

Water Energy Nexus

Emerging Technologies

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to generate ENERGY ... is needed to generate WATER ... is needed to generate

Water : Energy Nexus

both challenges must be addressed together

Trends driving the future of wastewater treatment

Water Reuse

- Water scarcity drives reuse/reclamation
- Tiered criteria (potable, agriculture, industry, etc.)

Effluent Quality

- Increasingly stringent limits for env protection
- New parameters – micropollutants, metals

Residuals Management

- Rising costs for residuals treatment & disposal
- Regulation of environmental impacts

Energy Reduction & Recovery

- Target energy neutrality
- Minimize GHG emissions

Nutrient Recovery

- Nitrogen, Phosphorous, Sulfur
- Produce marketable products

Cost

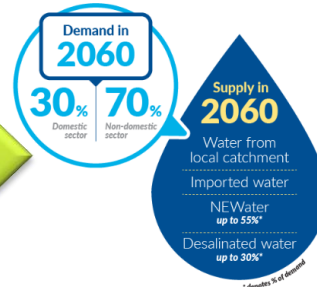
- Attention to CAPEX and LCC
- Asset recovery
- New business models

Shift from wastewater treatment to resource recovery

Introduction- Singapore Water Loop

Current Demand:

1863 MLD
430 MGD
40% NEWater
25% Desalted water

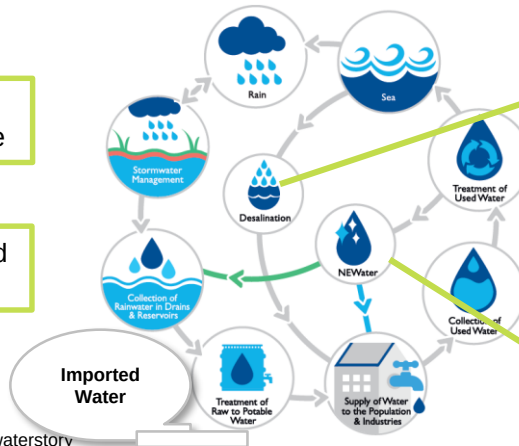


Predicted 2060:

~3727 MLD
860 MGD
55% NEWater
30% Desalted water

2060, non-domestic sector will use 70% of water in Singapore

Water import contracts will end year 2061



3.4-4.8 kWh power to produce 1 m³ of desalted water

The energy content of wastewater is 2-4 times the energy required to treat it

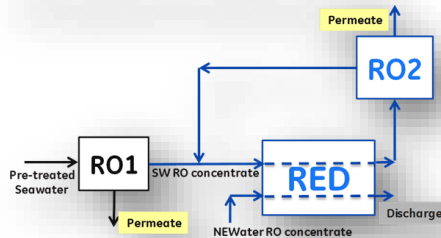
Current NEWater technology has recovery of 75%, increased recovery can displace SWRO energy demands

Technology Driven Approach

- Desalination
- NEWater increased water recovery
- Water Reclamation: Energy Neutral Flow Sheet
- Industrial Water/Wastewater
- Chemical Monitoring and Systems
- Digital tools

1. Reverse Electrodialysis (RED) based Desalination

RED based Advanced Desalination process



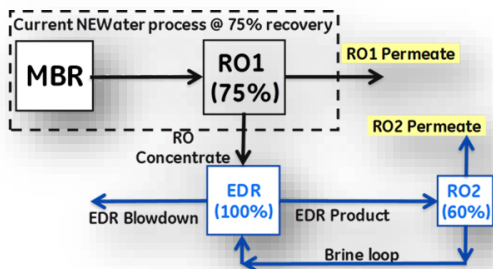
RED for ~100% SWRO recovery

- Leverage salinity gradient to drive higher SWRO recovery
- Cost savings on intake, pretreatment, and outfalls
- Co-located SWRO Desal and WW plants
- Tuas pilot validation in progress, feasibility confirmed at 9" x 10" scale

Benefits

- Higher water recovery
- 0.5 kWh/m³ lower energy consumption compared with SWRO
- Reduced discharge volume

2. Enhanced NEWater recovery using RO-EDR



Technology targets

- System recovery > 93%
- Energy < 0.6 kWh/m³

Benefits

- Higher water recovery
- Lower energy consumption
- Reduced discharge volume



3. Energy neutral **wastewater** treatment



Zeelung MABR

Simple installation & Small Footprint:

