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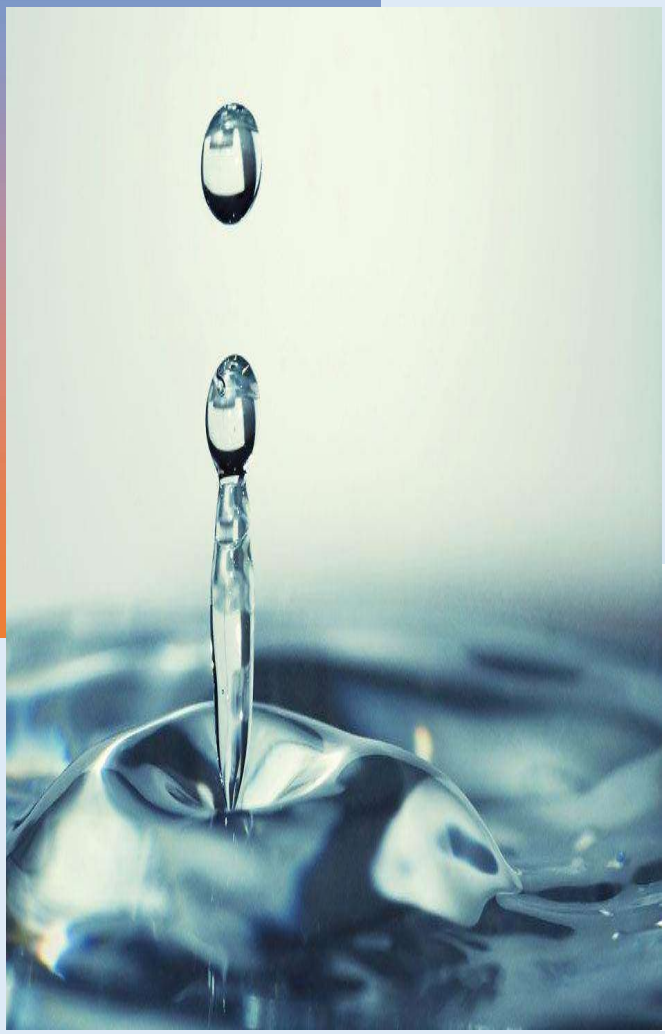
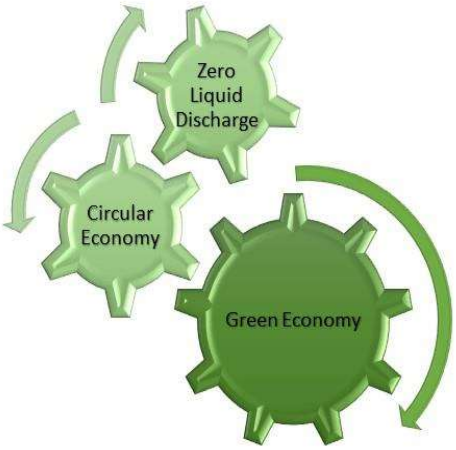


WHITE PAPER

Zero Liquid Discharge (ZLD)

An Industrial Water Management Solution for the Green and Circular Economy



This white paper is about how **Zero Liquid Discharge (ZLD) Water Management System** encompasses the concepts and principles of green and circular economies in managing wastewater produced from industries and minimizing their potable water intake. It uses the concept of reduce, reuse, regenerate, and recycle principles while protecting the environment and humans from the harmful effects of pollutants in this water and as well as improving financial bottom line.

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Introduction

A study by the UN Environment Programme (UNEP) in partnership with Sustainability and GlobeScan, using a compelling economic and scientific research and a wide-ranging collection of real-life studies has demonstrated the advantages of the **green economy** in action.

According to this report,

1. Grupo Bimbo in Mexico saved approximately US $700,000 and 338,400 m3 of water in 3 years through its water reduction programme.
2. Unilever's "one rinse" washing formulas saved an average of 30 litres per wash and are now used across 12.5 million households per wash, which is a 60% increase over 2010.

