Zero Liquid Discharge – Maximum recovery and why it finally makes sense.
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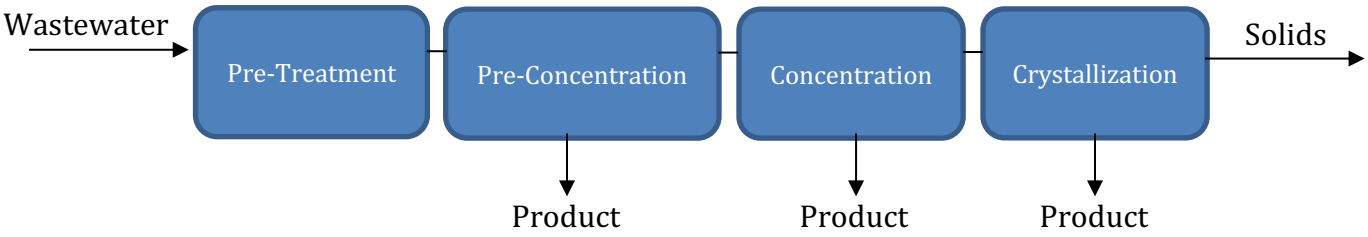
Our planet continues to become increasingly more crowded. Pollution and waste are showing irreversible impact on a global scale, and it has become necessary to come up with solutions in all industries. It is widely known, though perhaps not publicly thought of, that the process of purifying water creates waste. As we remove the minerals and impurities from water, we inherently condense those impurities into a smaller body of water. This waste affects the environment in various adverse ways. The solution lies in a concept known as Zero Liquid Discharge (ZLD).

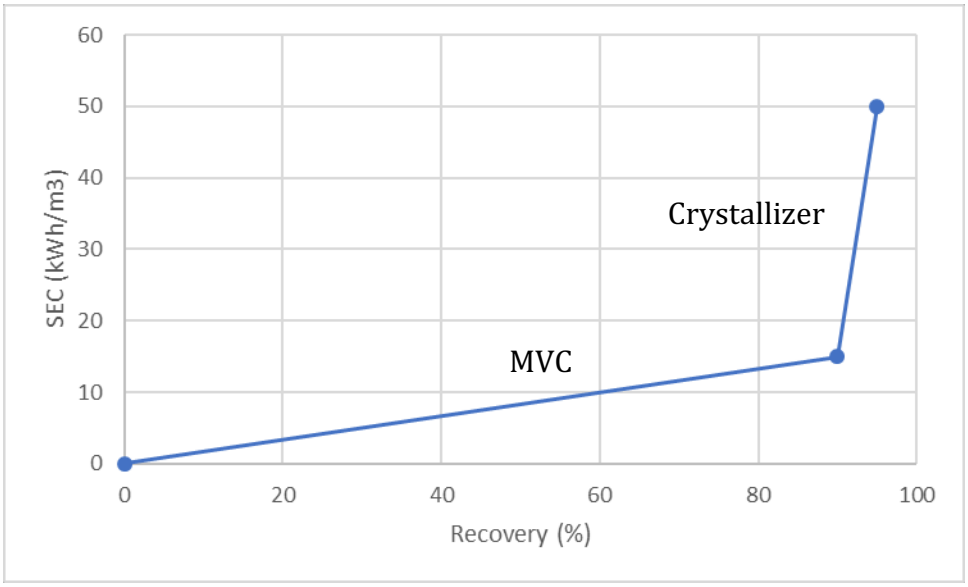
Zero Liquid Discharge (ZLD), as the name suggests, is a water treatment process focused on recovering 100% of the water from waste streams. This process certainly has the advantage of conserving the most water possible; however, ZLD is an energy intensive process that requires several steps to remove all solids from the water and hence, economics typically limit its widespread use. Regions like India and China have made moves towards tighter government regulations that require ZLD while brine disposal regulations in the US and Europe also drives some industries towards ZLD. Depending on brine disposal options, ZLD can also make sense for an industrial user looking to reduce waste volumes and disposal costs. In comparison to high recovery desalination discussed in the MI Systems' article "Turning Down the Power on High Recovery Desalination," removal of dissolved solids in the ZLD process requires even higher energy use since 100% recovery is needed. Reducing the energy requirement of ZLD is key to achieve wider adoption.

The Breakdown of ZLD Energy Consumption

ZLD is a multi-step treatment process that typically consists of pretreatment, pre-concentration, concentration, and crystallization as illustrated in the figure below.



The most energy intensive processes comprising ZLD are the concentration and crystallization stages. The energy required for the concentration or evaporation stage ranges from 15 kWh/m3 to 40 kWh/m3 depending on the technology used. Mechanical Vapor Compression (MVC) is the most efficient followed by Multi-Effect Distillation (MED) and Multi-Stage Flash (MSF). Crystallizers typically use around 50 kWh/m3. The figure below illustrates the energy consumption as a function of water recovery for the concentration and crystallization phases.



The total area under the curve represents the total energy required for the process. By adding a pre-concentration step, this area can be significantly reduced because the total volume sent to the evaporator is minimized. The capital cost of the evaporator is also reduced due to the smaller volume. Typical pre-concentration processes include forward osmosis, membrane distillation and electrodialysis reversal. These technologies will typically recover up to 60-80% of the feed water and the rest is fed to the evaporator stage.

Designing a ZLD Solution

Selecting a pre-concentration technology depends on the sources of energy available. Forward Osmosis and Membrane Distillation are energy intensive (30-50 kWh/m3) but make sense if waste heat is available from the industrial process. Electrodialysis reversal removes the salt from the water instead of the water from the salt and thus can use less energy than pressure driven membrane processes. Energy usage is, however, highly dependent on the amount of salt that must be removed. For the evaporation stage, MVC is typically the most efficient but is usually used for smaller volume flows and is capital intensive. For higher flow rates, MED or MSF is used followed by crystallization. The right

technology combination of pre-concentration and evaporation is a great start towards lowering the energy required to bring recovery to an acceptable level.

Pursuing Economical ZLD – Maximum Recovery, Minimum Energy™

Anything worth obtaining involves commitment, perseverance, and careful navigation around the obstacles threatening the goal. To succeed at reversing water scarcity around the globe, water waste must be minimized and recycled wherever possible. Zero Liquid Discharge is a method of achieving this and it becomes more economical with MI Systems through excellent technology choice in the pre-concentration stage. An electrically driven process, END™ technology minimizes the resistance of every part of the desalination cell including electrodes, membranes, and perhaps most importantly, the membrane spacers. The result is a lower-energy pre-concentration stage to make evaporation and crystallization more economical.

MI Systems continues to make installations all over the world. Systems designed for Zero Liquid Discharge are typically well served with the END™ technology platform. Innovative ideas revolving around what to do with the recovered resources is still up for debate. As stated time and again, the solution lies in partnering efforts. It is good to know that END™ is able to aid in the economical realization of Zero Liquid Discharge.