

Water Reuse and Desalination to Mitigate the Impact of Climate Change on Water Scarcity

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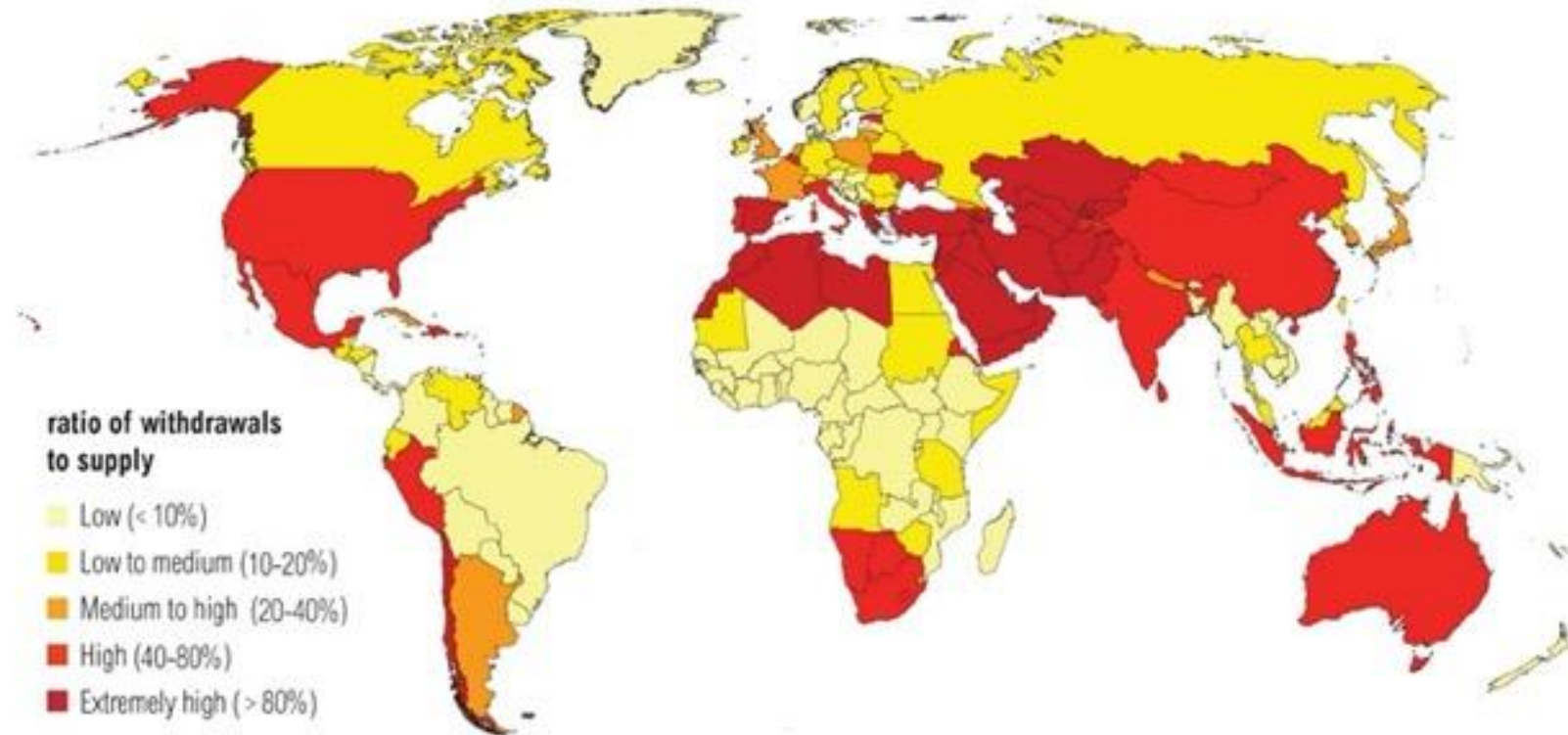
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Predicted global water deficit of 40% by 2040 under the Business-As-Usual scenario (2030 WRG)

Water Stress by Country: 2040



NOTE: Projections are based on a business-as-usual scenario using SSP2 and RCP8.5.

<https://www.visualcapitalist.com/extreme-water-shortages-are-expected-to-hit-these-countries-by-2040/>

For more: ow.ly/RiWop

Impact of Climate Change - Recent Flooding Events

China's Wuhan declares red alert as floods disrupt supply chains

Jul 17, 2020



1 of 5 An aerial view of the Yangtze River where the water level has risen in Jiangsu in China's central Jiangsu province on July 15, 2020. PHOTO: AFP

PUBLISHED JUL 17, 2020, 1:23 PM SGT | UPDATED JUL 17, 2020, 3:33 PM



SHANGHAI (REUTERS) - Large parts of central and eastern China were reeling on Friday (July 17) from the worst floods in decades, as disruption mounted for key supply chains, including crucial personal protective equipment for fighting the coronavirus, and economic damage piled up.

The central Chinese city of Wuhan and the provinces of Anhui, Jiangxi and Zhejiang declared red alerts on Friday as heavy rain swelled rivers and lakes.

Wuhan, on the banks of the Yangtze River where the novel coronavirus emerged late last year, warned residents to take precautions as water levels fast approached their maximum guaranteed safety level.

Peninsular Malaysia hit by '1-in-100-year' rainfall, govt says amid severe flooding

Dec 20, 2021



1 of 4 Floods wreaked havoc in the state's Klang Valley, with many areas submerged in water. PHOTO: THE STRAITS TIMES



Marina Hassan
Malaysia Correspondent

UPDATED DEC 20, 2021, 1:01 PM SGT



KUALA LUMPUR - The widespread flooding seen in many states in Malaysia in the last three days was caused by one-in-a-100-year heavy rainfall, a senior official at the country's Environment and Water Ministry said on Sunday (Dec 19).

"The annual rainfall in Kuala Lumpur is 2,400mm and this means yesterday's (Saturday's) rainfall exceeded the average rainfall for a month. It is something beyond expectations and only occurs once every 100 years," the ministry's secretary-general Zaini Ujang told a news conference. He was referring to rainfall as measured by a rain gauge.

Referring to measuring stations around Selangor-KL, he said as quoted by Bernama, that the Sentul station recorded the highest at 363mm, Gombak (247mm), Jinjang

Climate change: Pakistan floods 'likely' made worse by warming

Matt McGrath - Environment correspondent

Fri, September 16, 2022 at 3:09 PM · 3 min read



flooding in pakistan

Global warming is likely to have played a role in the devastating floods that hit Pakistan, say scientists.

Researchers from the [World Weather Attribution](#) group say climate change may have increased the intensity of rainfall.

However there were many uncertainties in the results, so the team were unable to quantify the scale of the impact.

The scientists believe there's roughly a 1% chance of such an event happening in any coming year.

- [Pakistan dengue cases soaring after record floods](#)
- [Going green could save world 'trillions' - study](#)
- [Satellites now get full-year view of Arctic sea-ice](#)

In the two months since [flooding began in Pakistan](#), tens of millions of people have been affected, with around 1,500 dying because of the rising waters.

The intensity of the downpours saw the river Indus burst its banks, while landslides

Impact of Climate Change – Severe Water Shortage Events

yahoo!news



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'Moment of reckoning:' Federal official warns of Colorado River water supply cuts

Ben Adler · Senior Editor
16 June 2022 · 4-min read

CLIMATE CHANGE

Get the latest

The Colorado River's reservoirs have diminished to the point that significant cuts to the water supplied to the seven states that rely on it will be necessary next year, a federal official warned Tuesday.

Bureau of Reclamation Commissioner Camille Calimlim Touton told the Senate Energy and Natural Resources Committee maintaining "critical levels" at the largest reservoirs in the United States — Lake Mead and Lake Powell — will require large reductions in water deliveries.

"A warmer, drier West is what we are seeing today," she said at a hearing. "And the challenges we are seeing today are unlike anything we have seen in our history."



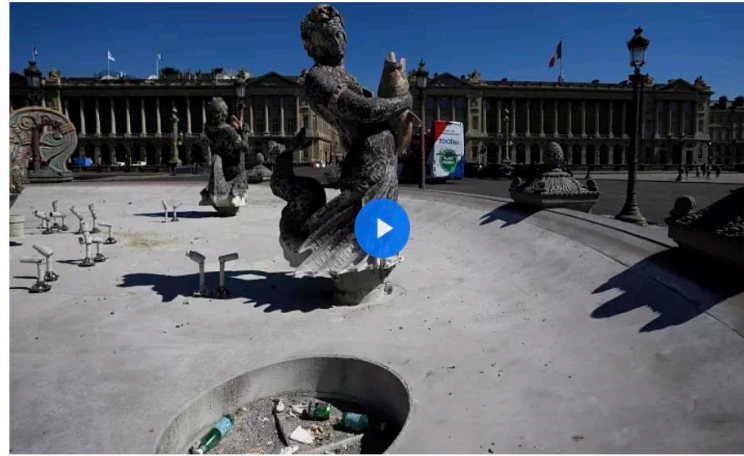
Home > News > World > Drought and heatwaves: How is Europe tackling unprecedented water shortages?

WORLD NEWS

Drought and heatwaves: How is Europe tackling unprecedented water shortages?

COMMENTS

By **Richard Good** & Alasdair Sandford & Joshua Askew · Updated: 09/08/2022



The fountains of Concorde plaza are empty in Paris, France, as Europe is under an extreme heat wave, Aug. 3, 2022. - Copyright AP Photo/Francois Mori, File



Soaring temperatures and a conspicuous lack of rainfall have left many European countries grappling with historic droughts this summer.

This is having wide-reaching effects across the region, significantly impacting agriculture, energy production and water supplies.

But how is each European country being affected and what are local authorities doing to combat the problems caused by these extreme temperatures?

France

The French government has set up a crisis team to tackle a historic drought that has left **more than 100 municipalities short of drinking water**.

Trucks are taking water to those areas as "there is nothing left in the pipes", said Christophe Béchu, the country's minister for ecological transition.

我国近70%城市群、65%的粮食主产区缺水问题突出



上游新闻

2022-04-08 15:38

重庆晨报上游新闻官方帐号

关注

4月8日，国新办举行2022年水利工程建设情况国务院政策例行吹风会。上游新闻（爆料邮箱：cnsangyou@163.com）记者从吹风会上获悉，我国水资源空间分布与人口经济布局、国土空间利用格局不匹配的问题依然没有得到有效解决，还有近70%的城市群、90%以上的能源基地、65%的粮食主产区缺水问题突出。



▲水利部副部长魏山忠。图片来源/国新网

水利部副部长魏山忠表示，我国水资源的时空分布极不均衡，这可能是中国水资源最大的特点。解决时间分布不均的问题，靠修水库调蓄。解决空间分布不均，靠跨流域、跨区域引调水，把水多的地方引到水少的地方。总的来看，我们国家水资源空间分布与人口经济布局、国土空间利用格局不匹配的问题依然没有得到有效解决，我们还有近70%的城市群、90%以上的能源基地、65%的粮食主产区缺水问题突出，已经成为这些区域发展的瓶颈，难以满足经济社会高质量发展的要求。

魏山忠介绍 今年推进南水北调后续工程高质量发展 目前 在中线一期工程已经

Climate Change is Water Change

- Too Much
- Too Little
- Wrong Timing
- Wrong Form
- Wrong Quality



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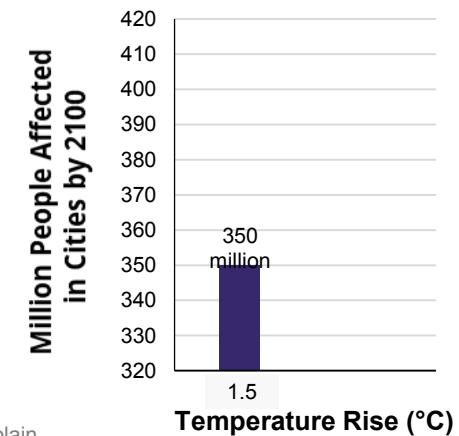


Melting ice, Antarctica by © Wim van Passel / WWF
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Drought



Dried up fishing pans in Liuwa plain
National Park by © Jasper Doest / WWF licensed under CC BY



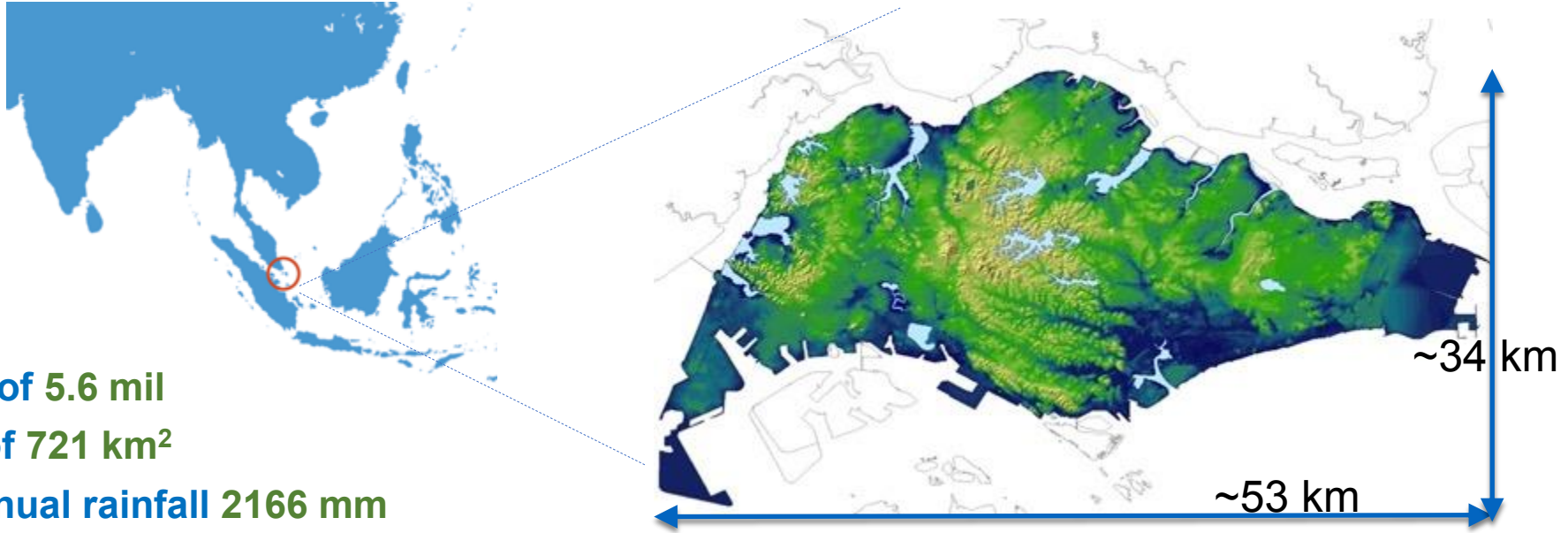
How to resolve challenges to “Too Little” and “Wrong Quality”?

- Practice conservation
- Increase catchment Increase water supply through alternative routes
 - Water Reuse and Desalination
- Enhance water quality through treatment processes



Singapore: A Small Island State

- Population of **5.6 mil**
- Land area of **721 km²**
- Average annual rainfall **2166 mm**
- Average Water Demand **1.9 mil m³/day**



WATER - A PRECIOUS RESOURCE

A sunny island set in the sea, Singapore depends on rain as a natural source of water. We receive plenty of rain, but we are constrained by our land area which limits our storage space for water.

SINGAPORE HAS NO:



Singapore was ranked first among the countries at the highest risk of high water stress in 2040 (source: World Resources Institute 2015 Report)

<http://www.mewr.gov.sg/topic/water-supply>

Courtesy from Mr Harry Seah from his presentation on Closing the Water Loop with Reuse (NEWater) at AWWTR2019 Preconference Workshop, Singapore, 29 July 2019.



Water is a national priority

A portrait of Mr. Lee Kuan Yew, an elderly man with white hair, wearing a dark suit, white shirt, and a patterned tie. He is smiling and looking towards the camera. The background of the portrait is dark.

Mr Lee Kuan Yew

Late Founding Prime Minister of Singapore
at Singapore International Water Week 2008

“ ... (Water) dominated every other policy. Every other policy had to bend at the knees for water survival. ”



Climate Change on Major Asian Cities: *Singapore*

CLIMATE CHANGE AND SINGAPORE

Singapore is a low-lying, densely-populated tropical island city-state. We are vulnerable to the effects of climate change and variability. Three examples of Singapore experiencing the effects of climate change and variability are shown on the right.

While natural climate variability may have played a part in these recent events, extreme conditions are likely to become more intense and frequent due to climate change. It is therefore important for Singapore to prepare for climate change.



Understanding Climate Change

The Issue

The build-up of greenhouse gases, such as carbon dioxide, in the atmosphere has trapped more heat, resulting in a warmer planet. Temperatures in Singapore have risen by 0.25°C per decade from 1948 to 2015, while 2016 and 2019 were the hottest years recorded thus far. A warmer climate leads to the thermal expansion of the sea and melting of glaciers and ice caps, which lead to rising sea levels, threatening our island nation. There may also be more frequent extreme weather events.

FUTURE PROJECTIONS FOR SINGAPORE

WHY?

Higher greenhouse gas emissions lead to larger changes in the climate.



Feb and Jun to Sep

Nov to Jan

RAINFALL

The contrast between the wet months (Nov to Jan) and dry months (Feb and Jun to Sep) are likely to become more pronounced. Increasing trends in both intensity and frequency of heavy rainfall events are expected as the world gets warmer.

Towards end of this century
1.4°C to 4.6°C



DAILY TEMPERATURE

Daily mean temperatures are projected to increase by 1.4°C to 4.6°C towards the end of this century (2070 to 2099), compared with the baseline period of 1980 to 2009.

SEA LEVEL

Sea levels are projected to rise between 0.25m and 0.76m in the last few decades of this century (2070 to 2099), compared with the baseline period of 1980 to 2009.

Towards end of this century (2070 to 2099)

Sea level rise between
0.25m and 0.76m

MEWR and MND (2016). Singapore's Climate Action Plan: A Climate-Resilient Singapore, For a Sustainable Future: <https://www.mnd.gov.sg/docs/default-source/mnd-documents/publications-documents/climate-action-plan---for-a-sustainable-future.pdf>

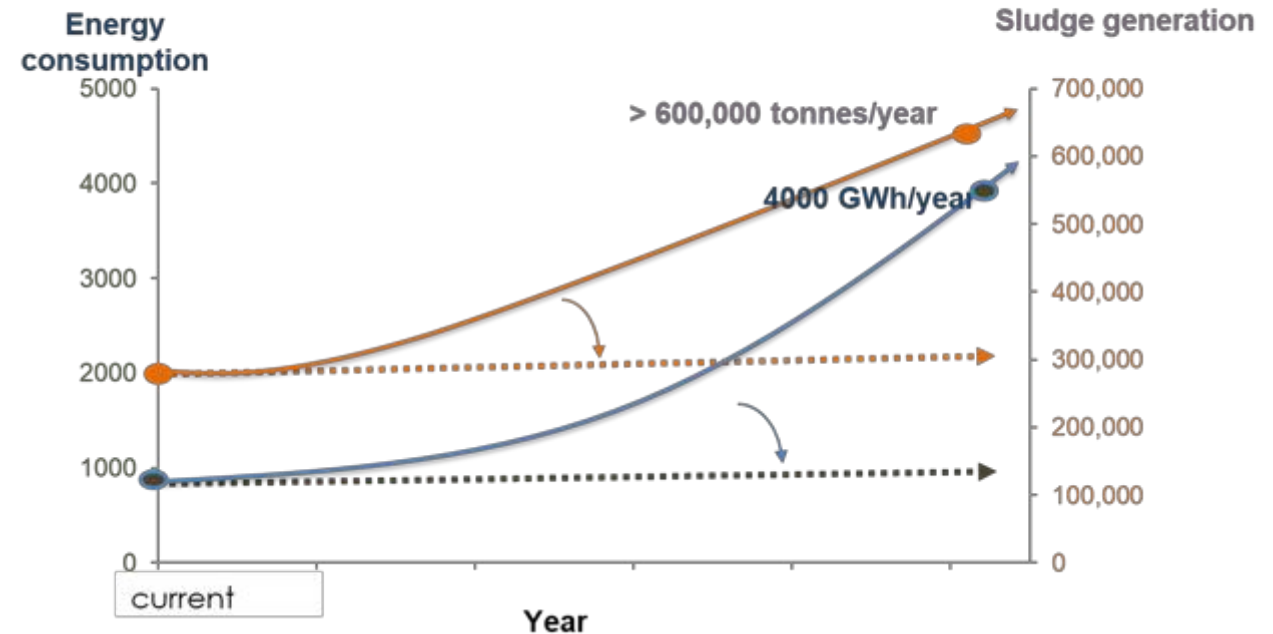
MEWR (2022). Climate Change: <https://www.mse.gov.sg/policies/climate-change>

Singapore's Water Demand – *Now and the Future*



Long Term Goal

Long Term Goal



Meet water demand in 2060 at
current energy & sludge footprint

Sustainable water solutions require coherent management from the different aspects

Water Treatment
水处理

River Management &
Rehabilitation
河流管理&修复

Wastewater Treatment
废水处理

Sanitation
卫生设备

Policy & Regulations
政策 & 法规

Water Reclamation
水再利用

Catchment Management
流域管理

Desalination
海水淡化

Resource Recovery
资源回收

And many more...还有更多...



3 Key Strategies in Providing Good Water

1

Capture every drop of water

As a city-state with scarce land, we have to make every drop of rain count



2

Reuse water endlessly

Water can always be reclaimed and retreated so that it can be used again



3

Desalinate seawater

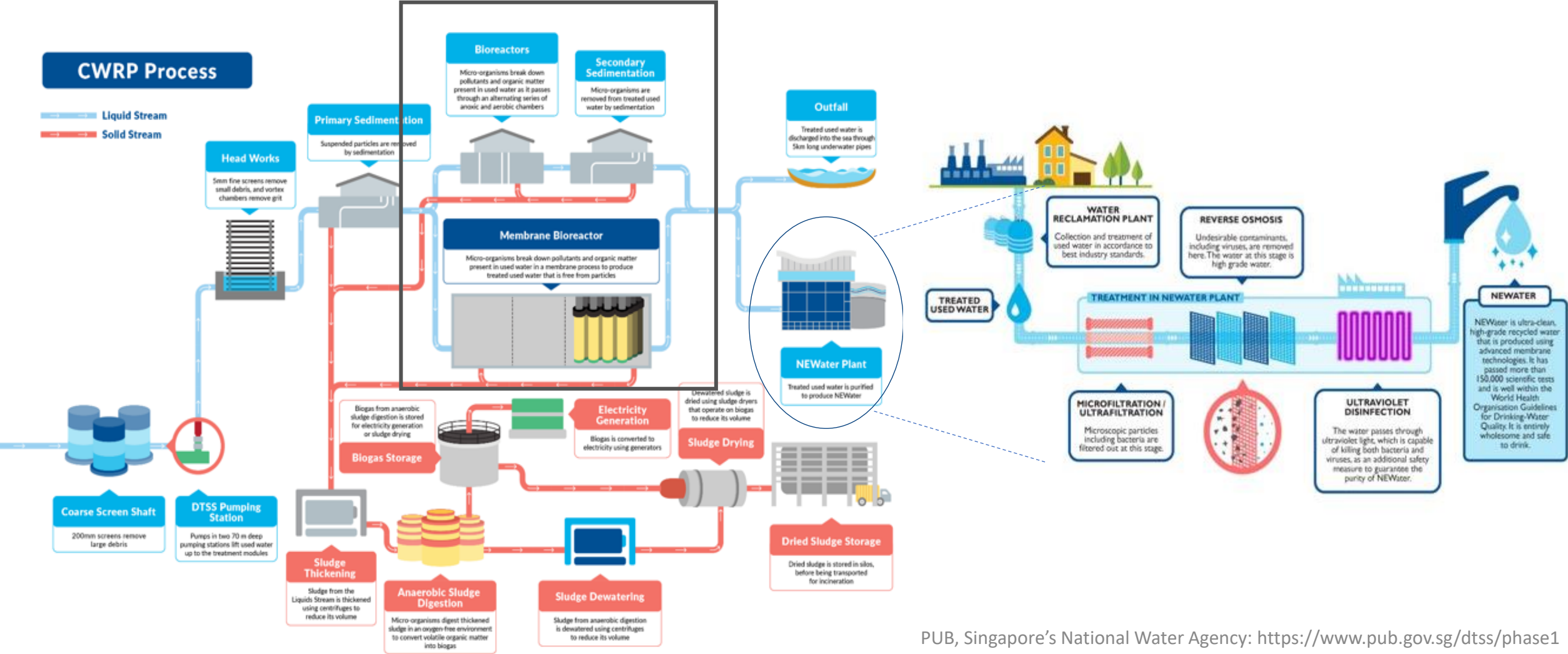
As an island surrounded by the sea, desalination is a viable and attractive option for Singapore



*Today, Singapore has a diversified supply of 4 different sources;
Residents enjoy 100% potable water at tap & 100% sanitation*

Water Reuse

Utilizing Membrane Technology for Water Reclamation



PUB, Singapore's National Water Agency: <https://www.pub.gov.sg/dtss/phase1>

Pilot-scale Membrane Bioreactor (MBR) At Short SRT



Field Trial of Pilot Aerobic MBRs at Short SRT (Project funded by PUB Singapore)

- To verify reduction in energy consumption of MBR for new Tuas WRP (800,000 m³/d)

- Biological reaction and biomass separation within the same compartment.
- Able to achieve high MLSS concentration (up to 16 g/L).
- Produces permeate of high quality:
 - High pollutant removals (> 95% COD removal & 97% nitrification efficiencies).
 - Free from suspended solids
 - Ability to remove large pathogens such as Cryptosporidium and Giardia.

Membrane Technology for Water Reclamation

MBR Using Ceramic Membranes

- Offers higher mechanical, stability, relatively narrow membrane pore size distribution, and higher chemical stability
- Requires more performance data for its wider application

Average MBR filtrate quality for Ceramic MBR Case Studies (extracted from Koh et al., 2017)

Case studies	Ulu Pandan Pilot (Noguichi et al., 2010)	Jurong Demo (Kekre et al. 2015)	Changi MBR Retrofit
Evaluation period	May – Oct 12	Nov – Jan 15	Dec 16 – Jan 17
Turbidity, NTU	0.1	0.19	0.04 (<0.1 max)
Total coliform (CFU/100 ml)	<1	<1	1.3
TOC (mg/L)	6.0	-	3.5
NH ₃ -N (mg/L)	<0.1	1.6	0.18 (<0.8 max)
pH	6.7	7.4	6.7

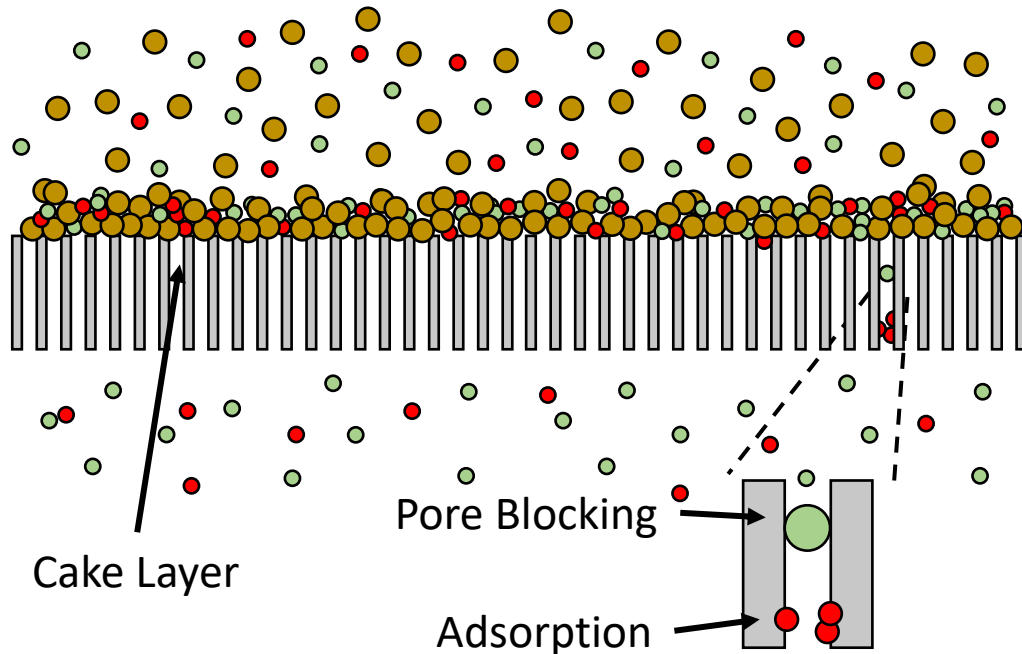
- The pilot to full scale plants showed production of *high filtrate quality* for industrial reuse or feed to further advanced water reclamation processes.



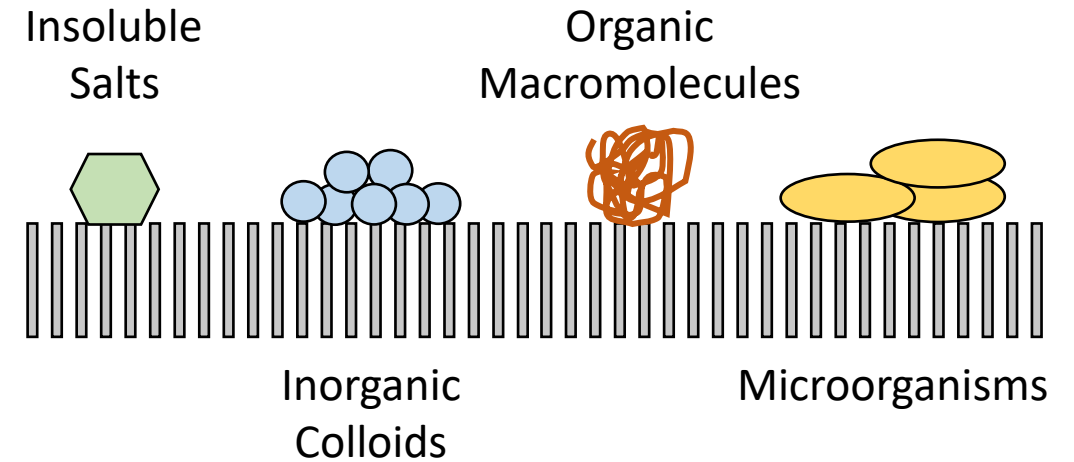
Full-scale flat sheet ceramic membrane at Changi WRP

- Full scale Changi MBR could meet the guarantee calculated specific energy value of **<0.5 kW/h per m³** of product water (operated at 10 days SRT) with optimized chemical cleaning regime and operating parameters.

Membrane Fouling – Types And Causes



Types of Membrane Fouling



Causes of Membrane Fouling

Membrane fouling is inevitable!
Fouling control is important

Physical Methods For Fouling Control – MBMBR

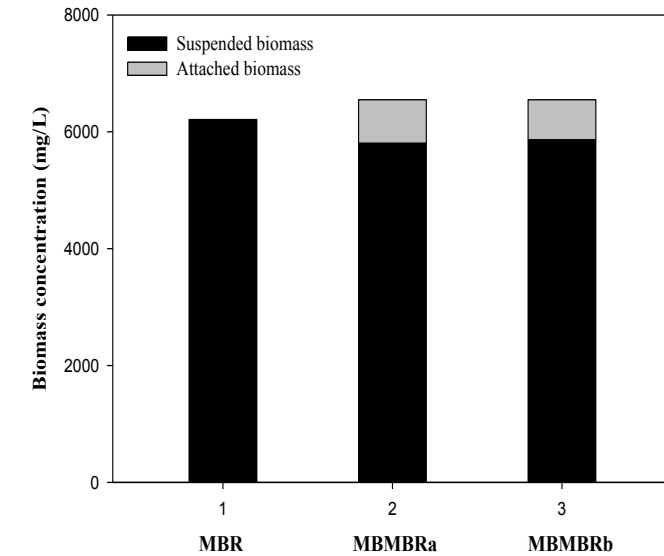
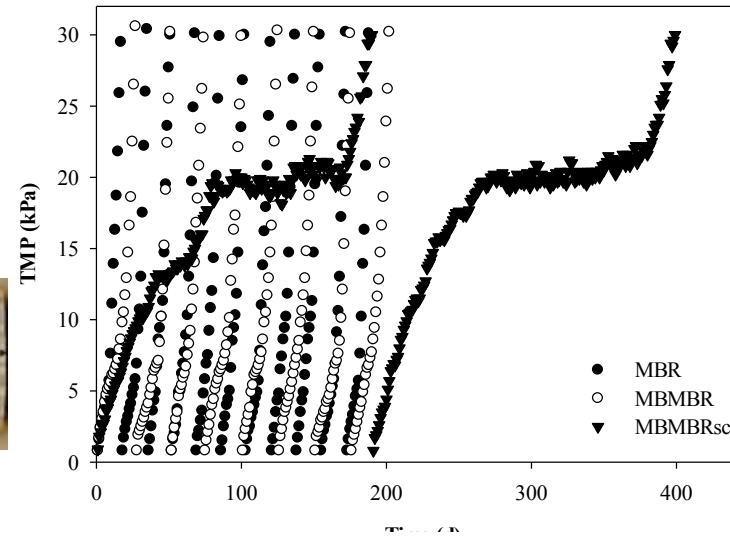
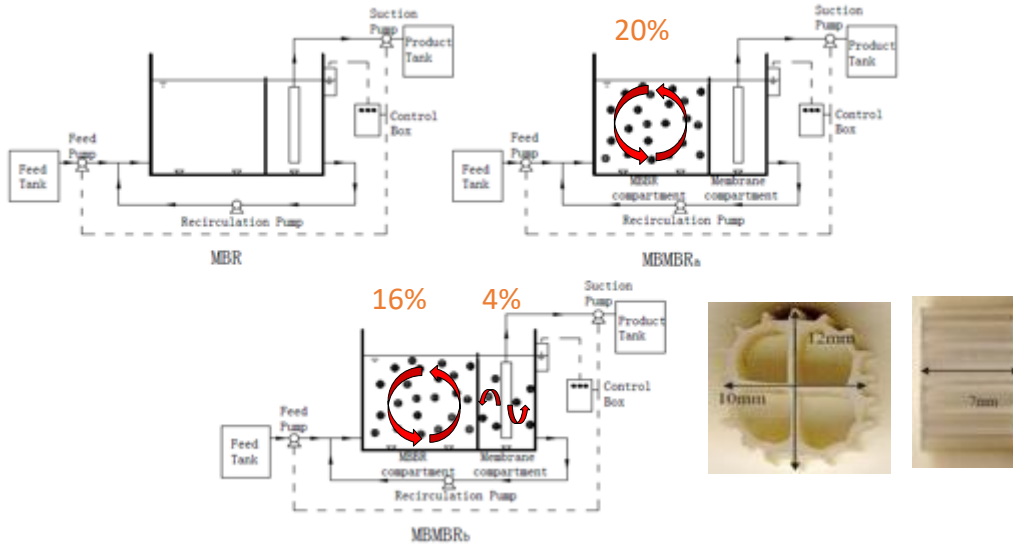
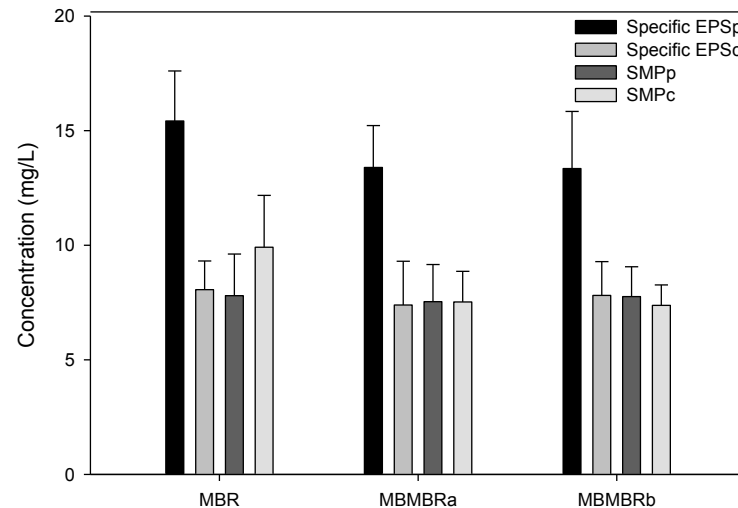


Table 1. Operating conditions of the MBR and the MBMBR.

Parameter	
Total volume (L)	12.8
HRT (h)	8
SRT (d)	20
Constant flux (LMH)	20
Organic loading ($\text{kg COD m}^{-3} \text{ day}^{-1}$)	$1.25 (\pm 0.19)$
Dissolved Oxygen (mg L^{-1})	$3.14 (\pm 1.04)$
Temperature ($^{\circ}\text{C}$)	25-30
pH	6.9-7.1

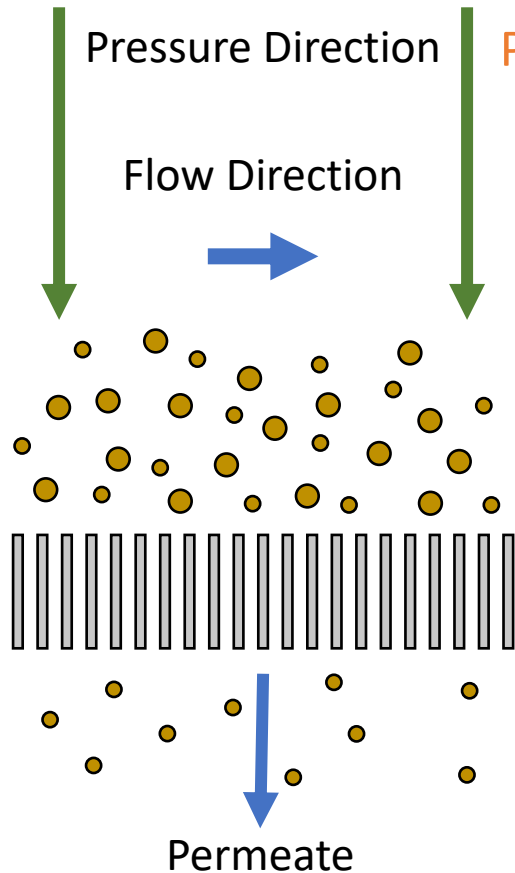


C. Fu et al. 2016, J. Membr. Sci. 499, 134-142

- MBR took about 17 d; MBMBRa took 25 d to reach a TMP of 30 kPa.
- TMP of the MBMBRb increased gradually in the first 80 d and stabled at pressure of 20 kPa for over 90 d and then rise to 30 kPa after 190 d.
- Lower fouling in MBMBR attributed to:
 - Lower suspended biomass in MBMBR.
 - Lower concentration of SMPc (31.8%).

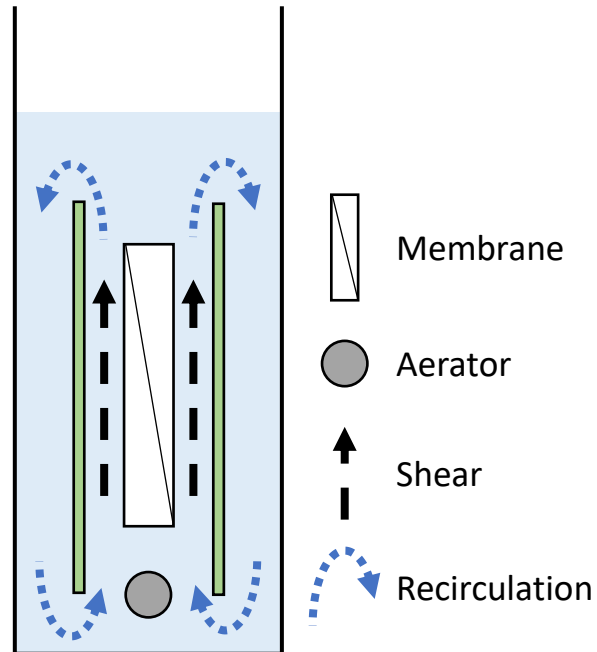
Physical Methods For Fouling Control – Vibrating MBR

Provision of shear/movement along membrane surface to minimise foulant attachment

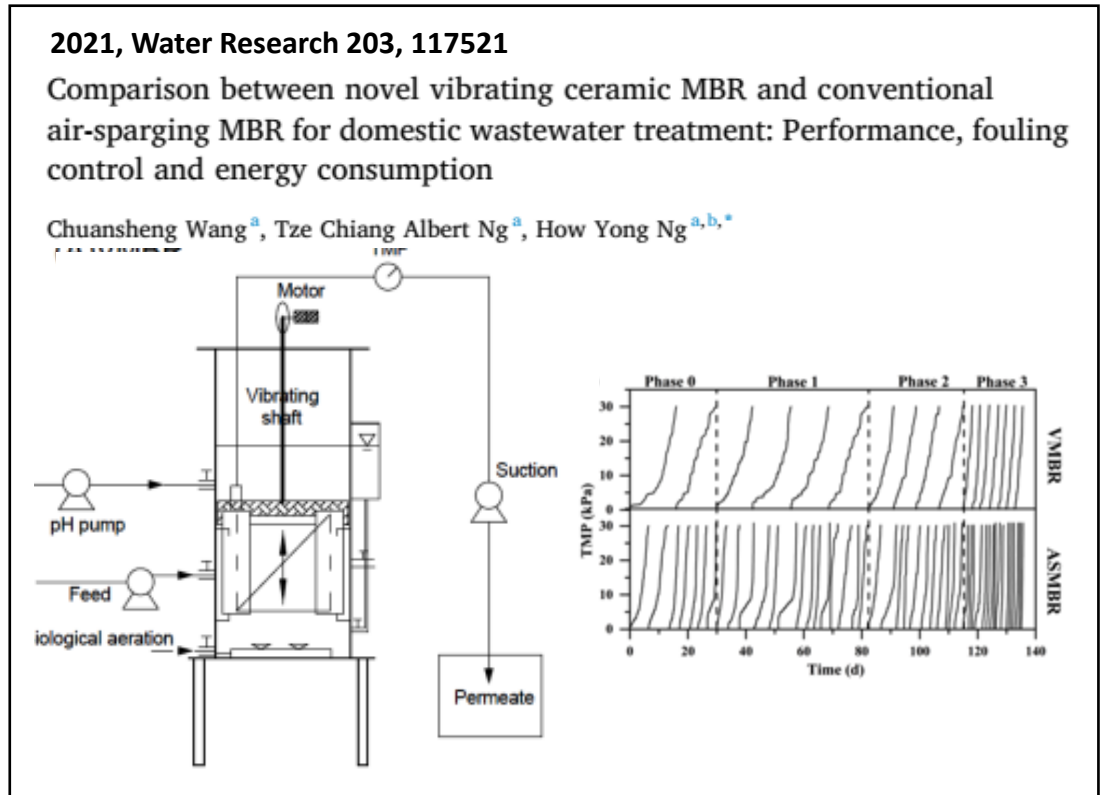


Crossflow Filtration

Using air/biogas to provide shear

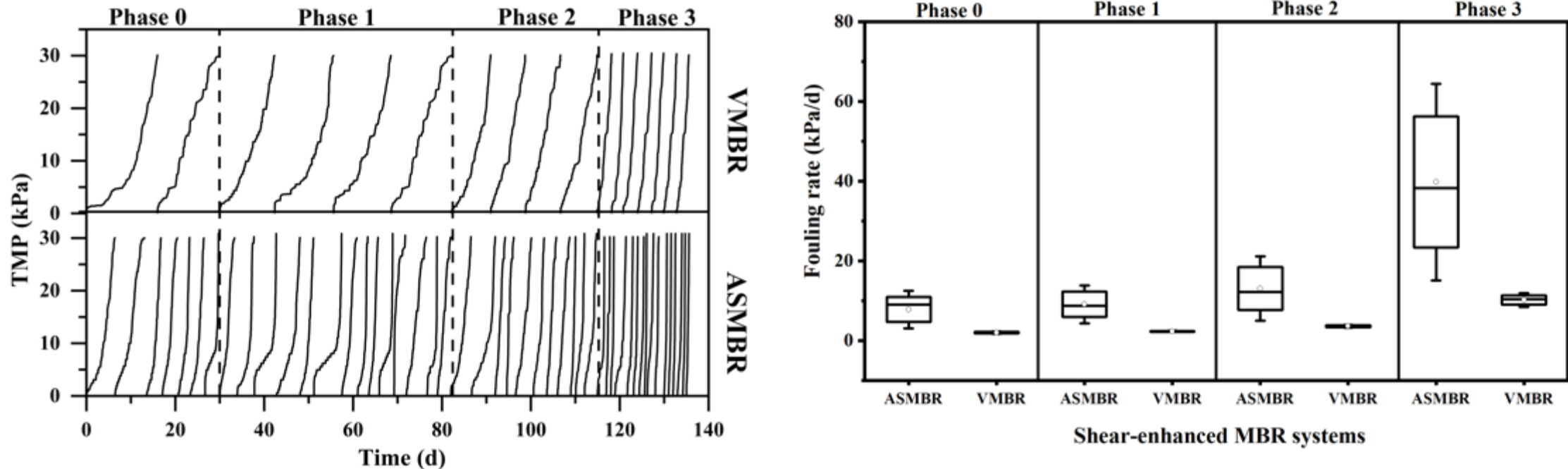


Simplified MBR Schematic



Vibrating/Rotating Membrane Module

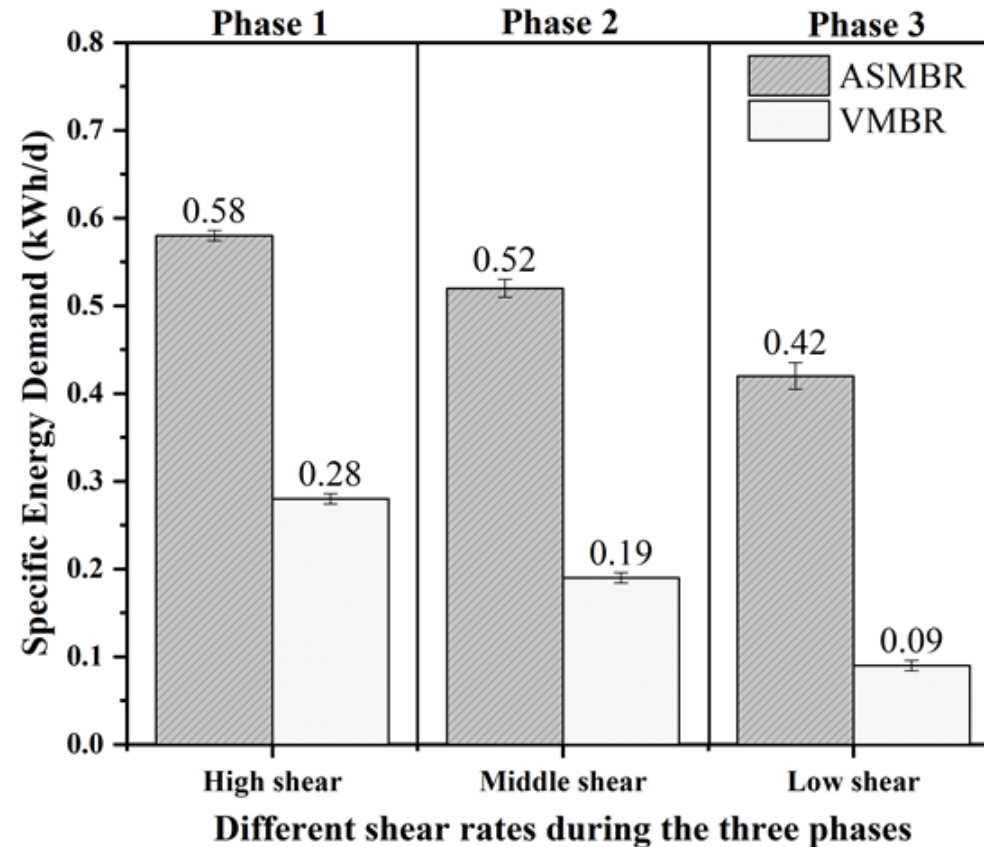
Results — Fouling Control



TMP profiles (left) and fouling rates (right) of the VMBR and ASMBR since start-up

- 1) Shear stress↓ TMP rise ↑: higher shear stress membrane fouling ↓.
- 2) Fouling rates: 2.31 kPa/d to 3.59 kPa/d and 10.15 kPa/d in VMBR << 9.07 kPa/d to 13.04 kPa/d and 39.76 kPa/d in ASMBR in Phase 1, 2, 3.
- 3) Better fouling control in VMBR, mainly retarding membrane fouling in the initial stage (i.e., low-TMP of <10 kPa).

Results — Specific Energy Demand

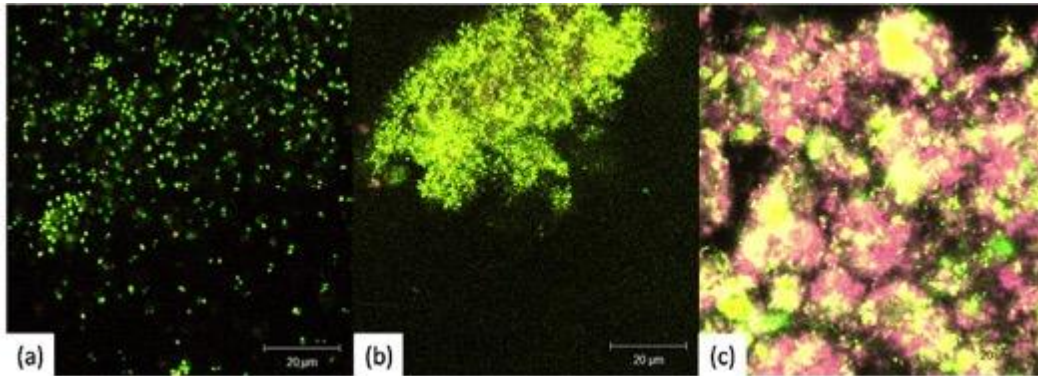


Specific energy demand (SED) of air-sparging MBR (ASMBR) (0.42-0.58kWh/d) was much higher than vibrating MBR(VMBR) (0.09-0.28 kWh/d). At similar shear stress, SED of ASMBR was around 2 to 4 times as VMBR.