> *Businesses cannot continue to ignore the benefits of transitioning to green economy for their sustainable growth*

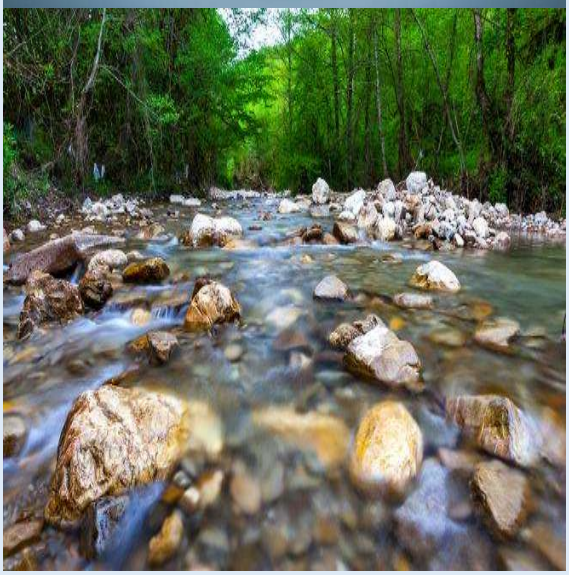
Transitioning to a circular economy offers businesses opportunities to reduce pressure on the environment, improves the security of the supply of raw materials, increase competitiveness, stimulate innovation and boost economic growth according to a study by the European Union parliament. The study found out that:

1. EU alone created 580 000 jobs as a result of transitioning to a circular economy.
2. Total annual greenhouse gas emissions could be reduced by 2-4%.

Water is a natural resource that can best be managed through both the green and circular economy. Industries that rely heavily on water for their production and produce highly polluted wastewater can use efficient and sustainable water management solutions to transition into both the green economy and circular economy.

> *Moving towards a more circular economy could deliver benefits such as increasing competitiveness, boosting economic growth, and creating jobs.*

This paper discusses one of those solutions: **Zero Liquid Discharge (ZLD)** industrial water management system.



Business Transition to Green and Circular Economy

Wikipedia defines the **green economy** as an economy that aims to reduce environmental risks and ecological scarcities and aims for sustainable development without degrading the environment.

> Green Economy can create green jobs, ensure real sustainable economic growth and prevent environmental pollution, global warming, resource depletion and environmental degradation.
>
> Chief Directorate: Communication, South African Department of Environmental Affairs, Pretoria

Unilever saved US$10 million annually by integrating sustainability into its business models, thereby increasing its financial bottom line, according to a study by the UN Environment Programme (UNEP) in partnership with SustainAbility and GlobeScan. Its CEO had this to say:

> "At Unilever we see no conflict between sustainability and economic growth. We have to have both, and increasingly we see that one is not possible without the other. This new report from UNEP confirms this, with cases drawn not just from our own business but many others in a variety of sectors, exploring the ways in which sustainability reduces risk, generates cost savings, and creates opportunities for growth, providing the foundation for a new business model for the 21st century."
>
> Paul Polman, Unilever's Chief Executive Officer

US $10 million saving annually realized by Unilever through green economy initiatives-UNEP

A **circular economy** is an economic development system designed to be beneficial to businesses, society and the environment by:

1. Creating a closed loop economic system through reuse, sharing, repair, refurbishment, remanufacturing and recycling of materials and products to keep them in circulation and preserving their value for much longer within the economy.
2. Minimising the use of non-renewable resources and the creation of waste, pollution and carbon emissions while enhancing the use of renewable resources in the economy

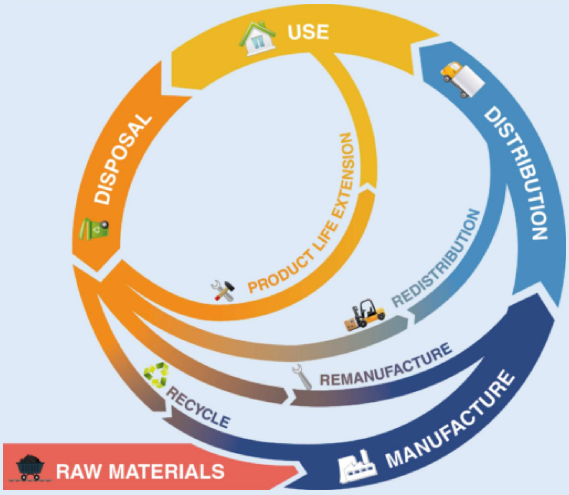


Figure 1: Circular economy processes (*Source*: http://www.wiretechworld.com)

According to a study by the European Parliament, measures such as waste prevention, eco-design, and reuse could save EU companies €600 billion - equivalent to 8% of annual turnover.

