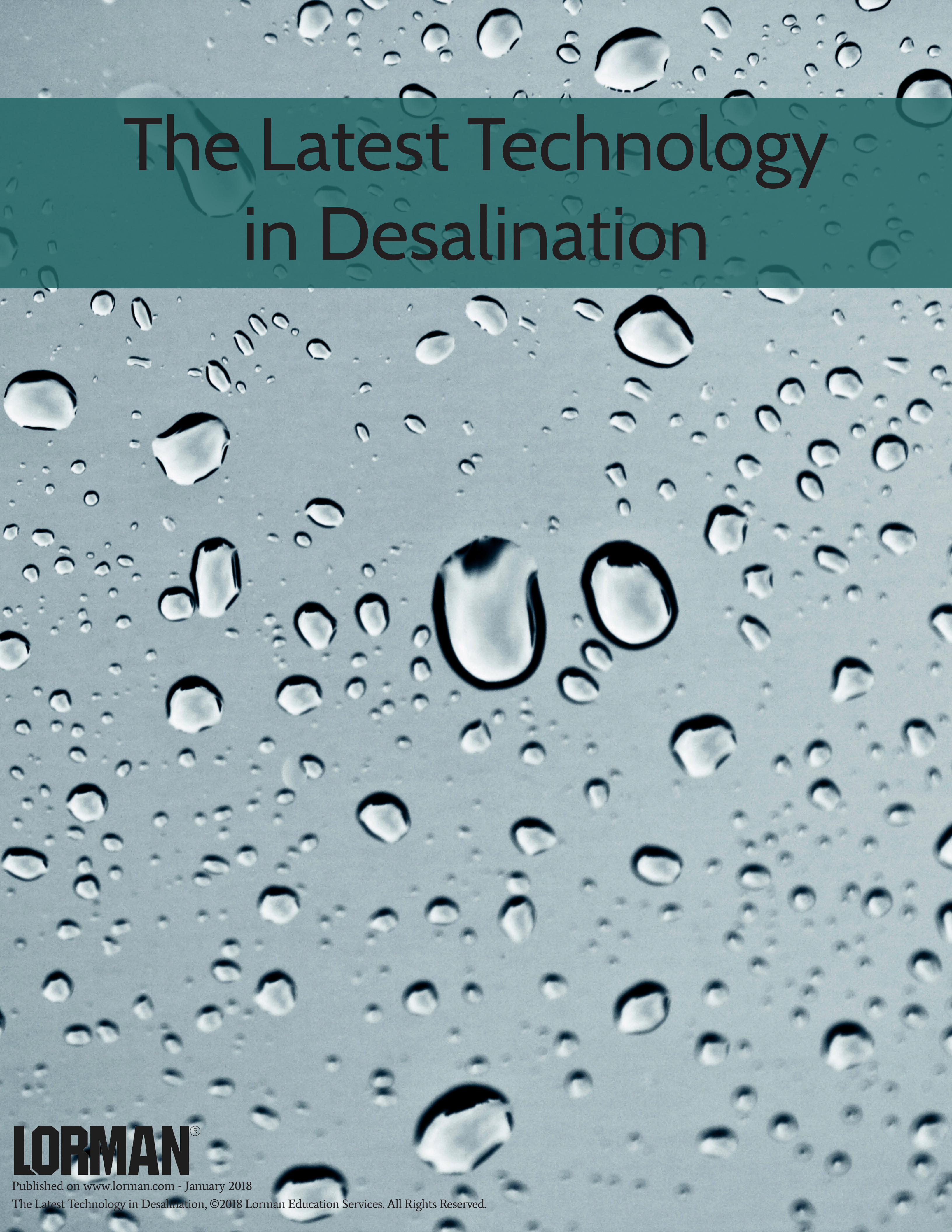

The Latest Technology in Desalination

LORMAN®

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Desalination is a collection of processes that eliminate a certain percentage of salt and minerals from saline water. Generally, salt water goes through desalination to generate fresh water that is safe for irrigation practices or human consumption. This desalination process leaves a great deal of salt as a byproduct. Seagoing ships and submarines in particular use the practice regularly.

In today's world, interest in desalination has magnified as cost effective methods of fresh water production have become high interest items. Aside from wastewater that has been recycled, this is one of but a few water sources that are not dependent upon rainfall. Still, desalination used on a large scale consumes vast energy stores and requires highly specialized, very expensive infrastructure to operate. This makes it a more expensive solution than obtaining fresh water from standard sources like groundwater or rivers.

Despite the heavy price, the benefits and potential of the process has made the goal of perfecting it an on-going endeavor. Desalination is especially pertinent in other countries such as Australia, where rainfall collection is heavily utilized to resupply stores of drinking water.