Biological Methods for Fouling Control

Foulants from biological treatment processes are biological (microorganisms) and organic compounds

Green – Bacteria; Yellow – Protein; Red - Polysaccharide

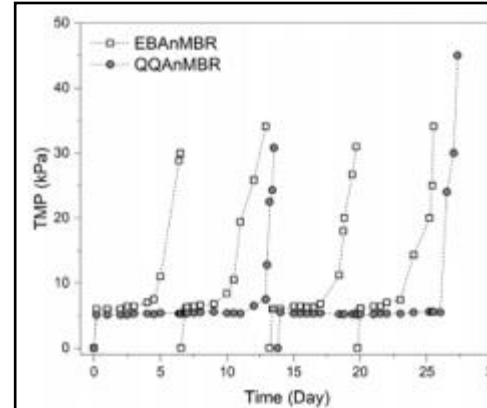


Initial Fouling Mid-stage Fouling Mature Fouling
(Research Group's unpublished data)

Biofouling – formation of biofilm, a living community of microbes, supported by an organic architecture



(2015, Journal of Membrane Science 283, 220)

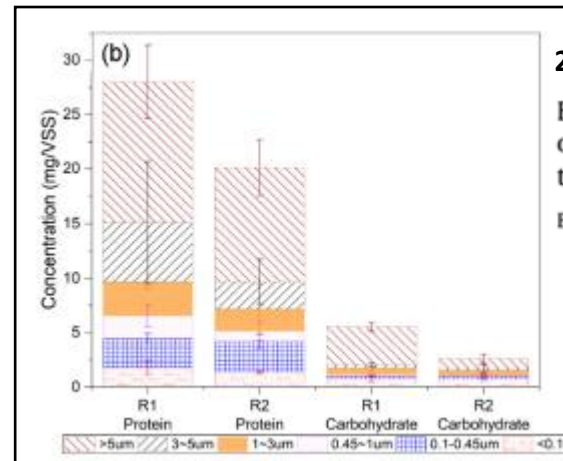


2020, Water Research 169, 115251

Feasibility of isolated novel facultative quorum quenching consortiums for fouling control in an AnMBR

Boyan Xu^a, Tze Chiang Albert Ng^a, Shujuan Huang^a, Xueqing Shi^b, How Yong Ng^{a,c,*}

First example of facultative QQ consortium used in lab-scale Anaerobic MBR



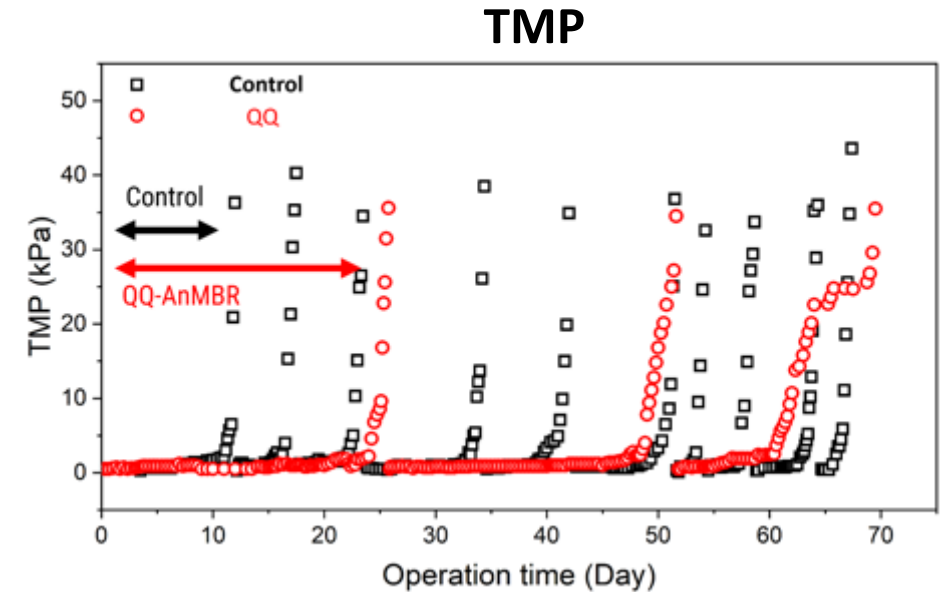
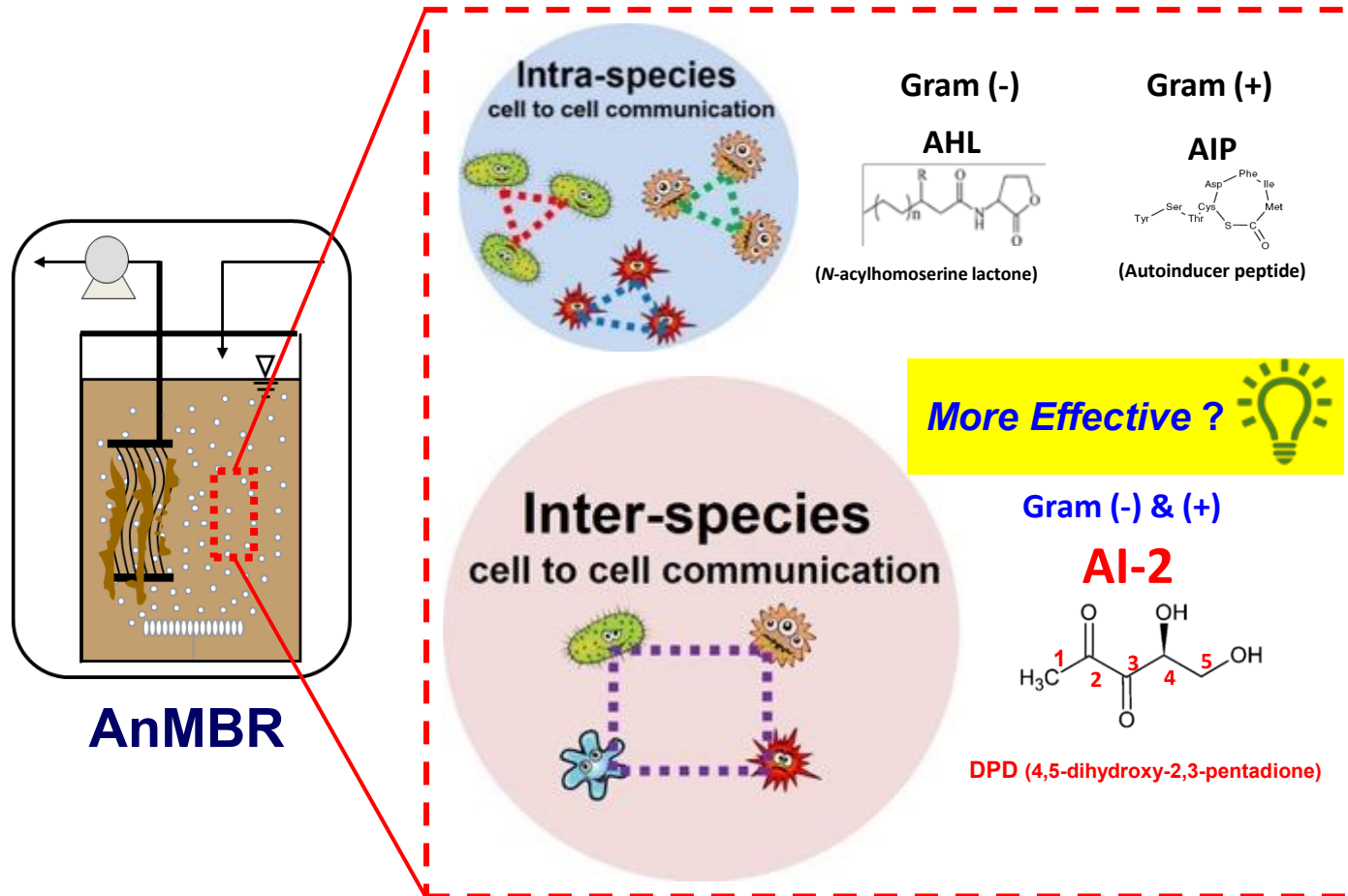
2020, Water Research 179, 115850

Effect of quorum quenching on EPS and size-fractionated particles and organics in anaerobic membrane bioreactor for domestic wastewater treatment

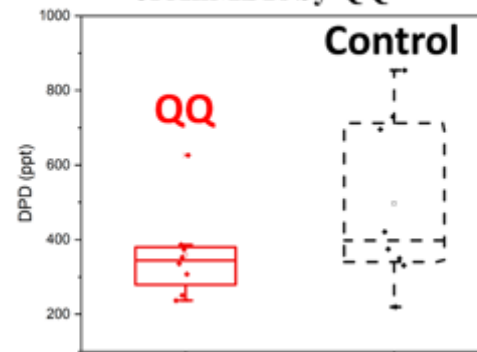
Boyan Xu^a, Tze Chiang Albert Ng^a, Shujuan Huang^a, How Yong Ng^{a,b,*}

- QQ extended membrane operation service period by 39-135%
- QQ reduces protein and polysaccharide concentrations

A New Paradigm Shift: From Intraspecific To Interspecific Regulation Of Quorum Sensing in AnMBR



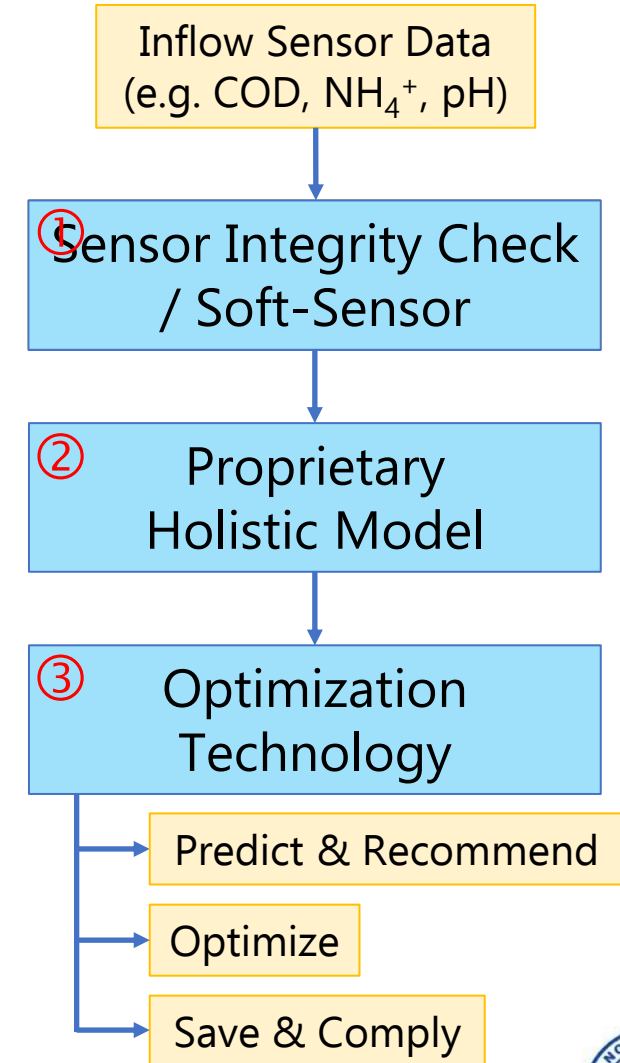
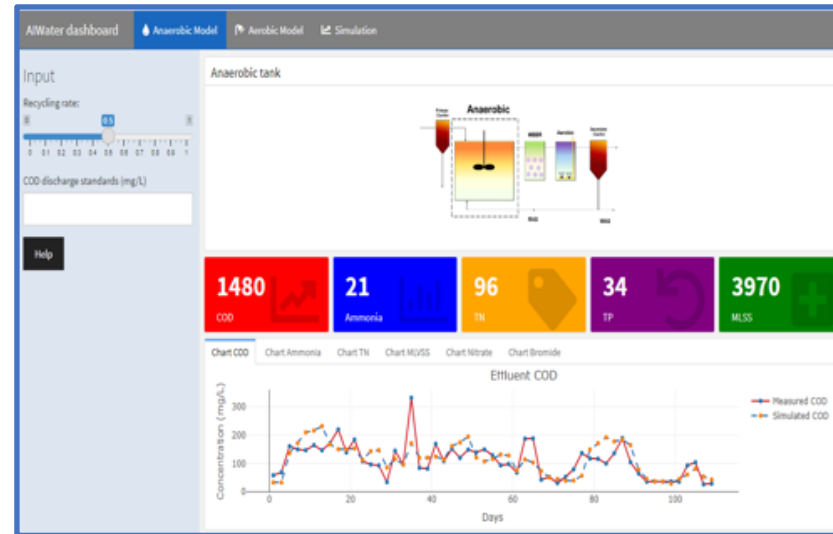
Reduced AI-2 in mixed liquor of AnMBR by QQ



Membrane fouling cycles:
Control: 6.17 d
QQ : 22.95 d
- Fouling is reduced by 3.2 times ($p < 0.05$)

Reduction of Energy and Chemical Consumption in Wastewater Treatment

- Combining biological process equations, big data models and AI optimization techniques to predict effluent quality
- Reduction of energy cost of used water treatment plants through process optimisation by up to 30% .



Main Challenges to be Resolved by Digital WWTPs

Common Challenges of WWTPs



Personnel management

- Production efficiency needs further improvement, and technical capabilities must be continuously strengthened.
- Aging personnel.



Operation and maintenance management

- There are various types of plant equipment and systems, and the daily operation and maintenance management capabilities need further improvement.



Energy management

- With the goal of carbon reduction and cost savings, energy conservation and consumption reduction have important priorities.



Process decision-making

- The source water quality fluctuates, and process operation is unstable. Through big data analysis and mining, process stability can be improved.
- Modeling enables the use of consumables based on demand, reducing operational costs.

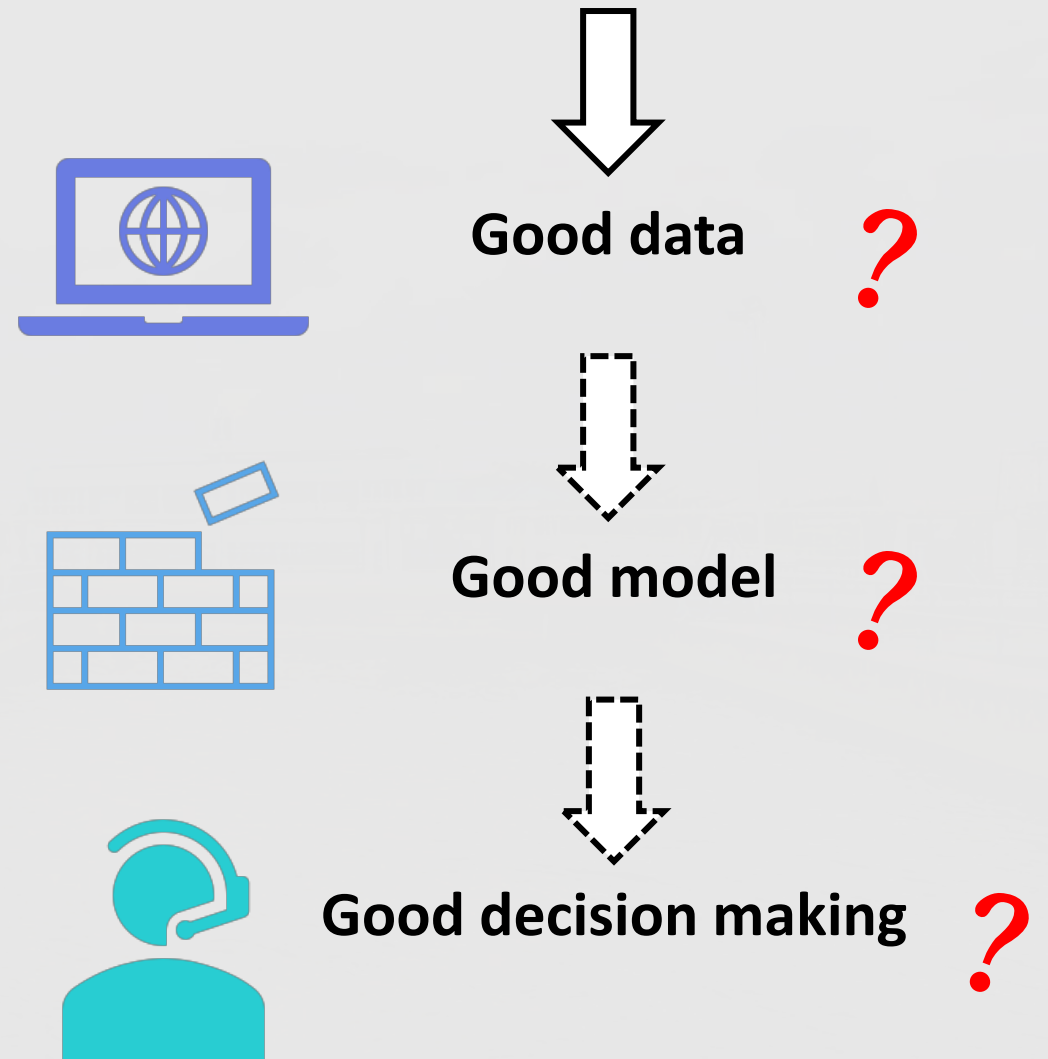


How can the management level of WWTPs be comprehensively improved?

- The integrated management platform is a key component in the development of smart WWTPs and the most effective way to ensure the standardized operation of WWTPs while improving energy efficiency.
- It can automate WWTPs, integrate standardization achievements, and provide timely information for operators, helping WWTPs to achieve the goal of "safety, stability, and efficiency".

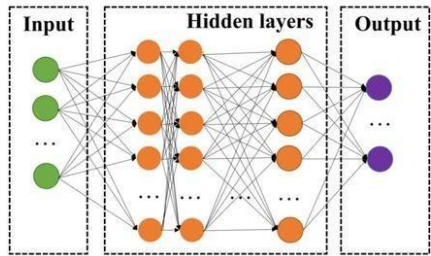
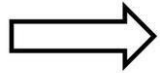
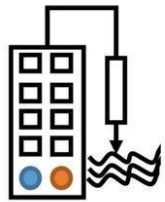


Digital, the digital twin ✓

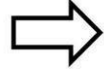


Machine Learning Modeling

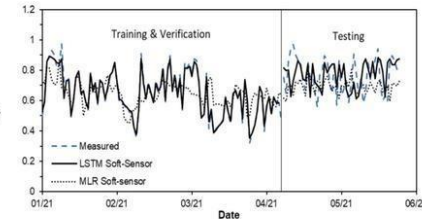
Cheaper and easier
to measure sensors



Long short-term memory neural network (LSTM)

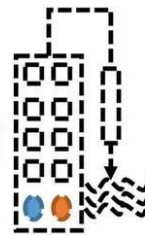


Validation of soft-sensors



Soft-sensors for
hard-to-measure parameters

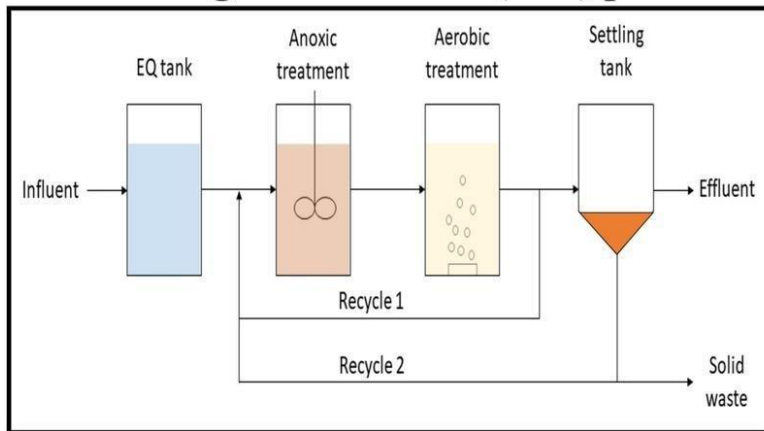
COD, TN, NH_4^+



Forecasting



Two-staged anoxic-oxic (A/O) process



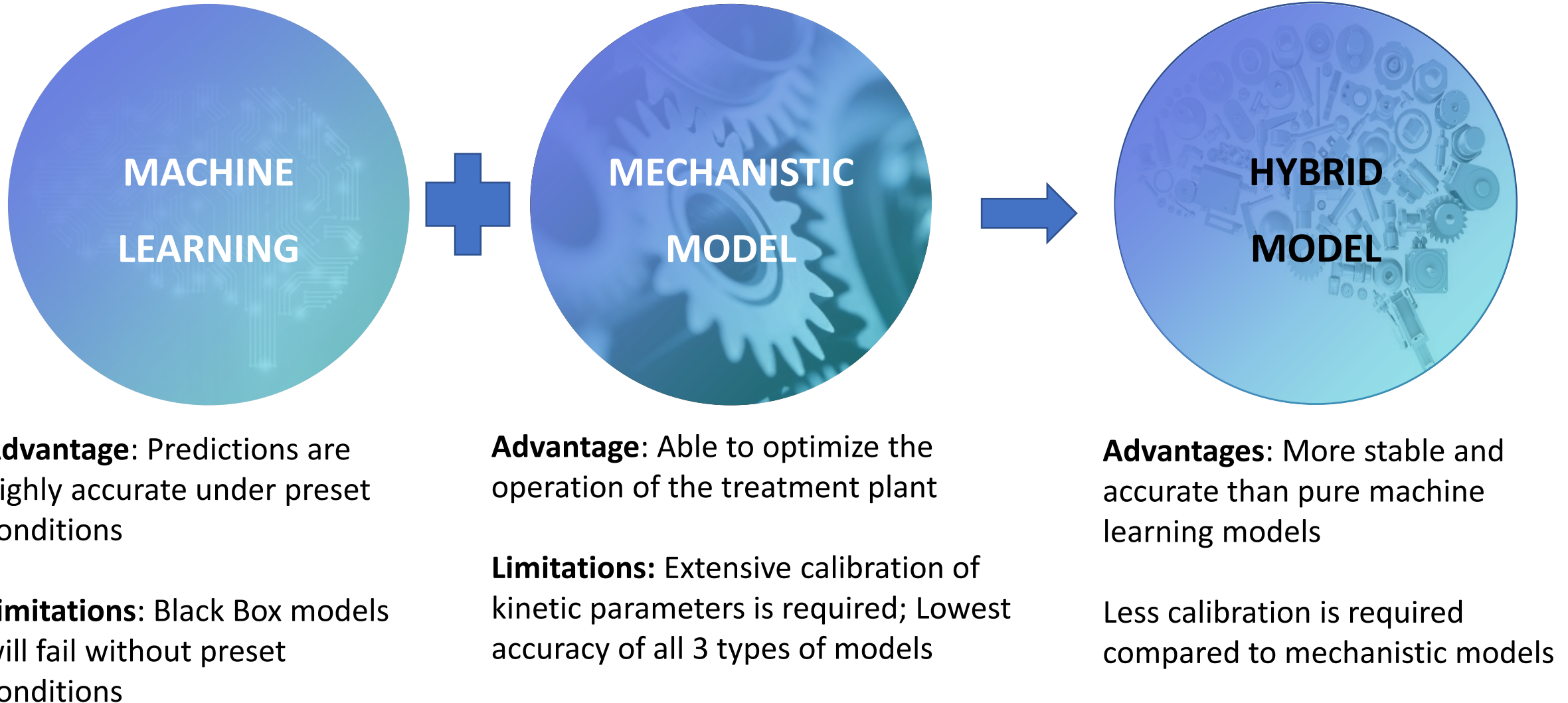
Predicting water
quality + sensor
self-errata

Journal of Water Process Engineering, Volume 54, August 2023, 104041

Sensors, such as ammonia and COD sensors, are susceptible to accuracy deviations.

- **LSTM Soft Sensor Development:** By utilizing low-cost sensor data—such as DO, redox potential, and SS—LSTM-based soft sensors can be developed for A/O wastewater treatment processes to monitor key parameters such as COD, NH_4^+ , and TN.
- **Model optimization:** Pearson correlation analysis is used to determine the input features, optimize the lookback period, and enhance prediction accuracy.
- **Cost-effectiveness:** LSTM soft sensors outperform multiple linear regression models in prediction efficiency and accuracy, thereby reducing equipment costs for WWTPs.

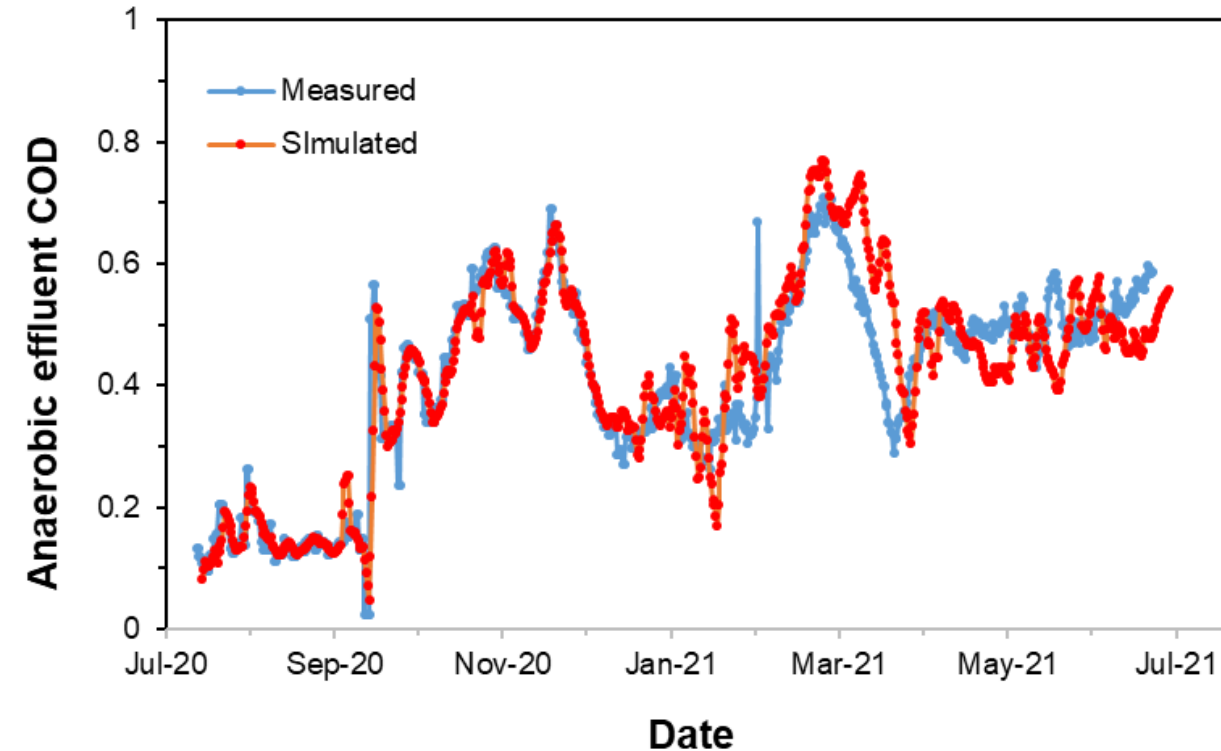
Comparison of Models



Full-Scale Industrial Wastewater Treatment Plant



Anaerobic Pretreatment



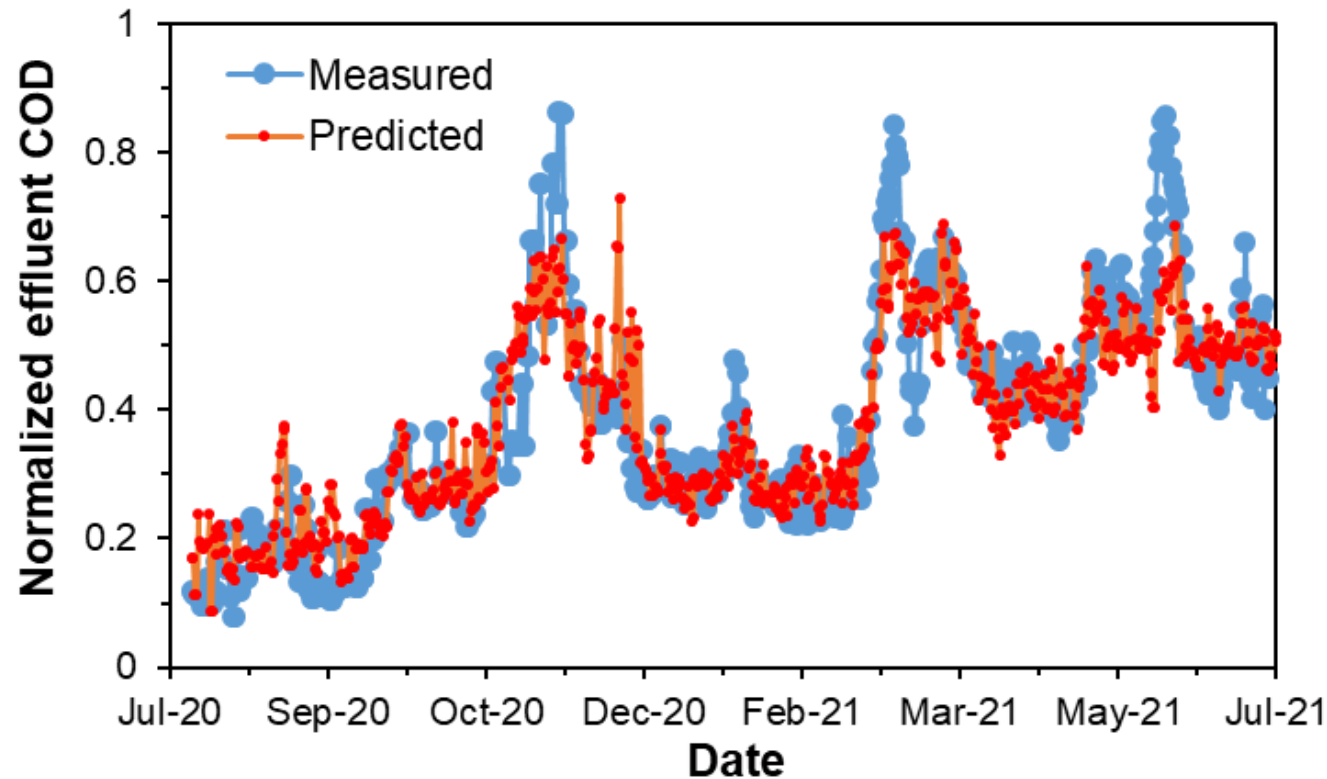
Results	
Mean average	13.8
Percentage error (%)	
Correlation	0.87

- Varying industrial characteristics resulted in differing performance of anaerobic treatment.
- The model accurately capture this trend.

Full-Scale Industrial Wastewater Treatment Plant



Aerobic Treatment

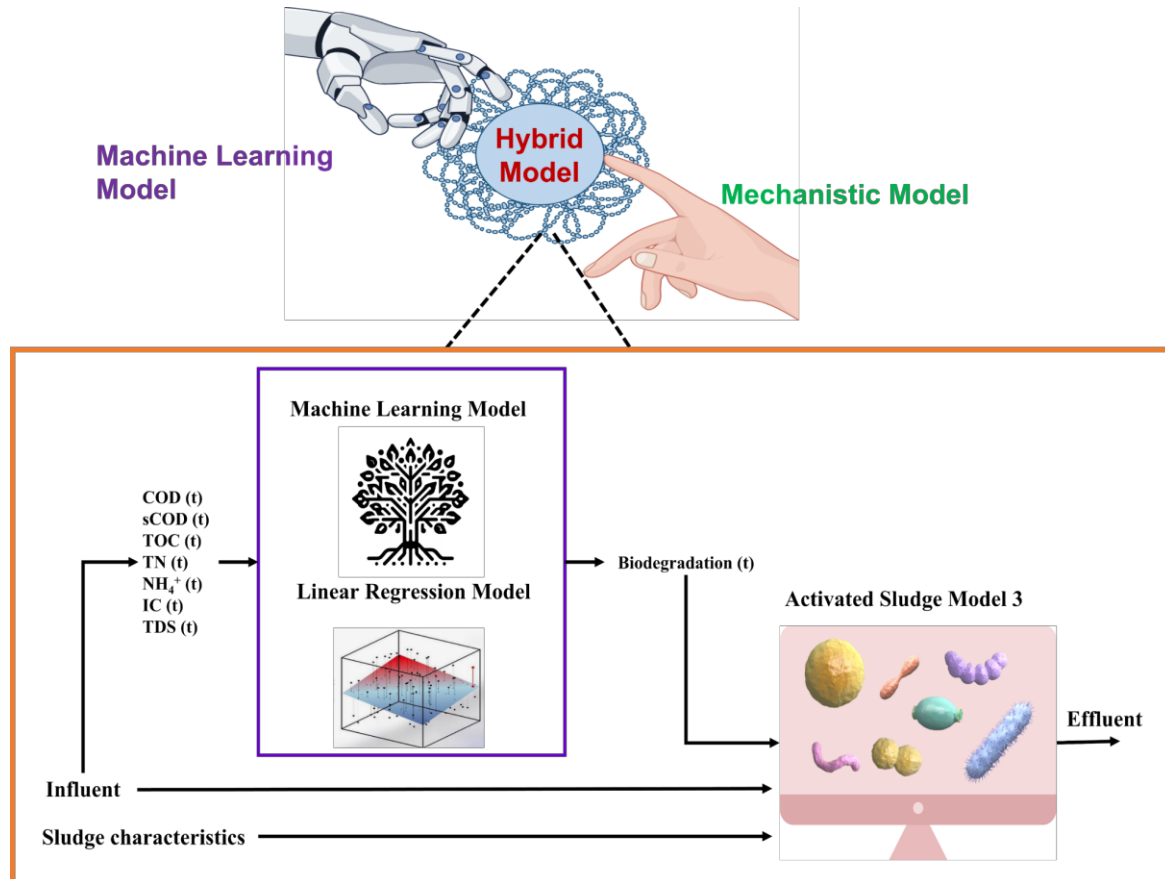


Results	
Mean average	13.1
Percentage error (%)	
Correlation	0.82

- Washout from anaerobic put stress on oxic reactor.
- Early alert system enables operators to initiate backup measures promptly.
- Ensuring discharge limits are met.
- Could utilize to increase the throughput of the WWTP.

Hybrid Model

Hybrid Model used for Petrochemical Wastewater Treatment



Motivation:

- Traditional models show high error (31–47%) & low correlation (0.47–0.50) in predicting treatment performance

Model Development:

- Hybrid model integrates Machine Learning (MLR, Decision Forest) with Activated Sludge Model (ASM3)
- Validated using petrochemical wastewater with different compositions

Results:

- DF-ASM3 outperforms MLR-ASM3 with lower error (<25%) & higher correlation (>0.7) on COD, MLSS, nitrate predictions
- Hybrid model improves accuracy and reduces biodegradation testing workload

Large Language Models

Growing need for specialized LLMs in water knowledge tasks — urgent & essential

• **Question:** How trustworthy are foundational models (e.g., GPT-3.5) for water tasks?

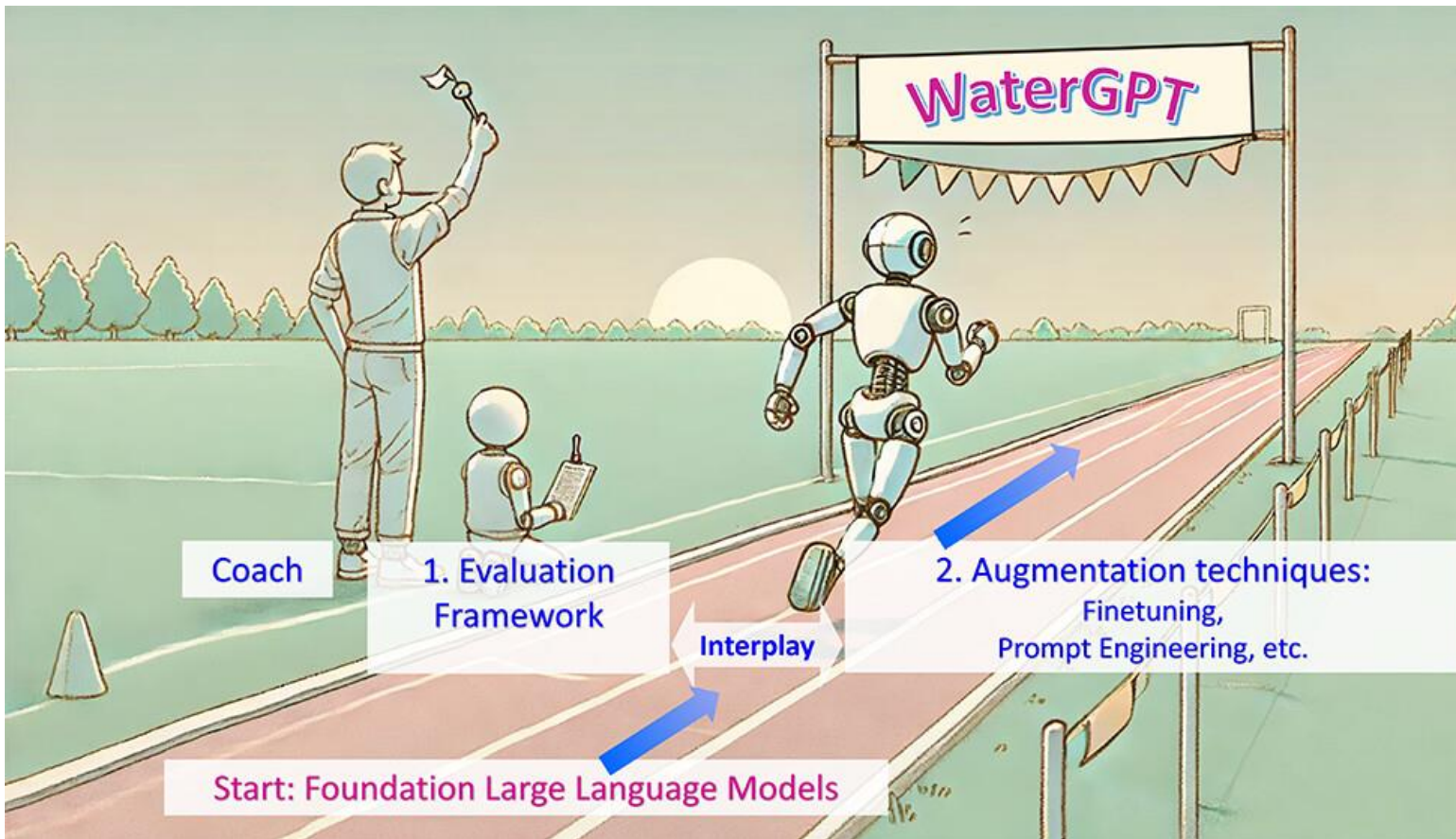
• Safety-critical nature of water sectors demands robust evaluation frameworks of LLMs to:

- a. Identify and mitigate risks
- b. Track progress accurately

Key considerations:

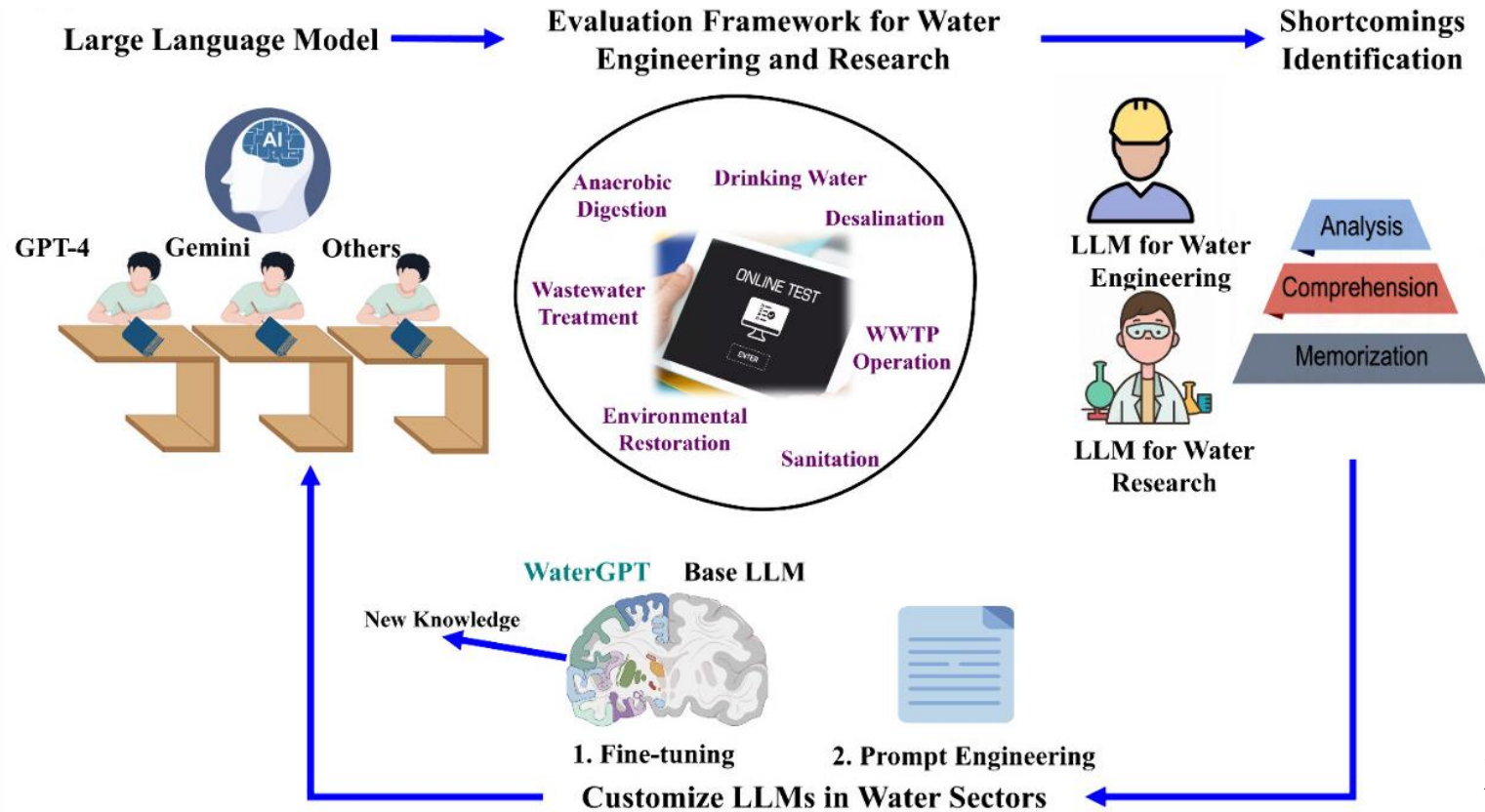
a. Which water engineering and research areas can directly benefit from foundational models?

b. If gaps exist, how to improve via fine-tuning on specialized datasets?



Xu et al., *ES&T Letters* 2025

Large Language Models



Xu et al., *ES&T Letters* 2025

- We developed WaterER, an **evaluation suite** to assess various LLMs on diverse water knowledge tasks in engineering and research.
- Testing **eight foundational models** revealed that they lag behind **human water expert professionals**.
- To enhance performance, we applied **prompt engineering** and **fine-tuned** the Llama3-8B model into **WaterGPT**, advancing its knowledge capabilities in the water domain.

Large Language Models

Table S1. Statistics of WaterER.

	Category	Denotation	# Questions	Sources
Water Engineering	Technical Book of Wastewater Treatment Fundamentals	WWTF	500	Water Environment Federation ^{1, 2}
	Examination for Certificate of Registered Environmental Protection Engineer of the People's Republic of China (2023)	ECREPE	263	https://www.gov.cn/zhengce/zhengceku/2023-01/20/content_5738275.htm
	Examination from Water Operator Practice Tests from Water Nuggets	WOPT	100	https://waternuggets.com/water-operator-practice-tests/
Water Research	In terms of topics			
	Treatment processes for wastewaters	WasteW	30	ScienceDirect
	Environmental restoration	ER	30	ScienceDirect
	Drinking water treatment	DrinkW	30	ScienceDirect
	Sanitation	SA	30	ScienceDirect
	Anaerobic digestion and waste management	AD	30	ScienceDirect
	Contaminants and related water quality monitoring and assessment	Contaminant	30	ScienceDirect

Task Categorization for LLMs Evaluation

Two task groups:

•Engineering tasks

- ✓ Wastewater Treatment Fundamentals (500 Qs, WWTF)
- ✓ China Registered Environmental Protection Engineer Exam (263 Qs, ECREPE)
- ✓ Water Operator Practice Tests (100 Qs, WOPT)

•Research tasks — 180 questions from 6 key topics (30 Qs each) sourced from 2024 journal keyword searches:

- ✓ Wastewater treatment processes (WasteW)
- ✓ Environmental restoration (ER)
- ✓ Drinking water treatment (DrinkingW)
- ✓ Sanitation (SA)
- ✓ Anaerobic digestion & waste management (AD)
- ✓ Contaminants & water quality monitoring (Contaminant)

Large Language Models

Name	Creator	Size	Launch time	Source types
GPT-4 (gpt-4-0613)	OpenAI	Unknown	Mar-23	Closed source
GPT-3.5-turbo (gpt-3.5-turbo-0125)	OpenAI	~175B	Nov-22	Closed source
Gemini (Gemini-1.0 pro)	Google	Unknown	Dec-23	Closed source
GLM (GLM-4)	Tsinghua	Unknown	Sep-23	Closed source
ERNIE Bot (ernie-4.0-8k-0329)	Baidu	Unknown	Oct-23	Closed source
Qwen (qwen-max-0428)	Alibaba Cloud	Unknown	Aug-23	Closed source
Llama3-8B (Meta-Llama-3-8B)	Meta	8B	Apr-24	Open source
Llama3-70B (Meta-Llama-3-70B)	Meta	70B	Apr-24	Open source

Foundational models evaluated in this paper

Water Engineering Query

Query: As a water engineer, please select the correct answer from the following options. **Which type of sludge require a non-ionic or anionic polymer?**

**A: Primary sludge B: Secondary sludge
C: Chemical sludge D: Septic sludge**

Expected Answer: **C**

Water Research Query

Query: As a water researcher, please generate a proper title using the Abstract.

Abstract: **XXX**

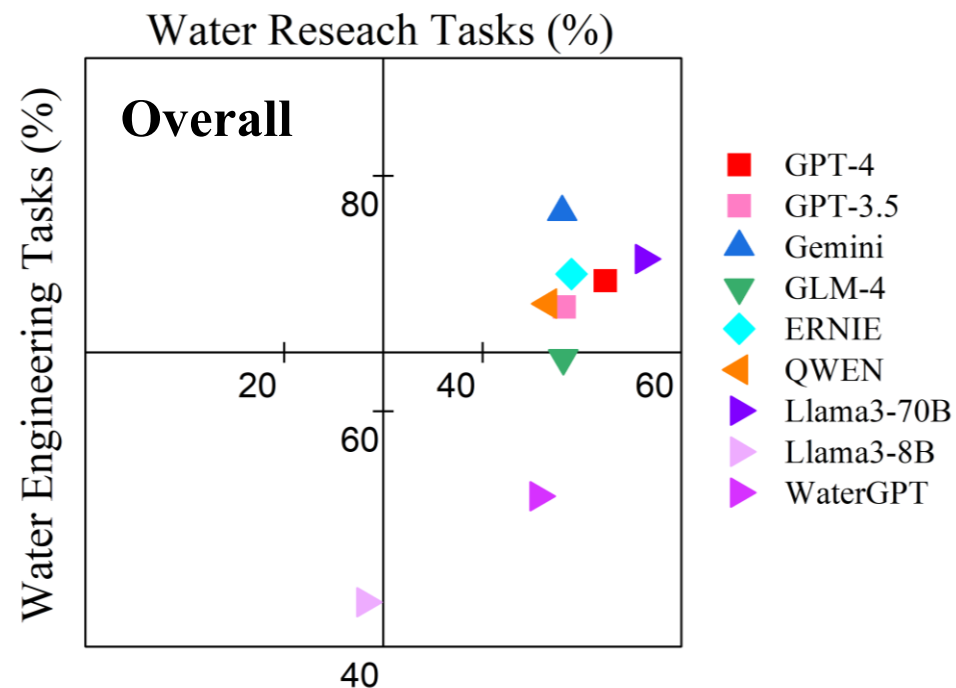
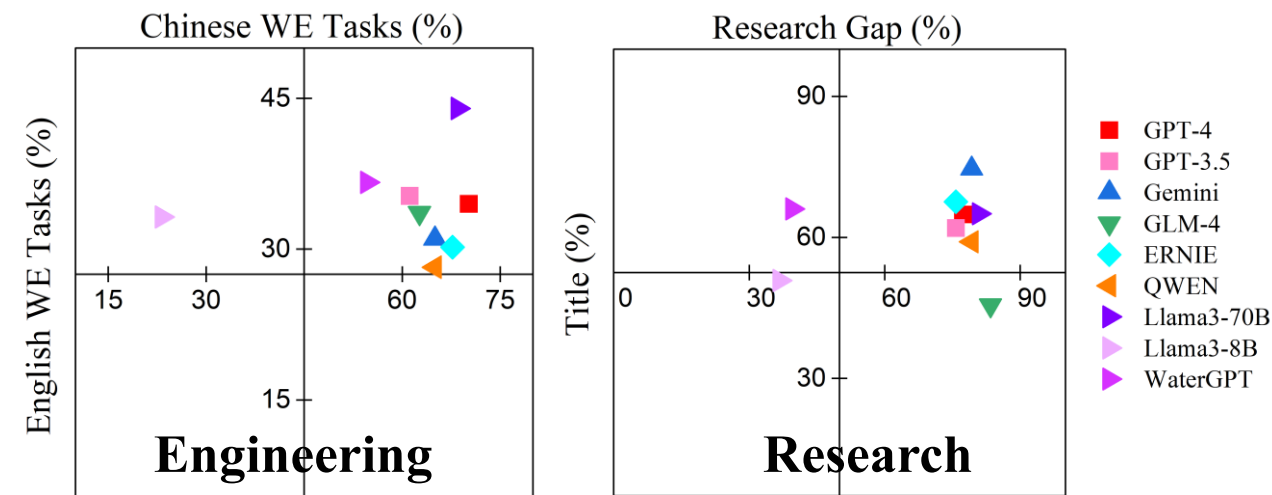
Answer: **The title of the published paper**

Query: As a water researcher, please identify the research gaps that the study aims to address. The Abstract of it: **XXX**

Expected Answer: **The research gaps of the published paper**

An example of a query from Technical Book and examples of queries for water research (requesting paper title and research gaps).

