Start-up of The First Full-scale Methanogenesis and Anammox System For Treating Mainstream Municipal Wastewater in Taiwan

International Forum 2022

Industrial Technology Research Institute (ITRI)

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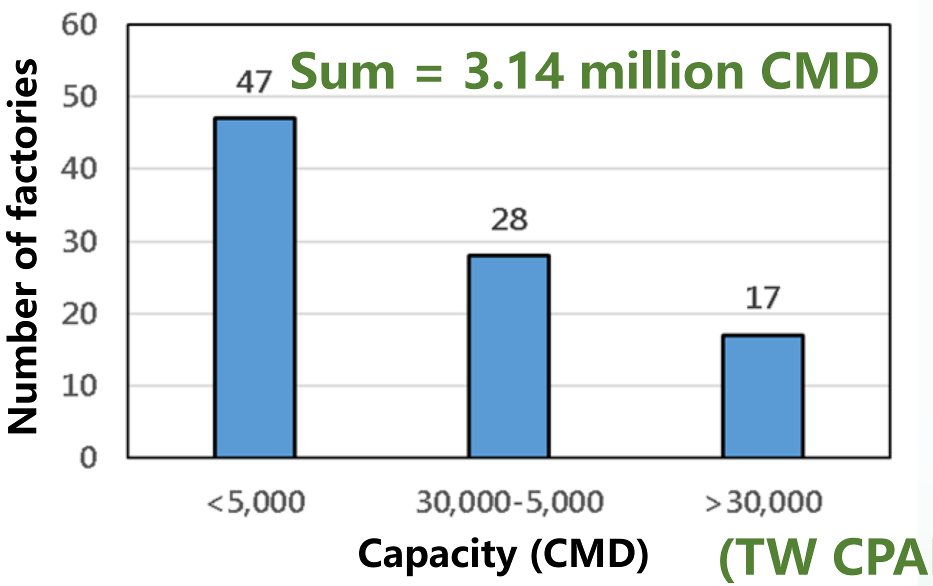
中華民國經濟部 Ministry of Economic Affairs, R.O.C.(Taiwan)
經濟部水利署 Water Resources Agency, MOEA
TAITRA Taiwan External Trade Development Council

Background – Why ANAMMOX?

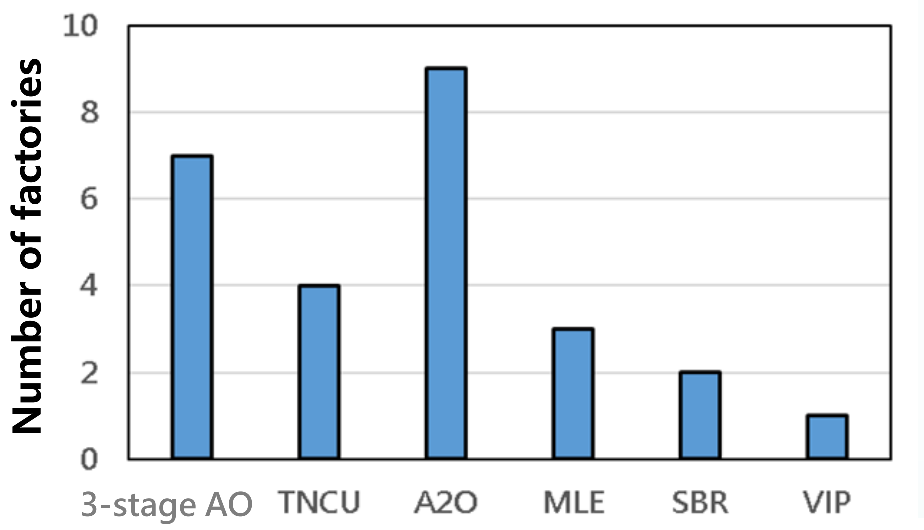
Effluent Standard for Municipal WWTP(TW EPA 2021): NH_4^+-N→6 mg/L; TN→20 mg/L

Total Municipal WWTP in Taiwan: 71 factories



(TW CPAMI, 2020)

Removal N by denitrification: 26 factories



(TW CPAMI, 2020)

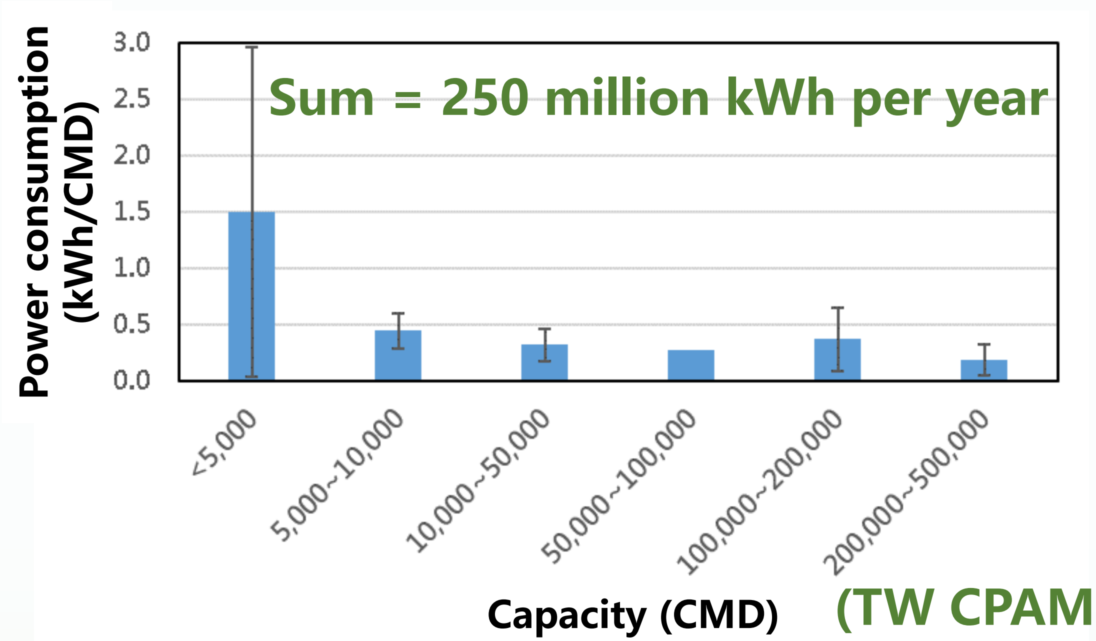
To achieve 2021 effluent standard (Nitrification 90% and Denitrfication 50%):

➡ **Over 100 million NTD per year for methanol cost!**

TAIWAN INT'L WATER WEEK

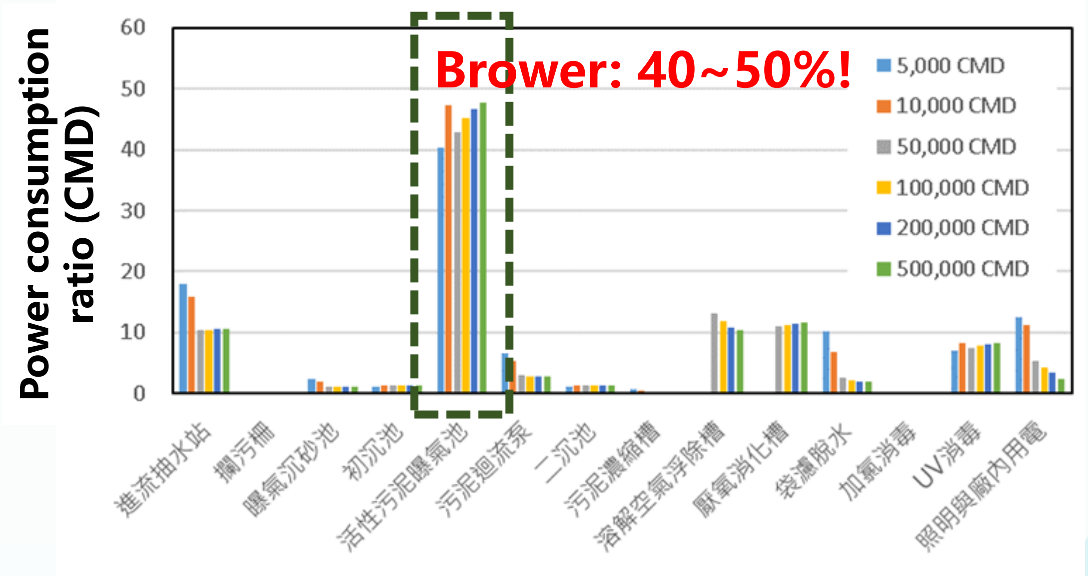
Background – Why ANAMMOX?

Power consumption of Municipal WWTP



(TW CPAMI, 2019)

Each unit power consumption ratio of total power consumption



(TW CPAMI, 2011; US EPA, 1978)

➡ **At least 300~400 million electricity cost per year for aeration (COD removal and nitrification)!**

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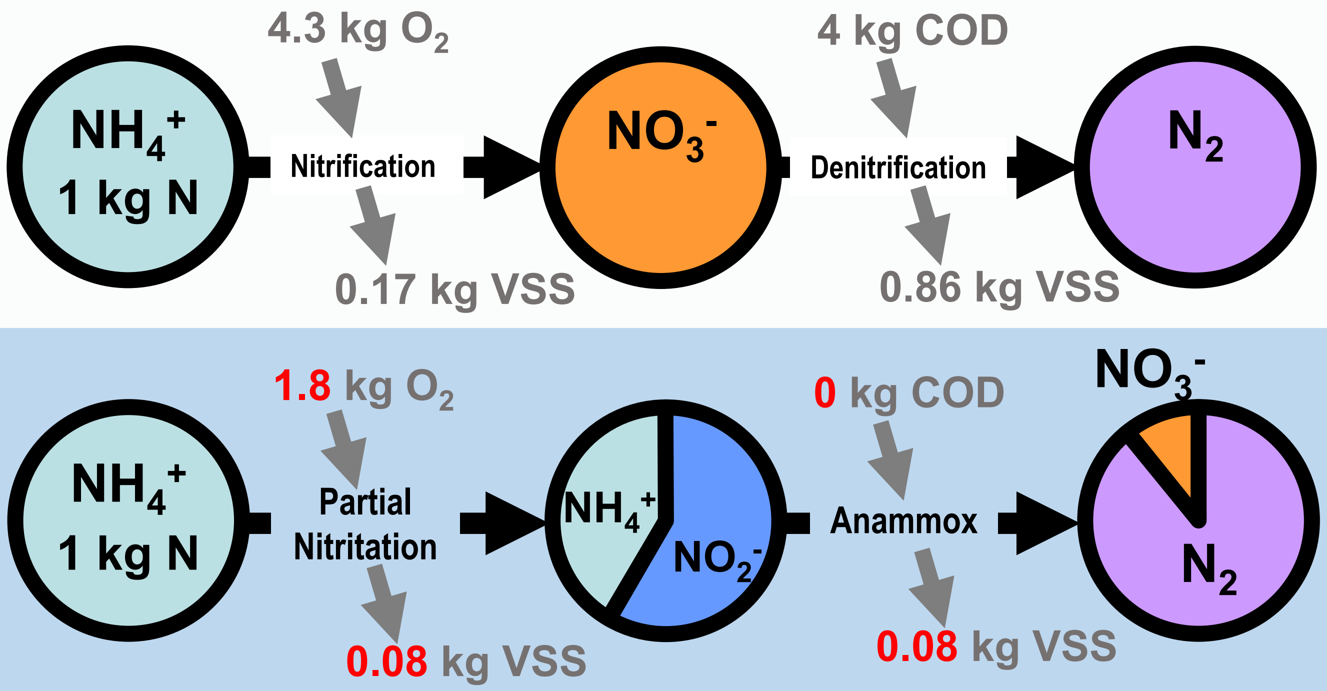
Background – Why ANAMMOX?

Nitrification/Denitrification

Partial nitritation /ANAMMOX



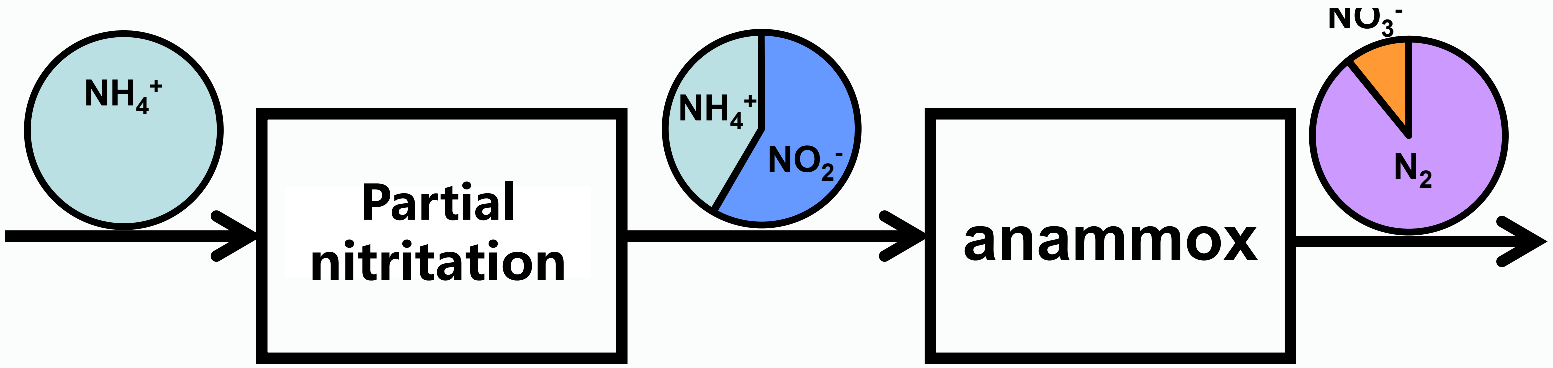
Comparison

	Nitrification/Denitrification	Partial nitritation/ANAMMOX	
Aeration	2.3	1	kWh $(kg\ N)^{-1}$
Methanol	2.3	0	kg $(kg\ N)^{-1}$
Waste sludge	0.5-1.0	0.1	kg VSS $(kg\ N)^{-1}$
CO_2 emission	> 4.7	0.7	kg $(kg\ N)^{-1}$
Cost	3-5	1.5-2.5	€ $(kg\ N)^{-1}$

Vereijken, 2006

Anammox-based technology

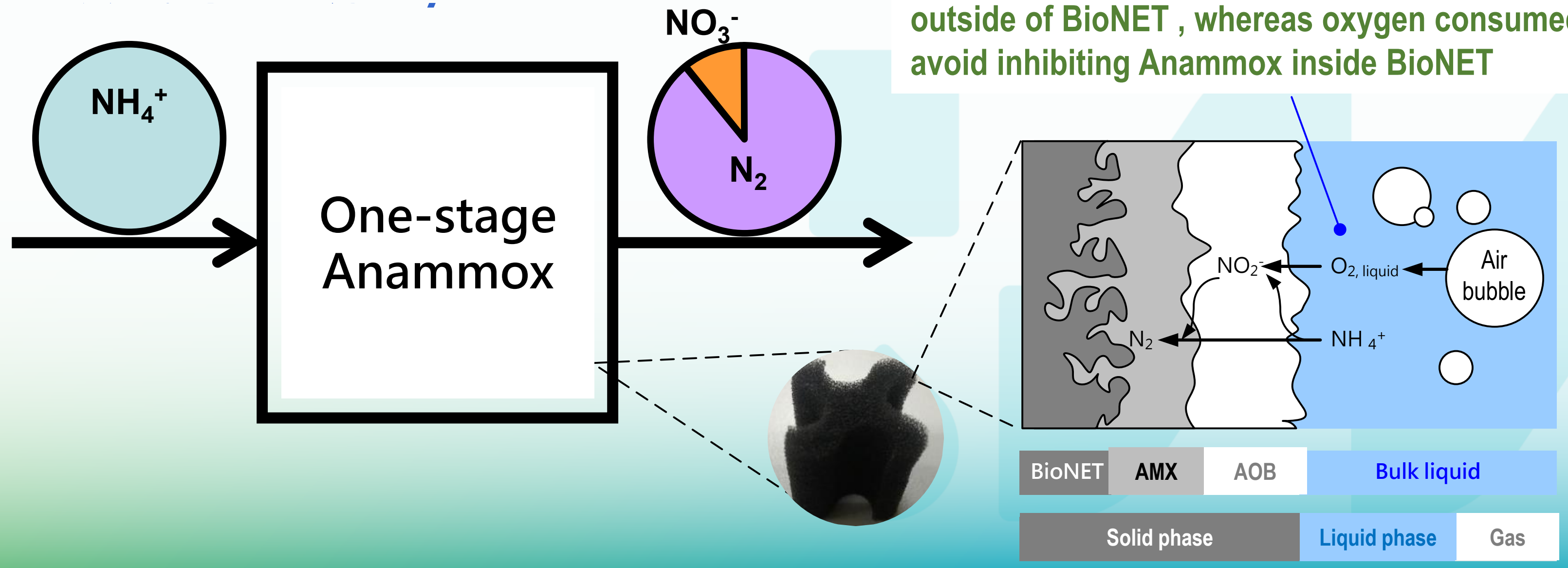
Two-stage
Partial nitritation /ANAMMOX



The NH_4^+-N concentration in mainstream sewage is too low to maintain adequate NH_3 concentration for suppression NOB

One-stage
Partial nitritation /ANAMMOX

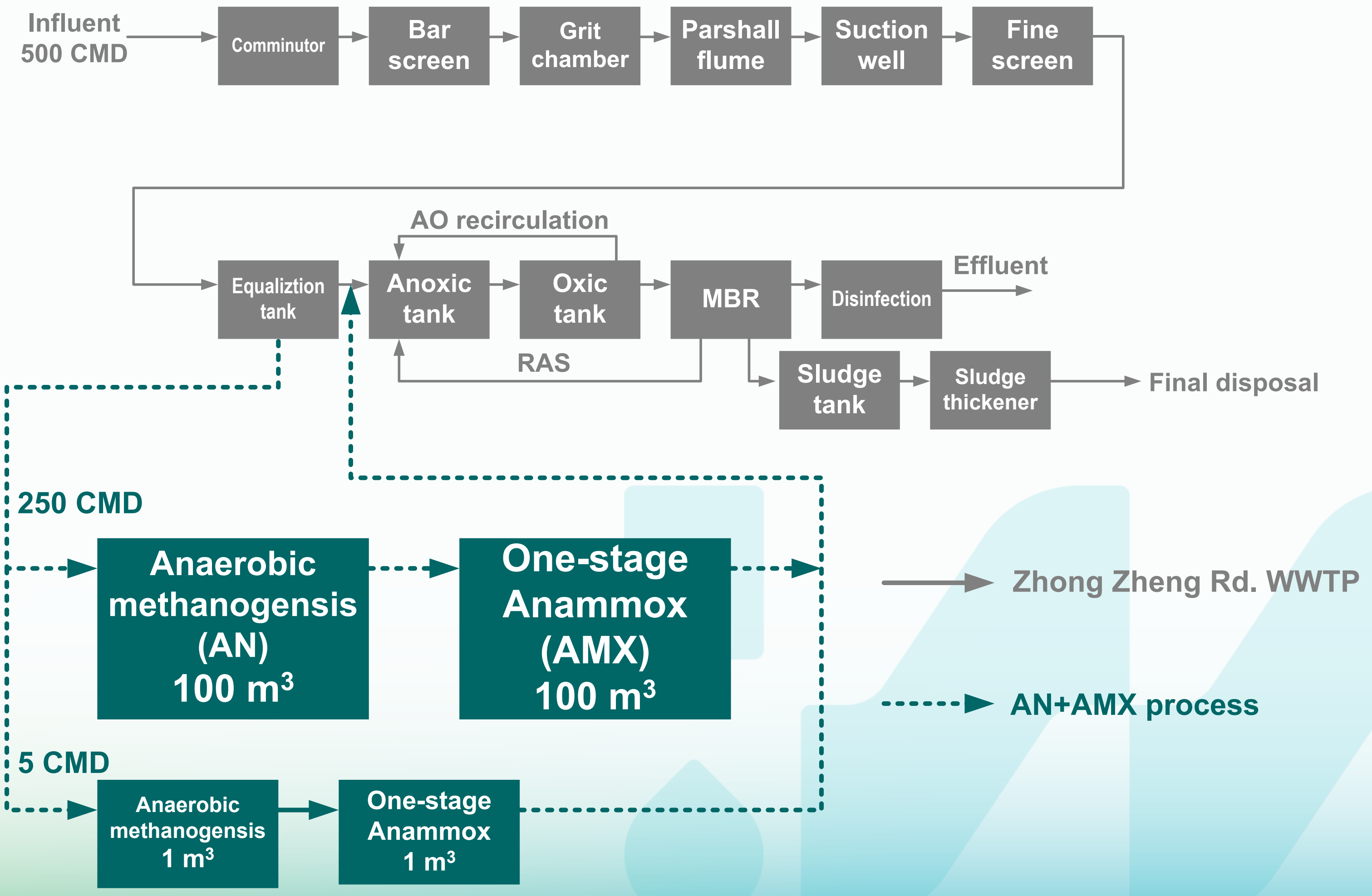
Key factor: Control aeration to grow Nitrifier outside of BioNET , whereas oxygen consumed to avoid inhibiting Anammox inside BioNET



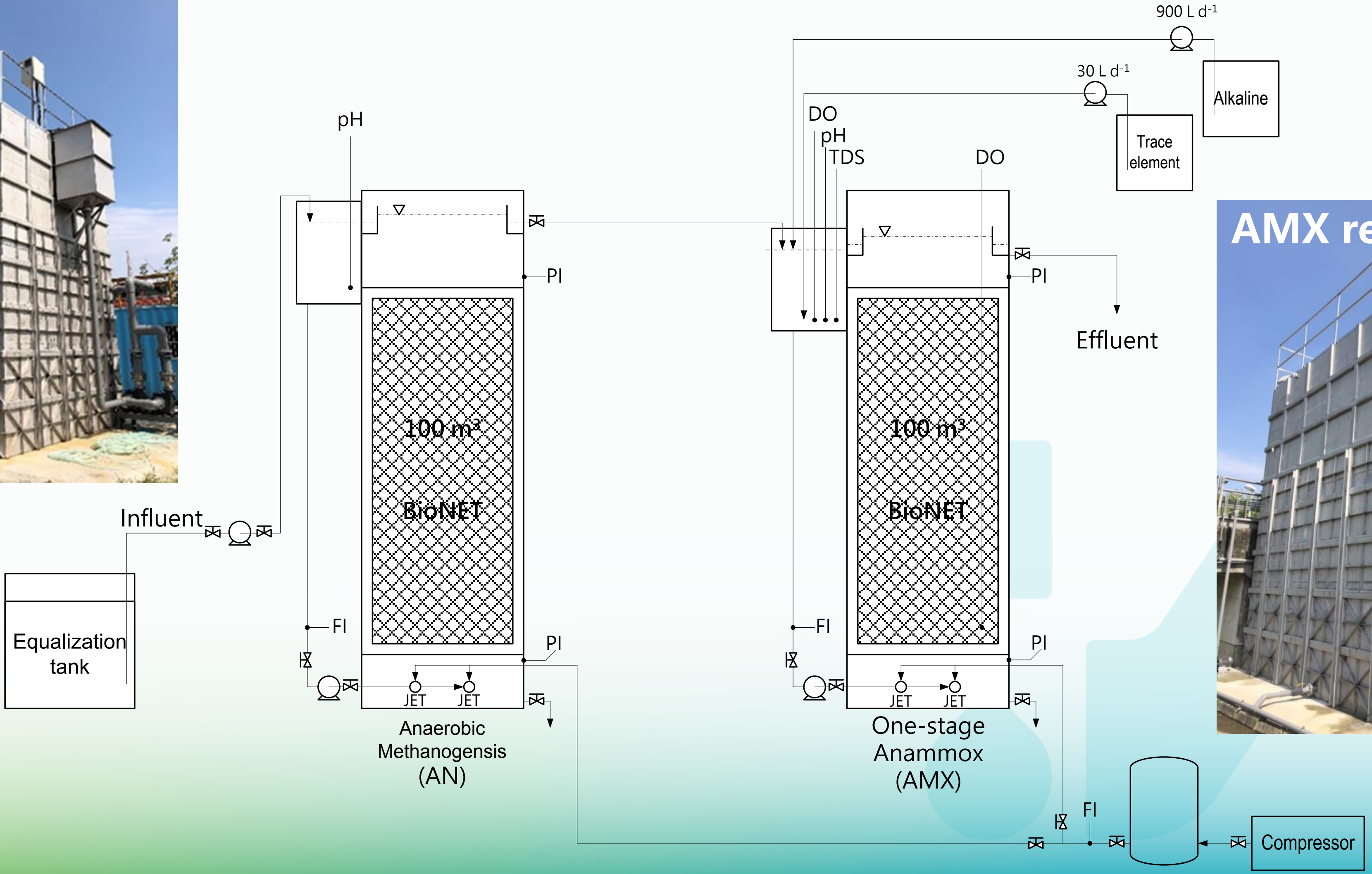
Location @Zhong Zheng Rd. WWTP (Zhong Xing New Village)

Wastewater characteristics and treatment process

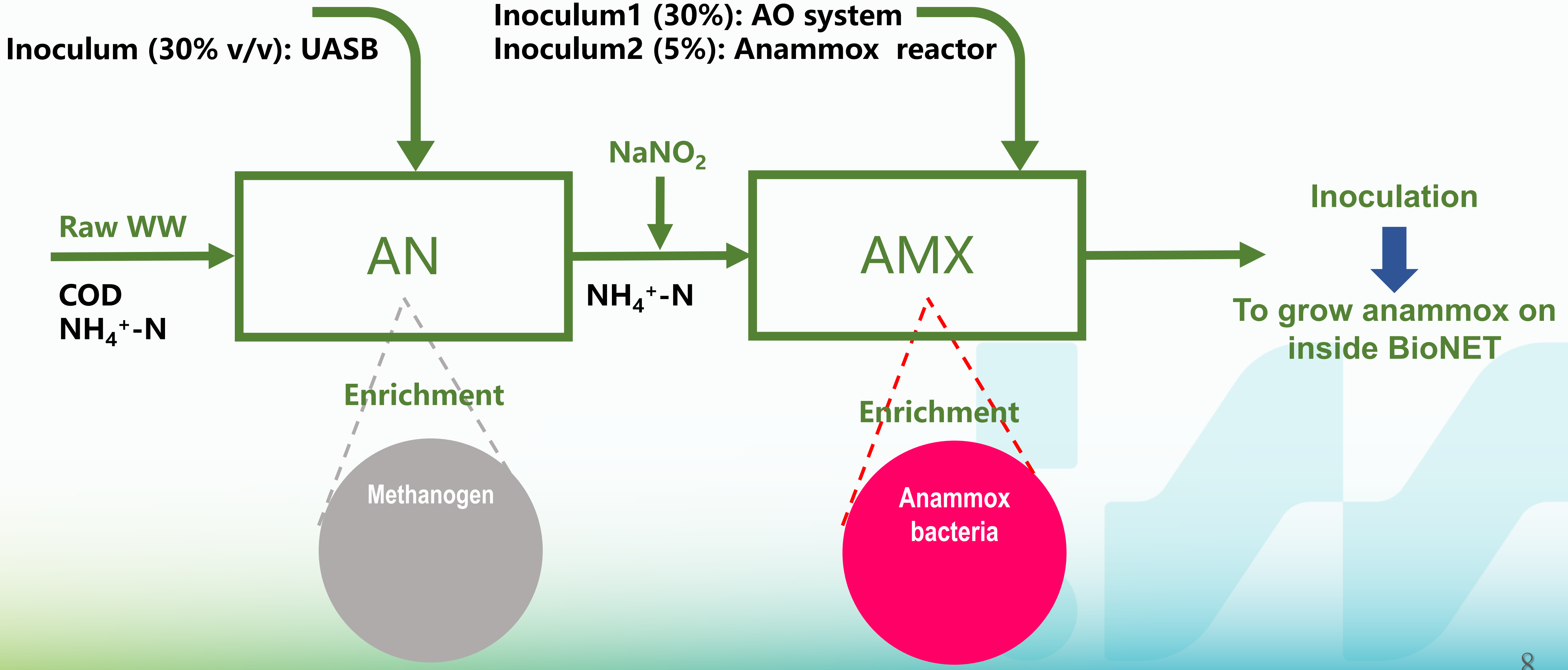
Unit	Influent	Effluent
Inflow rate (m^3 d^{-1})	545±67	-
BOD (mg L^{-1})	30±7	2
COD_S (mg L^{-1})	74±14	10±0.3
SS (mg L^{-1})	40±12	2.5
NH_4^+-N (mg L^{-1})	17±4	0.2±0.1
NO_2^--N (mg L^{-1})	na	na
NO_3^--N (mg L^{-1})	0.7±0.7	7.2±2.4
TN (mg L^{-1})	22±5	8±3
TP (mg L^{-1})	2±0.5	2±0.3