The International Desalination Association reports more than 14,000 desalination plants operate across the globe. They generate 68 million cubic meters per day and an incredible 120 million cubic meters are projected by the year of 2020. Jebel Ali, located in the United Arab Emirates, is the world's largest desalination plant.

Vacuum distillation is by far the most widely used process in these global plants. Vacuum distillation involves water being boiled at lower atmospheric pressures and thus at a greatly reduced boiling temperature. This happens because liquid boils when vapor pressure matches the pressure in the surrounding area while at the same time increasing with temperature. Because of distillation occurring in a vacuum, which decreases temperatures, a good deal of energy is saved. Another leading methodology, multistage flash distillation, is responsible for roughly 85% of worldwide production.

One alternative desalination process competing against vacuum distillation uses membranes, chiefly using technologies designed for reverse osmosis. Processes involving membranes apply semipermeable films and pressure to divide water from salt. Reverse osmosis systems in plants generally consume less energy that distillation of the thermal variety. Overall desalination prices have fallen over the last decade as a result. As stated, desalination continues to be an energy inefficient system, making costs in the future dependent on how much energy and technologies for the process cost themselves.

Cogeneration is another competitor to vacuum distillation. It uses surplus heat from power production to complete a different job. In the world of desalination, cogeneration is the manufacture of drinkable water from salinized groundwater or seawater inside of a power plant facility that has been dual purposed to provide the energy for desalinating. Additionally the facility may use the energy produced solely for generating potable water. In the fashion of true cogeneration plants, the facility may take excess energy and feed it back into its power grid. Any type of energy could theoretically be utilized in a cogeneration plant. Today, however, most of them use fossilized fuels or nuclear power as their energy source. Facilities in North Africa and the Middle East often use petroleum to counterbalance scarce water reservoirs.

ECONOMICS

Facility capacity, type of complex, feed water, location, labor, energy, disposal of concentrate, and financing are the common factors determining desalination costs. In order to optimize efficiency and minimize these costs, desalination stills have begun to manage temperature, pressure, and brine concentrations. On the whole, it is large-scale nuclear-powered processes that may prove to be the most economical practice.

Even though prices were falling and technology was improving, desalinated water was being considered as a viable option only for the more affluent areas closest to oceans. Economically weak areas or those well within a continents interior, found desalination a poor solution. In an unfortunate twist, those were often the places with the greatest water challenges. High transport costs meant moving freshwater could prove the more worthwhile endeavor. In reaction to this many regions like Saudi Arabia, built extensive pumping units which run hundreds of miles inland from their desalination plants, thus eliminating the need for transport. This solution broadened desalination's influence and has sparked a veritable renaissance in plant construction.

The Perth plant, for example, uses renewable energy transferred from the Emu Downs Wind Farm to partially power its operations. New South Wales utilized a Bungendore wind farm purposefully constructed to provide ample renewable energy to counter balance Perth's energy consumption, reducing harmful emissions of greenhouse gases to tolerable levels.

In South Australia plans for a new plant were announced for the city of Adelaide. Support for the plant was so locally favored that a poll illustrated a near 60% positive response despite citizens being fully aware that funding the project meant increased water rates.

Poseidon Resources Corporation was awarded approval to construct a desalination plant for $300 million just north of San Diego. With an estimated 50,000 gallons of potable water produced each day, the facility supplies water to nearly 100,000 residential homes. The continued improvement in available desalination technology is what makes this achievement possible. As more than half of operating costs have been cut, so too has the selling price of desalinated water. While average prices for 1200 cubic meters are around $700, Poseidon was able to close the distance to roughly $900, making them more expensive but still competitive when overall costs are factored in.

EXPERIMENTAL TECHNOLOGIES

Many experimental technologies and methods are being generated to further advance the process of desalination. The US government in particular is pushing for better and better solutions to its inherent dilemmas. One such solution is the adoption of solar desalination.

Solar desalination involves manipulating solar energies to de-mineralize water. The practice stretches back to the 1950s when simple stills were being researched for use in isolated desert and coastline communities. When water pumps, lines of pipe, and energy costs began to fall soon after, solar stills had become a less viable option for large-scale community projects. The trend has reversed, however, as fossil resources which power traditional desalination processes have dwindled. Many plants have undergone retrofit procedures, gaining more sustainable features which are being produced by specialized companies.

There are different varieties of solar desalination. Solar power can be used to thermally desalinate water or convert it into electricity. Reverse osmosis is employed with both electrical and mechanical systems. Akhter Iqbal Zuberi, of Pakistan, developed a tower type plant which generated 40 liters of water per square meter every day. The productivity of his plant exceeded every conventional solar desalination plant that was horizontally constructed by a factor of 10. The design necessitated an elevated cement tower, topped by a tank. Glass cut in the same shape covers the entire facility, with a gap separating them. The tower’s tank contains saline water while another tank outside the structure adds its own water drop by drop. Excess water drips from the interior tank, coating the cement of the tower whereby solar radiation evaporates the moisture. Condensation on the glass flows to a collection drain while the residual saline water passes through another dedicated drain.

