Promotion Strategies and Planning of Desalination Plants in Taiwan

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13th Oct. 2022

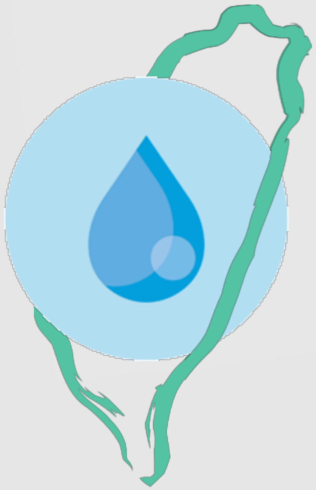
Outline

I. Overview of Water Resources Utilization and Desalination Promotion Plan in Taiwan

II. Status of Hsinchu and Tainan Desalination Projects

III. Evaluation of Desalination Plant Procurement Strategies

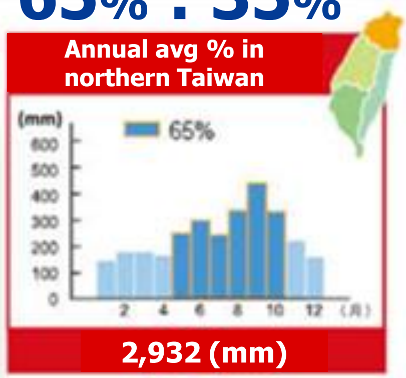
I. Overview of Water Resources Utilization and Desalination Promotion in Taiwan



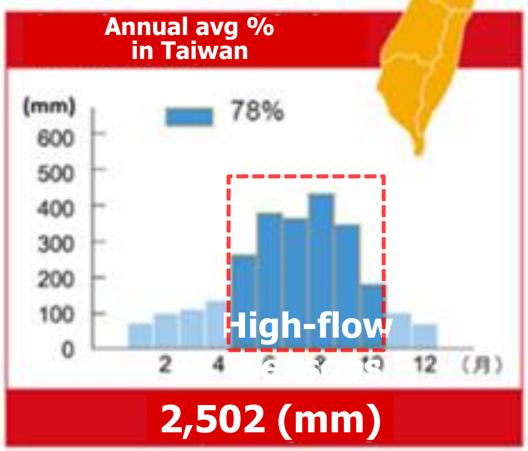
1. The Distribution of Rainfall in Taiwan

- Annual rainfall >2,500mm， 2.6 times of global average
- Extremely Uneven rainfall distribution in time and space

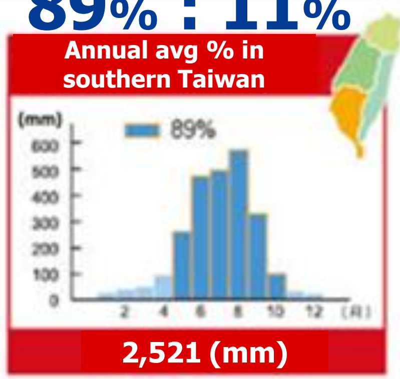
65% : 35%



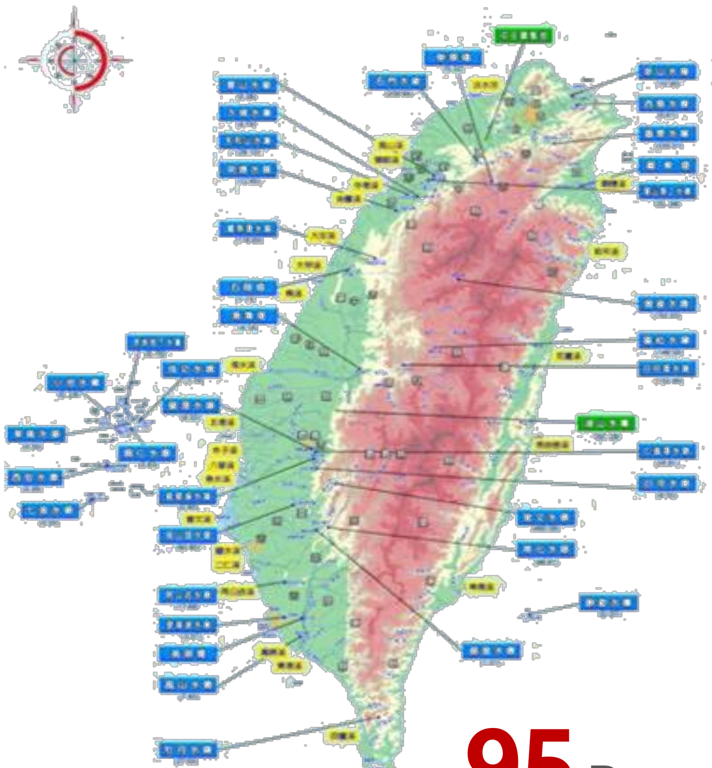
78% : 22%



89% : 11%



precipitation ratio in wet and dry season

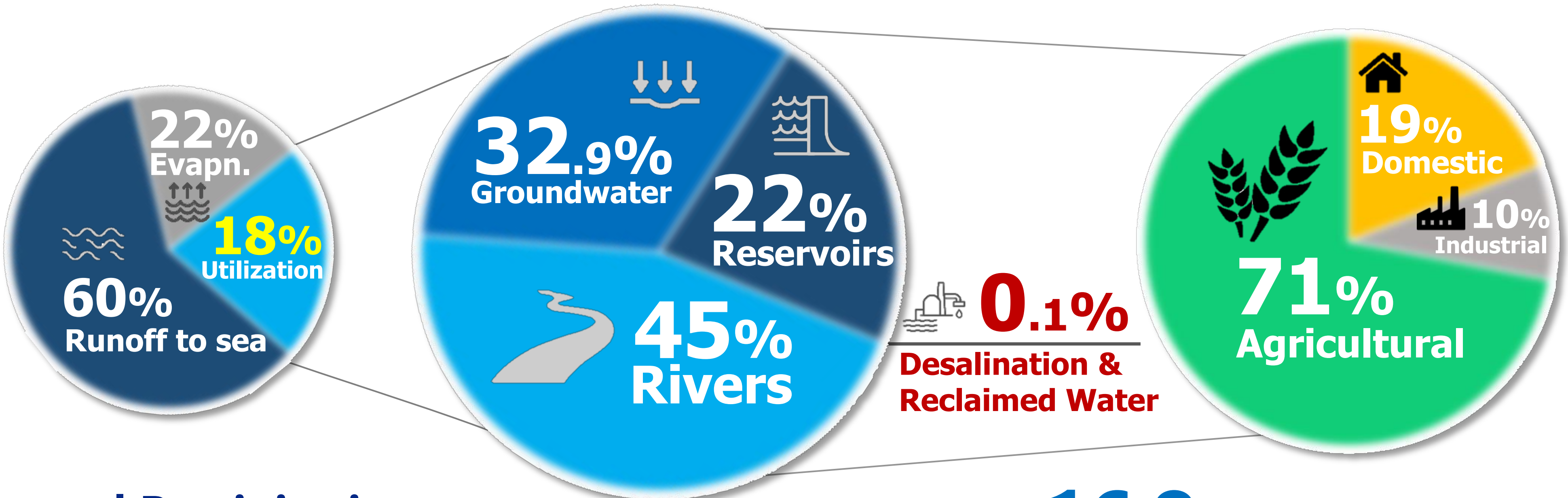


95 Reservoirs

(2.1 billion cubic meters)

2. Water Usage in Taiwan (2008~2019)

- Annual water usage in average : 16.8 billion m³/year
- Sources of water : Reservoirs , Rivers , Groundwater , Desalinated and Reclaimed Water



Annual Precipitation 91.5 (billion m³ of water / year)

Total Usage 16.8 (billion m³ of water / year)

3. Water Scarcity in Taiwan (1)

(IPCC AR6 scenario)

- Constant days of no rain: increase 5.5%~12.4%
- Max daily rainfall intensity: increase 20%~41.3%
- Frequency of typhoons： decrease 15%~55%

Flood

Drought

Sediment

Increasingly frequent and extreme floods and droughts worsen sediment issues of reservoirs.

