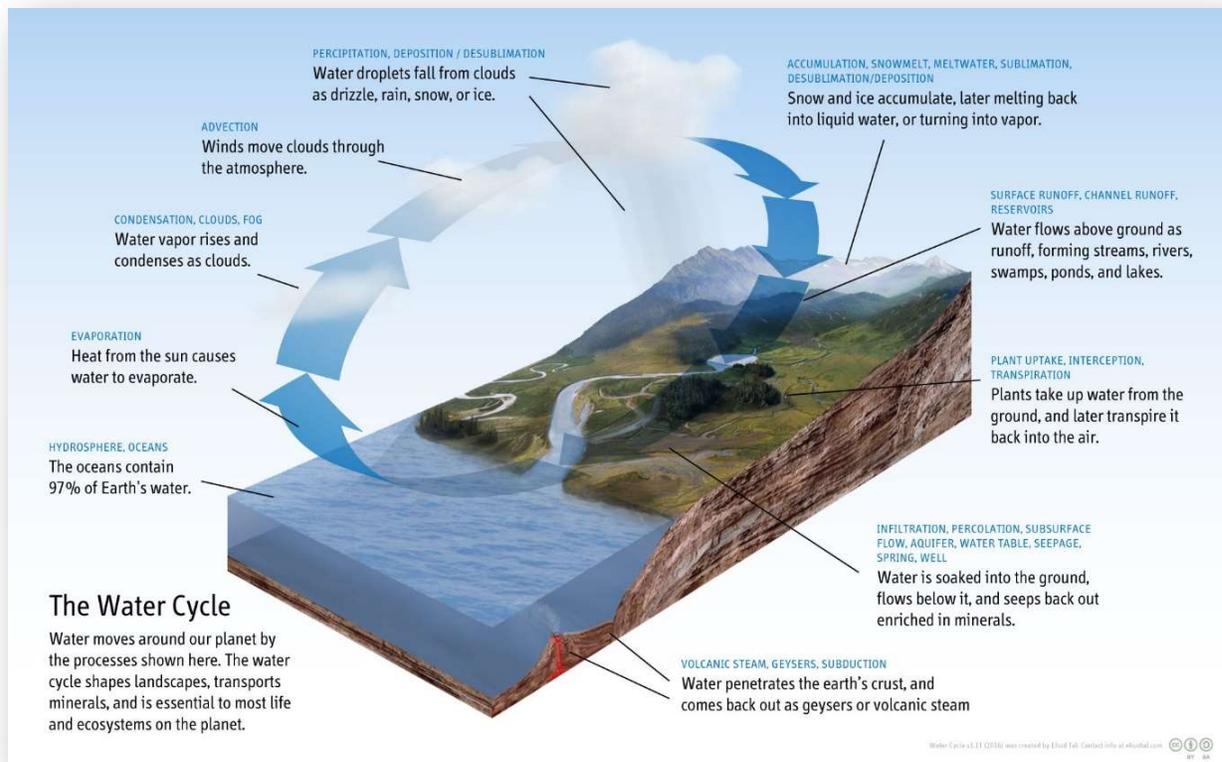


Enhancing Enhanced Evaporation

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Natural Evaporation

Since the creation of the oceans, mother nature has used evaporation to clean and move water around the earth through the water cycle. During evaporation, energy provided by the sun separates clean water vapor from dissolved solids, like salts. These water vapors disperse into the atmosphere to come back down as rain and snow while leaving the solids in place. As a natural process, the efficiency of evaporation is governed by the natural ambient conditions, like, air and water temperature, sunlight, salinity of water, and wind.



By Ehud Tal - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=47658638>

This natural phenomenon has created an opportunity, across multiple industries, as a cheap and effective means of disposing of wastewater. It has been used for thousands of years but not without issue. Natural evaporation can take enormous amounts of time and massive ponds to increase surface area and interaction with ambient conditions.

Enhanced Evaporation

To combat these issues a number of technologies have been created to enhance evaporation rates. These systems are typically variations of a traditional agricultural sprinkler or mister/snow making machine that aerosolize wastewater then blows it into the air. Aerosolizing the wastewater increases the surface area thereby increasing the evaporation rate. Misters have been the choice of industry for many years but if you talk to any evaporation pond operator you will understand these too have issues.