New saline water is constantly applied to the cement walls from the tower’s peak during this process. Once evaporated, the saline water left over falls and drains out, also continuously. These movements elevate molecular energy and provide a boost to the evaporation process. The height of the tower also adds to this increased production.

Unlike normal systems which hold water without movement for several days, an isolated space near the tower’s top contains a condenser which allows cold water to move through it. The hot vapors and heated water are compressed and thrown against the cement walls after passing through the condenser.

Zuberi’s vertical solar desalination plant has another valuable feature. Facilities built horizontally are only capable of collecting solar radiation at noon. These new, vertical towers are able to obtain solar energy from sunrise until sunset. Perpendicular radiation is collected during the early morning hours by one side of the facility. Noon provides the plant with energy equivalent to conventional horizontal plants. From then until the sun fades, the remaining side of the facility gains the maximum amount of radiation. Thus, the tower facility receives higher amounts of solar energy due to its height, while interior temperatures increase, producing greater water yields.

Since their conception, tower plants have received continuous upgrades and experimentation. Their productivity only continues to rise as new developments are always in the works.

Solar humidification-dehumidification (HDH) is a procedure which imitates the natural cycle of water, but at a reduced time frame, by evaporating and concentrating water away from various other substances. Also referred to as the solar multistage condensation evaporation cycle (SMCEC), the process uses thermal solar energy to generate vapor which is then separated into another chamber. Complex systems minimize waste heat by gathering it from condensed vapors while heating up the incoming source of water beforehand. Desalination systems of small to mid-level types utilize this method most effectively, especially in isolated regions due to low cost solar collectors.

PASSARELL SYSTEM

Another process, termed Passarell, involves the use of lowered atmospheric pressures, not heat, to push evaporative desalination. Distillation produces purified water vapor which is then condensed by a highly advanced compressor. Efficiency of the distillation is improved by this compression because of the evaporation chambers reduced pressure. After being siphoned through a demister, water vapor is centrifuged. Any leftover impurities are removed during this phase, as the pure water is pressed against the collection chambers tubing. The temperature of the compressed vapors increase and the heat produced is transferred into the tubes where the pressed water vapor is falling. The Passarell process joins many different processes which allow most of the energy generated to be reused throughout its sub-processes, chiefly demisting, evaporation, vapor compression, condensation, and the motion of water inside the system itself.

GEOTHERMAL ENERGY

Desalination may also be driven by geothermal energy. In the majority of locations using geothermal processes trumps the use of limited ground or surface water both from environmental and economic standpoints.

NANOTUBE MEMBRANES

Besides geothermal and solar desalination, effective water filtration may also be membranes as an alternative to reverse osmosis requires significantly less amounts of energy.

Coming in either a single nanotube form with an open end, or as a network of nanotubes layered perpendicularly like a honeycomb to form an impermeable film. This impermeable aspect is the key. It differentiates a membrane devised from nanotube technology from the more common membranes with porous surfaces. Molecules of gases and fluids may flow through this resistant membrane but only by way of the nanotubes. Molecules of water, for example, form ordered bonds of hydrogen which that move through nanotubes, behaving like chains. What results is a near frictionless, smooth interface on an atomic level of water and nanotubes. This directly relates to the hydrophobic interface's "slip length". Even though slip length properties are used to characterize non-continuum water behavior inside of pore walls, simple hydrodynamic systems completely ignore them. In fact, even the Hagen-Poiseuille equation does not include them. Water flow on molecular levels which pass through carbon nanotubes are more ably characterized by molecular dynamic simulations. These adopt a different form of the Hagen-Poiseuille equation which does include slip length properties.

Using single-tube membranes in order to transfer polystyrene particles of 60 and 100 nm diameter was first reported in early the early 2000's. Not long after, grouped membranes composed of double and multi-walled carbon nanotubes were fashioned and subsequently examined. It was illustrated that water is able to flow into the cores of graphitic nanotubes. It can move at magnitudes five times greater than common predictions of fluid dynamics allow, per the Hagen-Poiseuille equation. This applies to double-wall tubes with inner diameters greater than 2 nm or multiwall tubes with inner diameters of 7 nm.

Experiments were conducted whereby potable water was transferred by way of three sample, double-walled nanotubes of carbon make. The experiment was done in a matrix of silicon nitride with fluxing membrane thicknesses. Increased flow was discovered with these new membranes, which was roughly three times faster than projected a non-slip hydrodynamic system adhering to the Hagen-Poiseuille equation. The results of this experiment involving 1- to 2-nm diameter porous nanotubes corresponded to nearly 10 to 40 water molecules per nm2 per nanosecond. A comparable experiment with 7 nm diameter nanotubes within polystyrene was examined for the velocity of the fluid. The result illustrated that long slip-planes are held by nanotubes while much faster flow rates, four to five times greater in fact, were recorded as well. This was a major enhancement over conventional predictions for fluid flows.