3. Water Scarcity in Taiwan (2)

Main Idea

- ◆ Overall management of river basin : increase water resources and alternatives
- ◆ Water supply network of western Taiwan : strengthen water allocation among areas
- ◆ Tech-producing of water : increase resilience of water supply

Five Strategies

- Develop new water resources
- Reduce water usages
- Backup resources
- Water allocation
- Management

Conduction Measures

- ◆ Forward-looking Infrastructure Development Program
- ◆ Water Supply Strategy for Industrial Stability
- ◆ Backup Pipelines Construction Plan

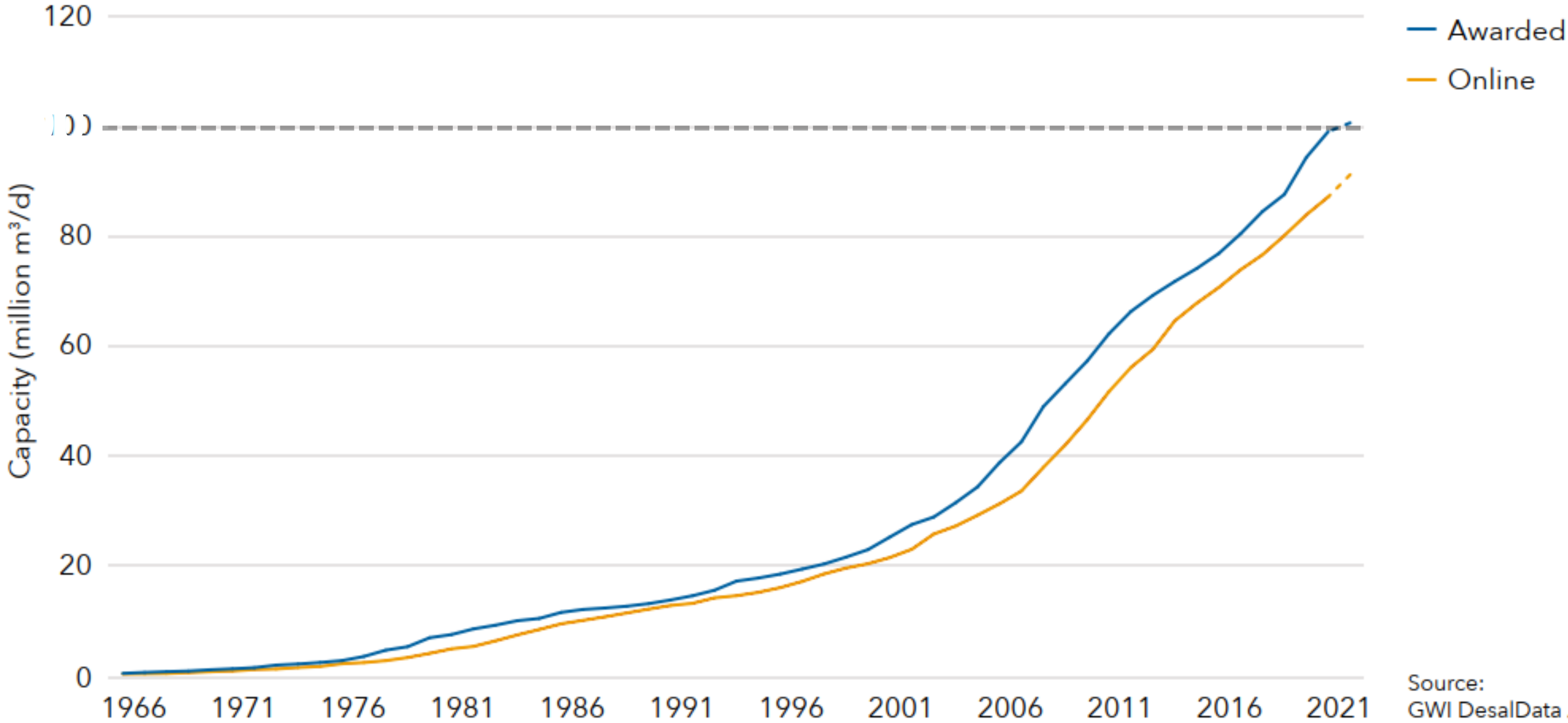
4. Global Desalination Status (1)

- Since 2000, there are approximately 650 desal. plants with the capacity ＞ 10,000 CMD , Asian countries(Middle East) account for 411 of which

Reference: IDA(International Desalination Association)

4. Global Desalination Status (2)

- The total capacity of desalination plants have constantly increased since 1966
- Cumulative capacity reached **100 million m^3/day** in 2021



Source:
GWI DesalData / IDA

5. Desalination Plants in Taiwan

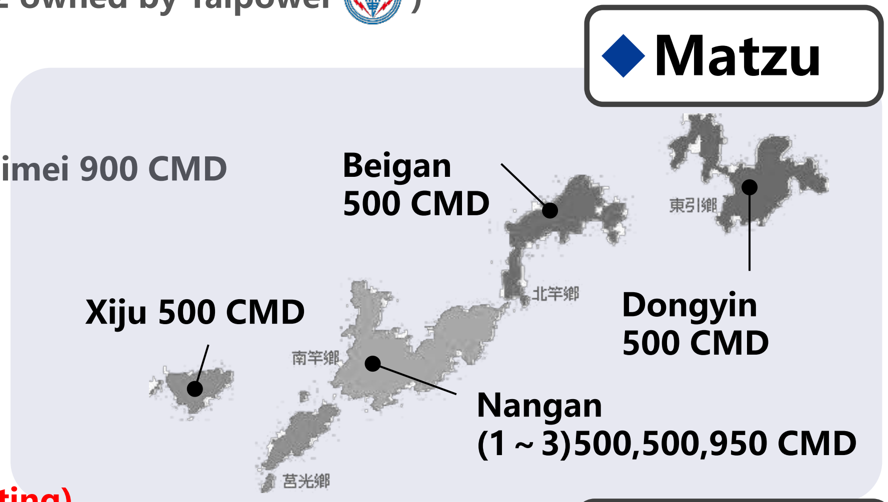
- **Desalination plants are mostly located in offshore islands.**
- **24 Completed： Capacity 51,720 CMD**

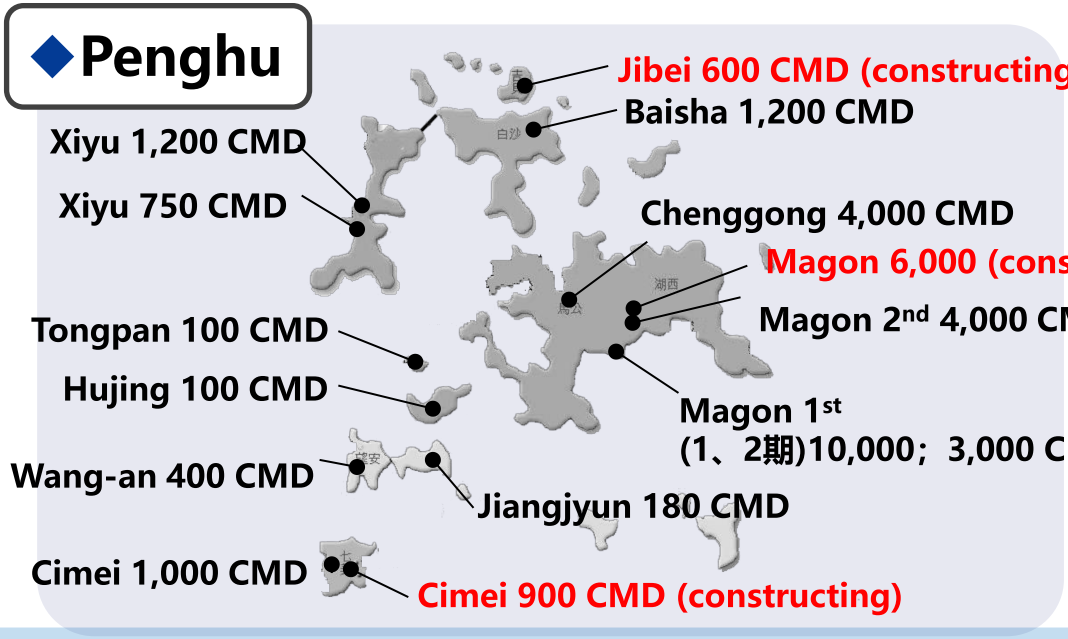
  3 on the Main Island: 4,260 CMD (3 owned by Taipower)

  21 on Offshore Islands: 34,460 CMD (19 for residential use、2 owned by Taipower)
- **4 currently constructing:**