Temperature and Sunlight

Misters work very well when the sun is shining and the ambient air temperature is high. Similar to a semi-truck getting great gas mileage going downhill and dropping going uphill, when conditions are reversed, mister efficiency drops and can even stop. This is due to the capacity of air to hold water vapor. The simple fact is, at lower temperatures air can hold less water. This is compounded by the fact that evaporating water actually cools the ambient air though the evaporative cooling affect. This is a well-known affect and you have probably benefitted from it if you have a swamp cooler. This is also why misters are used as snow making machines at ski resorts, because they can create snow even before the ambient temperatures hit freezing. Unfortunately for evaporation pond operators in most places across the country, this means misters only work for part of the year and performance significantly decreases at night.

Total Dissolved Solids (TDS) and the Salinity of Water

Misters aerosol water by mechanical means. During this process, a large part of the water is broken into tiny droplets (aerosol) while the smaller fraction is vaporized and separated from dissolved solids as it travels through a spray nozzle or fan blade. This creates an opportunity for scale to accumulate on equipment. Even at low levels of salinity, scale will quickly build up and require maintenance. At high levels, scale accumulation can happen so fast that it makes running the mister impossible.



Wind

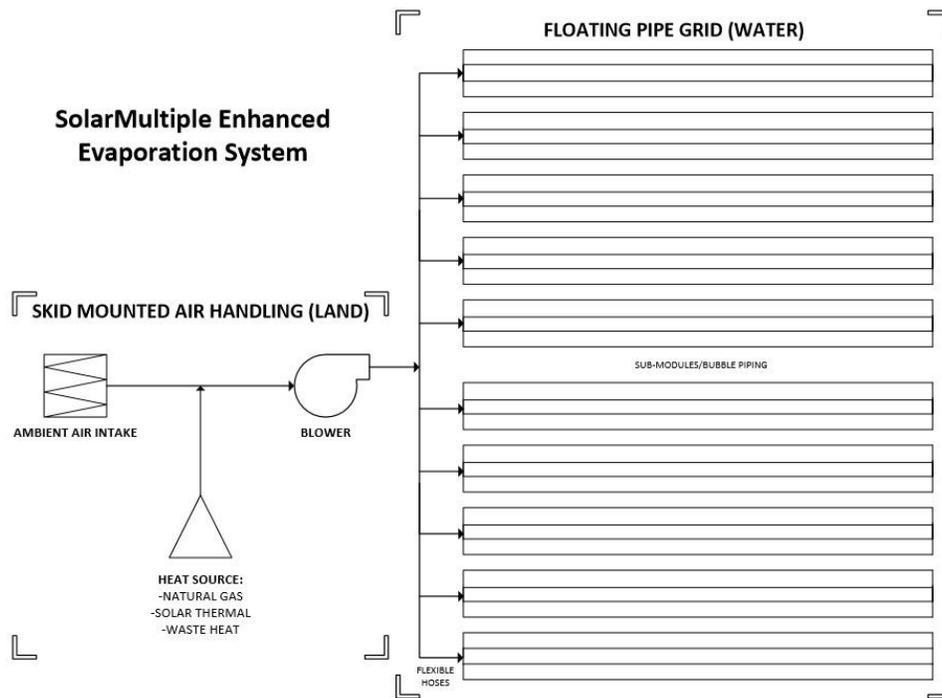
Wind can significantly increase evaporation. It can provide a continuous supply of drier air to break up the humid layer above the pond surface and transport water vapor away. The tiny droplets of water, still containing dissolved solids, leaving the mister do not evaporate immediately. They are sprayed upwards to maximize interaction time with the ambient air. This creates an environmental problem when the wind is blowing in that, droplets caught in the wind are blown across the edges of the pond leaving behind the solids on the shore. Most environmental regulatory boards have caught on to this issue and now require mister systems to be shut down during high wind events and imposed large fines if they are not. Some manufacturers have designed systems pointing back at the pond surface to decrease this effect stating that the decrease in hang time and increased humidity of the ambient air above the pond is actually offset by the increase in run time of their systems. In either case, this is not ideal.

The SolarMultiple Solution

SolarMultiple has developed a patented evaporation system that increases mother nature's wastewater solution while addressing the shortcomings of traditional mister systems. The system utilizes heated air, bubbled across the surface of an evaporation pond to increase rates.