Industrial Water Management in the Green and Circular Economies

As a result of global population growth and intensive use of natural resources, there has also been an increasing withdrawal of fresh water for agriculture, industry, and municipalities.

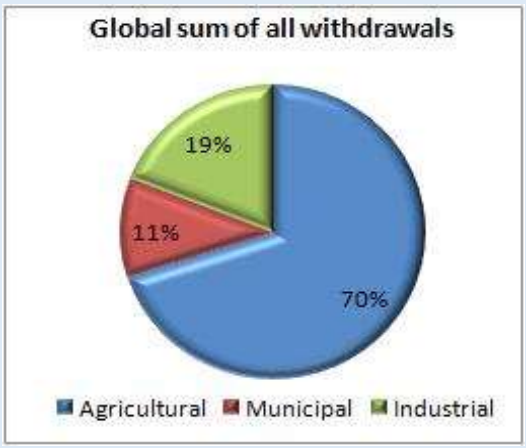


Figure 2: % Global Fresh Water Withdrawals (*Source*: http://www.fao.org/)

Water is one of the resources in the industrial processes inputs and outputs, as seen below.

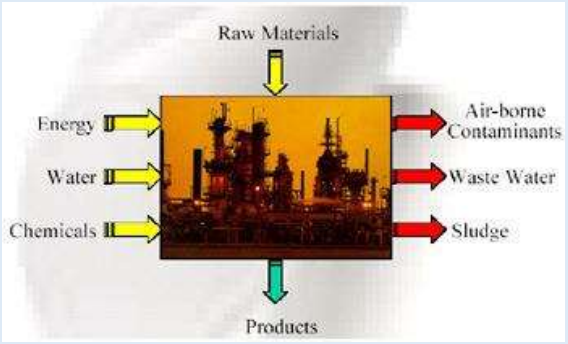


Figure 3: Industrial Input-Output

(*Source*: https://www.nap.edu/)

The demand for raw water, pretreatment (if necessary), consumption/use in the process, and the disposal/treatment of wastewater produced make up the industrial water management system.

From an industrial perspective, a sustainable water management solution that promotes the transition to green and circular economies should be the one that addresses the following while increasing the financial bottom line of the business.

- Reduces demand on resources (Raw potable water)
- That creates jobs from increased financial investment in infrastructure development and operations by bringing in new technologies and processes to the facility
- That increases the efficiency and value of the natural resources (water recycling/reuse and other resources recovery)
- That protects the environment from pollution

19% of total global water withdrawals are used for industrial purposes - FAO

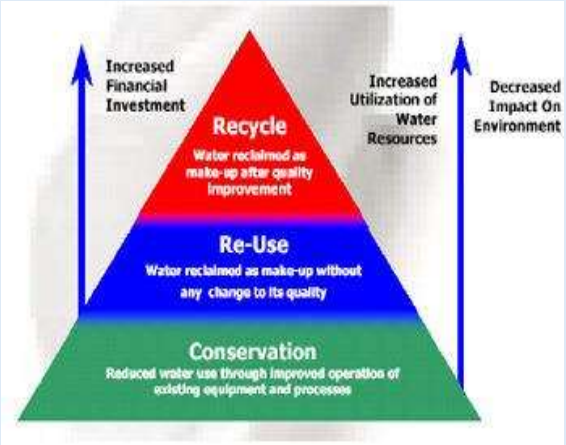


Figure 4: Green and Circular Water Management

Why Zero Liquid Discharge Industrial Water Management System.

The principle of "zero liquid discharge" is based on the concept of recycling and reusing all of the wastewater produced from the industrial process's inputs-outputs system. The produced wastewater is treated and used again in the process, thereby reducing the demand for raw potable water.

Zero Liquid Discharge (ZLD) may not be suitable for every industrial facility due to its complex nature and its high initial capital investment cost. The following are the drivers for installing a ZLD system in your industrial site in line also with the green and circular economies principles.