  1 on Main Island： Formosa Plastics Mailiao 100,000 CMD

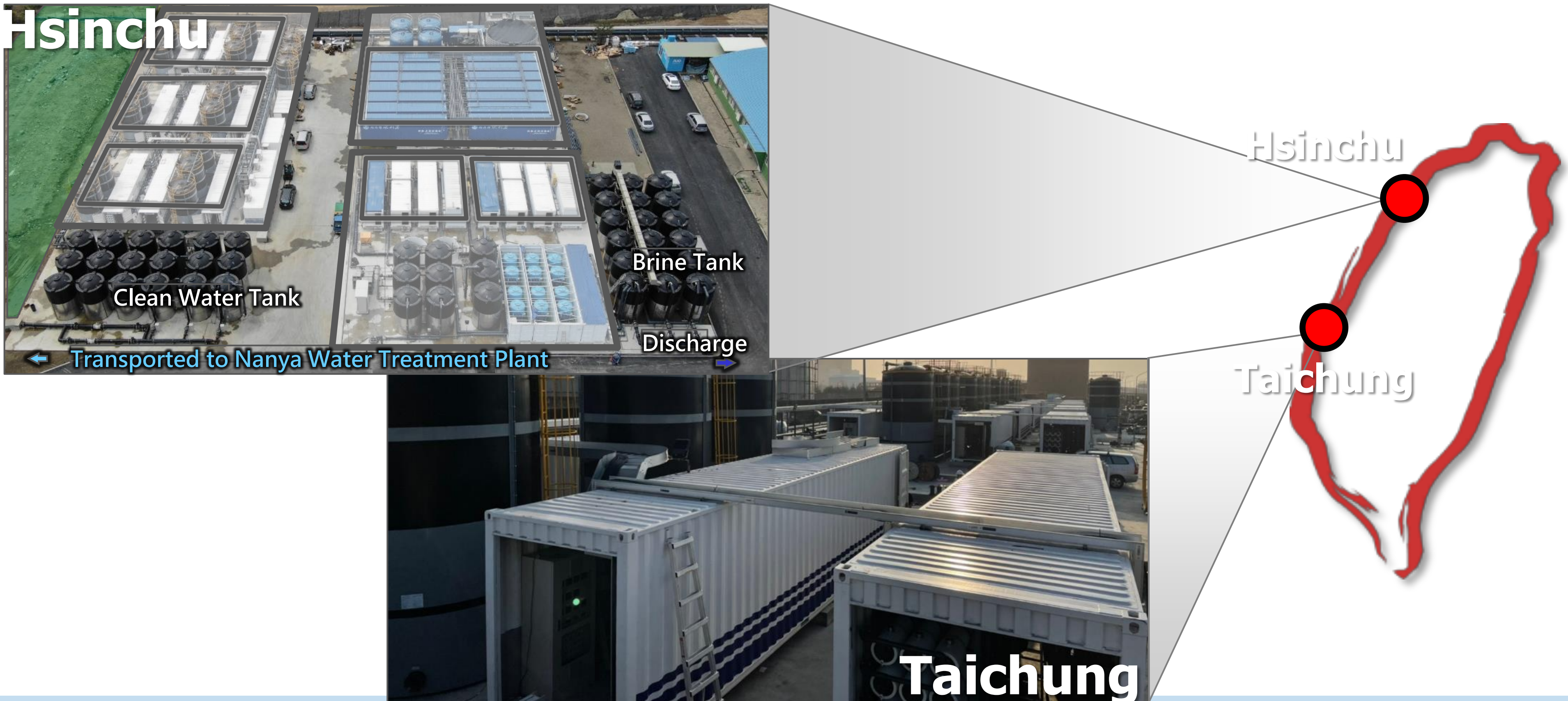
  3 on Outlying Island： Magon 6,000CMD; Jibei 600 CMD ; Cimei 900 CMD





6. Emergency Desalination Facilities

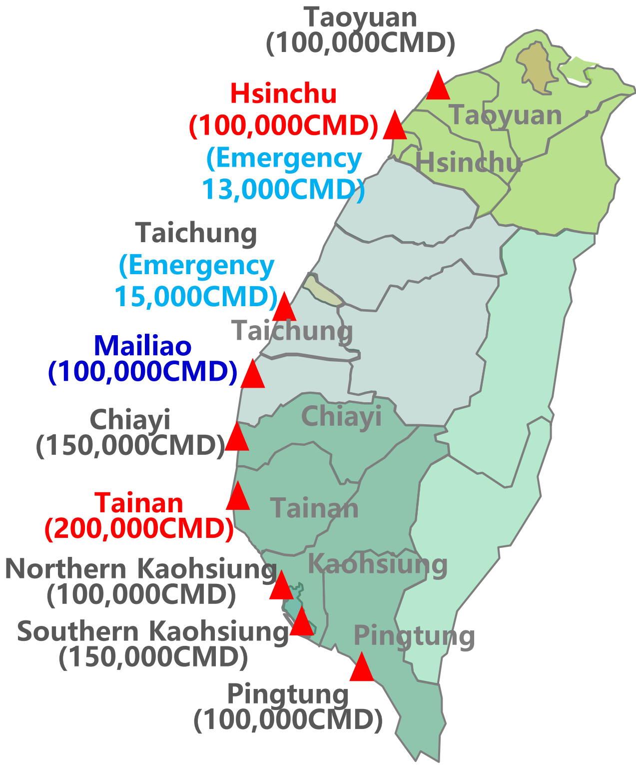
- **Lowest precipitation (880 mm) since 1911.** (June 2020 – May 2021)
- **2 emergency desalination units were installed in Hsinchu & Taichung, with capacities of 13 & 15 thousand cubic meters per day respectively.**



7. Status of Desal. Plants in Taiwan

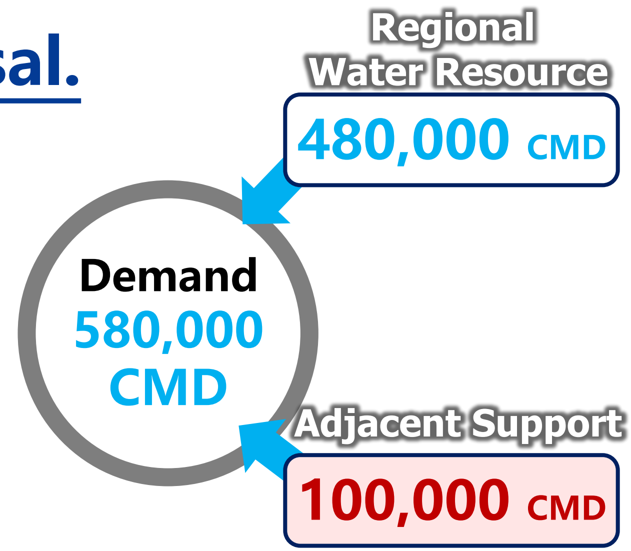
- The WRA has planned few large desal. Plants in Taiwan to deal with climate change and the growth of water usage
- Hsinchu and Tainan Desalination projects have passed the EIA on 13th, July 2022

Project	Capacity (CMD)	Estimated Cost	Remarks
Tainan (into the tap water system)	200,000 (two phases)	Phase I NTD 16.0 billion (USD 533 million)	Pass the EIA on Jul. 2022, and the construction period will be 5 years
Hsinchu (into the tap water system)	100,000	NTD 12.0 billion (USD 400 million)	Pass the EIA on Jul. 2022, and the construction period will be 4 years
Mailiao	100,000	--	Currently under construction, and will be constructed in 2023
Others	100,000 -200,000	--	Currently complete preliminary study and planning.



II. Status of Hsinchu and Tainan Desalination Projects

1. Project Origin (1) – Hsinchu Desal.



lack of regional water resource

- Current area demand is 580,000 CMD, but regional water resources is only 480,000 CMD
- cross-regional dispatch of water resources is not stable

Water resource development

- Traditional water resource 4,000 CMD (reservoir improvement)
- Desalination 100,000 CMD → increase regional water resource

- Reclamation water 98,000 CMD → for high-tech usage
- Underflow water 40,000 CMD → backup plan

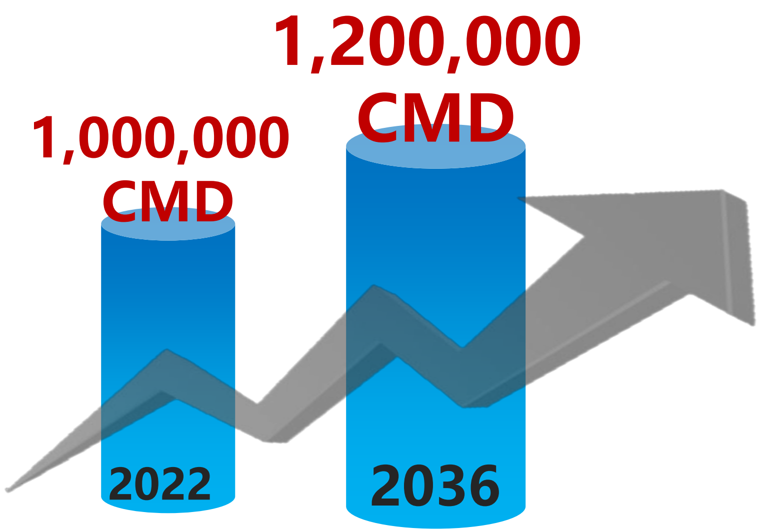
1. Project Origin (2) – Tainan Desal.