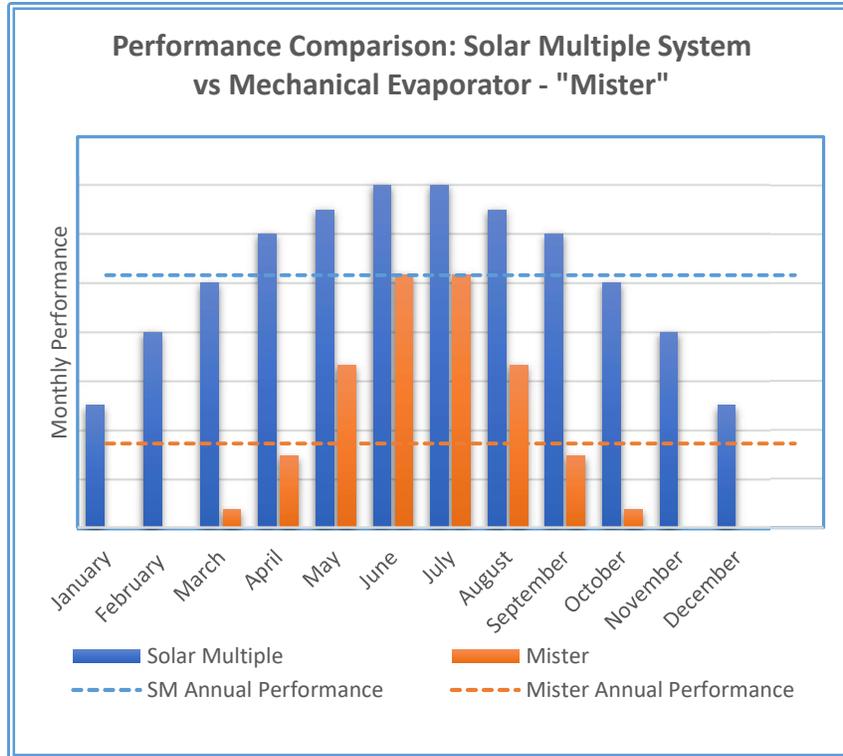
A single module of the SolarMultiple system is pictured above. A large blower and heat source (left) delivers heated air to a floating HDPE piping grid for distribution across the pond surface.



This allows the SolarMultiple system to:

- Operate all year round, including winters, with minimal effects on performance
 - For every $\sim 20^{\circ}$ C air is heated the amount of water vapor the air can hold doubles
 - No moving parts are exposed to water eliminating the chance of freezing and breakage
- Operate at high TDS levels and high corrosivity
 - Evaporation occurs with air movement, not mechanical equipment, to reduce scaling
 - Systems capable of complete evaporation to solids, or, Zero Liquid Discharge (ZLD)
- Operate with no downwind residue
 - Water is vaporized, not aerosolized, and no droplets containing salt ever leave the pond during even the highest wind conditions.
 - Humid boundary layer at pond surface is continuously broken up

The following is a generic performance comparison of a mister system and the SolarMultiple Enhanced Evaporation system rated at the “same” output on a monthly basis for a year. Note that this comparison assumes a TDS level acceptable to mister systems and allows for the 10-20x additional pond area required by the misters to mitigate overspray and interference between misters. If this was not assumed, the difference would be far greater.



As you can see, there is a considerable amount more water being evaporated over the year. This is because SolarMultiple designs systems to perform on an average annual basis, not a peak seasonal performance. Industrial wastewater is not a seasonal problem and should not be addressed as such. Using Typical Meteorological Year data provided by the National Renewable Energy Laboratory, from any specified location in the world, we can estimate system performance, down to the hour, with our quantitative model developed over five years of testing and validation.

Additional advantages of the SolarMultiple Enhanced Evaporation system are that it is constructed in modules and can be installed at virtually any location, new or existing, and it can utilize a number of different heat sources depending on the resources available. This optimization, and significantly better yearly performance, leads to **the lowest cost in terms of cost per gallon evaporated out of any system.**

When comparing enhanced evaporators, it is important to note these differences and the parameters you must work under. A system that cannot perform all year and requires a much larger foot print is not reflected in peak performance numbers. A versatile yet consistent system utilizing sustainable means to increase mother nature’s proven process is always the way to go.

About SolarMultiple

SolarMultiple applies deep engineering and design experience in renewable energy applications to real-world water and environmental challenges. Our flagship product, the enhanced evaporation system, can increase wastewater evaporation rates from oil and gas, power generation, industrial, or mining operations, year-round, by over 30 times using a variety of sustainable energies. For more information visit us online at www.solarmultiple.com or send us an email at info@solarmultiple.com