IDE Technologies | Your Water Partners

Case Study

How ENEL Power Plant's Cooling Tower Blowdown (CTBD) Effluent Reached 93.5% Recovery

HIGHLIGHTS

Technological leadership The first-of-its-kind demo unit in a power plant owned by one of the world’s largest power and energy companies.

Top notch efficiency High recovery rates and flexibility which translate into low investment and operational costs for the facility.

Operational efficiency No osmotic pressure, and/or chemistry constraints and no scaling/fouling in any of the system’s sub-units.

BACKGROUND

The power industry is considered one of the world's most water intensive industries. However, due to water shortages, increasing regulations and related effluent discharge and makeup water costs, power plants are required to manage their net water consumption in the most efficient way.
The major water consumers in a power plant are the cooling towers, which also produce the majority of wastewater as cooling tower blowdown (CTBD).

San Isidro Power Plant is a gas fired power station comprising two combined cycle units, in operation since 1998 (Unit 1) and 2008 (Unit 2), respectively. Each unit is equipped with a wet cooling tower (WCT) for condenser water cooling, and its total nominal power output is ~750MW. The plant is located in the Valparaiso Region in Chile, which is a water stressed area and the available water is decreasing.

THE CHALLENGE

Water shortages in recent years have affected the CT operation due to increased concentration of salts in the make-up water sources, resulting in a challenge in complying with the blowdown discharge regulations (D.S. N° 90). The main limiting parameters are the sulphates (≤1000 ppm) and the chlorides (≤400 ppm).

Currently, the source of CT make-up water is from relatively high-salinity brackish wells, which is not common as CT make-up water (therefore it is sometimes integrated with better quality water from external sources).

This fact limits the operational efficiency of the CT in two aspects: (1) low cycle of concentration (CoC) according to the regulatory restrictions and (2) low CoC limited by the water chemistry (scaling and corrosion potential increases). The operated CoC in the power plant is currently ~2, consequently, the required quantity of make-up water to the cooling towers is high, as is the blowdown discharge.

CTBD WATER QUALITY

Parameter	Unit	Design Value	Actual Value
pH		8.44	7.26 – 8.64
Total Alkalinity	ppm CaCO3	293	243 - 423
Total Hardness	ppm CaCO3	1,128	801 – 1,337
Calcium	ppm CaCO3	863	585 - 993
Magnesium	ppm CaCO3	266	216 - 344
Chloride	ppm	128	151 - 240
Sulphate	ppm	764	513 - 863
Silica	ppm	48	48 - 67
Phosphate	ppm	0.61	1.65 – 2.25
TDS	ppm	1,847	-
Conductivity	microS/cm	-	1,809 – 2,450
TOC	ppm	< 10	-
TSS	ppm	< 10	-
Turbidity	NTU	-	1.1 – 2.6
Free Chlorine	ppm	< 0.1	0.01 – 0.17
Temperature	C°	29	13.5 – 27.4
CaCO3 Log SI	-	1.89	1.01 – 2.33
CaSO4 SI	%	34.9	17.0 – 102.0
SiO2 SI	%	35.2	40.0 – 87.0

CURRENT VS FUTURE CT OPERATION

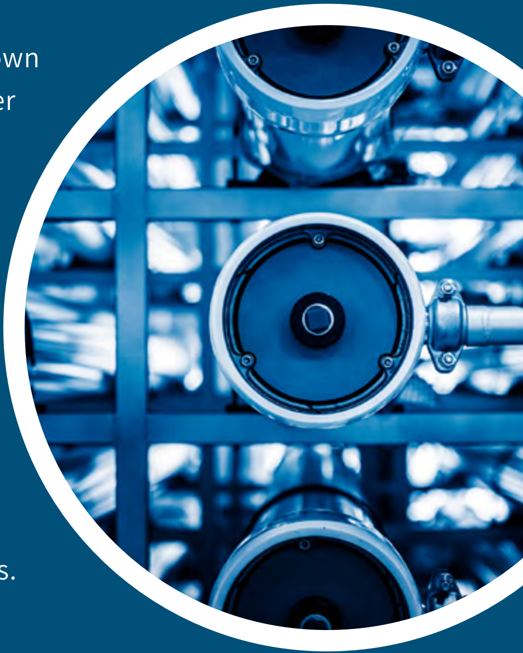
		Present CT operation at CoC ~2				Future CT operation at CoC ~4			
Parameter	**Unit**	**Purchased water**	**Wells water**	**Total make-up**	**Blow down**	**Permeate from treatment process**	**Wells water**	**Total make-up**	**Blow down**
Flow rate	m3/hr	501.3	833.5	1334.8	667	233	671	904	236
Calcium	mg/l	85.3	336.3	242.1	484	6.1	336.3	251.2	959.5
Chloride	mg/l	30	120	86	172	7	120	91	347
Sulphate	mg/l	70	689	457	970	9	689	513	2132
TDS	mg/l	401	1429	1013	1964		1429	1069	3898

