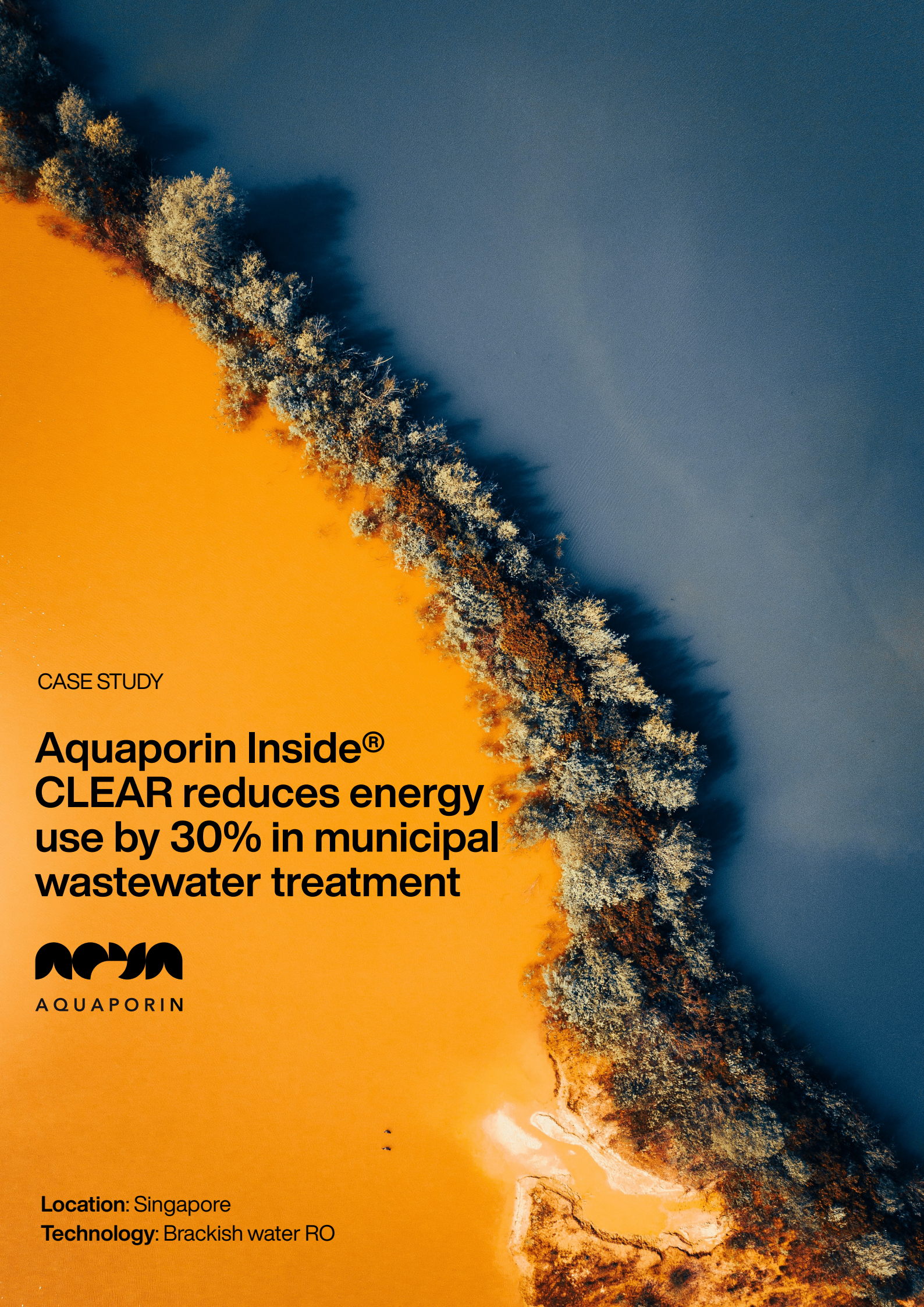

CASE STUDY

Aquaporin Inside® CLEAR reduces energy use by 30% in municipal wastewater treatment

AQUAPORIN

Location: Singapore
Technology: Brackish water RO

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A pilot project demonstrates that Aquaporin Inside® CLEAR membranes can reduce pressure requirements in reverse osmosis water treatment, significantly lowering energy consumption and carbon footprint, while meeting high permeate quality standard.

Water demand is growing across the globe, driven by high population growth, industrialization and rapid urbanization. This is increasing the need for diversified, sustainable and reliable water resources. As a result, many municipalities are ramping up efforts to reclaim municipal secondary effluents for industrial reuse – or even potable applications. But this is not easy. There are stringent quality requirements on recycled water to ensure it is safe and consistent. The ongoing drive to make every drop count and to minimize liquid discharge means soutions must be highly reliable.