Nutrient removal and capacity expansion in existing bioreactor volumes, no additional tank required

Low Energy:

Oxygen delivery is 4X greater than fine bubble aeration

Nutrient Removal:

Increase biomass by attached growth



Advanced Anaerobic Digestion

Complete solution:

Pre-treatment | Advanced digestion | Bio-waste digestion | Power generation

Higher energy production:

25-30% more bio-gas yield

Higher capacity/loading:

Patented biological hydrolysis technology to increase feed loading (>2 times) and digestion time (30-50%)

Class A/B bio-waste:

Valuable by-product



Anaerobic MBR

Reduced energy consumption & waste:

No aeration needed
80% less sludge waste

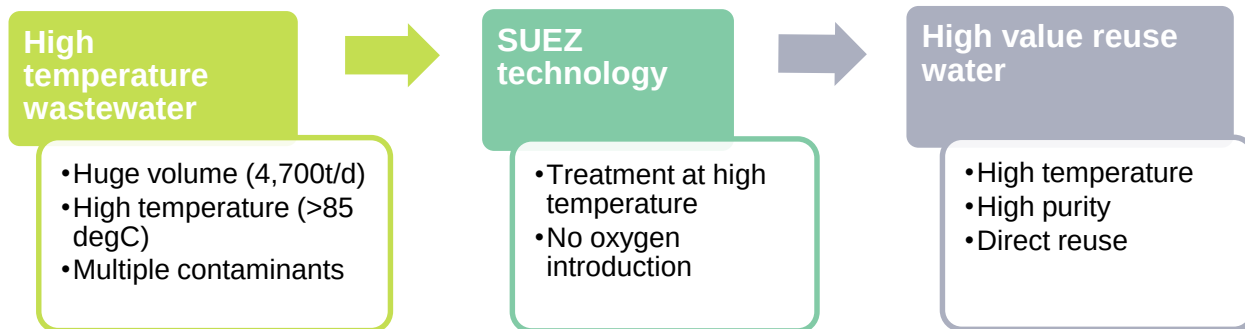
Bio-gas production:

Methane-rich bio-gas production as energy

Reliable & superior effluent quality:

ZeeWeed* 500 reinforced hollow fiber membrane

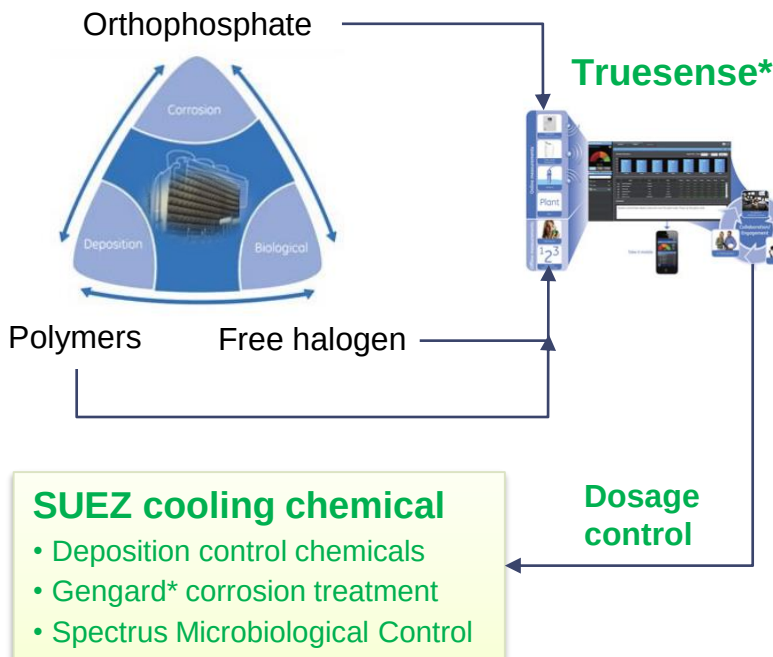
4. Industrial hot wastewater reuse: advanced membrane technology



Benefits

- Applicable to most high temperature industrial wastewater streams
- Saving on water intake (E.g., company A: **33% saving, 2,300 t/d**)
- Saving on cooling and heating energy (85 degC)
- Saving on feed water pre-treatment