Large Language Models



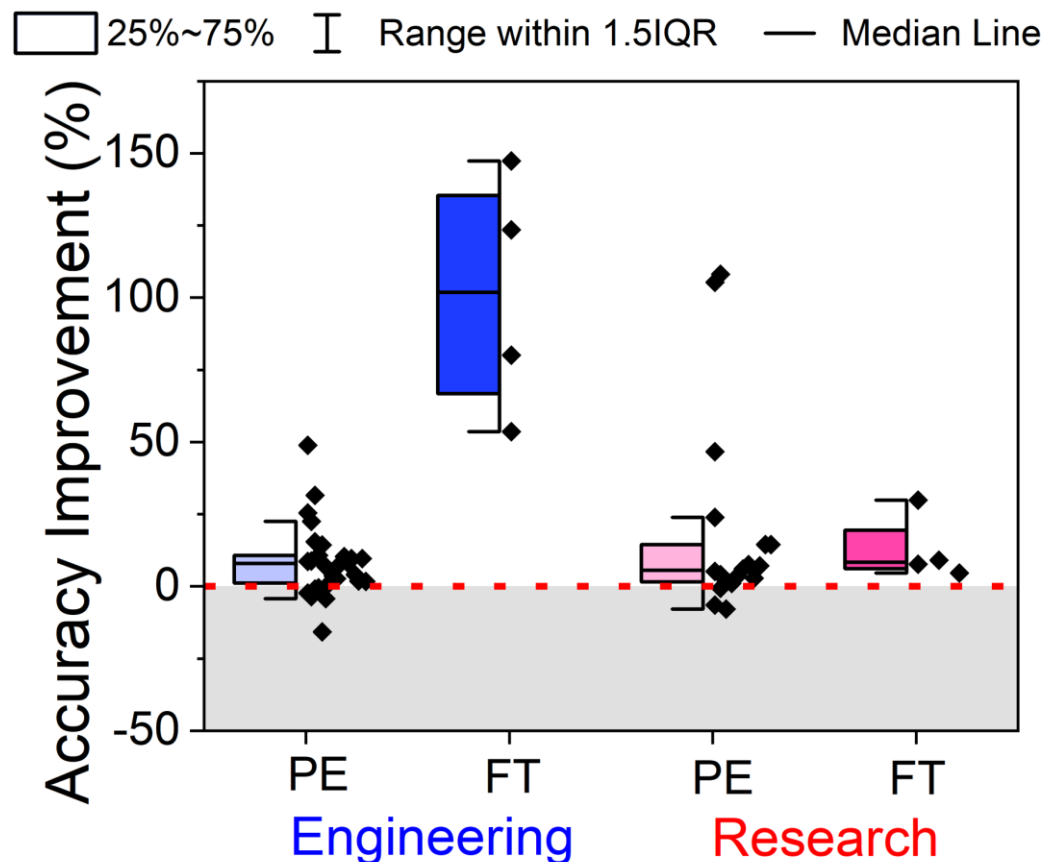
- GPT-4:** Strong performance in both engineering & research tasks;
- Gemini:** Excels in research tasks, reliable for literature analysis but needs output validation;
- Llama3-70B:** Strong on Chinese engineering queries;
- Chinese models (GLM-4, ERNIE4.0, QWEN):** Outperform GPT-3.5 in English engineering tasks

•LLMs perform better on **research tasks** than **engineering tasks**

•**Current LLMs' Strengths:** Comprehension, Analysis, Reasoning (good for scientific literature)

•**Current LLMs' Weakness:** Lack of base water sector knowledge, poor Memorization, leading to <70% accuracy on engineering tasks, especially in Chinese

Large Language Models



Enhancing LLM Performance: Few-Shot vs Fine-Tuning

•Five-shot learning:

- Boosted Chinese models' performance on Chinese engineering tasks
(Gains from integrating five-shot examples in instruction tuning)
- However, results were inconsistent and sometimes detrimental

•Fine-tuning approach:

- Created **WaterGPT** by fine-tuning Llama3-8B with specialized water knowledge
- Outperformed base Llama3-8B by 135.4% (English engineering) and 18.8% (research tasks)
- Matched GPT-3.5 on research gap generation tasks
- Offers transparency, reproducibility, and better data privacy vs closed models

•WaterER evaluation framework:

- Effectively captures performance improvements
- Guides further LLM enhancements

Desalination

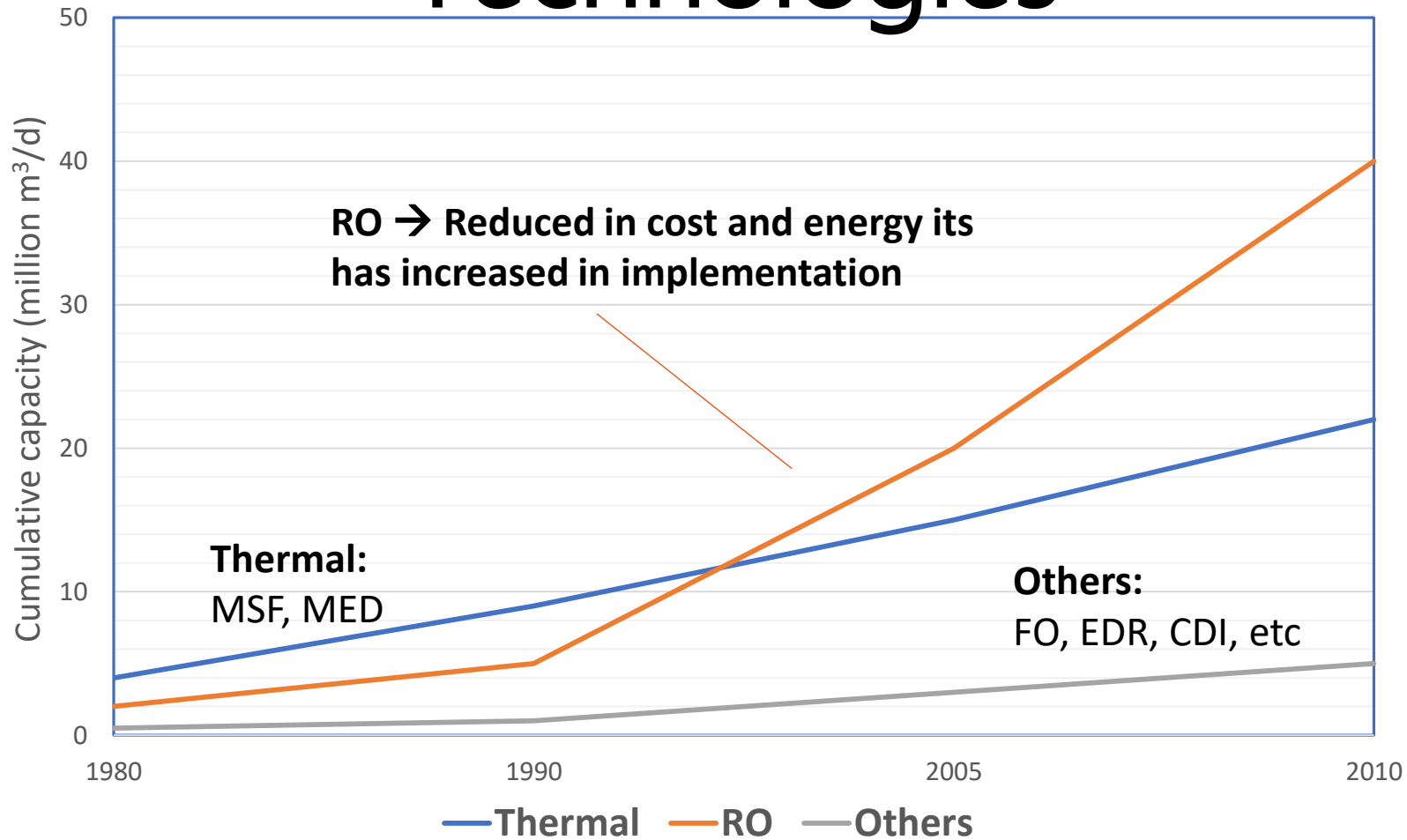
Desalination – from seawater to freshwater

From Early Years to the New Future.....



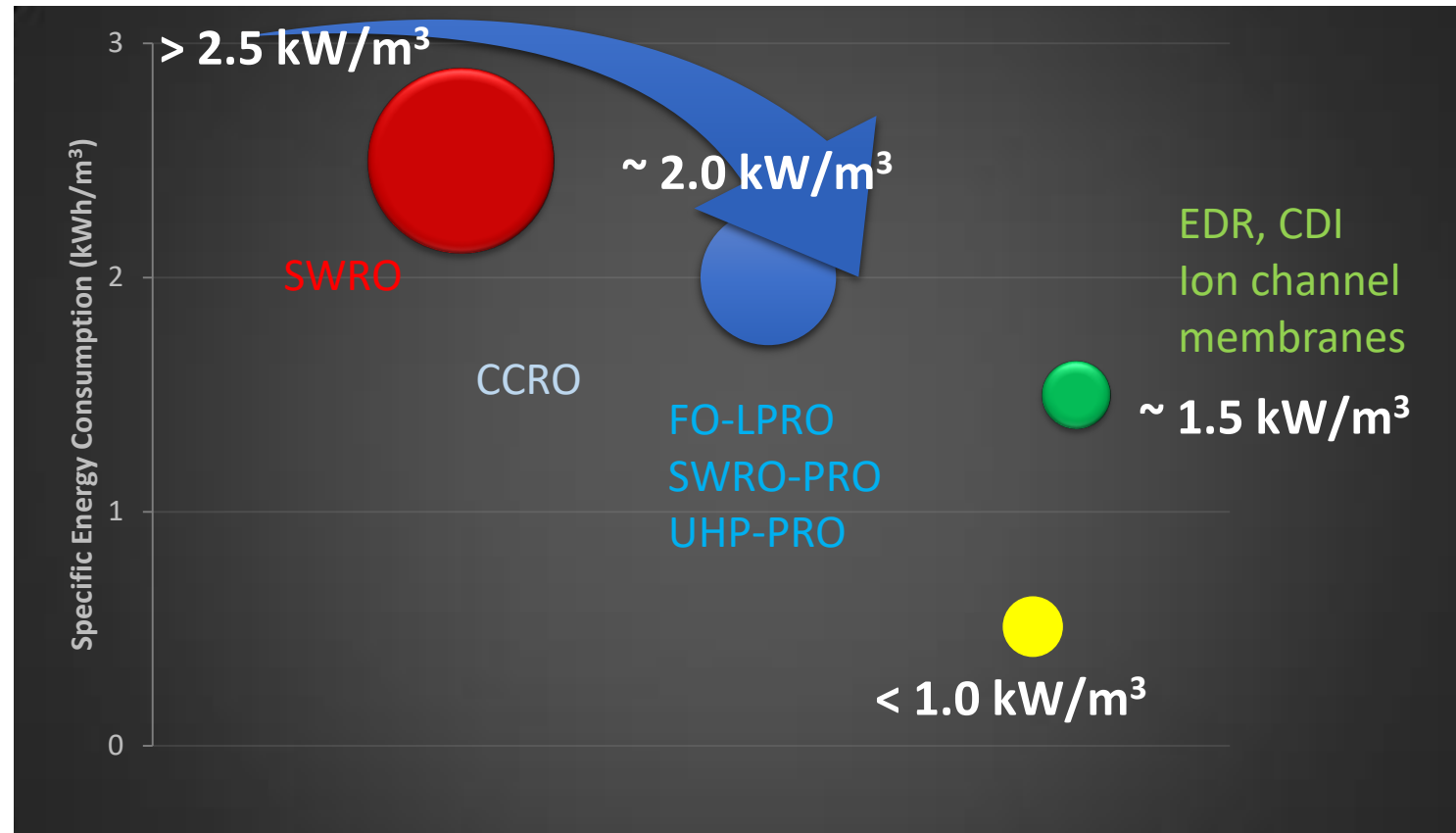
PUB, Singapore's National Water Agency (2022): Desalinated Water:
<https://www.pub.gov.sg/watersupply/fournationaltaps/desalinatedwater>

Progress in Technologies



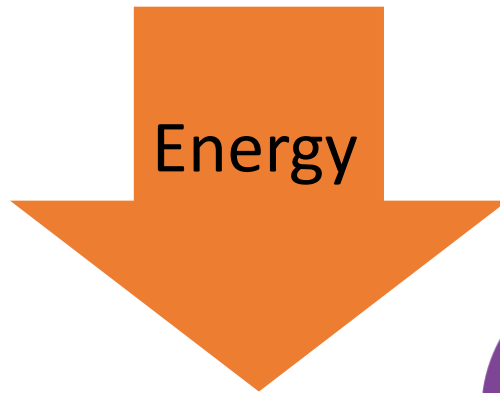
Cumulative installed worldwide desalination capacities (extracted from Villacorte et al., 2014)

Energy Demand of Current and Future Desalination Technologies



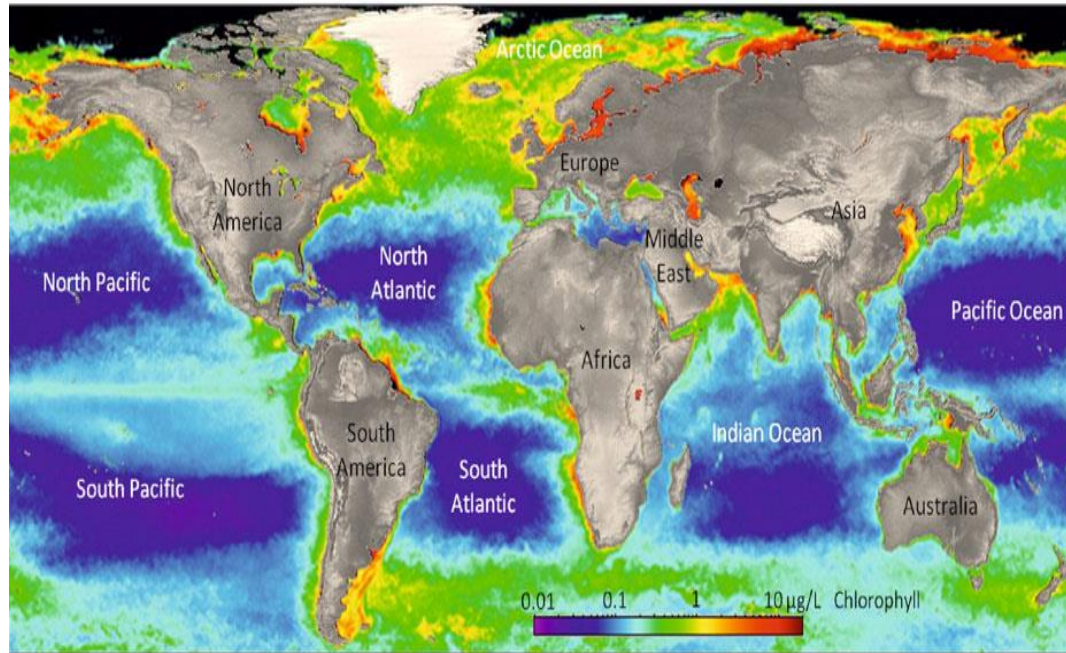
Challenges in Seawater Desalination

- More efficient pumps
- Energy recovery devices
- Development of Novel Seawater Pretreatment Technologies

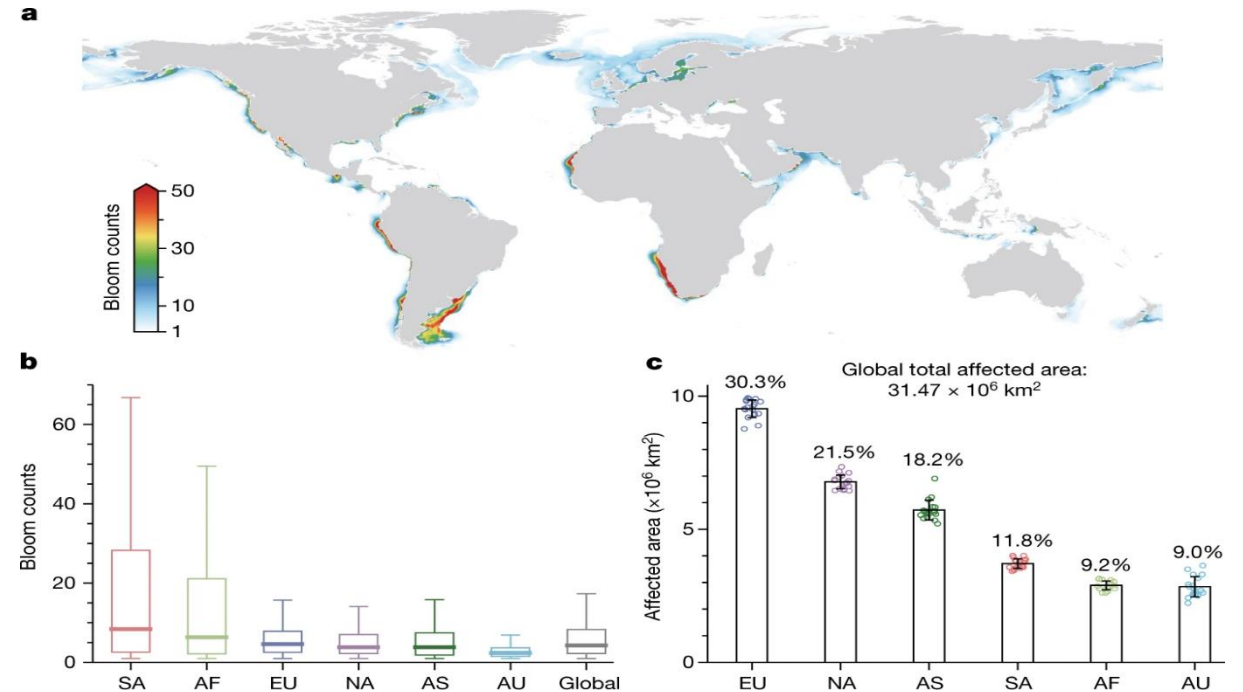


- Higher salinity
- Increasing pollutants concentrations
- Increasing events of algal bloom

Harmful algae blooms



The spatial extent and frequency of coastal harmful algal blooms (HAB) increase significantly between 2003 and 2020 (*Nature* volume 615, pages 280–284, 2023)



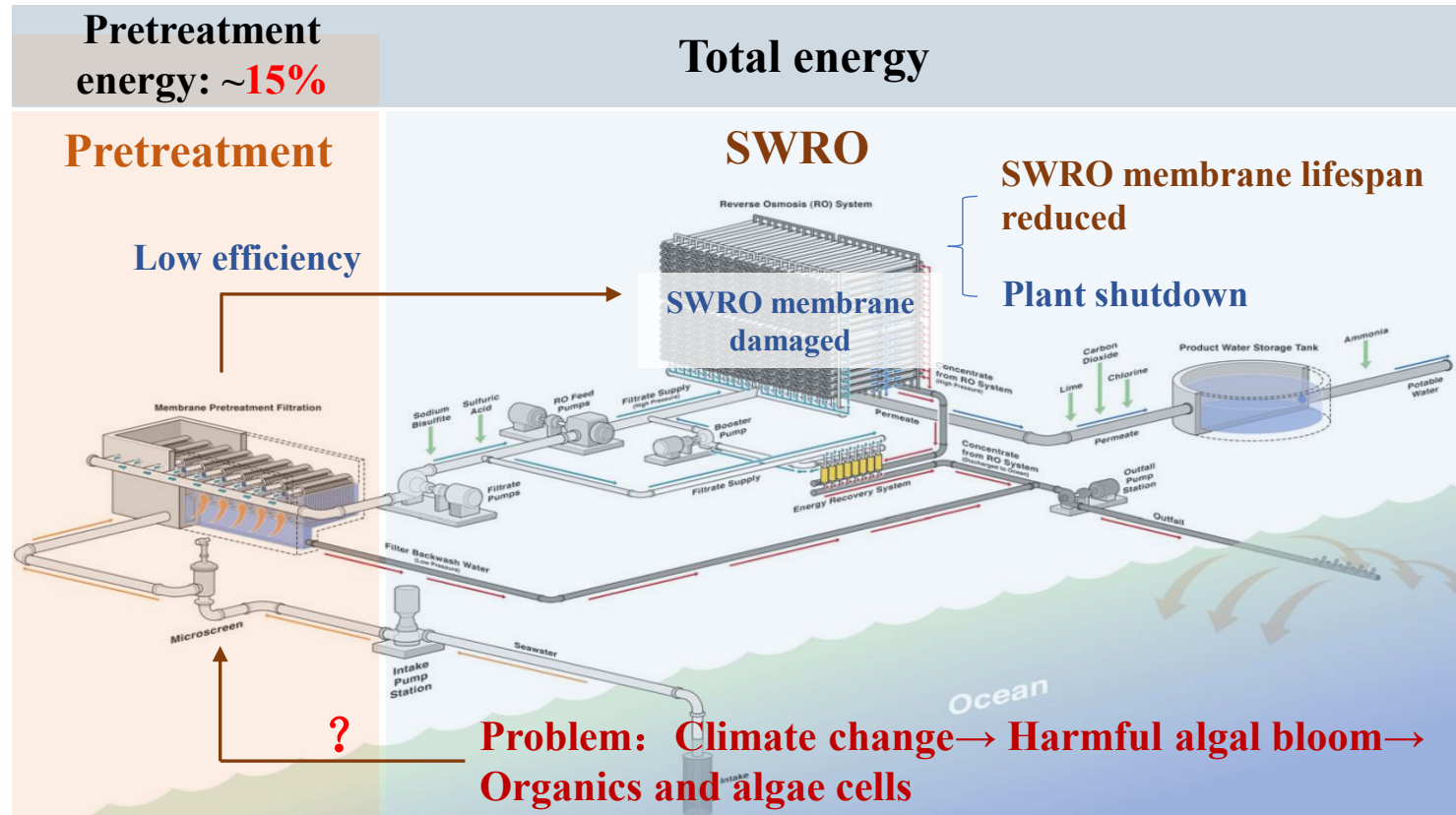
Marine harmful algae bloom (HAB) is a growing threat to desalination plants worldwide.

Conventional pretreatment for seawater desalination is challenged by harmful algae blooms

The importance of pretreatment

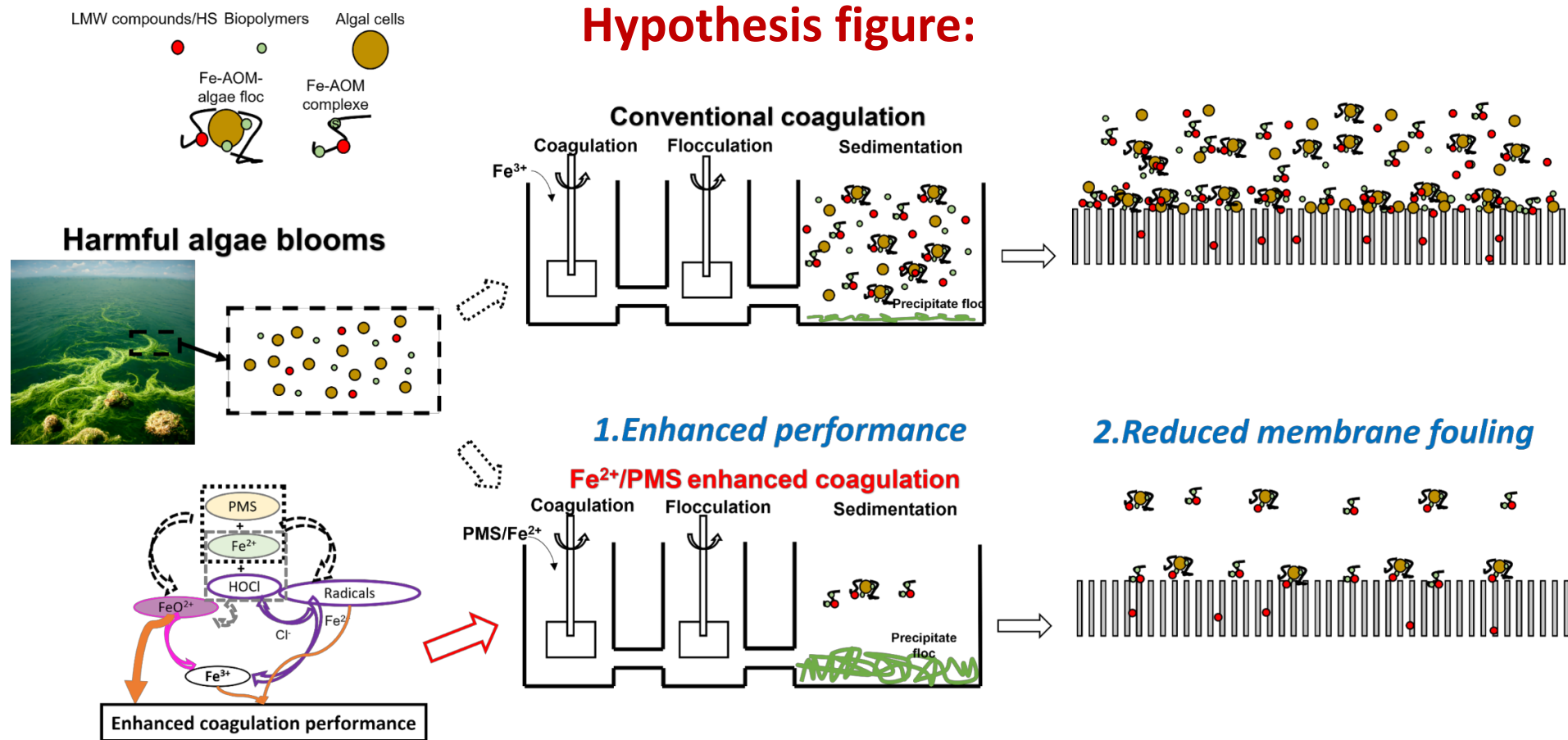
High Energy

Reduce risk of seawater desalination plants



- Conventional coagulation by using Fe^{3+} is **not efficient** due to the limited dosing range (<10ppm) for algal blooms
- Dissolved air flotation (DAF) can help to remove algae cells but not efficient for organics
- Energy consumption of DAF is **high** (0.05-0.075 kwh/m³)

Ferrous iron/peroxymonosulfate (PMS) VS Conventional coagulation



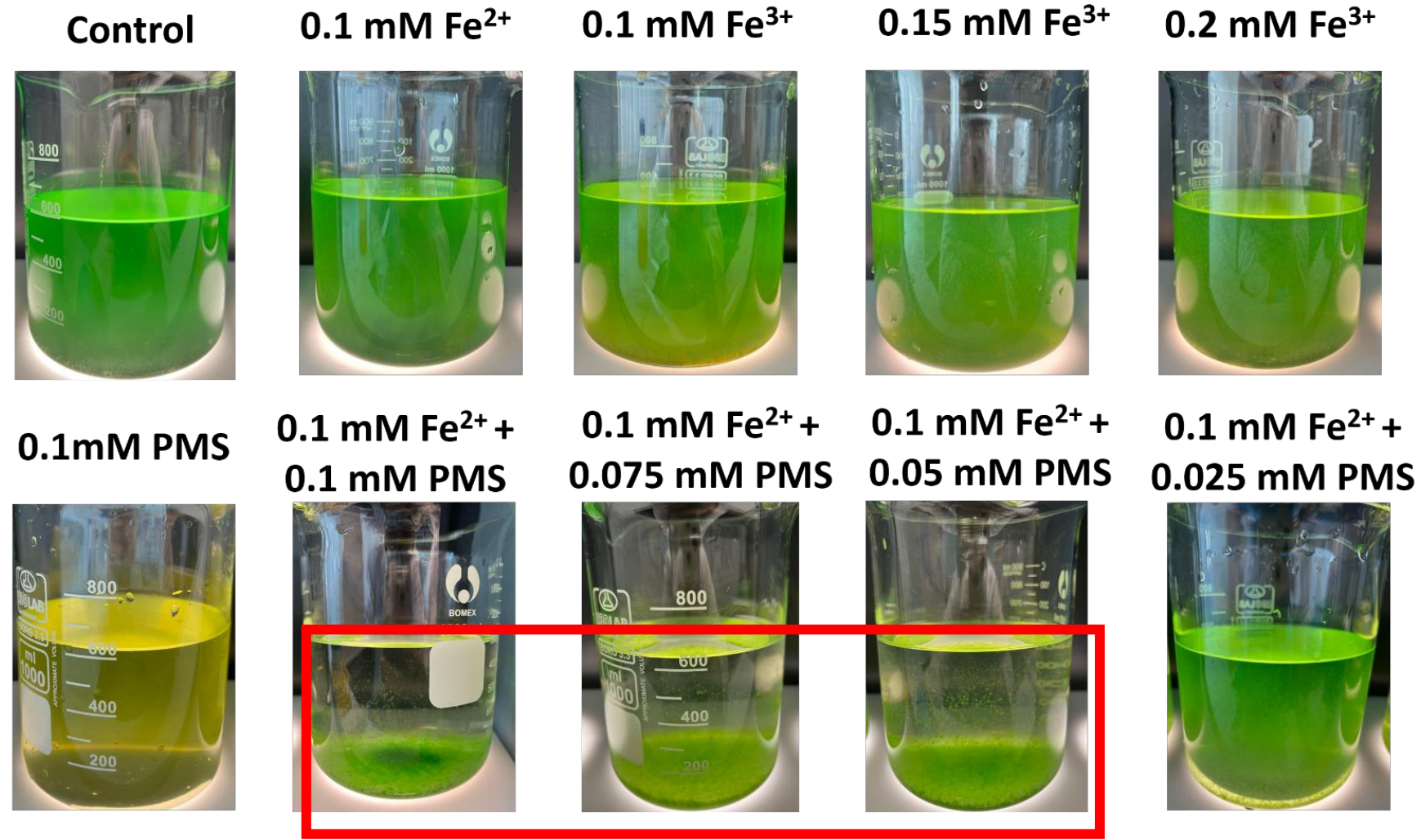
1. PMS/Fe²⁺ is promising for enhanced coagulation in river water, but no one applied PMS/Fe²⁺ into seawater
2. Oxidation process of PMS/Fe²⁺ is complex due to the presence of ~20000ppm Cl⁻ and other anions in seawater.
3. The oxidation intermediates (free radical/FeO₂⁺/Fe³⁺) have never been investigated in seawater before.

Performance and optimization of PMS/ Fe^{2+} : Appearance

Seawater with algae
density of 5×10^6 cells/ml

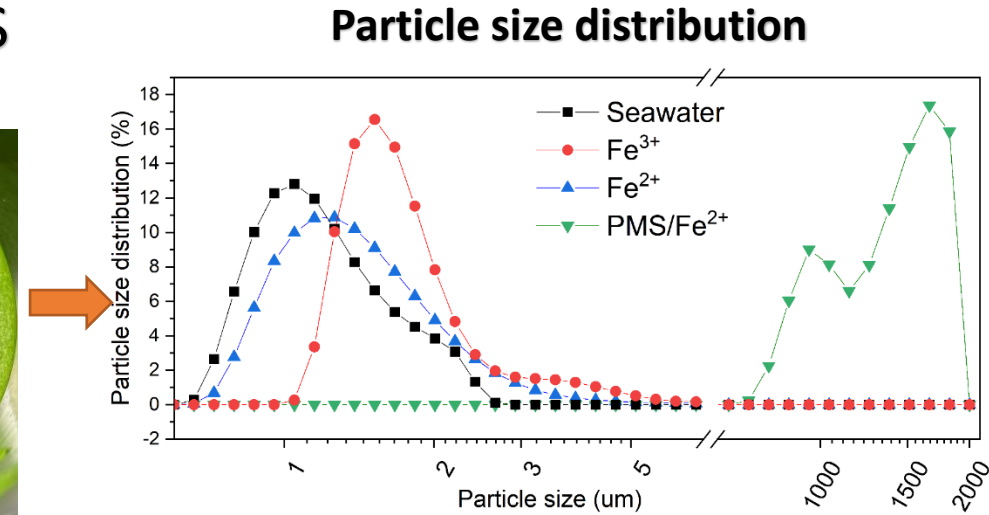
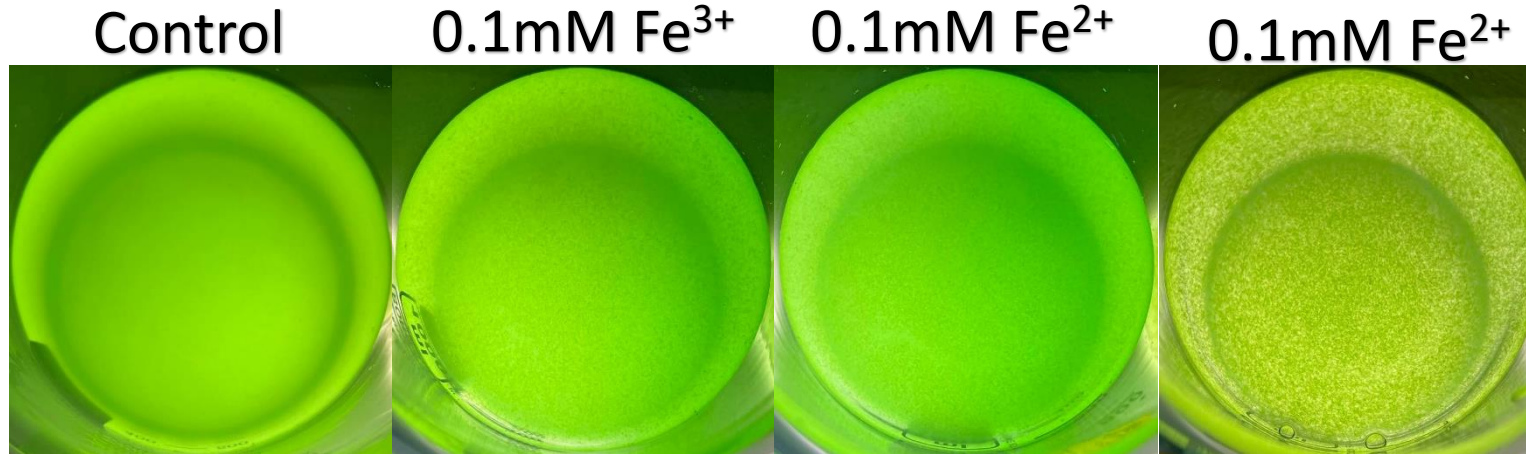


After
coagulation-
flocculation and
settlement

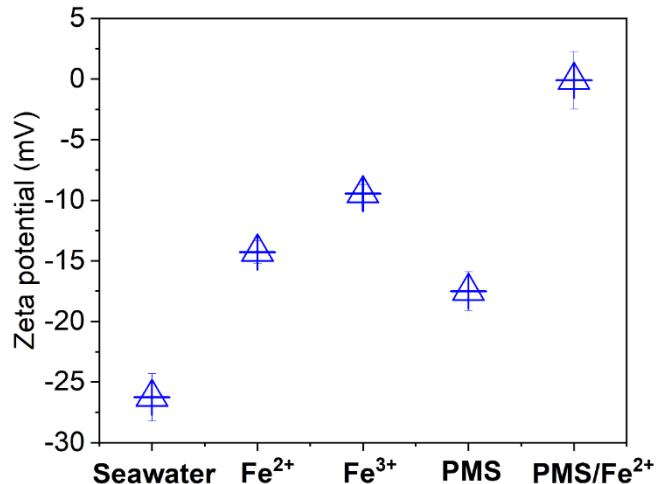


removal?

Before sedimentation



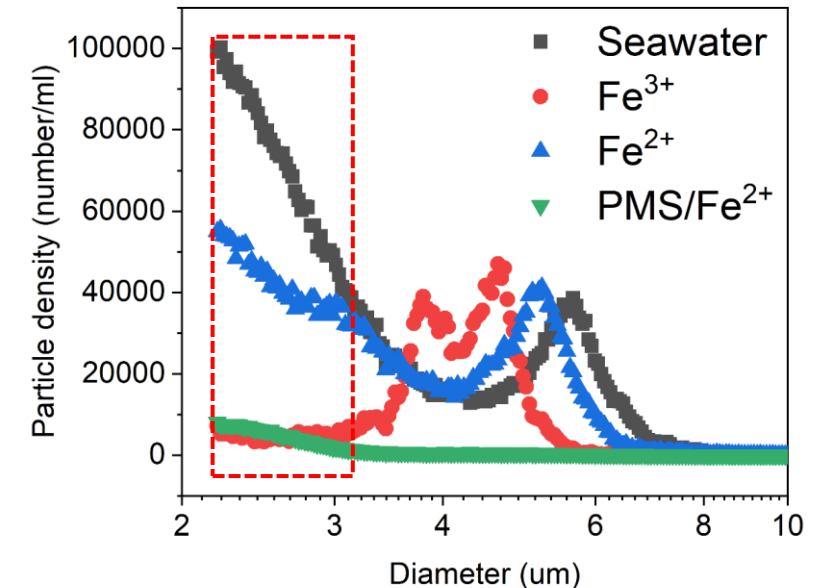
Zeta potential



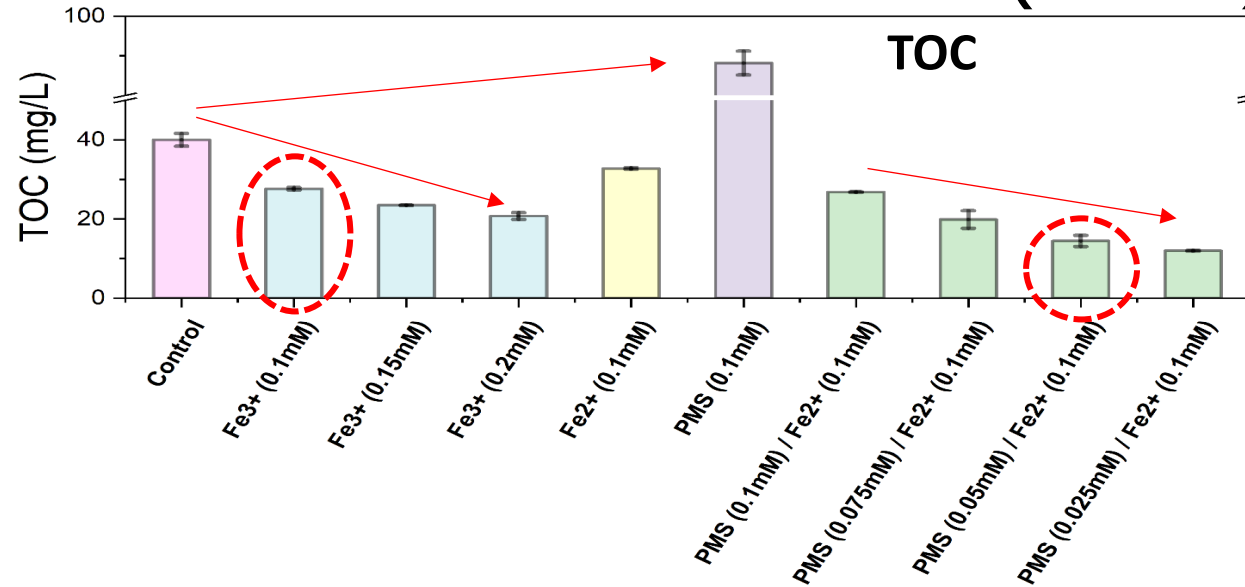
Advantages of PMS/ Fe^{2+} over conventional coagulation

- Improvement of flocculation and big flocculated particles
- High zeta potential reduction
- Lower micro-particle density after sedimentation.

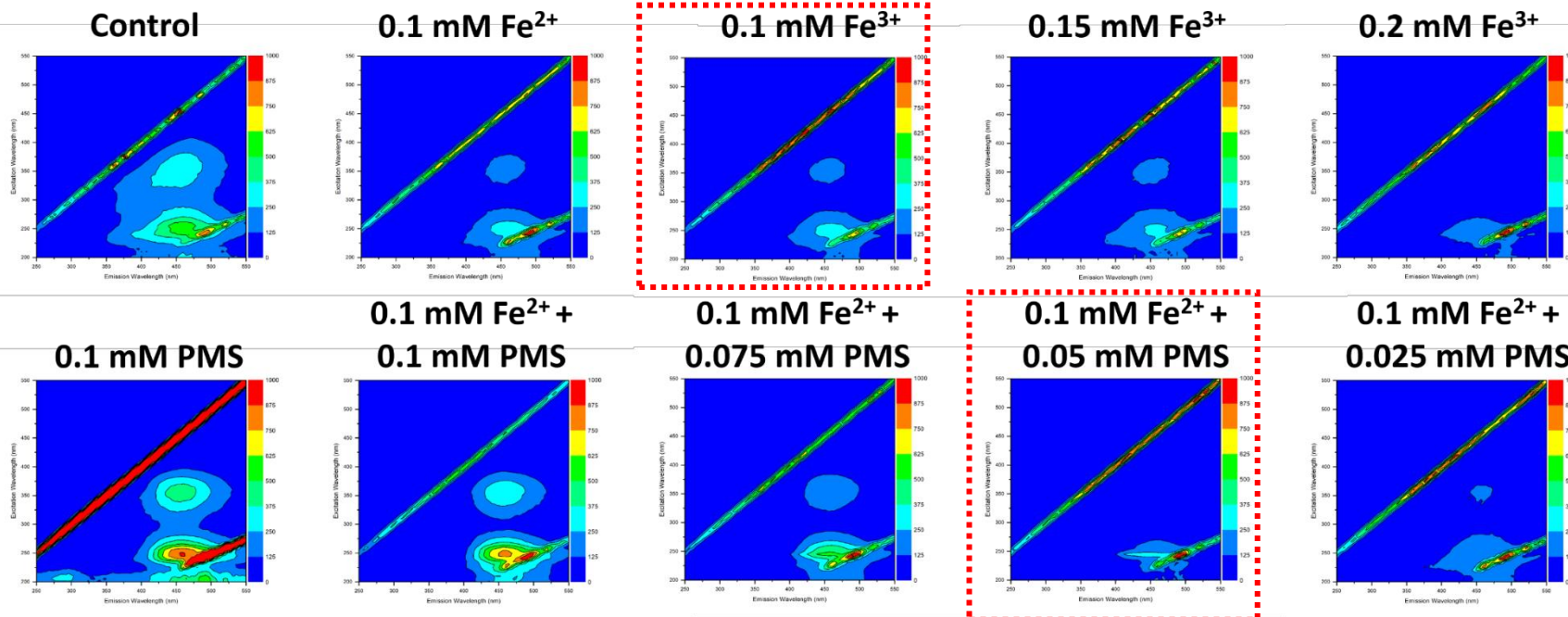
Particle density After sedimentation



Performance and optimization of PMS/Fe²⁺ : Organics (<1μm)

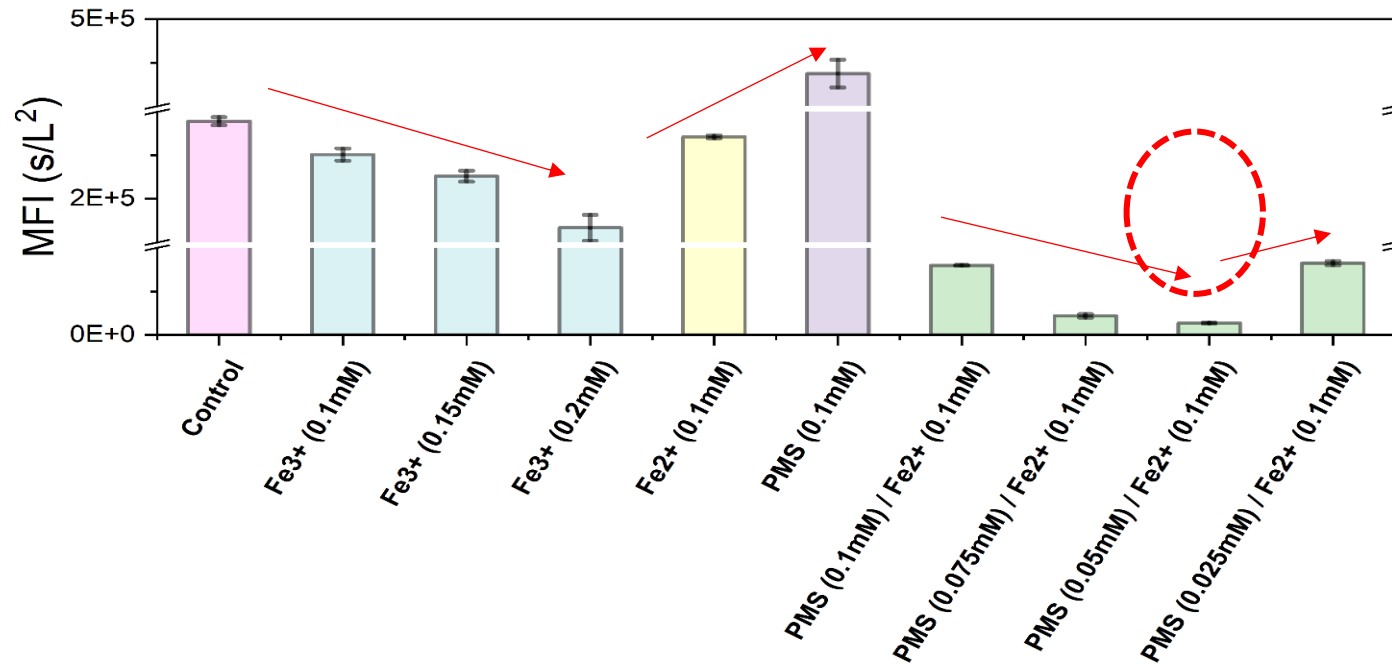


- Higher TOC removal of 0.1mM/0.1mM PMS/Fe²⁺ over 0.1mM Fe³⁺
- Lower PMS dosage of PMS/Fe²⁺ can achieve lower residual TOC.
- High PMS dosage can lead to algal cell rupture to release intracellular organic matters (IOM).



- Higher fluorescent compounds(i.e., humics substance and fulvic acids) removal of 0.1mM/0.1mM PMS/Fe²⁺ over 0.1mM Fe³⁺
- Lower PMS dosage of PMS/Fe²⁺ can achieve lower residual fluorescent compounds.

Performance and optimization of PMS/Fe²⁺ : modified fouling index (MFI)

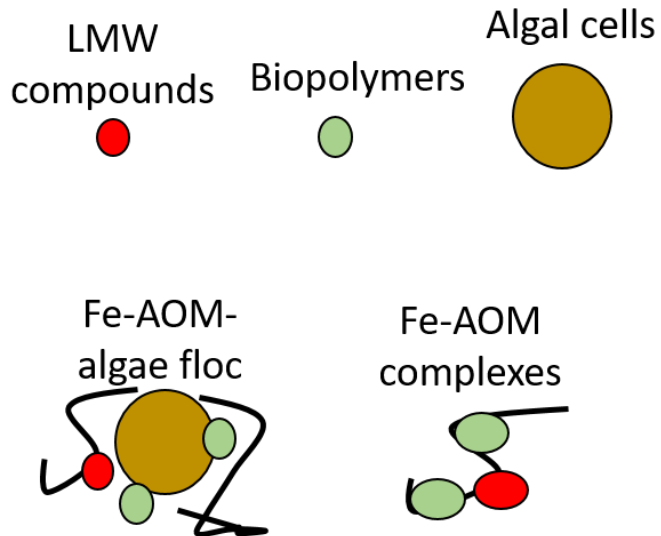


- The MFI increased with respect to the increase of PMS doses from 0.05-0.1mM. It could be attributed to the overdose of PMS to increase TOC to increase MFI
- PMS alone significantly increased MFI due to secretion of IOM.
- MFI increased with respect to the decrease of PMS doses from 0.05-0.025mM. It could be attributed to the limited dosage of PMS leading to a poor flocculation performance
- There was trade-off between particles/algal cells and organics for MFI minimization, and the optimal PMS dosage was 0.05mM for 0.1mM Fe²⁺.

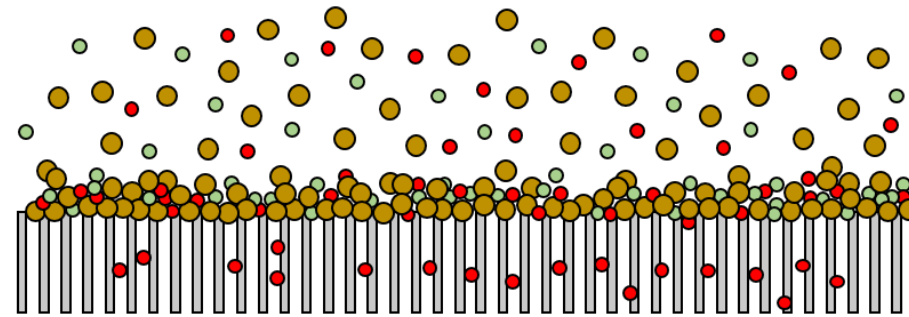


Fouling Mechanisms

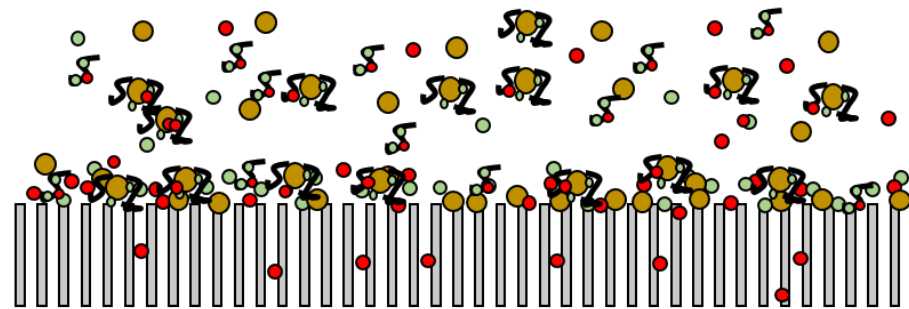
Types of foulants



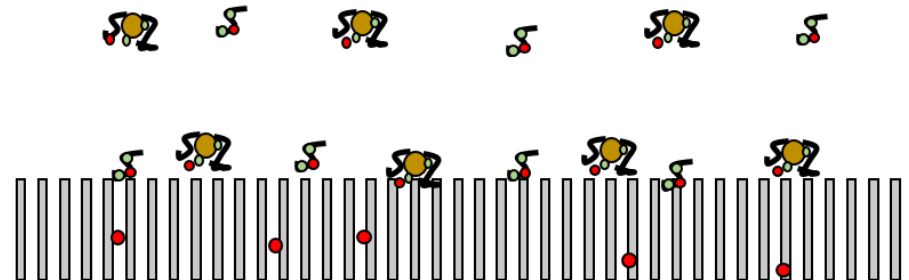
Algae-laden seawater



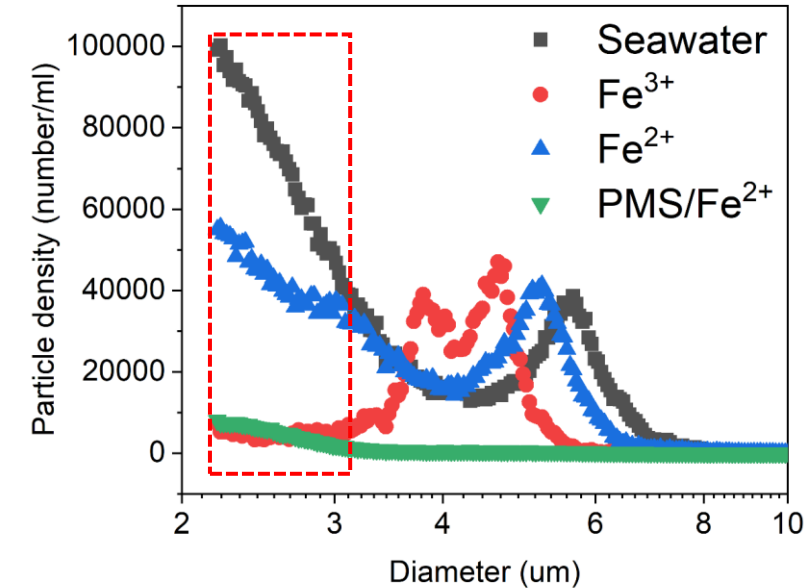
Conventional coagulation



PMS/Fe²⁺



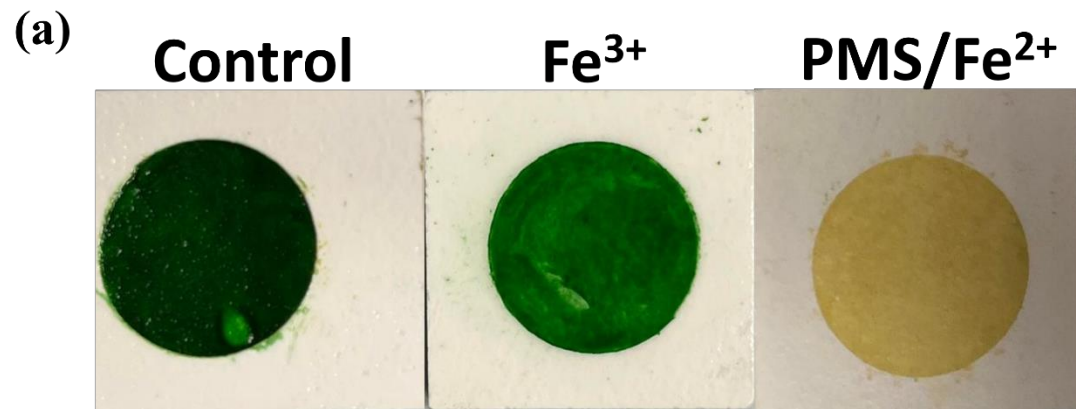
Particle density After sedimentation



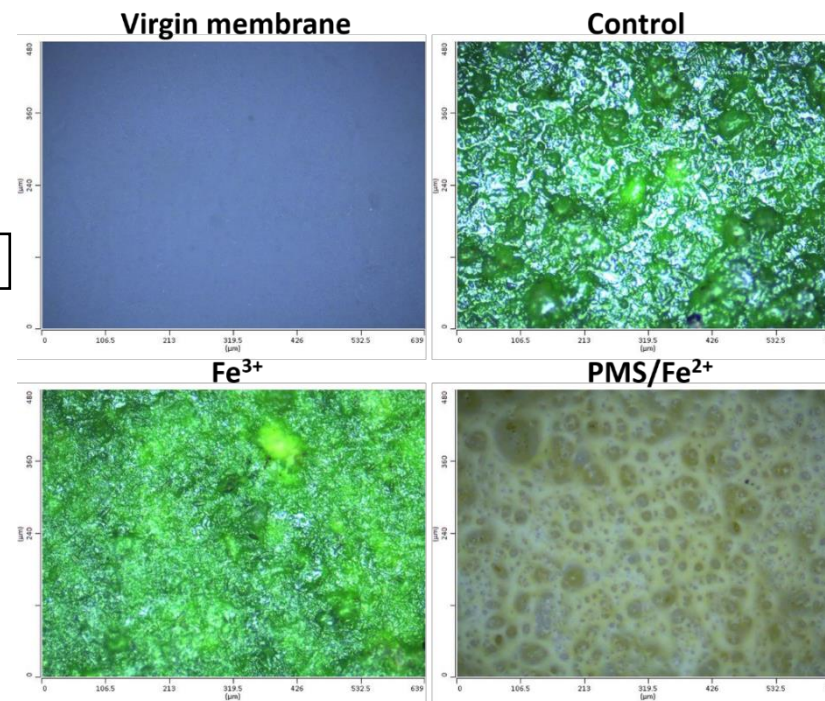
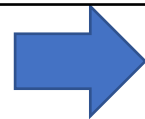
- Reduced cake layer could be attributed to the lower micro-particle density, lower residual algae and turbidity
- Low humics and low molecular weight compounds could be implicated to reduce pore blockage

Cake layer autopsy after filtration

Comparison of supernatant of control, Fe^{3+} (0.1mM), and PMS/ Fe^{2+} (0.05mM/0.1mM)