One common solution is to improve recovery in reverse osmosis units. However, reverse osmosis is a very energy-intensive process. Municipalities are looking for ways to improve energy efficiency of reverse osmosis solutions. This enables greater water reuse while minimizing carbon footprint and protecting reclamation plants against energy price shock or supply shortage.

Designed for municipal wastewater recycling, our Aquaporin Inside® CLEAR membranes can significantly reduce feed pressure requirements and drive down energy consumption – as this pilot project shows.

Aquaporin Inside® CLEAR membranes

The challenge:
Increasing efficiency and quality in municipal wastewater recycling

Reducing the energy consumption of a reverse osmosis operation while maintaining the permeate quality is a delicate balancing act. Municipal wastewater treatment plants often use conventional anti-fouling brackish water membranes to improve operational stability. But these membranes have high rejection rates and are not energy efficient.

Aquaporin's solution is the Aquaporin Inside® CLEAR series. Utilizing biomimicry, advanced membrane chemistry and smart element design, Aquaporin Inside® CLEAR membranes bring energy efficiency, stable operation and high permeate quality to municipal reverse osmosis wastewater recycling.

The demonstration:
A 100 m^3 per day wastewater recycling system

In order to determine if Aquaporin Inside® CLEAR membranes can deliver significant energy reductions while maintaining good permeate quality, a pilot study is conducted at a municipal wastewater reclamation plant in Singapore.

Technical system set-up and operation
100 m^3/day pilot system employs Aquaporin Inside® CLEAR Plus 4040XL elements in a 2-stage design, achieving > 75% recovery. The feed is taken from a membrane bioreactor (MBR) permeate stream with average TDS between 400 – 700ppm, with suitable sodium bisulfite (SBS) and anti-scalant dosing, coupled with cartridge pre-filtration of 25um followed by 5um.

The system operates with average designed flux of 17 LMH. A regular Clean-in-Place (CIP) operation is performed on a monthly basis to simulate actual plant operation. Operation is automated to maintain stable permeate production, with online monitoring and data logging for analysis. This system operation is repeated similarly to benchmarking with commercially available membranes that are commonly found in municipal wastewater recycling operation.

Table 1: Operational details of pilot demonstration

Array	**2×7 – 1×7**
Element model	**Aquaporin Inside® CLEAR Plus 4040XL**
Recovery	**> 75 %**
Flux	**17 LMH**
Feed flow	**4 m^3/hr**
Feed Source	**MBR permeate**
Chemical Dosage	**SBS & Anti-scalant**
Clean-In-Place	**Monthly**

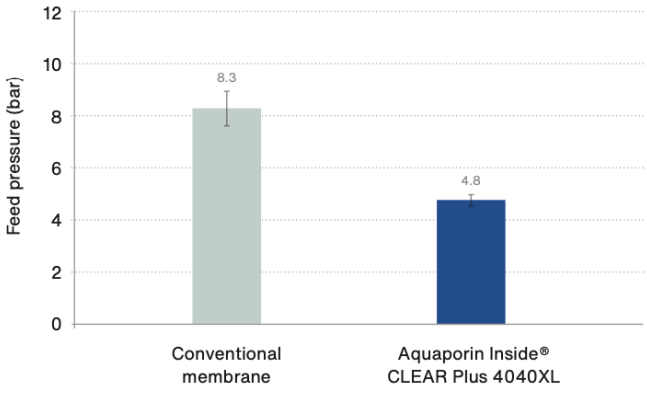

Figure 1: Feed inlet pressures

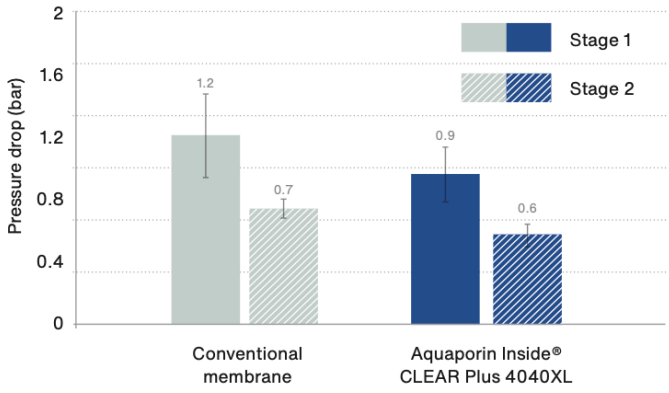

Figure 2: Pressure drop across element array

The results:
Lower pressure reduces energy use by 30%

System performance data demonstrates that at 100 m^3/day capacity, 75% recovery and 24/7 operation, Aquaporin Inside® CLEAR Plus 4040XL elements deliver exceptional performance, with consistently low feed hydraulic pressure (< 5 bar) compared to conventional membranes (> 7 bar). This translates to > 30% reduction in energy consumption compared to a conventional membrane operating in the same conditions and for the same duration (Figure 1).