- Among recent 10 years in Tainan, reduced water supply happened in 7 years due to insufficient rainfall; during 2014~2015 and 2020~2021 land fallowing was conducted since the severe drought
- Area water demand continues to increase and needs to be prepared in advance

Zengwen Reservoir	Nanhua Reservoir
5.8%	8.5%
Storage capacity	Storage capacity
29,530,000 cubic meters	7,760,000 cubic meters
May 27th, 2021	May 27th, 2021

➡ Water stress exacerbates

Area Water Demand

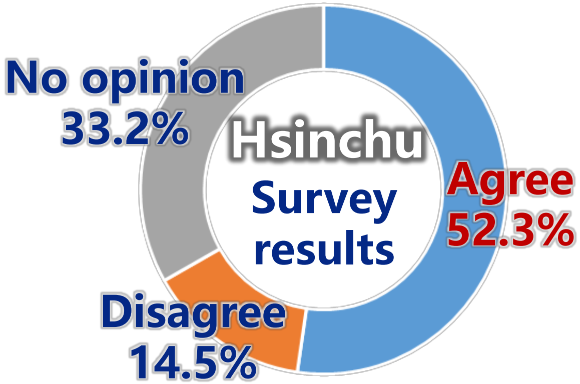


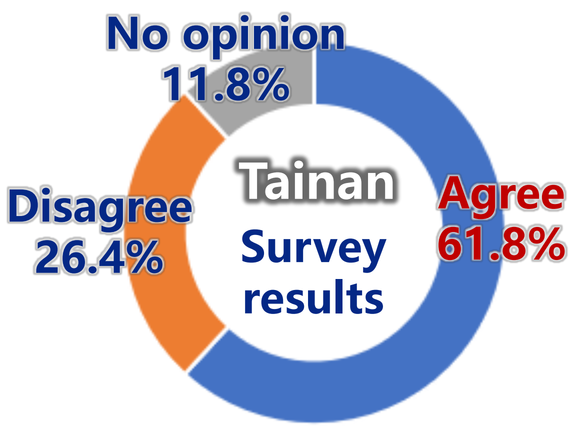
Resource : WRA

1. Project Origin (4)– Social engagement

To gel local consensus and listen to different opinions

Until 2022, 26 forums in Hsinchu and 70 forums in Tainan are held， to thoroughly understand residents' opinions





- **Anticipation : water supply improvement**
- **Worry : potential impact of brine discharge on fishery**

➡ **Keep negotiating and striving for support**


Local forum with residents


Forum with fishermen

Pass the EIA on Jul. 2022

2. Hsinchu Desalination Plant (1)

- **Site :** South of Hsinchu Fishing Port, Hsinchu County
- **Capacity :** 100,000 CMD
- **Area :** 10.1 ha
- **Treatment Process :** Intake+Pretreatment+RO+Post Treatment

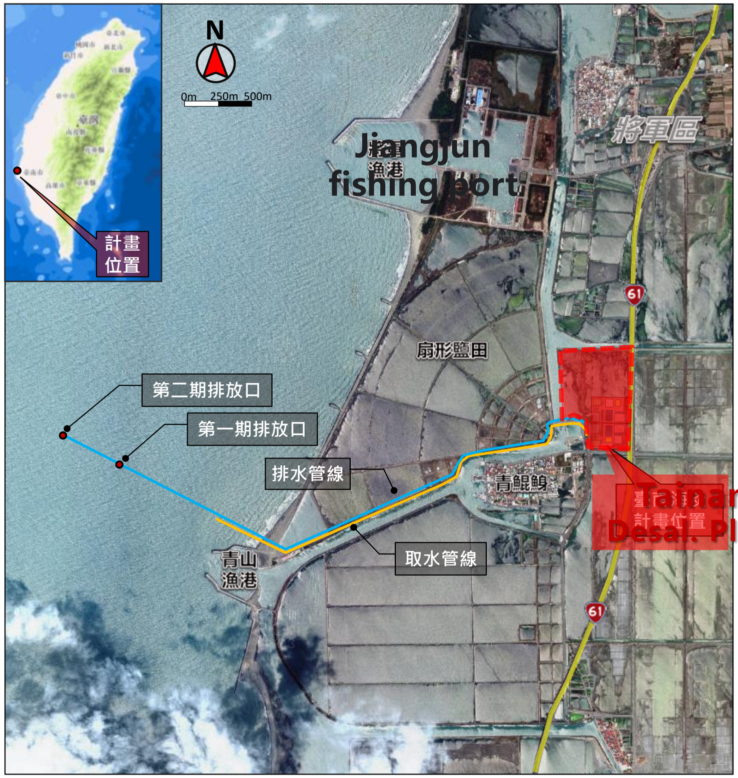
2. Hsinchu Desalination Plant (2)

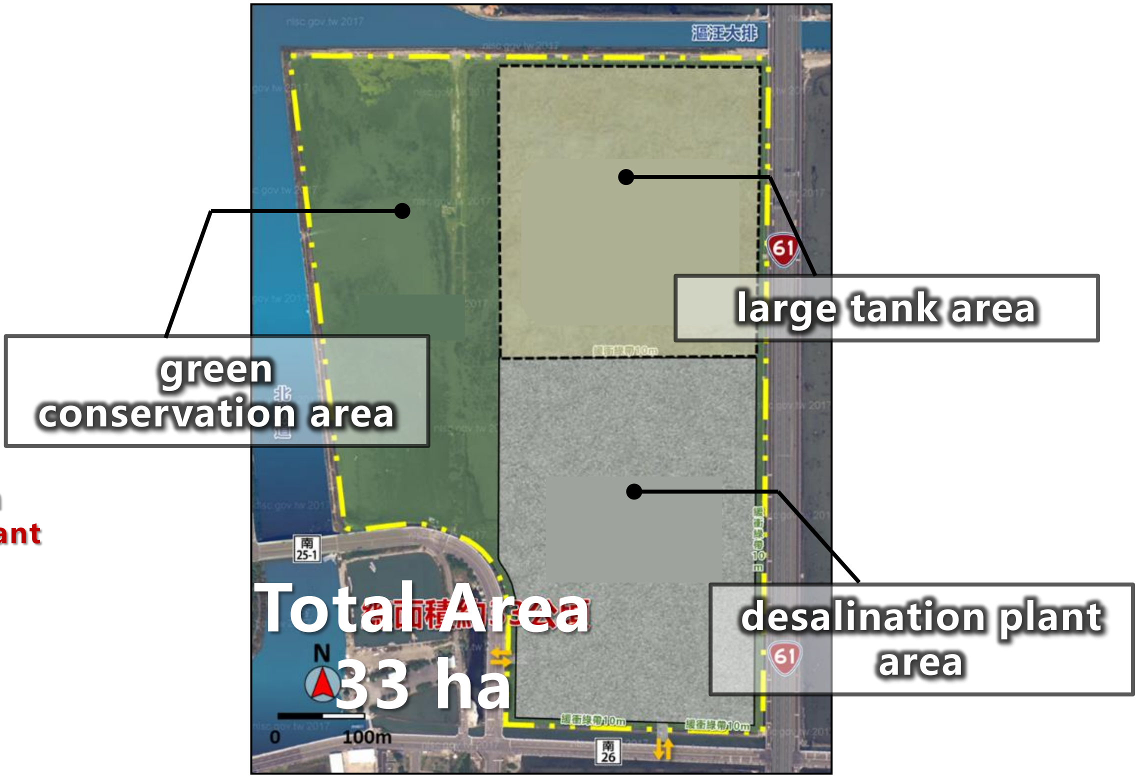
- Desalinated water will be transferred into **tap water system** by a 9.72 km-long pipe
- The pipe length is around 9.72 km, with the diameter of 1,350 mm
- The destination is Hsinchu 2nd Water Treatment Plant