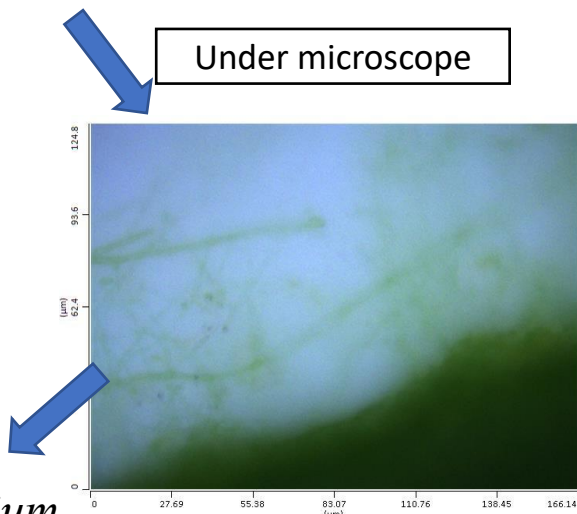


Under microscope



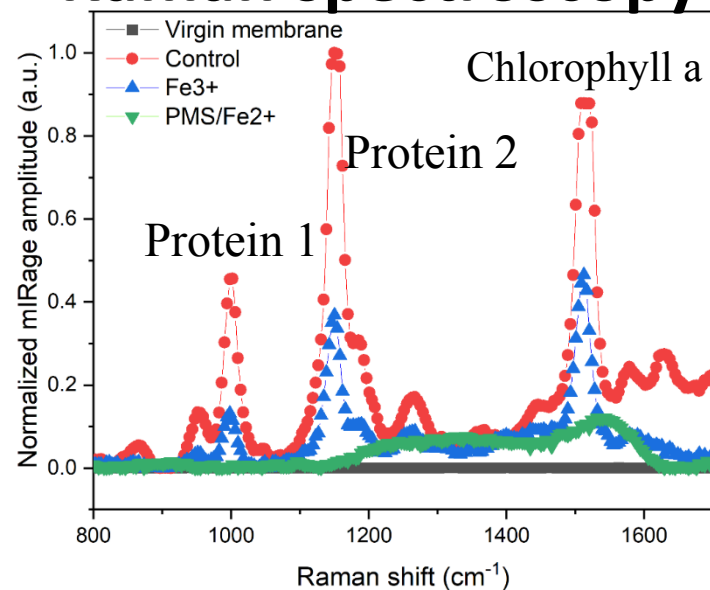
(b)

Under microscope



Phormidium

Raman spectroscopy

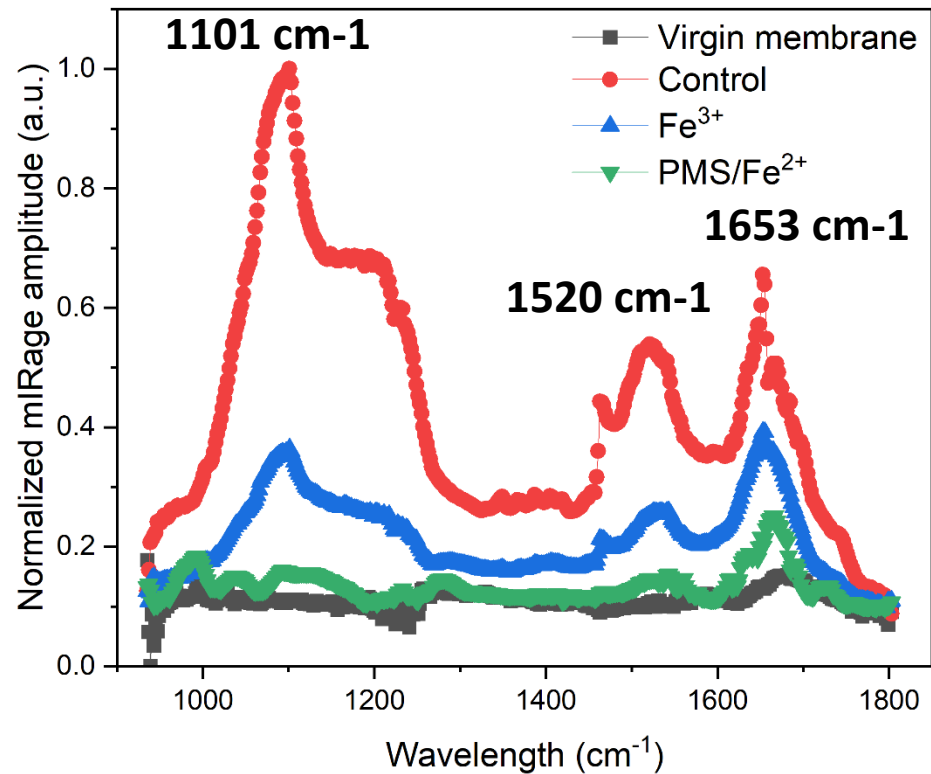


- Fouling autopsy indicate that PMS/ Fe^{2+} reduce algae cells on membrane surface such as *Phormidium*
- Raman spectroscopy indicates that PMS/ Fe^{2+} could further remove proteins and algal cells on membrane surface as compared to Fe^{3+}

Optically based photothermal method (O-PTIR) to obtain infrared spectra

- Obtain IR in the fingerprint region at a sub-micrometer spatial resolution improved the confidence of spectral interpretations of subtle spectral differences.
- PMS/Fe²⁺ mitigated complicated fouling including not only proteins but also humics acids at a sub-micro resolution as compared to that of Fe³⁺

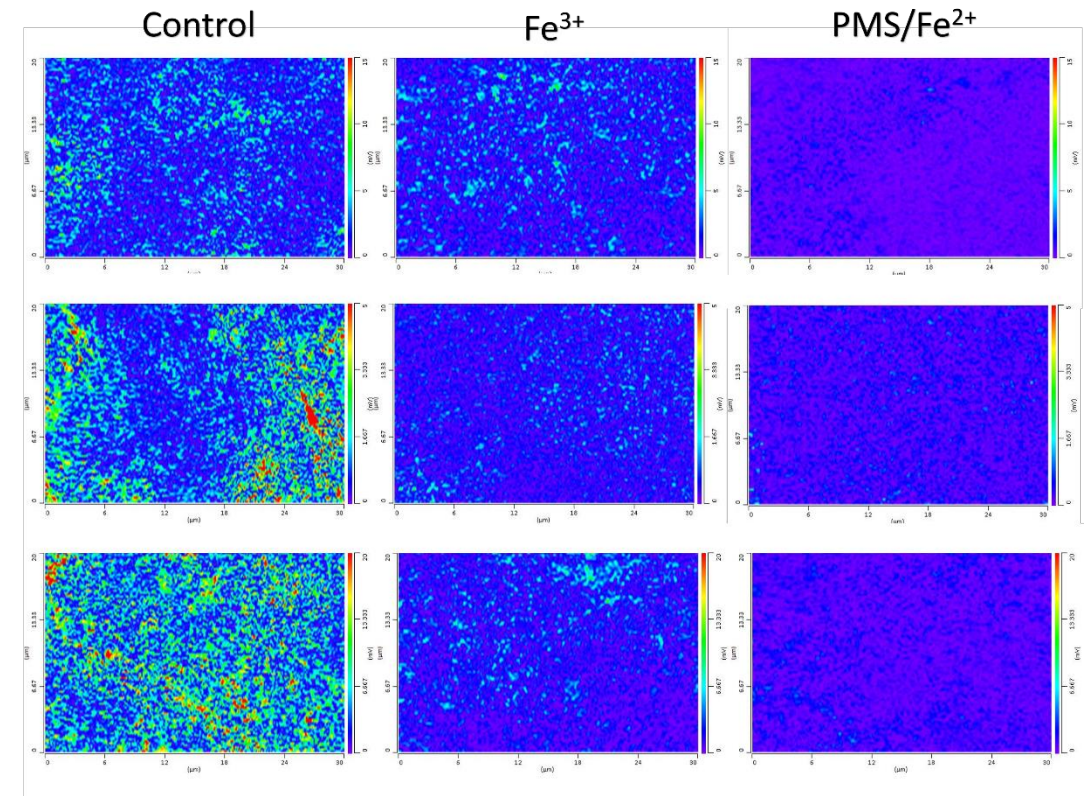
IR of fouled membrane



1101 cm⁻¹
Humics

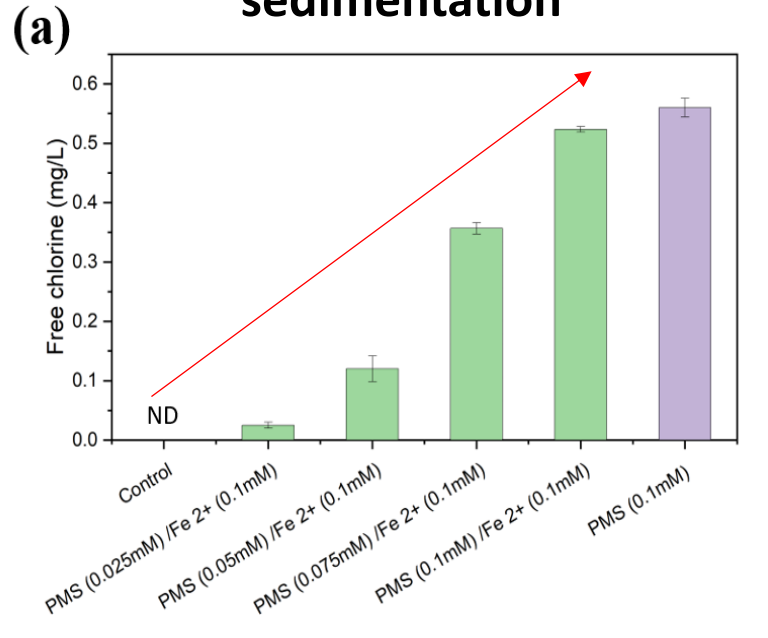
1520 cm⁻¹
Protein 1

1653 cm⁻¹
Protein 2

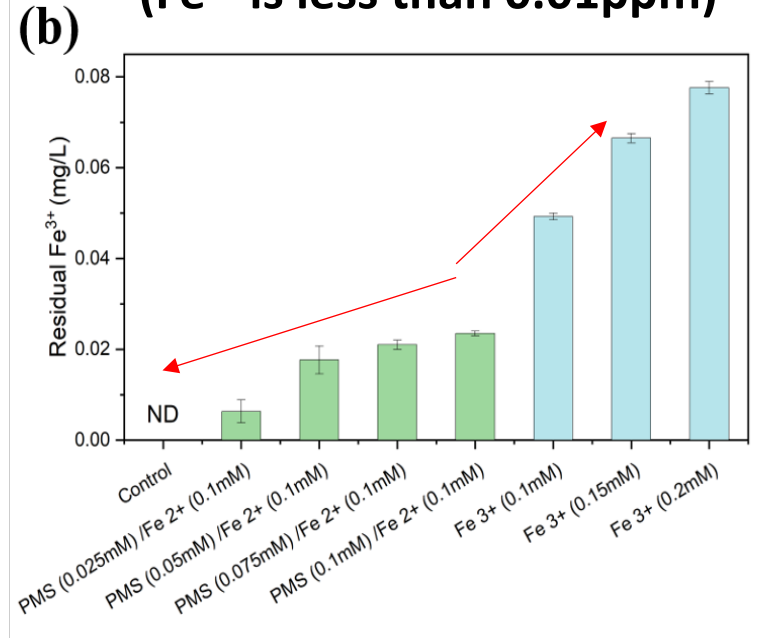


Water quality: free chlorine and dissolved Fe^{3+} in permeate

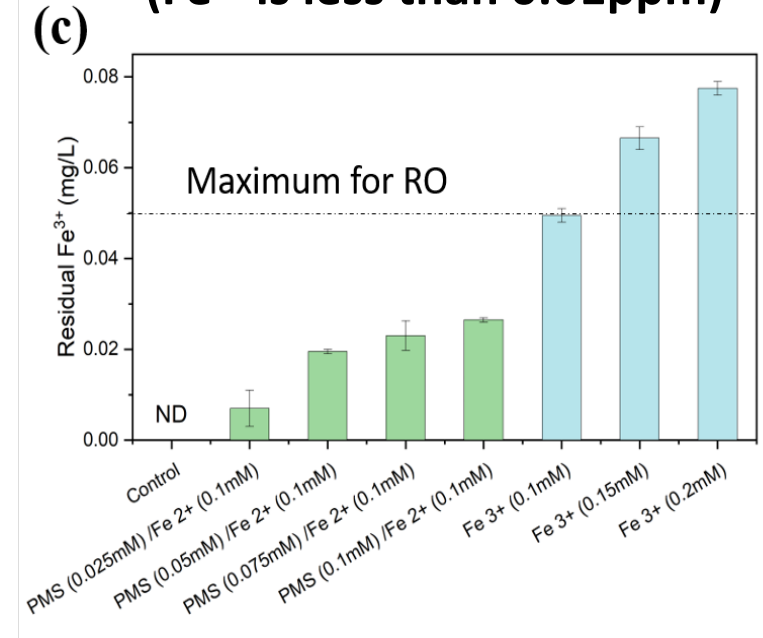
Free Cl_2 after
coagulation-flocculation-
sedimentation



Residual Fe^{3+} in supernatant
(Fe^{2+} is less than 0.01ppm)

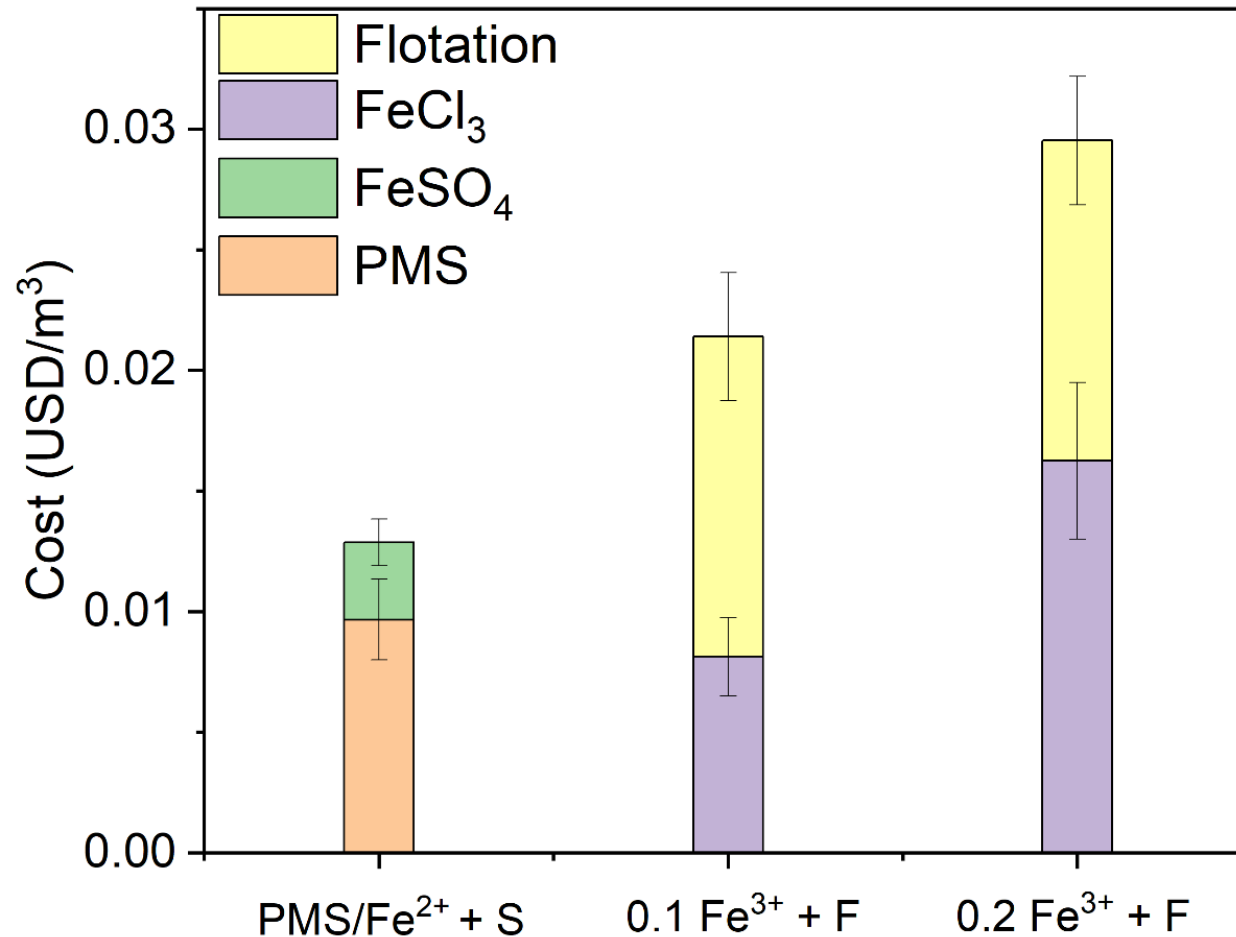


Residual Fe^{3+} after UF
(Fe^{2+} is less than 0.01ppm)



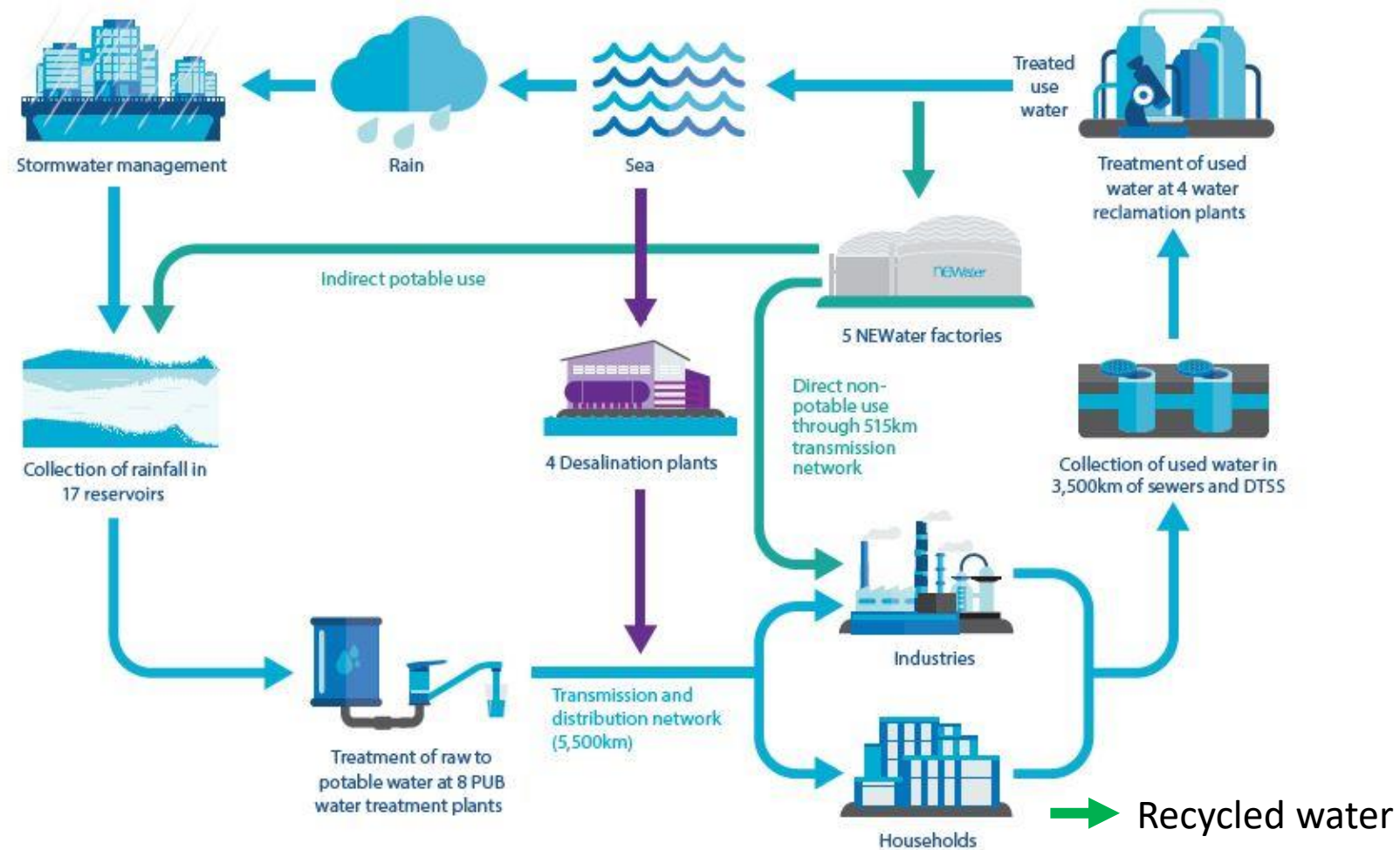
- PMS/ Fe^{2+} generated free Cl_2 and reduced the consumption of NaOCl needed for pre-disinfection.
- Although increase dose of PMS in PMS/ Fe^{2+} resulted in decrease of Fe^{3+} in supernatant and permeate, PMS/ Fe^{2+} generally had lower dissolved Fe^{3+} even at PMS dose of 0.1 mM in supernatant and permeate, as compared to conventional coagulation at all dosage from 0.1 to 0.2 mM.

Cost of desalination pretreatment scenarios of PMS/Fe²⁺ and DAF

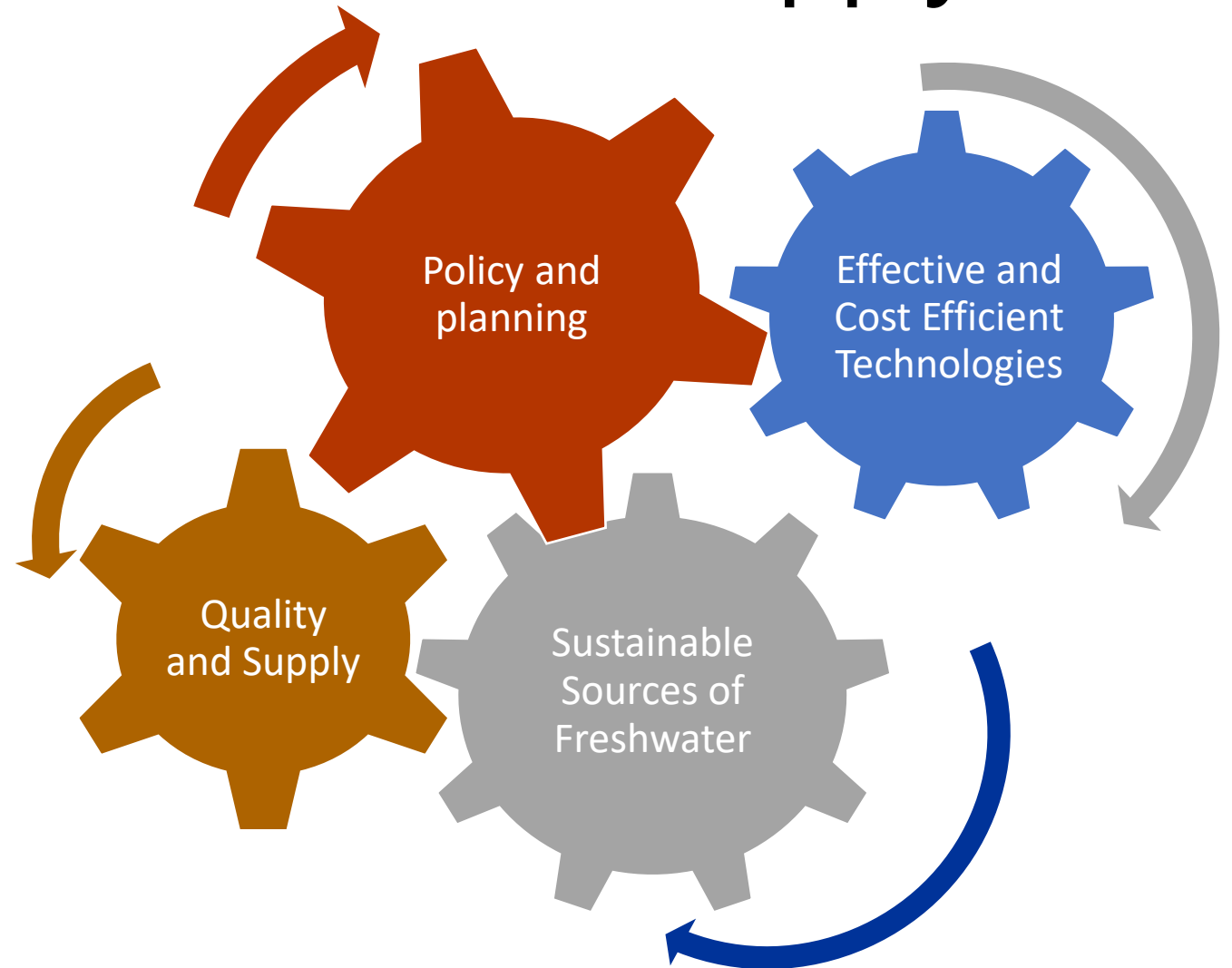


- Cost for the electricity required for the flotation take account for more than 50% for conventional DAF.
- The **overall cost of the PMS/Fe²⁺ was reduced more than 50% against conventional DAF** with double Fe dosage, at even higher coagulation performance.

Closing the Water Loop



Strategic changes and adaptation towards sustainable freshwater supply



Thank you!

謝謝聆聽!



Desalination & Water Reuse: Global Market View, Technologies & Trends

MIGUEL ANGEL SANZ

29 OCT 2025

Smart Watershed,
AI-Driven Innovation
智慧流域 AI領航
International Forum 2025

Our Blue Planet ...



Ø 3,474 km

71% of Earth Surface is Water

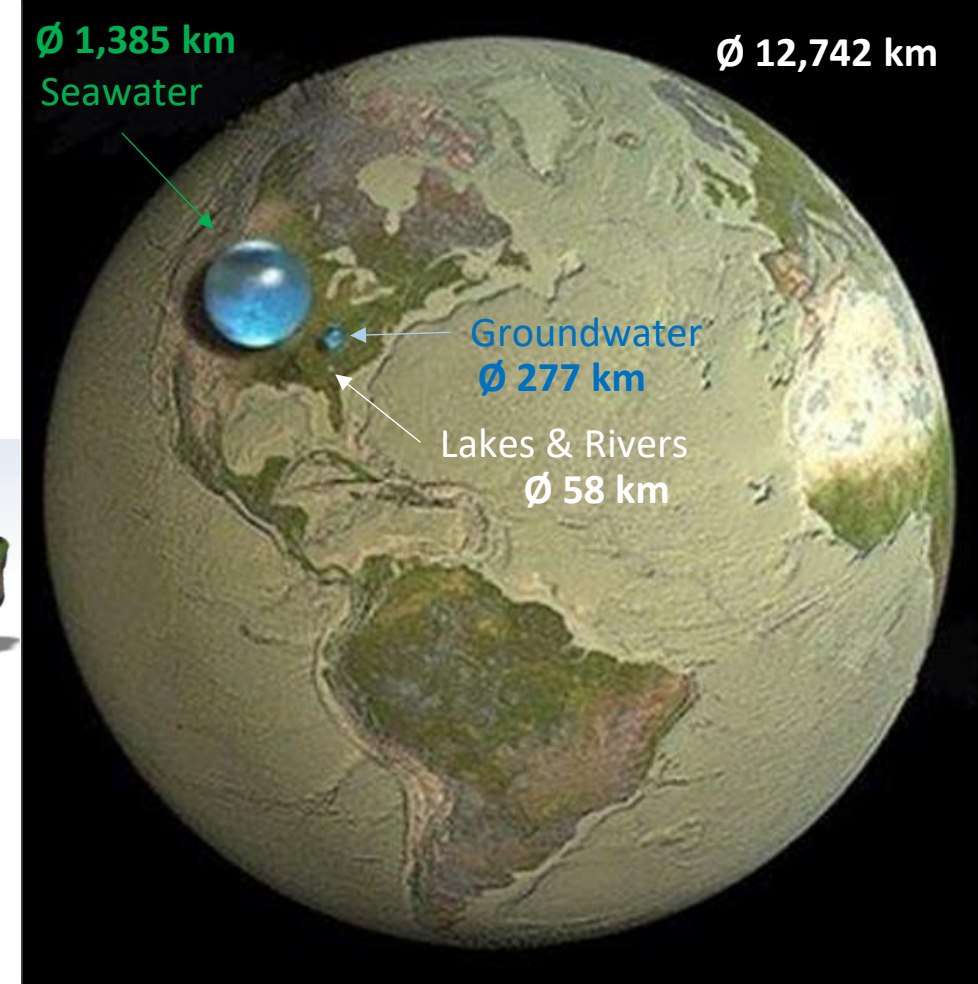
97.4% **Sea Water**
2.6% **Fresh Water**



68.6% is Frozen
30.1% is **Ground Water**
(0.783 % Earth Water)
1.3% is Surface Water

Only **21% Lakes & Rivers**
(0.0071 % Earth Water)

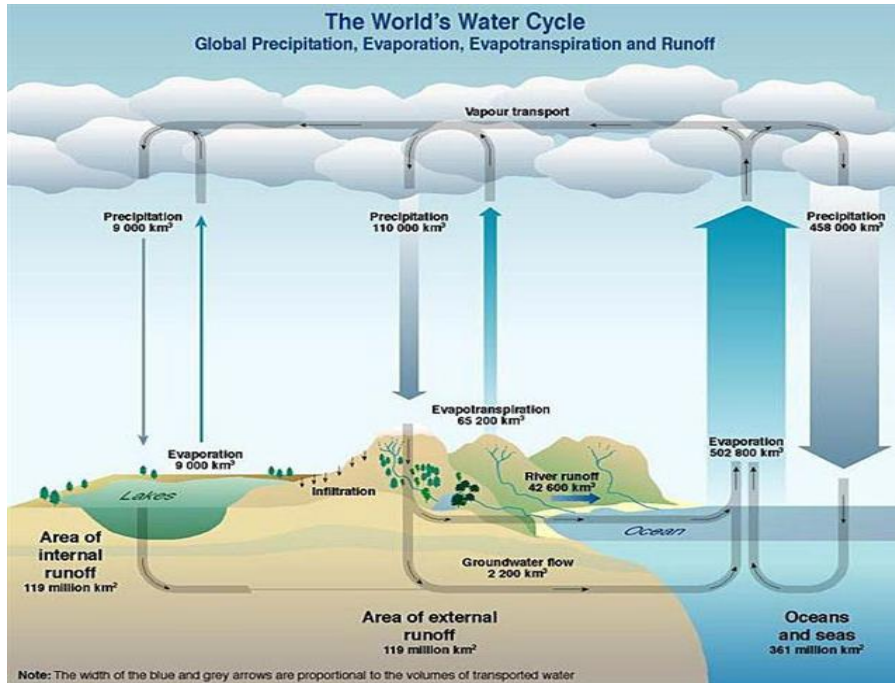
... and the Water



The same Water from the Origin.....
..... 4,500 Millions years ago

We have the responsibility to preserve these blue
“satellites” of our Blue Planet

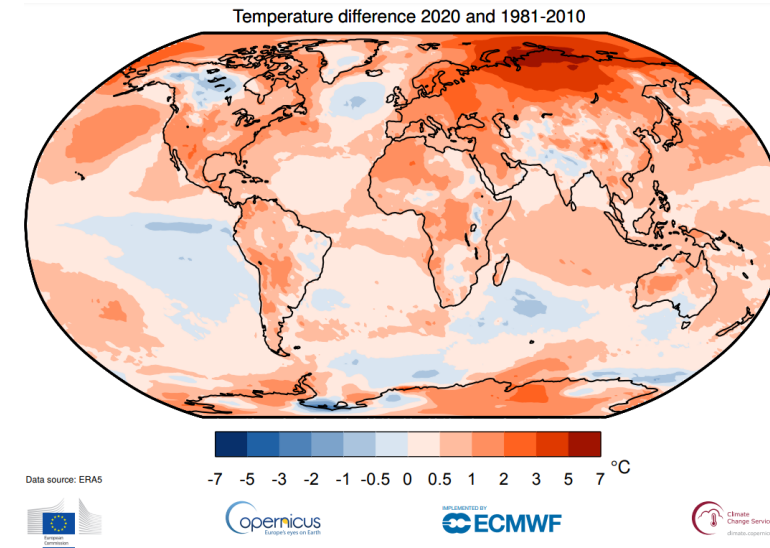
The World Water Cycle



World Water Cycle
is preserving the “Equilibrium”

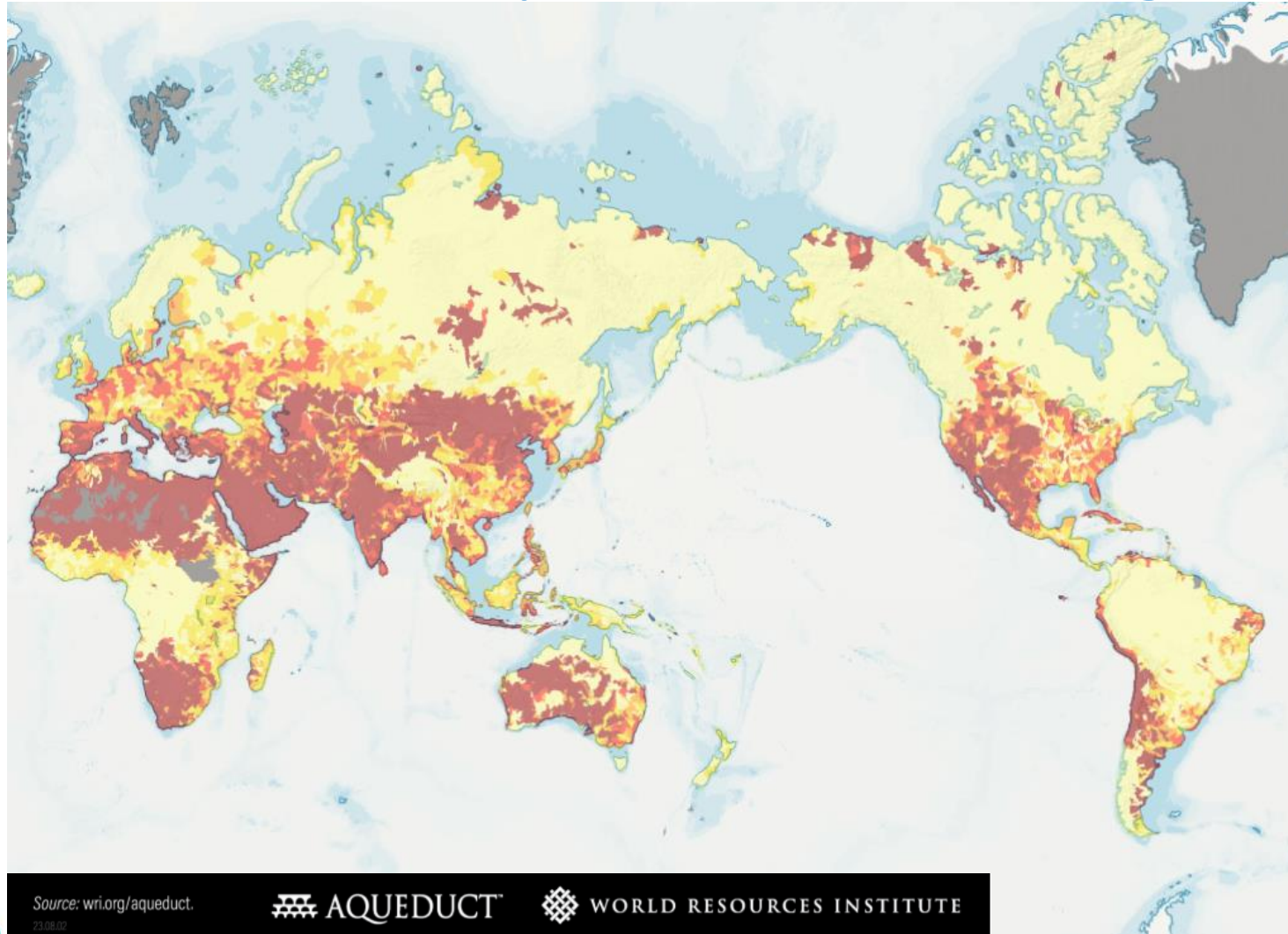
... But ...

Climate Change is impacting the Water Cycle



- Extreme Temperatures
- Longer Summer season
- Less rain and water resources
- Lower agriculture production

25% World Population faces High Water Stress



EXTREMELY HIGH BASELINE WATER STRESS

- | | | | |
|------------|-----------------|--------------------------|------------------|
| 1. Qatar | 6. Libya | 10. United Arab Emirates | 14. Pakistan |
| 2. Israel | 7. Kuwait | 11. San Marino | 15. Turkmenistan |
| 3. Lebanon | 8. Saudi Arabia | 12. Bahrain | 16. Oman |
| 4. Iran | 9. Eritrea | 13. India | 17. Botswana |
| 5. Jordan | | | |

HIGH BASELINE WATER STRESS

- | | | | |
|-------------|-----------------|------------------|--------------|
| 18. Chile | 25. Uzbekistan | 32. Turkey | 39. Niger |
| 19. Cyprus | 26. Greece | 33. Albania | 40. Nepal |
| 20. Yemen | 27. Afghanistan | 34. Armenia | 41. Portugal |
| 21. Andorra | 28. Spain | 35. Burkina Faso | 42. Iraq |
| 22. Morocco | 29. Algeria | 36. Djibouti | 43. Egypt |
| 23. Belgium | 30. Tunisia | 37. Namibia | 44. Italy |
| 24. Mexico | 31. Syria | 38. Kyrgyzstan | |

MEDIUM-HIGH BASELINE WATER STRESS

- | | | | |
|------------------|-----------------|----------------|---------------|
| 45. Thailand | 51. Tajikistan | 57. Guatemala | 63. Lesotho |
| 46. Azerbaijan | 52. Macedonia | 58. Estonia | 64. Denmark |
| 47. Sudan | 53. South Korea | 59. France | 65. Indonesia |
| 48. South Africa | 54. Bulgaria | 60. Kazakhstan | 66. Peru |
| 49. Luxembourg | 55. Mongolia | 61. Mauritania | 67. Venezuela |
| 50. Australia | 56. China | 62. Germany | 68. Cuba |

LOW-MEDIUM BASELINE WATER STRESS

- | | | | |
|------------------------|-----------------|--------------------|----------------------------|
| 69. North Korea | 77. Sri Lanka | 85. Ukraine | 93. Czech Republic |
| 70. Romania | 78. El Salvador | 86. Poland | 94. Russia |
| 71. United States | 79. Tanzania | 87. Chad | 95. Bolivia |
| 72. Zimbabwe | 80. Netherlands | 88. Senegal | 96. Ethiopia |
| 73. Dominican Republic | 81. Ecuador | 89. United Kingdom | 97. Bosnia and Herzegovina |
| 74. Haiti | 82. Lithuania | 90. Georgia | 98. Swaziland |
| 75. Japan | 83. Philippines | 91. Nigeria | 99. Moldova |
| 76. Angola | 84. South Sudan | 92. Argentina | 100. Somalia |

LOW BASELINE WATER STRESS

Overall Water Risk



■ No data

Desalination & Water Reuse are key tools



Desalination and **Water Reuse** can help to solve Water Scarcity bringing new resources and preserving natural resources.

Key Tools for IWM Decision Makers

IWM: Integrated Water Management

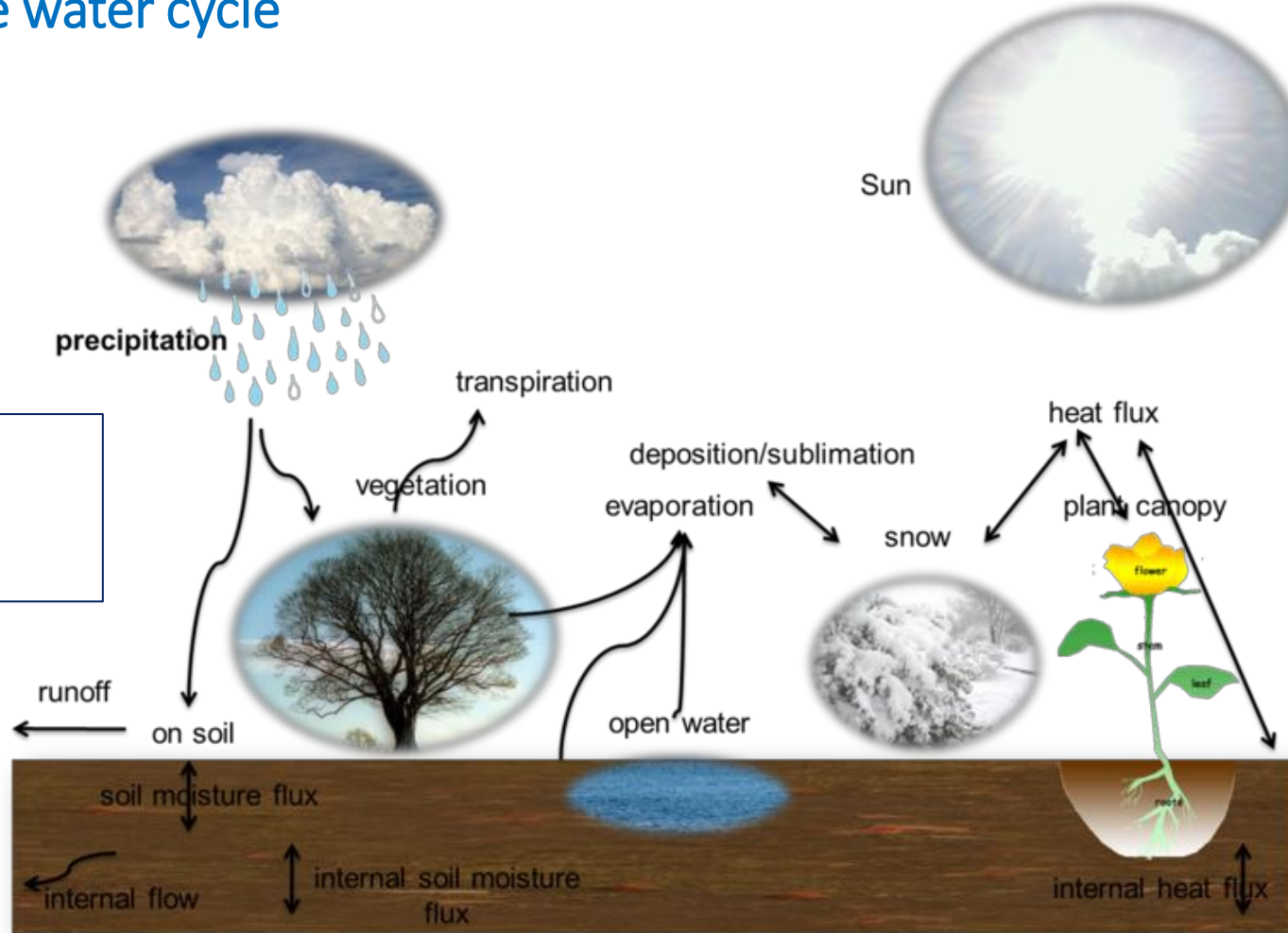
- **Desalination Technologies**
- Global Desalination Overview
- Desalination in World Regions
- Key Subjects in Desalination and Trends
- Water Reuse & Forecast

**Smart Watershed,
AI-Driven Innovation**
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Desalination: A Natural Process Used Every Day

the basis of the water cycle

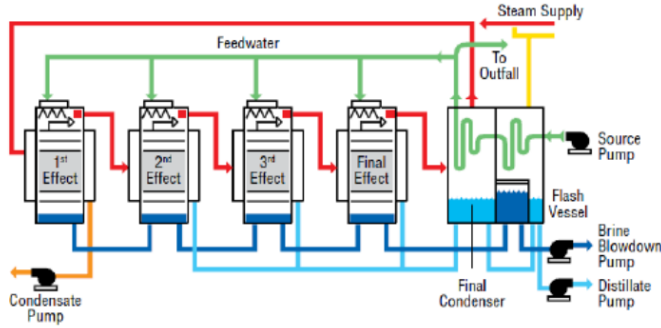
**Evaporation +
Condensation**



**Natural
Direct
Osmosis**

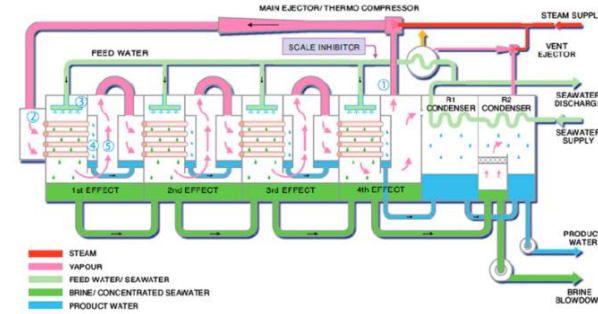
Desalination Thermal Technologies: MSF & MED

Multi Stage Flash distillation (MSF)



MSF Desalination Plants- Jebel Ali
Dubai - UAE

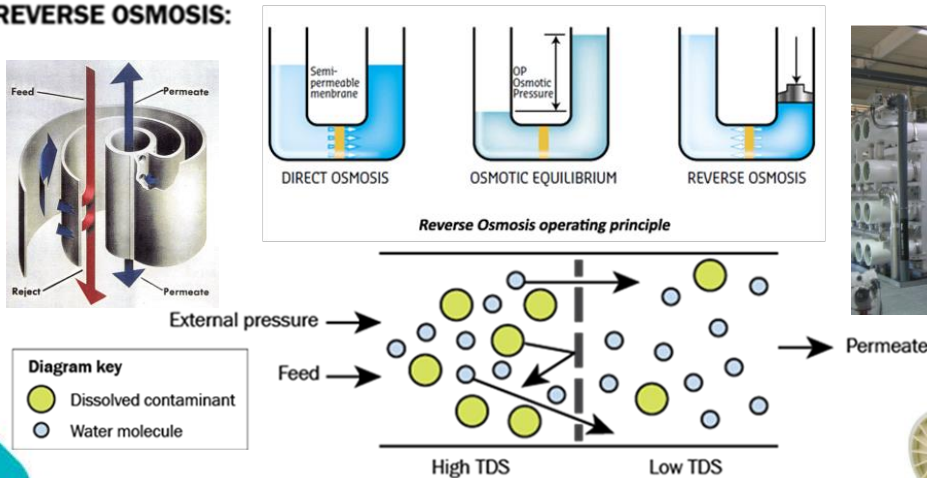
Multi Effect Distillation (MED)



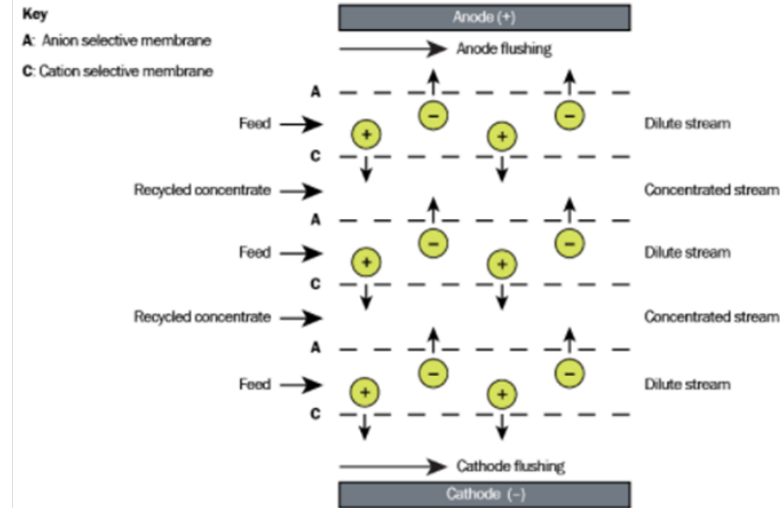
MED Desalination Plants-
Al Jubail - KSA

Desalination Membrane Technologies: RO & EDR

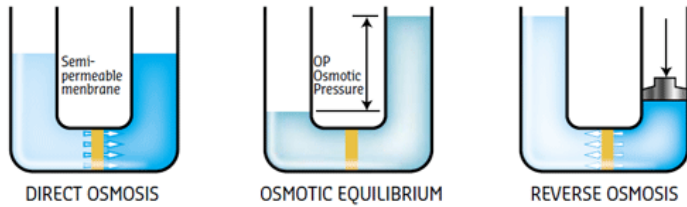
REVERSE OSMOSIS:



Electrodialysis reversal (EDR)

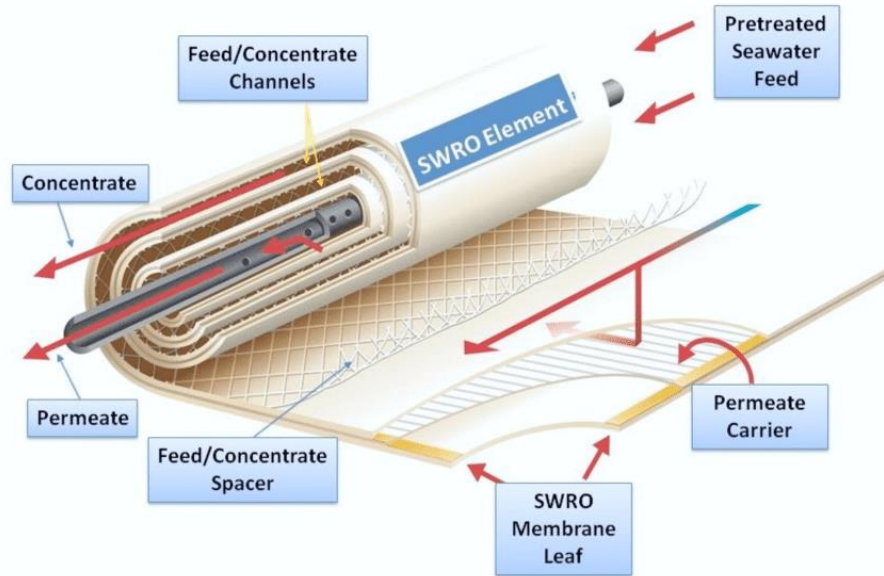
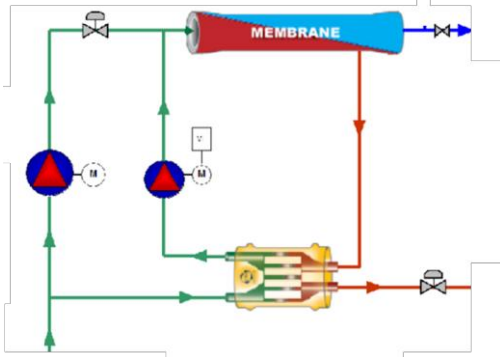