CURRENT VS FUTURE CT OPERATION

IDE proposed to test the MaxH$_2$O DESALTER technology for the treatment of the ENEL power plants CTBD effluent in Chile. The main objective of the unit was to confirm that the proposed process, based on the MaxH$_2$O DESALTER technology, is feasible, stable and cost effective in terms of a full-scale plant compared to other alternatives, and to determine the design parameters of the full-scale plant.

IDE has recently developed a new technology, the **MaxH$_2$O DESALTER**, for the treatment and the minimization of reverse osmosis brines and industrial effluents.

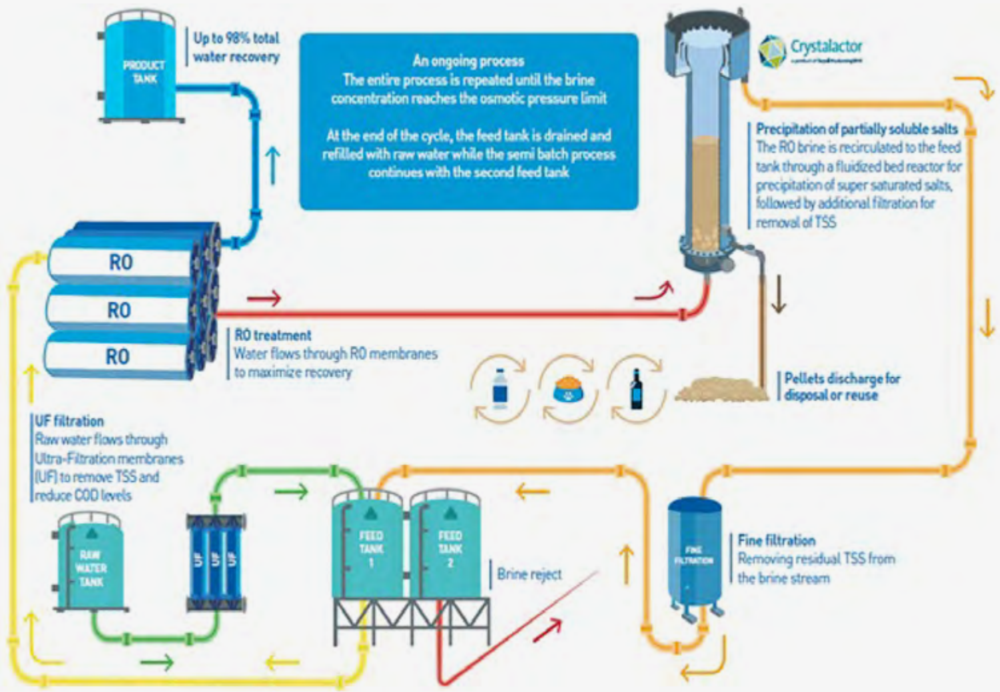
This technology is beneficial for the treatment of cooling tower's blowdown effluents saturated with high levels of silica, hardness, sulphate and other impurities that are limited to certain levels by the discharge regulations.



Its many benefits allow this technology to address the different challenges successfully, such as calcium carbonate and silica scaling, bio-fouling and organic fouling potential in order to increase the cooling tower's operation efficiency and increase their cycles of concentrations.