1. Stricter regulations on wastewater disposal
2. Severe water scarcity in the region putting intensified pressure on freshwater resources use
3. Inhibiting high costs of wastewater disposal into the municipal sewer system or complete prohibition of industrial wastewater into the municipal sewer system, environment or landfills.
4. Prohibitive costs of disposal into landfills or evaporation ponds.

The following are some of the benefits for ZLD systems.

- Compliance with environmental regulations
- Supplementing water suppliers
- Cutting wastewater disposal costs
- Protecting the environment hence becoming a responsible citizen
- Minimising waste, while treating and recovering commercially sellable products like potassium sulfate, caustic soda, sodium sulfate, lithium and gypsum
- High recovery (%) of reusable water

The more and more stringent environmental regulations to protect natural resources demand and degradation, as well as the rising cost of water and wastewater disposal, are therefore driving the technological innovations for ZLD systems and applications.

Choosing a ZLD treatment system

Deciding on the effective and appropriate ZLD treatment system and infrastructure can be a very complex process that requires a lot of time and effort, and very specialist knowledge. It depends on a number of factors such as:

- The quality of water needed for reuse or recycling
- The quality and quantities of contaminants in the wastewater generated from the main facility
- The system required flowrates
- The technologies and equipment and infrastructure required to treat the system required flowrates and remove contaminants to the quality needed for reuse or recycling
- The business case study to determine the most effective and sustainable solution

Businesses can use the Zero Liquid Discharge water management system to transition into green and circular economies.

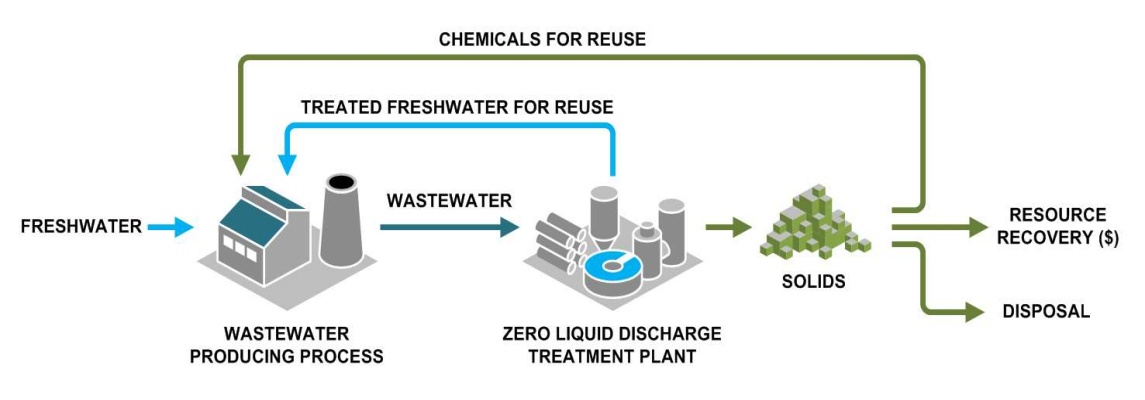


Figure 6: The ZLD water treatment system

(Source: https://www.saltworkstech.com/)

Some of the ZLD applications

Some of the typical ZLD applications include:

- Cooling tower blowdown in heavy industry and power plants
- Ion exchange regenerative streams particularly in food and beverage processing
- Flue gas desulphurisation, the wet wastewater stream
- Municipal potable water systems, wastewater streams and leachate
- Process water reuse from agricultural, industrial and municipal streams
- Various industrial wastewater streams from the textile, coal-to-chemical, food and dairy or battery industries
- Landfills Leachate

Technological Solutions for Zero Liquid Discharge

The **Conventional Thermal ZLD Technology** is based on evaporation and crystallization operations only.

Process Brine concentrators commonly use mechanical vapour compression (MVC) for water evaporation. MVC consume large amounts of energy and require high-grade electric power, typically in the range of 20-25 kW_e/m^3 of treated feedwater and up to 39 kW_e/m^3 of untreated water.

Evaporation stage can achieve solid concentration up to 250,000 mg/L, with 90–98% of recovered water having total dissolved solids of 10 mg/L. Operational and capital costs are still very high due to high energy consumption, use of chemicals and expensive corrosion-resistant materials.