Reverse Osmosis Membranes



Reverse Osmosis operating principle

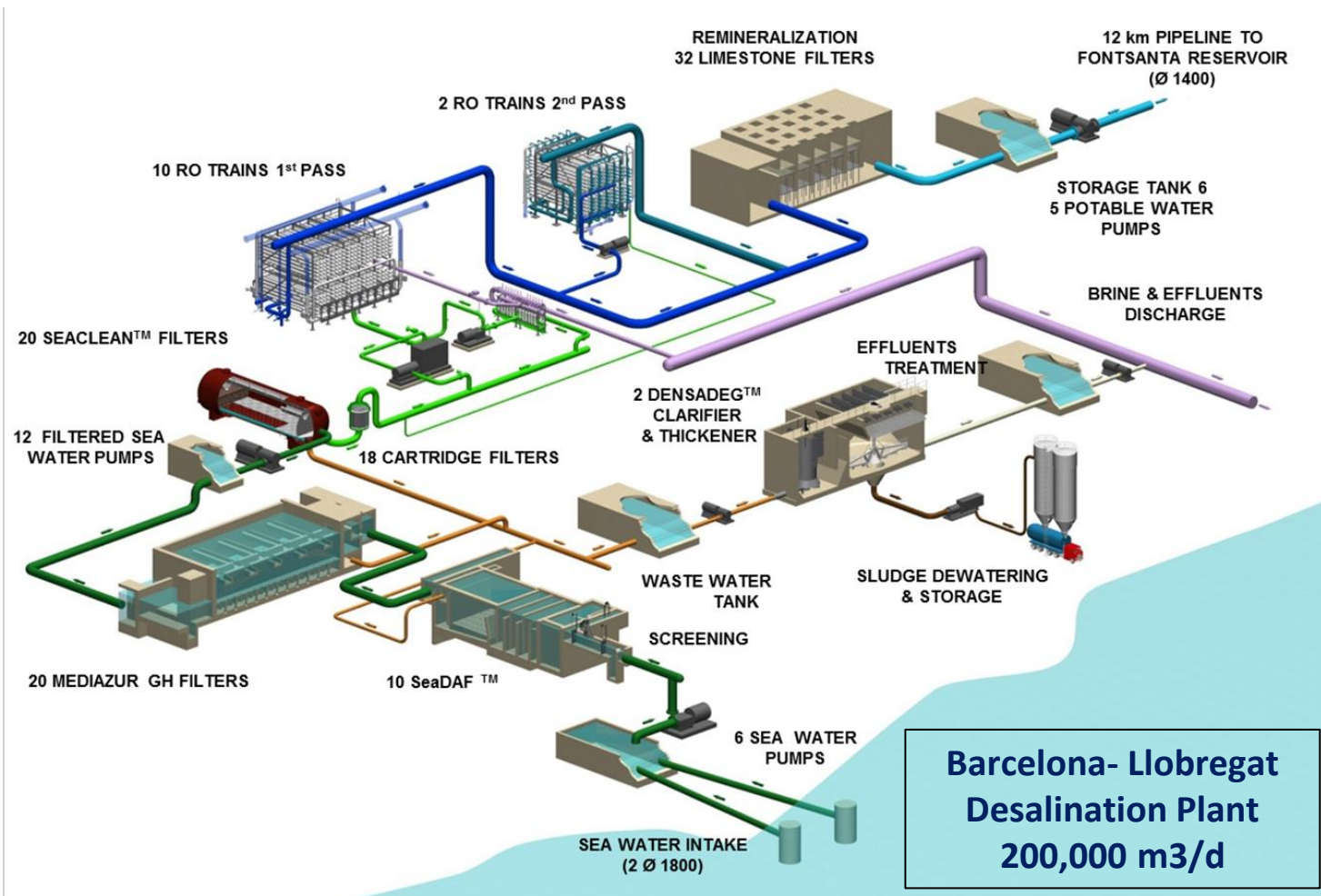
SW High Pressure Pumps (55 to 70 bar)
Energy Recovery Devices



Usually 4, 6, 7 or 8
Membranes
Per Pressure vessel (PV)



SW Reverse Osmosis Plant: Treatment Line



SWRO Treatment Line:

- SW Intake & Pumping
- Screening
- Pre-Treatment Steps (1, 2 or 3)
- Cartridge Filters
- HP Pump and Energy Recovery
- Reverse Osmosis Trains (1 or 2 passes)
- Post-Treatment
- Storage and Pumping
- Effluent & Sludge Treatment
- Concentrate Discharge

Barcelona- Llobregat
Desalination Plant
200,000 m³/d

Reverse Osmosis is the Technology with lower Energy Consumption in Seawater Desalination

SPECIFIC ENERGY CONSUMPTION BY DESALINATION TECHNOLOGY	MSF	MED	SWRO
Electrical Energy SEC (kW.h/m ³)	4,0 – 6,0	1,5 - 2,5	2,5 - 4,0 (*)
Thermal Energy SHC (kW.h/m ³)	9,5 - 19,5	5,0 - 8,5	0
Steam extraction pressure (bar abs)	2,5 - 2,2	0,35 - 0,5	NA
<u>Total equivalent SEC (kW.h/m³)</u>	<u>13,5 - 25,5</u>	<u>6.5 - 11,0</u>	<u>2,5 - 4,0 (*)</u>
(*) depending on Seawater TDS			

Energy Consumption in SWRO has been drastically reduced in the in the last decades

Energy Consumption has been the **driver** of Desalination Development

- Desalination Technologies
- **Global Desalination Overview**
- Desalination in World Regions
- Key Subjects in Desalination and Trends
- Water Reuse & Forecast

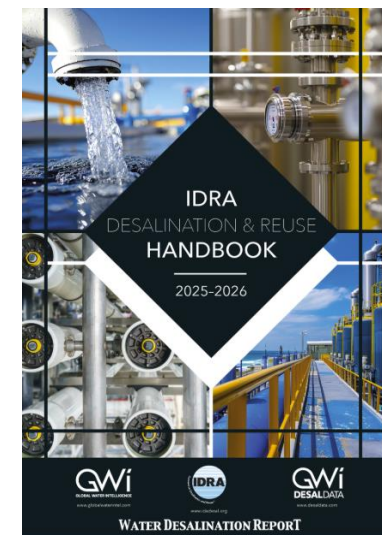
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2025 Desalination Inventory

19,200 Plants – 142 Million m³/day (Constr. + Operation)

Plants	Desalination Plants 37th Inventory (Sept 2025)	Capacity - m ³ /day
23.031	Total Plants	151.465.344
3.843	Off Line	9.434.333
18.782	In Operation	118.614.372
406	Under Construction	23.416.639
19.188	Under Construction + Operation	142.031.011

Plants	Seawater Desalination Plants 37th Inventory (Sept 2025)	Capacity - m ³ /day
7.179	Total Plants	94.775.713
920	Off Line	5.757.892
6.033	In Operation	67.716.927
226	Under Construction	21.300.894
6.259	Under Construction + Operation	89.017.821



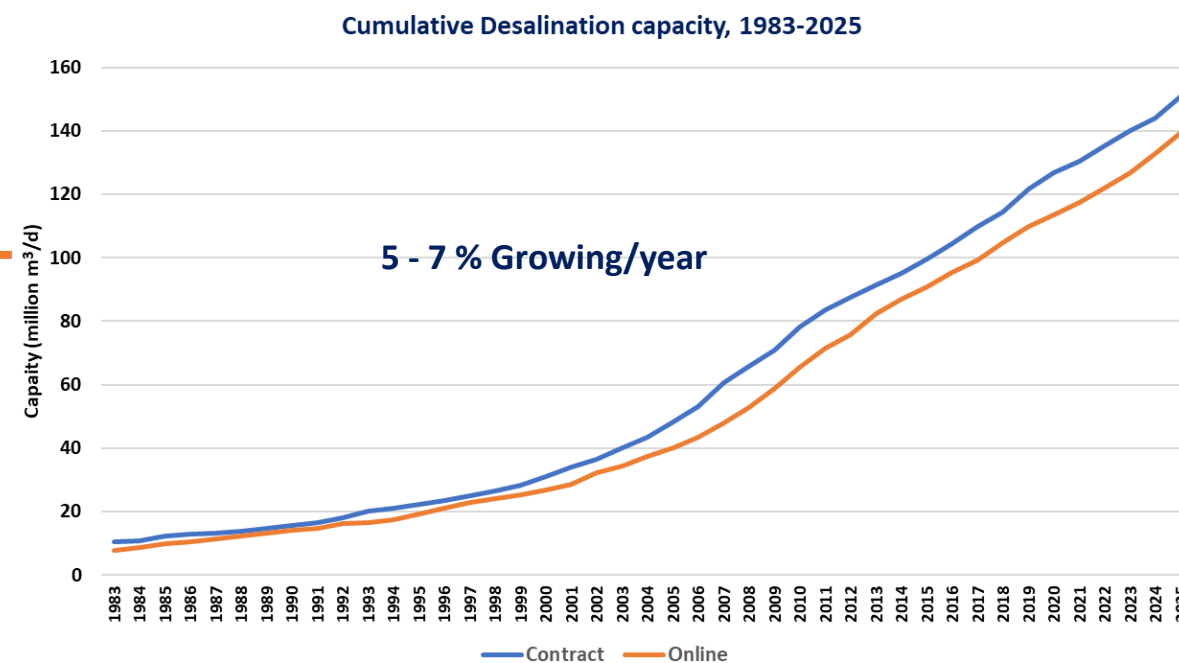
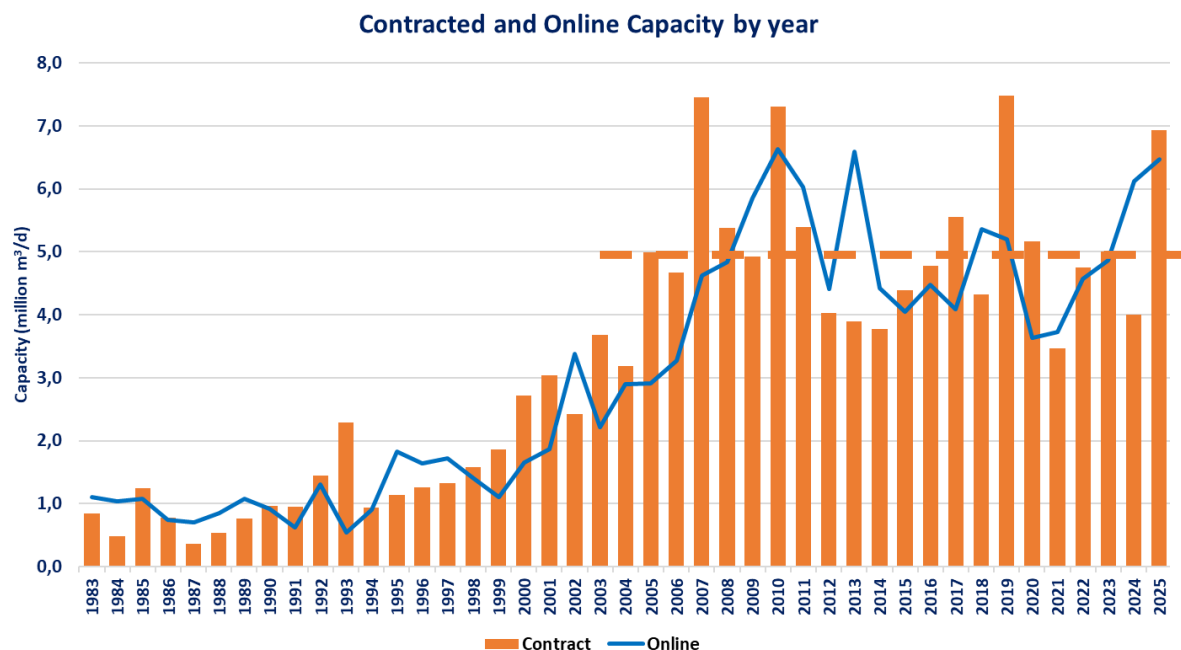
SW
32%
Plants

SW
63%
Capacity

Desalination Evolution

DESALINATION is a mature Technology with a large Experience and References

Every year 5.000.000 m³/day more (average)

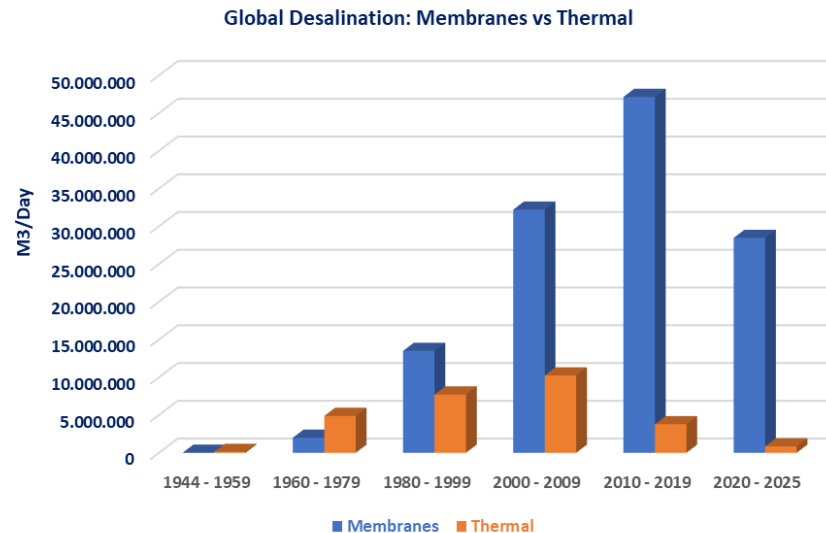
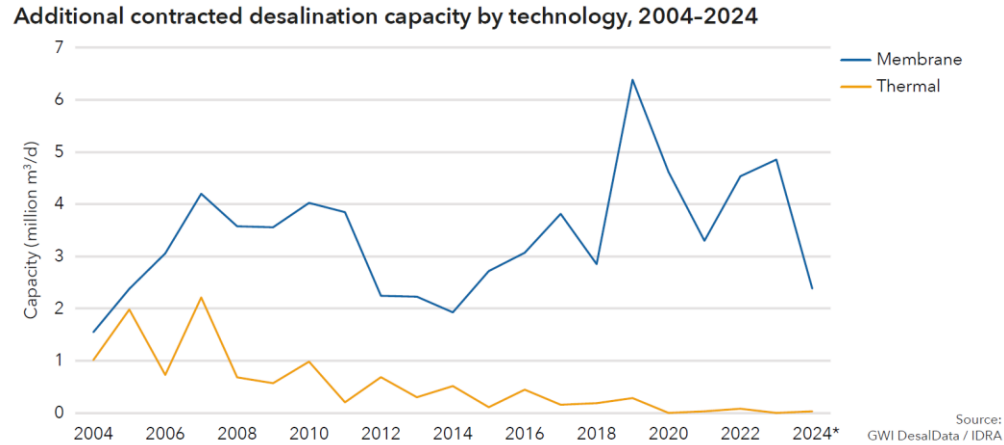


180 Million m³/day is the expected Desalination Production Capacity in 2030

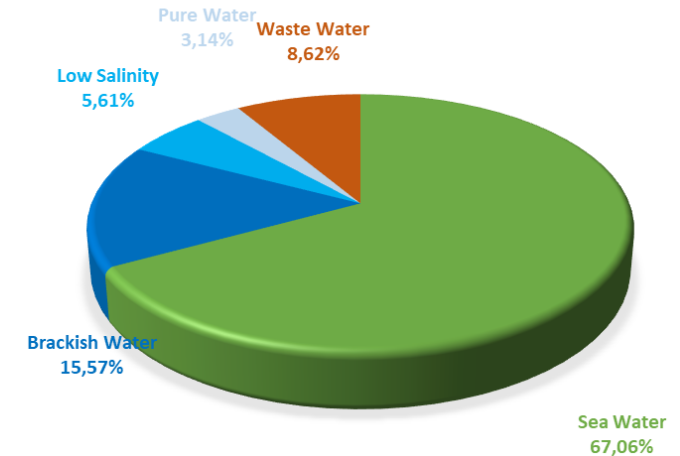
Desalination Technologies, Feedwater and Users

**Thermal Desalination
is mainly limited to
MLD or ZLD**
(Minimum Liquid Discharge or
Zero Liquid Discharge)

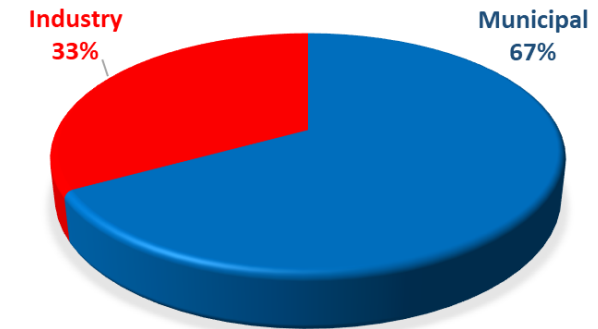
**Since 2020:
Over 97%
of new plants
use only
Membranes**
(even in MENA Region)



WATER SOURCE > 2010



2/3 of the Market is Municipal (including Irrigation)
...and using mainly SW as source



Desalination: Size & Feedwater

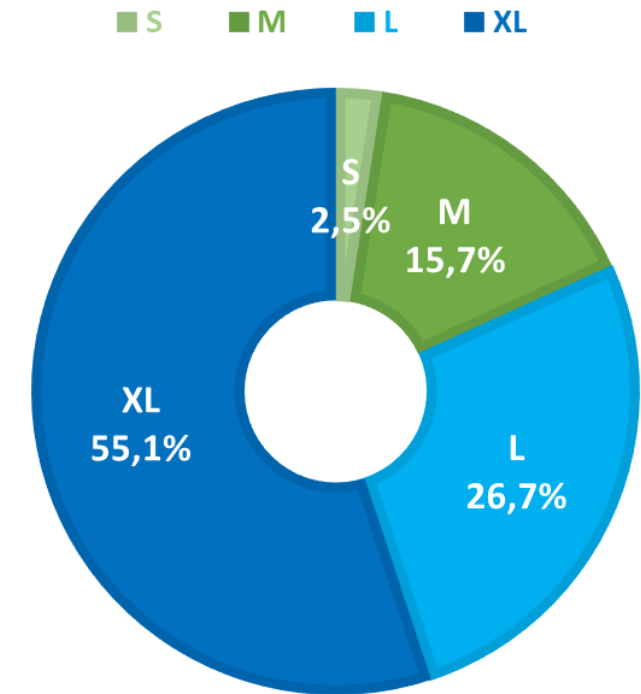
Total Plants in Operation & Construction

By Size			Capacity (m ³ /d)	%	#	%	Av. Size (m ³ /d)
<1.000	S		3.521.178	2,5%	9.613	50,3%	366
>1.000 <10.000	M		22.356.872	15,7%	7.137	37,3%	3.133
>10.000 <50.000	L		37.930.854	26,7%	1.857	9,7%	20.426
>50.000	XL		78.221.108	55,1%	505	2,6%	154.893
Total			142.030.012	100,0%	19.112	100,0%	7.431

50% of the Plants → 2.5% of Capacity

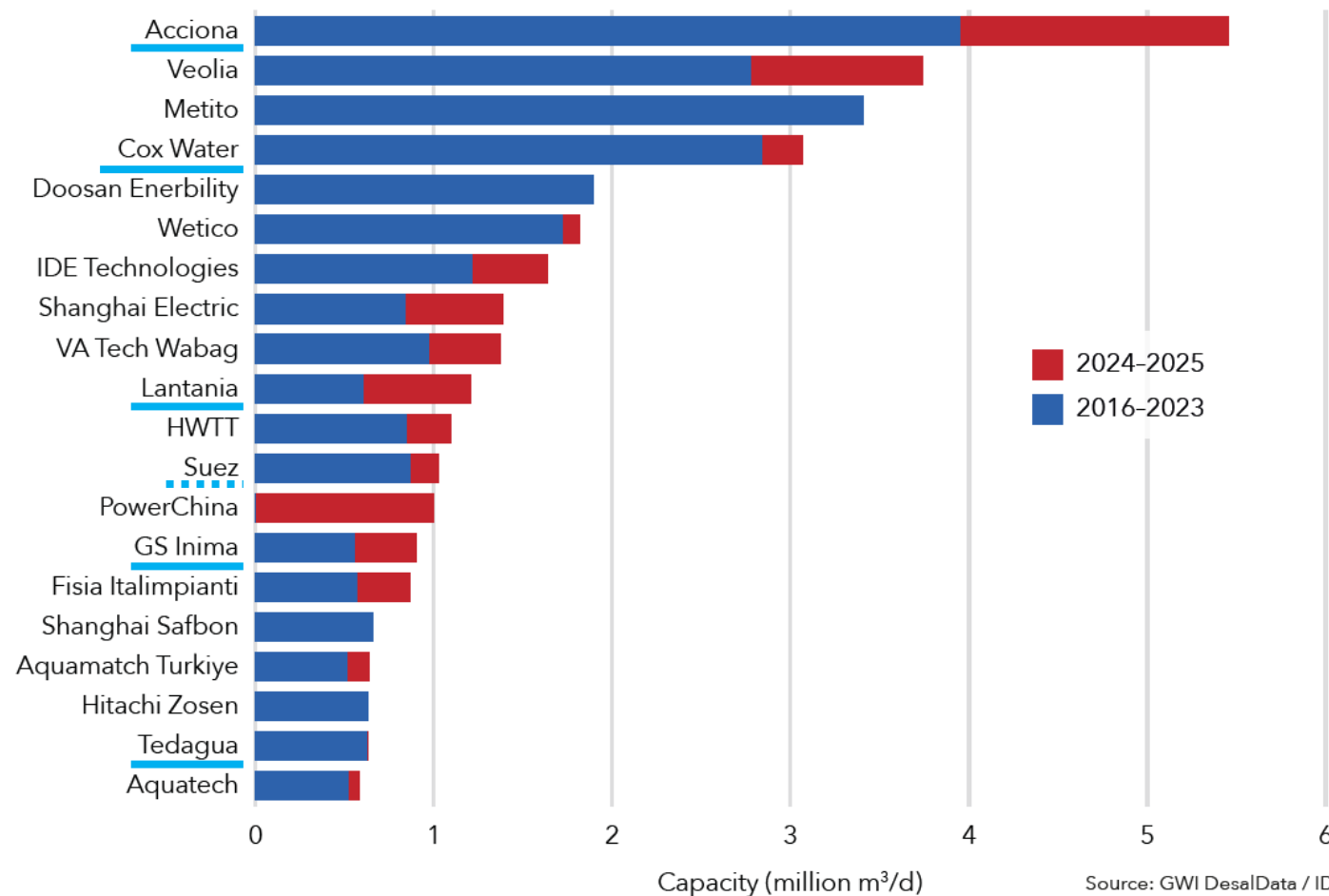
2.6% of the Plants → 55% of Capacity

Desalination Capacity by Size



Desalination Main Actors

Top 20 plant suppliers by awarded desalination capacity, 2016-2025



**Spain is the Country
having more
Key Players in the
Desalination Market**

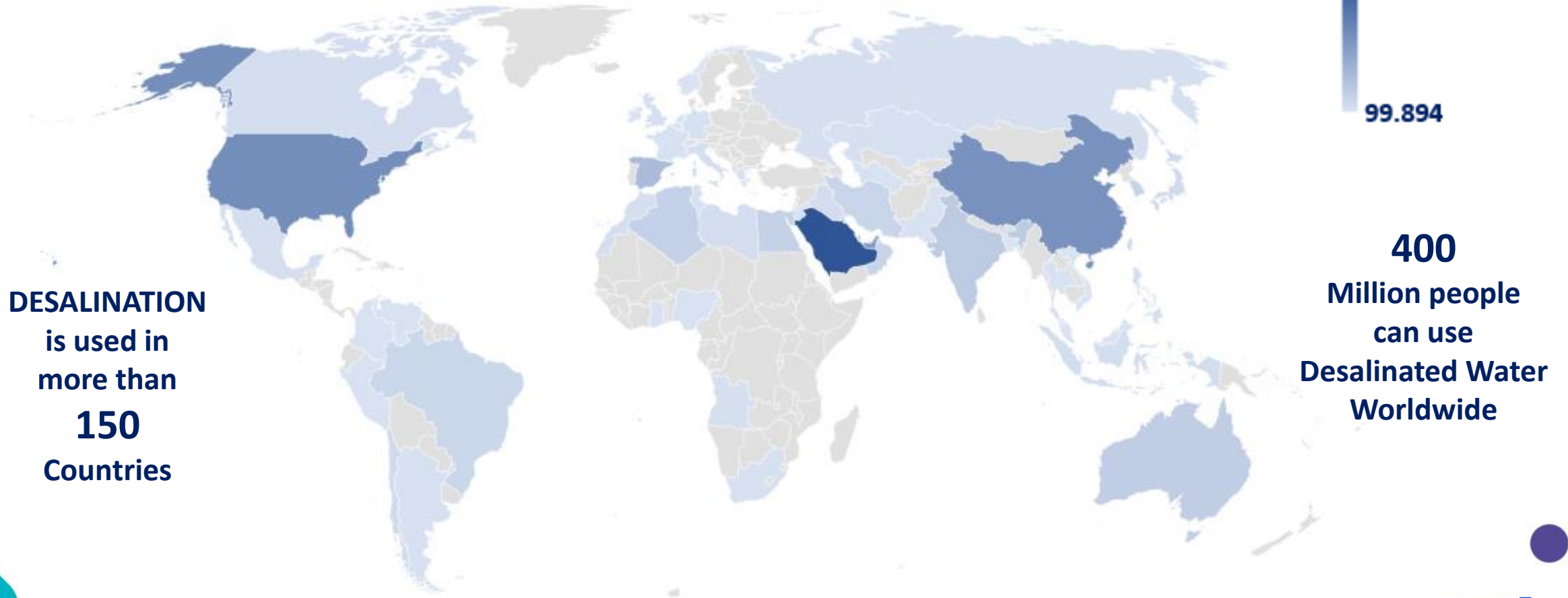
Source: GWI DesalData / IDRA

- Desalination Technologies
- Global Desalination Overview
- Desalination in World Regions
- Key Subjects in Desalination and Trends
- Water Reuse & Forecast

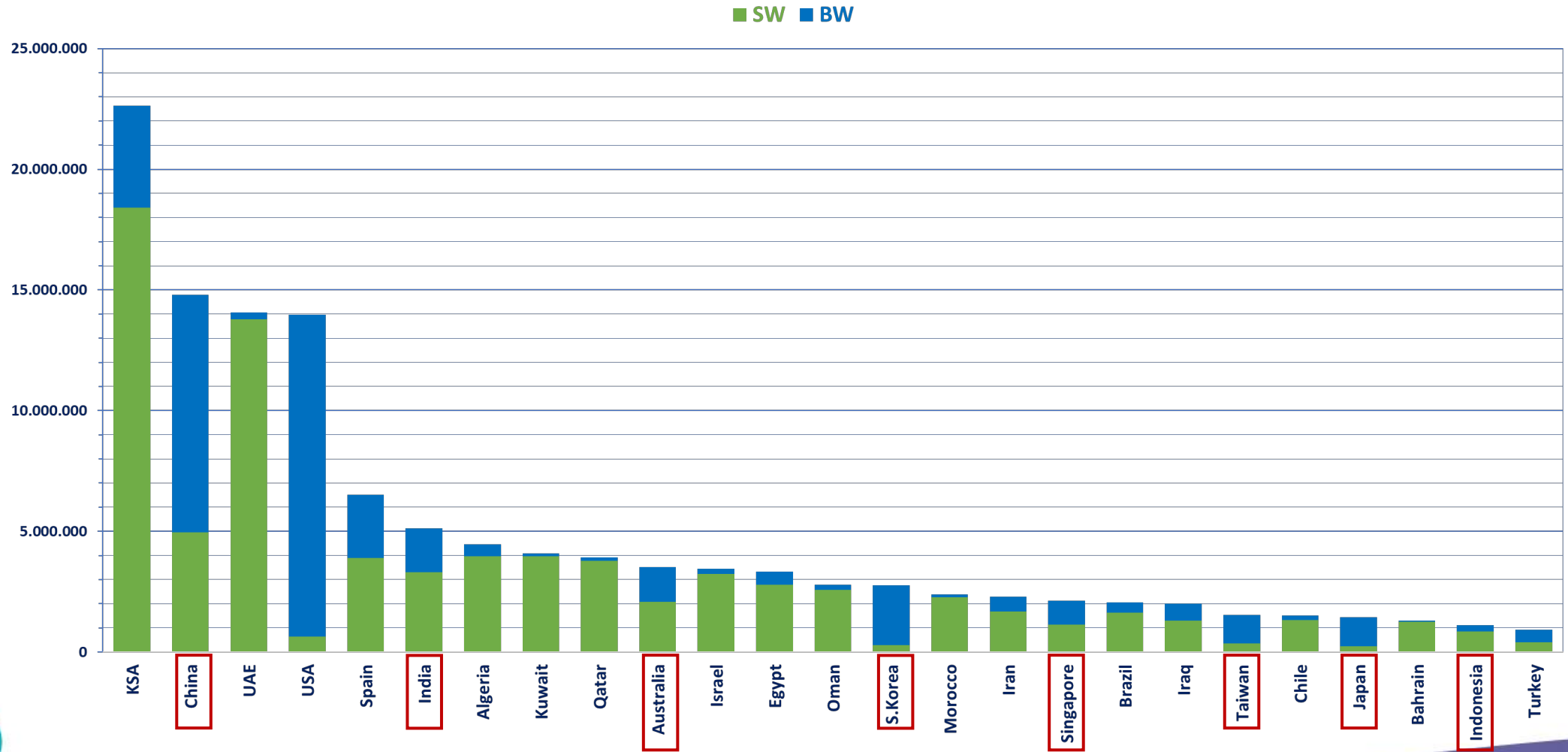
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Desalination in the World

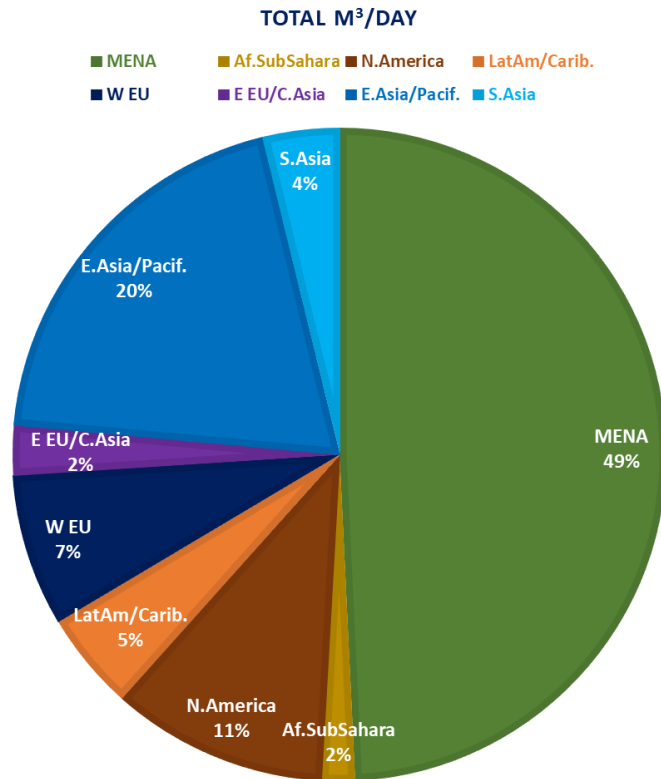
Countries +100,000 m³/day installed capacity



Top Desalination Countries by Capacity (m³/day)



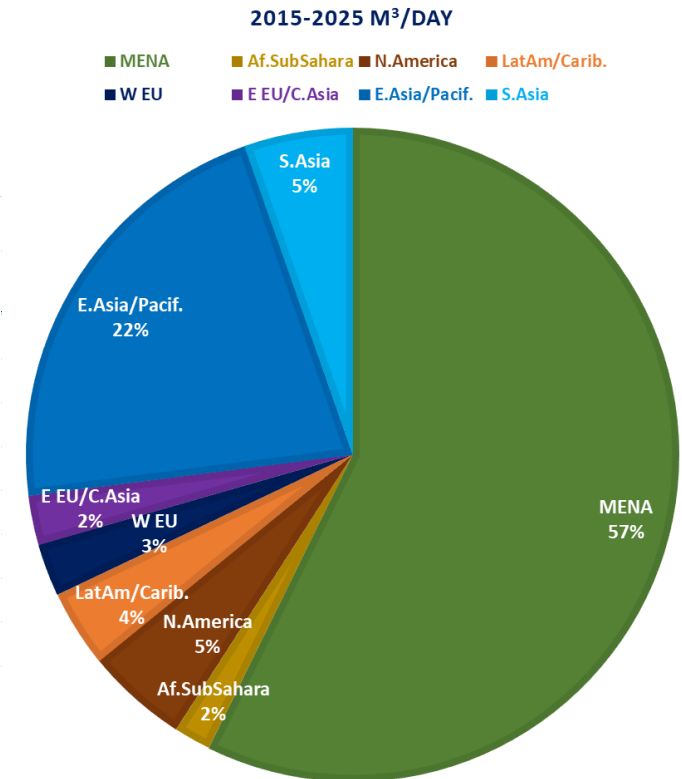
Desalination in World Regions



50% of World Desalination
based in MEA.
25% EU and Americas
25% Asia and Pacific

Market	Total		2015-2025	
Regions	m ³ /day	Plants	m ³ /day	Plants
MENA	74.577.902	6.972	31.990.385	857
Af. SubSahara	2.502.461	419	1.016.874	102
N. America	16.206.001	3.556	2.818.766	517
LatAm/Carib.	7.366.713	2.123	2.137.249	551
W EU	11.405.689	3.230	1.450.014	429
E EU/C. Asia	3.732.010	811	1.358.362	222
E. Asia/Pacif.	29.917.015	5.055	12.090.455	1.063
S. Asia	5.757.553	865	2.991.673	190

70% of SW Desalination
based in MEA.



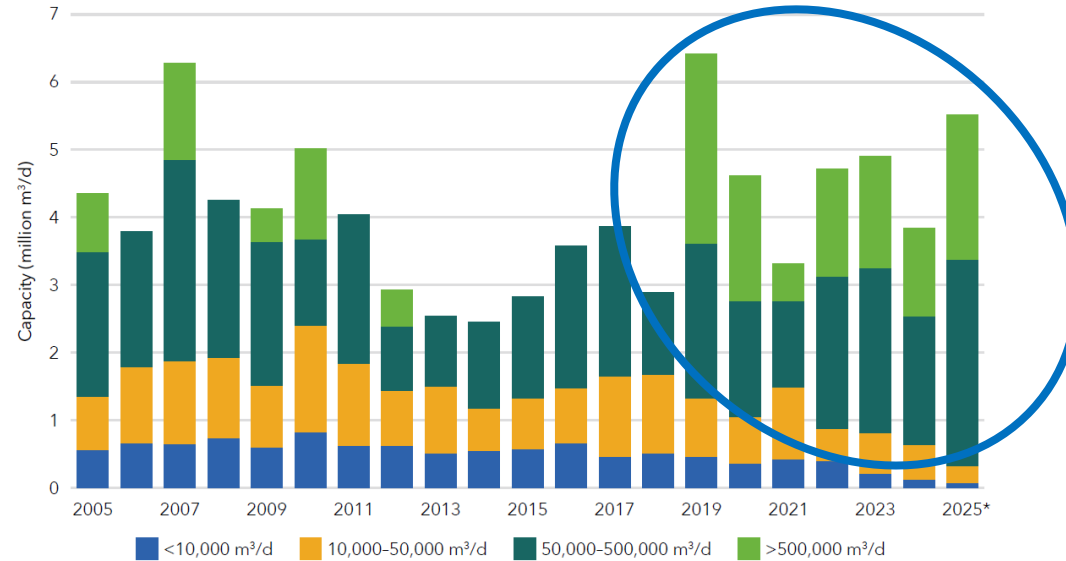
MENA and Asia are the main
Desalination Markets today:
Over 85%

- Desalination Technologies
- Global Desalination Overview
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- **Key Subjects in Desalination and Trends**
- Water Reuse & Forecast

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Desalination: Size of SW Plants Size increasing

Contracted desalination capacity by plant size, 2005-2025

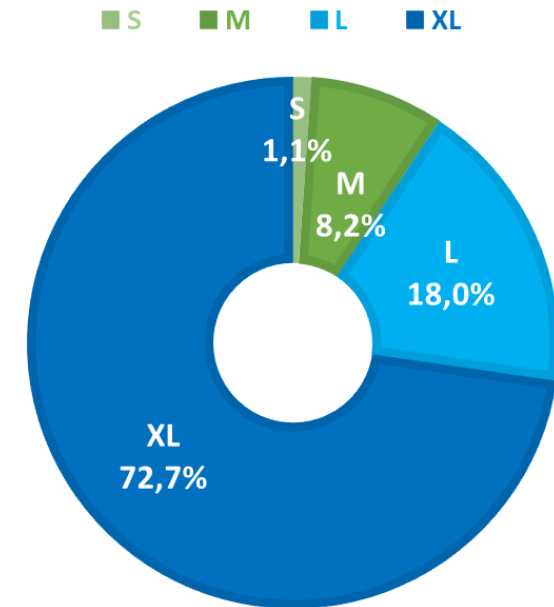


Source: GWI DesalData / IDRA

Sea Water Plants in Operation & Construction 2000 - 2025

Sea Water By Size			Capacity (m³/d)	%	#	%	Av. Size (m³/d)
	<1.000	S	1.002.390	1,1%	2.806	44,9%	357
>1.000	<10.000	M	7.282.834	8,2%	2.304	36,8%	3.161
>10.000	<50.000	L	16.000.837	18,0%	781	12,5%	20.488
>50.000		XL	64.731.760	72,7%	362	5,8%	178.817
Total			89.017.821	100,0%	6.253	100,0%	14.236

SW Desalination Capacity by Size



18% of the Plants → 91% of Capacity
6% of the Plants → 73% of Capacity

Desalination Procurement: O&M included

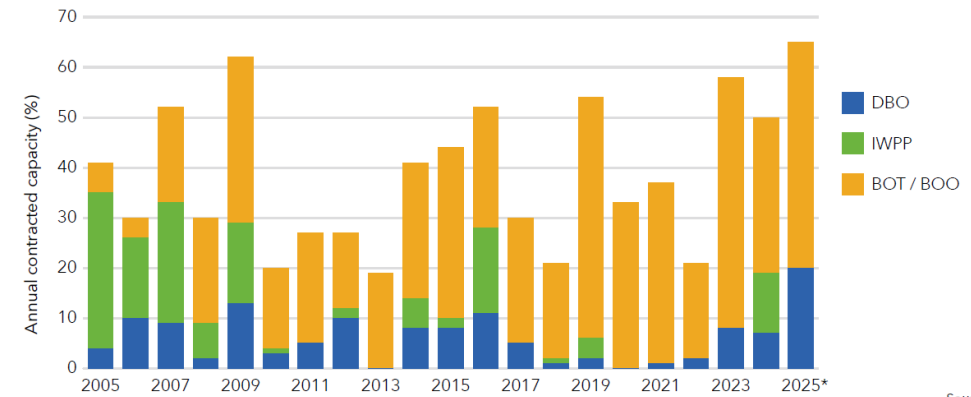
Contracted 2005 - 2025

Total Plants	Procurement	m ³ /day	%	Av. Size (m3/d)
367	DBFO/BOT/IWP/DBO	36.796.056	34,6%	100.262
10.314	DB / EPC	69.598.597	65,4%	6.748
10.681	Total	106.394.653	100,0%	9.961
SW Plants	Procurement	m ³ /day	%	Av. Size (m3/d)
277	DBFO/BOT/IWP/DBO	33.859.541	48,5%	122.237
3.031	DB / EPC	36.024.103	51,5%	11.885
3.308	Total	69.883.644	100,0%	21.126

Water Market:
Desalination is bringing
more opportunities in
Financing
than DWT or WWT

Procurement includes long term
O&M in most of large plants...
and also financing

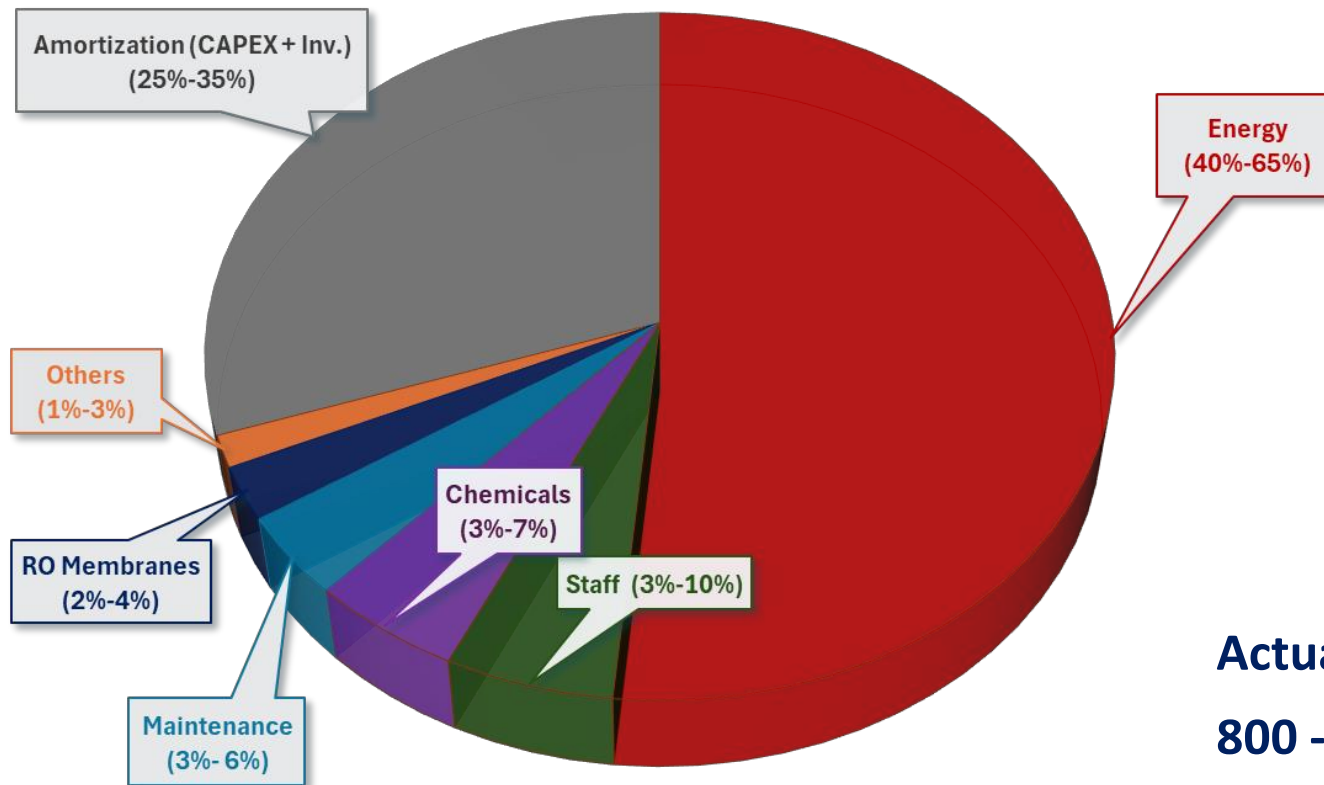
Almost 50% for Sea Water



Source:
GWI DesalData / IDRA

Main Target in SW Desal: Total Water Cost

Water Cost breakdown for Large SW Desalination Plants



Actual Desal Water Cost:

0,40 - 1,50 USD/m³

- CAPEX + OPEX
- Long Operation (20-25 y)
- ENERGY is the main cost
- Focus: optimisation of OPEX
- Coupling to Renewable Energy?

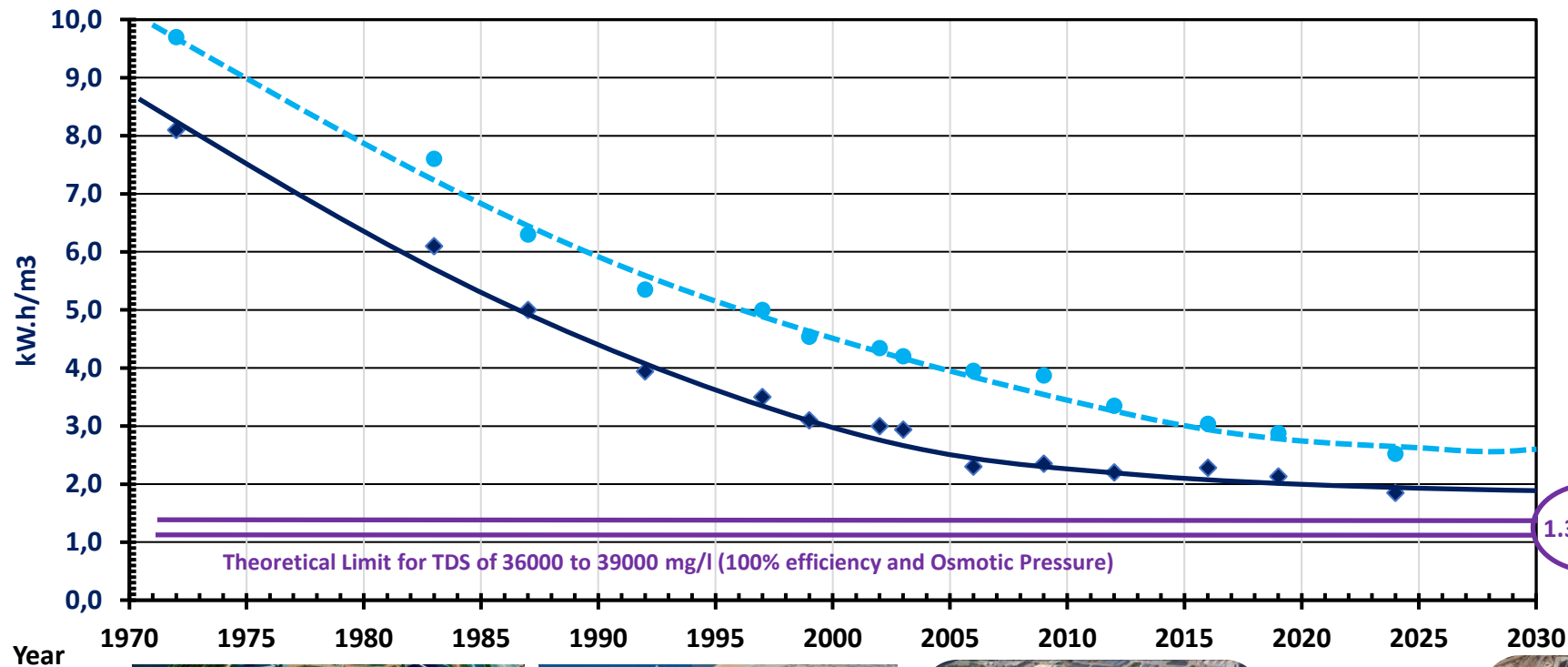
Actual Desal CAPEX Cost for XL plants:

800 - 1400 USD/m³/day

Energy Consumption in SW Reverse Osmosis

Historical Evolution of Energy Consumption in SWRO

◆ 1st RO pass Consumption ● Total Consumption



We are on the limits of the actual technology due to many improvements in last decades:

Evolution & Innovations

Size of the plants/trains

Membrane evolution

Pumps & Motors Efficiency

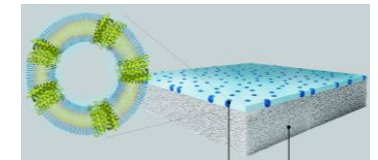
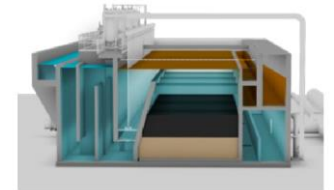
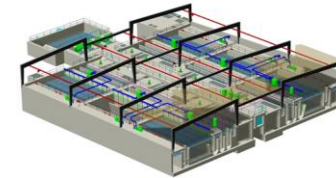
Energy Recovery systems

To reduce the energy costs, it is necessary to use other sources : Renewable Energy

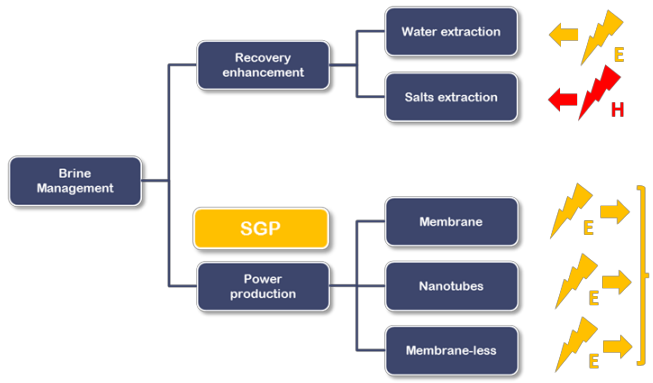
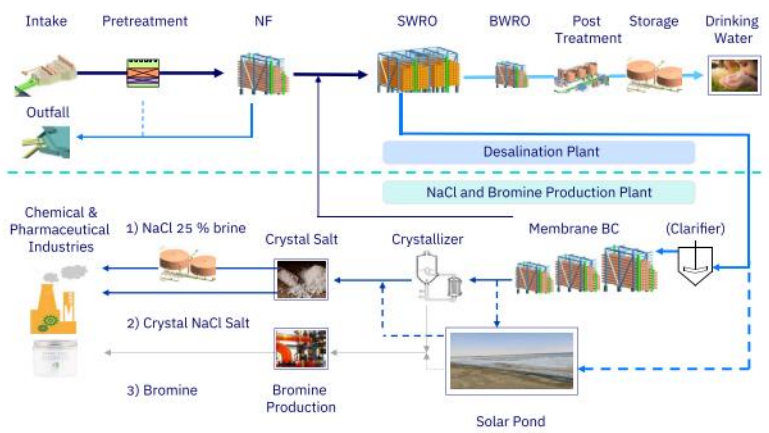
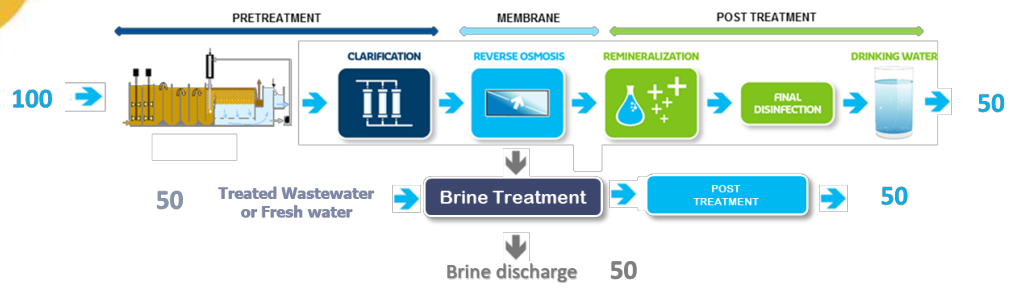


Other SWRO Trends

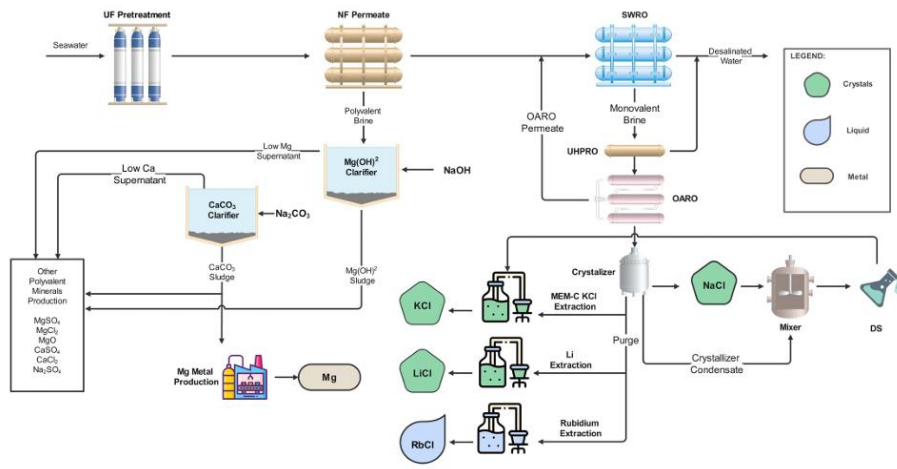
- Pretreatment optimization
 - High Speed DAF
 - DAF-Filters high rate
 - Membrane Pretreatment: Ceramic Membranes high potential
- New Membranes development (graphene, electrically charged, antifouling, new materials, coating...)
- Use of AI to improve O&M performance and costs (machine learning, digital twins...)
- Minimize Carbon Footprint
- Circular Economy



Circular Economy: Brine as Source

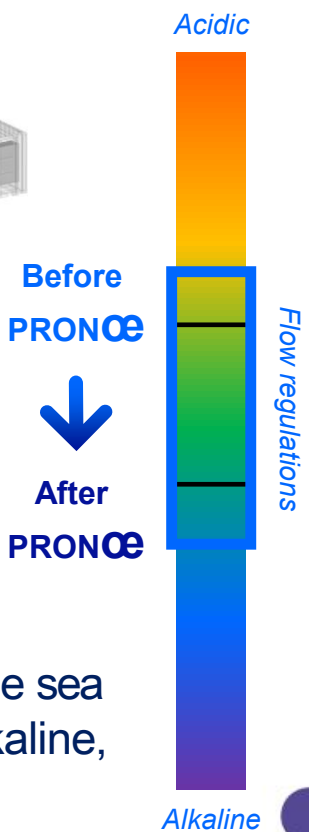
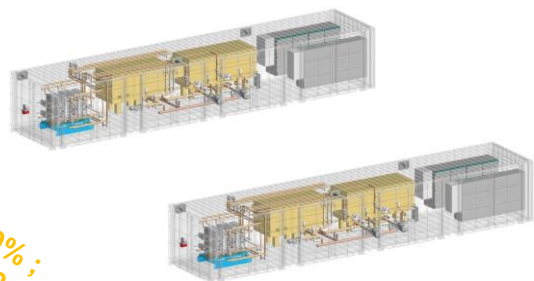
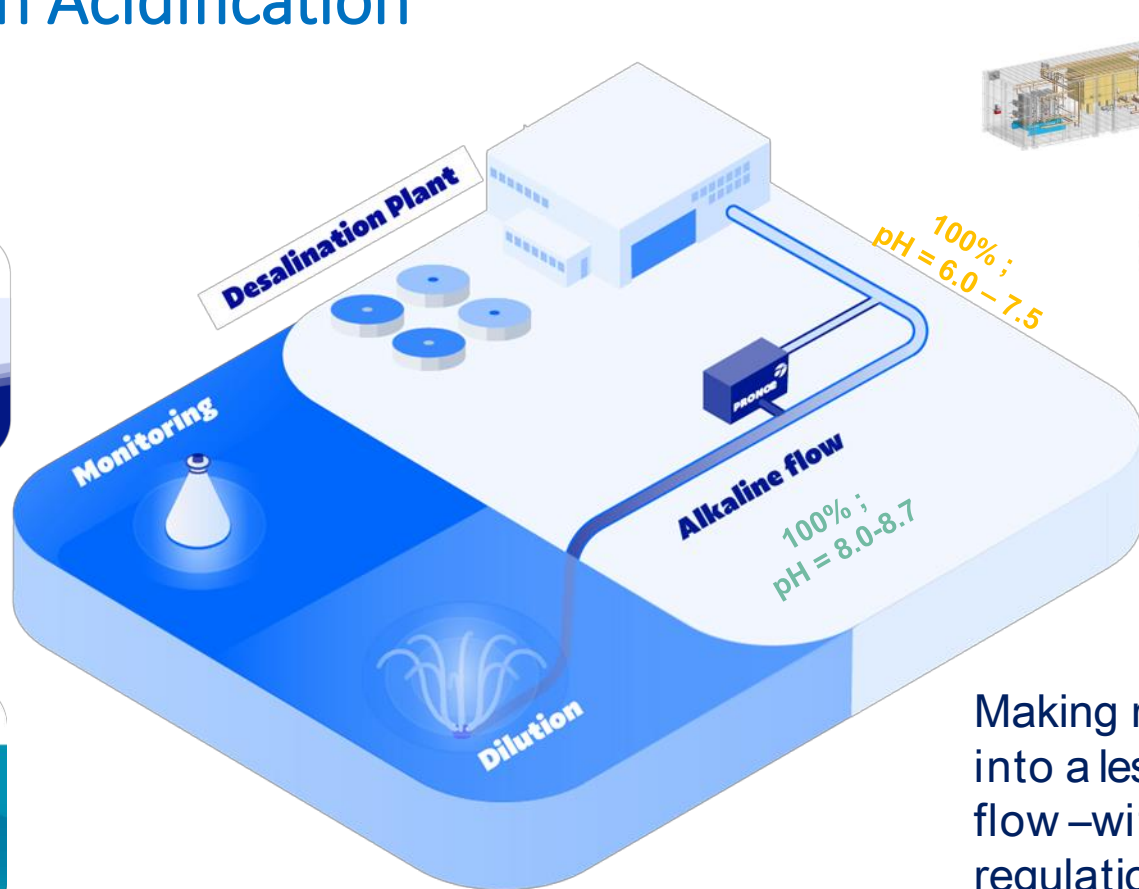
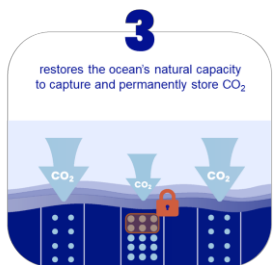
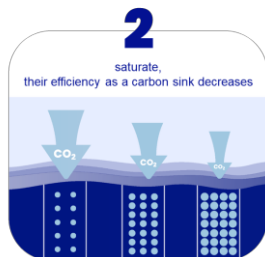
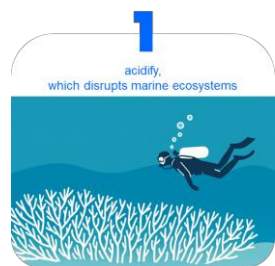


Compatible with Existing Facilities
Increase Water Production
 (+ Recover Salts)
 (+ Produce Energy)
 (+ WW Reuse)
Salinity Gradient Power



Using Discharge to Ocean Alkalinity Enhancement

Reducing Ocean Acidification



Making return flows to the sea into a less acidic, more alkaline, flow –within applicable regulations.