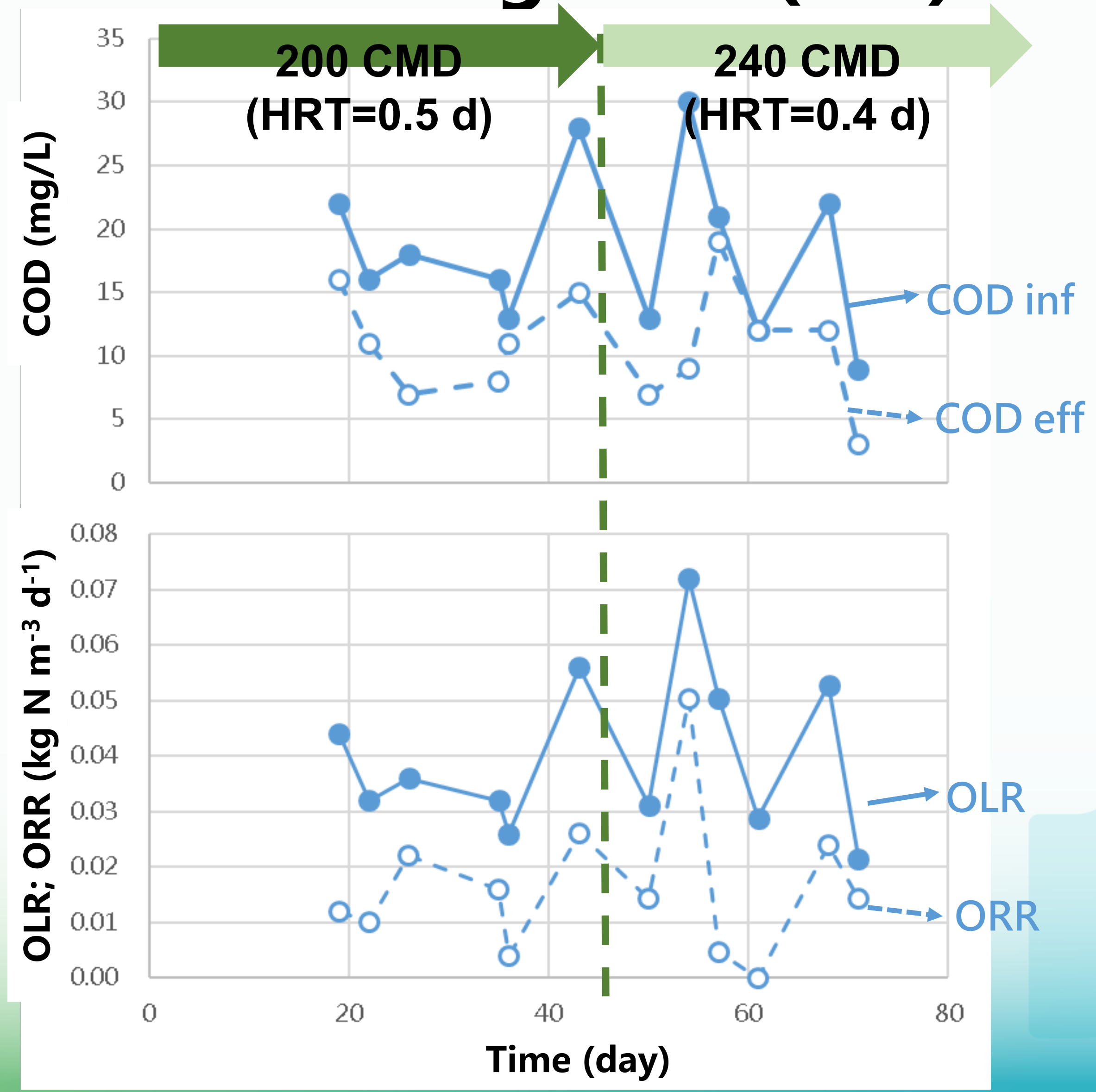
Anaerobic methanogensis and one-stage anammox syetem



Phase I of Start-up: Inoculation and Enrichment

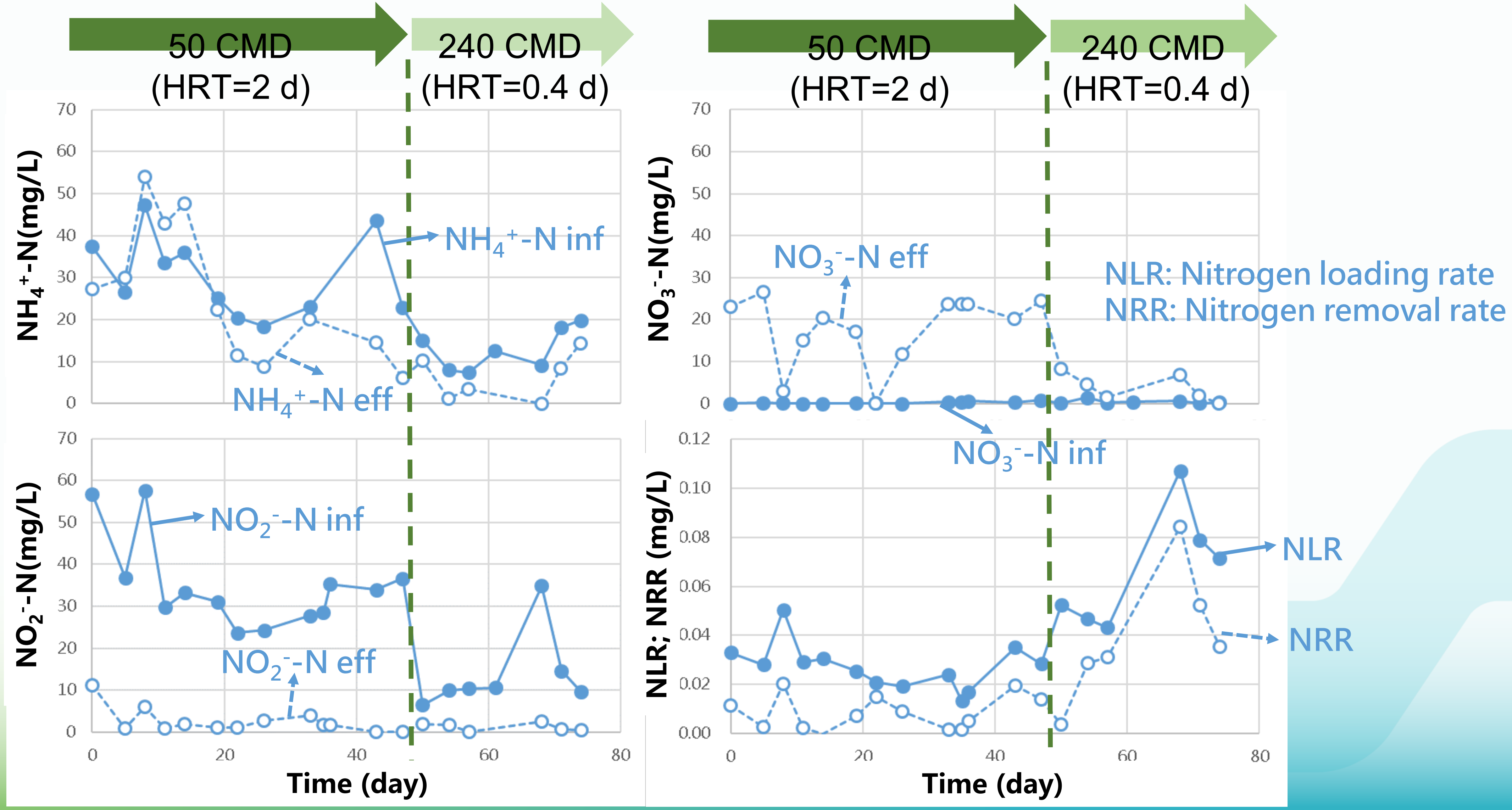


Performance of methanogensis (AN) in Phase I

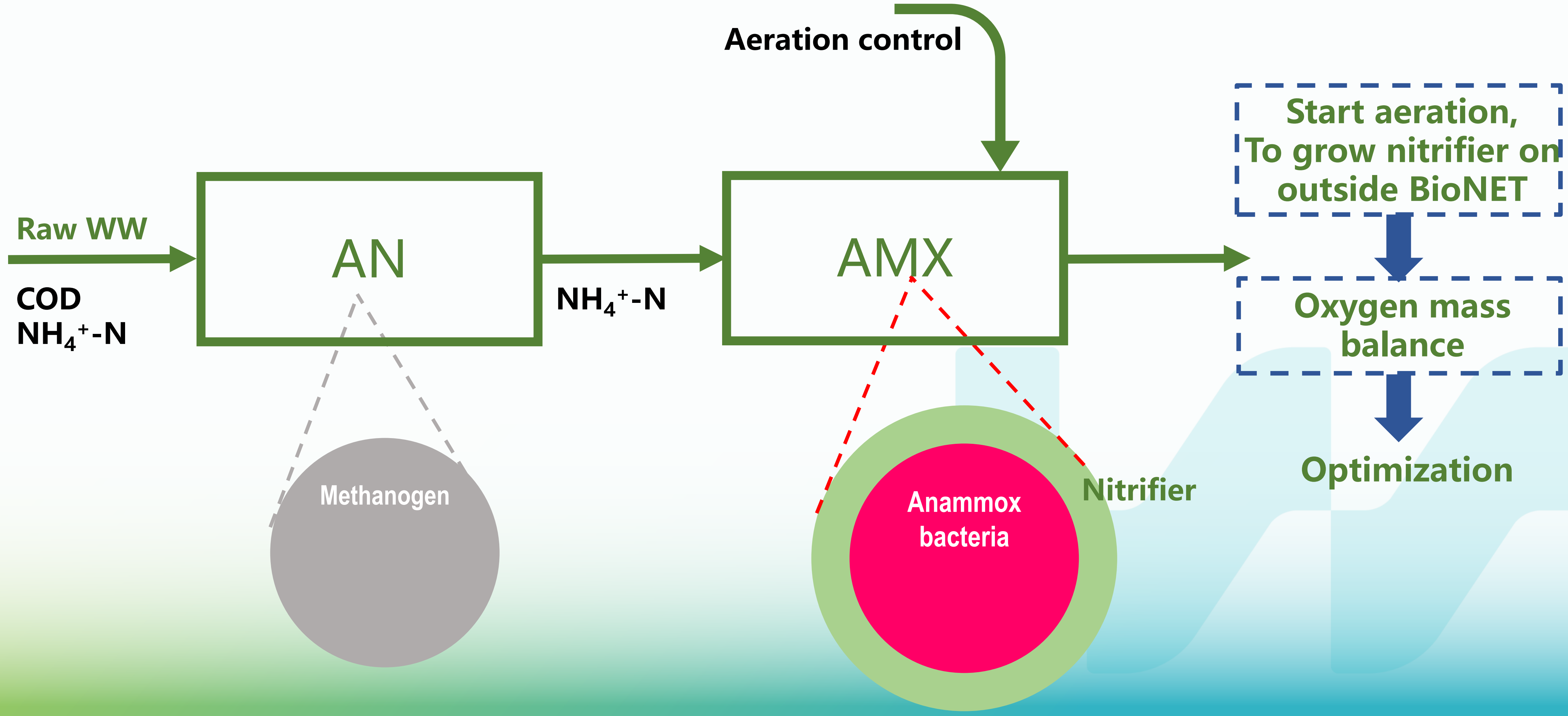


OLR: Organic loading rate
ORR: Organic removal rate

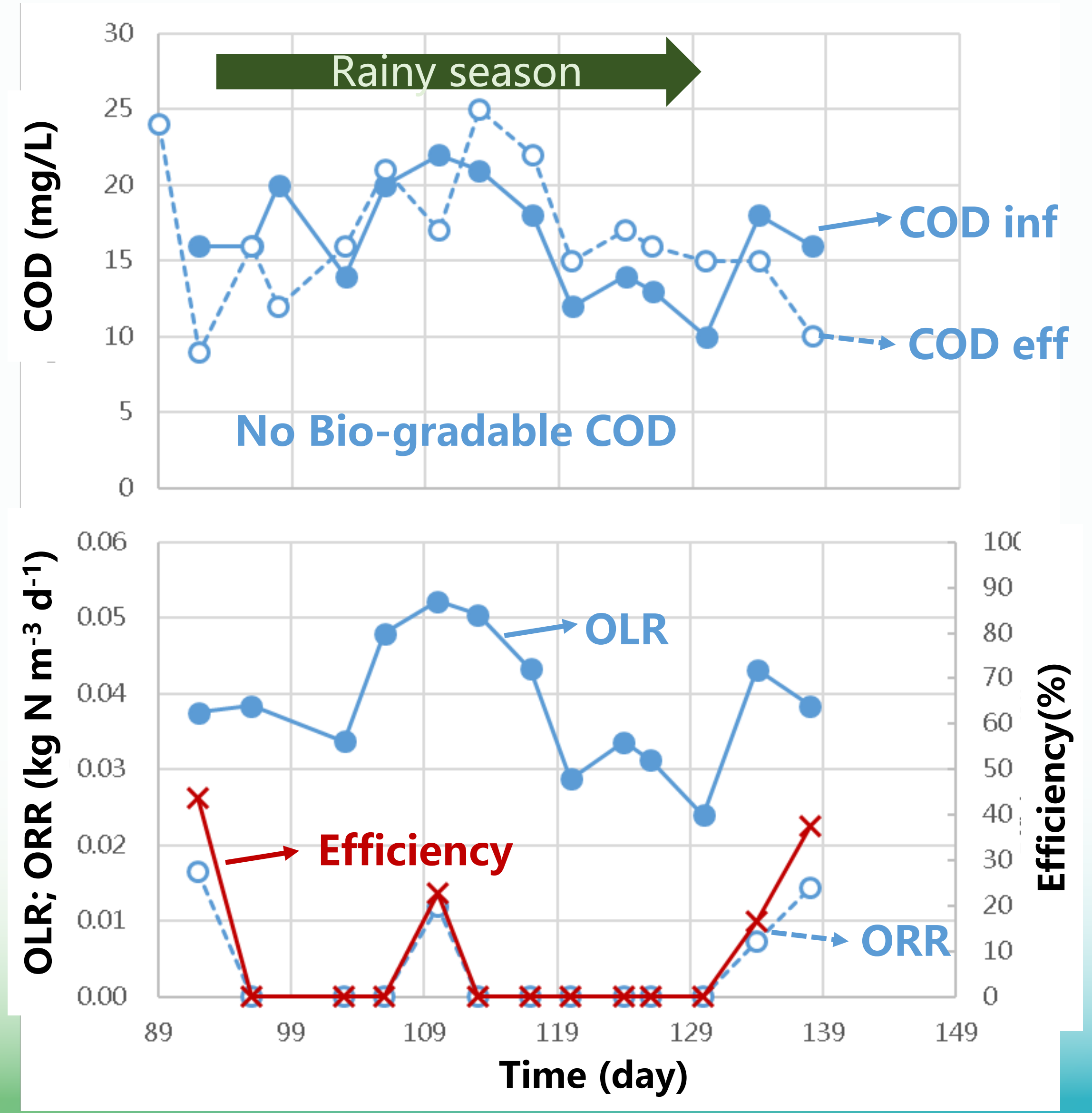
Performance of Anammox (AMX) in Phase I



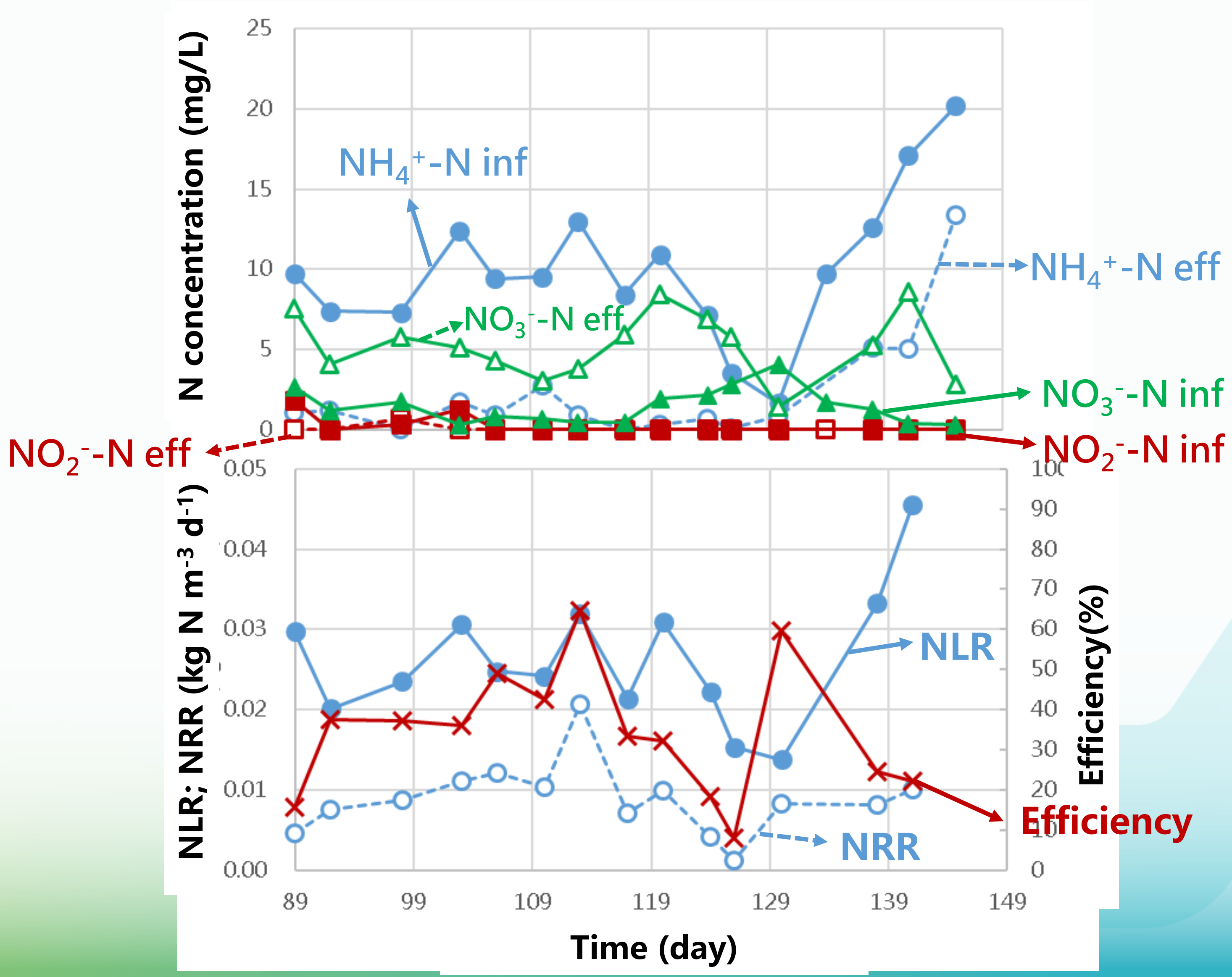
Phase II of Start-up: Aeration and mass balance



Performance of methanogensis (AN) in Phase II



Performance of Anammox (AMX) in Phase II



Oxygen mass balance with Anammox reactor

Nitritation:

$$NH_4^+ + 1.44\ O_2 + 0.0496\ CO_2 \rightarrow 0.01\ C_5H_7NO_2 + 0.990\ NO_2^- + 0.970\ H_2O + 1.99\ H^+$$

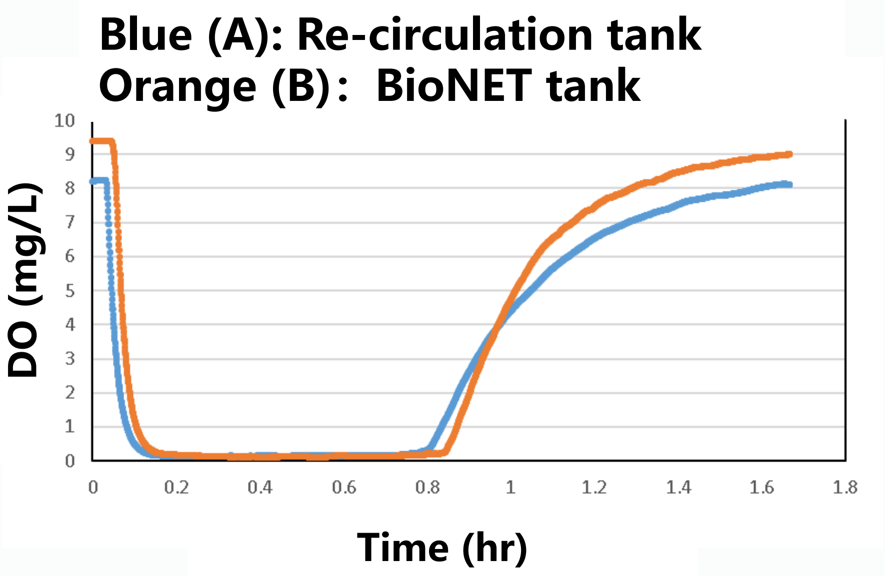
Anammox:

$$NH_4^+ + 1.32\ NO_2^- + 0.066\ HCO_3^- + 0.13\ H^+ \rightarrow 1.02\ N_2 + 0.26\ NO_3^- + 0.066\ CH_2O_{0.5}N_{0.15} + 2.03\ H_2O$$

According Anammox stoichiometry, mole of $NH_4^+:NO_2^-$ =1:1.32
1 mol = X mol +1.32X mol
→X= 0.433 mol
→ 0.567 mol of 1 mol NH_4^+ will be oxidized to NO_2^-

Covert to Oxygen
0.567 mol N × 1.44 O_2 N^{-1} × 32 g mol^{-1} O_2 = 26.13 g O_2
1 mol × 14 g mol^{-1} N = 14 g
→26.13/14 = 1.87 kg O_2 kg^{-1} N

$K_L a$ coefficient



$$OTR = \frac{dDO}{dt} = K_L a(DO_S - DO)$$

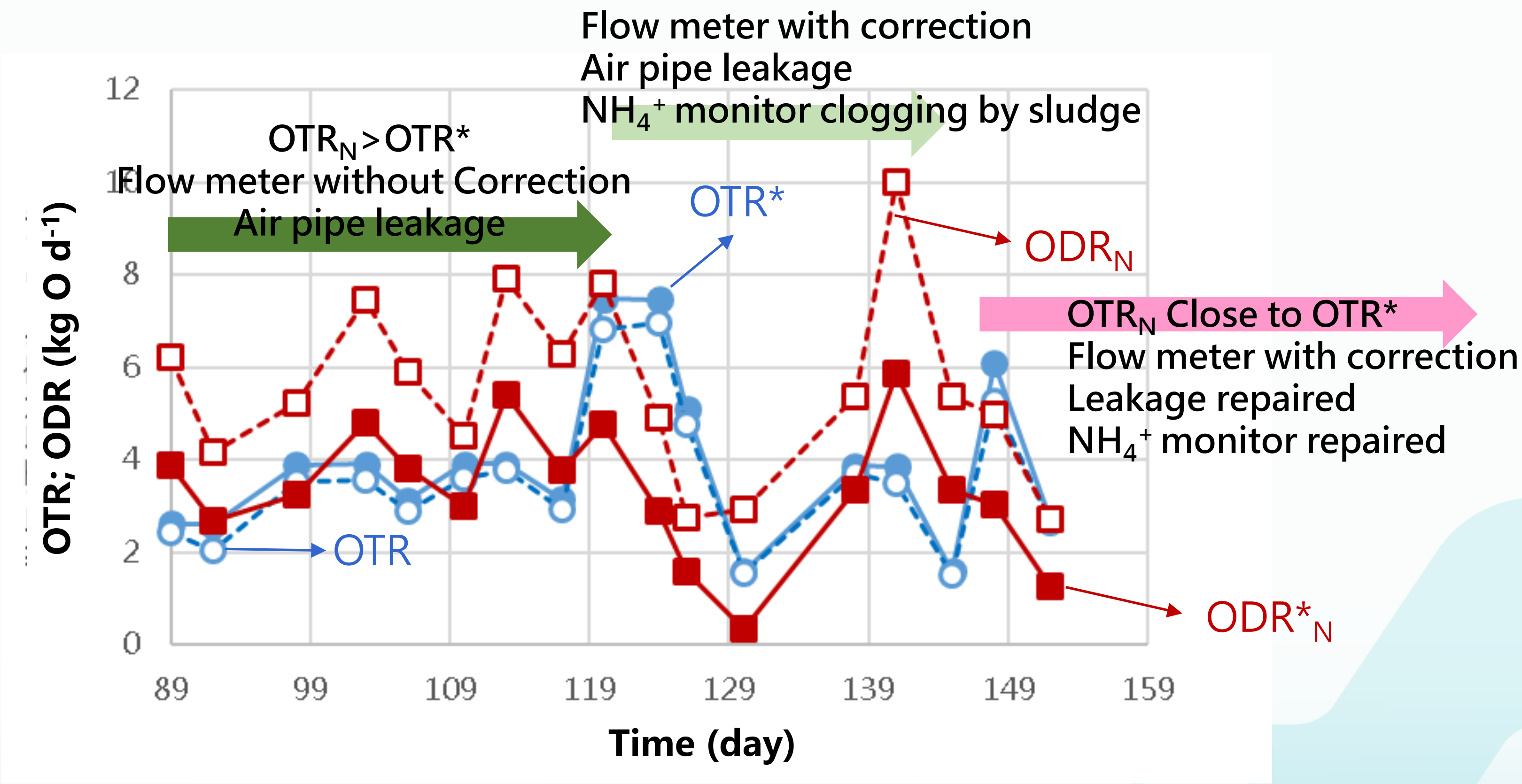
Table –$K_L a$ (without BioNET)

Test NO Unit	Air flow CMH	Recirculation CMH	KLa_{20}(A) /hr	KLa_{20}(B) /hr
A	49	99	1.16	0.97
B	62	99	2.41	2.54
C	49	48	1.62	1.63
D	62	48	1.92	1.99

Table-$K_L a$ (with BioNET)

Test NO Unit	Air flow CMH	Recirculation CMH	$K_L a_{20}$(A) /hr	$K_L a_{20}$(B) /hr
E	62	99	3.48	3.67
F	49	99	3.01	2.99
G	49	48	2.04	1.86
H	62	48	2.22	2.06
I	60	99	3.21	3.59
J	60	48		2.06
K	62	99	3.31	3.74
L	49	48	2.84	3.07

Oxygen mass balance with Anammox reactor



OTR*: Oxygen transfer rate (Count in average DO)
OTR: Oxygen transfer rate (ignore average DO)

ODR*: Oxygen demand rate (NH_4^+ as O consumption)
ODR: Oxygen demand rate (NO_2^-+NO_3^- as O production)

Energy consumption of AN+AMX system

Zhongzheng Rd. WWTP: 1,500~2,000 kWh/d, 500 CMD
AN+AMX system: 350~400 kWh/d, 250 CMD

	Average energy consumption (kWh)		
	A Zhongzheng Rd. WWTP +(AN+AMX)	A-B Zhongzheng Rd. WWTP	B AN+AMX
Oct-21	3,381 ± 155		
Nov-21	1,631 ± 104		
Dec-21	1,526 ± 93		
Jan-22	1,504 ± 94		
Feb-22	1,511 ± 98		
Mar-22	1,469 ± 321		
Apr-22	1,893 ± 290	1,543	Commissioning Start-up
May-22	1,964 ± 153	1,614	
Jun-22	2,042 ± 161	1,614	
Jul-22	2,279 ± 264	1,929	
Aug-22	2,382 ± 345	2,038	344 ± 47
Sep-22	2,410 ± 246	2035	375 ± 18

I

*If electricity data is not recorded, the default value is 350 kWh

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The End
Q&A

Thank you for your attention

桃園市政府
Taoyuan City Government

Introduction of The Reclaimed Water BTO Project at Taoyuan North District Water Recycling Center

桃園北區水資源回收中心再生水BTO計畫介紹

Speaker：
GM Hu, NianYing (胡念英總經理)

CTCI 中鼎集團 日勝生中鼎企業聯盟

Outline

01 Project content 計畫內容
02 Planning concept 規劃理念
03 Operation plan 營運計畫
04 Potential user 潛在水戶開發
05 Sustainable innovation 創意永續

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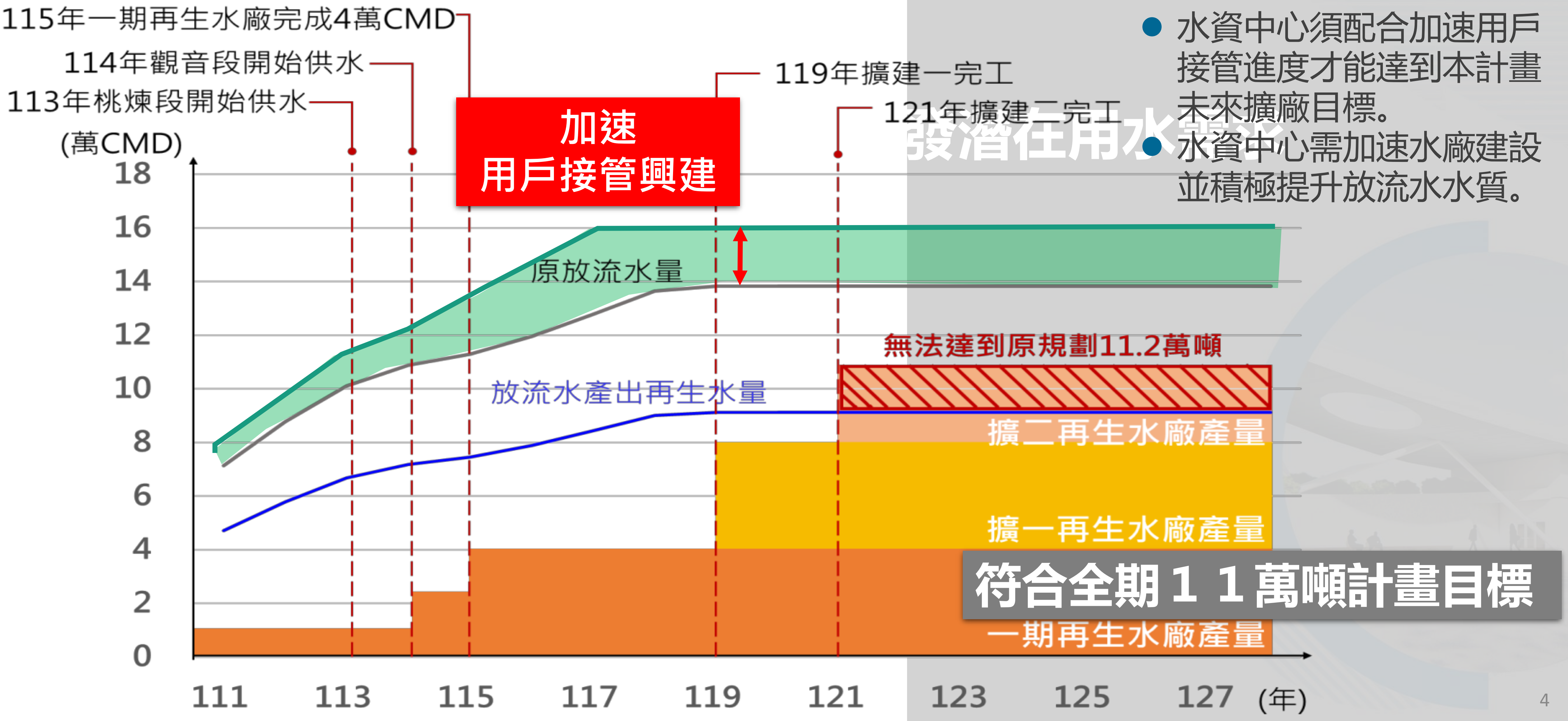
01 Project content 計畫內容