Moreover, with conventional membranes, pressure increases significantly over time, driving up energy consumption. In comparison, Aquaporin Inside® CLEAR Plus 4040XL elements following the same CIP regime show stable performance over the same duration of operation, ensuring energy use remains stable (Figure 3). The element design of Aquaporin Inside® CLEAR Plus 4040XL also results in a 15% lower pressure drop across 2-stage compared to conventional membranes (Figure 2), lowering energy use even further.

Table 2 shows the filtration effect on selected parameters – clearly demonstrating that the Aquaporin Inside® CLEAR Plus 4040XL elements achieve permeate of high quality. This can be compared to the recommended reverse osmosis permeate quality composition set out by Singapore's NEWater target.

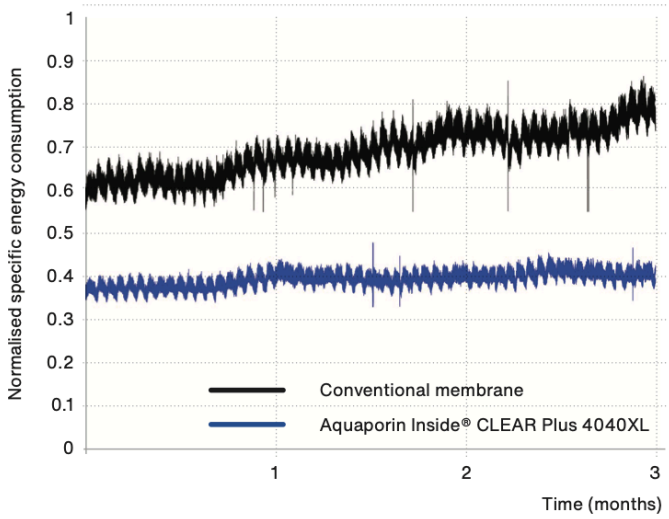

Figure 3: Trending of specific energy consumption

The benefits:
Reduced energy use, costs and carbon footprint

A 30% reduction in energy consumption results in important potential benefits for companies and local authorities running municipal wastewater recycling operations. At a 100,000 m^3/day wastewater treatment plant, Aquaporin Inside® CLEAR Plus BWRO membranes could deliver savings of more than 4,000,000 kWh per year compared to conventional membranes, while still ensuring high permeate quality. This would enable plant operators to reduce operating costs and lower carbon footprint, while helping municipalities increase resilience to energy shortages and price fluctuations – which are all important considerations when tackling the water challenges of the 21st century.

Table 2: Filtration effect on selected parameters

	Unit	Permeate	NEWater quality	System rejection (%)+	Permeate quality in compliance with NEWater target
Ammonia as NH_3-N	ppm	0.1 – 0.3	< 1.0	> 97.0	✓
Barium as Ba*	ppm	-	< 0.1	-	✓
Calcium as Ca	ppm	0.1 – 0.2	< 20	> 99.7	✓
Chloride as Cl	ppm	2 – 3	< 20	> 99.1	✓
Conductivity	uS/cm	20 – 40	< 250	> 98.3	✓
Fluoride as F*	ppm	-	< 0.5	-	✓
Iron as Fe*	ppm	-	< 0.04	-	✓
Magnesium as Mg	ppm	< 0.01	-	> 99.9	-
Nitrate as NO_3-N	ppm	0.3 – 0.5	< 5	> 95.5	✓
Nitrite as NO_2-N	ppm	0.1 – 0.2	-	> 96.0	-
Phosphate as PO_4-P	ppm	< 0.01	-	> 99.6	-
Potassium as K	ppm	0.5 – 0.7	-	> 98.4	-
Silica as SiO_2	ppm	0.2 – 0.3	< 3	> 98.5	✓
Sodium as Na	ppm	3 – 4	< 20	> 97.5	✓
Sulphate as SO_4*	ppm	-	< 5	-	✓
Total Dissolved Solids, TDS	ppm	15 – 20	< 150	> 98.2	✓
Total Hardness as $CaCO_3$	ppm	0.3 – 0.5	< 50	> 99.5	✓
Total Organic Carbon, TOC	ppb	20 – 40	< 500	> 99.6	✓
Total Phosphorus as TP	ppm	0.1 – 0.2	-	> 98.3	-

* permeate concentration below detectable limit
+ rejection = 100 x (1 – permeate concentration / (average of feed and reject concentration))

Sources:
Singapore PUB NEWater Quality 2020 - www.pub.gov.sg

Disclaimer
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