5. Cooling water treatment and optimization



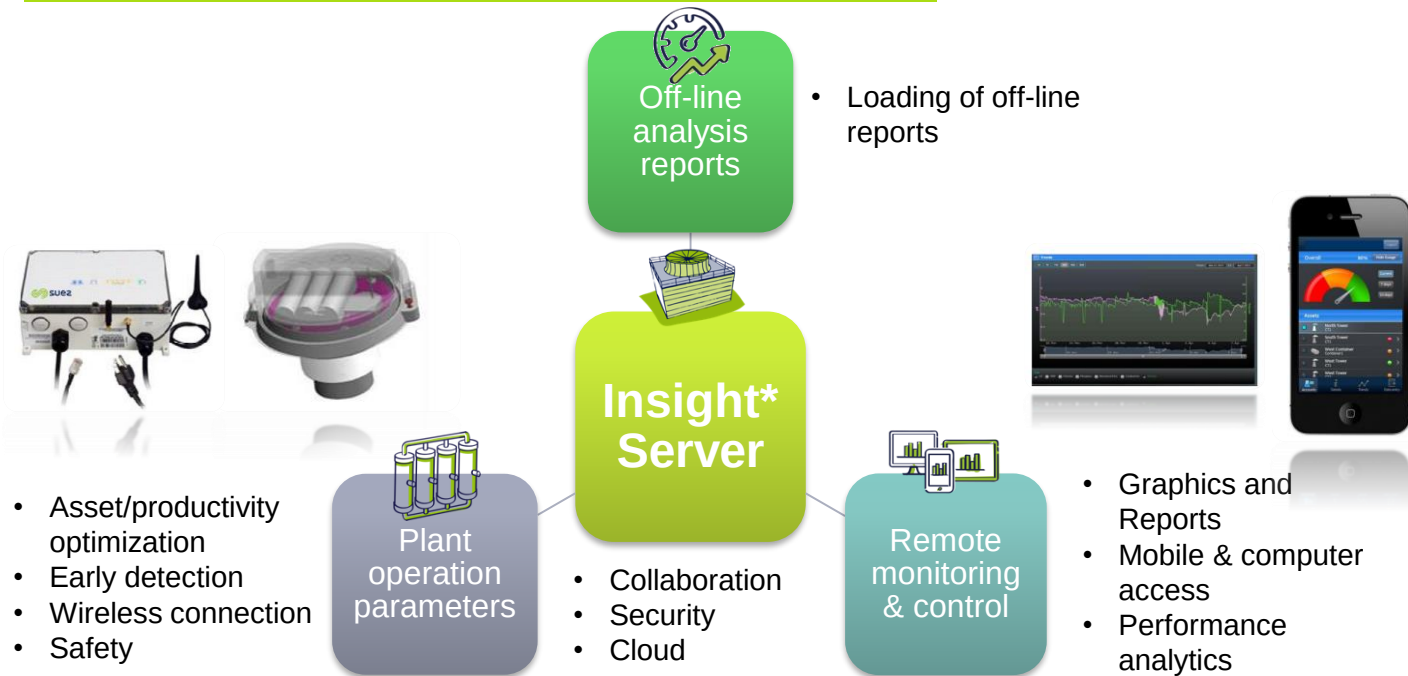
Highlights

- All-in-one measurement
- Accuracy
- Low maintenance
- Insights* connection
- Chemical dosage control

Benefits

- Save water
- Cut water cost
- Reduce manpower

6. Digital solutions for remote monitoring and diagnostics, water and energy usage optimization



: Simplicity : Mobility : Security : Reliability :

Summary

Treatment	Technologies
Desalination	RED Technology: Reducing 0.5kWh/m ³
Water Reclamation	Development of Energy Neutral Flowsheet • Zeelung • Advanced Biological Hydrolysis • Anaerobic MBR
NEWater	Increase water recovery from 75% to greater than 90% using EDR technology, thereby reducing reliance on Seawater
Industrial Wastewater	High end technologies for hot water recycling
Digital and Chemical Monitoring	Enhanced capabilities to monitor and optimize energy-water efficiencies

Quote....

“I never believed it would be impossible forever; I thought sometime, some place, technology will be found that would make it nearly possible.”

Lee Kuan Yew, former Prime Minister of Singapore, on the prospect of Singapore achieving water self-sufficiency.