Supply (wastewater) and Demand (reclaimed water)
污水、再生水供需關鍵



- 水資中心須配合加速用戶接管進度才能達到本計畫未來擴廠目標。
- 水資中心需加速水廠建設並積極提升放流水水質。

Project content 計畫內容

■ Building content 建設內容

1. Capacity(Phase 1): 40,000CMD
2. Capacity(Phase 2): 112,000 CMD
3. Pipeline: 26.5KM

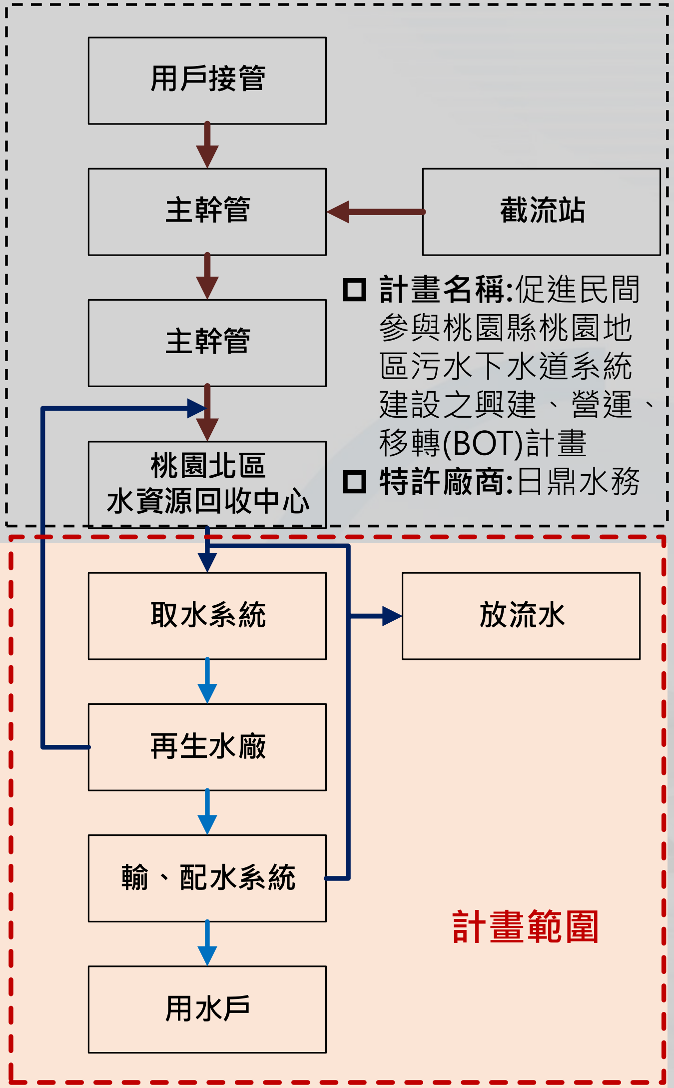
Model: BTO

■ Construction: 3 years

■ Operation: 15 years

■ Franchising: 18 years

期別	再生水廠興建	
	供水量(CMD)	供水對象
1	40,000	桃煉、觀音工業區、南亞塑膠
2	40,000	航空城產業專區及大園工業區
3	32,000	
總供水量(CMD)		112,000



02 Planning concept 規劃理念

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2.1 Design planning of RWP
再生水廠設計規劃

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Planning of RWP 再生水廠規劃

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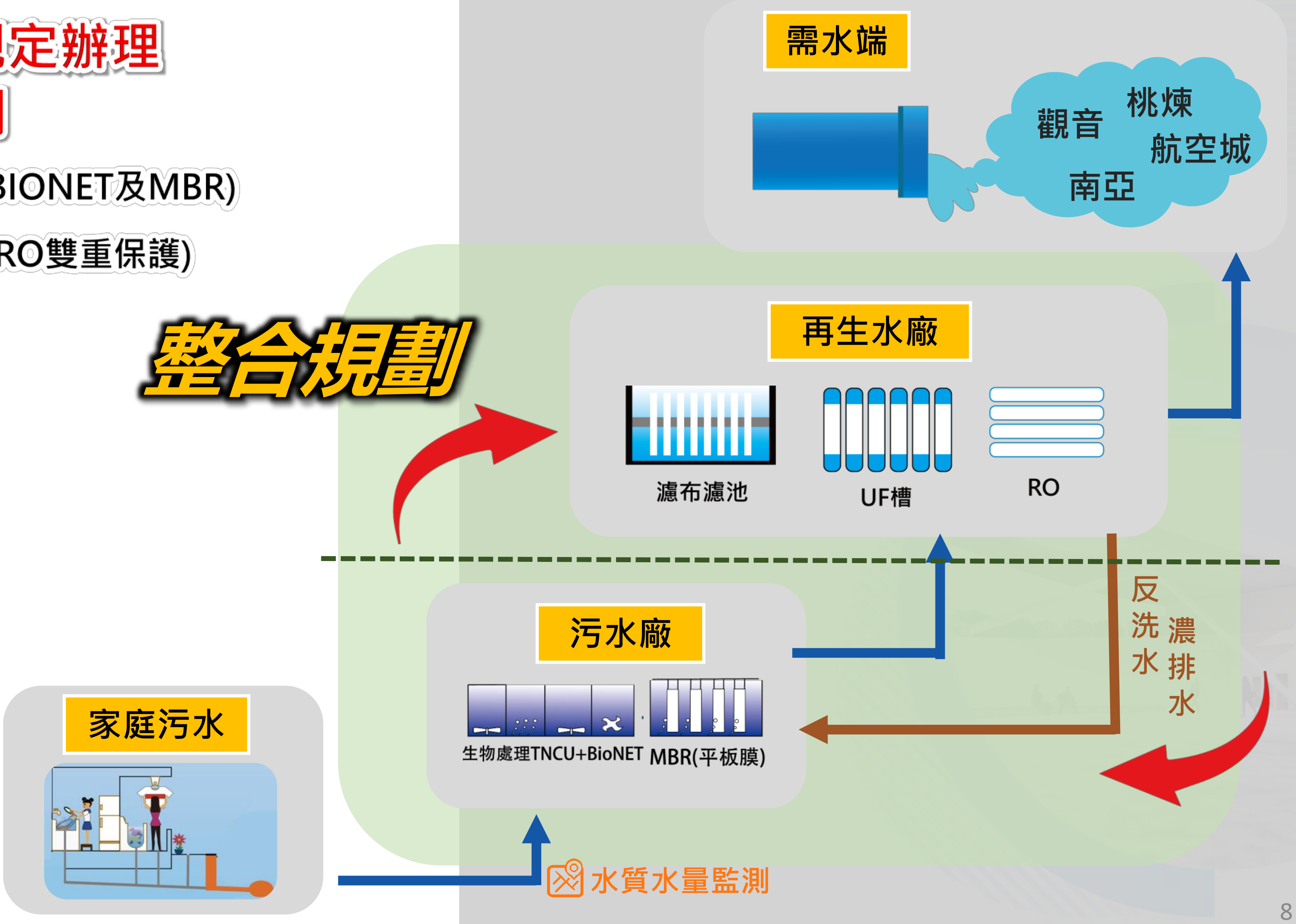
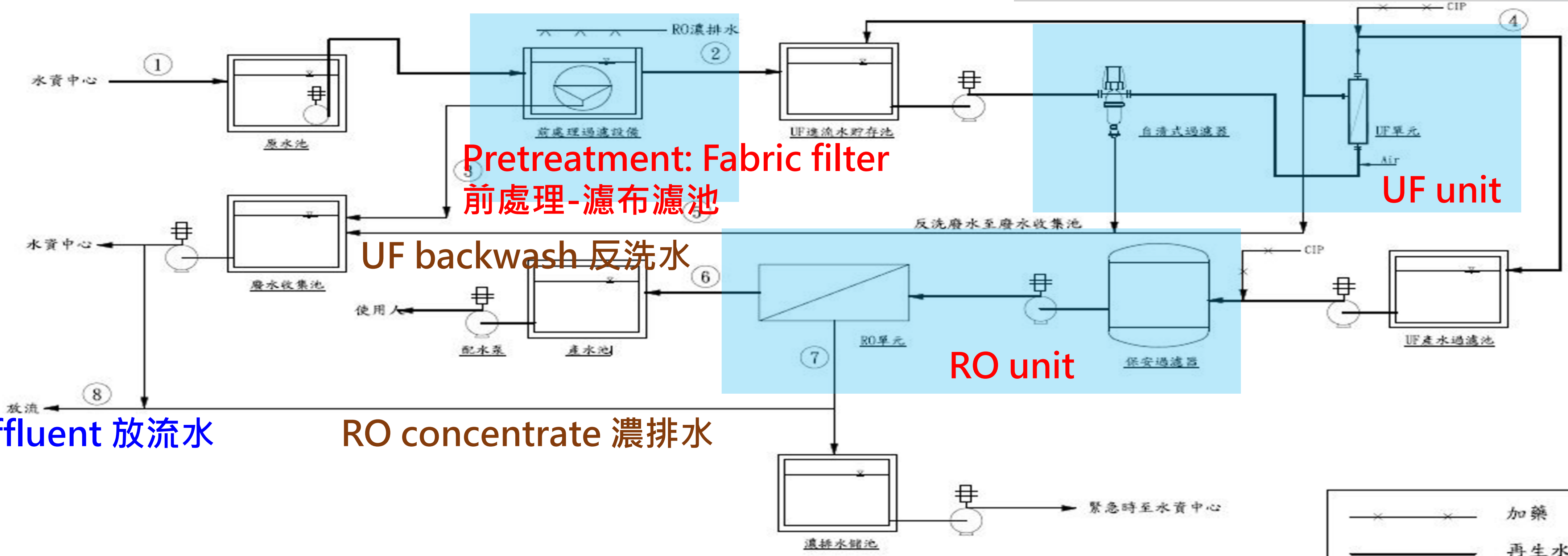
- **系統配置依據需求書規定辦理**
- **再生水及污水整合規劃**
  - 系統整合之適切性。(污水前處理BIONET及MBR)
  - 設備選用適宜性。(如濾布濾池、RO雙重保護)
  - 節能(能源回收裝置)
  - 污水廠處理效果優質化
  - 反洗及濃排水再利用
  - 排放水符合原環評承諾
- **增設水質預警系統**
  - 更強化水資中心既有排放監測
  - 增設下水道水質預警系統
- **導入AI智能系統**
  - 結合水資中心既設MIS/AI系統



Process flow diagram 系統流程圖



北桃園再生水廠質量平衡計算

流體代號		水質運算結果摘要表（35℃）					
		流量	TDS	COD	SS	硝酸鹽	氨氮
		CMD	mg/L	mg/L	mg/L	mg/L	mg/L
1	進流水	**57,971.0**	585.0	30.00	10.00	8.00	10.00
2	前處理過濾設備出流水	**57,971.0**	585.0	27.00	5.00	8.00	9.50
3	前處理過濾設備反洗水	**1,449.3**	2,327.0	203.81	203.97	30.90	55.29
4	UF出流水	**53,333.3**	585.0	21.60	1.00	8.00	9.03
5	UF系統廢水	**4,637.7**	585.0	89.10	51.00	8.00	14.96
6	RO產水	**40,000.0**	6.44	0.86	0.01	0.40	0.27
7	RO濃排水	**13,333.3**	2,327.0	83.81	3.97	30.90	35.29
8	放流水	**13,333.3**	2,327.0	83.81	3.97	30.90	35.29

Pre-treatment: Fabric filter
前處理系統: 採用濾布濾池

Effluent of WWTP
with hair and fiber

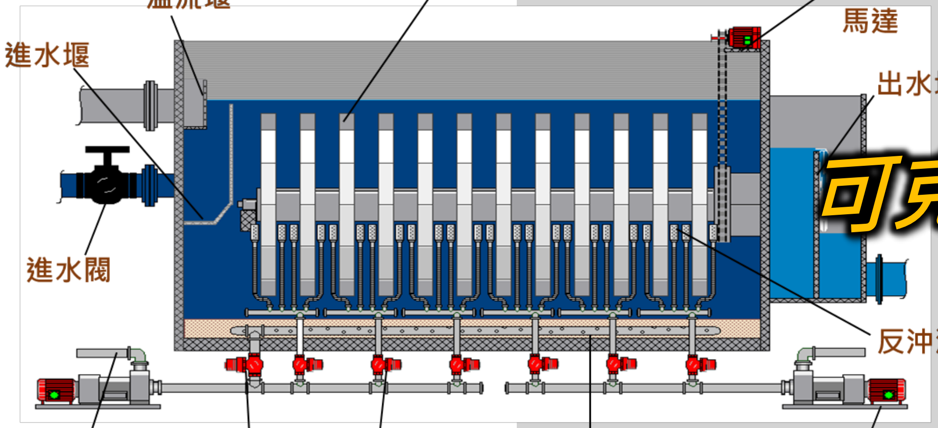
放流水含有細小纖維、棉絮

如採用不適當設備
將導致**處理效果降低**

本團隊採用
迴轉式機械過濾設備
解決纖維及棉絮問題!

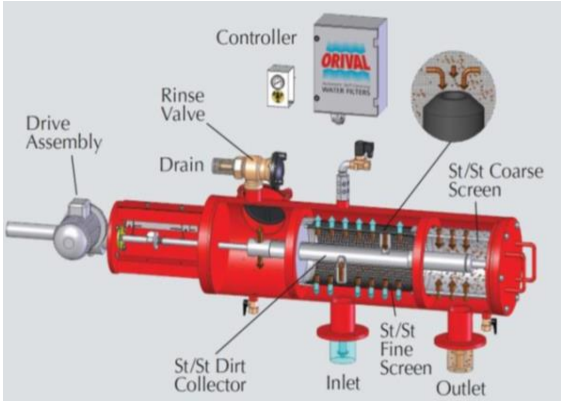
■ Advantage 濾布濾池優點

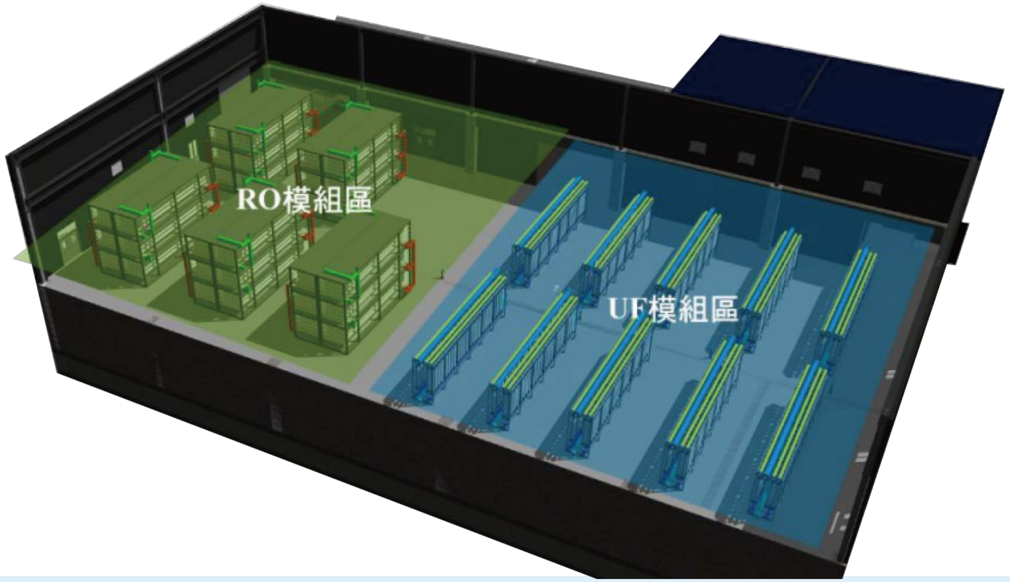
- Stablility 系統穩定
- Easy maintenance
  維護方便
- Small footprint
  佔地面積小
- Lower backwash cycle
  低反沖洗週期(反洗水量少)
- High removal efficiency
  可有效去除纖維與毛髮
- High adaptability
  可依水質特性選擇最適濾布



可克服放流水質含有棉絮問題

UF unit





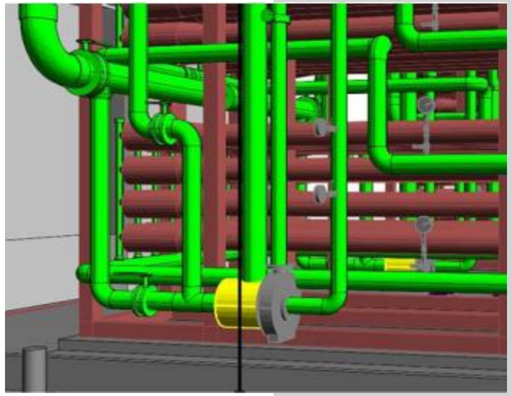
■ UF(超濾膜)

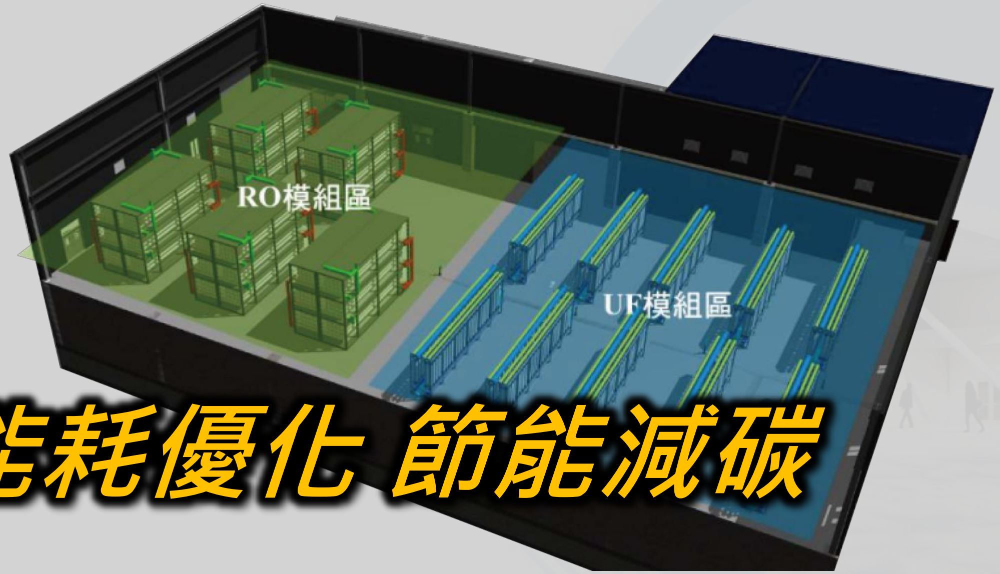
- ■ 選用正壓式UF系統
- ■ 選用歐美日知名品牌
- ■ 進水前端設置自清式過濾器
- ● 產水通量<60LMH
- ● 共設置10組(8+2)，餘裕量25%
- ● 具有線上藥洗功能

RO unit

■ 逆滲透膜(RO)

- 二段式設計
- 使用低壓膜
- 選用歐美日知名品牌
- 設置10組(8+2)，餘裕量25%
- 採用能源回收裝置加壓
- 具有就地化學清洗





減少能耗使用

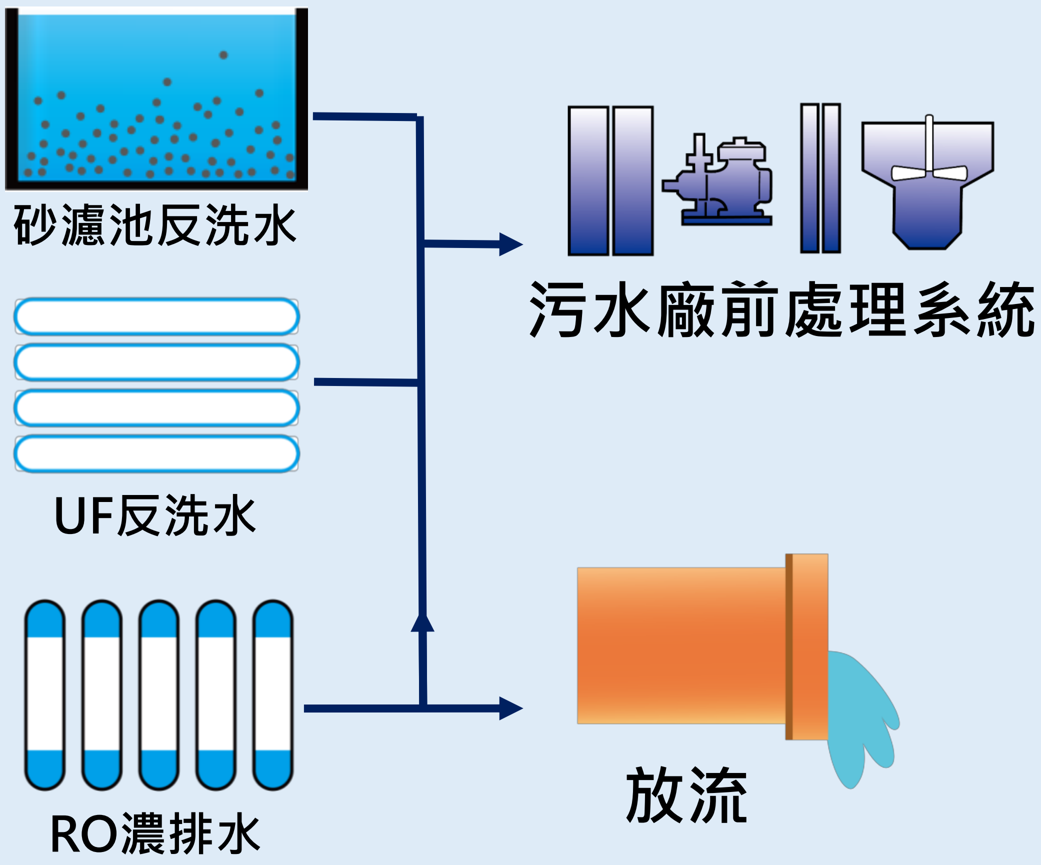
提升薄膜壽命

減少經費支出

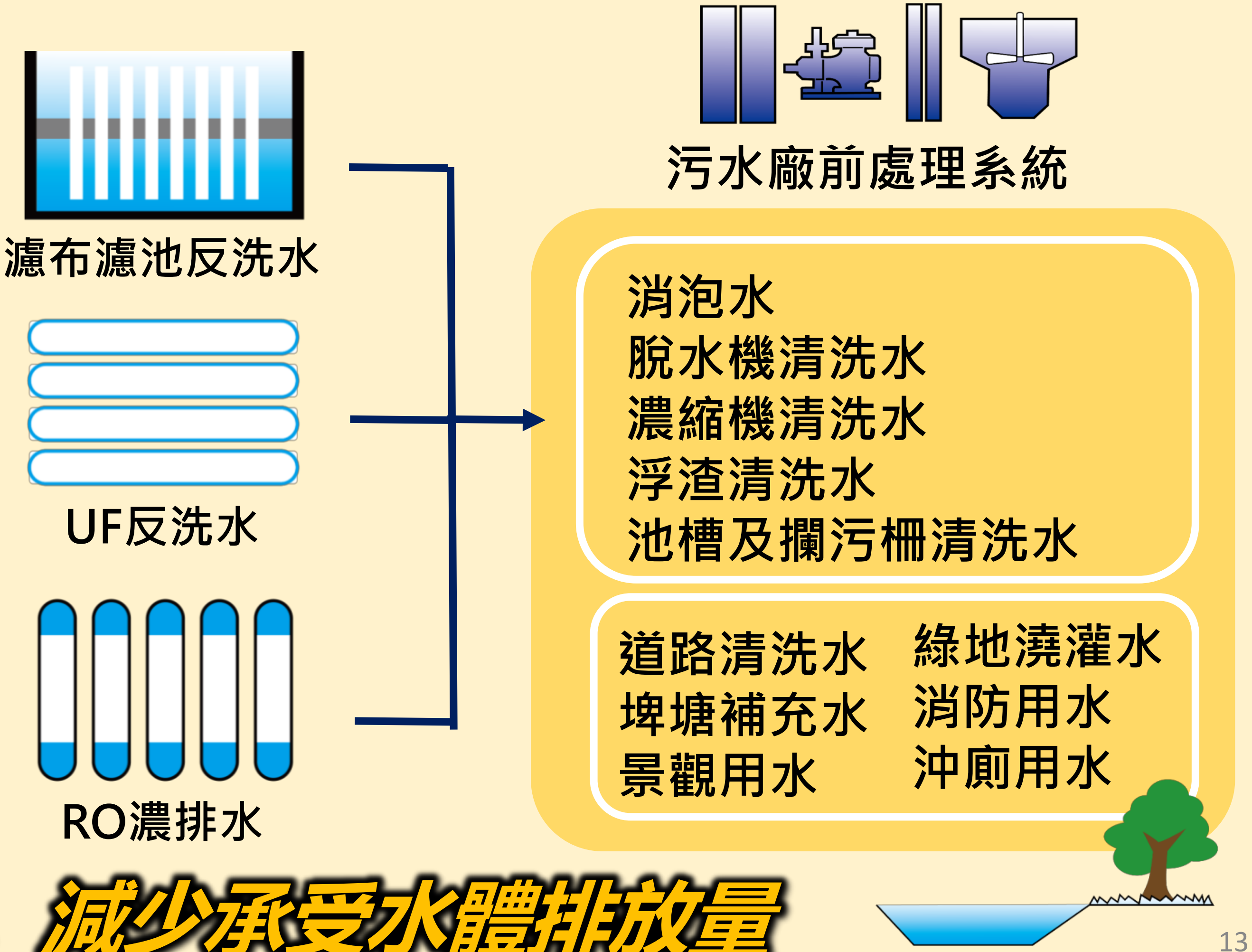
能耗優化 節能減碳

Reuse of UF backwash and RO concentrate
反洗水、濃排水的再利用

Old 原先期規劃



New 本團隊規劃



水資源有效再利用，減少承受水體排放量

Management of water source
水質源頭管理機制

- 下水道系統增設七處監測設備，建立完善巡檢機制

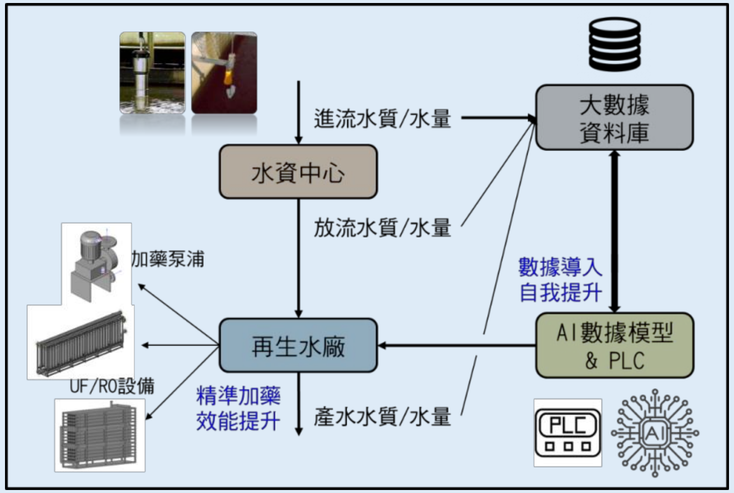
避免鳳山溪再生水廠污染事件再次發生，於下水道管網設置監測設備提早預警。

- 新設異常水質貯存槽

建置水質預警系統
確保污水廠供水水質穩定

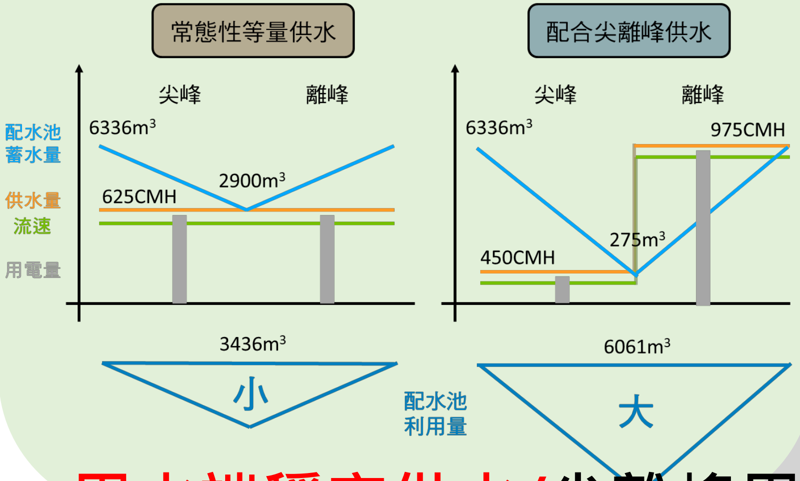
AI and equipment automatization
智能化+自動化應用

應用AI智能化
模擬預測、建立規則庫



建立最佳化操作及預警系統，穩定產水水質

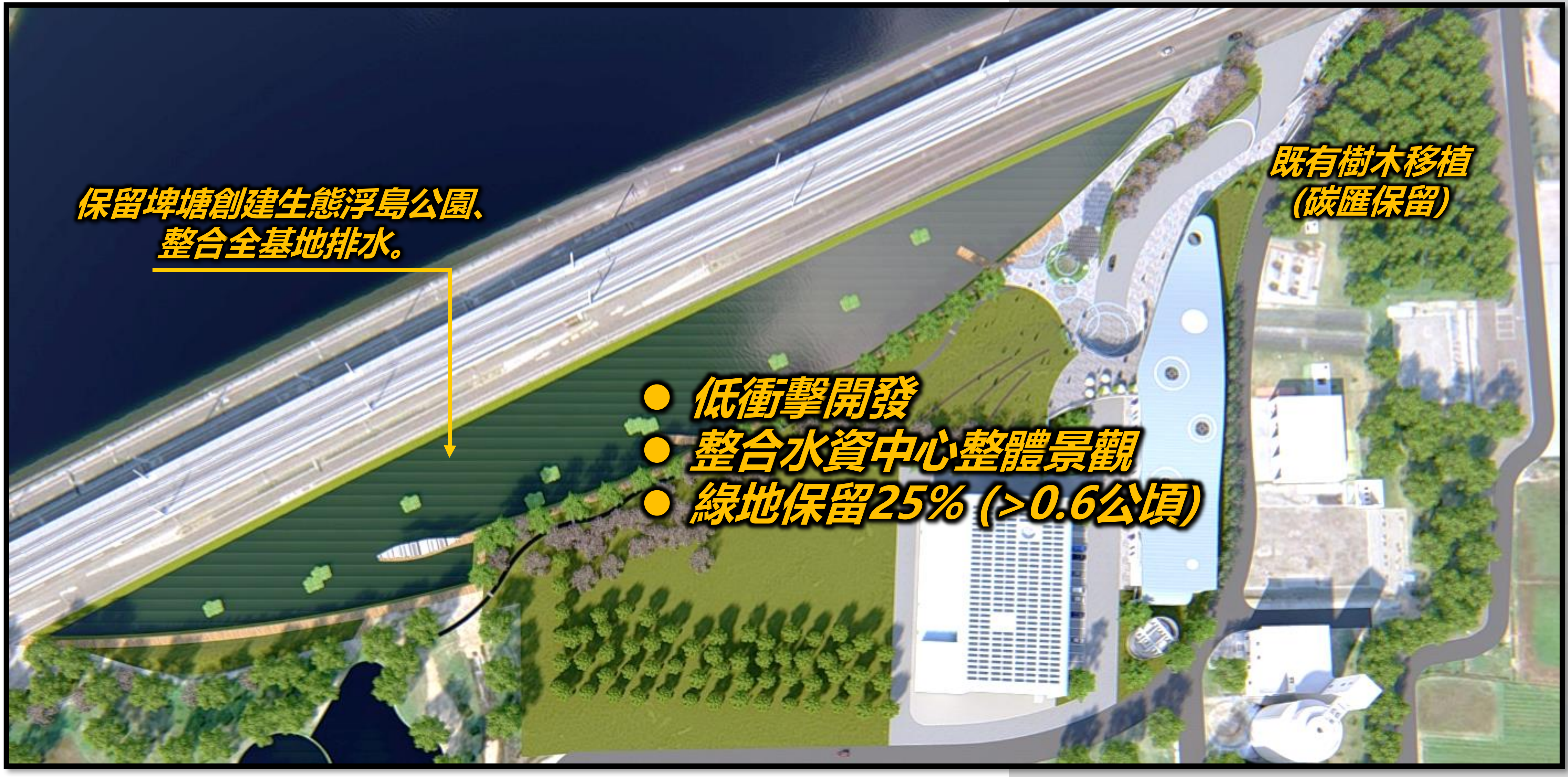
應用工業4.0
自動化操控設備運轉狀態



用水端穩定供水/尖離峰用電，降低電力使用

預期節能10%以上!!

