ZERO BRINE

ZERO BRINE PILOT DEMONSTRATION

DEMINERALIZED WATER PLANT IN BOTLEK, ROTTERDAM, THE NETHERLANDS

1. Context

At the Botlek industrial district of the Port of Rotterdam, demineralized water is an essential commodity required for the many production processes of surrounding enterprises. To produce demineralized water, reverse osmosis (RO) has become one of the main demineralization processes; however, RO alone is not sufficient to produce water of the required purity from the available water resources (fresh surface water), requiring several pre- and post-treatment processes to reach the desired purity for industrial use.

At the Evides demineralized water plant (DWP), one of the largest demineralized water production facilities in Europe, surface water is treated by RO combined with ion-exchange softening (IEX) and other technologies that results in the generation of brine as spent regenerant of IEX and RO concentrate (see Fig. 2).

2. Impact

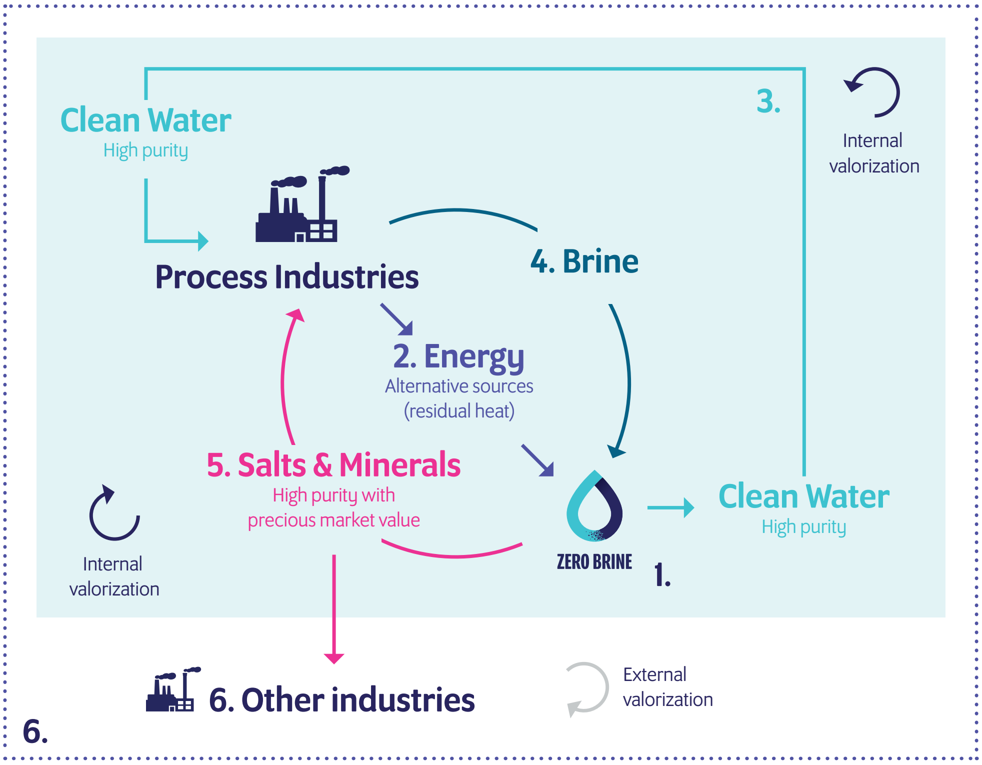
Industrial saline effluents (brines) are an environmental challenge and an economic opportunity.

ZERO BRINE demonstrated the circular economy approach to treat brine through redesigning the current scheme of discharging the generated brine – from linear to a circular model – to recover minerals, salts, and demi water from the discharges of the DWP. To achieve this, two large-scale demonstration pilots were tested at Plant One Rotterdam, a test facility focused on sustainable technology and innovation in the Energy Port and Petrochemical cluster of Rotterdam Port.

