

How much energy that ozone generator can save?

In HVAC system, ozone for water cooling system has been adopted to maintain heat exchanging at maximum capacity where scale and slime problems will be mitigated.

Comparing between Ozone and Traditional (Chemical) Treatment, there are many issues to consider on expenses and here are as follows:

1. Electrical consumption of chillers
2. Make-up water
3. Chemical
4. Condenser cleaning
5. Electrical consumption of treatment system

Example of the existing system in Thailand

HVAC system and basic data

Chiller	800	Tons	2 Units
Energy consumption rate of chiller	0.65	kW/Ton	
Cooling tower	1,000	Tons	2 Units
Water circulating rate of cooling system	1,020	m ³ /hr	
Load factor	0.70		
Operating time	24	hour per day	
	365	day per year	
Electrical tariff	0.08	Usd per kW-hr	
Water supply tariff	0.40	Usd per Cubic meter	
Softener Expenses	0.08	Usd per Cubic meter	
Chemical	500	Usd per month	
Condenser tube cleaning	520	Usd per Unit	

Solution

1. Electrical consumption of chillers

From HVAC system, the electrical expenses

$$= \text{Tons of Chiller} \times \text{kW/Ton} \times \text{Load factor} \times \text{Operating time [hr]} \times$$

Electrical tariff

$$= (2 \times 800) \times 0.65 \times 0.7 \times (24 \times 365) \times 0.08$$

$$= 510,182 \text{ Usd/year}$$

Unfortunately, efficiency of chiller would continuously decrease because condenser tubes inside the chiller are being coated by slime and scale, that would make heat transfer coefficient decreased where trend of condenser approach temperature and energy vs time are shown in Figure 1.

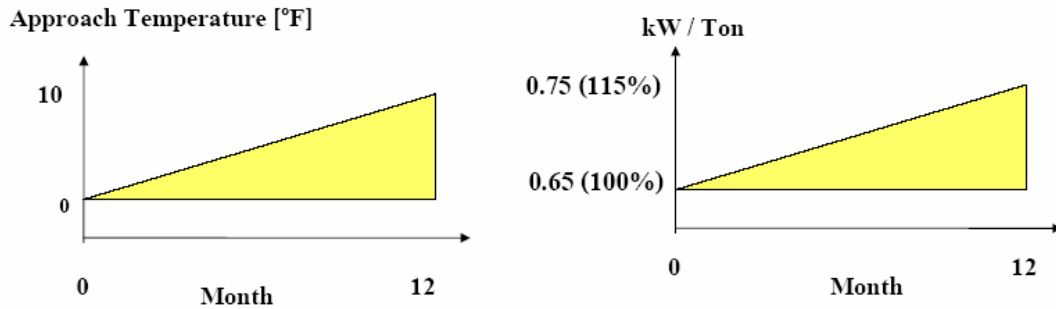


Figure 1: Trend of approach temperature and energy are being increased.

Empirically, cost of electricity would be increased by 1.5 % every 1 °F increased of condenser approach temperature.

Practically, after using chemical treatment, operators would leave condenser approach temperature reaching to 5 - 10 °F from newly cleaning of condenser tubes. From Figure 1, the cost of electricity would increase 0% to 15 % within a year after cleaning condenser tubes. Optimistically, we would use only 5% to be average value of increasing for this calculation.

Therefore, electrical expenses would be increased

$$= 0.05 \times 510,182$$

$$= 25,509 \text{ Usd/year}$$

Total cost of electricity for **chemical treatment**

$$= 510,182 + 25,509$$

$$= 535,691 \text{ Usd/year}$$

For ozone system, condenser approach temperature is constant at newly cleaning condition. Therefore, there is no increasing cost after adopting ozone system.

Total cost of electricity for **ozone treatment**

$$= 510,182 \text{ Usd/year}$$

2. Make-up water

Obviously, water in cooling system is always evaporated to reduce water temperature which quantity of vapor water is designed on 1% of water circulating rate of cooling system. Consequently, make-up water is filled to compensate vapor water.