The technology overcomes the limitations of conventional systems such as a difficulty to address variable feed water quality, variable recoveries, and high supersaturation conditions of sparingly soluble salts.

MAXH2O DESALTER PROCESS SCHEME



THE OBJECTIVES

- Achieve a total recovery of 80% or more.
- Achieve permeate quality of TDS < 300 mg/l.
- Demonstrate that the proposed process based on the MaxH_2O DESALTER technology is feasible, safe and stable for the treatment of San Isidro CTBD effluent:
    - Maintain the RO membrane permeability with no significant change during operation
    - Maintain the RO feed / brine differential pressure with no significant change during operation
    - Determine the required chemicals and chemical consumption
    - Achieve continuous operation of the MaxH2O DESALTER unit without a deterioration in performance

THE EXECUTION

The **MaxH$_2$O DESALTER** demonstration unit was designed for the production of 12-72 m3/d of treated permeate and was automatically controlled and operated. The unit was designed to simulate the process conditions of a full-scale MaxH2O DESALTER unit.

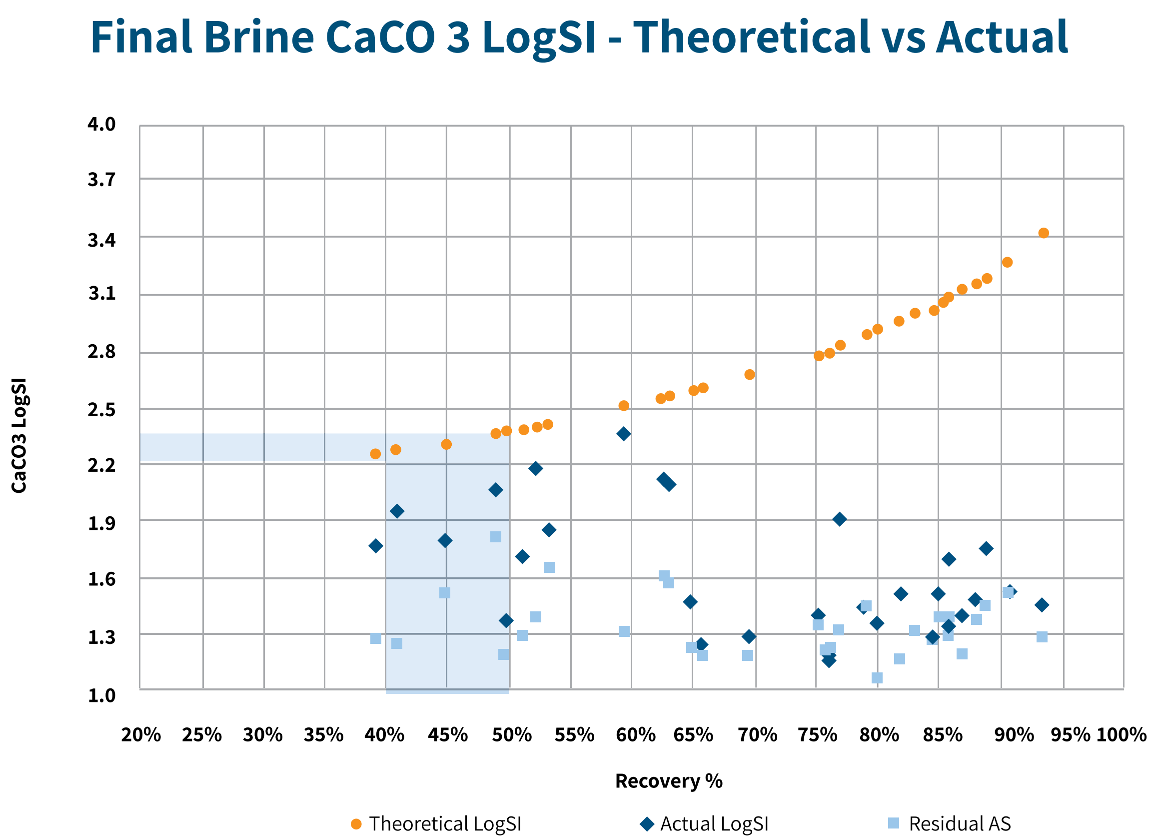
DEMONSTRATION UNIT MAIN PARAMETERS

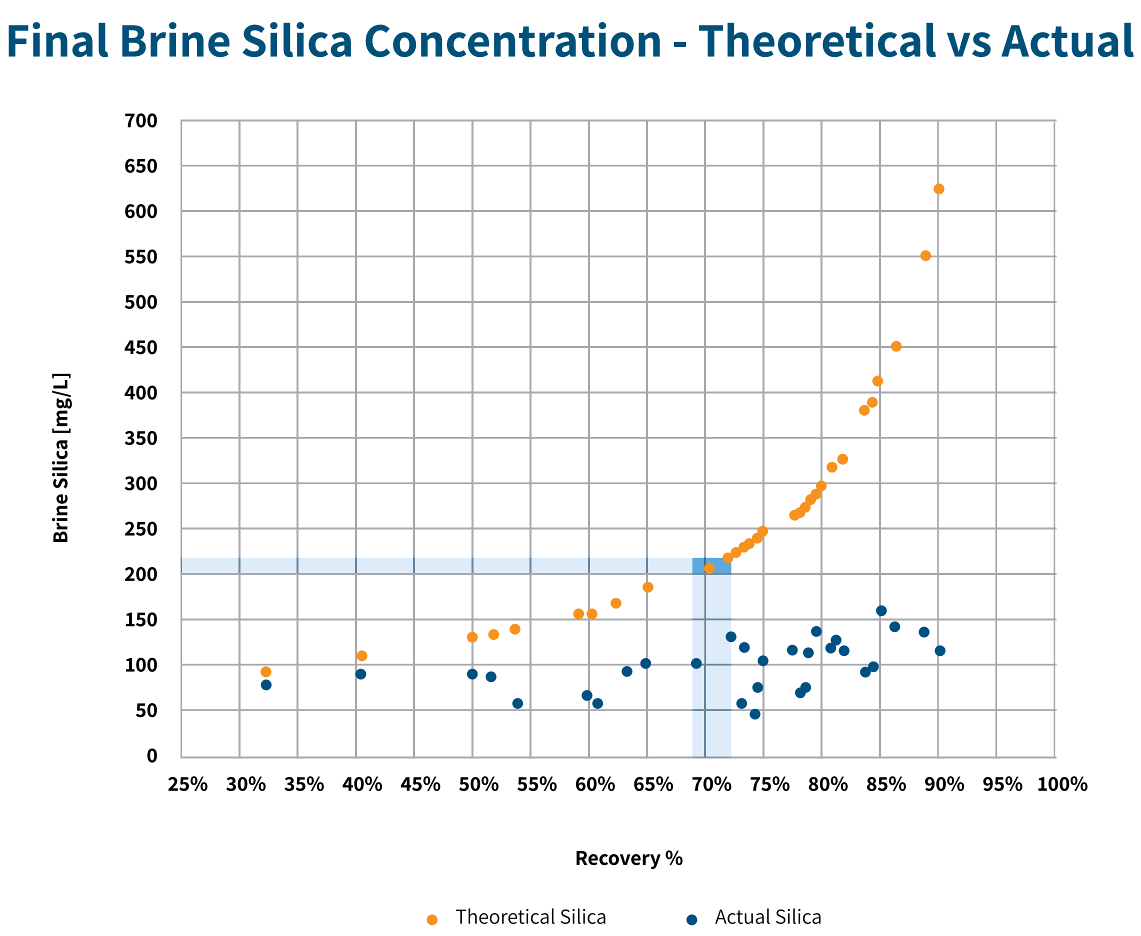
Description	Specifications
Feed flow rate	14-125 m3/d
Product flow rate	12-72 m3/d
Maximum recovery rate	Up to 98%. Actual recovery depends on feed water characteristics
Removal of sparingly soluble salts	CaCO3, CaSO4, SiO2
Pretreatment	UF included
Feed TSS	<50 mg/L
Optional Chemicals	Antiscalant, Coagulant, SBS (optional), NaOH, Ca(OH)2, Na2CO3. Required chemicals are pending each specific case analysis.
UF flux	20-90 LMH (2 x 100%)
UF CEB System	Included. Manual chemicals addition
CIP System	Included. Manual chemicals addition
RO Flushing	Automated
Footprint	12.0 x 5.6 m | Desalter skid - 40ft container. Pretreatment skid - 20ft container
Unit Height	6.1 / 5.4 m (With / without legs)