Planning of land use
土地使用計畫



Landscape imagery 地景視覺意象

日勝生中鼎企業聯盟

公園化景觀設計
提供市民休憩空間

在整體建築造形上以「**風生水起**」自然環保的意向為主要概念，期能透過串聯現有之桃花源意象、埤塘地景的變化、自然生態的蓬勃發展，最後連結至水資源中心完成一個完整的**「陽光」、「綠意」與「綠水」的「新桃花園」**永續生態環境體驗經驗。

Building and landscape design
建築景觀整體設計構想

CTCI
中鼎集團
日勝生中鼎企業聯盟

Public art: Solar energy tower
公共藝術_能源塔

結合「環保」與「再生」概念，**將再生水廠的廢棄管線轉化成為再生藝術裝置**，上方太陽能板可提供夜間照明之相關用電。

Green art park
再生藝術公園

產水池上方空間規劃景觀大草坡，除提供民眾休憩與活動之空間外亦達到動線的串聯；周邊設置生態溝渠提供民眾戲水、親水之空間。

Recycled brick wall
廢棄物再生_污泥磚圍牆

以水處理過程產生的污泥所製作的磚材作為基地圍牆、鋪面構材，落實廢棄物的轉化與再利用概念。

Convention center
大型會議中心

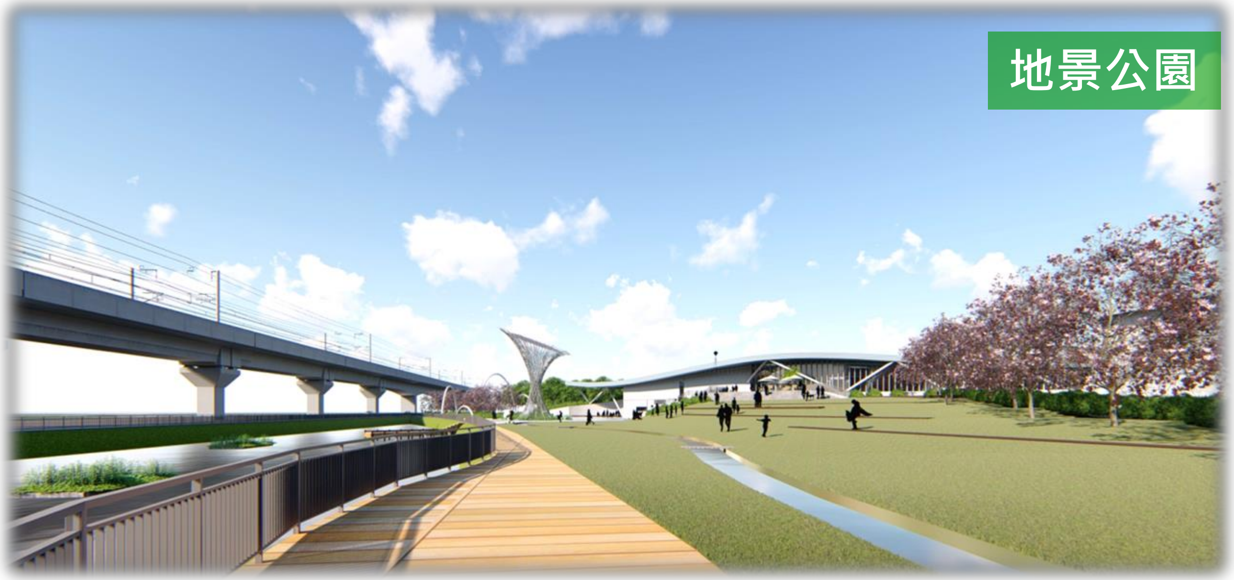
挑高之屋頂造型既是門廳
亦是用於迎賓的
可遮陽、遮雨活動廣場。

Certification center
1F 驗證中心

驗證中心位於管制點之後，平時不對民眾開放。提供相關檢驗、設備控制、辦公、會議等使用空間。

Perspective drawing of Building
建築模擬透視圖

日勝生中鼎企業聯盟



Administration building
管理中心建築設計

2F-水科技教育館及咖啡廳

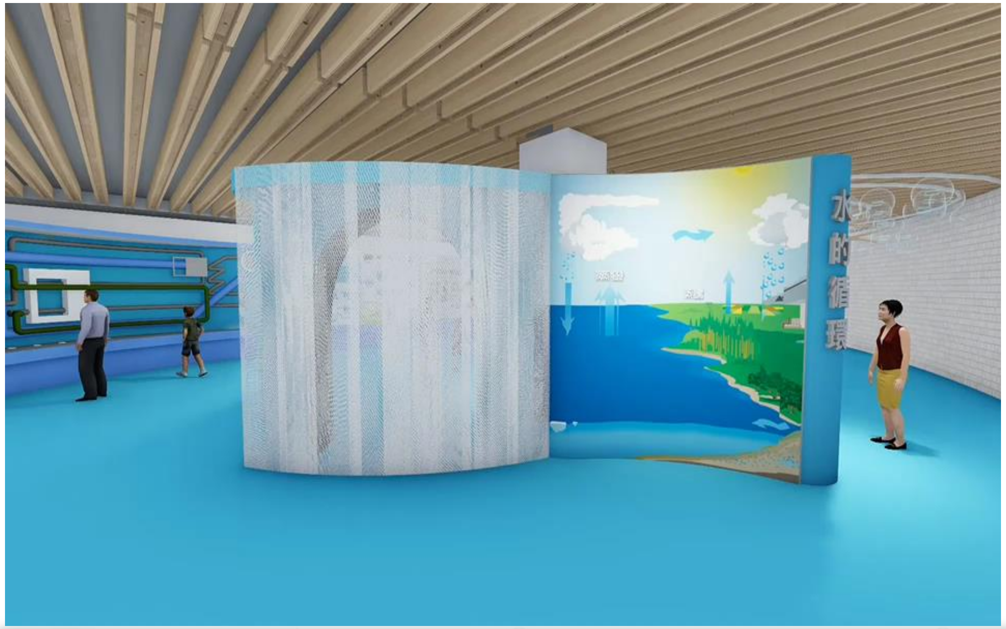
1F-會議中心與驗證中心

打造黃金級綠建築及銀級智慧建築

Administration building: 1F layout
管理中心 1F平面配置圖

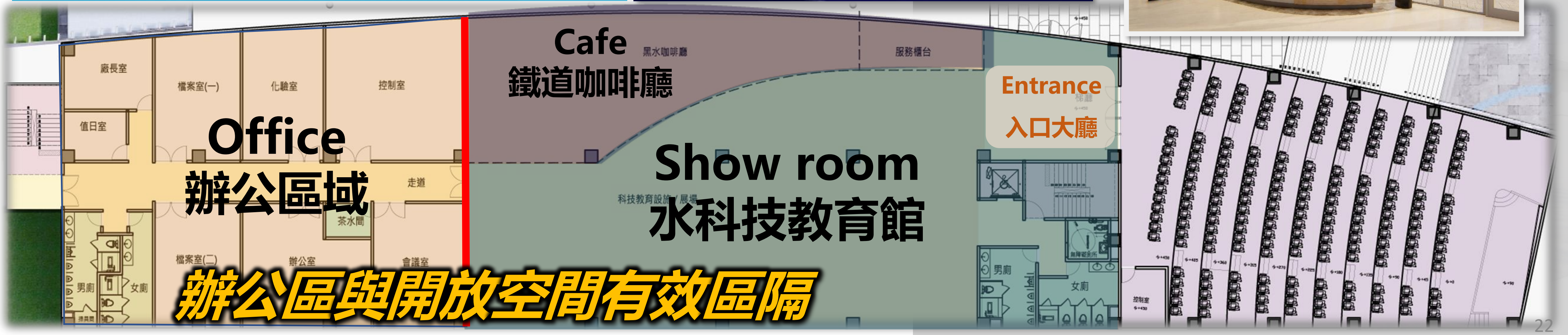
中鼎集團 日勝生中鼎企業聯盟

Administration building: 2F layout
管理中心 2F平面配置圖



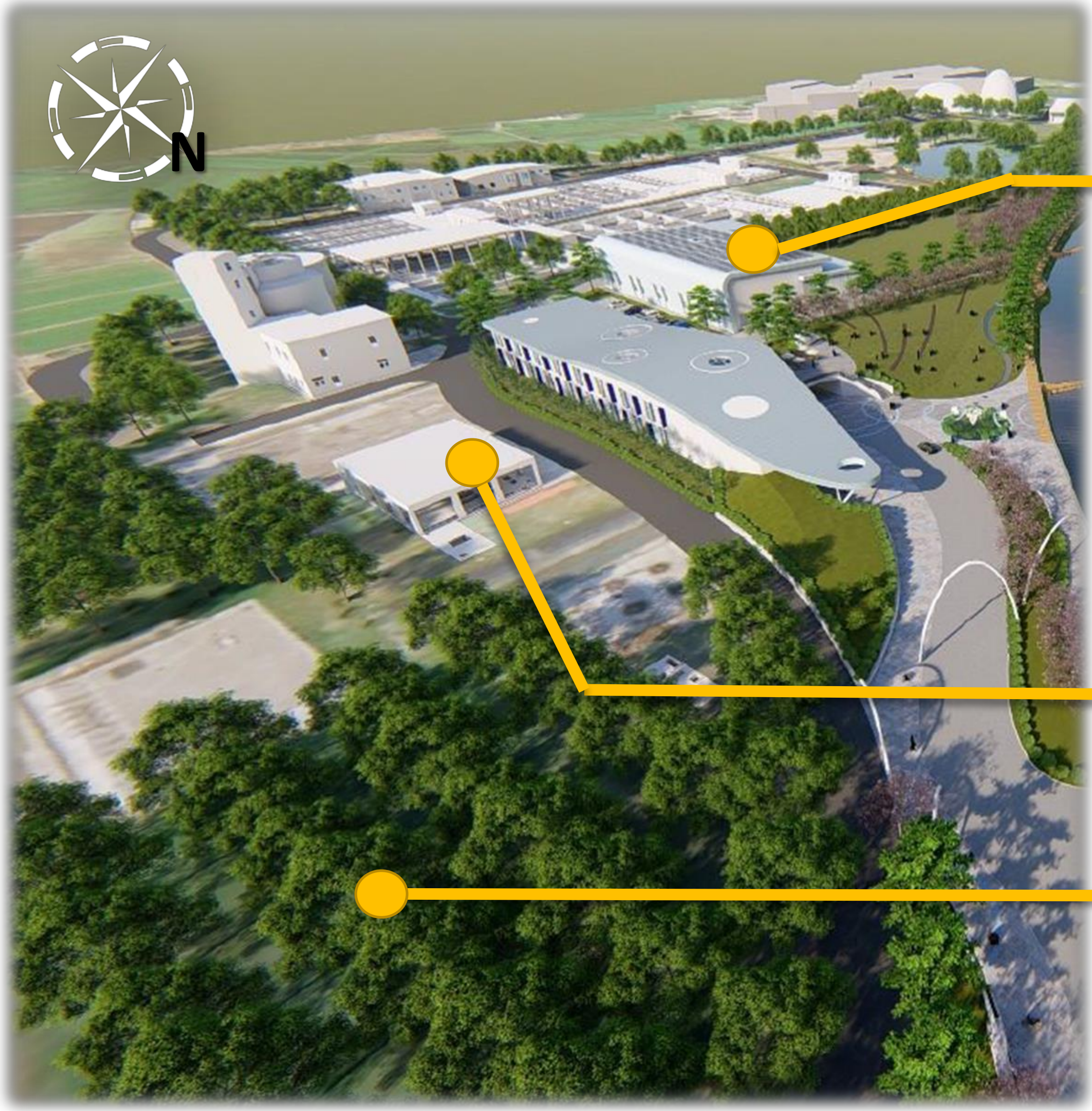
■ 打造光影、互動、體驗式水科技教育館

■ 預留鐵道咖啡廳空間，提供休憩與交誼場所



Building design
廠房規劃設計

CTCI 中鼎集團 日勝生中鼎企業聯盟

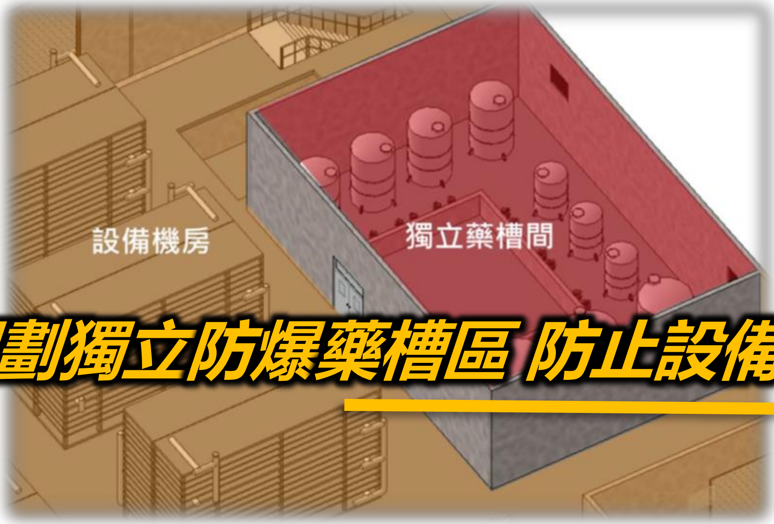


廠房採自然通風，並設置太陽能板

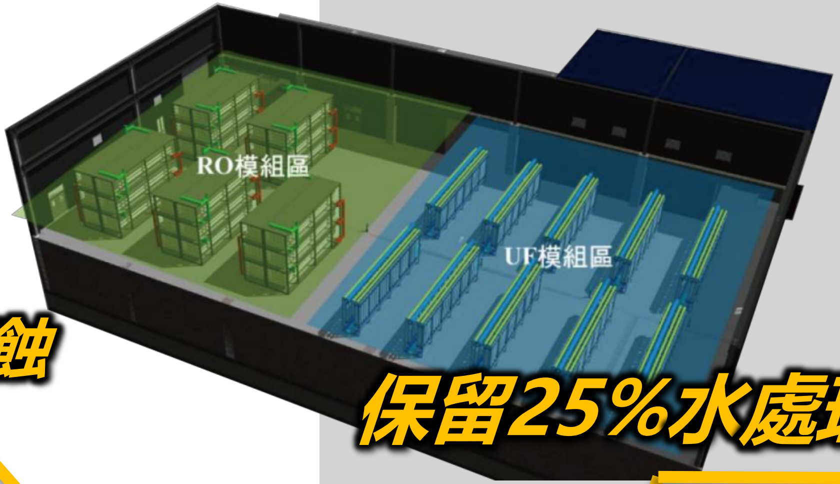
廠房位置 鄰近水資中心放流井

原有廠區樹木 現地移植

Building interior design
廠房內部設計與配置

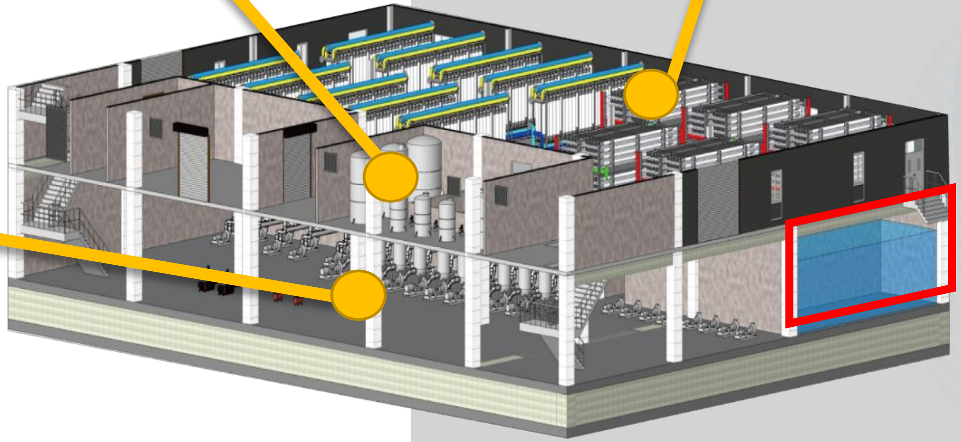


規劃獨立防爆藥槽區 防止設備受酸氣腐蝕



保留25%水處理設備擴充空間

獨立機房配置、阻絕噪音影響



水槽地下化

2.2 Pipeline design
輸水管線設計規劃

CTCI 中鼎集團 日勝生中鼎企業聯盟

Pipeline construction
輸水管線施工關鍵

- **施工介面多，**行經捷運、高鐵、國道、河川及航空城，
- **輸水管壓力大**(桃煉段)，**輸水管線長**(觀音段19KM)，**營運風險高**
- **地下管線障礙多、交通衝擊大**
- **潛在用水端開發之考量**

Criteria of pipeline design
管線設計規劃準則

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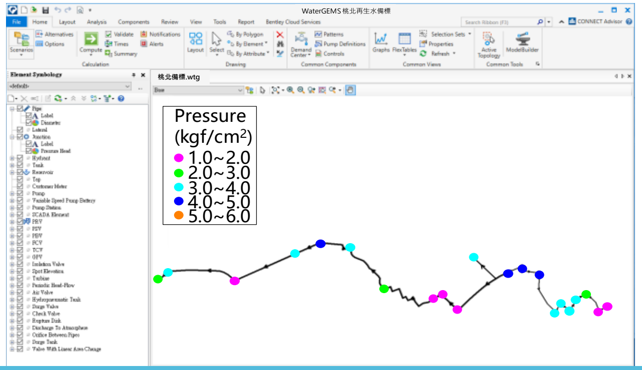
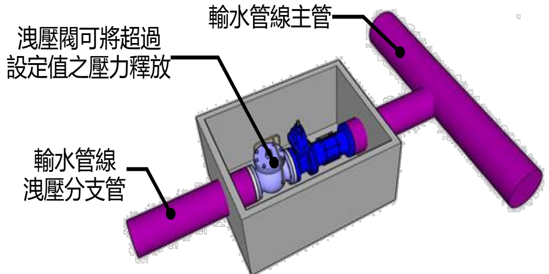
- 管網全段水力分析
- 設置水錘減緩設施

- 利用3D-BIM模型模擬管線配置

- 選用最高品質南亞HDPE管

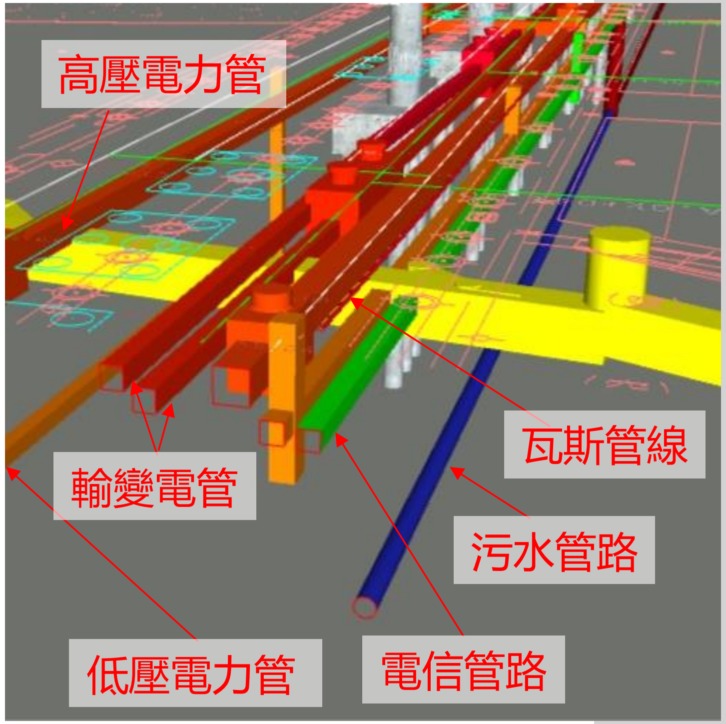


管網水力分析



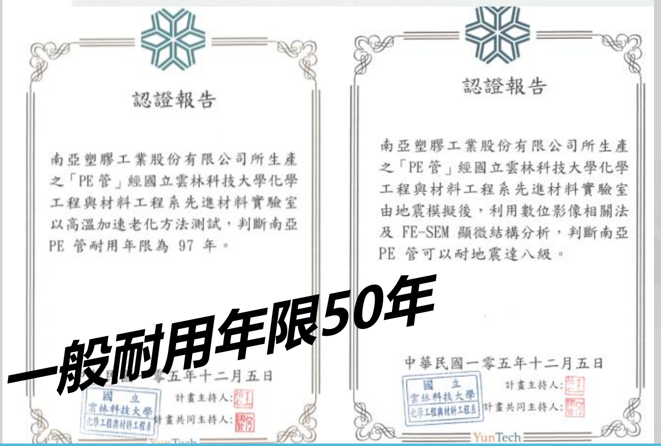
安裝洩壓閥

建構安全輸水系統



中正北路3D管線模擬

減少管線衝突

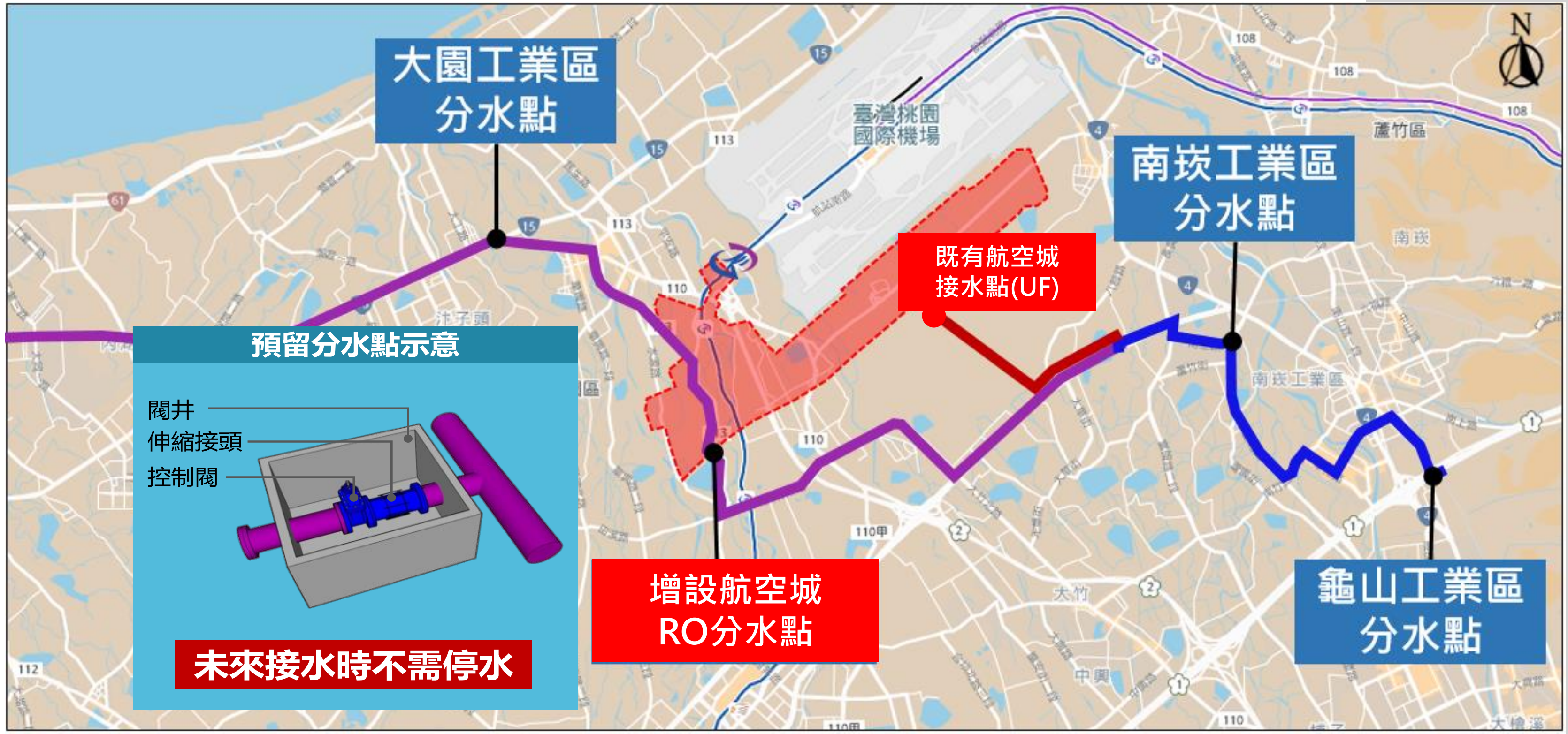


耐用年限97年，耐地震達8級

百年 環保永續

Pipeline design
管線設計 潛在用水端開發考量

- 設置4處分水點(大園、龜山、南崁工業區及航空城)。
- 提供航空城產業專區多元供水(超濾(UF)及逆滲透(RO)處理水)，打造國內首座三元供水園區。



積極開發潛在用水端，順利達成全期目標

03 Operating plan 營運計畫

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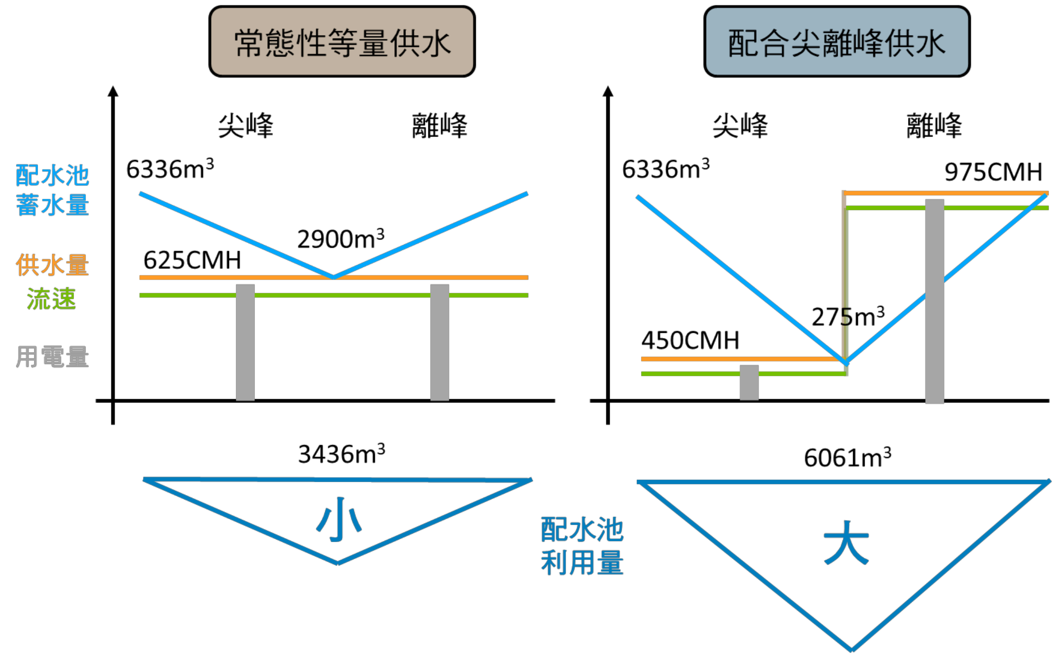
AI management
建立AI智能管理

工業4.0數位轉型達到資訊化、智慧化、自動化，設備延壽、操作最佳化

Industry 4.0：Automated water supply
工業4.0自動化配水

中鼎集團 CTCI 日勝生中鼎企業聯盟



完整瞭解用戶端需求

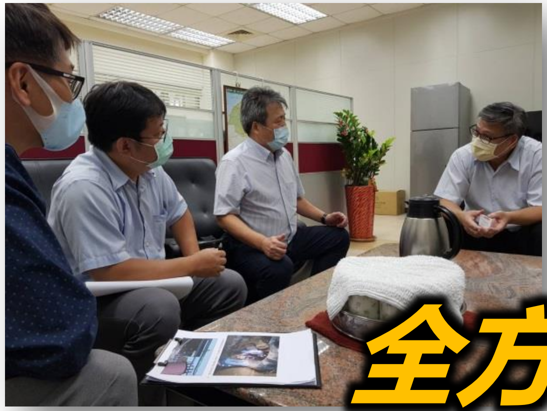
＋

工業4.0自動化模式

↓

智慧化配水

- 多出2,000噸額外貯存量
- 降低電力成本及負荷
- 避免微生物孳生



全方位服務最為客戶著想

Water quality monitoring system
完整的水質水量監測系統

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Kitchen waste 廚餘

Sewage 生活污水

Night-soil 水肥

7處水質監測
(進流水預警使用)