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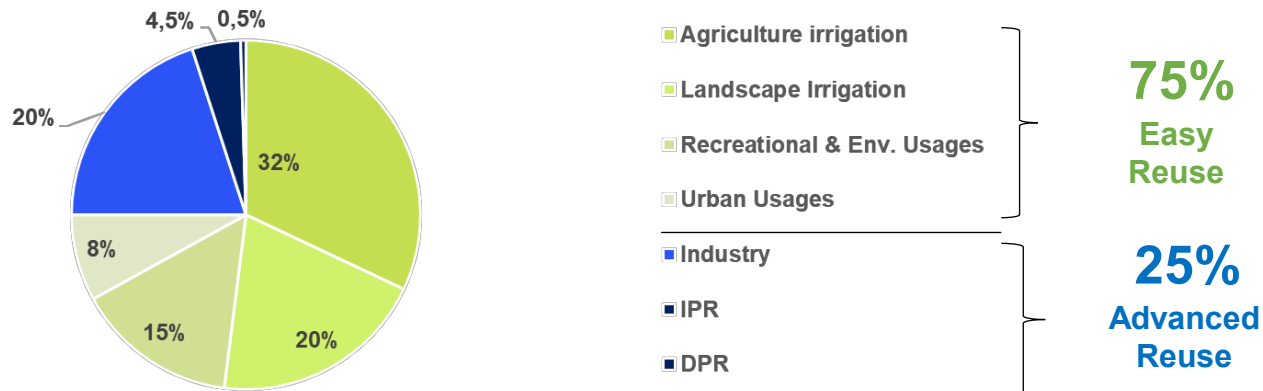
4 Types of Water Reuse<> 4 Technology Levels

Before Wastewater Reuse:

Need to Sanitation and WWTPs infrastructure



Wastewater Reuse Practices Worldwide 1990 - 2014



IPR: Indirect Potable Reuse; DPR: Direct Potable Reuse



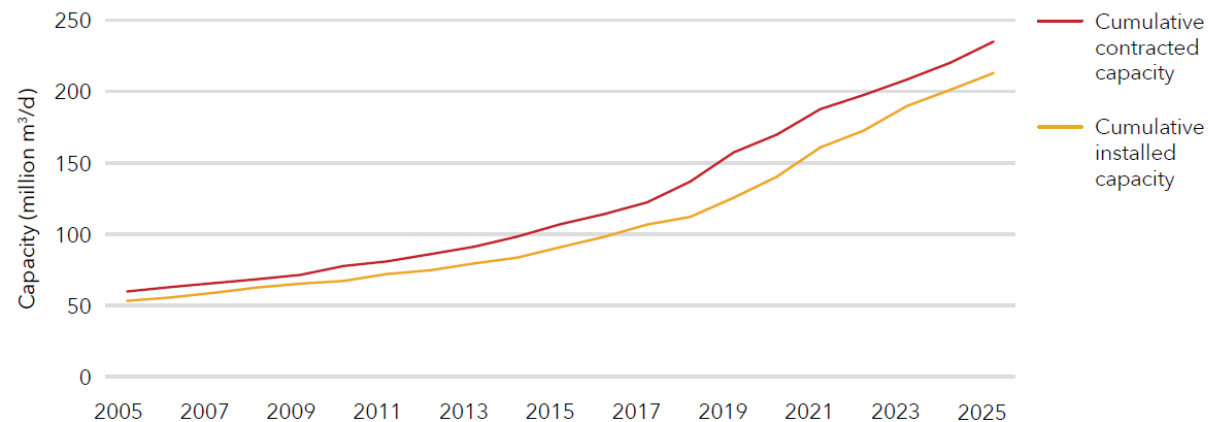
WWTP Pinedo
Valencia (Spain)



AWTP Beenyup
(W. Australia)

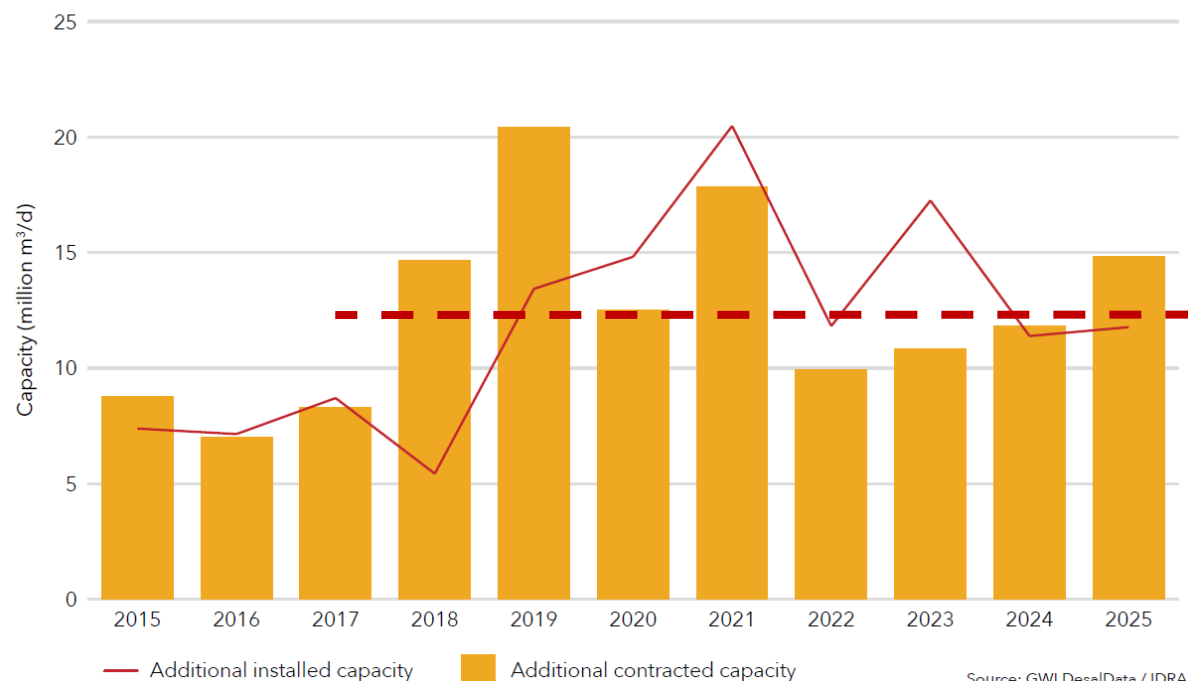
Water Reuse in figures

Cumulative contracted and installed reuse capacity by year, 2005-2025



Source: GWI DesalData / IDRA

Annual contracted and installed reuse capacity by year, 2015-2025



Source: GWI DesalData / IDRA

Water Reuse capacity is growing faster than Desalination

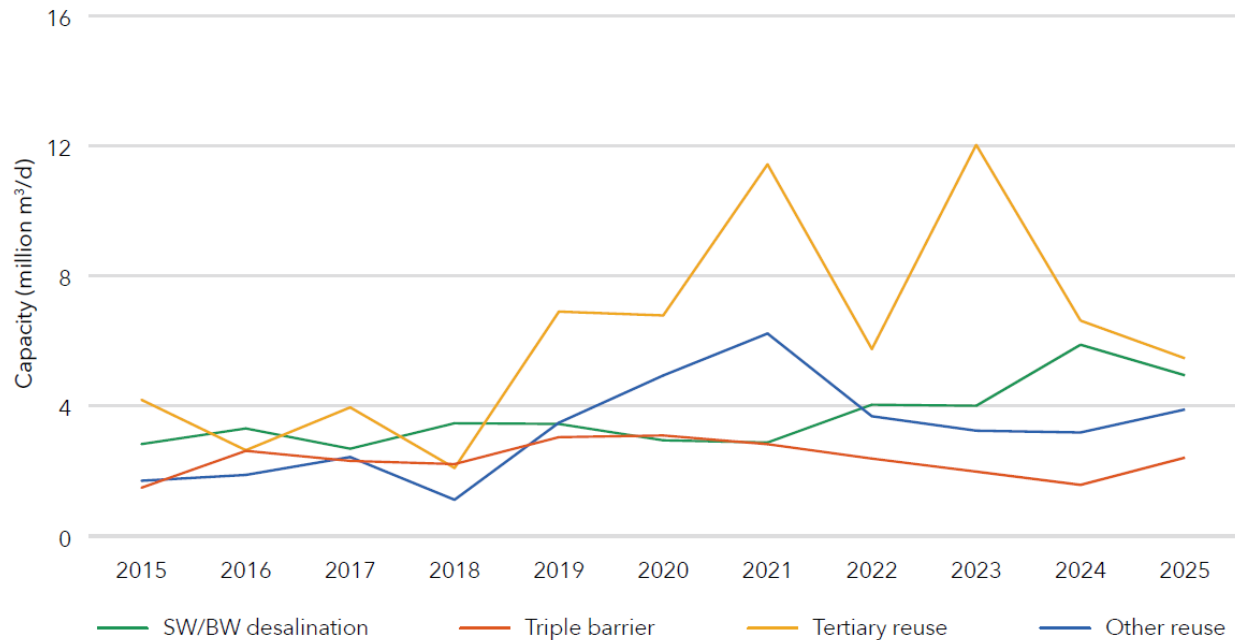
Over 12.000.000 m³/day new capacity every year

Water Reuse Capacity: Regions and Technologies

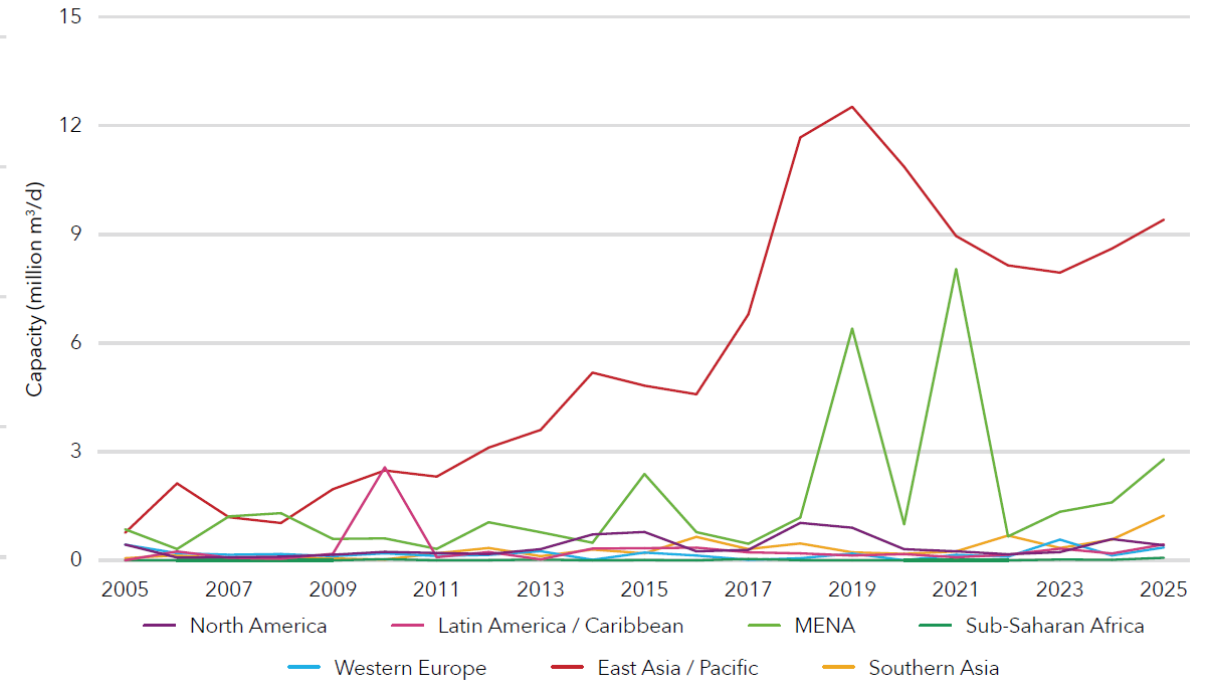


AWTP West Basin, LA
California, USA
1st Multipurpose WRP

Annual installed desalination and reuse capacity by technology, 2015-2025



Additional contracted reuse capacity by region, 2005-2025

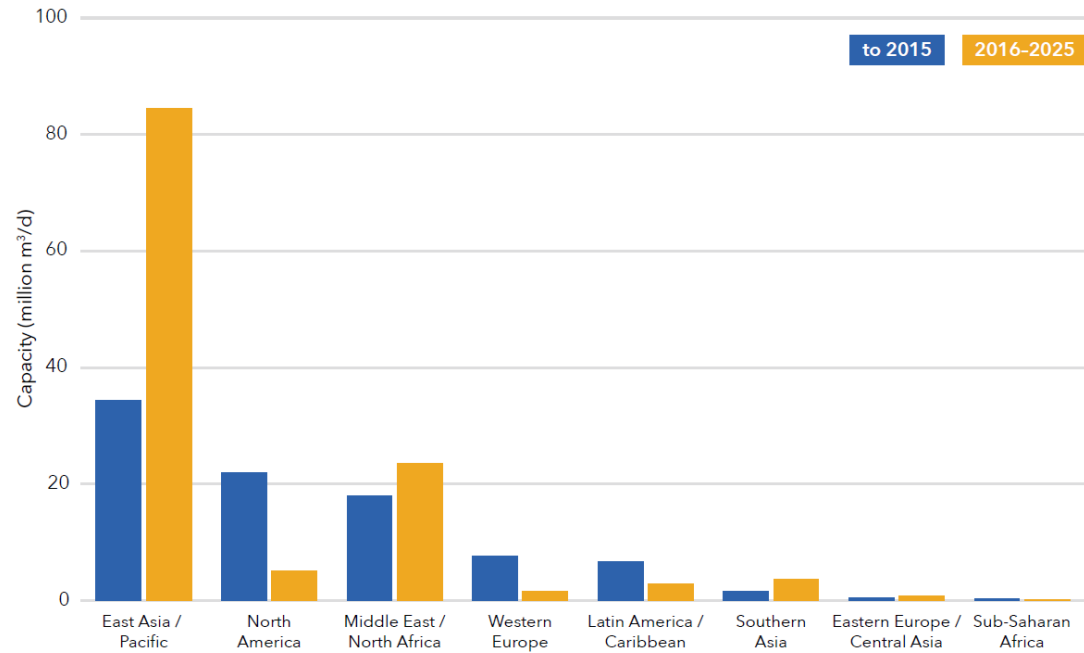


Water Reuse Capacity: Regions and Technologies



**AWTP Windhoek
Namibia
1st DPR**

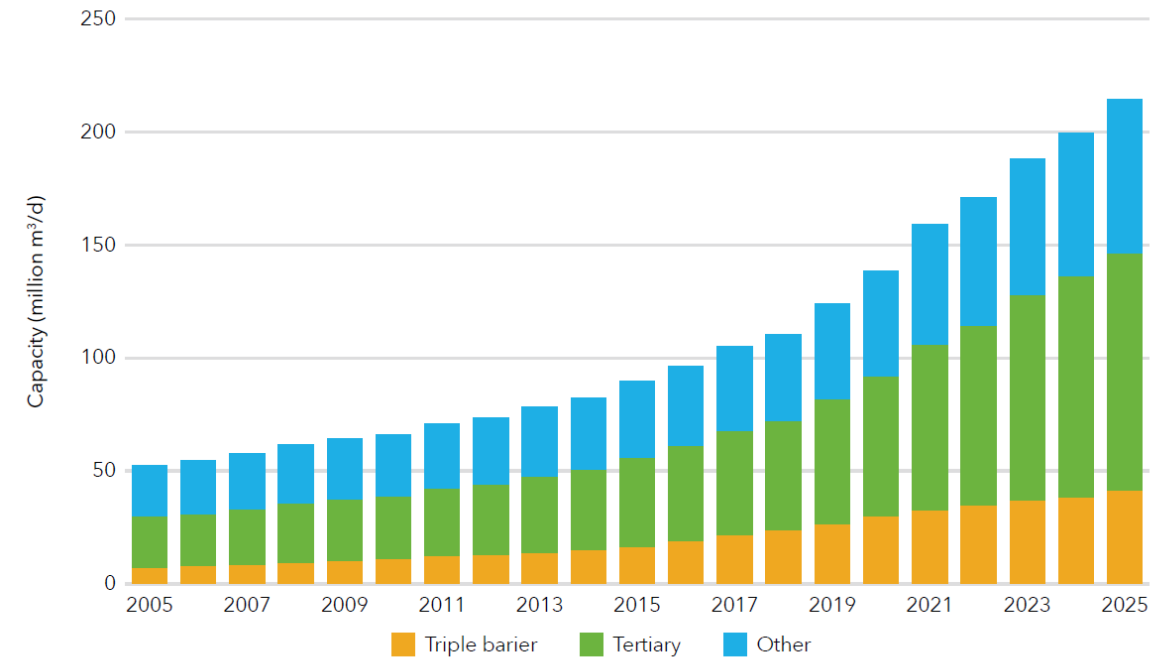
Installed reuse capacity by region to 2025



Capacity figures for mainland China are based on data published by MOHURD

Source: GWI DesalData / IDRA

Cumulative installed reuse capacity by treatment level, 2005-2025



Capacity figures for mainland China are based on data published by MOHURD

Source: GWI DesalData / IDRA

Industry and Irrigation are the main Reuse applications > 75%

WWR Market:

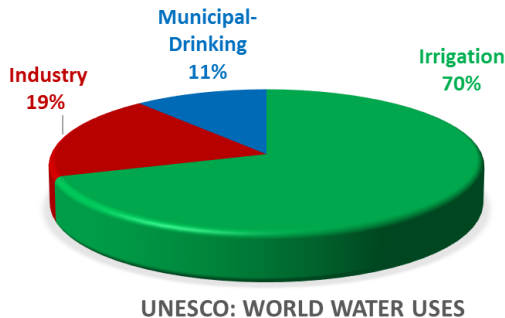
Industry & Irrigation are the largest by Volume

DPR/IPR & Industry are the more technological

Installed capacity by water reuse application, 1991-2025

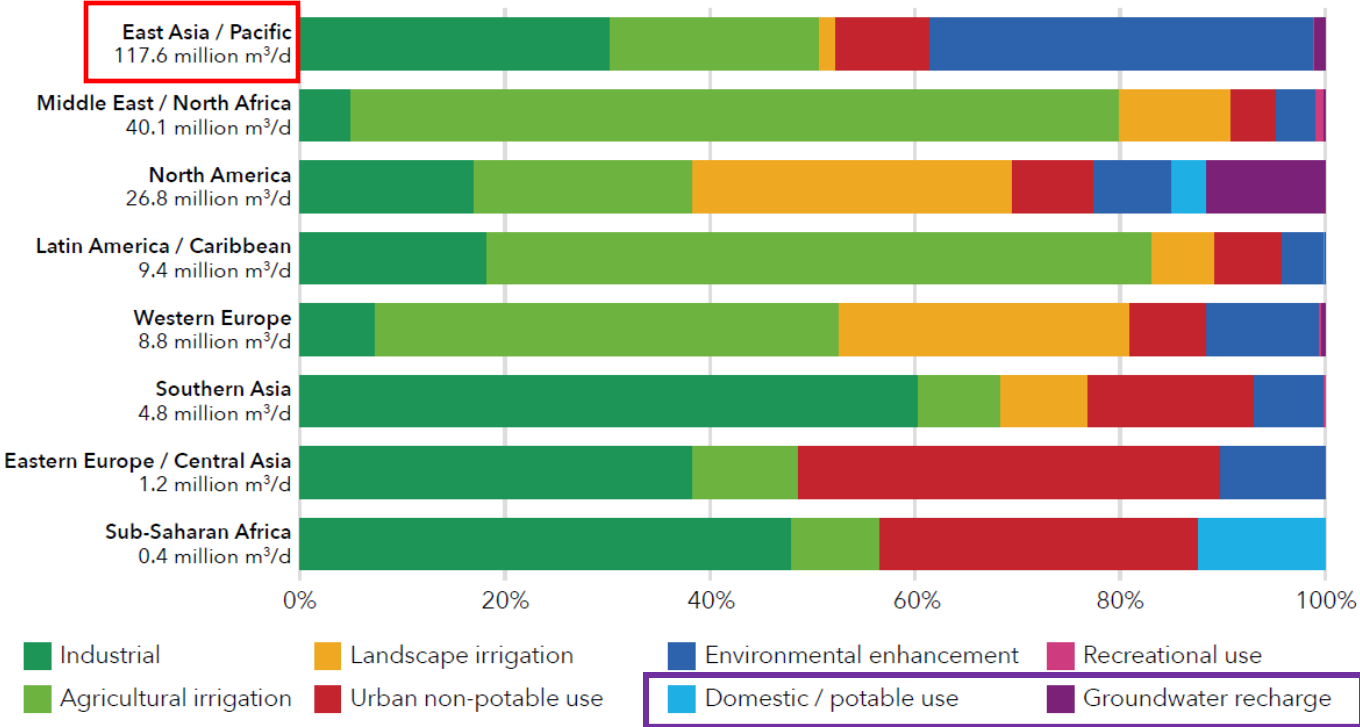


A&WWTP Depur-Baix (BCN)
Spain
Multipurpose WRP - IPR



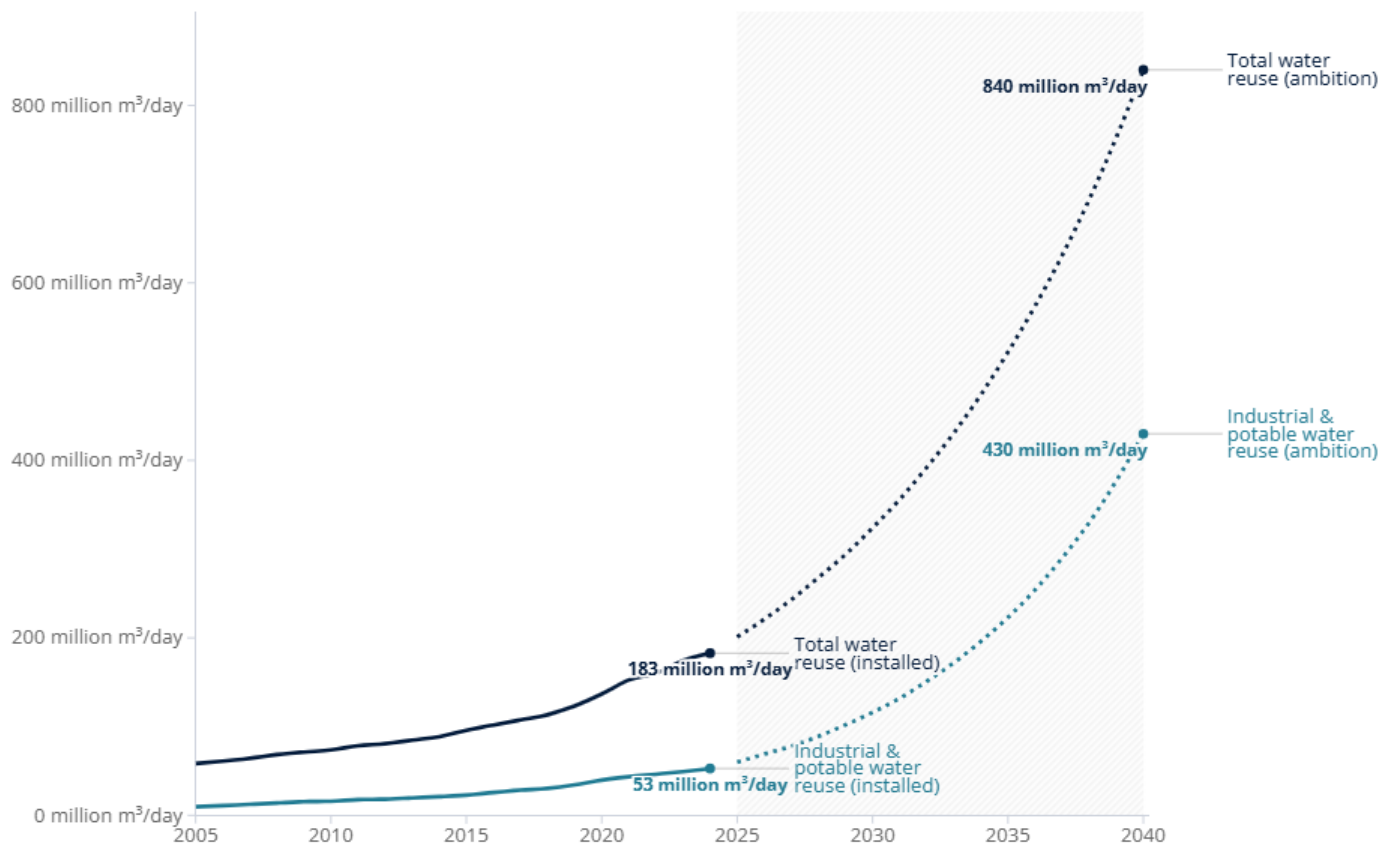
Evolution of WWR Market:

In last decade **Industry** has overtaking the **Agriculture**, particularly in Asia



A Huge Potential of Water Reuse in the Future

Water reuse potential by 2040, in million m³/day



WWR a Promising Market:

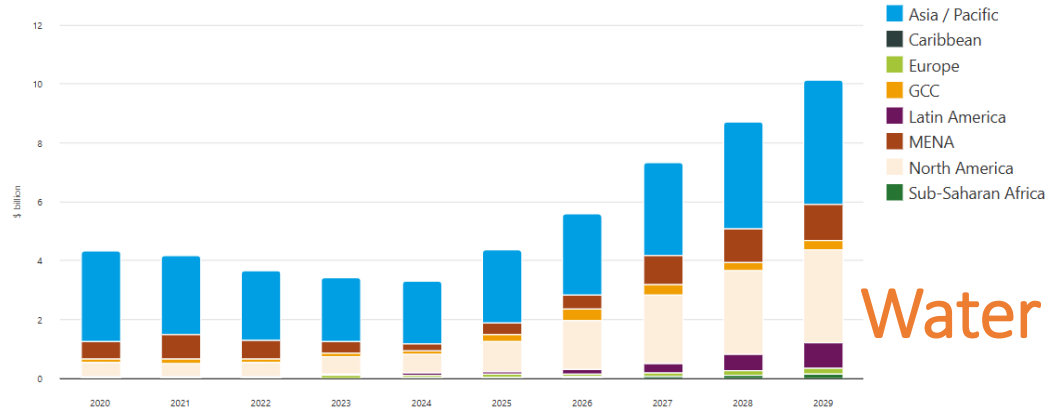
> 10 % Annual growth

840 Hm³/day in 2040 (WB)

Source: Adapted from World Bank (2025). Scaling Water Reuse: A Tipping Point for Municipal and Industrial Use. • Notes: In addition to industrial and potable reuse, total reuse includes agricultural irrigation (amounting to 88 million m³ per day in 2024), landscape irrigation (amounting to 21 million m³ per day in 2024), urban non-potable reuse (17 million m³ per day in 2024), and recreational/ miscellaneous reuse (4 million m³ per day in 2024). Installed capacity from GWI data; municipal freshwater withdrawals assumed to grow at 1% per year.

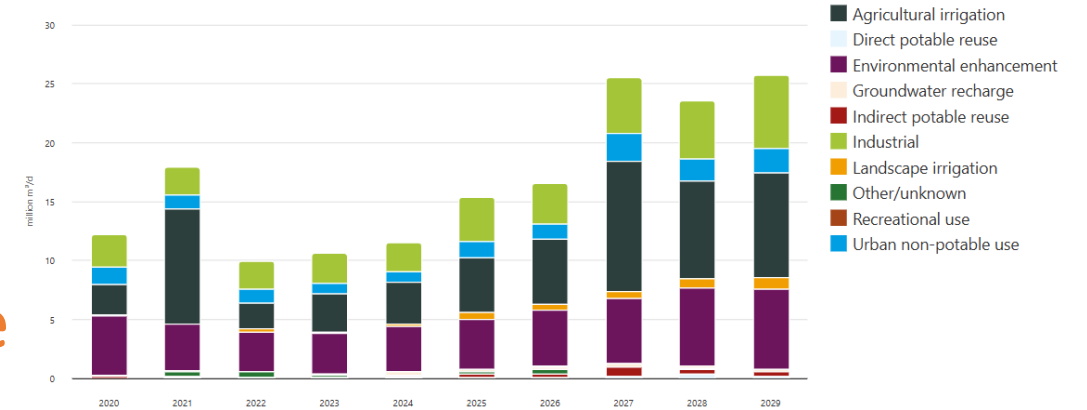
Forecast: An Important Growth

Capex by region

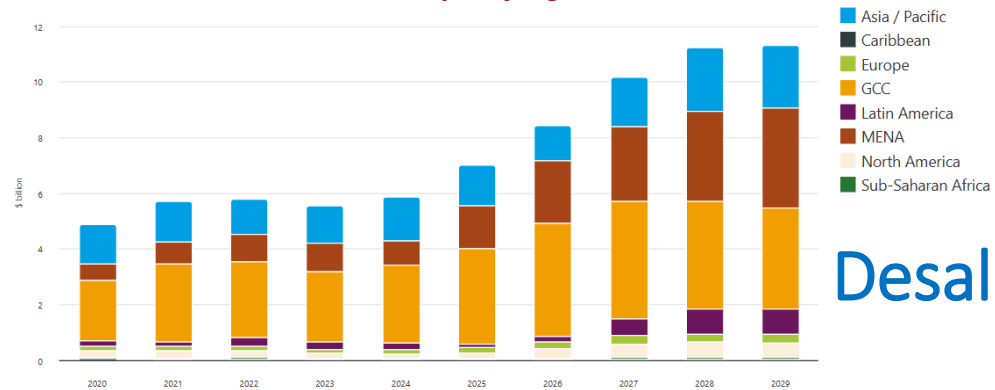


Water Reuse

Contracted capacity by reuse sector

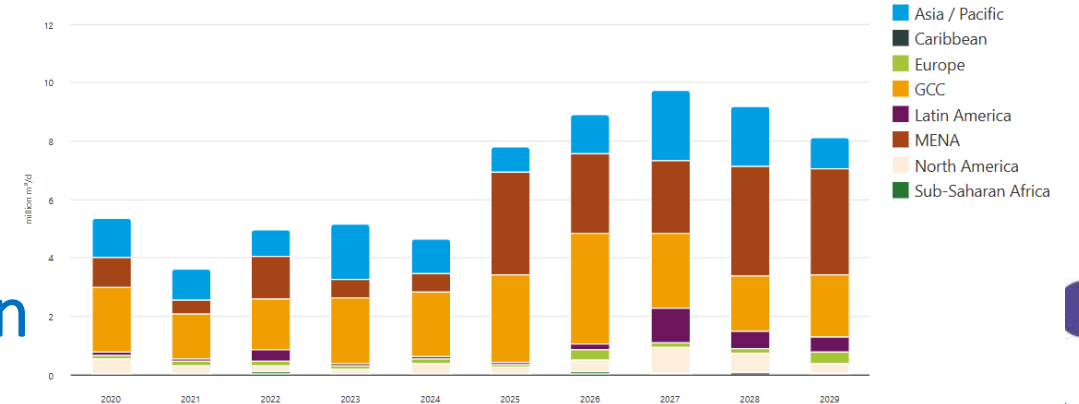


Capex by region



Desalination

Contracted capacity by region



The most expensive water is
what we don't have

THANK YOU

Miguel Angel SANZ

MS Water Consult

Smart Watershed,
AI-Driven Innovation
智慧流域 AI 領航
International Forum 2025

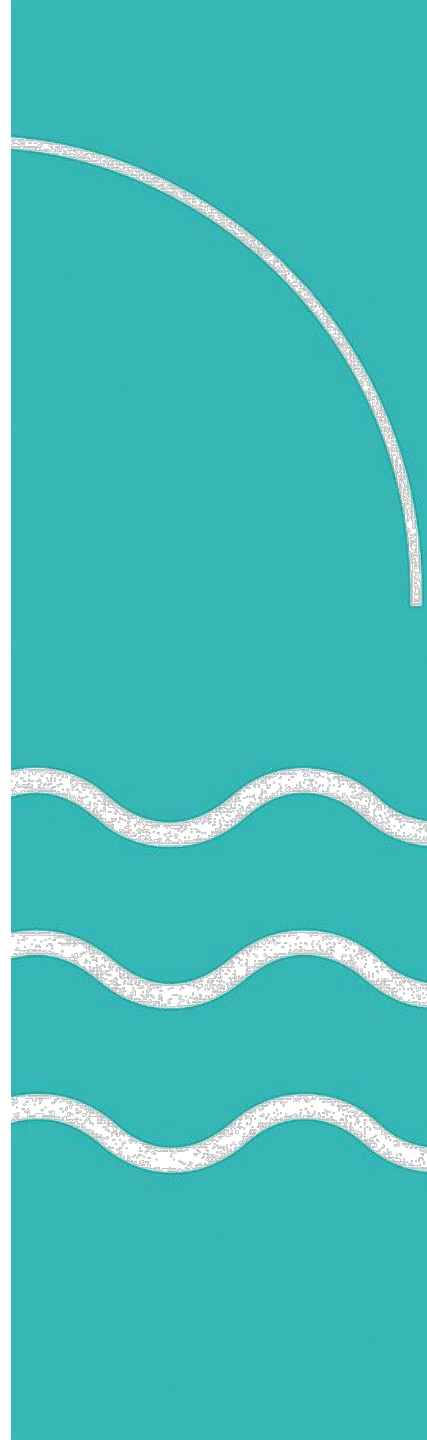


Evolution and Strategies of Taiwan's Desalination Policy

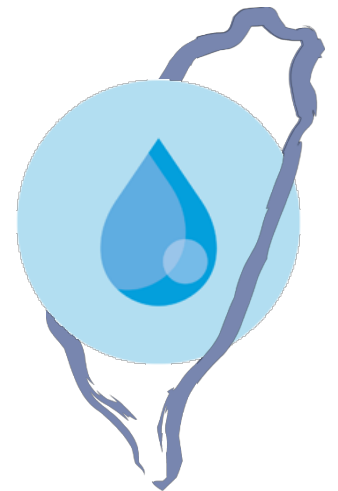
郭純伶 (Kuo Chun-Ling)
Director | Water Resources Agency, MOEA

Outline

- 1. Challenges of Water Resources in Taiwan**
- 2. Policy Evolution**
- 3. Promotion Strategies**
- 4. Conclusion**



1. Challenges of Water Resources in Taiwan



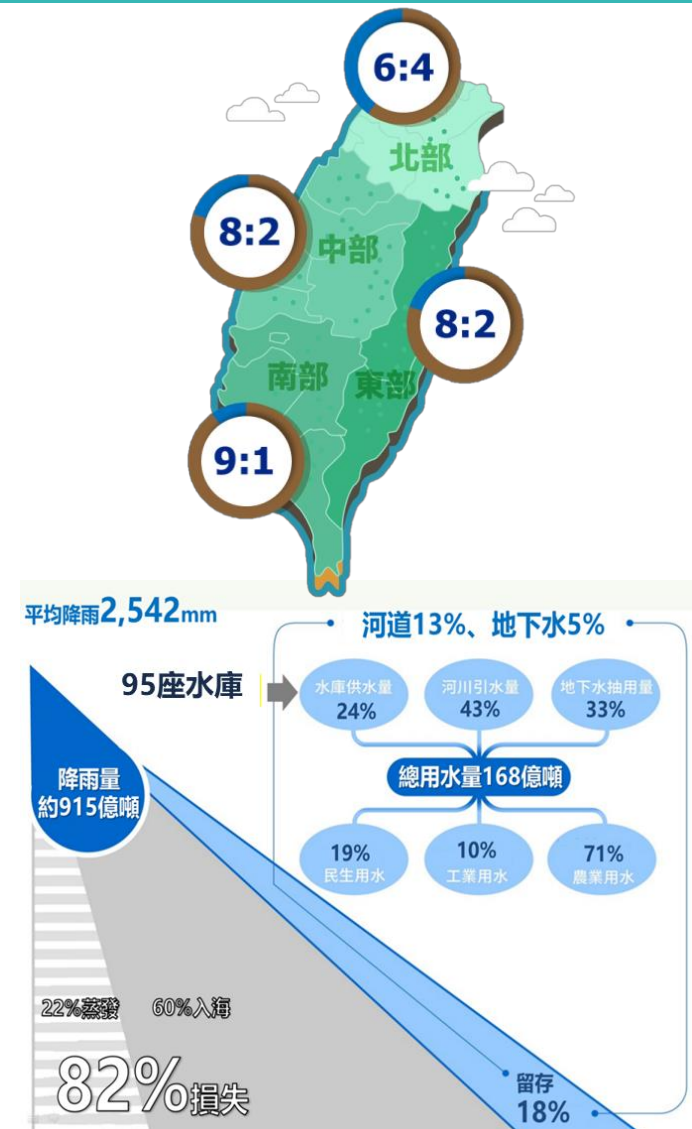
Natural Limitations

◆ Uneven Distribution of Rainfall

- Average annual rainfall: 2.6× the global average, **but uneven across time and regions.**
- Clear **wet–dry season contrast** in central and southern Taiwan.

◆ Topographic Constraints on Water Utilization

- Reservoir storage **strongly influenced by rainfall** patterns
- Steep terrain and rapid runoff - only **about 18% of rainfall** can be retained



Socioeconomic Change

◆ Urban population concentration

- Rising water demand and increasing supply risks.

Population Growth Map of Taiwan

Taoyuan and Hsinchu are high-growth regions, while major metropolitan areas remain growth hotspots.

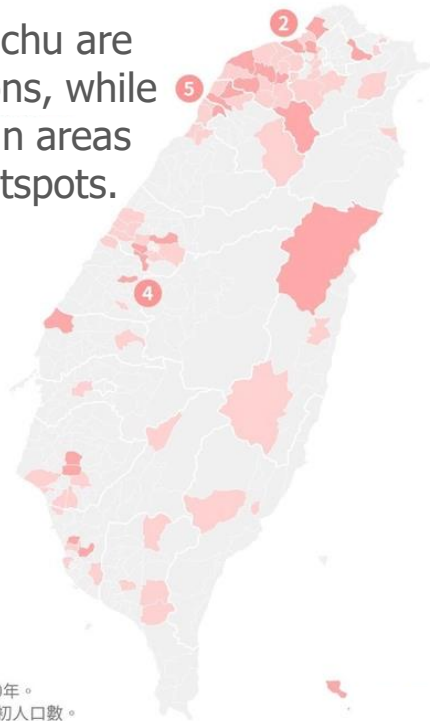


Annual growth rate

年成長率



資料來源：內政部 統計報告。統計年為2020年。
年成長率計算方式為全年人口增減數除以年初人口數。



◆ Rapid industrial expansion

- Thriving industries driving future water demand growth.

Semiconductor Industry Clusters

Factory count

工廠家數



Climate Change



Extreme heat (May–September)

Future hot days may exceed 100 days per year



Reduced rainfall in dry seasons

More frequent droughts



Increased rainfall in wet seasons

Heavier downpours



Fewer but stronger typhoons

Higher proportion of severe storms



Under a +2°C Warming Scenario:

10-year recurrence

Heatwave: +2.6°C

Rainfall intensity : +14%

Drought frequency: 2.4× higher

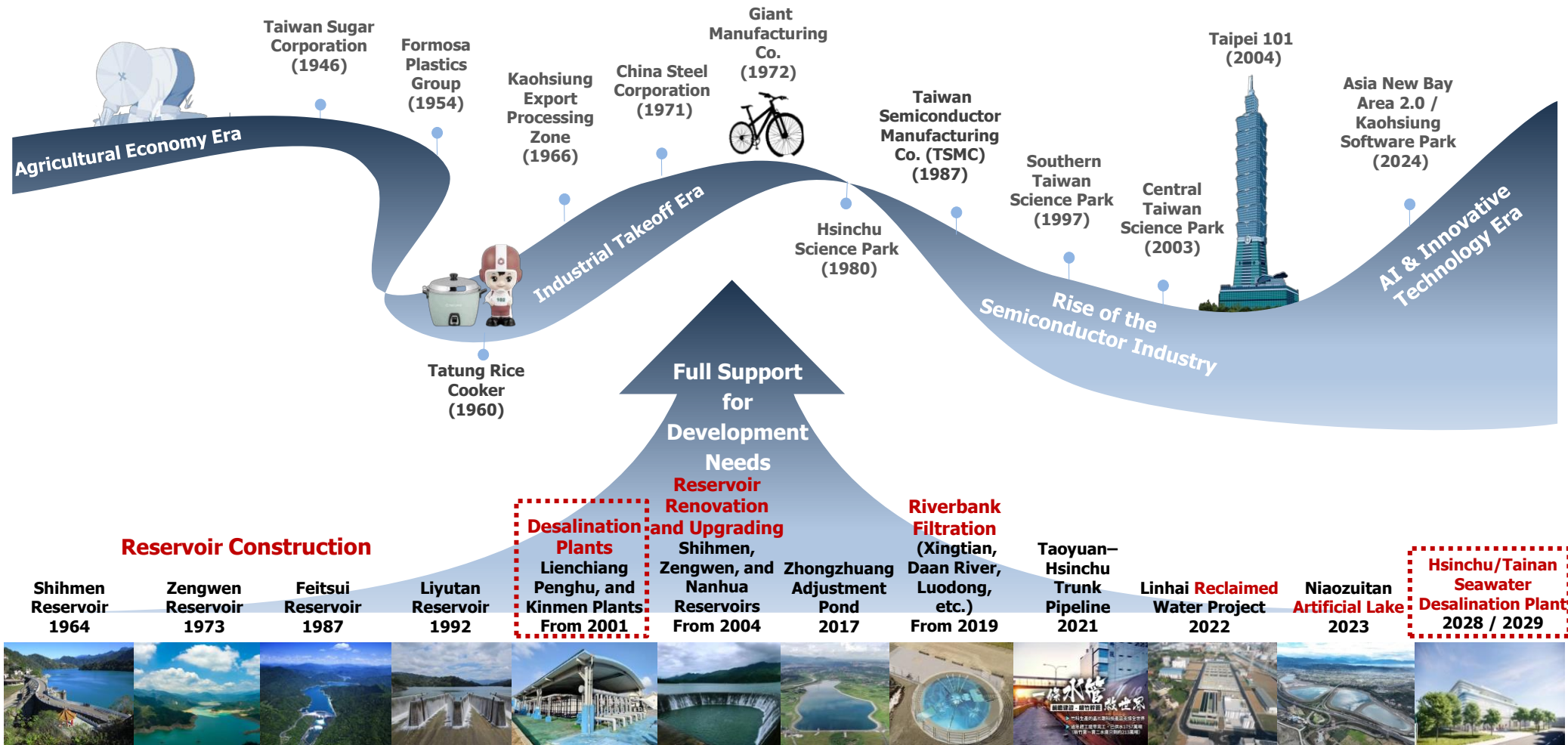
- ◆ **Higher annual temperatures, shorter winters**
 - Rising water demand
- ◆ **More consecutive dry days and stronger single-day rainfall**
 - Higher drought and flood risks
- ◆ **Typhoons fewer but stronger**
 - Sedimentation worsens, smaller reservoir capacity, higher turbidity
- ◆ **Drier dry seasons, wetter wet seasons**
 - Harder water allocation, stronger water disasters



2. Policy Evolution

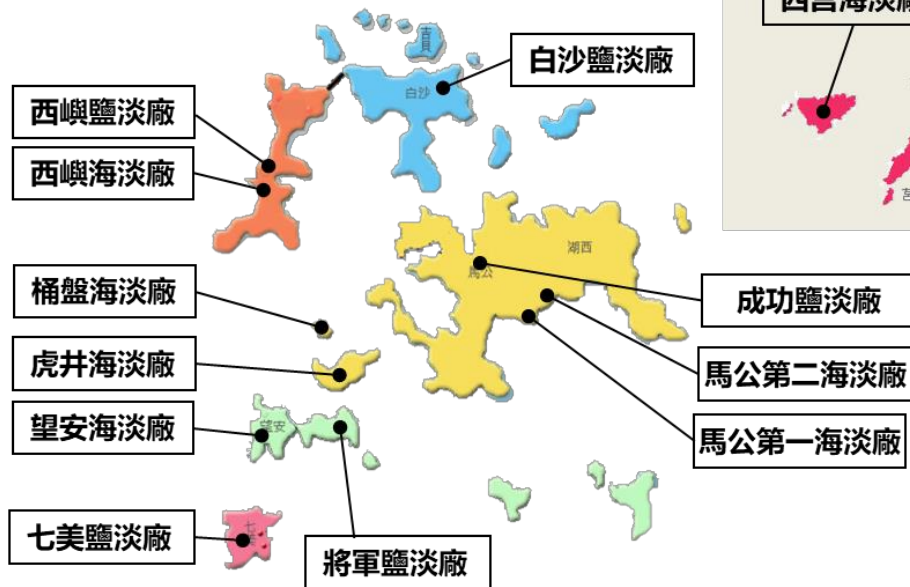


From Traditional to Diversified

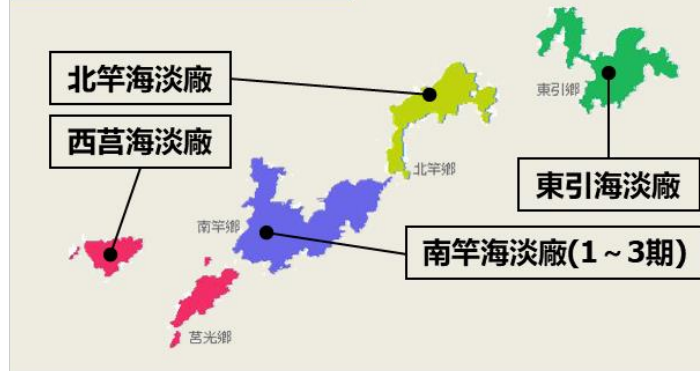


Desalination for Offshore Islands

Penghu Islands



Matsu Islands



Kinmen Islands



- Uneven Rainfall & Limited Water Resources
- Low annual rainfall; highly uneven wet-dry distribution
- Small land area and steep terrain limit water retention

Example – Penghu Water Supply:

Desalinated water: ~63%

Reservoir water: ~12%

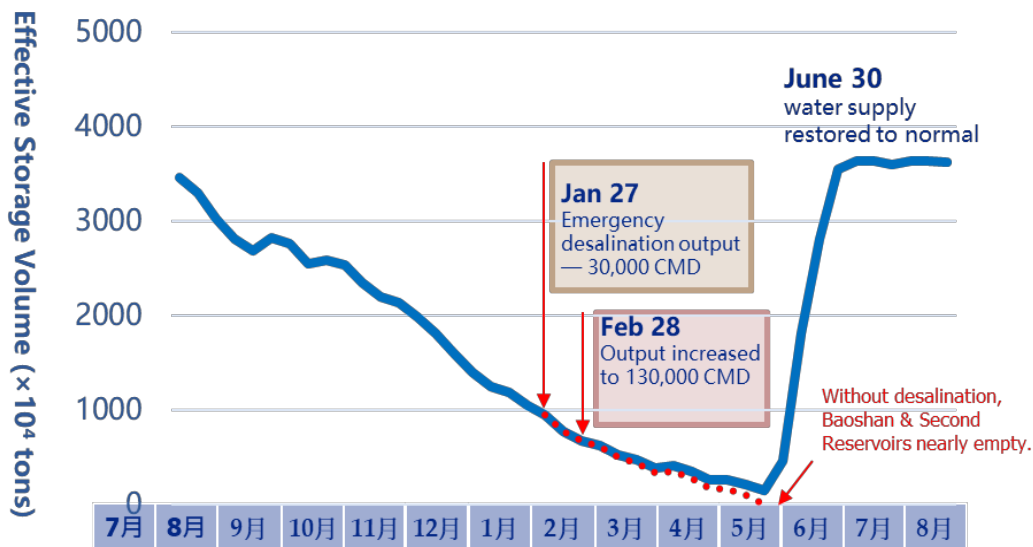
Groundwater: ~25%



Emergency Desalination Support During Droughts

- ◆ In 2021, Taiwan's severe drought: An emergency desalination plant was built in Hsinchu within just 66 days, producing 13,000 tons of water per day — enough for 50,000 people's daily use.
- ◆ In 2023, drought in southern Taiwan: Hsinta Power Plant's temporary desalination facility was completed in 40 days, supplying 15,000 tons/day.