THE RESULTS

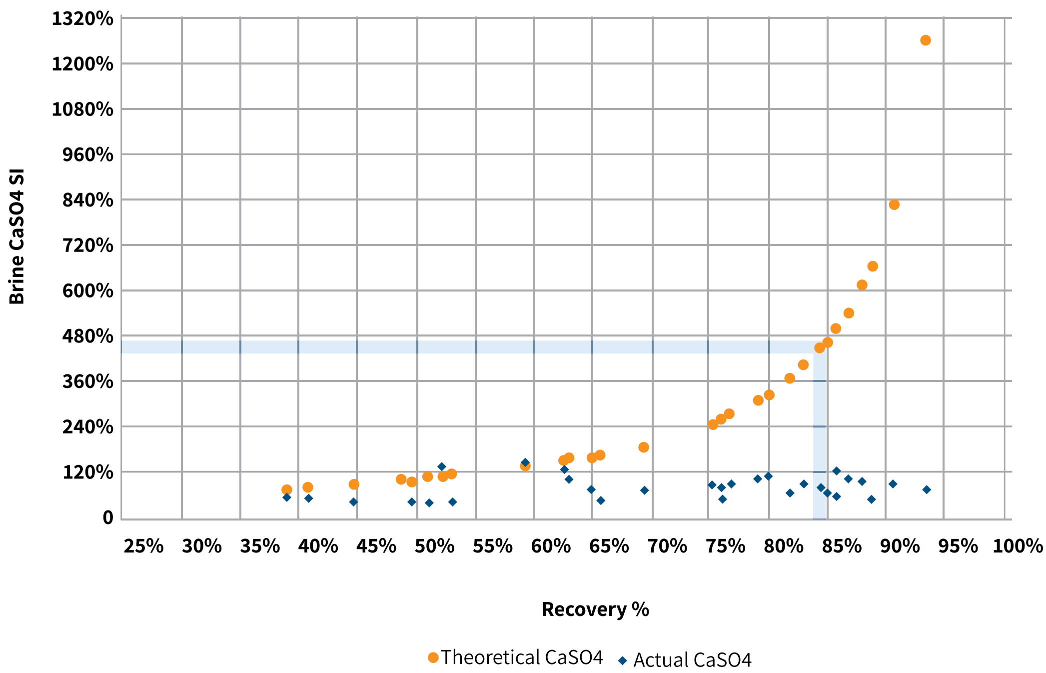
The IDE MaxH$_2$O DESALTER demo unit was successfully operated with the San Isidro cooling tower blowdown effluent over six weeks of continuous operation in two phases of operation. All KPIs were achieved:

- Total system recovery > 80%. The **MaxH$_2$O DESALTER** recovery reached 91% in the first phase of operation and ~94% in the second phase of operation. Maximal total system recovery for both phases reached 86% (in commercial system Desalter recovery vs. Total recovery can be reduced to 1-2%).
- Permeate TDS < 300 mg/l, averaged quality of the permeate reached maximal value of ~55 mg/l.
- MaxH$_2$O recovery was limited to 94% only by the gravity media filters which were already designed as pressurized for the full-scale plant so the recovery ratio is expected to be even higher. No osmotic pressure and/or chemistry constraints have been observed.
- There was no scaling/fouling in any of the system's sub-units (except from the dedicated subunit-crystalactor) during the operation period.