處理單元
水質監測

進/出流水
水質監測

用戶端池槽液位
工業4.0智慧輸配水

Sewer 污水下水道

WWTP 污水廠

RWP 再生水廠

End user 用戶端

62處水量監測
(污水廠操作使用)

進出流水
水質(量)監測

管線壓力計

進流水
水質監測

共計 119 站以上 400+ 監測項目，全方位即時監控

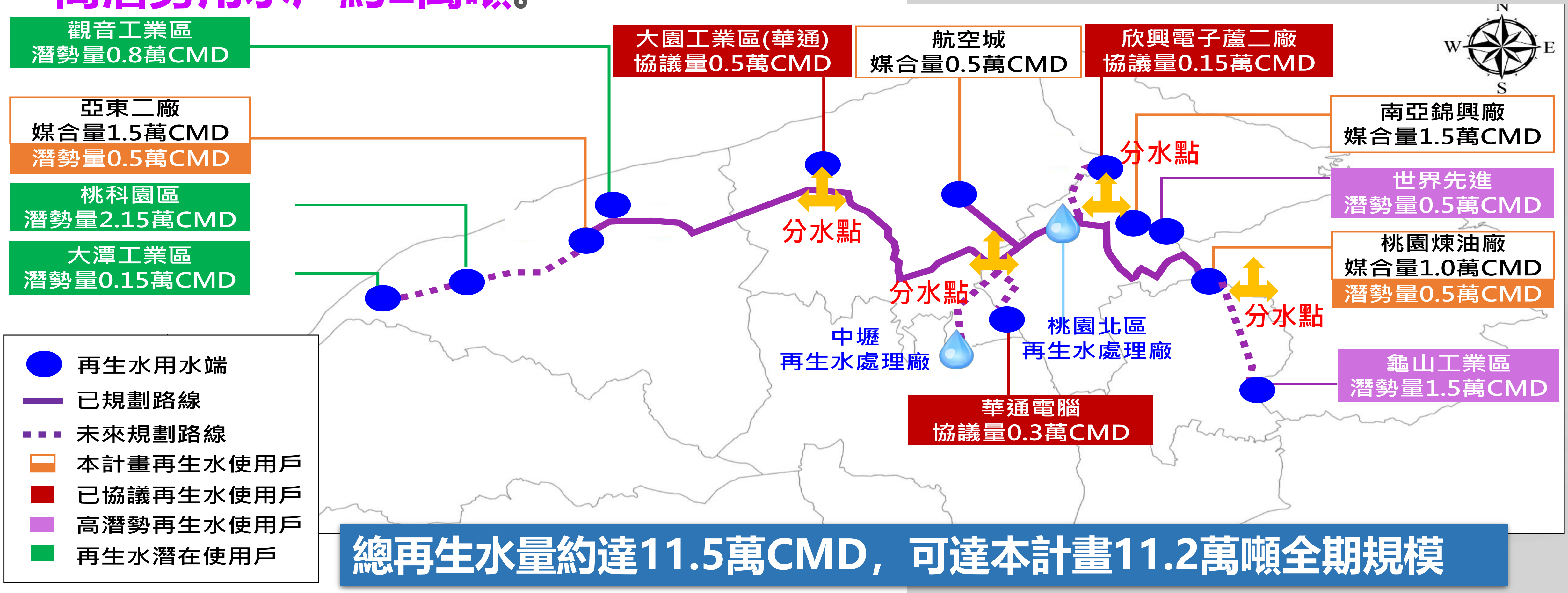
04

Potential user
潛在用水端開發

CTCI 中鼎集團 日勝生中鼎企業聯盟

打造水循環永續城市 的再生水藍圖

- 本團隊初步調查計畫區內用水潛勢量約11萬噸。
- 協議中用水約0.95萬噸。
- 高潛勢用水戶約2萬噸。



總再生水量約達11.5萬CMD，可達本計畫11.2萬噸全期規模

05 Sustainable innovation 創意永續

Sustainable innovation 創新永續經營

國產薄膜系統之驗證
-微波清洗薄膜技術

開發二次組件強效再生技術
-微波清洗薄膜技術

民生污水厭氧氨氧化技術開發
-單段式亞硝化/厭氧氨氧化系統

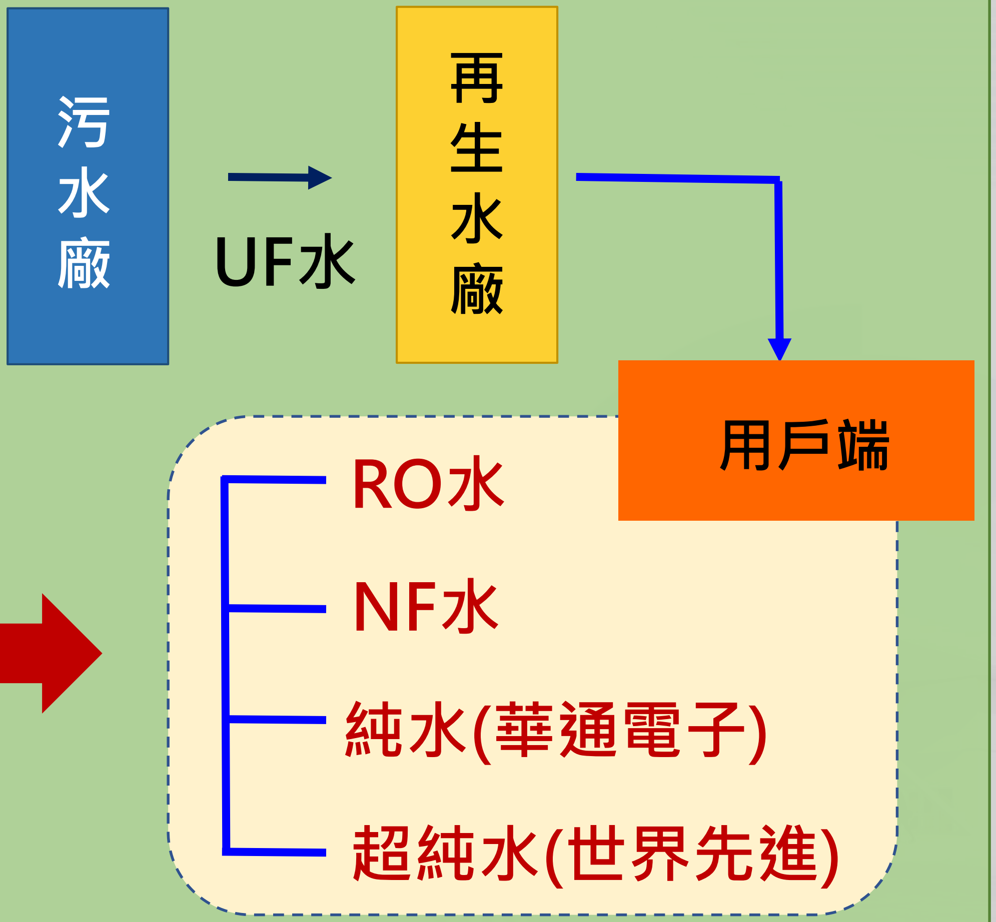
抗旱水井設置移動式淨水設備
-抗旱設施之全日供水及車輛運輸壓力測試

水及能資源全回收低排碳薄膜系統
-薄膜蒸餾

與多方機構簽訂發展合作意向書
-最佳化操作及智慧化控制建置

前處理保護構想
能源回收之裝置
RO濃鹽水再利用

處理廠自主認證
節能減碳新作為
操維管理科技化



持續創新研發 強化系統操作與效能

達到多元供水與穩定化

Sustainable environment
環境永續

CTCI 中鼎集團 日勝生中鼎企業聯盟

低衝擊開發策略

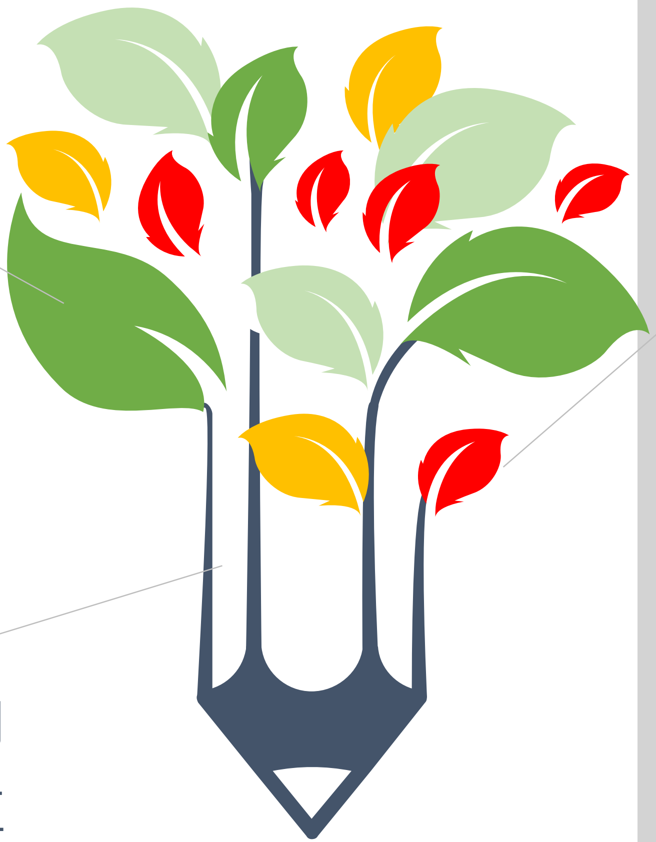
- 處理設施及廠房-最小化
- 管理及會議中心-最適化

不過度設計與開發

綠色園區之塑造

- 植栽計畫-原生植物為原則
- 植栽模式-自然化之複層植栽

重視豐富性與多樣性



綠建築及智慧建築規劃願景

- 涵養水資源-透水鋪面
- 建築量體-導入智慧型電能管控系統
- 減碳-建材優先採用低二氧化碳排放量

達成銀級綠建築為基礎

達成銀級智慧建築為基礎

朝向黃金級綠建築做為目標

創造一個對環境生態友善的環保園區

Certification center of key equipment
驗證中心構想

驗證中心


厭氧氨氧化技術模廠


平板膜效能試驗


微波清洗薄膜


NF膜模廠


中原大學水及能資源回收


水利署-抗旱設備

延續過往處理技術開發與實廠驗證

達成

願景

- 技術本土化
- 設備國產化
- 系統自製化

TAIWAN INT'L WATER WEEK

Oct. 12 ▸ 14

綠色永續下 創新水戰略

Innovative Strategies for Water Sustainability

International Forum 2022

中華民國經濟部 Ministry of Economic Affairs, R.O.C.(Taiwan)
經濟部水利署 Water Resources Agency, MOEA
TAITRA Taiwan External Trade Development Council

Brine Management Strategy and Recovery Technology

Dr. Guan-You Lin

Manager

Material and Chemical Research Laboratories

Div. of Water Technology Research

ITRI

Global Zero Liquid Discharge (ZLD) Market

- Significantly Increasing Wastewater Volume to Shape Market Growth
- Stringent Environmental Regulations to Push Demand for ZLD Systems
- Growing Application of ZLD Technologies in Desalination

"The desalination plants worldwide currently produce about 142,000,000 m^3/day of freshwater and have an average freshwater recovery of 40%."

IDA and GWI DesalData (2019)

Brine

A saline wastewater generated from several industries (e.g., desalination, energy and chemical) and its disposal can have adverse environmental impact.

Brine treatment (salt and water recovery) can be a promising option to eliminate the wastewater discharge.

Treatment systems should be designed that can maximize the freshwater recovery and achieve resource recovery by minimizing the volume of the brine effluent.

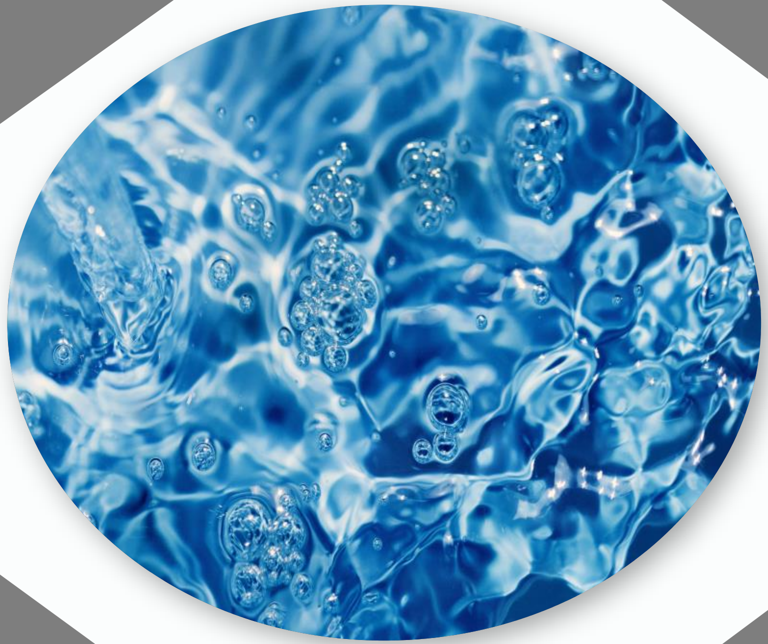
TAIWAN INT'L WATER WEEK

Key Motivation of Zero Liquid Discharge (ZLD)

High Fresh Water Demand

- Intensified freshwater scarcity
- Increasing demand for freshwater
- Alternative strategies to obtain freshwater have to be found
- The recovery of both freshwater and other useful materials

Attempts to Recover Valuable Resource



Public Environmental Awareness

- Increasing public awareness of the adverse impacts of brine effluents
- Adaptation of stricter regulations for brine disposal that may restrict several disposal methods in the coming years

Stricter Regulation for Brine Disposal

The development and adoption of ZLD systems can achieve these goals:

- ✓ **Compliance with environmental regulation**
- ✓ **No cost on wastewater disposal**
- ✓ **Augmenting water supply**
- ✓ **Protecting the environment**
- ✓ **Salt mining**

Environ. Sci. Technol. 2016, 50, 6846−6855
J. Environ. Chem. Eng. 2020, 8(5), 104418

Trends of ZLD

"The global ZLD market size reached US$710 million in 2018 and is expected to reach US$1,760 million by 2026, demonstrating a CAGR of of 12.1 % over the forecast timeframe."

IDA and GWI DesalData (2019)

Vendor for ZLD technologies in EU:

- Veolia
- Suez
- Condorchem Envitech
- Aquarion Group
- Hydro Air Research
- Lenntech

Asia: China and India (first in 2007) have the regulation for ZLD in industry:

✓ Tannery
✓ Textile
✓ Coal industry

America: First implement ZLD for wastewater (2015)

✓ Tightened the regulation for salinity water discharge to surface water.
✓ Limitation for cooling water and FGD wastewater discharge from power plant

Vendor for ZLD technologies:

- Aquatech
- Saltworks
- Desalitech
- Oasys
- SafBon Water Technology
- Fluence Co. Ltd.

Taiwan: Some industrial Park have the regulation for ZLD or the conductivity limitation of wastewater discharge.

✓ Tongluo science park
✓ Sinji industrial park

Vendor for ZLD technologies in Asia:

- Toshiba Infrastructure Systems & Solutions Co.
- Arvind Envisol
- Samco Technologies Inc.
- Shiva Global Environmental Pvt. Ltd.

J. Environ. Chem. Eng. 2020, 8(5), 104418

ZLD policy vs. Brine Issue

Brine water produced from seawater desalination and wastewater reclamation have huge environmental impact on receiving water.

State of desalination and brine production:

- 15,906 operational desalination plants
- Desalinated water production: 95.4 million m^3/day
- Brine production: 141.5 million m^3/day

Science of the Total Environment 657 (2019) 1343-1356

Taiwan mulls measures to increase water supply by 2031

-Water recovery rate reaches to 80% for industry

-770,000 m^3/day recycled water from domestic wastewater treatment plant

-**Total brines will be produced about 2 million m^3/day**

TAIWAN INT'L WATER WEEK

O&M Aspect of ZLD/ZWD

ISSUE 1. Reducing ZLD cost

Reduce chemical/energy of water recovery

- Utilization of advanced biological treatment system for ammonia and COD removal to reduce membrane fouling and promotion of recovery water quality. (BioNET®/MBR)
- Using energy-saving technology to minimize RO reject concentrate, and thus reduces inlet volume of brine water of the evaporator. (EDR/CDI/FO/MD)

ISSUE 2. Reducing ZWD cost

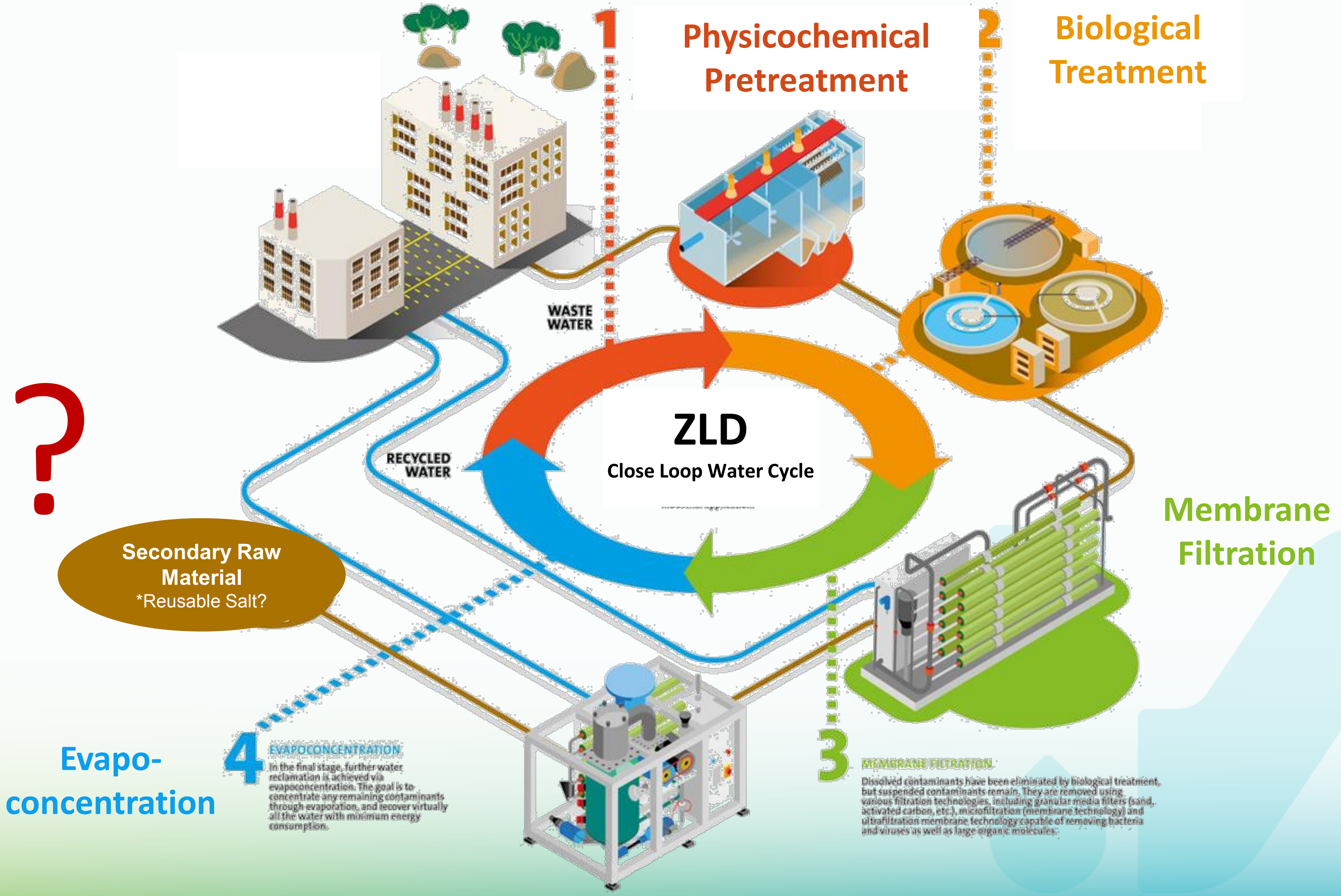
Reduce solid waste mixed salts (now incapable for reuse)

- On-line separation and regeneration of anionic/cationic ions into resources by membrane-based electro-separation technology will produce a value-added chemical product.
- It also reduces mixed salt quantity and the volume of spent liquid to evaporators.

ISSUE 3. Dynamic control of system performance

- Installing intelligent system (IoT) of ZLD/ZWD plant for performance optimization.
- On-line monitoring for membrane fouling/scaling prevention, automatic chemical dosing, and system optimization, etc.

ZLD technology aims to reuse wastewater in a system



Ref: Veolia
Modified by ITRI

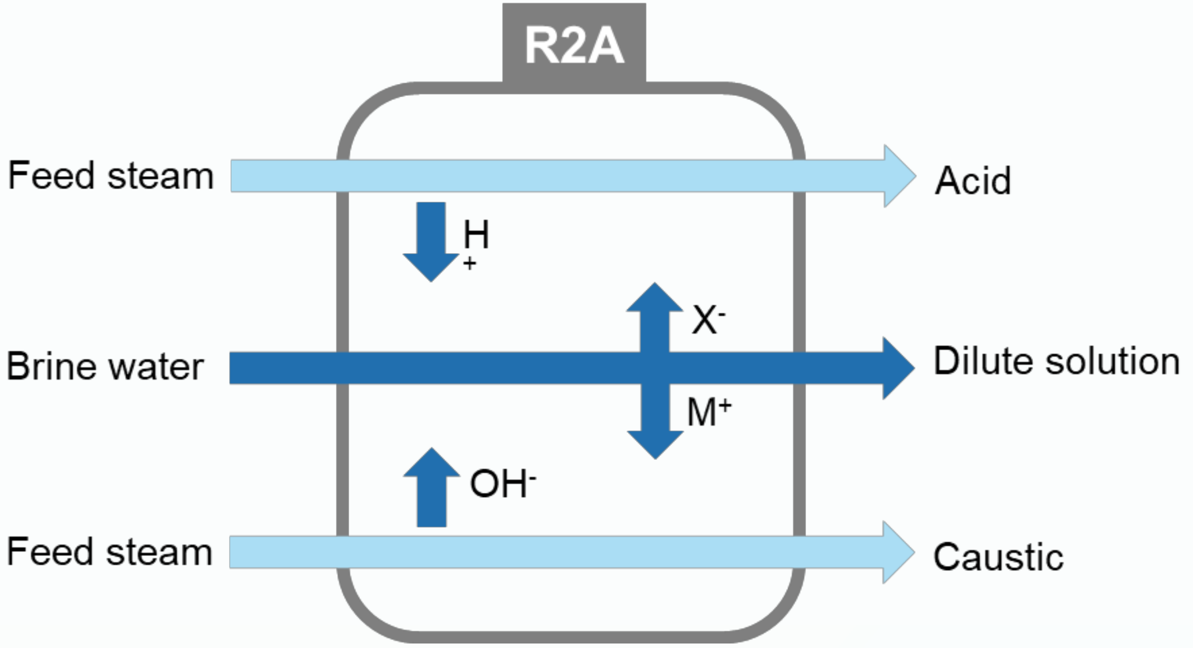
Solid waste mixed salts are now incapable for reuse

- In-line salts recovery in liquid phase

Urgent Issue in ZLD

Membrane-Based Electro-Separation Technology

In-line separation anionic/cationic ions
Selective production of HCl/H_2SO_4/NaOH



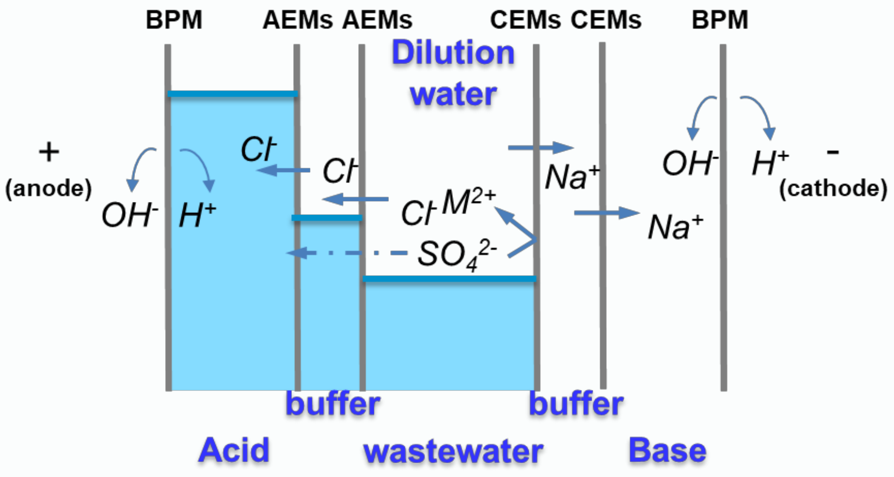
R2A (Recovery to Acid and Alkali)

an IEM processes applies a selective membrane to split water into H^+ and OH^- for acid and alkali production.

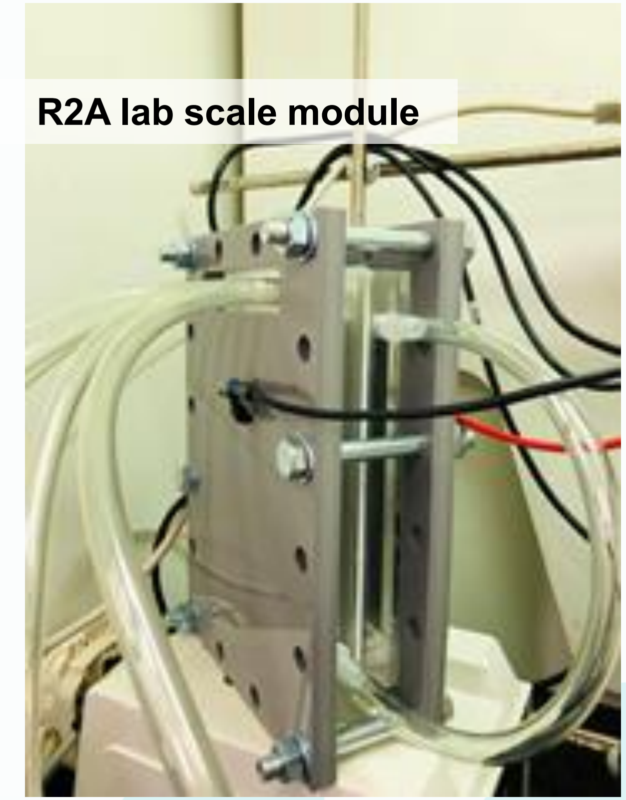
Applications

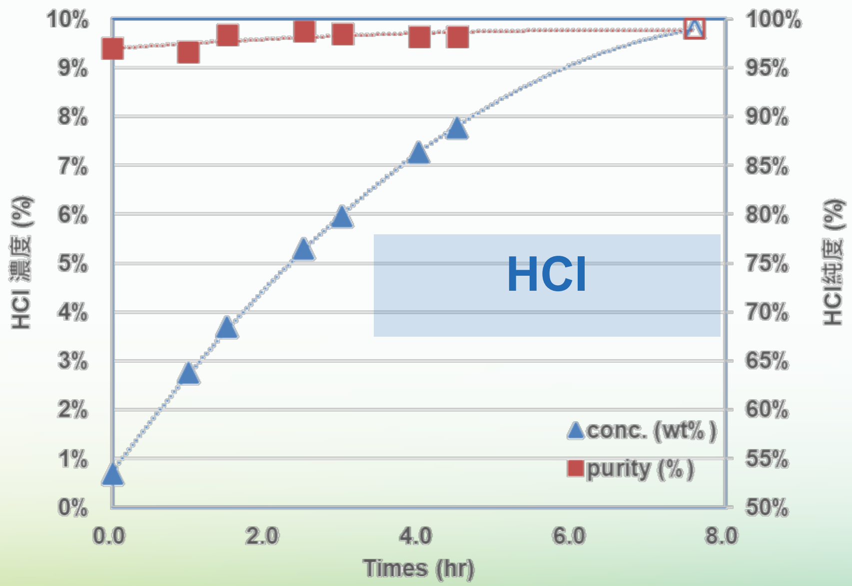
- Brine recovery (cation/anion)
- Production of acid/caustic from mixed salt in liquid phase
- Pretreatment for final MVR/MEE/chiller of ZLD process

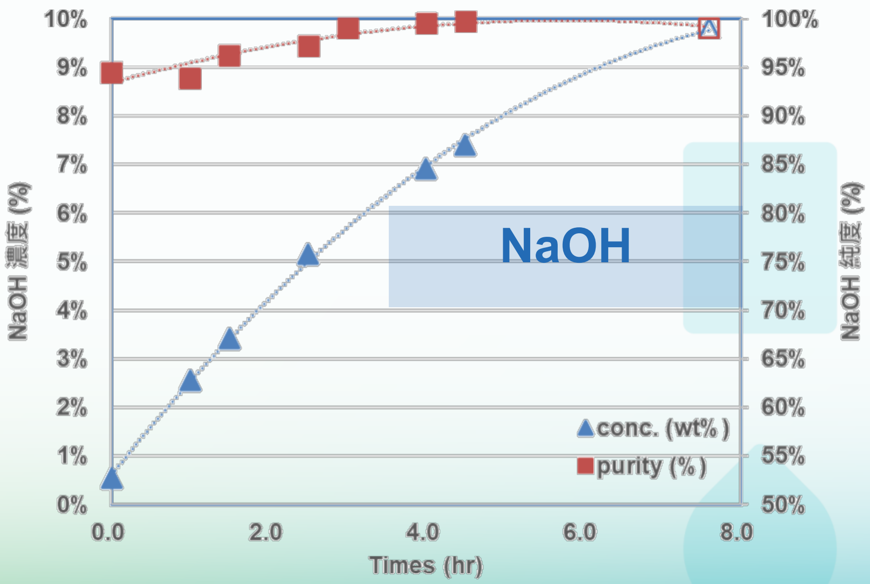
R2A Feasibility Test
Synthetic High TDS Wastewater



The 10 wt% synthetic brine contained 8 wt% NaCl and 2 wt% Na_2SO_4 was successfully converted to 1.0 M HCl (96% purity) and 1.0 M NaOH (99% purity) respectively and the chloride ion recovery reached to 91%.