The concentrated brines are fed to a brine concentrator for further water recovery following similar operations as brine concentrator. Vapour compressor crystallisers are commonly operated in a forced-circulation mode. Industries can recover close to 100% of the water from these additions. The energy consumption of crystallisers is almost three times that of brine concentrators as it can be as high as $52-66\ kWh_e/m^3$ of treated feed water. The reason behind this dramatic increase is due to much higher salinity and viscosity, although volumes are now much smaller.

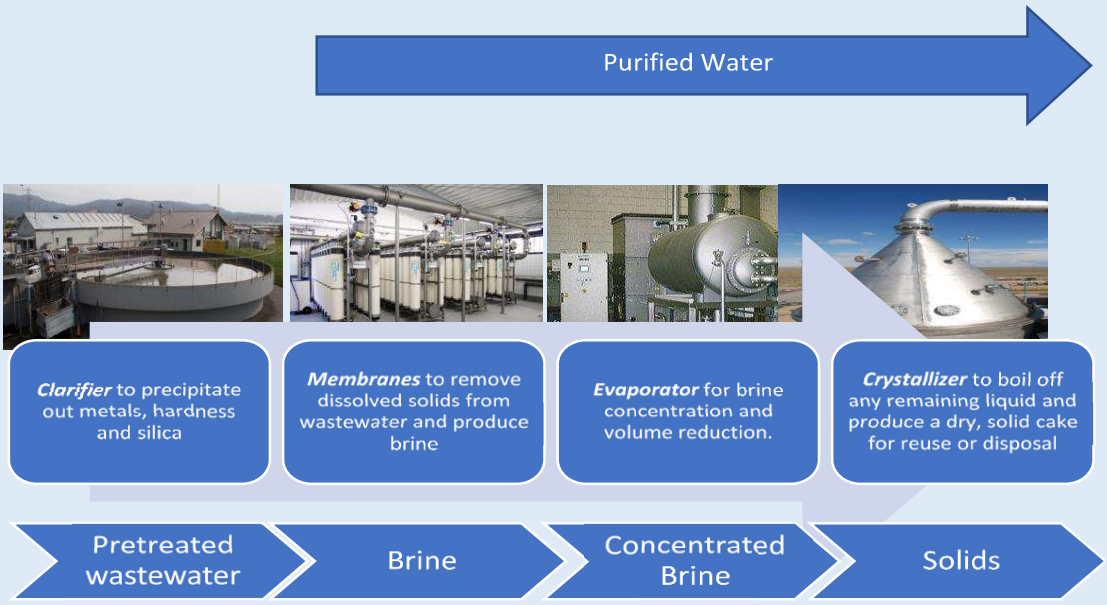


Figure 5: Zero Liquid Discharge

Evaporation ponds are cheaper but can only be used where volumes are smaller, and the land is available as well as adequate environmental controls and management systems.

Hybrid ZLD Technologies have been developed to incorporate membrane technologies (Reverse Osmosis (RO), Nanofiltration (NF), Electrodialysis (ED) or ED reversal (EDR)) to the conventional thermal ZLD processes, to reduce high energy demand and costs.

Emerging membrane-based ZLD technologies (Forward Osmosis (FO), Molecular distillation (MD)), which are further improvements on membrane systems have also been incorporated into the Thermal ZLD processes to improve efficiencies.

RO system is used to recover as much water as possible before MVC so that the footprint of MVC and crystalliser or evaporation ponds is smaller, leading to reduced energy demand and costs. The higher the recovery of the RO systems, the lower the price of ZLD.

RO is however limited by:

- Osmotic pressure becomes too high for TDS ~ 80,000 ppm
- Scaling by sparingly soluble salts (Ca, Mg, SO_4, PO_4, silica), may be alleviated to some degree using antiscalants
- Fouling (by organics, colloids, biofilms, etc.)