3. Tainan Desalination Plant (1)

Pass the EIA on Jul. 2022

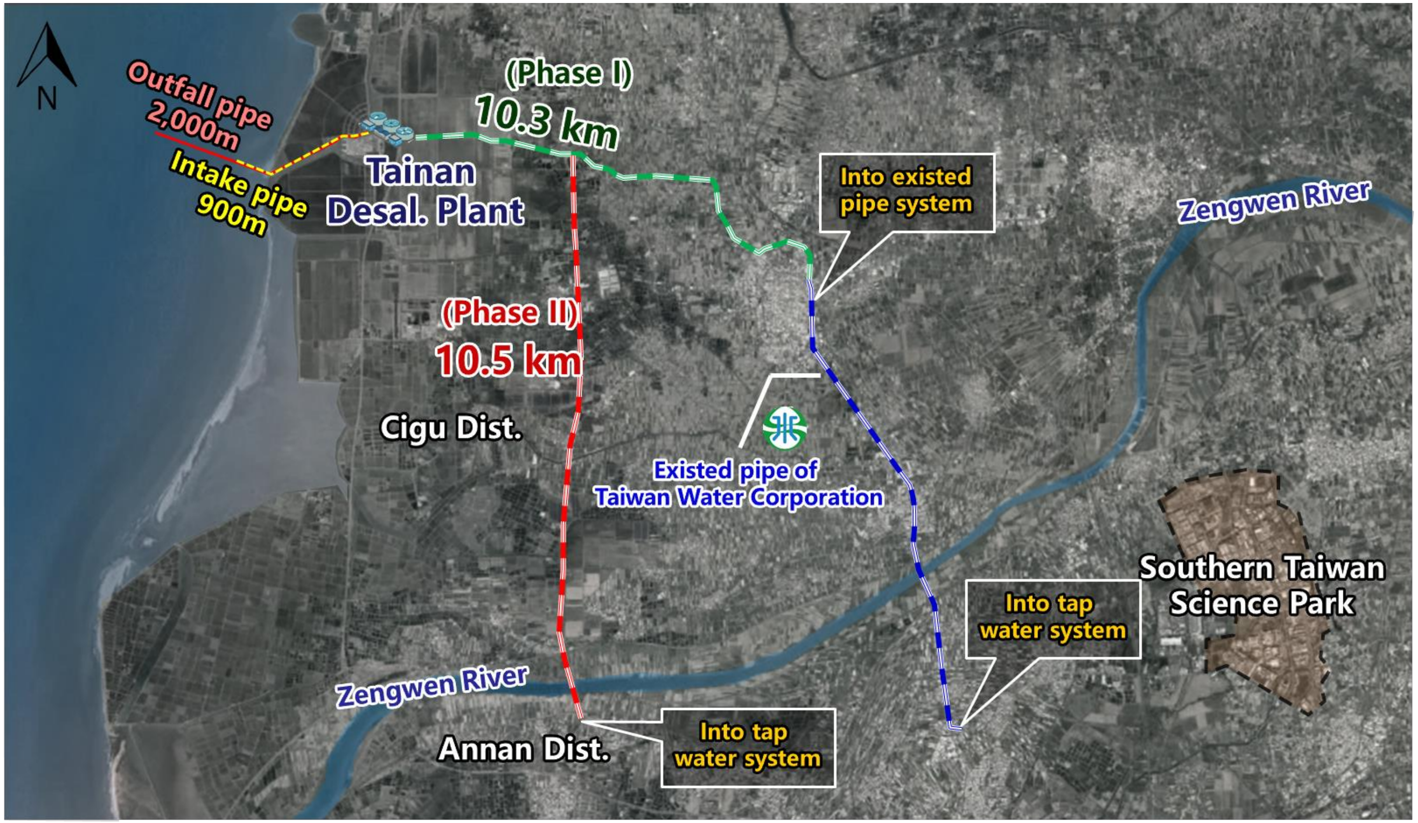
- **Site :** Jiangjun District(將軍區), Tainan, an abandoned salt field
- **Capacity :** 200,000 CMD (Two phases, 100,000 CMD for each)
- **Area :** 33 ha (two phases involved)
- **Treatment Process :** Intake+Pretreatment+RO+Post Treatment





3. Tainan Desalination Plant (2)

- Desalinated water will be transferred into **tap water system** by two pipes
- The distance of two delivery pipes is around 10 km, with the same diameter of 2,000 mm



4. Energy Saving of Desalination (1)

- Energy saving had been thoroughly considered in EIA status
- Set up energy recovery devices (ERD) to reduce energy consumption in RO process, and recycle up to 90% of pressure energy

Reverse osmosis process

2.5 kWh/m^3

Energy recovery device

Up to 90% energy recovery

4. Energy Saving of Desalination (2)

- The EIA requests both Tainan and Hsinchu projects utilize green energy(solar energy)
- Both promise to build solar panels with the installed capacity be 10% of the desal. plants' contract capacity
- If the construction contractor can't satisfy 10% demand by installing solar panels, they can choose to gain Renewable Energy Certificates (再生能源憑證)

Taiwan Renewable Energy Certificate (T-REC)

Project	Contract Capacity (estimated)	Installed Capacity (Solar panel)
Tainan	36.6 MW	Installed capacity is 3.66MW, and it is estimated that the solar panels can avoid 2,380 tons of CO_2 emissions per year
Hsinchu	18.3 MW	Installed capacity is 1.83MW, and it is estimated that the solar panels can avoid 1,132 tons of CO_2 emissions per year

Barcelona Desalination Plant (Spain)

4. Energy Saving of Desalination (3)

◆Active Deload

- **Maximum production will be 1,500,000 cubic meters/month during Jun. to Sep.**
- **Maximum production will be 3,000,000 cubic meters/month during Oct. to May**

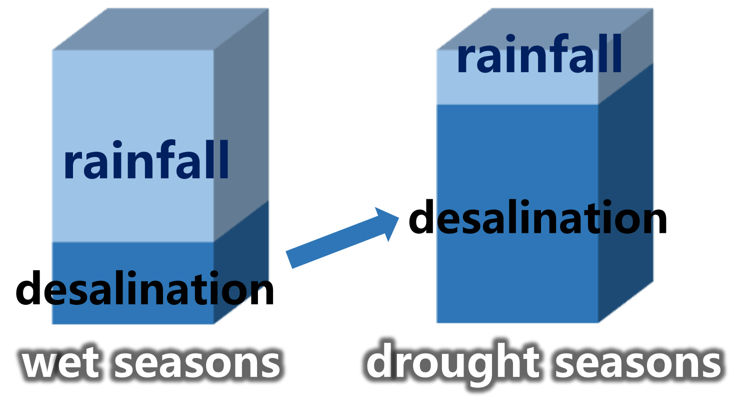
◆Passive Deload (cooperate with Taipower)

- **When Taipower notice that the power supply is insufficient, desal. plants will reduce the production of water**

Operation Strategy

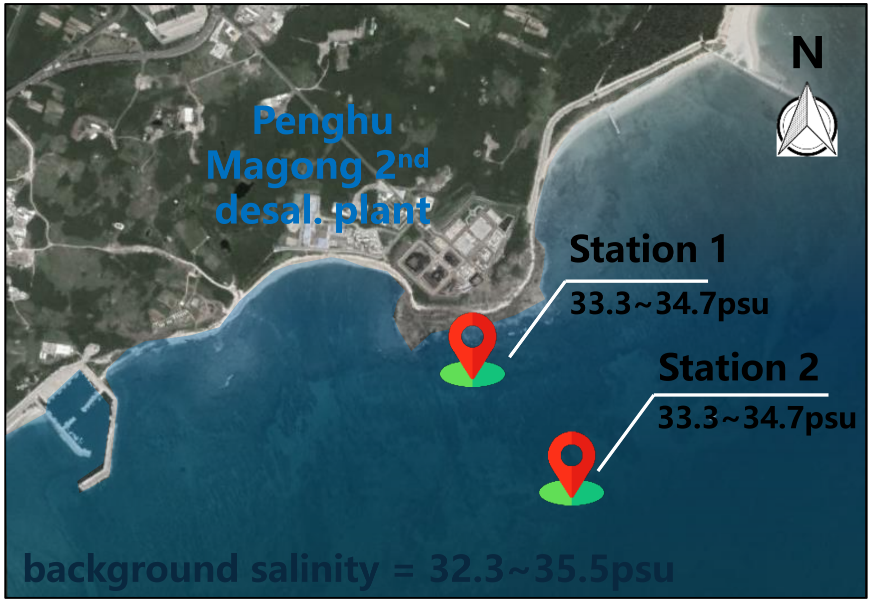
✓ **Reduce production during summertime (Jun. - Sep.) and in low energy hours**

- **Wet seasons : water supply mainly rely on rainfall**
- **Drought seasons : desalinated water fill the shortage**



5. The impact of brine discharge(1)

- **Multi-port** outfalls are applied in many desal. plants, and proved to have great dilution effect; desal. plants in Penghu island mostly apply multi-port diffusers
- Underwater investigation at Magong 2nd desal. plant shows that fish still gather near the diffusers and are not impacted
- Environmental supervision at Magong 2nd indicates the dilution effect is great

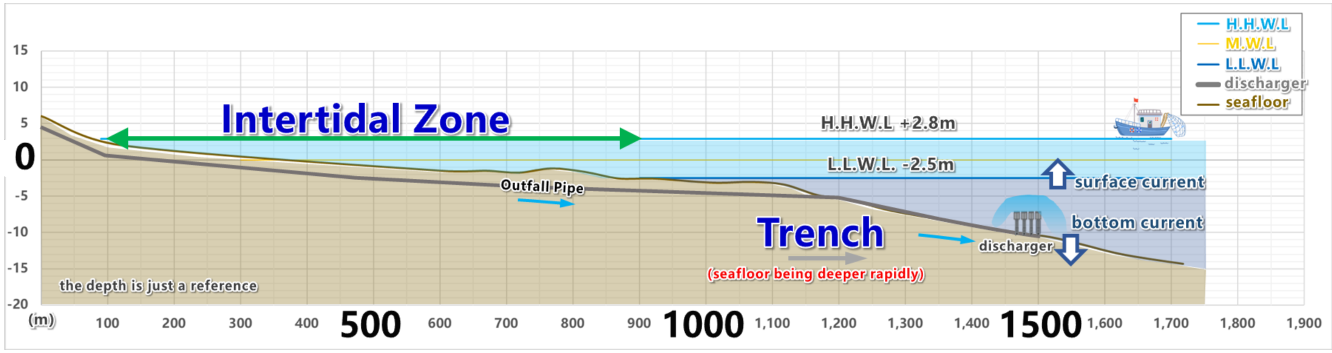



Multi-port diffuser
(Cimei Desal. Plant)