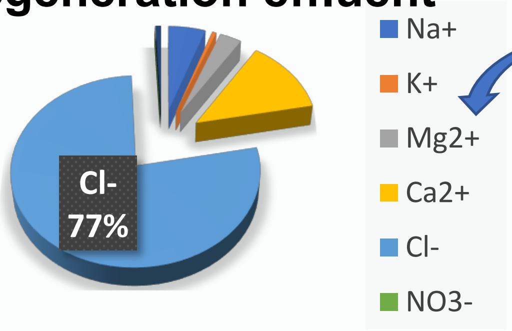




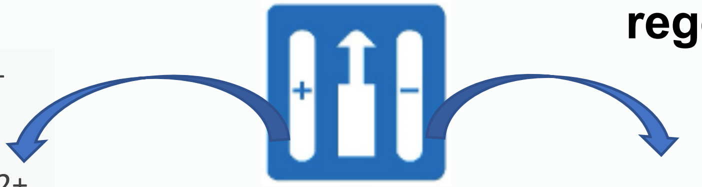


R2A Feasibility Test
Resin Regeneration Wastewater

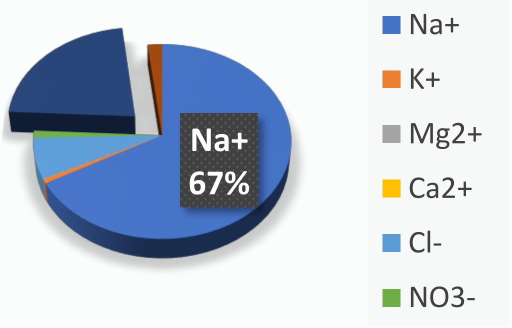
AIX regeneration effluent

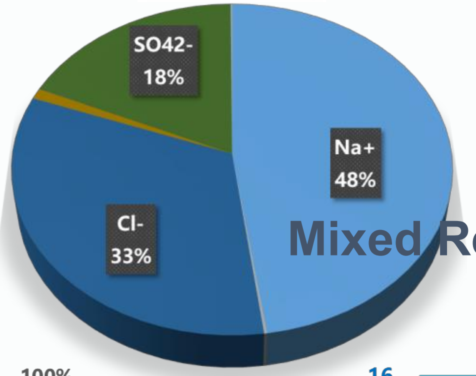


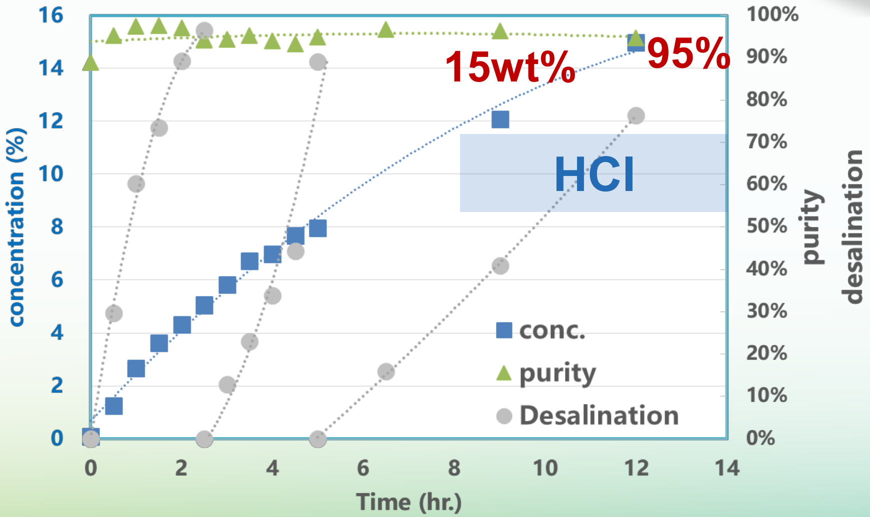
2B3T Resin tower

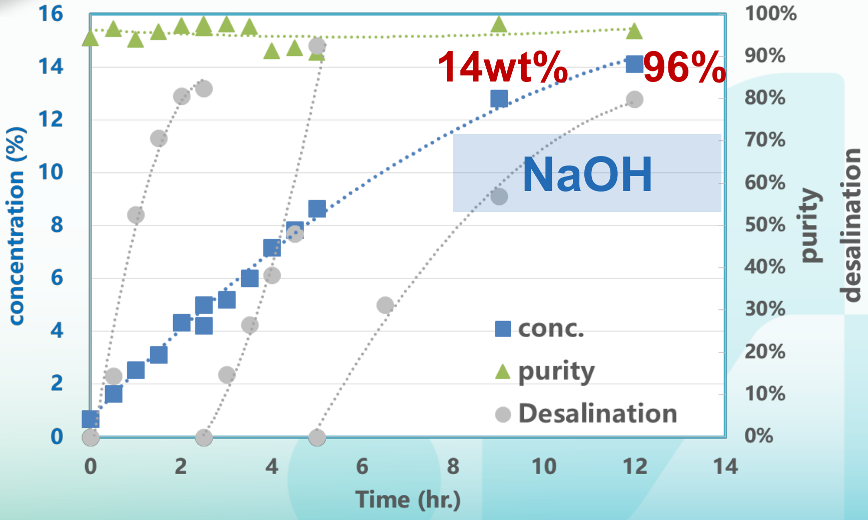


CIX regeneration effluent



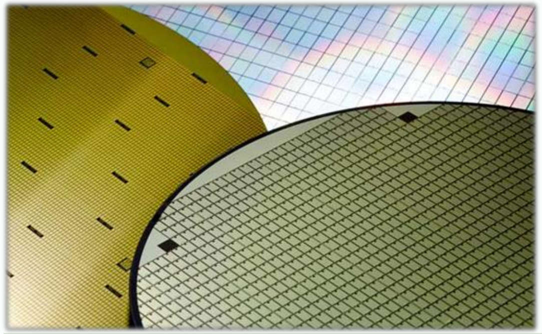






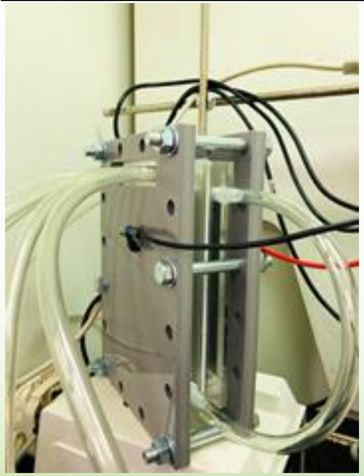
In-line anionic/cationic ion separation to produce HCl and NaOH selectively

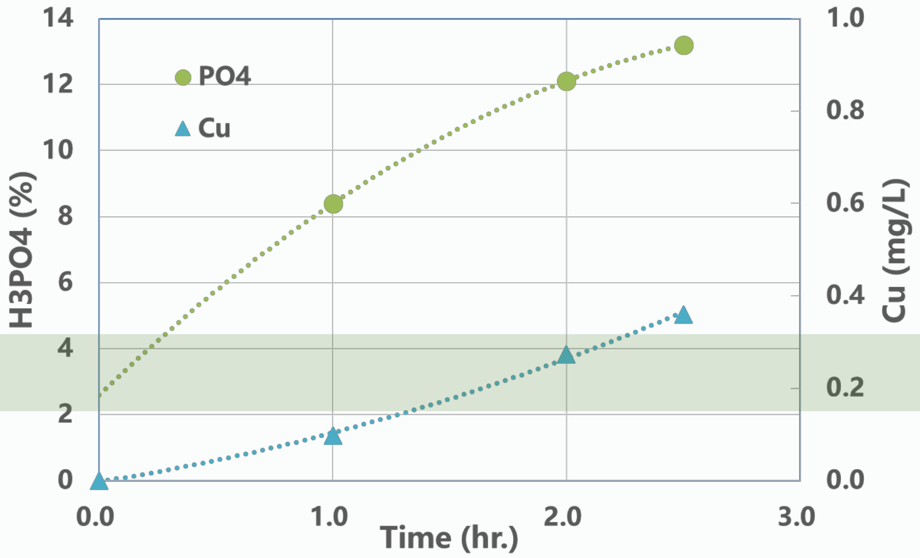
R2A Feasibility Test
Acid Recovery from Semiconductor Manufacturing Wastewater



Waste Etching Solution

PO_4^{3-}	mg/L	20,000
Cu^{2+}	mg/L	300





Industrial-grade phosphoric acid

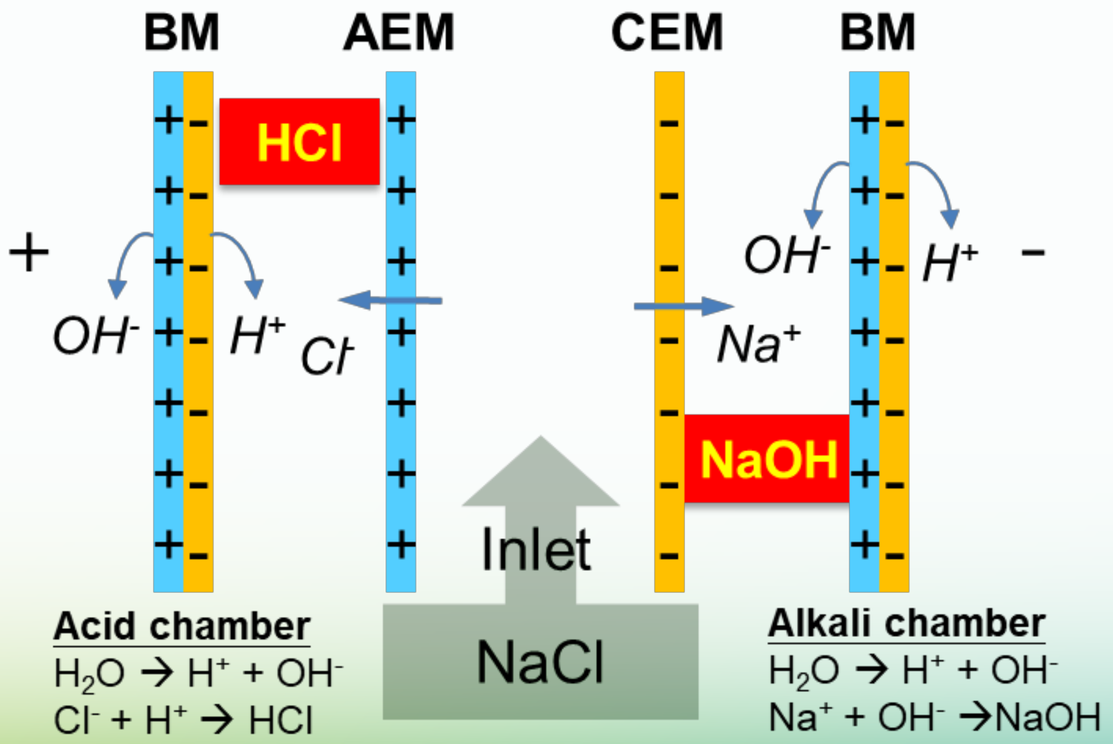
Recycling of waste acid etching solution:
Reconcentration of waste phosphate: from 2wt% to 13wt%
(Impurity: Cu^{2+}=0.36 mg/L)

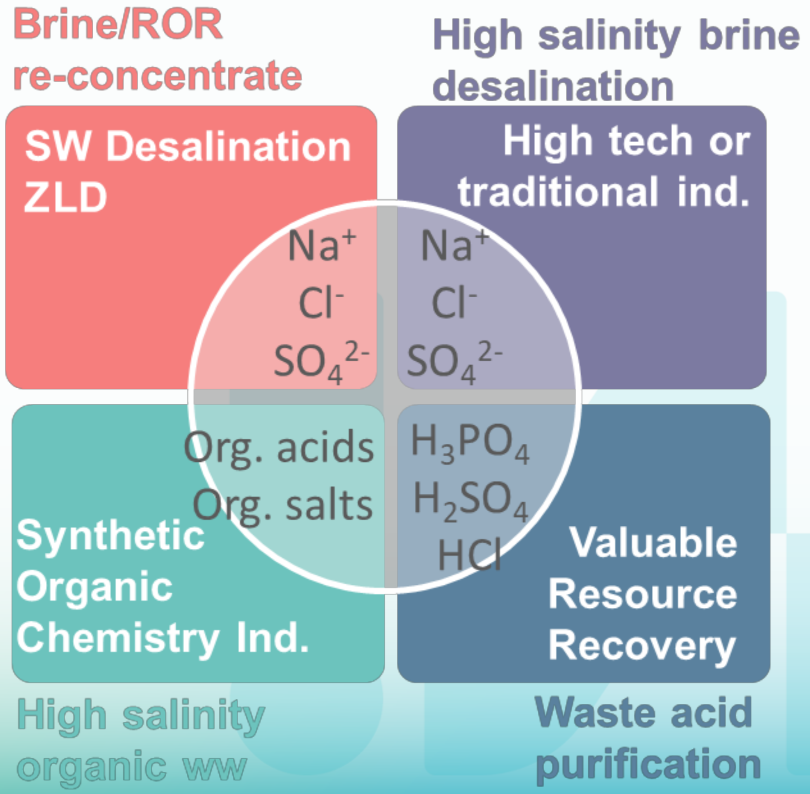
Meet the acceptance criteria: H_3PO_4 > 10wt%, Cu^{2+} < 1 mg/L

TAIWAN INT'L WATER WEEK

Lab-Test module (1 L)

Pilot (0.5 m³)





Conclusion

- Owing to the stricter regulation on wastewater disposal, intensified freshwater scarcity, high cost of wastewater recovery, and increasing public environmental awareness, a novel technology for brine management and treatment is in urgent need.
- In comparison with conventional thermal processes, the non-thermal ZLD process, R2A, for brine treatment shows the capability of valuable resource in-line recovery in liquid phase with less energy consumption and environmental impact.
- For the R2A system, both synthetic brine and real wastewater contained Na^+, Cl^-, SO_4^{2-} was successfully converted to HCl and NaOH with > 10wt% of recovered acid/alkali concentration and > 90% of purity.
- Aside from treating or using recovered acid/alkali, R2A for desalination is important to improve the water recovery rate.

TAIWAN INT'L WATER WEEK

ChiMei's Experiences in Water Reclamation from Effluent

莊鴻億 處長
Chuang Hung-Yi

2022/10/14

Contents

CHIMEI Corporation

Company Introduction

CHIMEI
a step up

CHIMEI is a Taiwan-based performance materials company.

Established
1960

Headquarters
Tainan, Taiwan

Employees
3,400 persons

Subsidiaries
Zhenjiang CHIMEI
Zhangzhou CHIMEI
CHILIN Technology
LINSHINE Engineering Plastics

Business Revenue (2021)
USD 6.4 Billion

* Exchange rate: 28.0272

CHIMEI

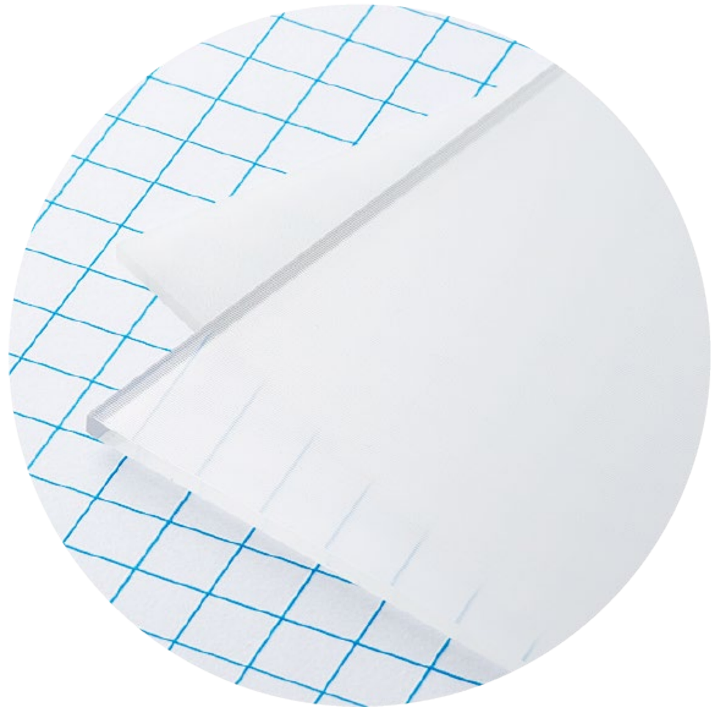
We have long been known as the world's largest vendor of ABS resins.

CHIMEI

We design and manufacture a wide range of cutting-edge materials that raise our global customers’ products to the next level.

Plastics

Synthetic Rubbers



Electronic Materials

Specialty Chemicals

CHIMEI

Our comprehensive materials are used in a wide range of applications and industries.

Building Materials & Construction

Cosmetics & Personal Care

Electrical & Electronics

Food Contact

Home Appliances

Housewares

Medical Devices

Sports & Leisure Goods

Transportation

CHIMEI

We strive to achieve a step up in everything we do.

Client-Side Innovation™

Clean & Green

Social Benefactor

CHIMEI

We develop creative new applications for our materials that make our customers' products stand out.

Boost Performance

Increase Durability

Improve Aesthetics

Raise Efficiency

Reduce Impact

CHIMEI

Clean & Green

We are maximizing resource efficiency, and reducing industrial waste and emissions.

Green Production

Green Energy

Green Initiatives

CHIMEI

Social Benefactor

We've invested in culture and the arts, sponsored education, and emphasized "Xingfu: Well-Being Through Contribution", since before CSR was a buzzword.

CHIMEI
Culture
Foundation

CHIMEI
Museum

CHIMEI
Hospitals

Artificial
Intelligence
Academy

Our purpose is to create Xingfu around the world.

Employees

Societies

幸福 (Xingfu):

Well-Being Through Contribution

Clients & Partners

Environment

CHIMEI

Clean & Green

CHIMEI
a step up

Four Crucial Green Projects:

Solar Power Plant
Heat & Power Station

80%

energy self-sufficiency from solar power and natural gas

140,000 tons

annual carbon reduction

EDR Water Recycling System

3,000 tons

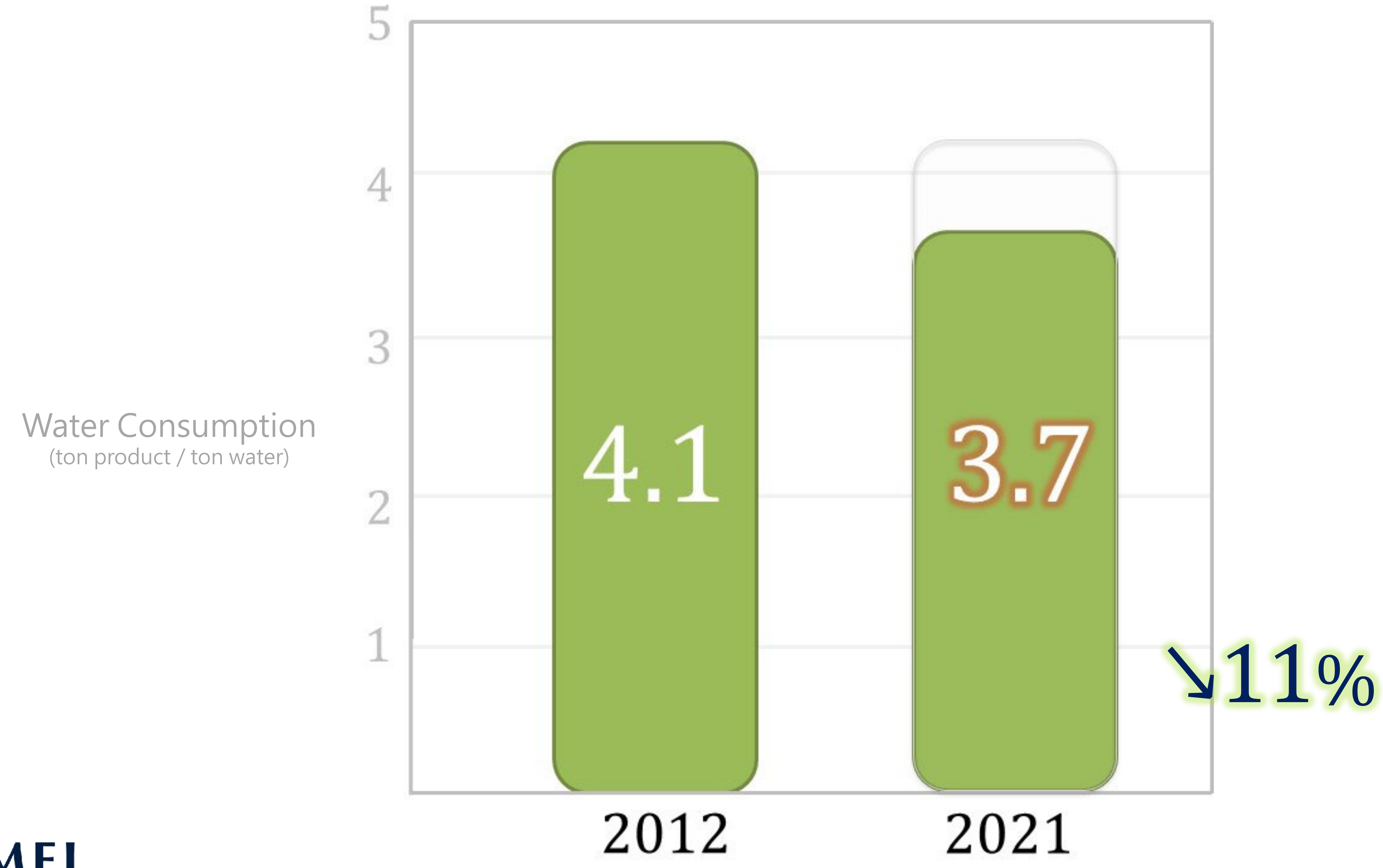
daily water reclamation

Resource Recycling Furnace

98%

sludge waste reduction

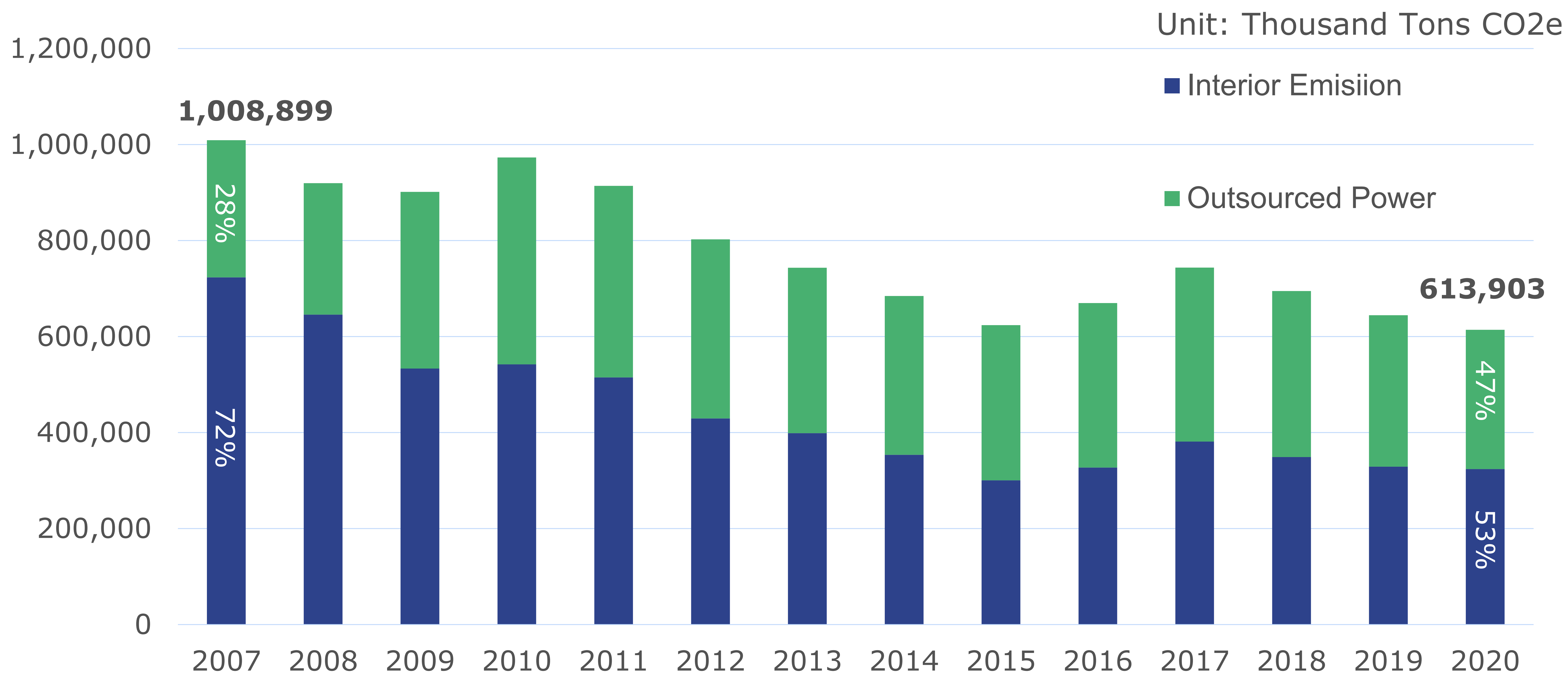
Water Consumption



CHIMEI

Greenhouse Gas

40% greenhouse gas reduction in 2020 compared to 2007.



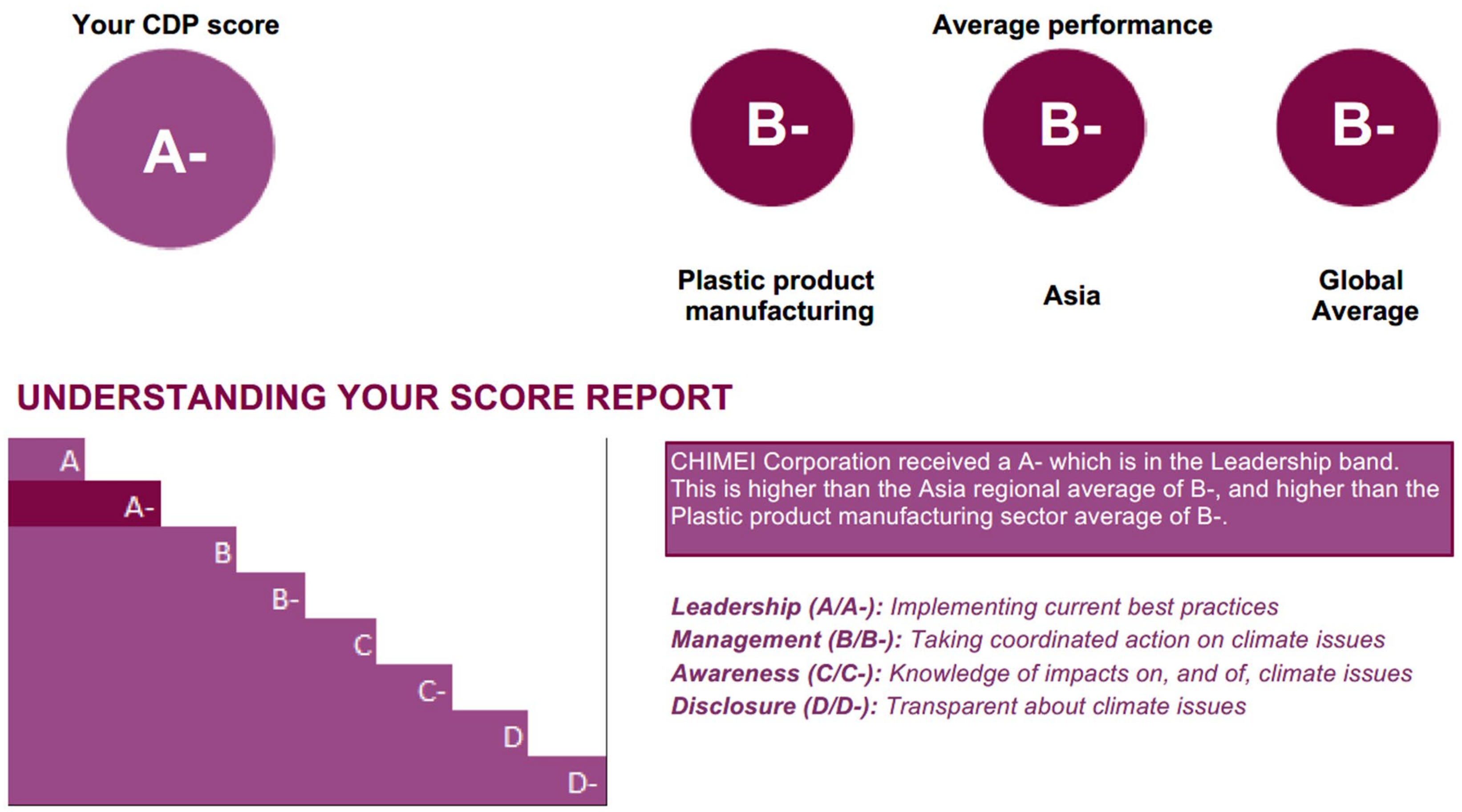
CHIMEI Commits to Net-Zero Carbon Emissions by 2050

- **The first petrochemical company in Taiwan to join the Science Based Targets Initiative (SBTi) to achieve net-zero by 2050.**

- **Achieves Leadership Band in CDP Climate Change 2021.**

SCIENCE BASED TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION



ESG Performance

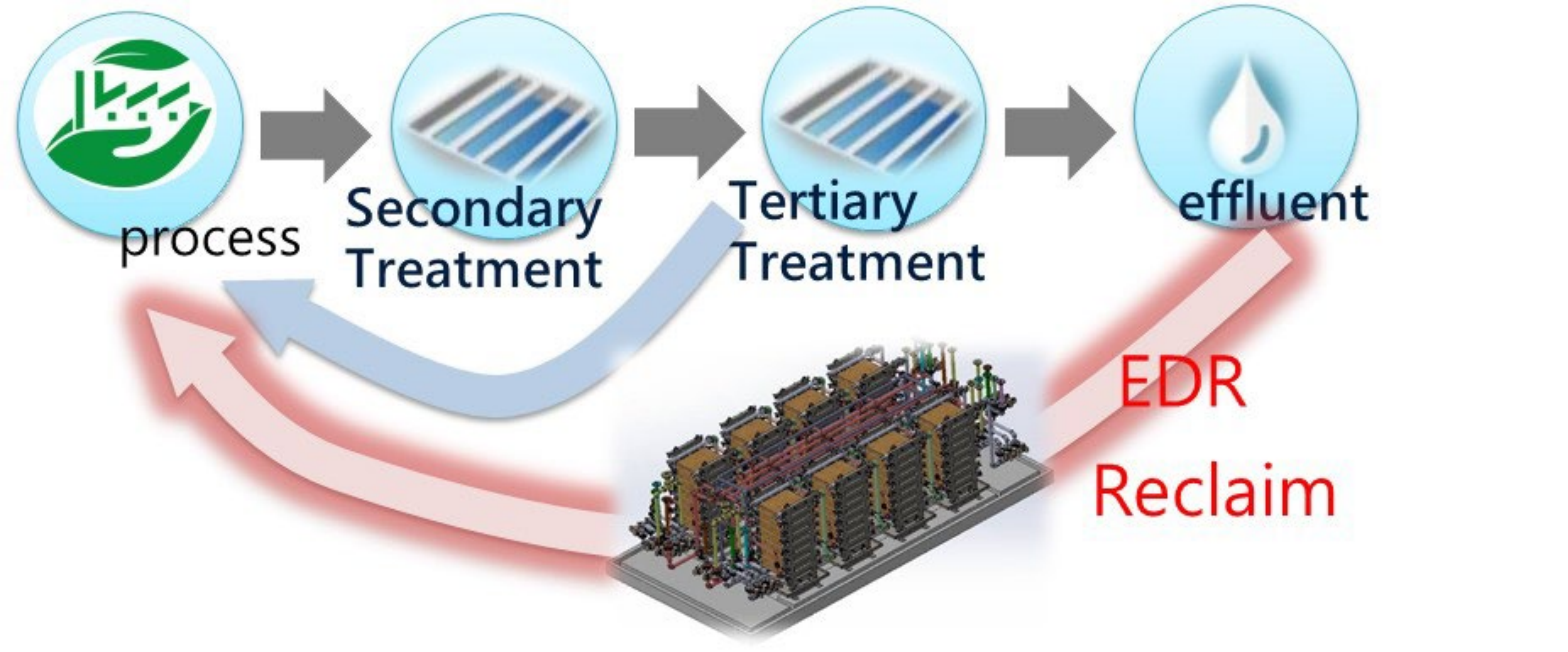
CHIMEI Awarded Gold Medal in EcoVadis CSR Rating

Effluent Recovery by EDR

- In recent years, climate change has greatly impacted Taiwan. For industrial sectors, water scarcity is a major issue. CHIMEI is eager to conserve water resource to satisfy the goal of ESG.
- In 2016, CHIMEI began the construction of the "EDR Water Resource Center". Before construction, An EDR pilot plant was conducted to obtain design and operating parameters.
- This project is carried out by the ITRI's Team including ITRI and Centurytech(松橋)and CTCI. ITRI's team conducts to turn key a project of EDR plant including the basic design, installation of the packaged equipment (ASF, SMF, EDR), and commissioning. CTCI perform the detailed design of this project and construct the building of this EDR center.
- Currently, the EDR water Resource Center can treat 6,000 tons of effluent every day, producing 3,000 tons of reclaimed water before RO system. The full scale system has been operated smoothly more than two years and can provide stable water supply for our production lines during drought seasons.