For chemical treatment, make-up water is produced by water supply reduced the quantity of hardness and alkalinity by softener before supplying to cooling tower. Therefore, water expenses of **chemical treatment**

$$= \text{Water circulating rate of cooling system} \times 1\% \times \text{Operating time} \times \text{Water tariff (water supply + softener)}$$

$$= 1,020 \times 0.01 \times (24 \times 365) \times (0.40 + 0.08)$$

$$= 42,889 \text{ Usd/year}$$

For ozone system, water supply is adopted to be make-up water directly. Therefore, water expenses of **ozone treatment**

$$\begin{aligned} &= \text{Water circulating rate of cooling system} \times 1\% \times \text{Operating time} \times \text{Water tariff (water supply)} \\ &= 1,020 \times 0.01 \times (24 \times 365) \times 0.40 \\ &= 35,741 \text{ Usd/year} \end{aligned}$$

3. Chemical

For chemical treatment, chemical is filled in water to react with substance which is the cause of scale and algae.

Therefore, chemical expenses of **chemical treatment**

$$\begin{aligned} &= 12 \times 500 \\ &= 6,000 \text{ Usd/year} \end{aligned}$$

For ozone treatment, no chemical is filled in this system. Dissolved ozone in water oxidize substance and bacteria which are the cause of scale and algae.

Therefore, there is no chemical expenses of **ozone treatment**.

4. Condenser cleaning

Exactly, condenser cleaning is the practical process to increase the efficiency of chiller whenever condenser approach temperature is higher than limitation causing by scale and biofilm covering to surface of condenser tube.

For chemical treatment, even chemical used properly to each particular water system, typically, condenser cleaning by hazardous chemical is always done every 6 months.

Therefore, condenser cleaning expenses of **chemical treatment**

$$\begin{aligned} &= \text{Times of cleaning} \times \text{Units} \times \text{Cleaning cost} \\ &= 2 \times 2 \times 520 \\ &= 2,080 \text{ Usd/year} \end{aligned}$$

For ozone treatment, scale is perfectly prevented. Consequently, condenser cleaning is not necessary to increase the efficiency of chiller because condenser approach temperature is always kept constant at the highest efficiency. Therefore, there is no condenser cleaning expenses of **ozone treatment**.

5. Electrical consumption of treatment system

For chemical treatment, injecting pump used for feeding chemical to cooling tower consumes 1 kW. Therefore, electrical consumption of **chemical treatment**

$$\begin{aligned} &= 1 \text{ kW} \times \text{Operating Time [hr]} \times \text{Electrical tariff} \\ &= 1 \times (24 \times 365) \times 0.08 \\ &= 701 \text{ Usd/year} \end{aligned}$$

For ozone treatment, ozone generator, oxygen concentrator and mixing pump composed to be ozone system consume 6 kW. Therefore, electrical consumption of **ozone treatment**

$$\begin{aligned} &= 6 \text{ kW} \times \text{Operating Time [hr]} \times \text{Electrical tariff} \\ &= 6 \times (24 \times 365) \times 0.08 \\ &= 4,205 \text{ Usd/year} \end{aligned}$$

List of expenses for treatment system

<u>Description</u>	<u>Chemical [Usd/year]</u>	<u>Ozone [Usd/year]</u>
Electrical consumption of chiller	535,691	510,182
Make-up water	42,889	35,741
Chemical	6,000	0
Condenser cleaning	2,080	0
Electrical consumption of treatment system	701	4,205
Total expenses [Usd/year]	<u>587,361</u>	<u>550,128</u>
Saving by ozone system [Usd/year]		37,233

Payback calculation

Investment of ozone system for this project = 55,000 Usd

Therefore, if we use ozone treatment instead of chemical treatment, payback period would be

$$\begin{aligned} &= 55,000 / 37,233 \\ &= 1.5 \text{ years} \end{aligned}$$