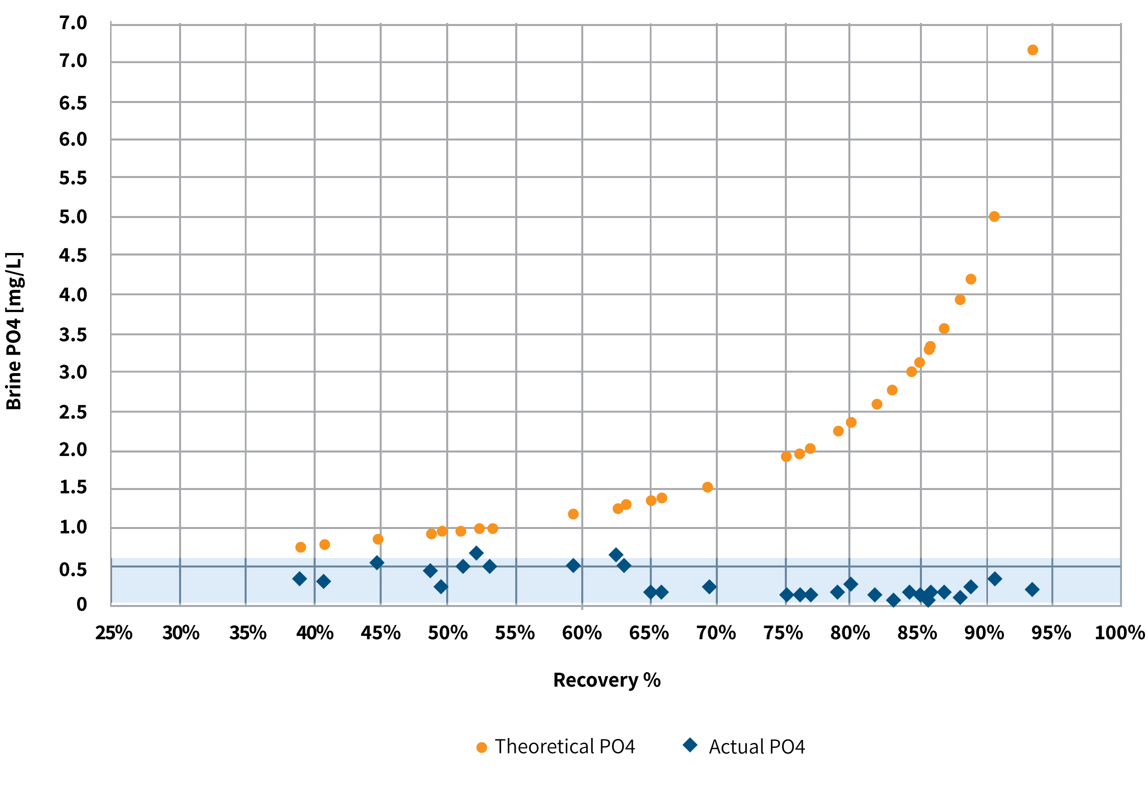

Final Brine CaCO 3 LogSI - Theoretical vs Actual
4.0
3.7
3.4
3.1
2.8
2.5
2.2
1.9
1.6
1.3
1.0
CaCO3 LogSI
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Recovery %
Theoretical LogSI
Actual LogSI
Residual AS


Final Brine Silica Concentration - Theoretical vs Actual
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Brine Silica [mg/L]
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Recovery %
Theoretical Silica
Actual Silica

Final Brine CaSO 4 SI - Theoretical vs Actual



Final Brine Phosphate Concentration - Theoretical vs Actual



SUMMARY

Water scarcity and increasing regulations have compelled power plants to optimize their water consumption. This case study highlights the remarkable achievement of ENEL power plant's cooling tower blowdown (CTBD) effluent reaching an impressive 93.5% recovery.

The implementation of IDE's **MaxH$_2$O DESALTER** technology resulted in exceptional efficiency with high recovery rates, offering flexibility, and significantly reducing investment and operational costs for the facility. The operational efficiency of the system was enhanced due to the absence of osmotic pressure, chemistry constraints, scaling, or fouling in any of the sub-units.

ENEL's adoption of IDE's **MaxH$_2$O DESALTER** technology exemplifies a breakthrough solution for power plants to address water scarcity, comply with regulations, and enhance operational efficiency, ultimately leading to substantial water and cost savings.

Case	Recovery [%]	First phase – Energy consumption [kWh/m3 product]	Second phase – Energy consumption [kWh/m3 product]
Current operation (Calculated)	91	7.70	
Current operation with ERD (calculated)	91	3.91	
Current operation (Measured)	94		~3.5

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