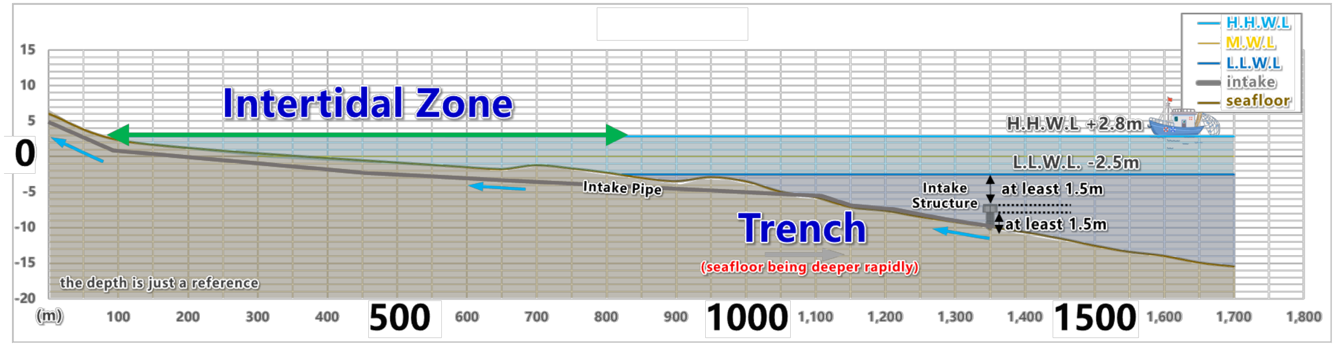

Fish gathering near the diffuser
(Magong 2nd Desal. Plant)

5. The impact of brine discharge(2)

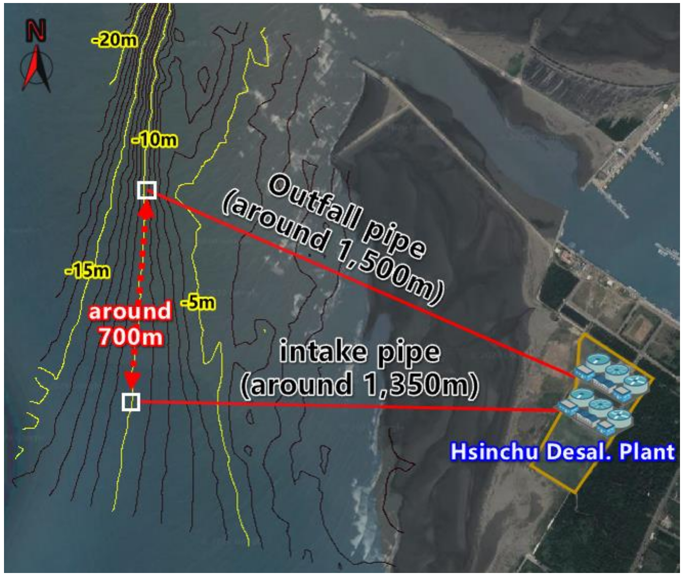
- ✓ Intake and outfall pipes are installed under the seafloor
- ✓ Intake velocity is lower than 0.15m/s (0.5fps) to avoid sucking in fish
- ✓ Multiport (4 ports) discharge to make sure well dilution effect



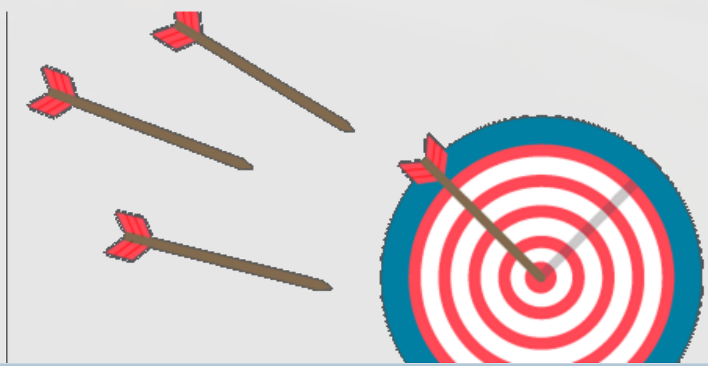
■ Outfall = 1,350m; Discharger locates at -10m (trench area)



■ Intake pipe = 1,350m; Intake structure locates at -10m



III. Evaluation of Desalination Plant Procurement Strategies



1. Procurement Model

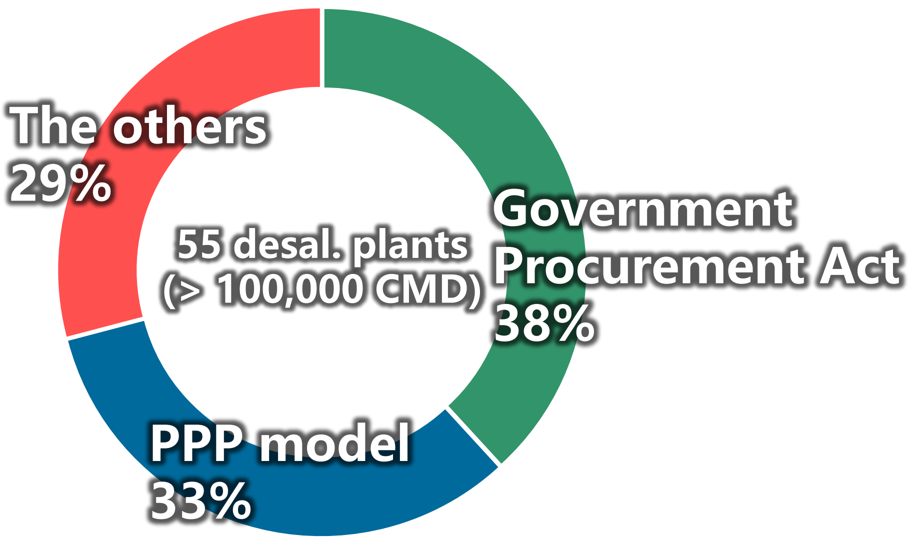
- **Public-Private Partnership(PPP)**
  Project execution and contract change is flexible, which can reduce the initial construction cost and decrease the financial burden, but the total cost may be higher.
- **Government Procurement Act (DBO)**
  (procurement of infrastructure and labor service)
  The government can regulate variable amount of water production in the contract, but initial finance burden is relatively high to the government.
- **Government Procurement Act (procurement of water)**
  The government purchase water from enterprises but does not own the desalination plant, which means the government should take the risk of water supply.
- **Constructed by the private companies or enterprises (Ex. Mailiao)**
  The government does not need to undertake the construction and operation risk of the plant. Only water cannot be distributed by the government at random.

<Recommendation>

PPP(Public-Private Partnership) and Government Procurement Act are both possible, the government needs to consider overall financial situation and then makes a decision

2. Procurement Model Cases Study

- There are 55 desal. plants (>100,000 CMD) in the world since 2015
- Government procurement accounts for 21, PPP model accounts for 18, and the others account for 16
- Most Desal. Plants in Taiwan develop with a DBO model
- Nankan (III) Desal. Plant was financed by a BTO contract



Global Status

Location	Desal. Plant	Procurement Model
Penghu	Magong 2nd	DBO
	Cimei	DBO
	Jibei	DBO
Matsu	Nankan 3rd	BTO
	Xiju	DBO
Kinmen	Big Kinmen	DBO

3. Evaluation of Promotion Strategies

- **The cost of desalinated water is approximately 3 times higher than the price of tap water.**
- **Thus, the government needs to stipulate acquisition price and quantity to enhance private companies' willingness to invest.**

Water source / location	Desalination water				Traditional water source		Tap water price
	Desalination Plant	Construction cost(1)	Maintenance operation cost(2)	Water production cost(3)=(1)+(2)	Lake& reservoir water	Ground water	
Kinmen	Big Kinmen 4,000CMD	*18*	*32*	*50*	*40*	*8*	*11*
Penghu	Magong First 10,000CMD	*17*	*29*	*46*	*55*	*8*	*11*
	Magong Second 4,000CMD	*20*	*35*	*55*			
	Xiyu 750CMD	*30*	*50*	*80*			
Matsu	Nankan 1st 、2nd stage1,000CMD	*17*	*37*	*54*	*72*	*10*	*11*
	Nankan 3rd 950CMD	*33*	*32*	*65*			
	Xiju 500CMD	*29*	*55*	*84*			
Main Island	Tainan/Hsinchu desalination (estimated)	*17*	*31*	*48*	*10~15*	*2*	*11*

Around USD 1.6

Epilogue

- According to IPCC AR6, extreme weather may exacerbate in the future.
- To respond in advance, the WRA has made water resource development strategies, including desalination
- Energy saving is an important issue in desalination. Energy recovery devices and solar panels will be applied to decrease energy consumption and carbon emission
- Both Tainan and Hsinchu projects have passed the EIA, and the decision of procurement model depends on the government's financial condition

Thanks for your listening

Water Resources Agency ,MOEA

台灣國際水週
Taiwan International Water Week

Advanced Water Technologies for Seawater Desalination and Brine Mining

先進水科技於低能耗海水淡化與有價礦產(鋰)捕捉

Chia-Hung Hou, Ph.D.

