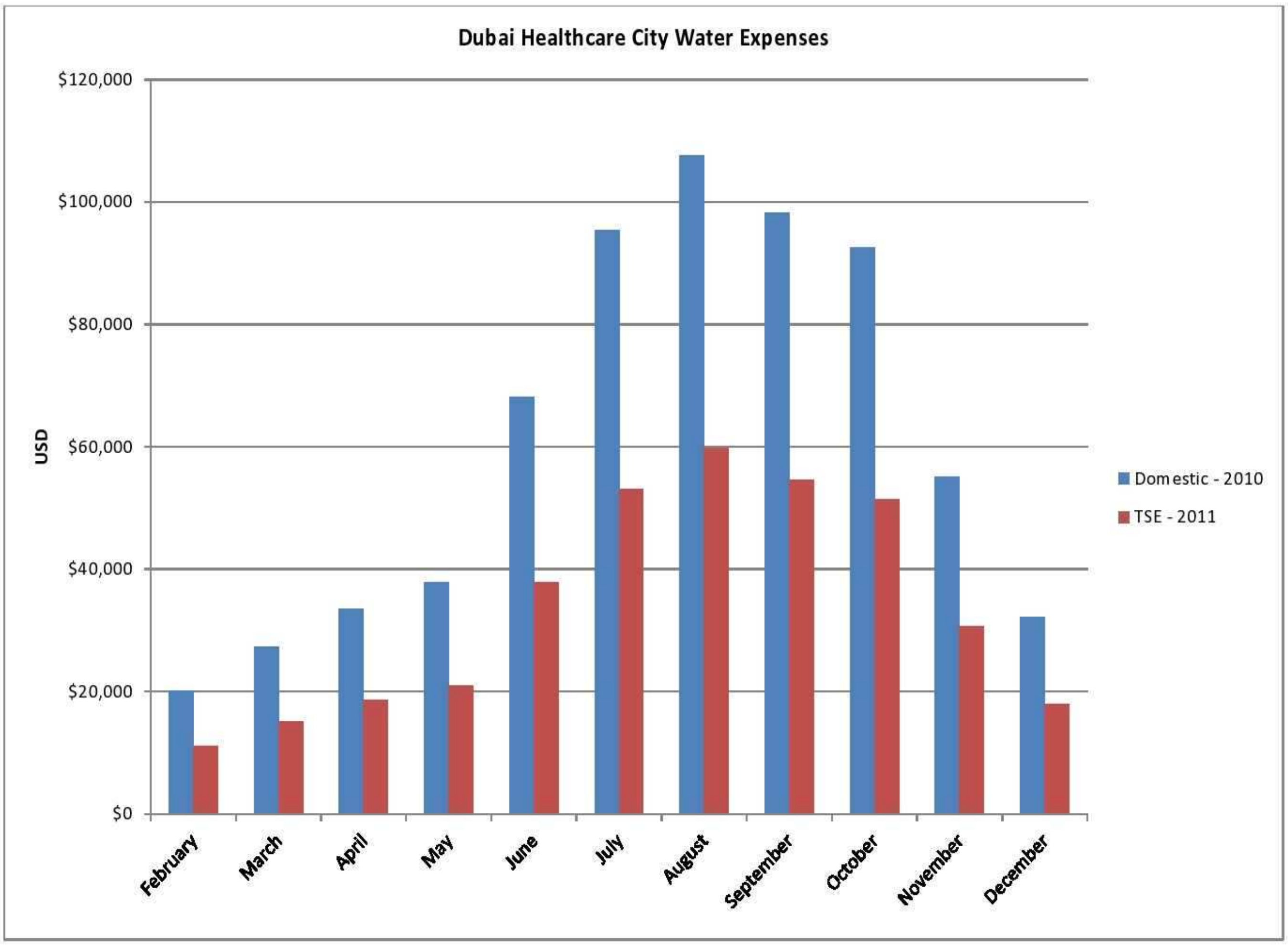
Attachment 1

Chart -1: Roadmap for the selection of the alternative water source to domestic water



Attachment 2

Chart -2: Water expenses



Attachment 3

Table -1: Comparison between different types of the shortlisted water options

Water	*Domestic Water*	*TSE (raw)*	*TSE (RO)*	*Blend (80% RO + 20% TSE)*
Cost	1.25 cents/Gallon	0.14 cents/ Gallon	0.22 cents/ Gallon	0.19 cents/ Gallon
Quality (TDS (mg/L))	100 – 300	> 1000	< 100	100 - 300
Impact on Cooling Tower operation	6 COC	3 COC	8 COC	8 COC
(Cooling Tower Chemical Treatment) Blowdown status	Organic - Non hazardous	(Contains elements restricted by municipality for discharge) [1]	(Contains elements restricted by municipality for discharge) [1]	Organic - Non hazardous
System Integrity	No risk	Risk of fouling	Risk of corrosion	No risk

[1] ENVIRONMENTAL STANDARDS AND ALLOWABLE LIMITS OF POLLUTANTS ON LAND, WATER, AND AIR ENVIRONMENT, *Dubai Municipality*, May 2003.