**Baoshan & Second Reservoirs —
Effective Water Volume (Jul 2020 – Aug 2021)**



**Hsinchu Emergency Desalination
Plant — 13,000 tons/day Output**



**Kaohsiung Emergency Desalination
Plant — 15,000 tons/day Output**

Advantages of Emergency Desalination Plants

Easy Assembly

Rapid
Deployment

Quick Disassembly
& Transport

Flexible
Mobility



Advantages of desalination

Faster, Compact, and More Stable than Traditional Water Sources



**Hsinchu
Desalination Plant**

**Example:
Hsinchu Area
Planning**



**Baoshan & Third
Reservoirs**

100,000 m³/day

4 years

NT\$12 billion

Low

Supply Volume ✓

✓ **Construction**

✓ **Cost**

✓ **Environmental Impact**

250,000 m³/day

15 years

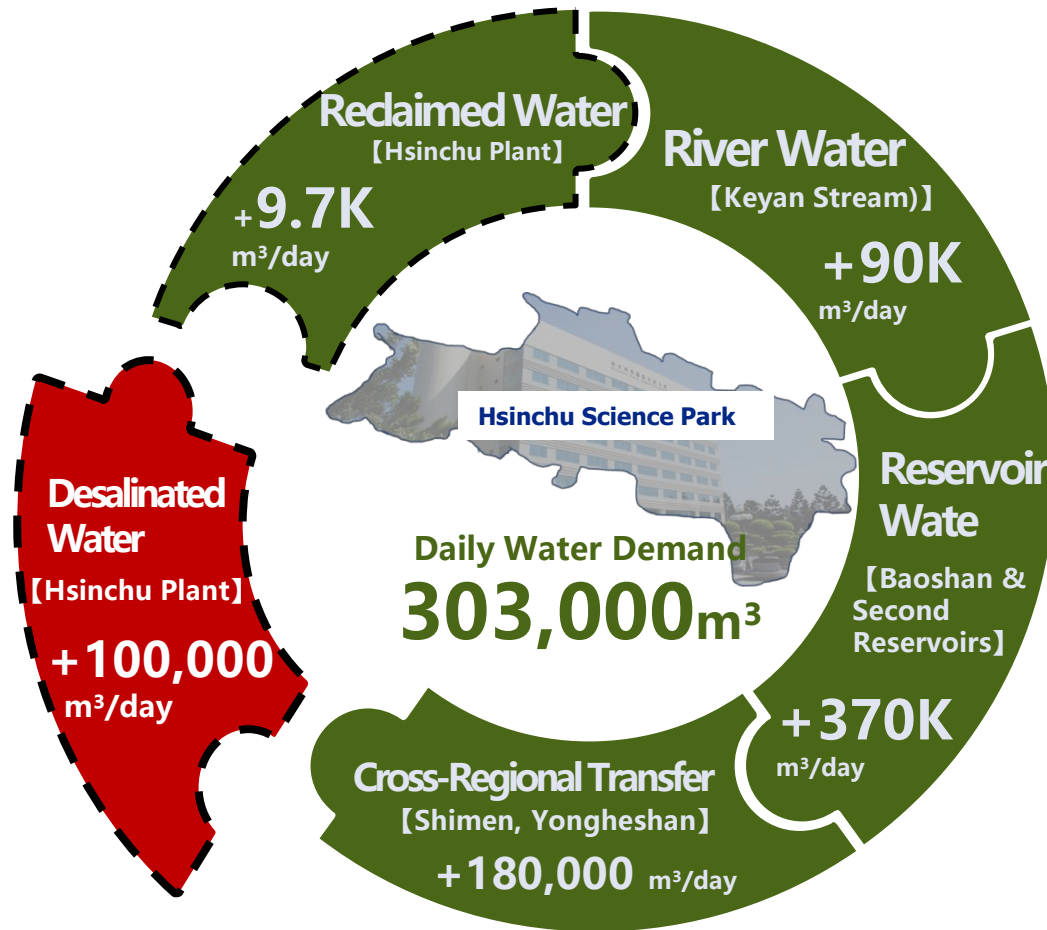
NT\$35 billion

High



Enhancing Water Resilience Through Desalination for High-Tech Industries

Example: Hsinchu Area



Ongoing Efforts

Riverbank filtration, reclaimed water, and inter-regional transfers are key infrastructure projects.

Hsinchu Desalination Plant

A key component

A vital facility ensuring a stable water supply for Hsinchu Science Park



Expanding desalination for water resilience

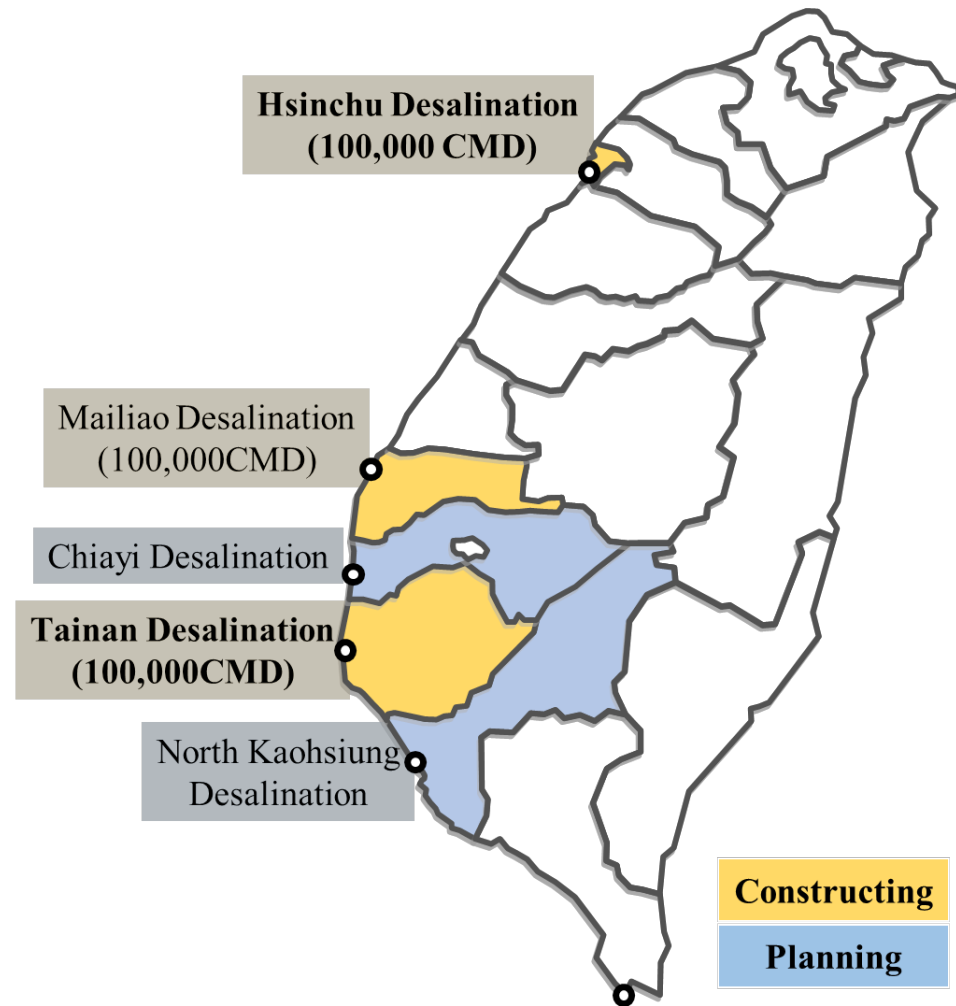
3 Plants Under Construction

Mailiao Desalination

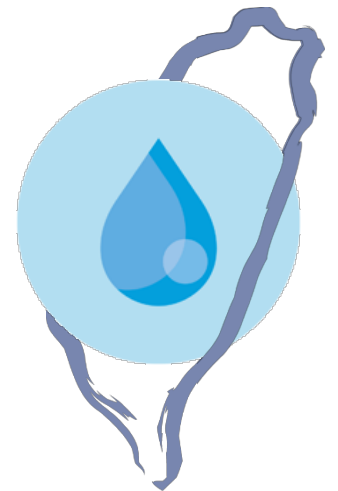
Hsinchu & Tainan Desalination —
Operation expected in 2027–2028

2 Plants Under Planning

Chiayi
North Kaohsiung



3. Promotion Strategies

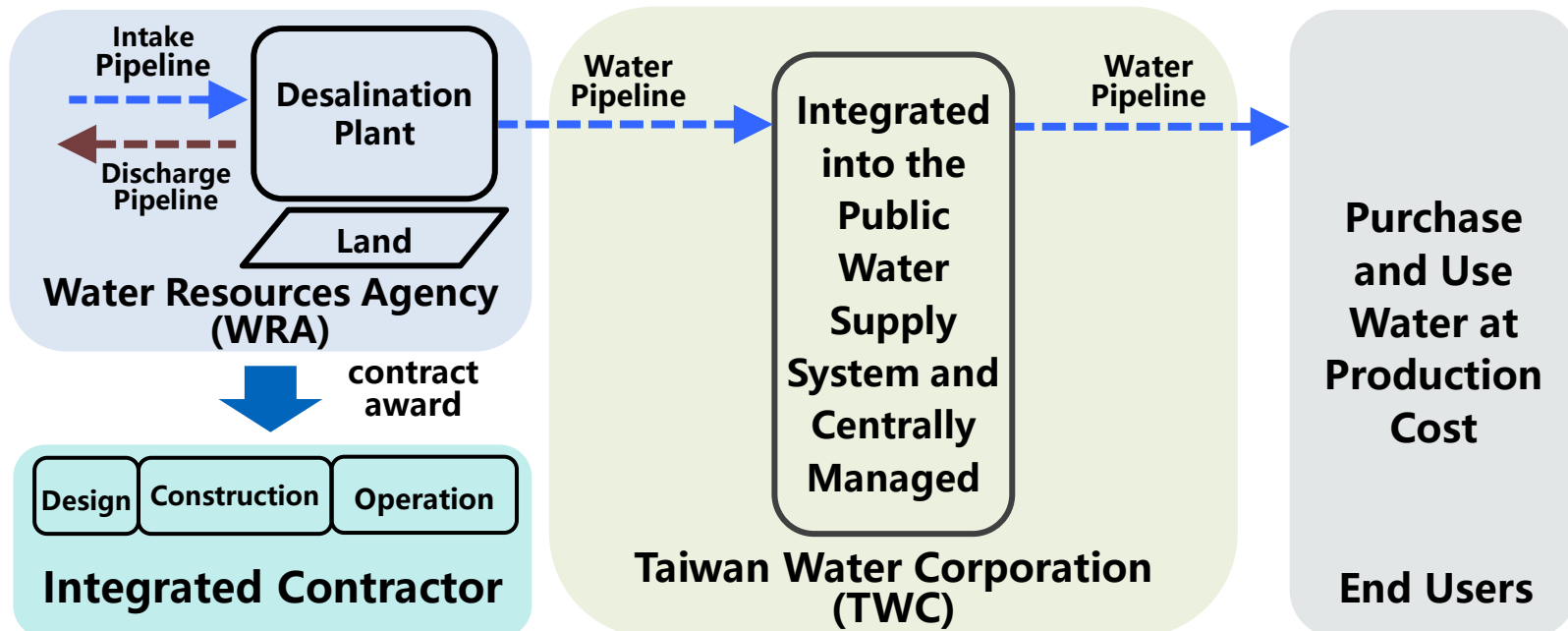


Construction Pattern of the First Two Large-Scale Desalination Plants

Public Construction Model Implementation:

- ✓ Adopts an integrated design–build approach for joint planning and design, ensuring quality through a three-tier control system, and promoting technology transfer and local industry development via domestic and international cooperation.
- ✓ Considers industrial water demand, regional characteristics, and flexible water allocation.

Division of labour and operating authority



Corporate Participation to Ease Government Burden

Encouraging Corporate Purchase of Desalinated Water

High-tech companies are encouraged to buy desalinated water.

Reduces government spending by about

NT\$ **14.7** billion per year

Corporate participation ensures additional water sources for high-tech industries.

Promotes new water resource development and industrial resilience.

Serves as a regional water security measure.

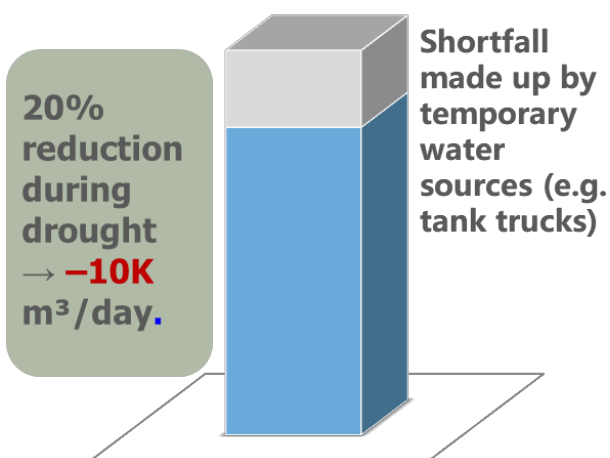
Priority of Desalinated Water Allocation

Example:

A company using 50K m³/day faces a 20% cut during droughts. With a 10K m³/day desalinated water purchase, supply is maintained.

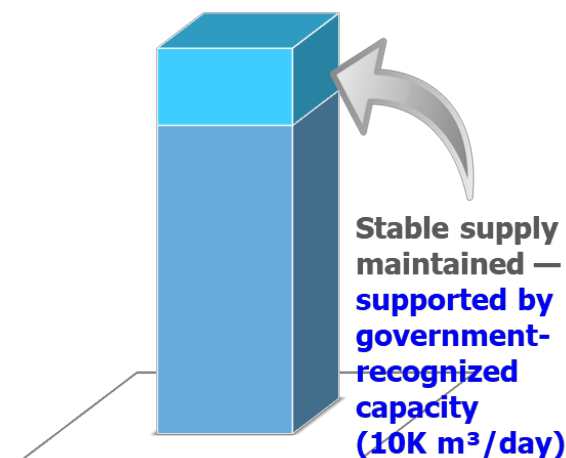
Without Desalinated Water Purchase

Total Supply: **40K** m³/day



With 10K m³/day Desalinated Water Purchase

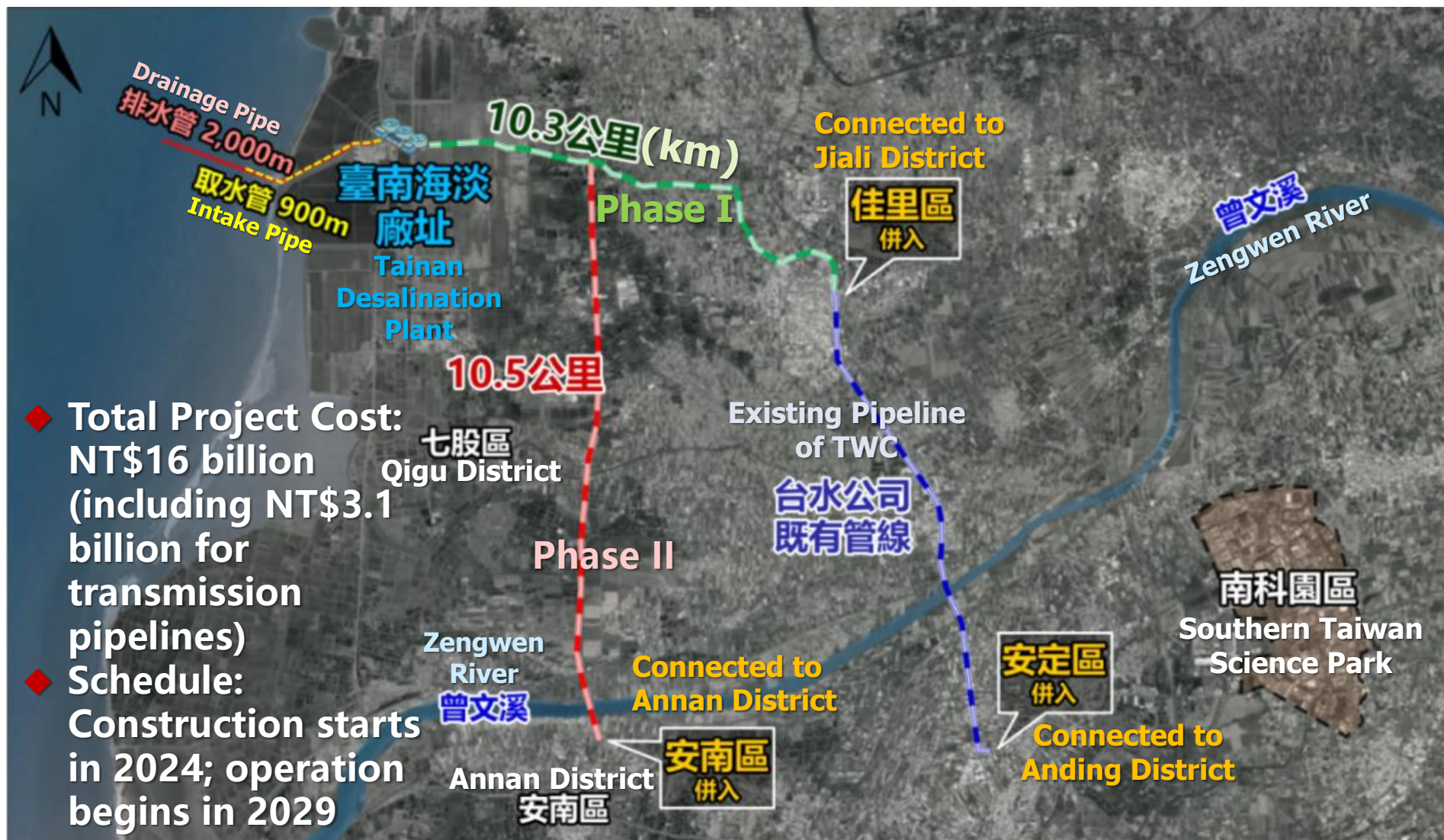
Total Supply Maintained: **50K** m³/day



Hsinchu Desalination Plant



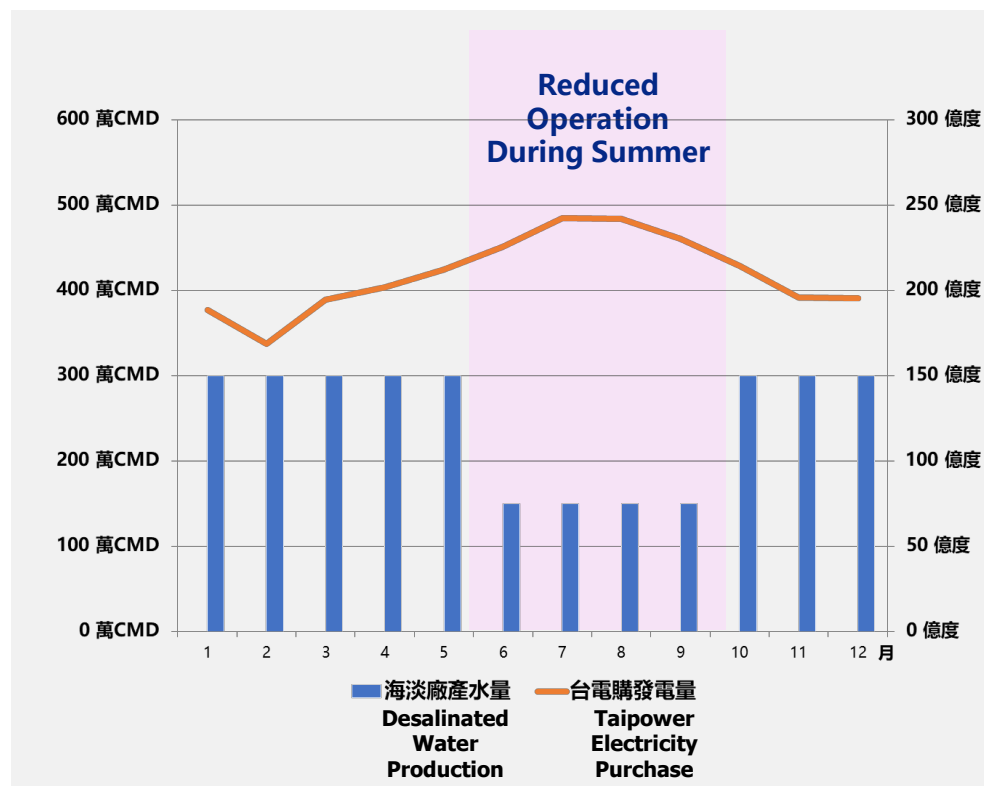
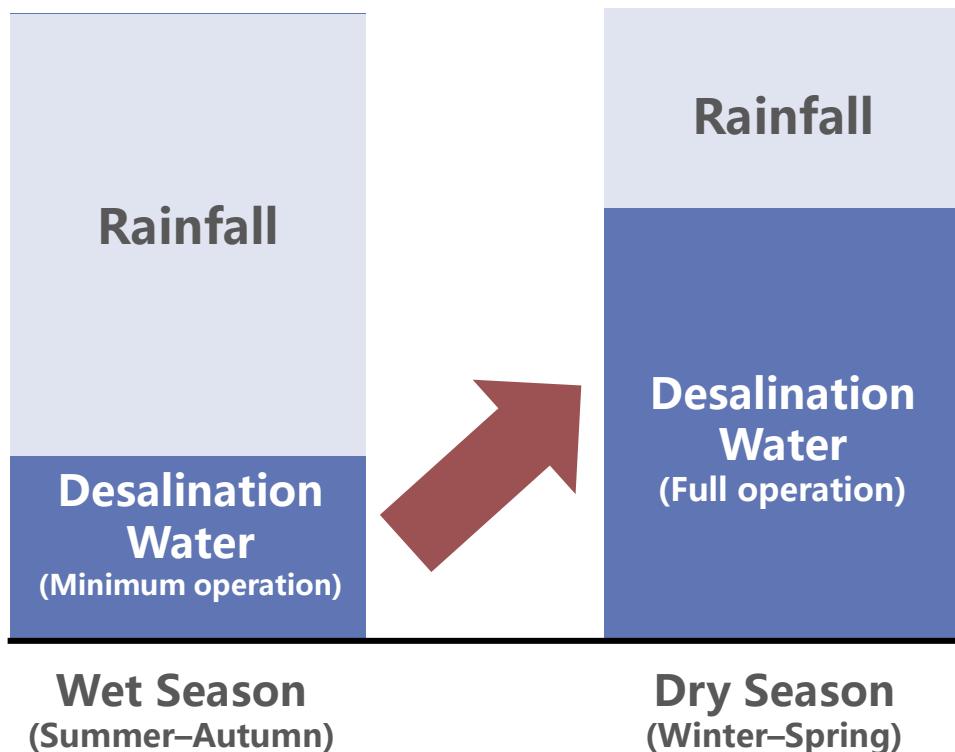
Tainan Desalination Plant



- ◆ **Total Project Cost:** NT\$16 billion (including NT\$3.1 billion for transmission pipelines)
- ◆ **Schedule:** Construction starts in 2024; operation begins in 2029

Integrated Use of Desalinated and Regional Water

- ◆ **Wet Season (Summer–Autumn):** More rainfall → **Lower desalination output**, reduced power consumption
- ◆ **Dry Season (Winter–Spring):** Less rainfall → **Higher desalination output**, stable power and water supply



Desalination in Harmony with the Local Environment

A New Benchmark for Sustainable Operation



Green Building



Landscape Integration



Environmental Education



Sustainability & Low Carbon



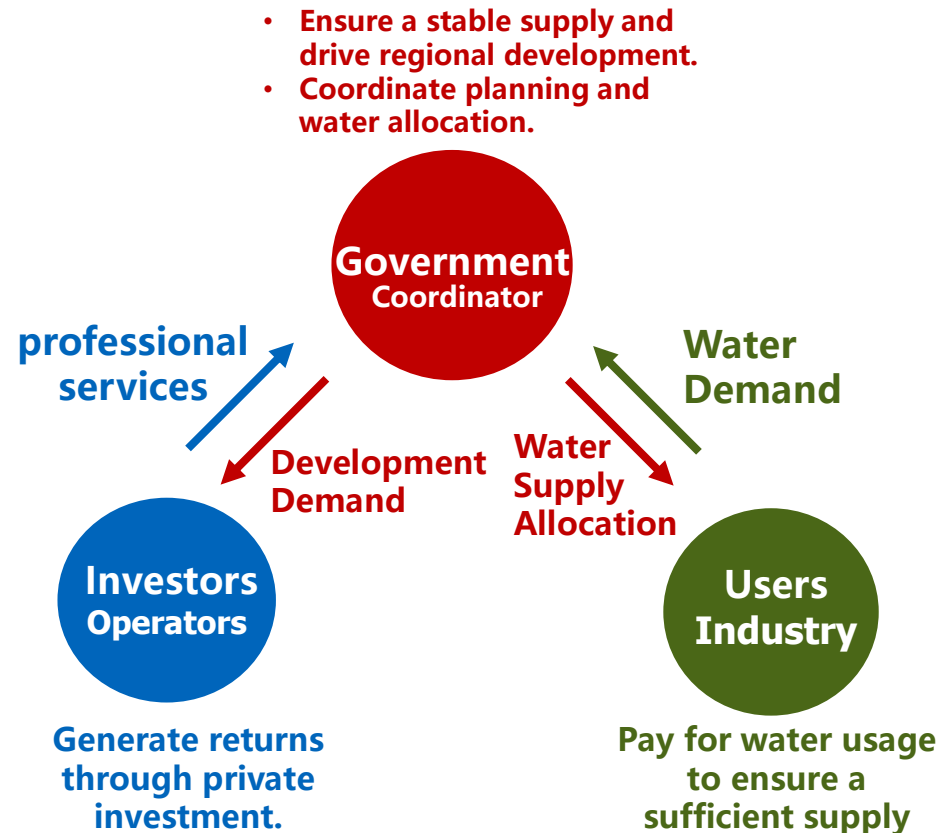
Hsinchu Desalination Plant



Tainan Desalination Plant



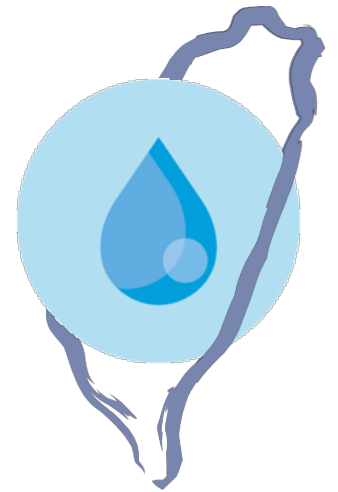
Future Desalination Plants Adopt the PPP Model



Tripartite Win-Win PPP Model



4. Conculsion



Conculsion

◆ Introducing **International Technology** — Driving Desalination Industry Growth

Adopting the latest RO technology improves efficiency, reduces brine discharge, and strengthens local desalination capability.

◆ **Diversified Water Sources** — **Reliable Supply**

Desalination enhances stability and flexibility, ensuring uninterrupted water for industries.

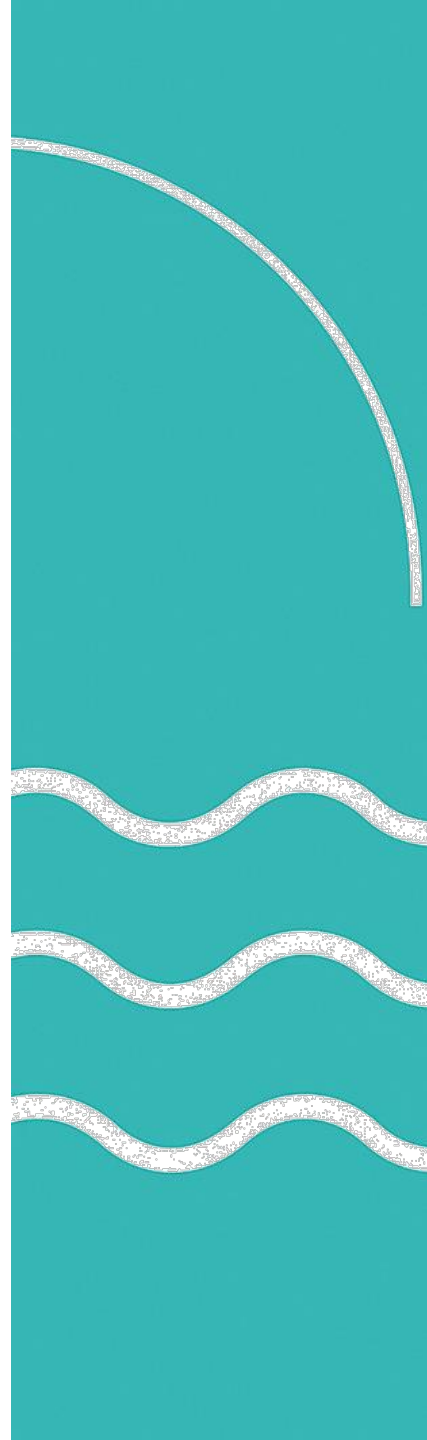
◆ **Integrating with Local Environment** — Driving Tourism & Community Growth

Boosting the economy and local vitality by blending desalination plants into the landscape.



End of Presentation

Thank you



Experience Sharing on the Promotion of Hsinchu Desalination Plant



Northern Region Water Resources Branch, WRA, MOEA

Director : Chiang, Ming-Lang



Contents

I. Project Overview

II. Experience Sharing

III. Conclusion

新竹

An aerial photograph of a large, modern building complex, possibly a university or corporate campus, featuring multiple interconnected buildings with flat roofs and large windows. The complex is surrounded by lush green trees and landscaping. The entire image is overlaid with a semi-transparent blue filter and a fine dot grid pattern. Centered over the image is the text 'I. Project Overview' in a bold, dark blue serif font with a thin yellow outline.

I. Project Overview



Approval of the project 核定計畫



■ 2022/07/13

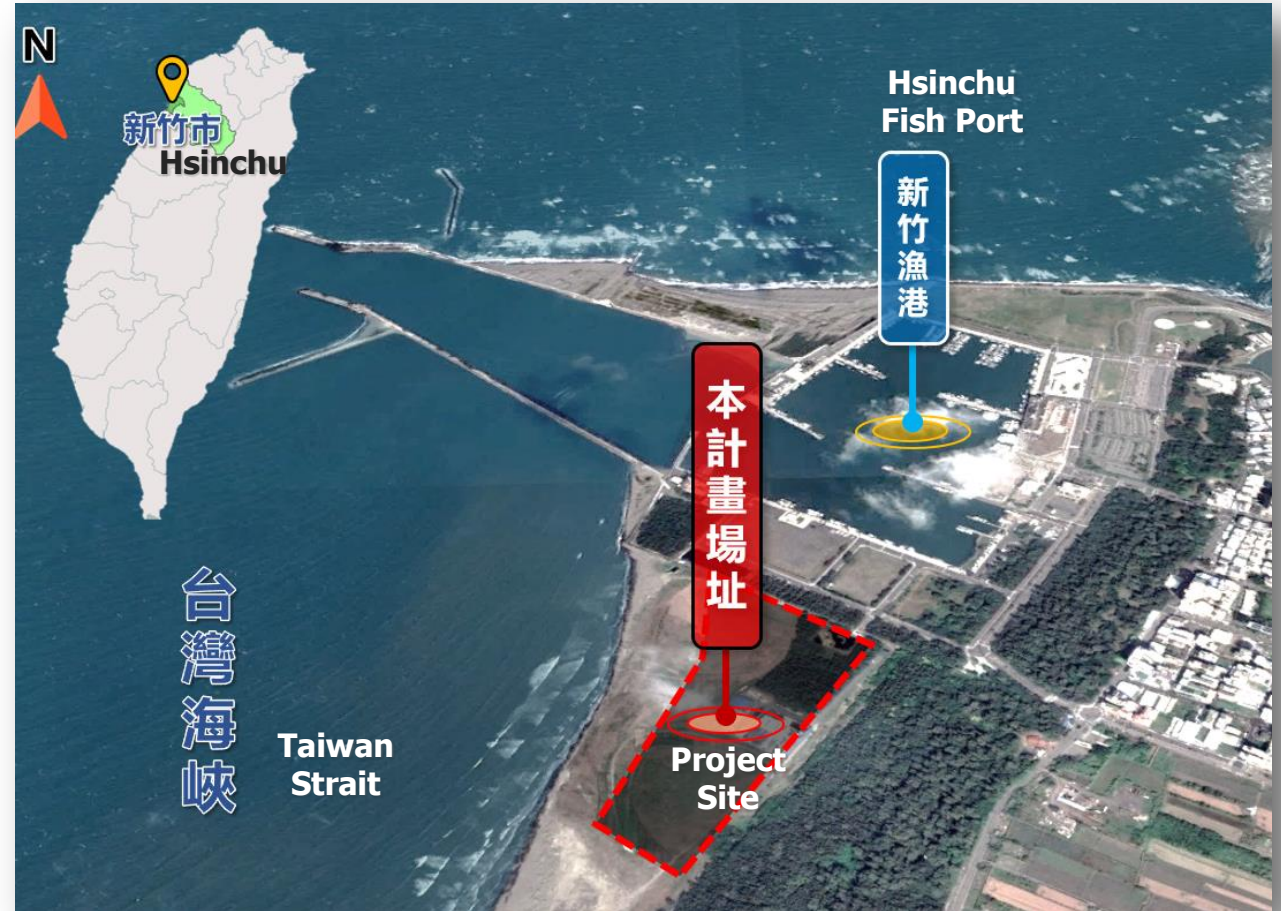
The environmental impact assessment passed after reviewing.

■ 2023/04/27

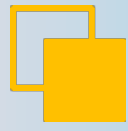
The Executive Yuan approved the project with a total budget of NT\$12 billion.



- The water storage rate of Baoshan II Reservoir in Hsinchu dropped below 3%, in 2021.



- PROJECT SITE



Main work items 主要工項



Intake, Discharge Pipe & Desalination Plant

- ◆ Intake Pipe: 1.6 km
- ◆ Discharge Pipe : 1.8 km
- ◆ Desalination Plant: 100,000 / day

Water pipeline & Water Distribution Tank

- ◆ Water pipe : 9.9 km
- ◆ Water Tank: storage 30,000 m³





Full life circle of the plant 海淡廠生命週期



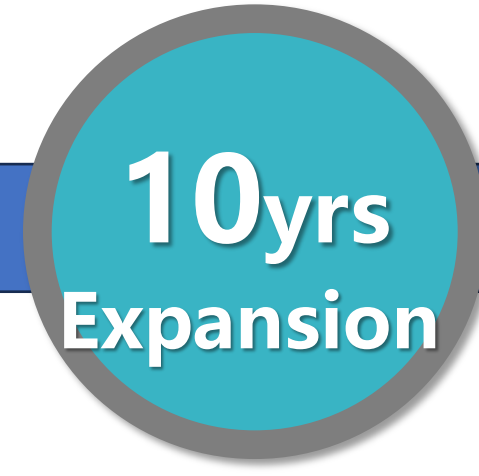
- Planning Work
- Design Work
- Construction of the Desalination Plant
- Construction of Intake and Discharge Pipelines



- 1 year commissioning
- Desalinated water quality should meet the standard in the contract (better than drinking water)



- Operation, and Maintenance
- The amount of water will be adjusted according to the demand of WRA
- Minimum daily production: 10,000 cubic meters



- If the operational performance remains well for over 10 consecutive years, the turnkey contractor may continue the subsequent 10-year expansion O&M work.

<Project period approved by the Executive Yuan>



Joint Venture contractors 統包團隊

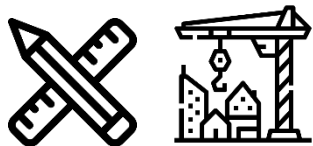


Construction period

CTCI 中鼎

Main Project Items

- Basic and Detailed Design
- Desalination Plant Construction



 **suez**

Main Project Items

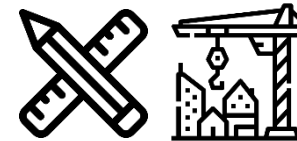
- Basic and Detailed Design
- Desalination Plant Construction
- Operation and Maintenance



 宏華

Main Project Items

- Basic and Detailed Design
- Construction of Intake and Discharge Works



ECOVE 信鼎

Main Project Items

- Desalination Plant Operation and Maintenance



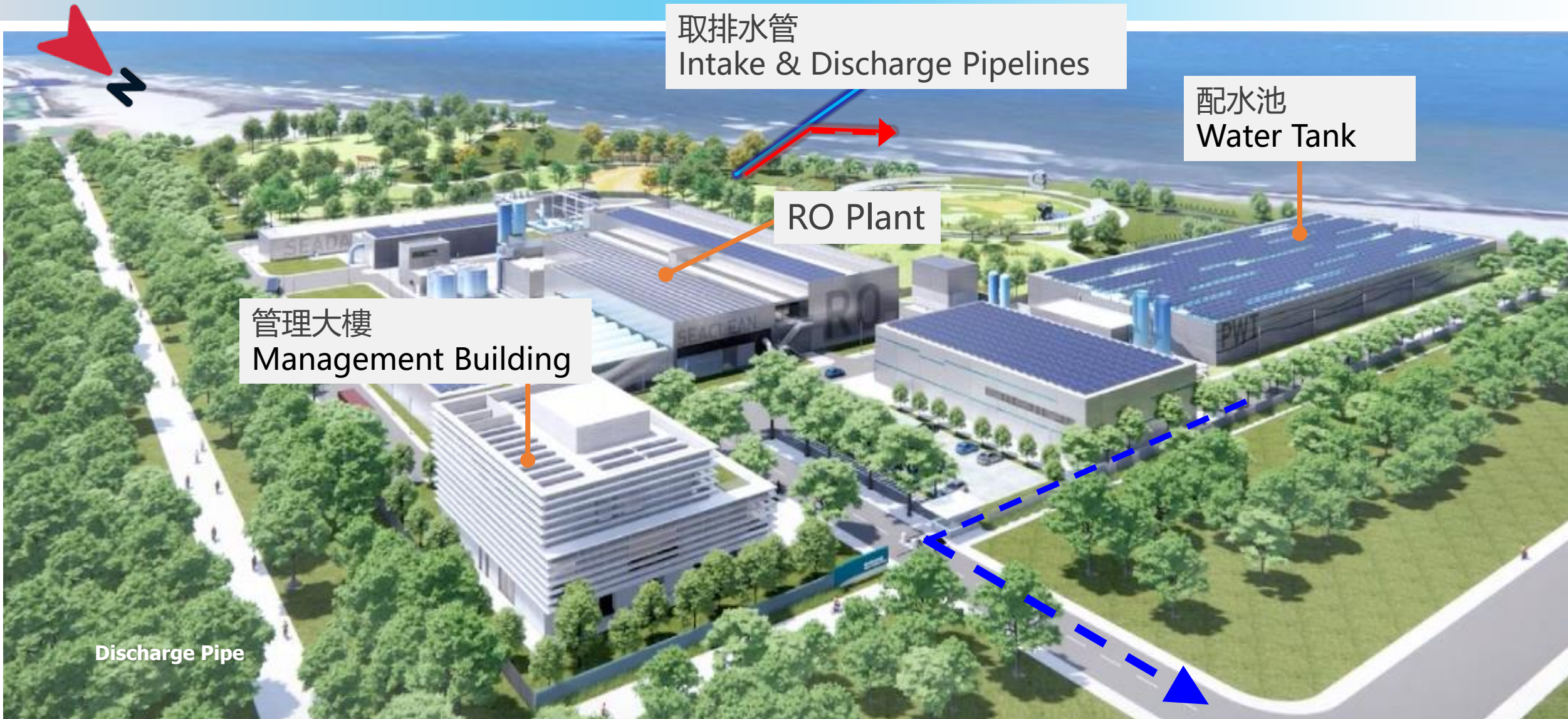
Project timeline 計畫期程



Work Phases	Work Items	Project Timeline				
		2024	2025	2026	2027	2028
Design and build	Intake & Discharge Pipelines					
	Desalination Plant					
	Water pipe & Distribution Tank					
Trial operation	Phase I					
	Phase II					

★Progress Status : 32.3%

Vision Diagram 完工願景圖





Video of Vision



新竹海水淡化廠興建及操作維護



An aerial photograph of a modern university campus. The campus features several large, multi-story buildings with blue facades and white accents. The buildings are surrounded by lush green trees and landscaped grounds. In the background, a body of water is visible under a clear sky. The overall scene is bright and vibrant, suggesting a sunny day.

II. Experience Sharing



Procurement or PPP? 招商模式



- According to statistics from 2015, among large-scale desalination plants with a capacity of over 100,000 CMD around the world, 21 were implemented through procurement採購, while 18 were developed under PPP models促參.

- **Construction Phase**: Financing



- PPP: contractors face heavy financial pressure
- Government Procurement: requires large short-term budget allocation

- **Operation Phase** : Operation Cost



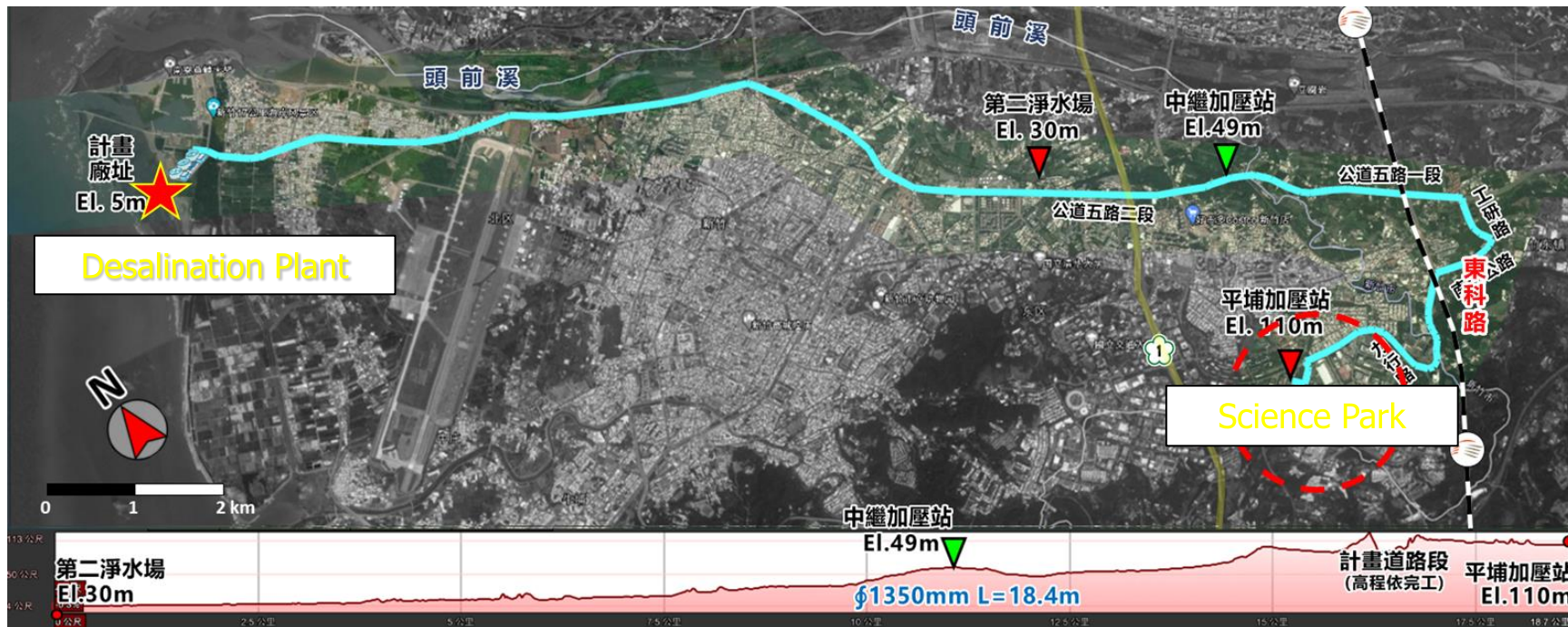
- The plant will mainly act as backup water supply備援性質, often unable to run at full capacity.
- Fixed water price 自來水價 makes true costs unrecoverable.
- ❖ Decided to proceed in accordance with the Government Procurement Act政府採購法, with the government owning and operating the facility, similar to reservoir.



Water supply mode 供水模式



- Direct supply to Hsinchu Science Park(EL.110m) requires high pumping power → low power efficiency.
- Serving only industrial users工業專管 lacks justification.
- ❖ Integration into the regional water network自來水系統 improves drought resilience and public acceptance.





Water Production mode 產水模式

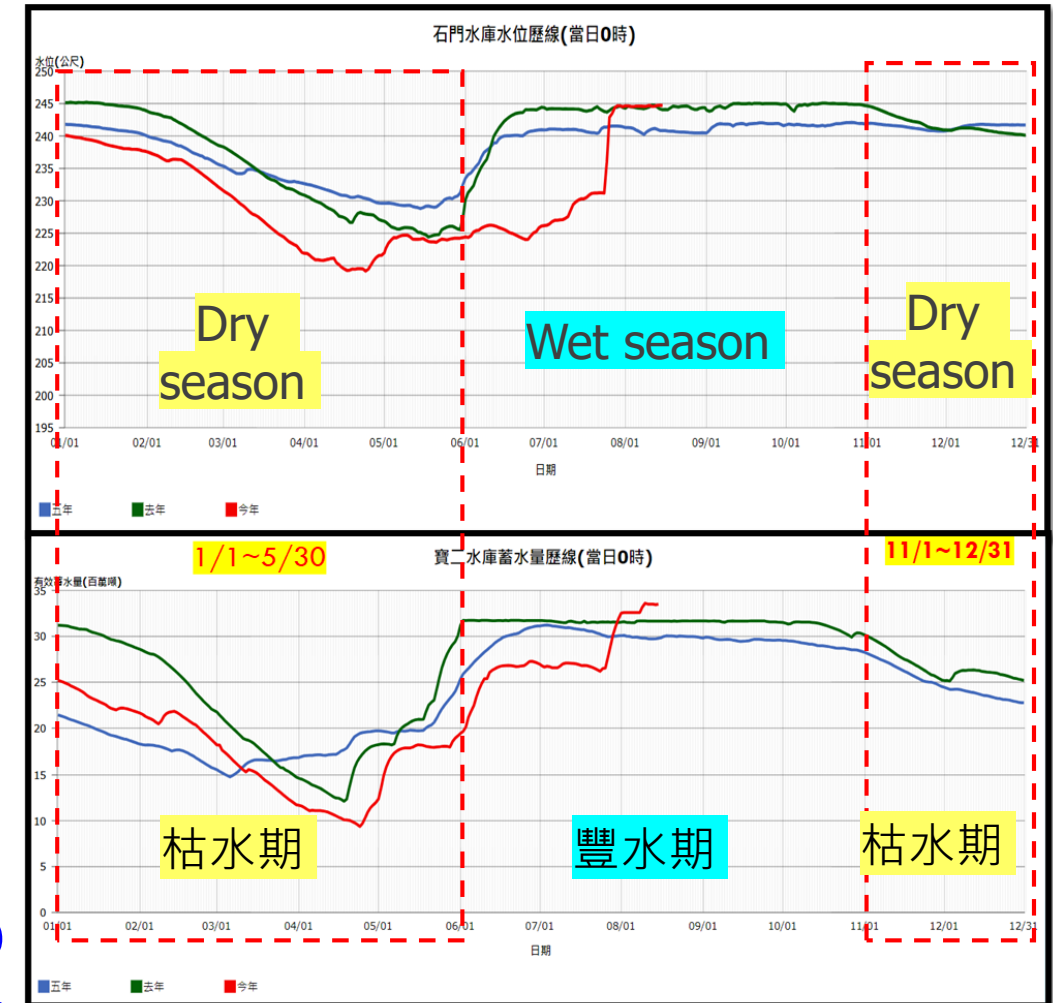


- Baoshan II Reservoir & Shihmen Reservoir → all share similar hydrological conditions.
- Large variations between wet and dry season :
 - Wet season: Low demand for desalinated water.
 - Dry season: High demand, which means the desalination plant should operate in maximize production to prevent shortages.

❖ Water Production mode :

Wet season (Jun. to Sep.) : min 10,000 CMD

Dry season (Nov. to May) : max 100,000 CMD

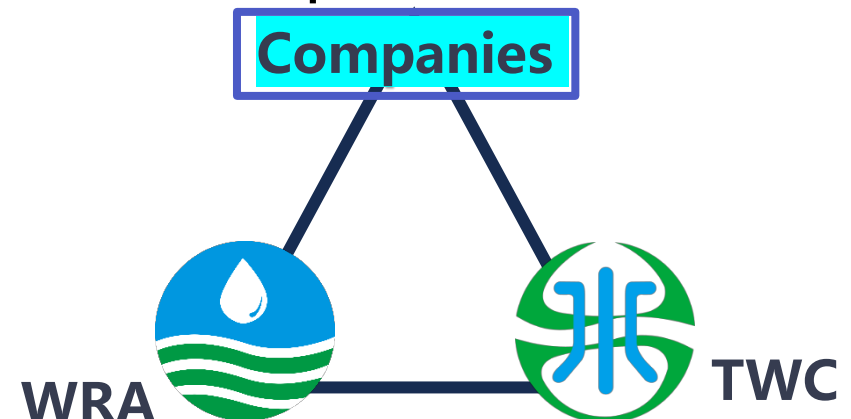




Operating Expenses 營運費用籌應



- ◆ The operating cost is around NT\$25~30 per ton, nearly three times the current tap water price.
- ◆ According to the Executive Yuan, the construction cost of the desalination plant is funded by the government, and the operating cost will be covered through **corporate subscription**企業認購.
- ◆ Six companies of the science park have signed the tripartite contract with the government and Taiwan Water Corporation, subscription rate 100%.
- ◆ the government guarantees the priority of water supply to these 6 companies during drought season.

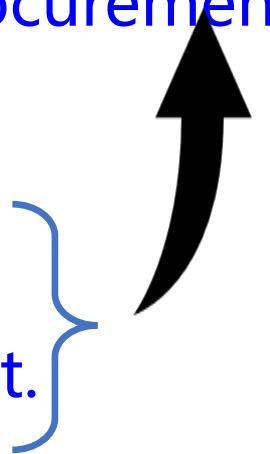




Procurement Strategy 採購策略 (1/2)



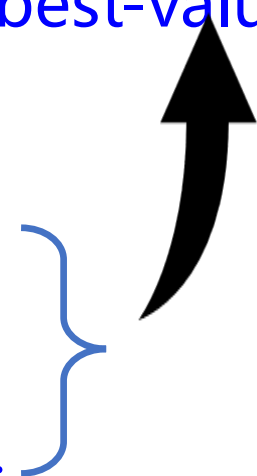
- ◆ The Executive Yuan only promised the construction budget, not included operating cost.
- ◆ Possible procurement alternatives:
 1. Conduct separate procurements — first for construction works, followed by a separate tender for operation and maintenance.
工程興建、操作維護分別發包
 2. Combine construction、operation & maintenance into one procurement
工程興建、操作維護合併發包
- ◆ Procurement Decision:
 - Desalination requires high technical expertise.
 - Corporate subscription is financially uncertain for procurement.
 - Splitting tenders may cause coordination issues.



Procurement Strategy 採購策略 (2/2)



- ◆ The total cost amounts to nearly NT\$20 billion, including NT\$7.27 billion for construction and NT\$10.44 billion for operation and maintenance.
- ◆ Possible tendering methods under the Government Procurement Act:
 - alternative 1: Open tender with the lowest bid passing evaluation criteria.
公開招標評分及格最低標
 - alternative 2: Open tender with the most advantageous bid (best-value selection). 公開招標最有利標
- ◆ Procurement Decision
 - First large desalination project by the WRA —symbolic value.
 - Taiwan is not familiar with large desalination plants.
 - Required joint tender between local and international partners.