The demonstration plant comprised two sites combining residual heat (mimicked by low-pressure steam) and wastewater streams with the aim to eliminate the brine effluent at DWP (zero brine discharge). At Site 1, the aim was to treat the spent regenerant of the IEX unit and to recover valuable minerals and salts as well as water from the brine stream. This was done by nanofiltration, crystallization, and evaporation of IEX brine (see Fig. 3). Site 2 was an innovative design that aimed to treat the reverse osmosis concentrate of DWP by electro-oxidation followed by activated carbon adsorption, nanofiltration, reverse osmosis filtration, crystallization, and evaporation to remove the organic matter and to recover salts as well as water from the brine stream (see Fig. 4).

The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

Fig. 1 – Circularity concept of Zero Brine



1. ZERO BRINE technology
- High CAPEX / Low OPEX
- Required lower energy compared to current treatment practices

2. Energy
- Alternative and cheaper energy source to reduce CAPEX

3. Clean Water
- Lower water consumption by reusing the recovered water

4. Brine
- No water required for dilution
- No brine discharge
- No environmental levies

5. Salts & Minerals
- Internal use of salts and minerals
- Trading salts and minerals as a new source of revenues

6. Other Industries
- New supply chain of water and minerals lead to lower water pollution and potentially would lead to lower carbon emission on global scale

Within the demonstrations, materials with commercial values were recovered on the two sites for potential internal and external valorisation.

3. Business opportunities

The concept of circularity proposed by the ZERO BRINE technology presents potential circular benefits for the companies at the Botlek industrial area. This is shown with the possible internal valorisation of salt and minerals that can be reused in the production of demi water at the Evides DWP, by recovering an NaCl rich solution that can be reused in the regeneration of IEX resins, as well as pure water that can be used internally in mixed bed polishing at Evides to produce ultra-pure water.

Additionally, the external valorisation of salts and minerals is also possible. The recovered resources from Site 1, magnesium hydroxide crystals ($Mg(OH)_2$) can be used in the pharmaceutical industry, food industry (added directly to human food and wastewater treatments (neutralized acidic wastewater). Calcium hydroxide crystals ($Ca(OH)_2$) can be used in industrial settings, such as sewage treatment, paper production, construction, and food processing, as well as medical and dental uses.

Recovered resources from Site 2, sulphate salts (Na_2SO_4), can be used in the manufacturing of kraft paper, paperboard, glass, and detergents and as a raw material for the production of various chemicals, while the ice recovered by EFC can be used for cooling and cleaning purposes.

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4. Key results

	Reductions in:			
	Water	**Emissions**	**Energy**	**Recovered resources**
Water plant	• 15%-20% reduction in water withdrawal at Evides DWP	• >98% brine discharge into the environment eliminated (>2.5 million m^3/year) • Reduction in CO_2 emissions by 1,012 tons/year or 14% by recovering minerals, salts, and clean water	• Thermal energy required for the evaporation process can be supplied by waste heat/residual heat of neighbouring industries • 44% less energy used by MED evaporator when compared to conventional methods	• 92% water recovery for intenal use (demi water) • 6.2% IEX regeneration solution recovery for internal use (purity > 3.1%) • 94.7% Calcium recovery ($Ca(OH)_2$) for external valorization (purity > 95.6%) • 87.8% Magnesium recovery ($Mg(OH)_2$) for external valorization (purity > 88.9%) • 93% Sulfate recovery (Na_2SO_4) for external valorization (unwashed: 94.6% purity)

For more information, see D2.6 Report on the operation and optimization process of the pilot plants at Botlek