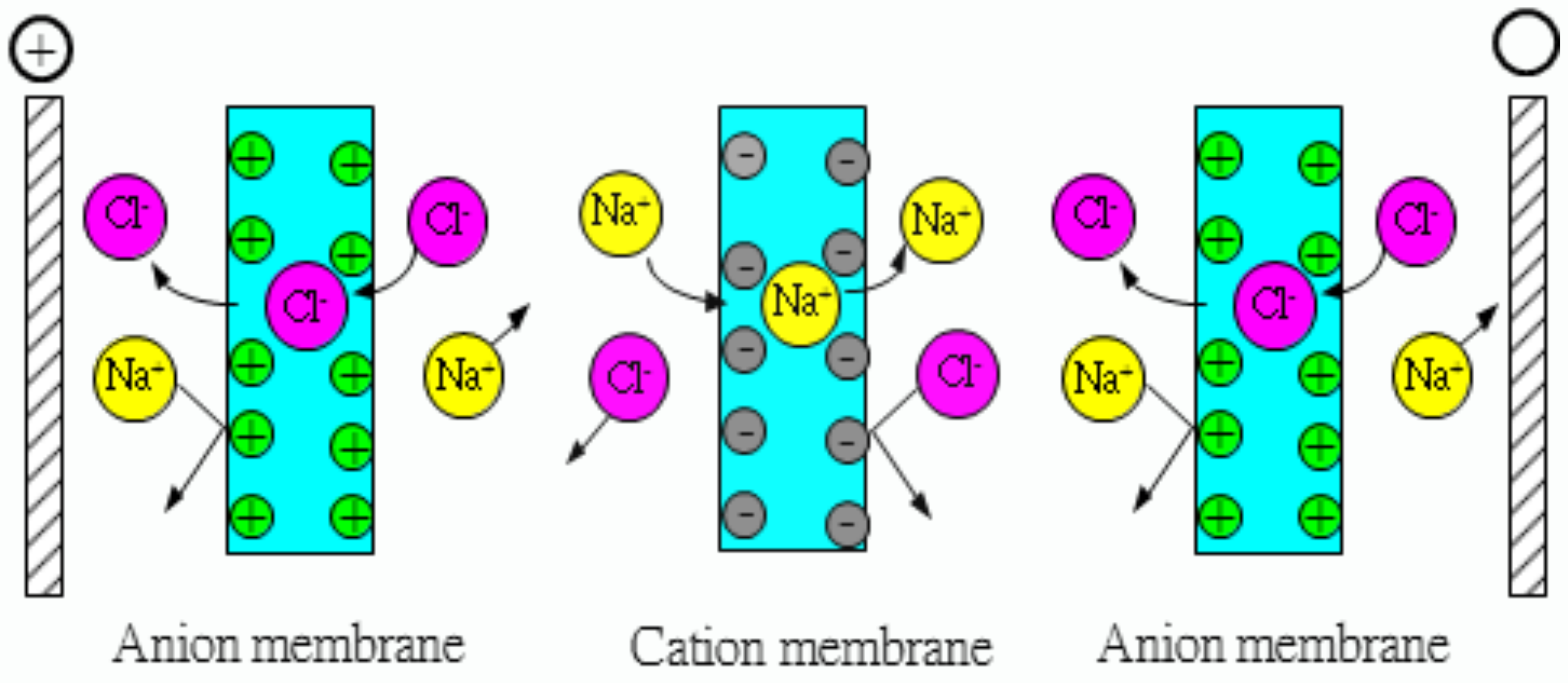
View of EDR Water Resource Center

Land area: 100m(L)×40m(W)


process
Secondary
Treatment
Tertiary
Treatment
effluent
EDR
Reclaim

TAIWAN INT'L WATER WEEK

Electrodialysis Reversal (EDR)



- **Electrodialysis reversal** can effectively remove ions from water and wastewater by applying a direct current.
- The electric charge drives the ions penetrating anion or cation exchange membranes.
- EDR reduces conductivity and dissolved solids of bulk solution.

Advantages

- Hard water softening without chemical additions
- Remove sodium chloride, calcium, magnesium, sulfate and nitrate
- Compared to RO; EDR can treat influent with SDI higher than RO
- Flexibility for pre-treatment technology

Applications

- Desalination of RO concentrate
- Reclamation of Cooling tower condensate
- Desalination of Salty groundwater
- Treatment of City water
- Reclamation of Wastewater
- Treat concentrated brine for ZLD

EDR Technology

TAIWAN INT'L WATER WEEK

Industrial treated effluent → **Electrodialysis Reversal(EDR)** →

- **Industrial process water**
- **Cooling water**

※ Converting Industrial Wastewater into Resource

EDR desalination of Ground water for rinsing water (50 m³/day)

EDR desalination of RO reject for rinsing water (electronics) (300 m³/day)

Recovery of wastewater from screw manufacturing factory for rinsing water by EDR process (450 m³/day)

Recovery of wastewater from PCB manufacturing factory for cooling tower by EDR process (1200 m³/day)

Recovery of fluoride-containing wastewater from wafer factory for scrubber by EDR process (1200 m³/day)

EDR desalination of high conductivity river water for process water (2400 m³/day)

Desalination and reuse of RO concentrate stream (Food industry) (300 m³/day)

Recovery of cooling water from electronics manufacturing factory by EDR process (Tiger company) (550 m³/day)

Desalination and reuse of wastewater from precious screw manufacturing factory by EDR process (Nitto company, 350 m³/day)

Desalination and reuse of direct cooling water from steel rolling by EDR process (China steel company,550 m³/day)

Recovery of wastewater from chemical company for cooling water by EDR process (800 m³/day)

Recovery of wastewater from zinc-plating process for rinse water by EDR process (China steel company, 700 m³/day)

Recovery of wastewater from nylon fiber manufacturing company for cooling water by EDR process (800 m³/day)

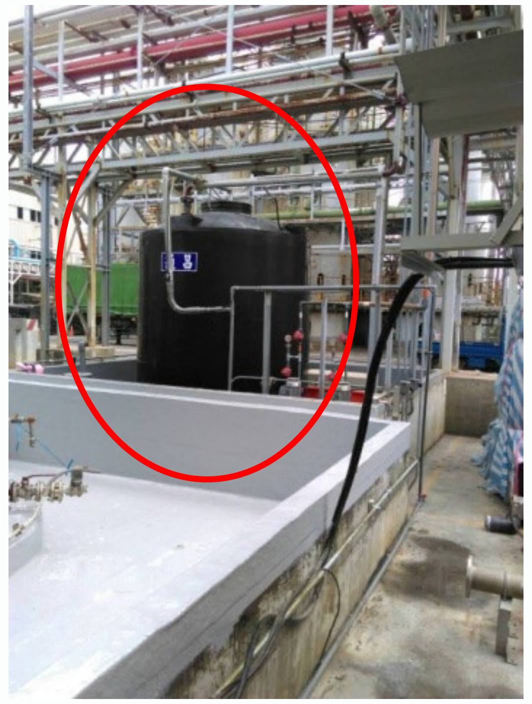
TAIWAN INT'L WATER WEEK

EDR pilot plant

Influent water

(tertiary discharged water)

Raw water Tank (10 m^3)



Submerged membrane Filtration Tank

Bag Filter (5 μm)

EDR Influent Tank

Electrodialysis module

4 electric stage
8 hydraulic stage
Total 80 pairs membrane
Total path length 5.0 m

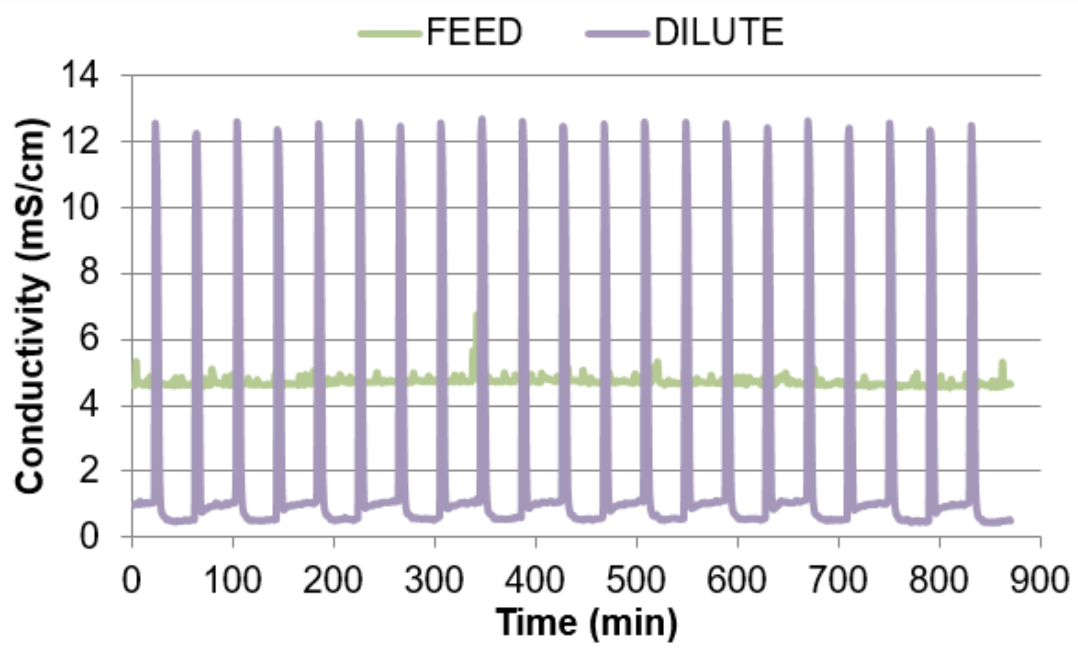
Diluted Tank

Experimental Results of EDR Pilot Plant

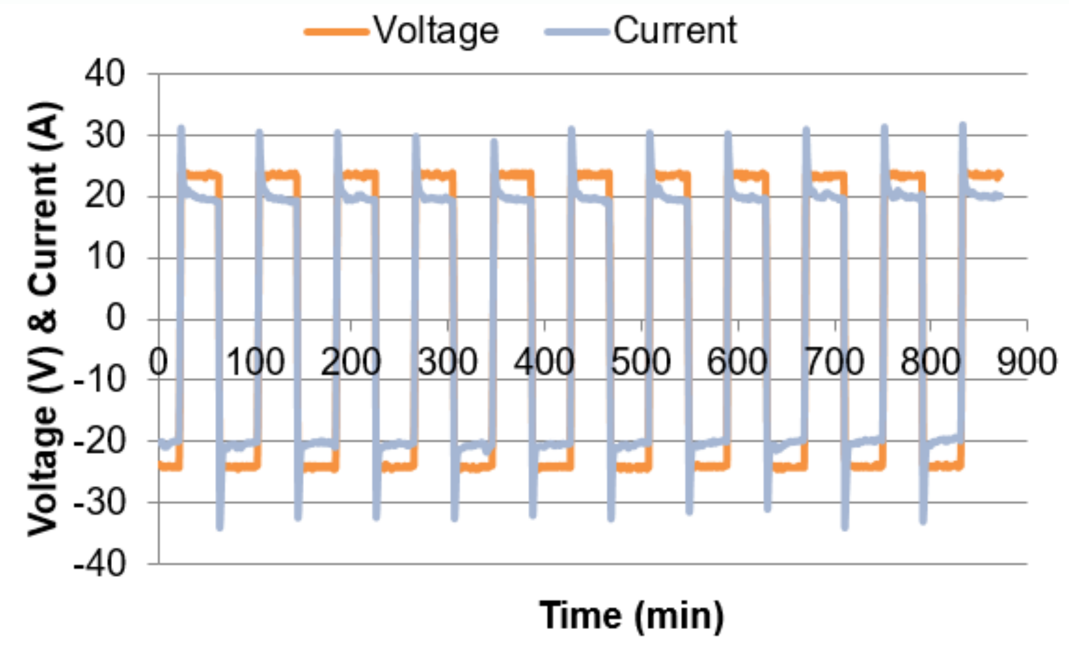
The water characteristics of EDR pilot plant

Constituent	EDR Feed			EDR produced water			EDR brine		
	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.
pH	8.0	8.8	6.8	6.0	7.2	3.8	4.0	6.9	2.5
EC (μS/cm)	4590	5710	3780	581	838	267	9890	14700	8350
COD (mg/L)	45	89	15	33	76	15	90	177	54
Si (mg/L)	14	30	2	11	23	4.4	14	25	5
Na^+ (mg/L)	296	359	224	64	93	38	504	742	278
K^+ (mg/L)	270	325	199	41	56	22	574	960	261
Ca^{2+} (mg/L)	413	480	347	14	26	4	1010	1820	460
Mg^{2+} (mg/L)	26	33	21	1	2	0.4	57	89	27
Cl^- (mg/L)	1610	1950	1380	155	227	83	3710	6330	1750
NO_3-N^- (mg/L)	4.0	7.5	0	0	1.2	0	11	23	6
SO_4^{2-} (mg/L)	445	509	371	76	119	32	946	1550	479
data period	2015.12.08~12.28			2015.12.08~2016.01.11					

This effluent wastewater contains high concentrations of calcium ions and sulfate ions, which is easily to result in scaling of the membrane.



Conductivity of feed and diluted water



The pattern of voltage and Current during EDR pilot run

TAIWAN INT'L WATER WEEK

Scaling potential analysis of EDR feed and concentrated discharge

Based on 50% water recovery rate in EDR system, the analysis of scaling potential results indicated that both $CaCO_3$ and $CaSO_4$ scaling potential is low in EDR feed and concentrated discharge

Scaling potential of $CaCO_3$	EDR feed
Alkalinity (ppm as $CaCO_3$):	241
Ca^{2+} (ppm as $CaCO_3$):	2501
TDS (ppm):	7424
pH	6.2
Temperature (℃)	35.0
pCa=-log[Ca]+5	1.6
pAlk=-log[Alk/50000]	2.3
C=0.1038*log[TDS]-0.0189*[T]+2.3681	2.1
pHs=pCa+pAlk+C	6.0
LSI=pH-pHs	0.14
LSI<1 ($CaCO_3$ scaling potential is low)	
Scaling potential of $CaSO_4$	EDR feed
I=	0.19
$CaSO_4$ 0.8*Ksp=	3.68E-04
$CaSO_4$ 1.75*Ksp=	8.05E-04
$CaSO_4$ IP=	2.37E-04
IP<0.8*Ksp ($CaSO_4$ scaling potential is low)	

Scaling potential of $CaCO_3$	EDR concentrated discharge
Alkalinity (ppm as $CaCO_3$):	272
Ca^{2+} (ppm as $CaCO_3$):	3085
TDS (ppm):	9215
pH	6.0
Temperature (℃)	35.0
pCa=-log[Ca]+5	1.5
pAlk=-log[Alk/50000]	2.3
C=0.1038*log[TDS]-0.0189*[T]+2.3681	2.1
pHs=pCa+pAlk+C	5.9
LSI=pH-pHs	0.11
LSI<1 ($CaCO_3$ scaling potential is low)	
Scaling potential of $CaSO_4$	EDR concentrated discharge
I=	0.23
CaSO4 0.8*Ksp=	4.32E-04
CaSO4 1.75*Ksp=	9.45E-04
CaSO4 IP=	3.50E-04
IP<0.8*Ksp ($CaSO_4$ scaling potential is low)	

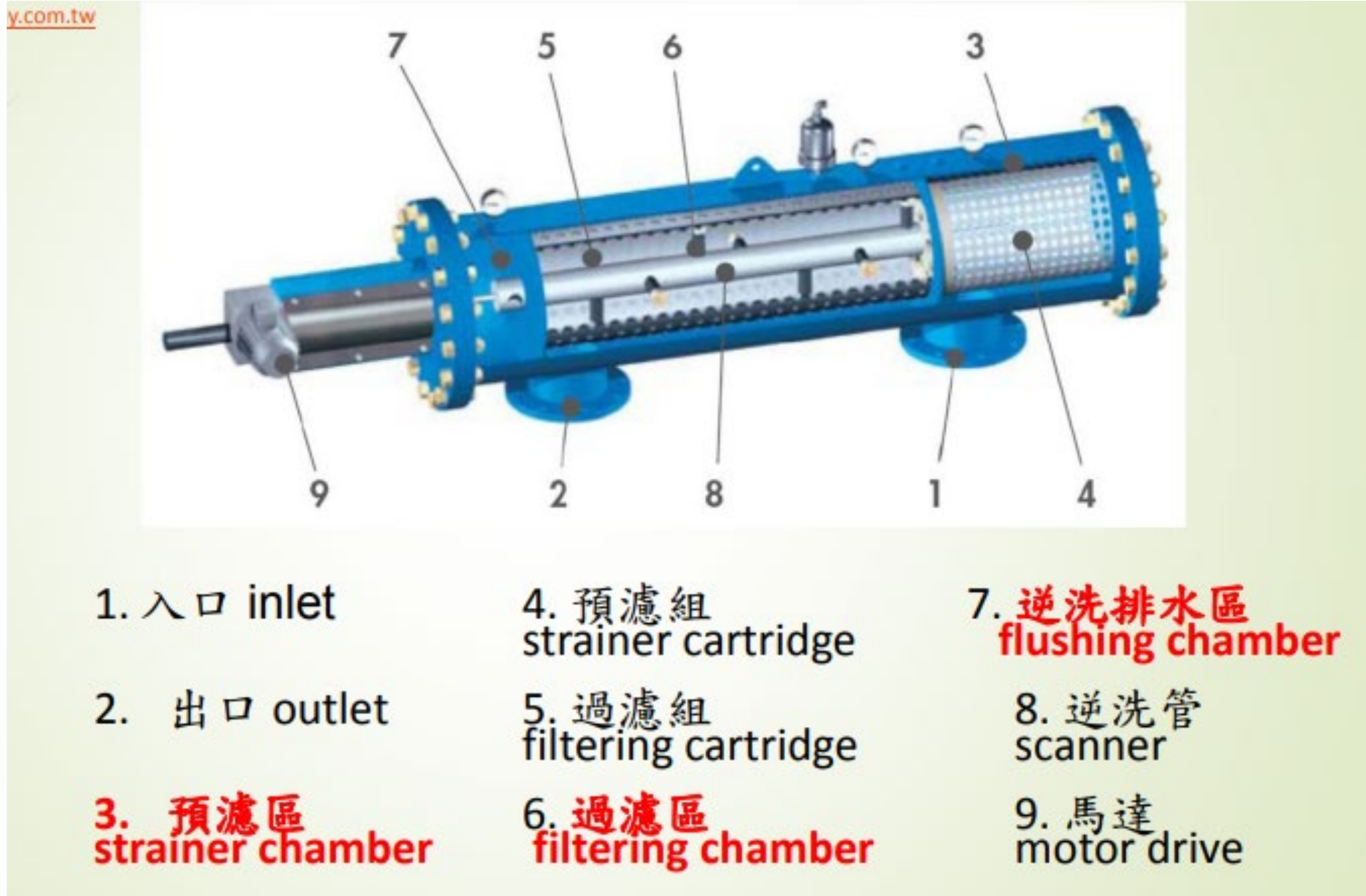
TAIWAN INT'L WATER WEEK

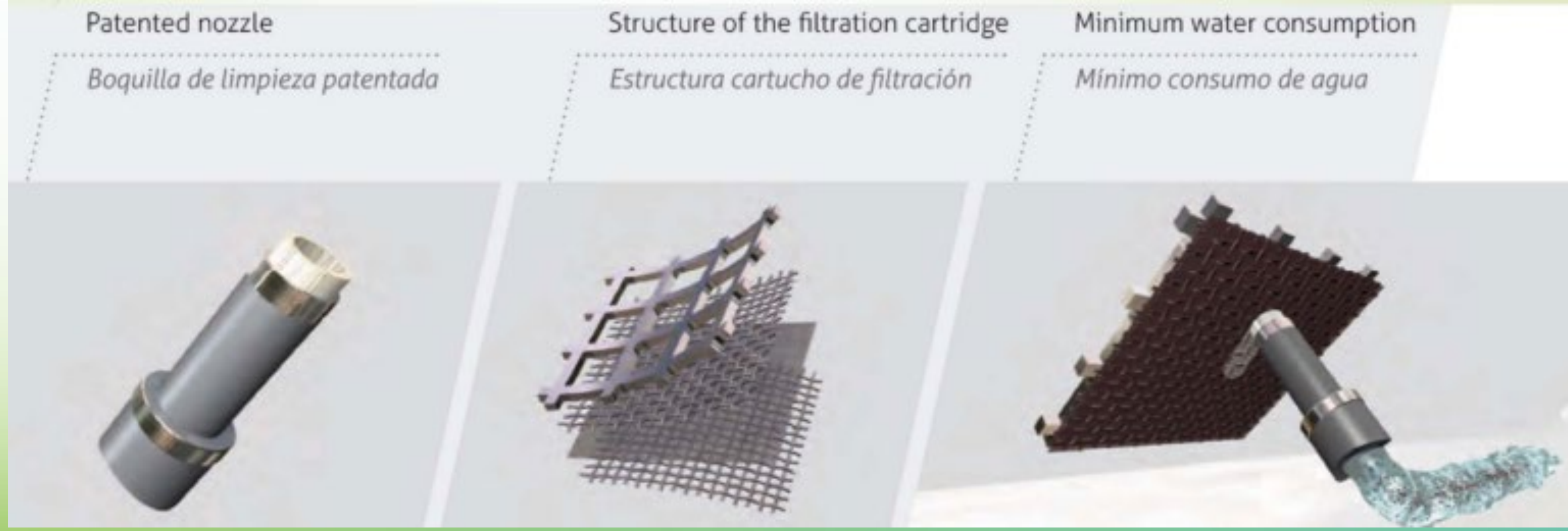
Process Flow and design criteria

Effluent → ASF (100 μm) → SMF (0.05 μm) → EDR → RO → Product water

Item	Effluent	EDR product requirements	EDR waste requirements	RO product requirements
pH	6.5-9.0	5.5-7.5	6.0-9.0	4.5~7.5
Conductivity (μS/cm)	<6,500	<550	no regulation	<50
COD (mg/L)	<70	<60	<100	<10
Na^{+} (mg/L)	<350	<100	no regulation	<20
Ca^{2+} (mg/L)	<600	<80	no regulation	<20
Mg^{2+} (mg/L)	<35	<10	no regulation	<10
Cl^{-} (mg/L)	<2000	<250	no regulation	<20
NO_3—N (mg/L)	<10	no regulation	<50	-
SO_4^{2-} (mg/L)	<600	<200	no regulation	<20
NH_3-N (mg/L)	<5	no regulation	no regulation	-
SS (mg/L)	-	<5	<30	-
PO_4^{3-} (mg/L)	<10	no regulation	no regulation	
Temperature (℃)	Month 5~9 <38, Month10~4<35	-	Month 5~9<38, Month10~4<35	-
Recovery rate (%)	---	≧50%	---	>80%
Effluent flow (CMH)	≧250	≧125	---	-

Automatic Screen Filter (ASF)





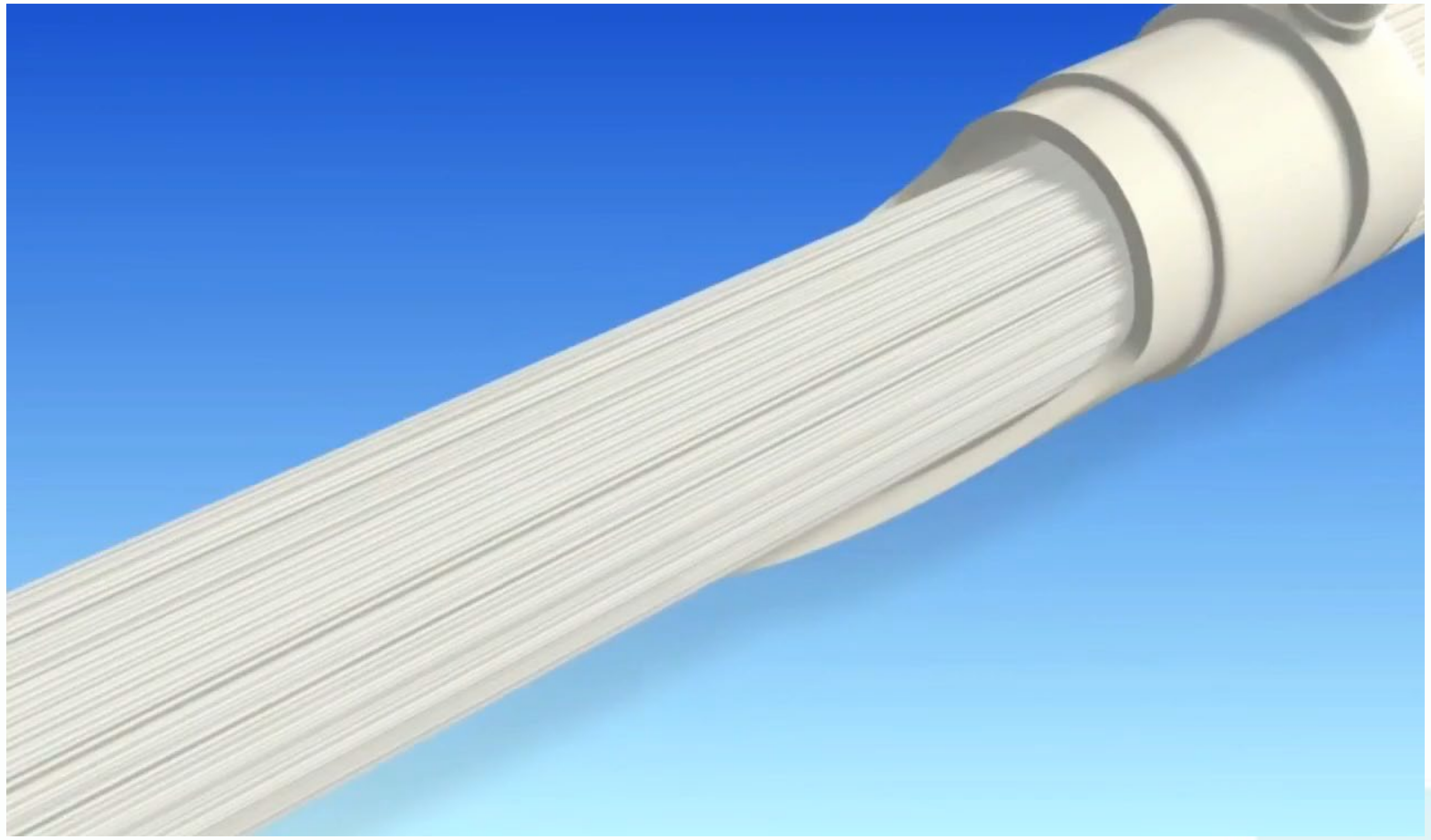
- Raw water gets into the filter through the prefiltration chamber, where thick particles(> 6 mm) are retained, as it was a strainer.
- Then, water runs from the filter screen (100 μm) interior into the exterior.
- Automatic backwashing start when the pressure difference inside and outside the filter reaches 0.3 bar; when the pressure difference between the inside and outside is equal, the backwashing stops.
- Backwashing process is about 25 sec .