Turn resistance into driving force(1/2)

化阻力為助力



1. Before construction 施工前: Relief and Compensation for the Impact on fishermen's livelihoods 漁業補償

Affected Parties:

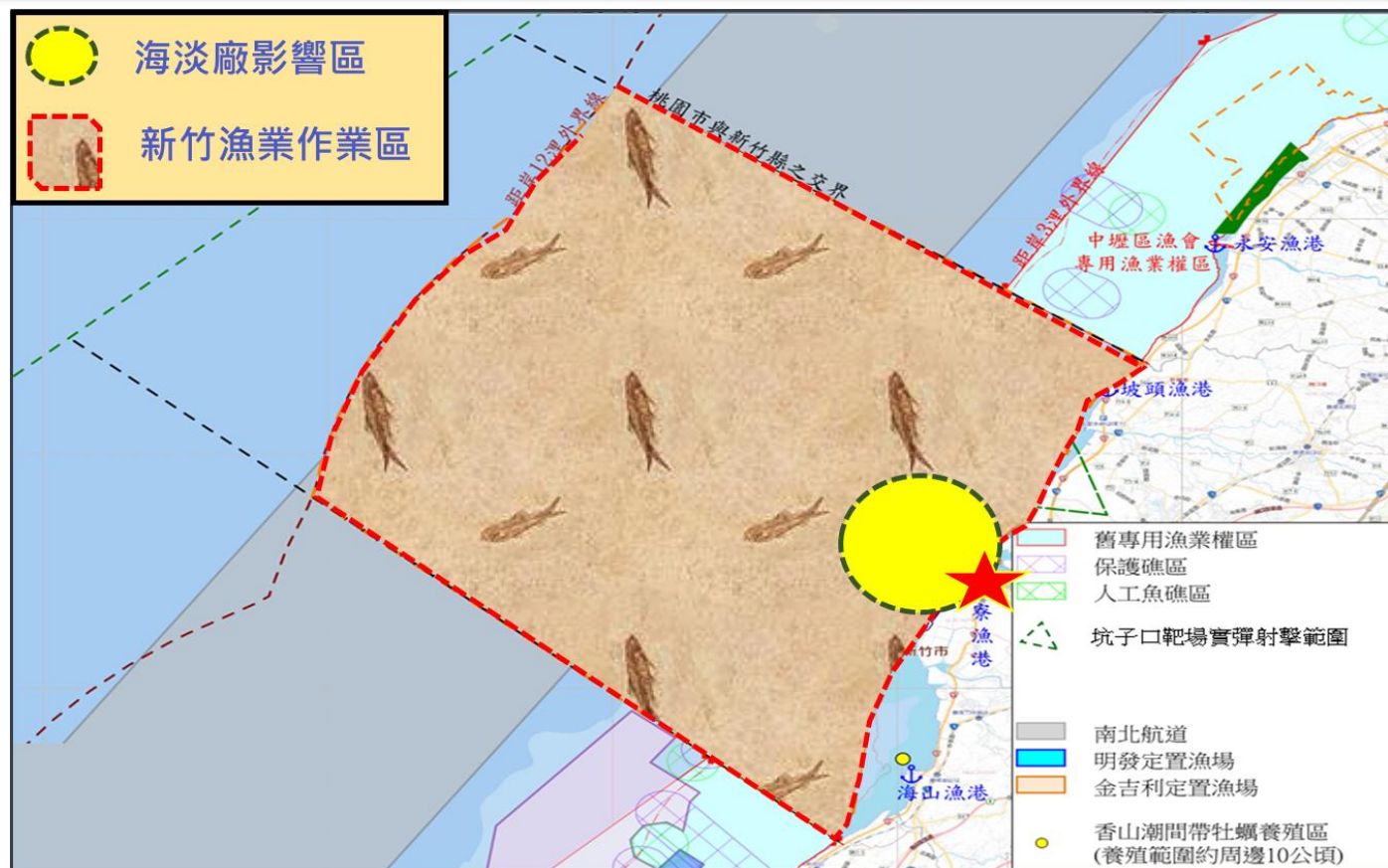
Hsinchu Fishermen Union Members

Number of People Affected: **12,815**

Number of Vessels Affected: **458**

Area of Impact: **9.3 km²**

- ❑ Compensation provided equivalent to that for exclusive fishery rights
- ❑ Multiple rounds of communication and negotiation conducted
- ❑ Relief payments totaling NT\$175 million
- ❑ Disbursed before construction commencement





Turn resistance into driving force(2/2)

化阻力為助力



2. Construction Phase 施工期: Assistance to Local Construction 周邊環境改善

- a total of NT\$274 million (3% of the direct cost of project) was allocated.
- The funding supports Hsinchu City Government to improve near environments and landscapes.

3. Operation 營運期: Support for Local Public Welfare Projects 公益支出

- A public welfare budget is allocated each year based on the water supply revenue of previous year. Approximately NT\$8 million is allocated annually as local subsidies, totaling NT\$200 million over the 25-year operation period.
- These funds are used to **subsidize nearby local agencies, public schools, and public welfare organizations or groups.**



An aerial photograph of a modern university campus. The image shows several large, multi-story lecture halls with tiered seating, surrounded by lush green trees and landscaped grounds. The architecture is contemporary, with flat roofs and large windows. The overall scene is bright and clear, suggesting a sunny day.

III. Conclusion

Conclusion



- ❑ Hsinchu Desalination Plant is **the first large-scale desalination plant in Taiwan** and serves as a solution to stabilize public water supply in the Hsinchu area.
- ❑ The unit cost of desalinated water is higher than the tap water, and the industrial water usage accounts for a significant portion in Hsinchu, that makes it possible for **corporate subscription** to cover the **O&M costs of the desalination plant**.
- ❑ The smooth implementation of large-scale public construction projects depends on the support of local residents. **Communicating to achieve the greatest consensus** on compensation plays an important role at the beginning of the project.



Thank you for your attention.

Comprehensive Planning and Experience of Reclaimed Water Development in Taoyuan City

Presenter :

Department of Water Resources, Taoyuan
LI, JIN-JING (Deputy Director General)

October 29, 2025



Water and Electricity in the AI Industry

黃仁勳抵台 談關稅戰稱台灣仍是科技生態系核心

2025/5/16 16:51 (5/16 20:53 更新)



Jensen Huang

(中央社記者吳家豪台北16日電)輝達(NVIDIA)執行長黃仁勳今天下午飛抵台灣，談到關稅戰議題表示，當全球經濟重整完成後，台灣仍會是科技生態系的核心，因為這裡有許多聰明、具有創新精神的公司，他完全看好台灣會持續蓬勃發展。

OpenAI重金結盟超微遭遇難題！蘇姿丰認了「要先搞定這件事」

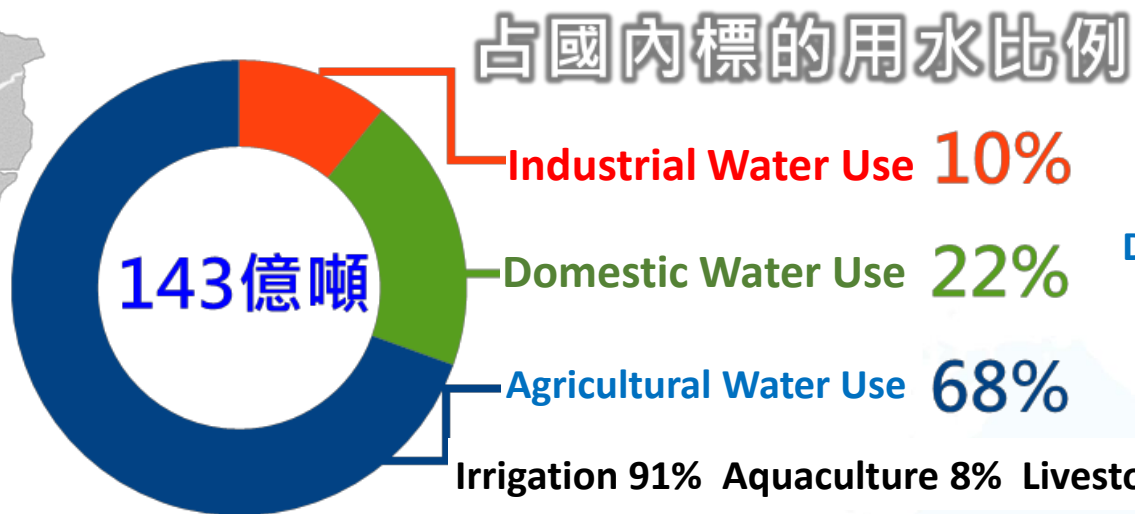
ChatGPT開發商OpenAI與美國晶片大廠超微6日敲定重磅協議，計畫未來數年部署總算力達6吉瓦的超微AI晶片。但龐大的運算規模也引發外界對電力需求暴增、可能造成缺電的疑慮。AMD執行長蘇姿丰對此表示，晶片部署時程將取決於OpenAI與超微「何時能取得足夠電力」，並強調一旦條件允許，雙方將立即推進部署。



Chatting with AI also consumes water resources!
about 500 milliliters of water for every 5 to 50 questions answered.



Utilization of Water Resources in Taiwan



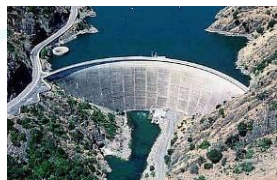
水量、水質不穩定
其他標的較難利用的水

水量、水質較穩定
其他標的亦可利用的水



Conventional
Water Resources

Sustainable Reuse
of Water Resources



Reservoir



Rainwater
Storage



Wastewater
Treatment



Seawater
Desalination

(Uneven Rainfall Distribution)

(Stable Water Supply) (Energy-Intensive)



General Information of Taoyuan City



Area
1,197.20km²

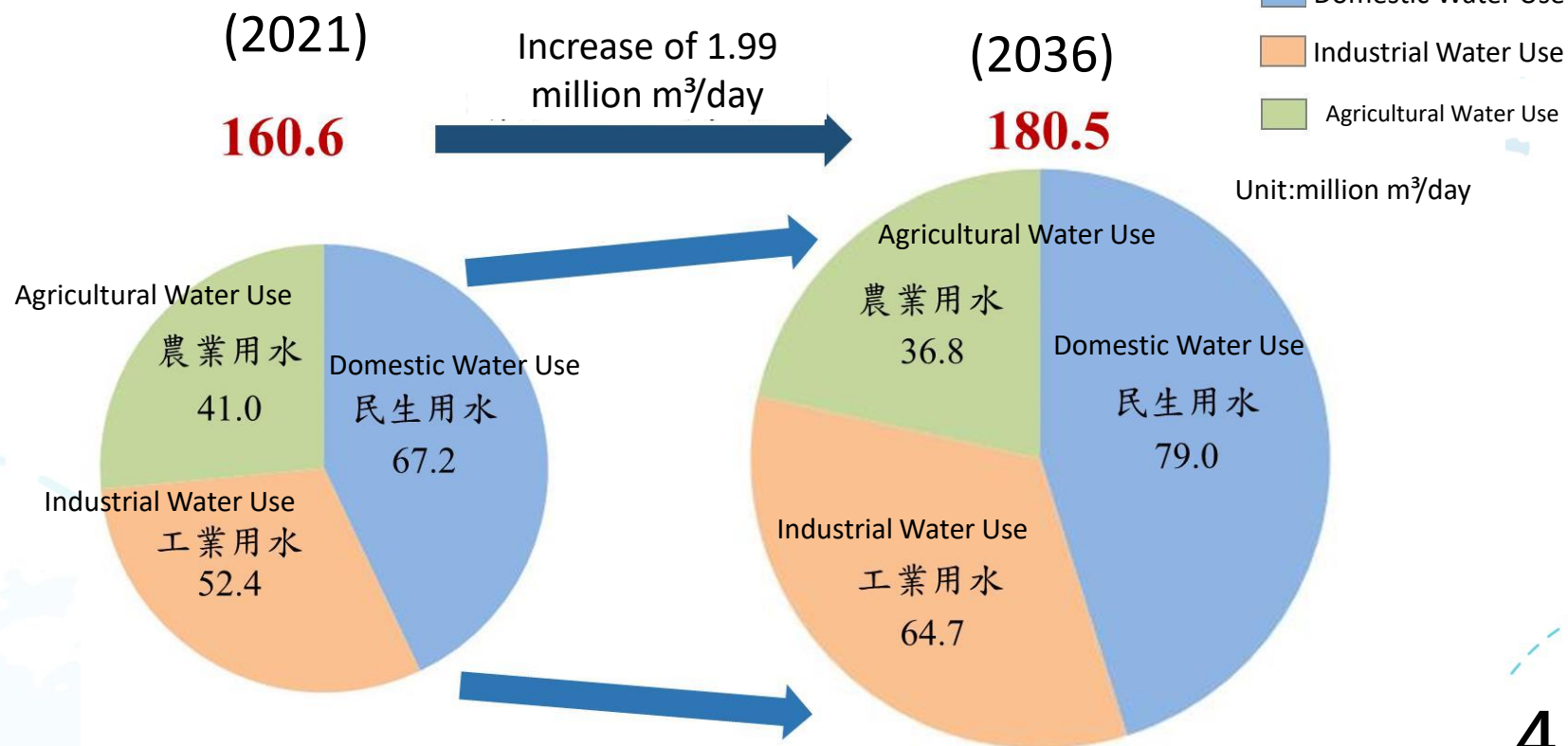


Population
2.352 million people



➤ Population Growth: **1st**

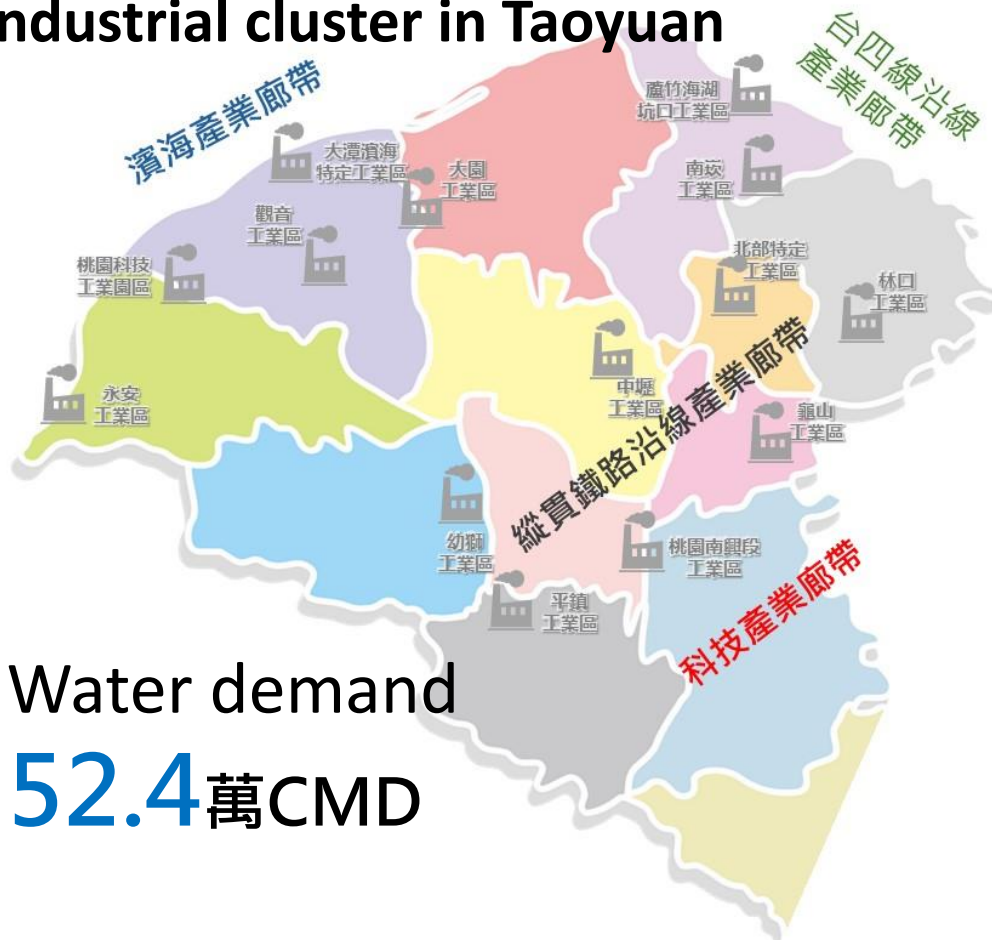
➤ Industrial Production Value: **NT\$3 trillion**



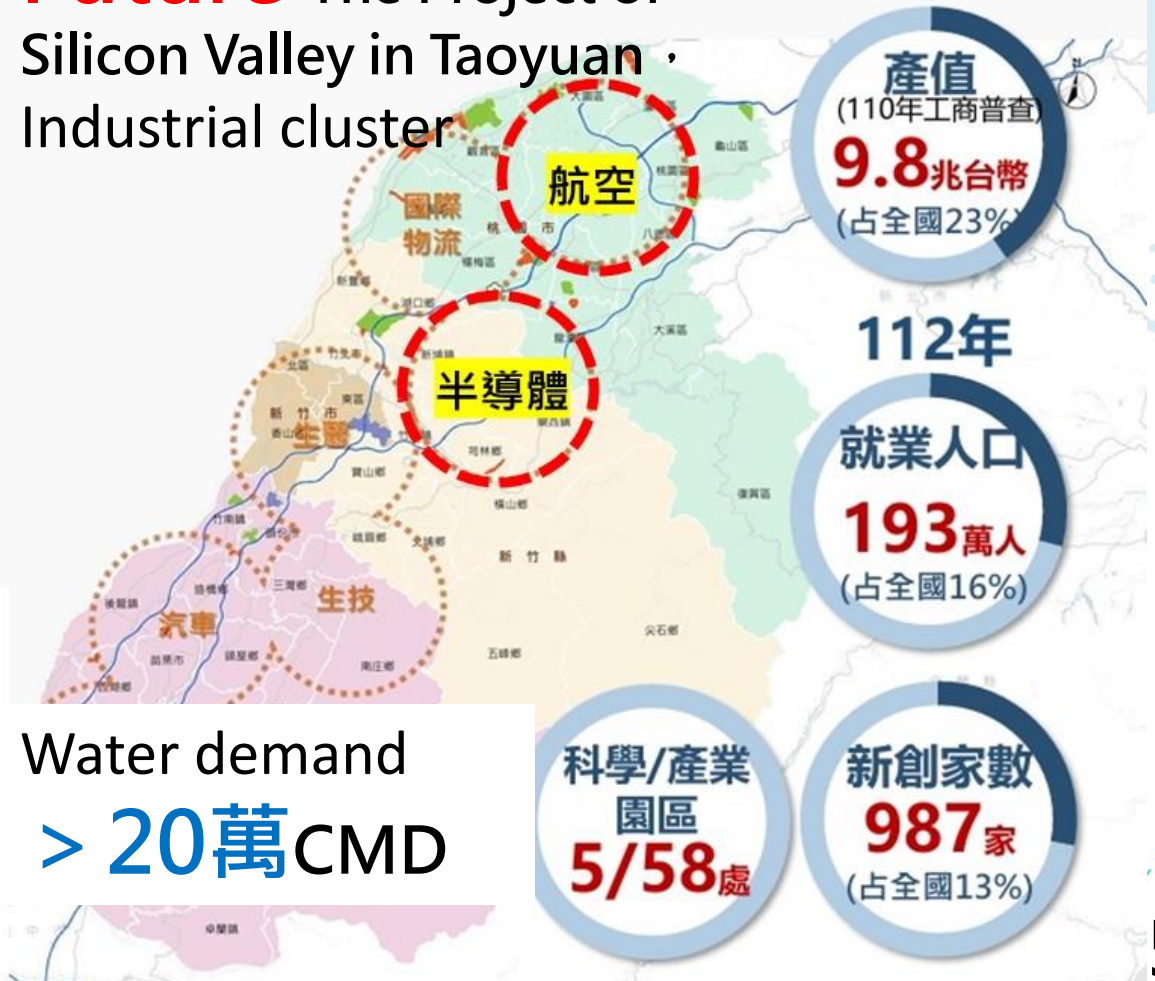
Industrial water use in Taoyuan City, Major challenge

NOW

Industrial cluster in Taoyuan



Future The Project of Silicon Valley in Taoyuan, Industrial cluster



Stable water supply is the key to economic growth.

01 Water Resource Development

- Reclaimed Water
- Groundwater
- Pond

04 Multiple Water Sources

- Industrial Reclaimed Water
- Treated Effluent for Agricultural Irrigation

03 Emergency Water Supply

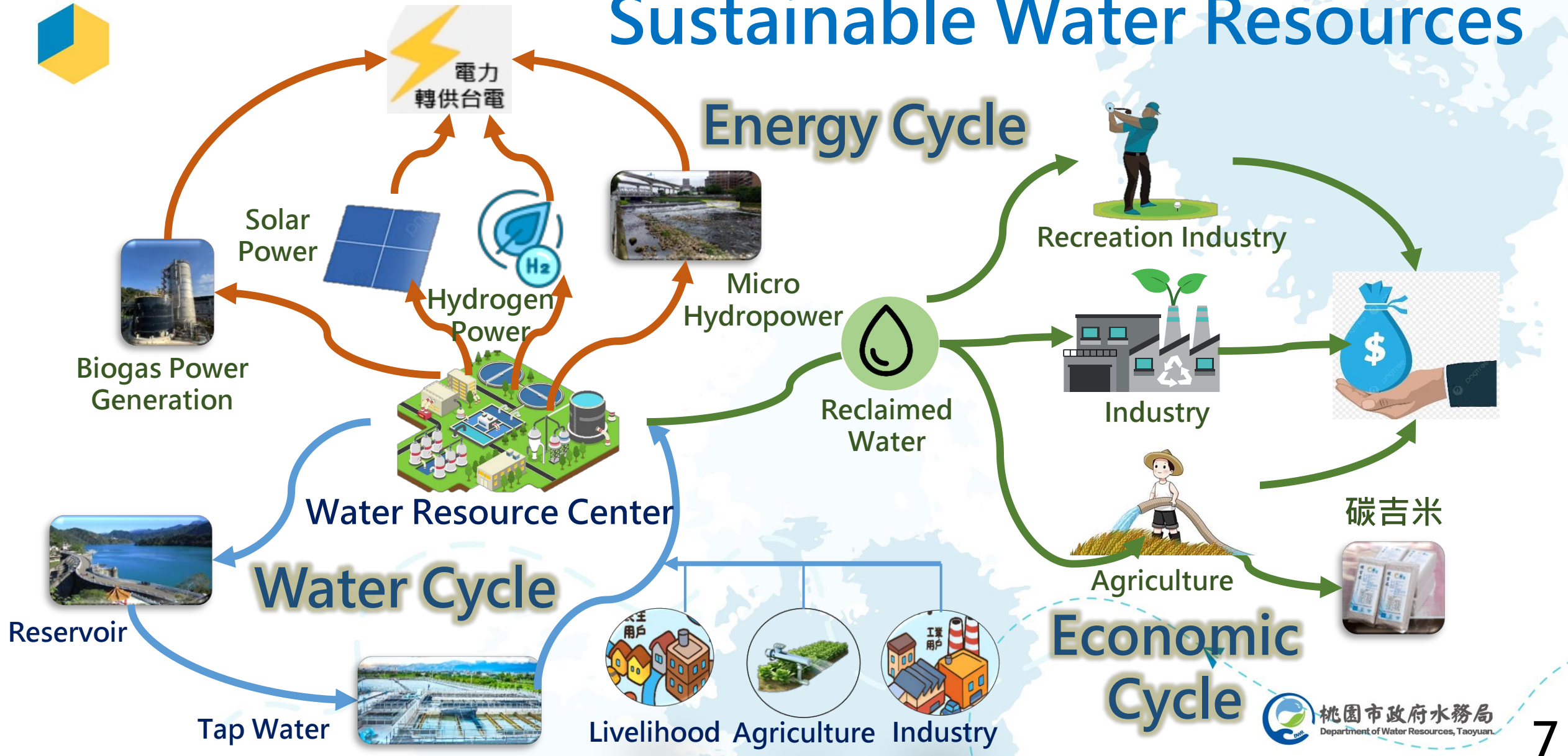
- Reclaimed Water Allocation
- Operation of Backup Wells

Stable Water Supply Planning

02 Water Conservation

- Groundwater Management
- Reuse of Industrial Water

Multi-Objective, Multi-Target, Multi-Level Sustainable Water Resources



Reclaimed Water Promotion Strategy

Water Supply of
Taoyuan City via
Networked
Treatment Plants

Smart Operations
and Management
Integrating IoT
Technology

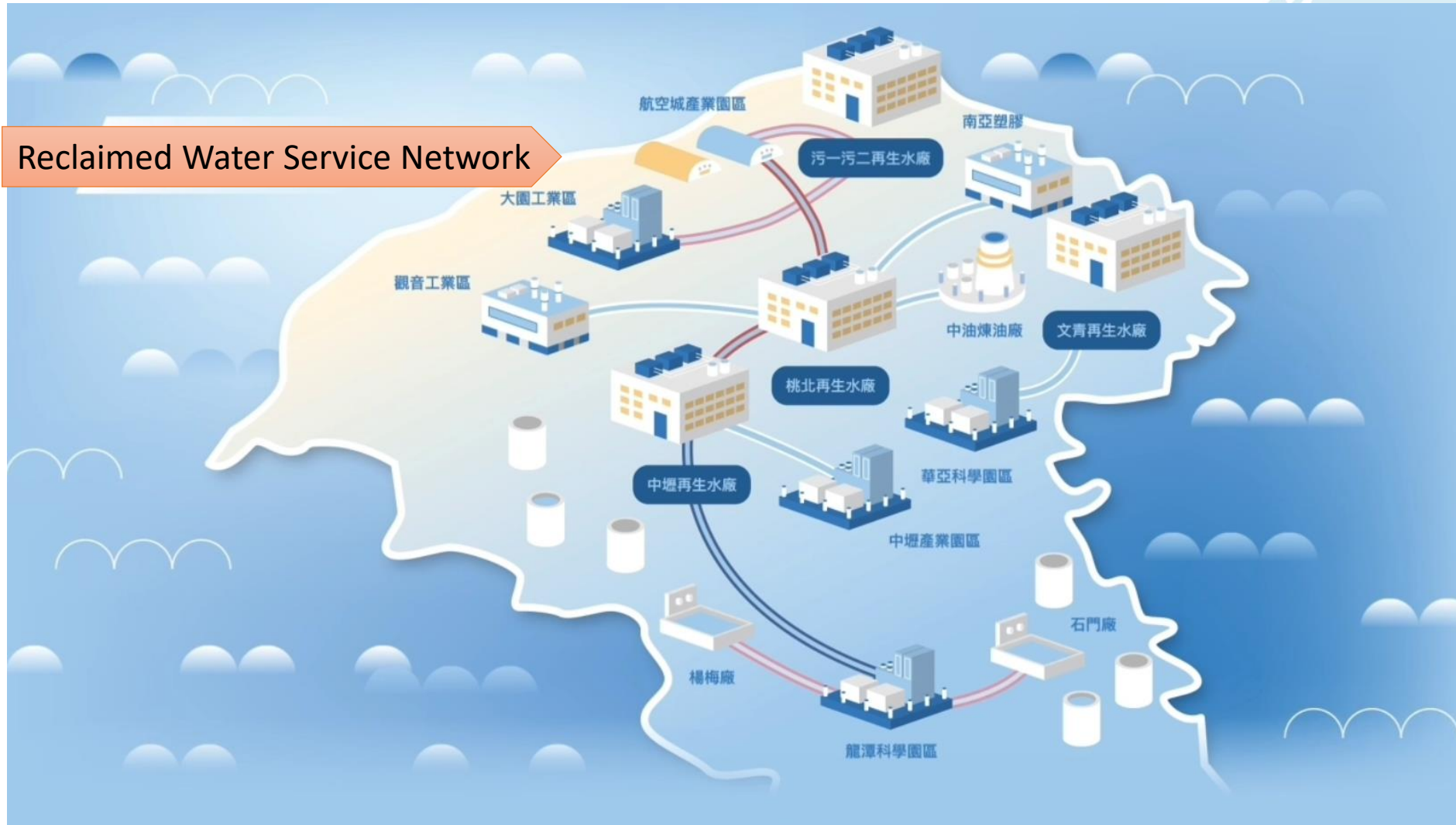


Providing New Water
Value Through
Diversified Services

City-Wide Carbon
Reduction Driven by
the Net-Zero Trend

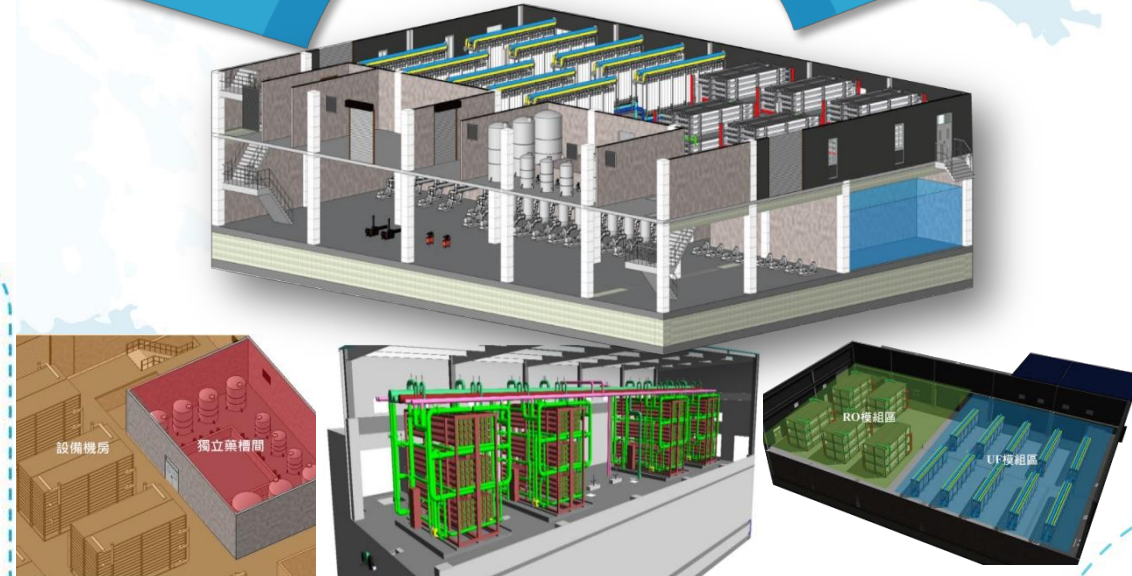
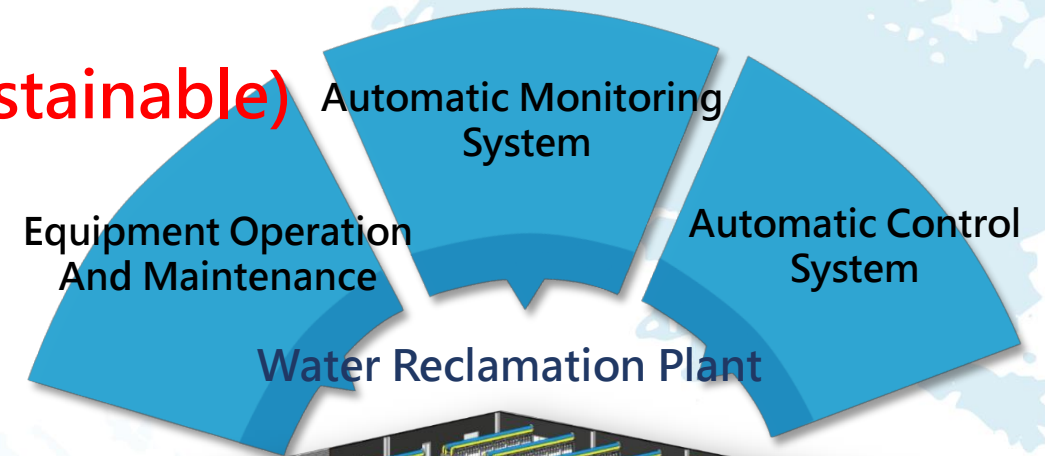
Establishing a **Second** Water Utility Company

Reclaimed Water Service Network



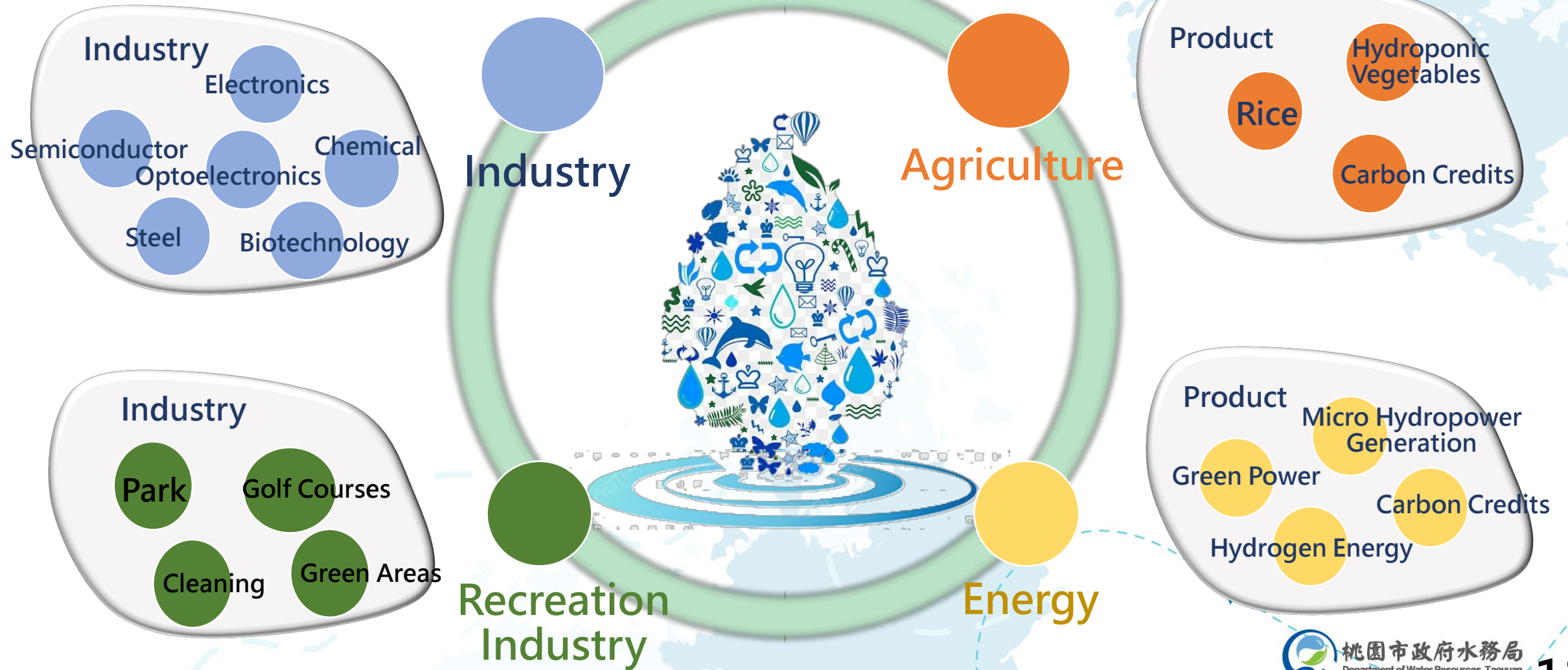
Real-Time Monitoring and Cloud-Based Response Ensure Stable Water Supply

Meet the 3S Objectives (Service, Smart, Sustainable) of National Land Management Agency





Water Resource Diversification



Industrial Reclaimed Water

Balancing Stable Water Supply Sources for Northern and Southern Taoyuan Industries

2025 桃北

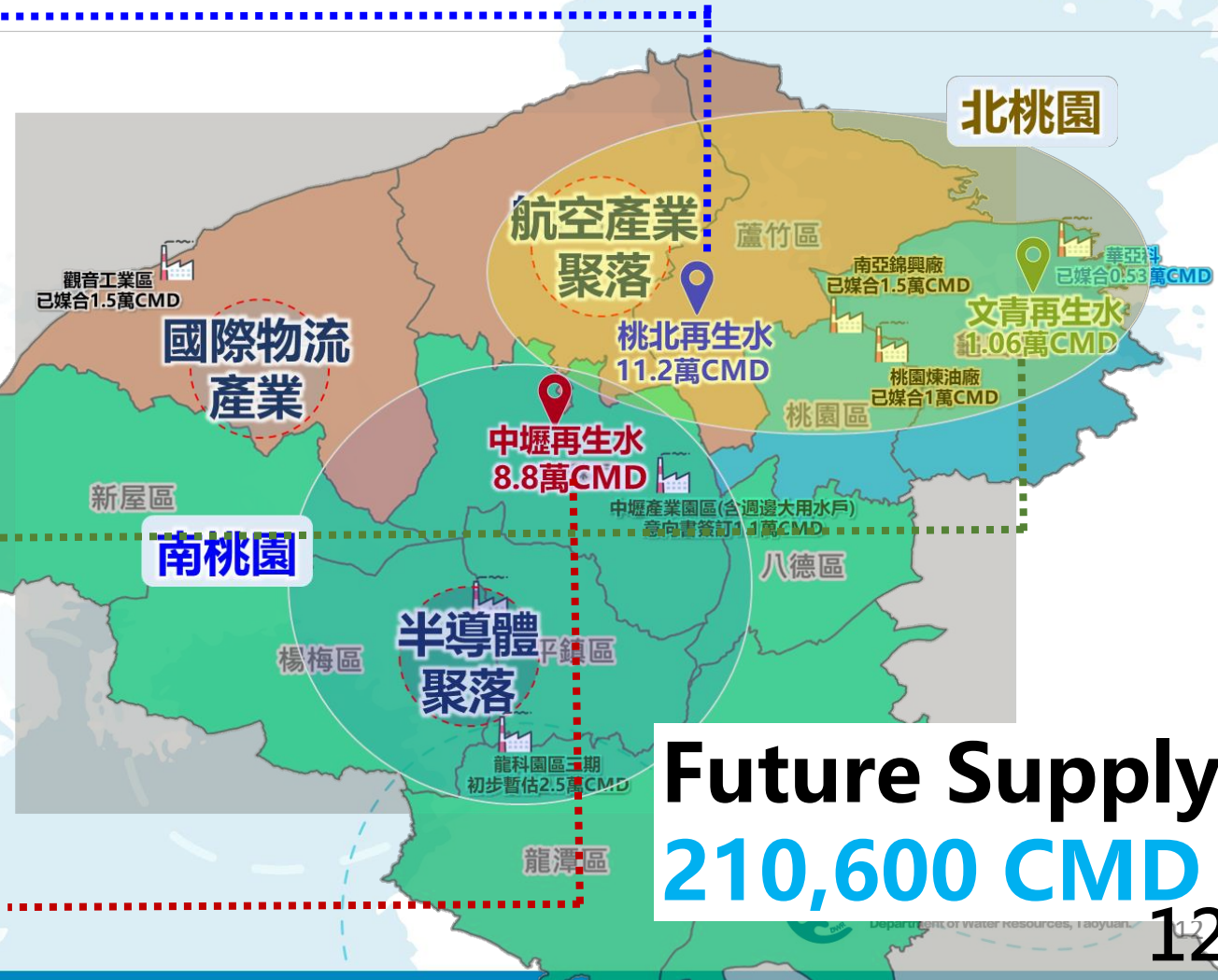
The total supply is **112,000** CMD.
Early supply 18,000 CMD in 2024.
1st supply **40,000** CMD in **2025**.
Supply CPC, NAN YA PCB, Guanyin Industrial Zone.

2027 文青

Turnkey concept **design**.
The total supply is **10,600** CMD.
1st supply **5,300** CMD in **2027**.
Supply Huaya Technology Park.

2029 中壢

Feasibility assessment stage.
The total supply is **88,000** CMD.
1st supply **22,000** CMD in **2029**.
Supply Zhongli Industrial Zone and Longtan Science Park.



Future Supply
210,600 CMD



Alternative Water Supply for Agriculture and the Recreation Industry

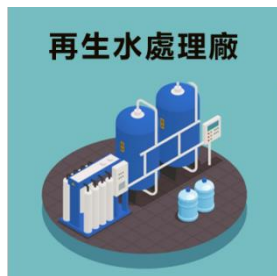
Current Situation



Treated

Effluent (100%)

※ Without Treating Industrial Wastewater

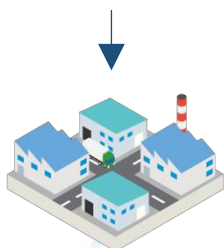


再生水處理廠

RO Concentrate Effluent (50%)

Dissemination

RO Reclaimed Water (45%~55%)



Industrial Utilization

Agricultural Irrigation



Golf Course

Agricultural Irrigation Using RO Concentrate Effluent with High Nutrient Content and No Heavy Metals

Ro Concentrate Water Quality Monitoring System

•水溫	22.4~27.6	•油脂	3.7~4.4
•pH	6.6~7.2	•總磷	3.5~13.7
•導電度	1311~1992	•正磷酸鹽	5.9~20.6
•溶氧	6.1~6.4	•氨氮	0.4~22.4
•懸浮固體	0.8~2.4	•硝酸鹽氮	29.3~47.4
•鈉吸著率	2.3~2.5	•總氮	37.6~57.8
•殘餘碳酸鈉	0.12~1.87	•有機碳	22.1~37.0
•氯鹽	1.7~161	•化學需氧量	59.9~93.9
•硫酸鹽	169~250	•濁度	0.2~0.5
•陰離子界面活性劑	0.05~0.09		



Treated Effluent for Crop Irrigation as a Substitute for Agricultural Water

Treated effluent becomes an alternative water source for **agriculture**.

Conducting the Treated Effluent Irrigation Trials for Rice in the Yangmei Water Resource Center Demonstration Area



Downstream Area About 28ha

- ✓ Completed in December 2024
- ✓ Dedicated Pipeline Project
- ✓ Constructing New Waterways and Drawing Water by Suspended Pipes

Upstream Area About 3.4ha

- ✓ Completed in February 2023
- ✓ Constructing New Water Storage Tank
- ✓ Conducting Irrigation Trials Using Treated Effluent



Service Diversification: Alternative Water Use (Treated Effluent) for Agriculture and Recreation

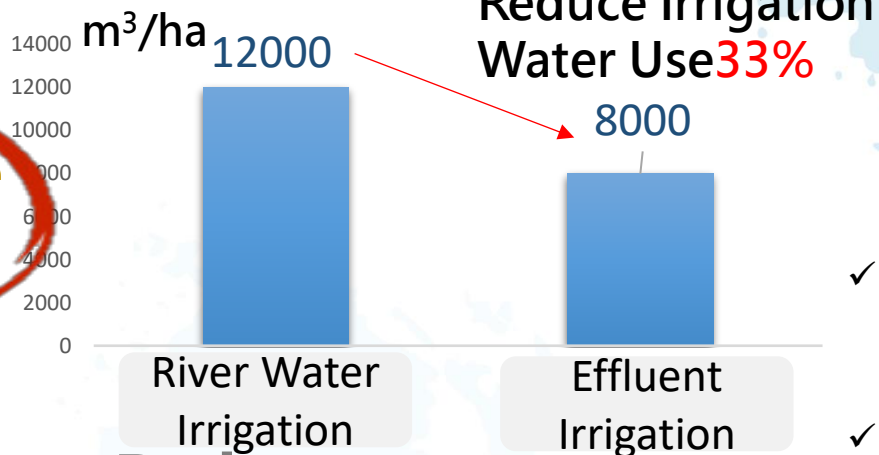
Save Water and Reduce Fertilizer Use

Proportion of Greenhouse Gas Emission Sources



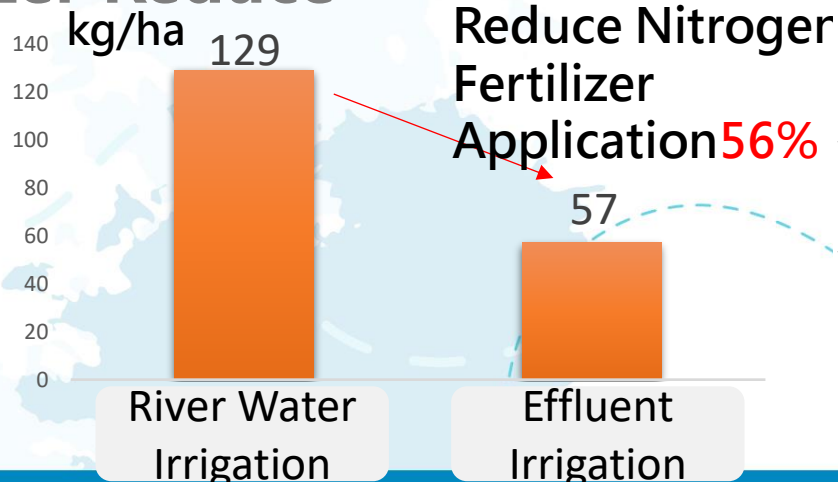
Nitrogen fertilizers are the main source of N_2O .

Water Save



✓ Nitrogen Fertilizer Saved **72 kg/ha**

Fertilizer Reduce



✓ Nitrogen Fertilizer Reduction Rate **56 %**

✓ Cost Reduction **6,400 元/ha**

✓ Carbon Emission Reduction **480 kg/ha**

資料來源：中華民國2024國家溫室氣體排放清冊報告・Ch5農業部門

Diversified Services: Using Treated Effluent as an Alternative Water Source for Agriculture and Recreation

Food Safety of Agricultural Products (Rice)



Heavy Metals in Water Quality Once per month

Cu, Zn, Pb, Sn, Cd, Cr, Ni, As



Heavy Metals in Rice Once per cropping season

Pb, Sn, Cd, As



Heavy Metals in Soil Once before and after each cropping season

Cu, Zn, Pb, Sn, Cd, Cr, Ni, As, Ca, Mg, Na, K





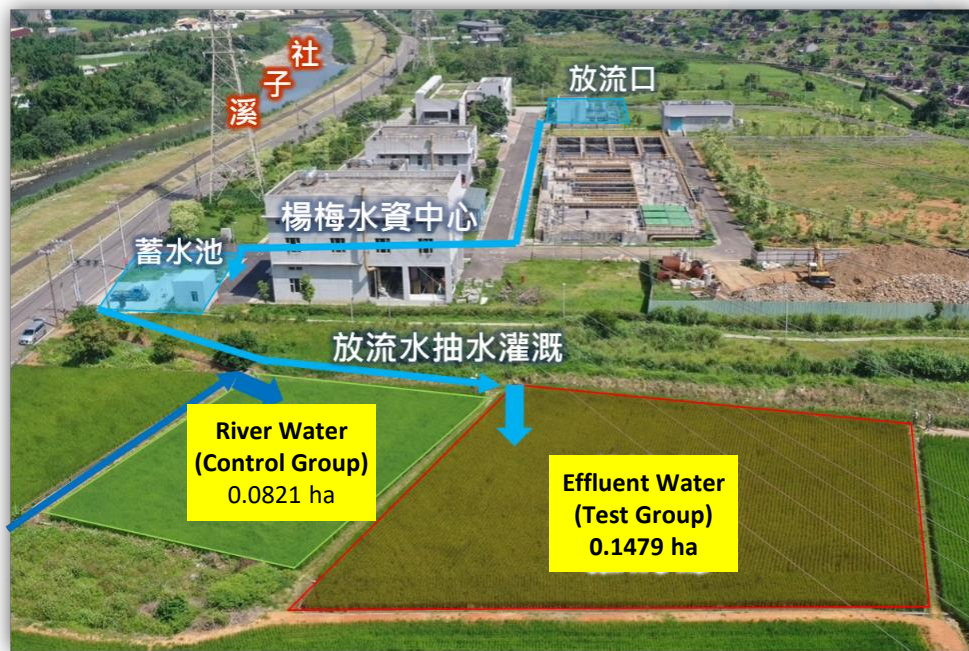
Carbon Reduction and Energy Saving

☑ Conserve Water Resources

Irrigating rice fields with **6,600 CMD of treated wastewater** reduces the need for groundwater and surface water.

☑ Reduce Carbon Emissions

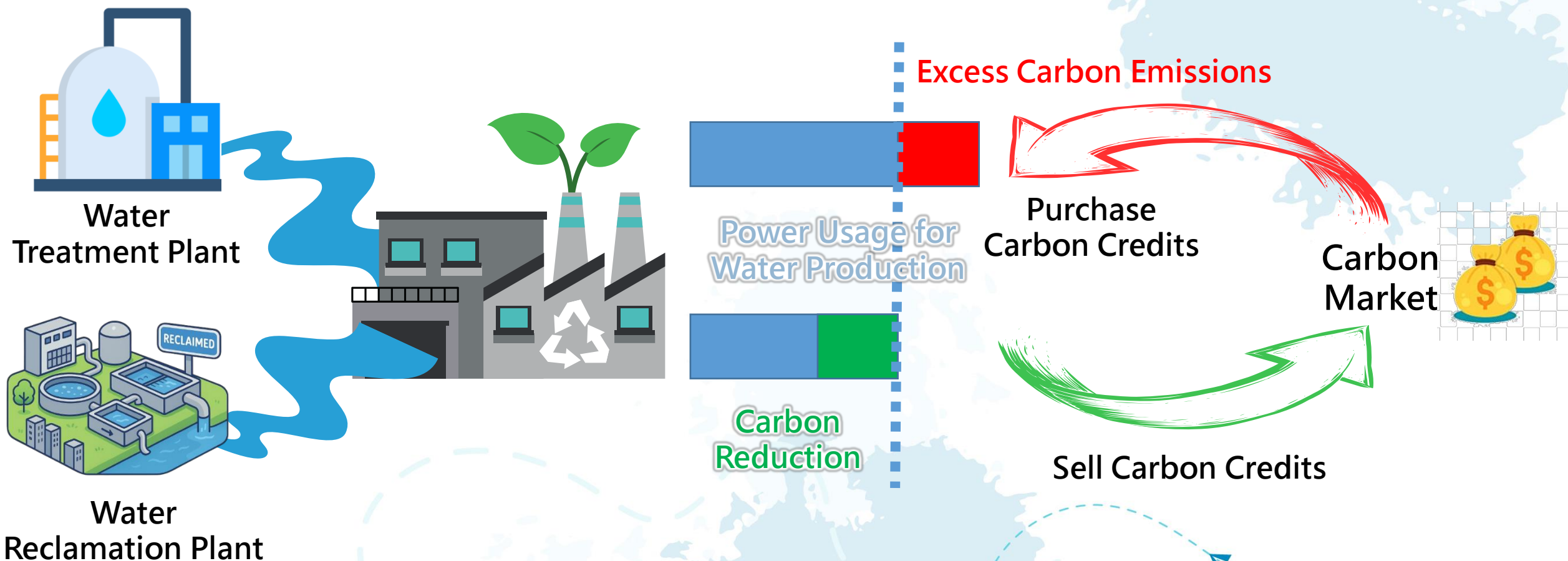
Irrigating farmland with reclaimed water saves energy and **reduces 2,409 tons of carbon emissions each year.**



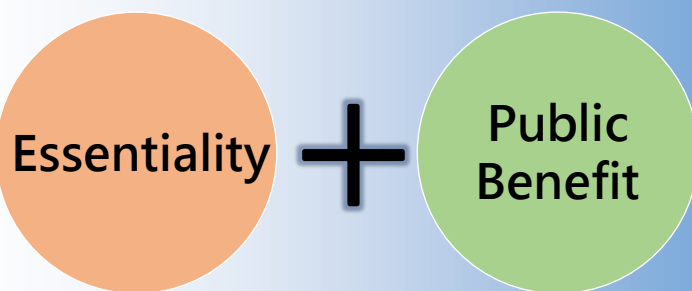
Zero Carbon by 2050

1. Water Conservation
2. Agricultural Sustainability
3. Energy Saving and Carbon Reduction
4. Carbon Trading

Carbon Reduction (pay less tax) of Companies



Conclusion : The key to sustainable water resources lies in reuse.



- 1 **【 Ensuring the Water Rights of All Citizens 】**
Treated effluent for agricultural irrigation and reclaimed water for industrial use to reduce the risk of drought
- 2 **【 Protecting the Ecological Environment 】**
Reduce pressure on rivers and groundwater extraction
- 3 **【 Aligned with Global Trends 】**
Implement water recycling management and move towards a net-zero sustainable society
- 4 **【 Fostering the Green Economy 】**
Create jobs and promote the circular economy
- 5 **【 Realizing the SDGs 】**
Promote social welfare and improve urban environmental quality and public services



Thank you for your attention.