Unexpectedly, it was further proven that electrical current application can control water flow through membranes of carbon nanotubes without filler matrixes, making nanotube membrane technology an increasingly viable option for water desalination.

BIOMIMETIC MEMBRANES

Biomimetic membranes are one more experimental approach being researched. Siemens Water Technologies unveiled new technology breakthroughs for the desalination of water. By employing electric fields, the company plans to de-salt one cubic meter of water with only 1.5 kWh of energy. This process means an incredible energy consumption rate half that of other available procedures. Oasis Water, which was the original developer of this technology, currently produces energy rates three times higher than this biomimetic process.

LOW-TEMPERATURE THERMAL DESALINATION

Researching the thermal energy conversion of oceans led to another new process in the field of desalination; low-temperature thermal desalination. This alternative system employs vacuum pumps to generate low temperature, low pressure atmospheres at which water begins to boil between two water volumes at 8-10 degree Celsius. Ocean water that has begun to cool is provided from up to 600 m depths. Coils are utilized to pump water through, condensing the liquid into water vapor. The condensation left over is potable water. Low-temperature thermal desalination also takes temperature gradients of power plants to its advantage, reducing the input energy requirements necessary to generate a temperature gradient when large volumes of warm water waste are discharged.

The United States and Japan were the first to experiment, testing the process for validity. A spray-flash system of evaporation was implemented in Japan. The experiment was conducted by Saga University. Across the globe the National Energy Laboratory in Hawaii tested an OTEC open-cycle facility producing power and fresh water with a difference in temperature of 20 degrees Celsius between surface level water and water obtained from nearly 500 m in depth. Low-temperature thermal desalination was also studied in India at the National Institute of Ocean Technology. India’s first facility opened in the Lakshadweep islands’ Kavaratti region. Plant capacity currently rests at 100,000 L and uses water from deep depths and temperatures which range between 7 and 15 degrees Celsius.

NON-THERMAL BRINE CONCENTRATOR

A recent study conducted by General Electric’s desalination technology team displayed a recovery rate for drinkable water which surpassed 99%. The discovery was from a plant designed for beverage bottling and could very well transform into yearly, billion dollar savings if the implementation were to spread wide enough.

Termed the AquaSel Non-Thermal Brine Concentrator, GE's system may be the breakthrough the beverage industry has been waiting for. This is chiefly because about 15 -25% of water flowing into the plant winds up discharging as brine, or wastewater, as the treatment takes place. The AquaSel takes the leftover brine and treats it through desalination before passing it back into the water system. The AquaSel further concentrates the desalinated brine, pulling out the crystallized salt. This produces a water recovery rate of nearly Zero Liquid Discharge, or 99%. It also decreases the intake of freshwater into the system by around 20%.

Previously, usable water by the billions of gallons had been lost every single day. Systems geared toward water treatment have been technologically, as well as economically, limited as to how much water can be reused after being treated. GE, by way of their AquaSel technology, have made it possible to turn billions of gallons of water loss into fresh, usable resources with the elimination of streaming wastewater.

The data from the initial studies show that if the AquaSel technology were adopted into every major bottling facility, a near 30 million gallons of water each day might potentially be recovered or saved. This would tally to nearly 11 billion gallons worldwide, per year.

Besides the incredible ability to recuperate most of the water loss in the waste stream, GE's AquaSel system consumes energy at a much lower than other systems, specifically any utilizing heat to divide and clean brine. Starting up this new technology for water treatment may result in substantial energy reductions and residual costs decreases. This would provide businesses with a worthwhile incentive to perform equipment investments as today's businesses deal with high discharge costs and water consumption. The technology presented through the AquaSel system is a tool that will raise water efficiencies with the necessity for energy and capital that accompany the installation and operation of a thermal system.

Desalination of any sort, be it thermal, geothermal, solar, biomimetic, or membrane based, is full of untapped potential in the global race for water resources. Though these processes have been researched and experimented with on countless occasions, they have still resisted total adoption across the world due to their high levels of energy consumption and large implementation and operating budgets. The gap between these two disparaging characteristics however, when compared to the industry standards, is steadily decreasing. New technologies supported on the backs of past trials and failures, are pushing desalination toward wider levels of acceptance. As the process presses forward into the future and beyond, it is hard to imagine that any alternative system currently established will be able to compete against the potable water production levels of these facilities. Without a doubt, desalination will continue to grow, providing water treatment services to the world on a scale previously unheard of.