Fig. 2 – Schematic view of the current processes at the DWP plant at Botlek

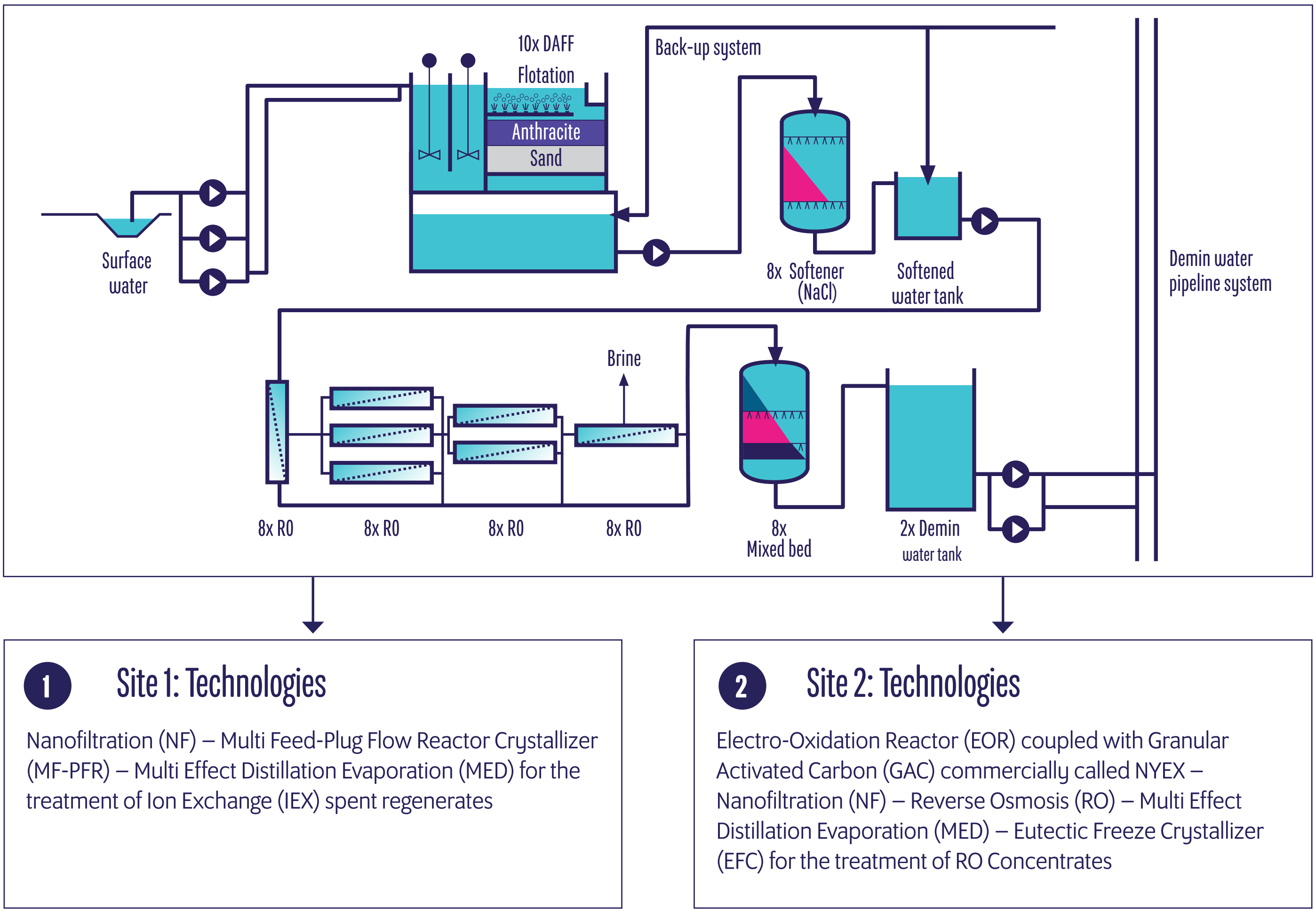

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Fig. 3 – Site 1 Technology scheme