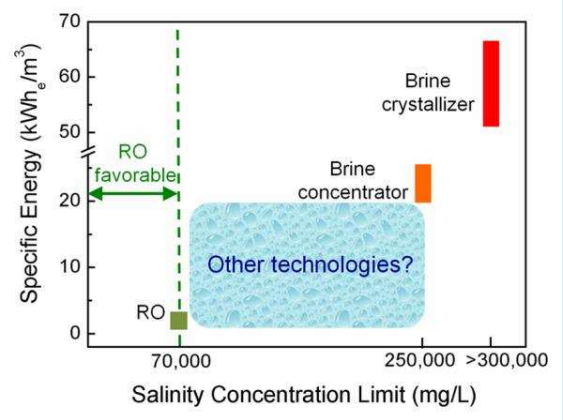


Figure 7: Specific energy consumption by RO, brine concentrator, and brine crystallizer.

(Source: https://www.researchgate.net/)

As a result of these limitations, the other membrane technologies already mentioned were developed.

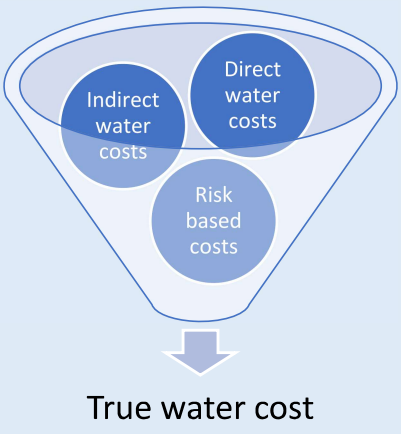
Zero Liquid Discharge Technologies Key Considerations

The following are some of the ZLD key design, performance and lifecycle costs indicators:

- Salinity tolerance limits
- Energy requirements and efficiency
- Water recovery rate
- Initial investment cost
- Running Costs
- Periodical maintenance

True Cost of Water: Economic and Financial Analysis

Veolia has developed a risk-based tool that can provide business with a more precise and bigger view of real costs of implementing or not implementing an industrial water management solution like Zero Liquid Discharge in its facilities.



It focuses on the financial implications of water-related risks. It combines three types of costs:

1. Direct costs: price of water, operational expenditures (OPEX) and investments (CAPEX) in water infrastructure
2. Indirect costs: administrative, legal and corporate social responsibility costs
3. Costs related to risks

The tool looks at risks identified during analysis and their likelihood vs the cost of impact in $/m^3. Some of those risks can be:

- Temporary loss of license to operate
- Plant shutdown due to water shortage
- Penalties due to water pollution
- Strengthening of discharge regulations

Return on investment can no longer just be based on the direct and indirect costs related to water treatment, purchase and saving but should be corrected to risk-based values. This tool can then be used by a business to determine the appropriate water management solution.

Conclusion

Businesses that are transitioning to green and circular economy with water management solutions like zero liquid discharge (ZLD) ahead of formal regulatory frameworks aimed at protecting natural resources such as water and the environment and human well-being, in general, are achieving competitive advantage by positioning themselves to capture the mainstream markets in the future.

The selection of a ZLD system and add-ons is a highly complex and customized process and it is heavily dependent on each individual facility's treatment goals and objectives and the quality and quantity of wastewater produced in that facility. It is therefore advisable to work with a water treatment specialist that will help you develop the best solution for your facility.

CASE STUDY

In a water stressed part of China, Procter & Gamble (P&G) needed to increase their cleaning and sanitising washouts and reduce overall water demand and use. In order to find a balance they opted to optimise water use during products formation while increasing the recycled water.

They pre-treated their wash water biologically before passing it on to the RO, where the permeate is sent to cooling towers and the brine concentrate goes to the MVC.

The condensate is recovered and used to run on-site utility system, with a storage tank balancing water streams. Treating the wash water is said to have saved 40,000 m^3 of water annually, and using recycled water within the facility saved an additional 20,000 m^3/year.

This is a success story of transitioning to green and circular economy through the use of ZLD industrial water management strategy

Considering Zero Liquid Discharge

WATEN Process Engineers are seasoned chemical engineers with post-graduate qualifications and extensive experience in water/wastewater treatment process engineering, design, and infrastructure development, including introducing new technologies into wastewater treatment plants.

For expert advice on Zero Liquid Discharge, please visit our website to schedule an appointment

GET IN TOUCH

SOURCES OF INFORMATION

- https://www.samcotech.com/how-to-choose-best-zld-system-for-your-facility/
- https://www.saltworkstech.com/articles/what-is-zero-liquid-discharge-why-is-it-important/
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