Professor/Chief Executive

Graduate Institute of Environmental Engineering

Water Innovation, Low-Carbon and Environmental Sustainability Research Center

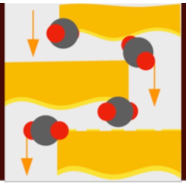
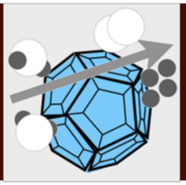
National Taiwan University

October 13, 2022

水科技與低碳永續創新研發中心(WInnER)

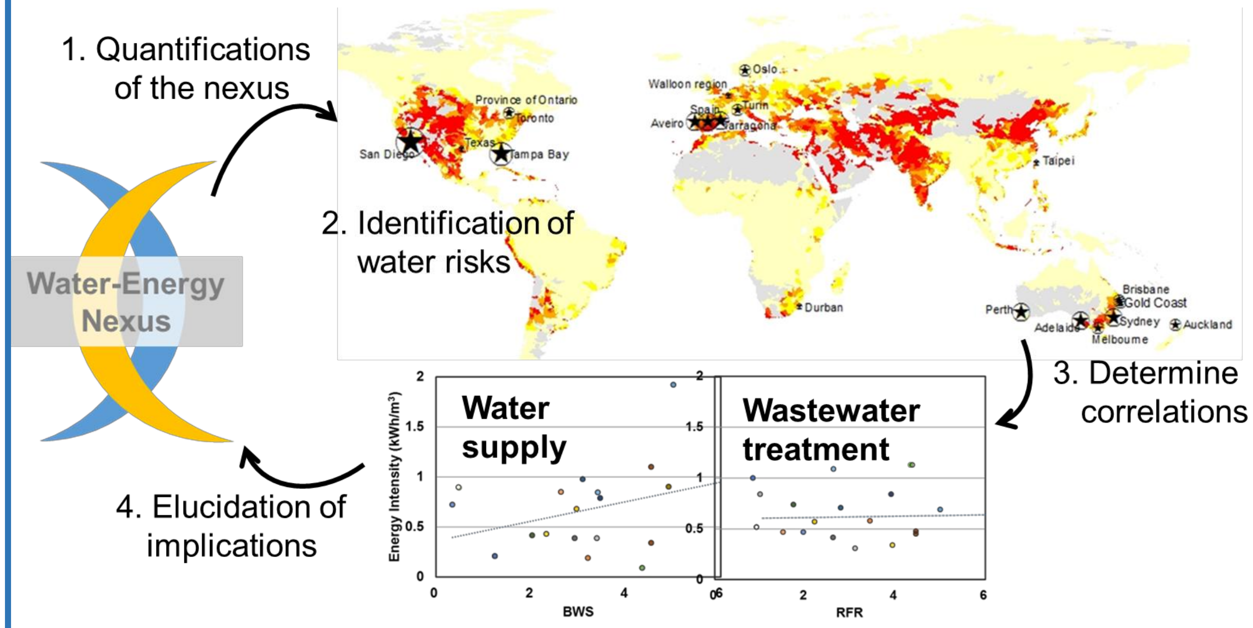
□Cross-discipline research

- Chemical engineering
- Civil engineering
- Environmental engineering
- Geosciences

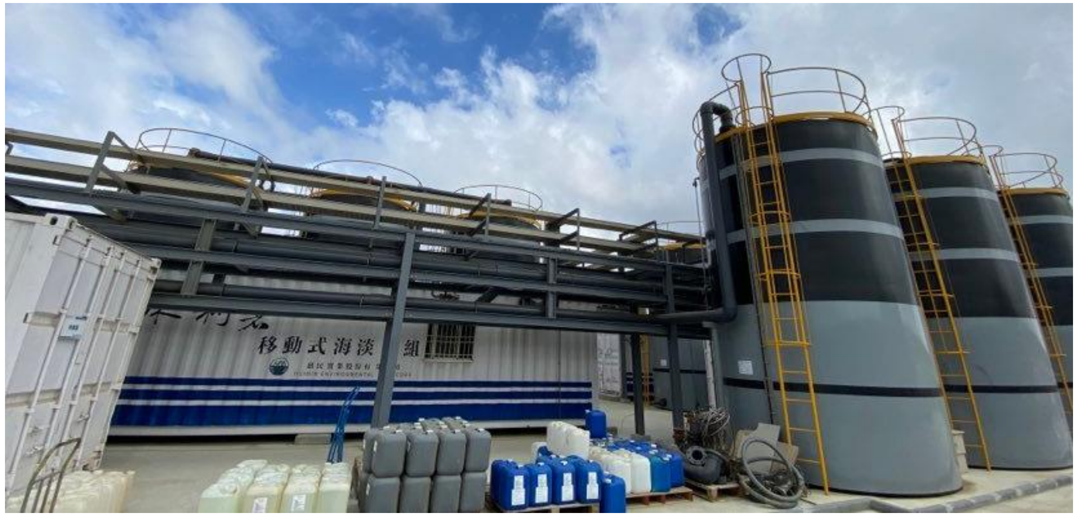
水科技關鍵技術		膜分離、電化學分離、臭氧與高級氧化、環境生物及環境光化學等新穎技術
低碳與碳捕獲技術		碳捕獲、碳封存及再利用技術
能資源規劃管理		環境規劃與管理、環境資訊管理與決策分析、環境衝擊分析、生命週期評估與管理

Water-Related Challenges: Water-Energy Interactions

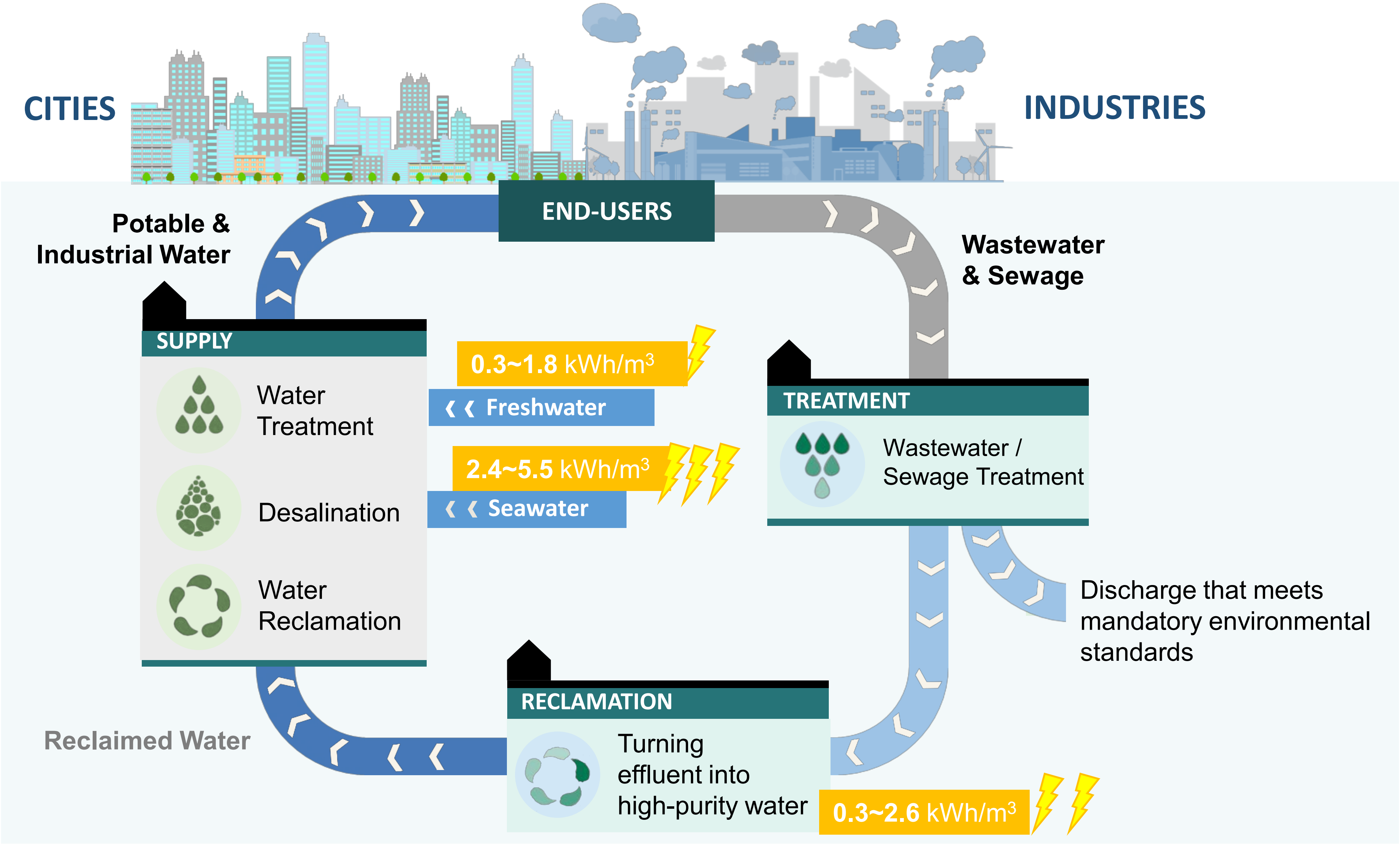
Water-Energy Nexus for Water and Wastewater Systems