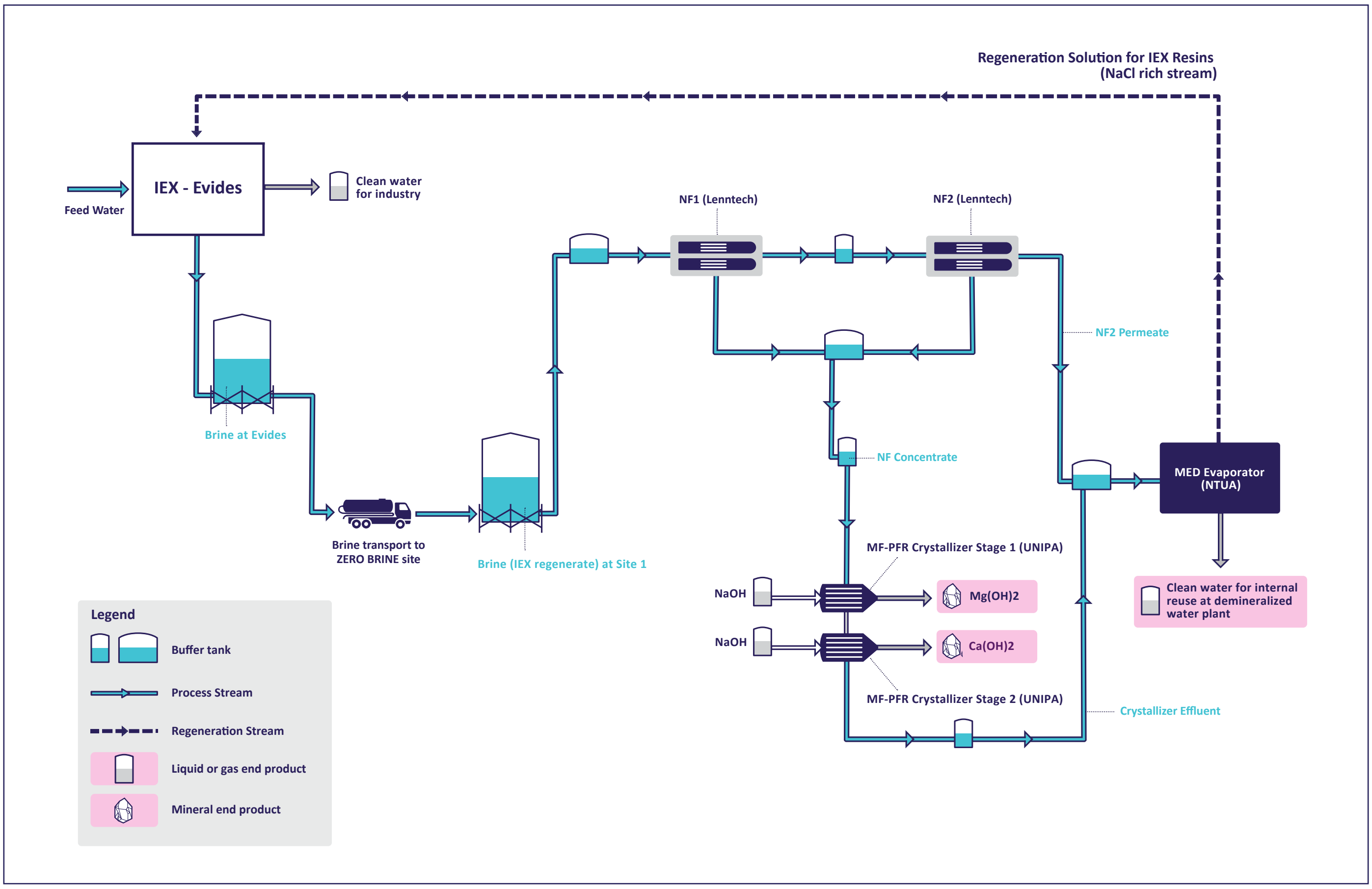
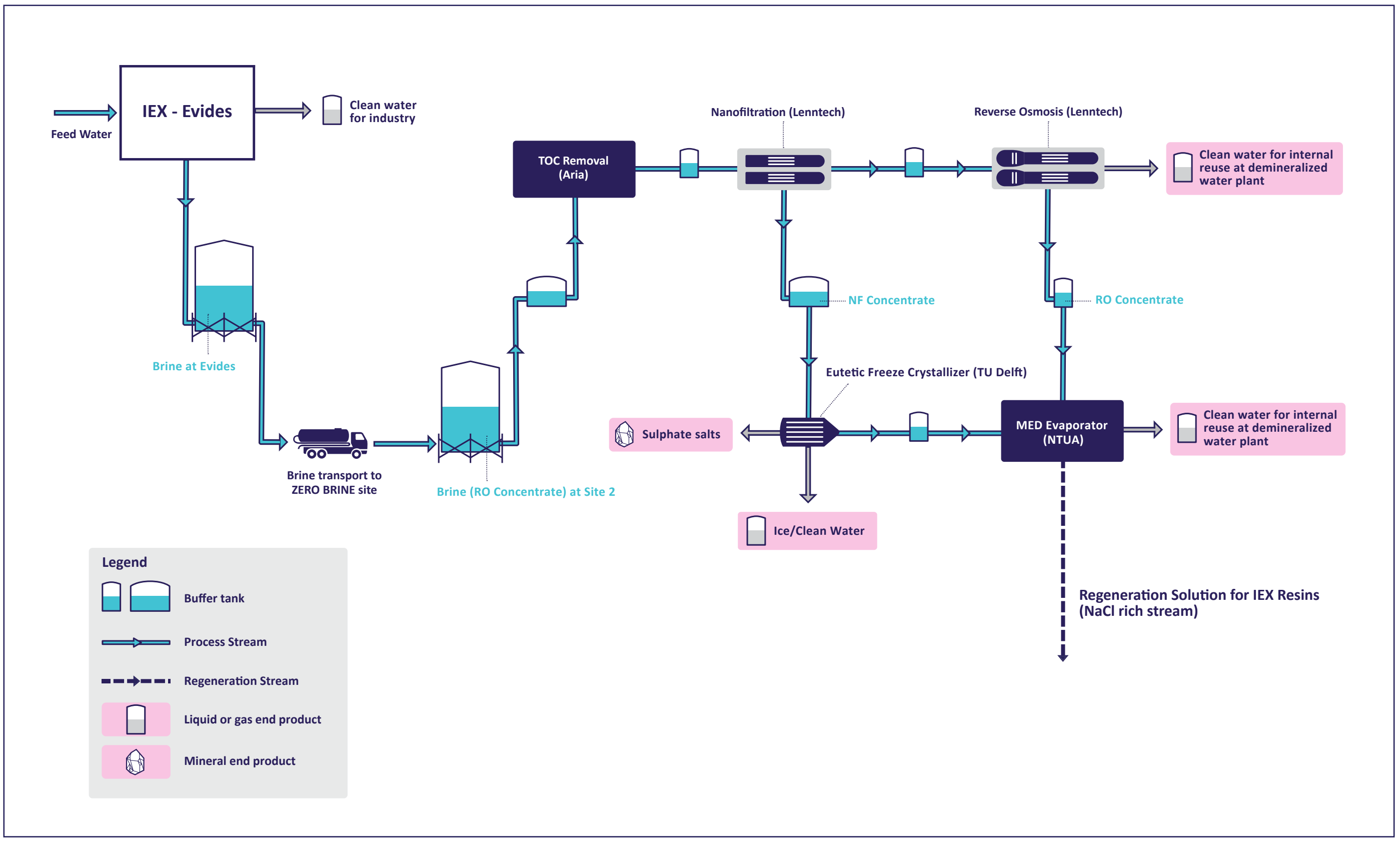


Fig. 4 – Site 2 Technology scheme



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