Submerged Membrane Filtration (SMF)

Treated water: 6,000 CMD

- 33 module/ rack; 6 rack/Train; 2 Trains
- Membrane area: 1500 m^2/rack
- Flux: 16~20 LMH
- Material: PVDF hollow fiber
- Membrane pore size: average 0.05 μm

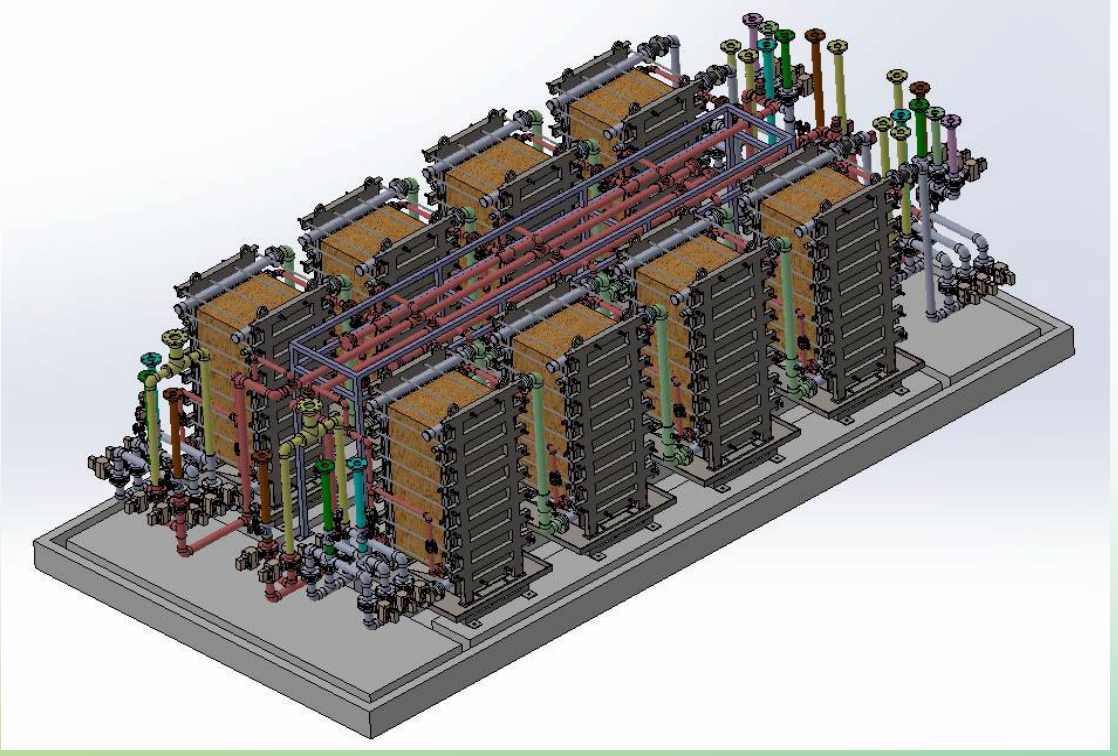
SMF working principle



The information linked from: YouTube
https://www.youtube.com/watch?v=BmuGP_RlFEU
AURORA SOLUTION Ltd.

SMF Equipment photo

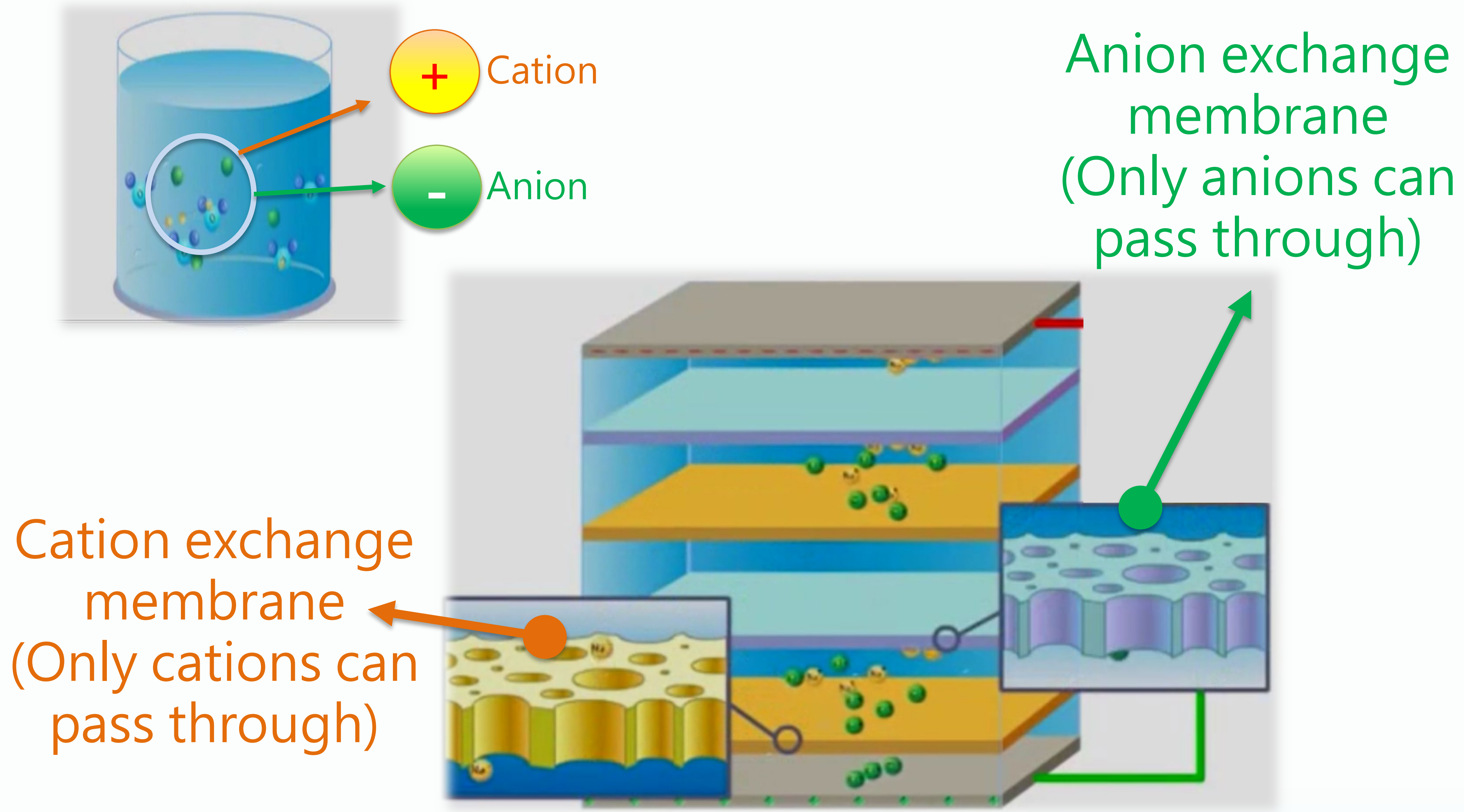
Electrodialysis Reversal (EDR)



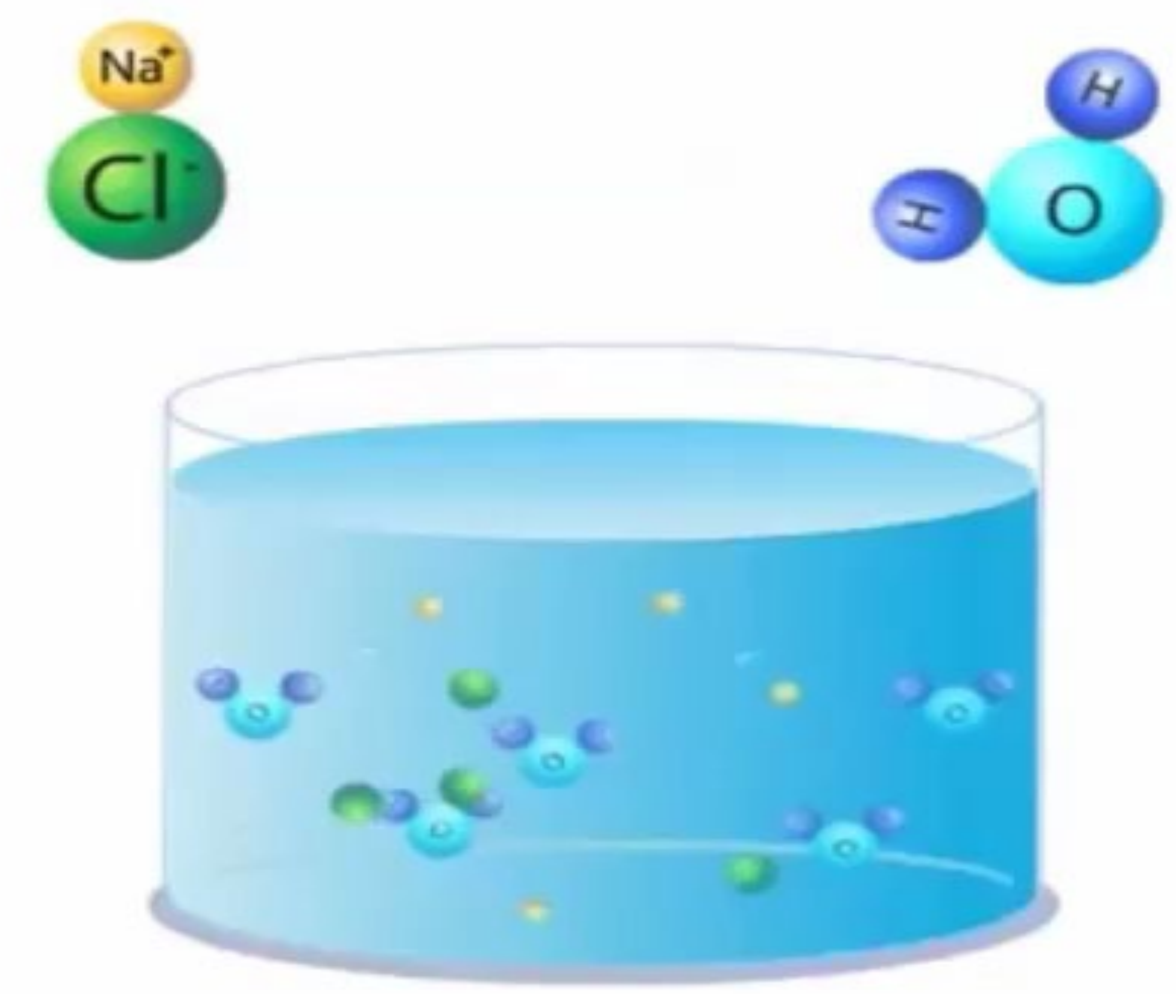
Treatment water: 6,000 CMD

- 56 EDR stack
- 4 stacks/line
- 14 lines
- 220 pairs membrane/stack

EDR working principle



EDR working principle (cont'd)



The information linked from:
https://www.youtube.com/watch?v=NgTYUiuxcvA
WTEF

EDR Equipment photo

View of EDR Water Resource Center (1/2)

Compressor (0.85 Nm^3/min)

Blower(108 Nm^3/min)

Chemical Tank & dosing pump area

HCl Tank & water seal tank

View of EDR Water Resource Center (2/2)

PLC panel and Marshalling cabinet

Rectifier (28 pcs)

2nd floor middle aisle

EDR CIP Tank

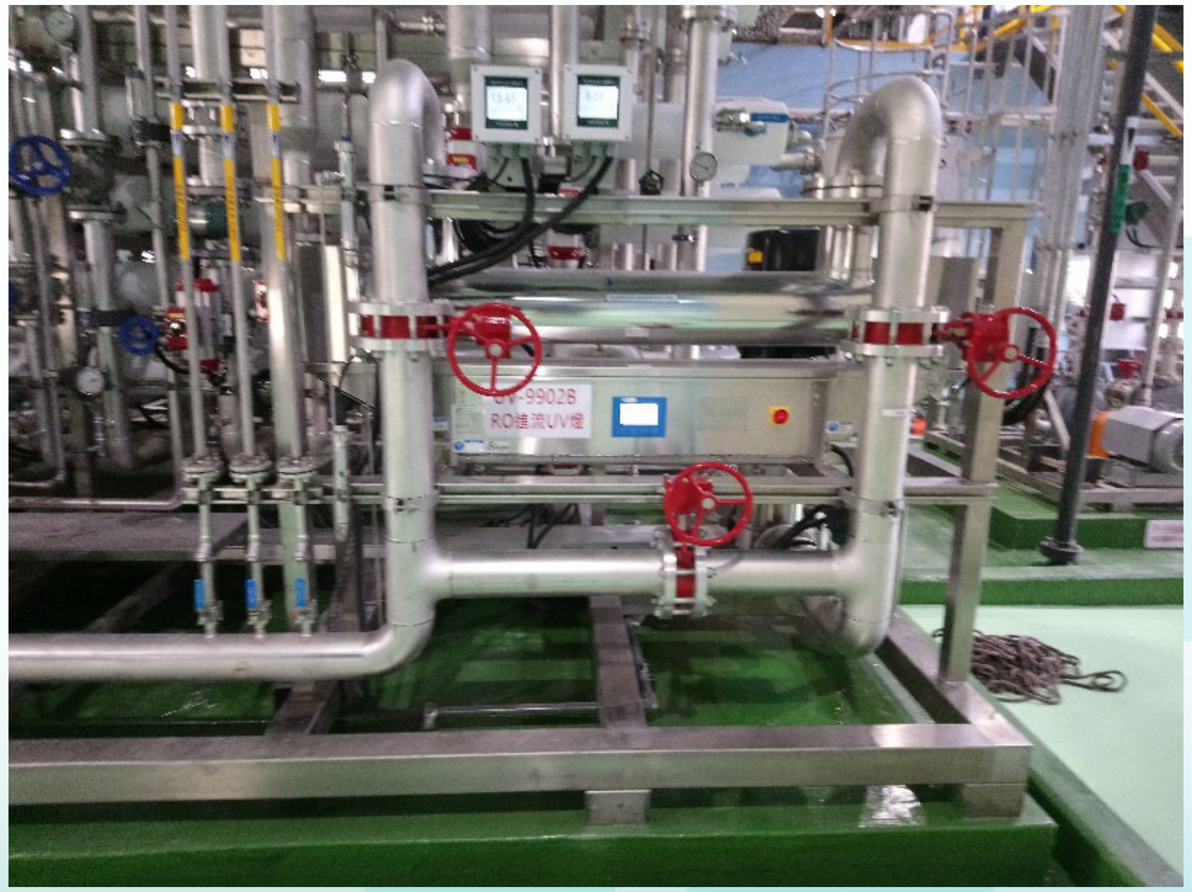
TAIWAN INT'L WATER WEEK

Reverse osmosis (RO)

The RO system mainly includes RO raw water pump, RO high pressure pump, UV sterilizer, pre-filter, RO modules, and CIP devices, etc.

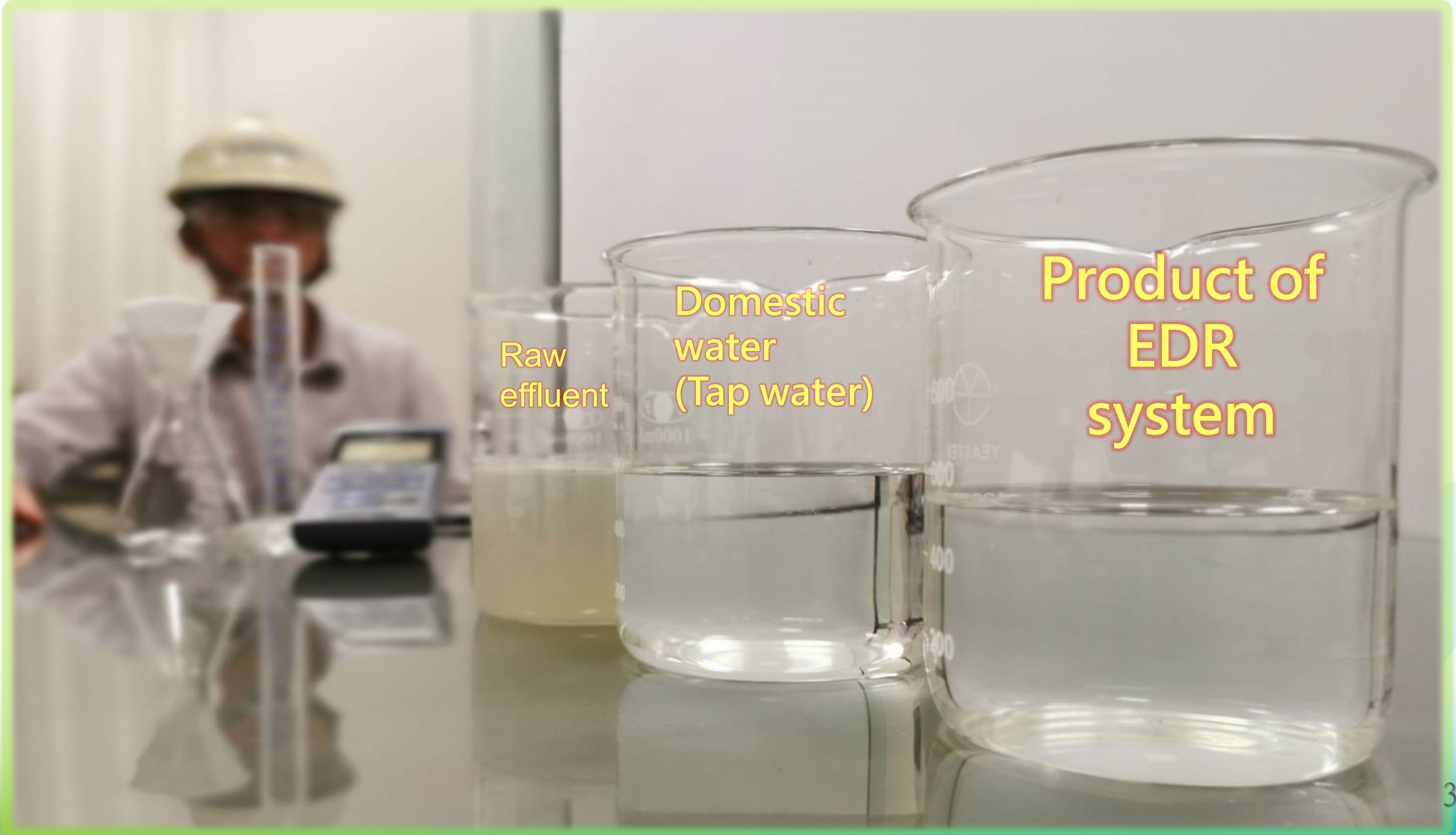
Influent water: 3,000 CMD
Water recovery rate: 80%
Capacity: 65 m^3/h * 2
RO Module(RO-9905A/B)
RO system: 2 trains, 1 pass/2stages
Total RO Elements: 150
Pressure vessel per train: 15 (first stage10+ second stage 5)
RO elements per pressure vessel: 5

RO units



UV units

Sample


Raw effluent
Domestic water (Tap water)
Product of EDR system

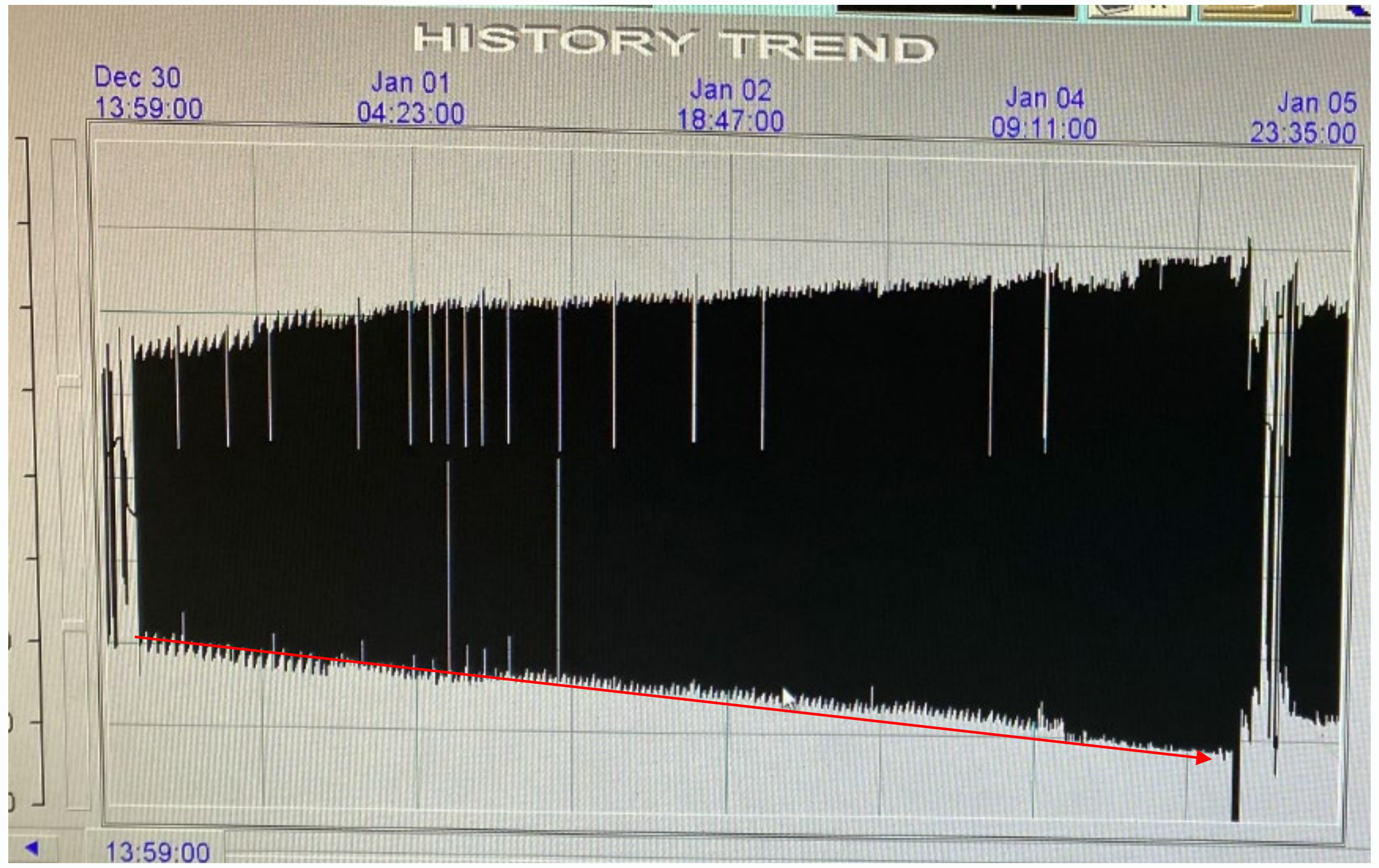
TAIWAN INT'L WATER WEEK

Operation condition(1/3)

SMF water production and physical cleaning mode

Service Mode	Operation time
Backwashing	1.1 min
Relax	0.2 min
Filtration	6 min
Relax	0.3 min

Analysis item	Immerse in 1% citric acid
pH	1.4
Conductivity (μS/cm)	1890
COD(mg/L)	7510
K(mg/L)	3.0
Al (mg/L)	2.0
Fe (mg/L)	41
Mn (mg/L)	18
Si (mg/L)	2.1



- SMF negative pressure continued to rise, reaching -0.55 kg/cm^2 in about 1 week.
- From the results of UF membrane fiber immersing experiment, Fe and Mn concentrations are the main pollutants.

SMF chemical cleaning test

SMF membrane chemical cleaning test experimental device

Comparison of the effects of three chemical cleaning methods (2021/1/15&1/18)

Chemical	Negative pressure (kg/cm^2)		Remark
	Before cleaning	After cleaning	
NaOCl+NaOH	-0.38	-0.22	Each 3000ppm
HCl	-0.38	-0.14	pH 2, 50min
Citric acid	-0.38	-0.03	1%, 50min

	Immerse in HCl		Immerse in Citric acid	
	before	after	before	after
pH	7.0	1.1	7.1	1.5
Conductivity (μS/cm)	505	5330	490	1670
COD (mg/L)	34	81	6	5980
Na^+ (mg/L)	28	35	38	14
Ca^{2+} (mg/L)	67	110	63	4
Mg^{2+} (mg/L)	17	20	18	0.6
Cl^- (mg/L)	58	847	47	20
NO_3^- (mg/L)	7	13	5.1	1.7
SO_4^{2-} (mg/L)	226	204	114	ND
NH_4 (mg/L)	1.6	3.0	2.0	1.8
PO_4^{3-} (mg/L)	ND	7	ND	ND
K (mg/L)	6.8	8.1	5.7	7.0
Al (mg/L)	0.2	0.6	0.1	0.4
Fe (mg/L)	1.2	4.6	0.1	16
Mn (mg/L)	0.2	1.3	ND	0.6
Si (mg/L)	5.7	6.1	5.6	6.1

After soaking, the concentrations of Ca, Mg, Fe, and Mn all increased slightly, which maybe pollutants that cause SMF fouling.

Operation condition (2/3)

SMF chemical cleaning

The negative pressure of SMF reaches -0.7 kg/cm^2 when the flow rate is 160 CMH, and the SMF washing operation is carried out.

SMF rack lifting operation

Spray the membrane with a hose to remove surface contamination

Cleaning with 1% citric acid for 1 hour in SMF immersing Tank (TK-9302)

Operation condition (3/3)

- Disassembly, inspection and assembly of EDR module by regularly

EDR Performance

Date of operation: 2019.11.04
EDR Influent Tank (TK-9501) makeup flow rate:196 m^3/h; conductivity: 4,236 μS/cm
EDR Concentrate Tank (TK-9502) makeup flow rate: 90 m^3/h; pH 6.0~6.2
EDR product conductivity (TK-9512): 440 μS/cm

	EDR module influent flow rate			EDR module Influent pressure			Rectifier (A)		Rectifier (B)		EDR module diluate outlet conductivity (μS/cm)
	Feed (m^3/h)	concentrate (m^3/h)	electrode (m^3/h)	Feed (kg/cm^2)	Concentrate (kg/cm^2)	Electrode (kg/cm^2)	output voltage (V)	output current (A)	output voltage (V)	output current (A)	
ED-9501	-	-	-	-	-	-	-	-	-	-	-
ED-9502	14	13	15	0.9	0.9	0.5	89.4	56.3	67.5	18.8	550
ED-9503	14	13	15	0.9	0.8	0.4	90.4	59.2	67.5	18.8	544
ED-9504	14	13	15	0.9	0.8	0.5	90.4	57.8	67.3	18.3	527
ED-9505	14	13	15	0.9	0.9	0.5	91.0	58.2	67.5	17.6	527
ED-9506	14	13	15	0.9	0.8	0.5	90.8	58.9	66.9	17.8	527
ED-9507	-	-	-	-	-	-	-	-	-	-	-
ED-9509	14	13	15	0.9	0.6	0.5	92.4	59.8	67.5	18.8	515
ED-9510	14	13	15	0.3	0.8	0.5	-89.8	-65.5	-37.7	-37.7	8316
ED-9511	14	13	15	0.8	0.8	0.5	90.8	58.4	66.9	18.4	527
ED-9512	14	13	15	0.6	0.6	0.3	91.9	59.1	67.5	17.1	486
ED-9513	14	13	15	0.8	0.8	0.5	89.8	60.0	67.5	17.4	469
ED-9514	14	13	15	0.8	0.8	0.5	89.8	59.4	67.5	17.4	463
ED-9515	14	13	15	0.8	0.8	0.5	90.8	62.0	67.1	14.6	440

just reversed

Item	Effluent (TK-9101)	Before SMF Filtrating TK-9301	EDR product (TK-9512)	EDR Concentrate blowdown (TK-9510)
pH	6.5~7.7	6.6~7.8	6.2~7.1	6.1~7.4
Conductivity (μS/cm)	3470~4160	3450~4680	410~508	6390~9430
COD (mg/L)	34~63	60~174	5~37	44~80
Si (mg/L)	5.8~6.3	5.6~7.3	5.8~7.2	5.2~6.7
Na^+ (mg/L)	185~289	188~481	46~74	369~847
Ca^{2+} (mg/L)	376~470	390~522	2.5~6.5	816~1120
Mg^{2+} (mg/L)	30.6~44	28.9~58	0.4~0.8	63.9~114
Cl^- (mg/L)	1220~1710	1270~2050	80~114	2540~4100
NO_3^-N (mg/L)	6.9~16.8	3.8~16.8	0.3~1.4	12.3~39.8
SO_4^{2-} (mg/L)	420~586	444~608	47~107	676~1350
NH_3-N (mg/L)	1.6~7.0	1.3~6.2	0.7~2.1	2.6~29.5
PO_4^{3-}(mg/L)	ND(<0.1)	ND(<0.1)	ND(<0.1)	ND(<0.1)

Data Period：108/10/22 14:00~108/11/5 14:00

The concentration of organic matter in the SMF filter tank continued to accumulate, resulting in increasing gradually the TMP of the UF membrane.

Evaluate O & M Cost

Item	Pricing basis	Annual cost (NT$/yr)	Cost* (NT$/m^3)
1.Electricity	=11,000 kWh/day×2.3 NT$/kWh×365 day	9,235,000	10.5
2.Chemicals	=830 kg/day×5 NT$/kg×365 day	1,515,000	1.7
3.Labor	=800,000 NT$/person/yr×1 person	800,000	0.9
4.Maintenance	=450,000,000(Capital cost) ×1%	4,500,000	5.1
	=18,600,000(Membrane replacement) ×20%	3,720,000	4.2
Total (1+2+3+4)		19,770,000	22.4

*Estimated at 2400 CMD of recycled water

TAIWAN INT'L WATER WEEK

Conclusions

- ChiMei EDR Water Resource Center has been operated smoothly for more than two years, the quality and quantity of reclaimed water can meet the design criteria.
- The fouled materials e.g. Fe、Mn、Ca & Mg and biopolymer were identified as major scaling and biofouling pollutants, respectively. The chemical cleaning of membrane especially SMF is necessary to reduce scaling and fouling potential.
- The EDR membrane is also chemical cleaning in advance to avoid the scaling and fouling phenomena without decreasing desalination efficiency in EDR module.
- The operating cost of 22.4 NT$ per ton of recycled water is obtained in this case, without considering equipment depreciation cost. Based on similar conductivity in influent, the running cost of EDR is lower than other desalination technology.
- Taiwan faced the 56-year drought in 2021, ChiMei EDR Water Resource Center play a key role to overcome the crisis of water shortage to maintain the stabilization of Chi Mei production line, which further highlights the economic benefits and ESG’s goal of the recycling of effluent.

Thank You