(Lee et al., Applied Energy, 2017)



Water Cycle: Water-Energy Interactions



Adopted from
https://www.sembcorp.com/

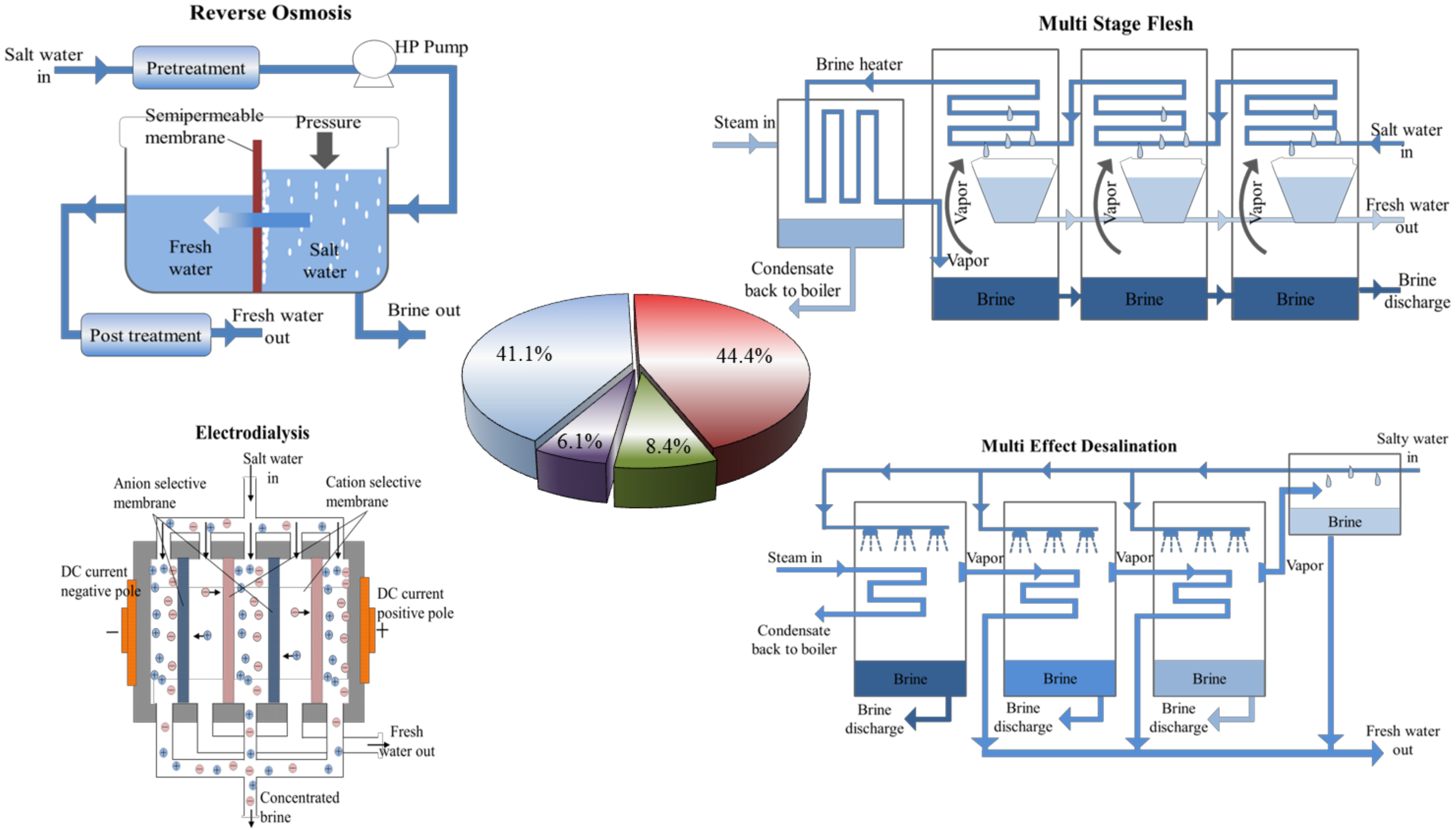
Water Security Grand Challenge for the United States to reach by 2030

U.S. DEPARTMENT OF ENERGY

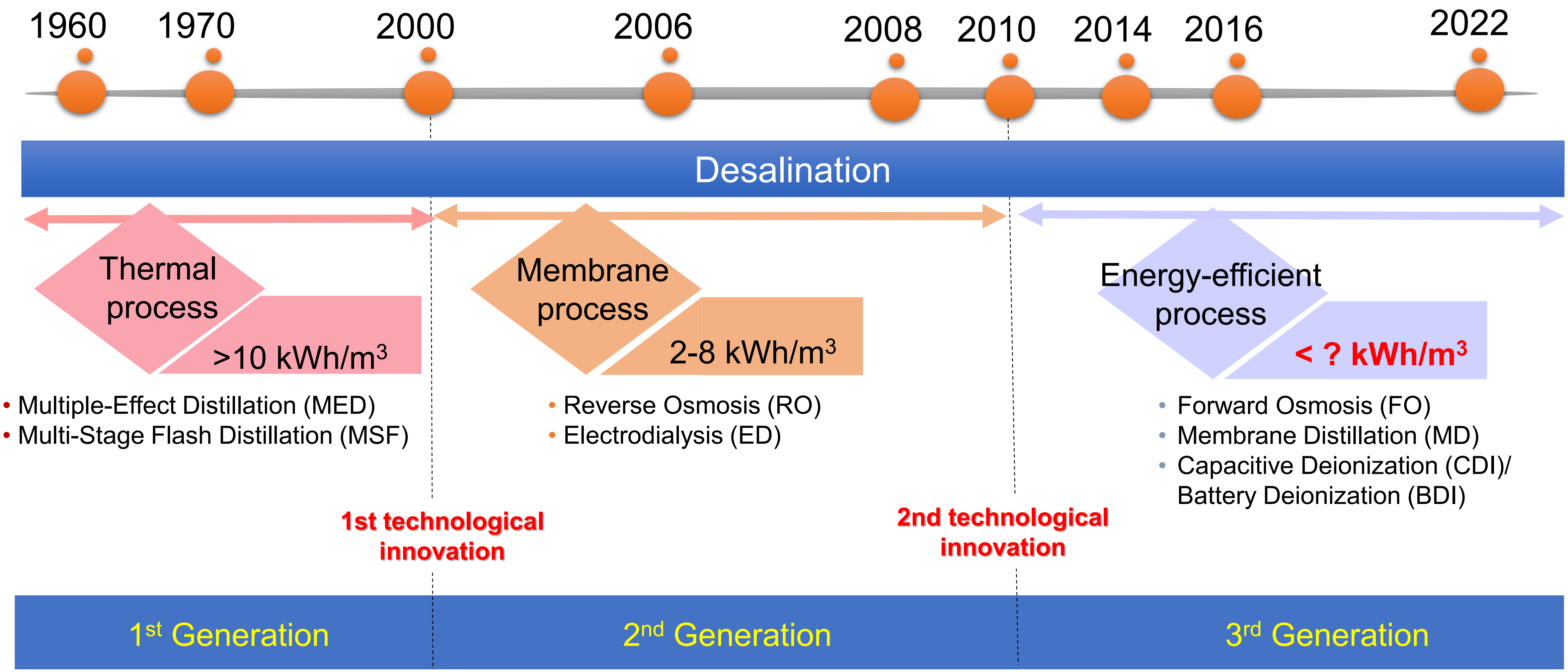
- Launch desalination technologies that deliver cost-competitive clean water.
- Transform the energy sector's produced water from a waste to a resource.
- Achieve near-zero water impact for new thermoelectric power plants, and significantly lower freshwater use intensity within the existing fleet.
- Double resource recovery from municipal wastewater.
- Develop small, modular energy-water systems for urban, rural, tribal, national security, and disaster response settings.

WATER SECURITY
GRAND CHALLENGE
Abundance Through Innovation

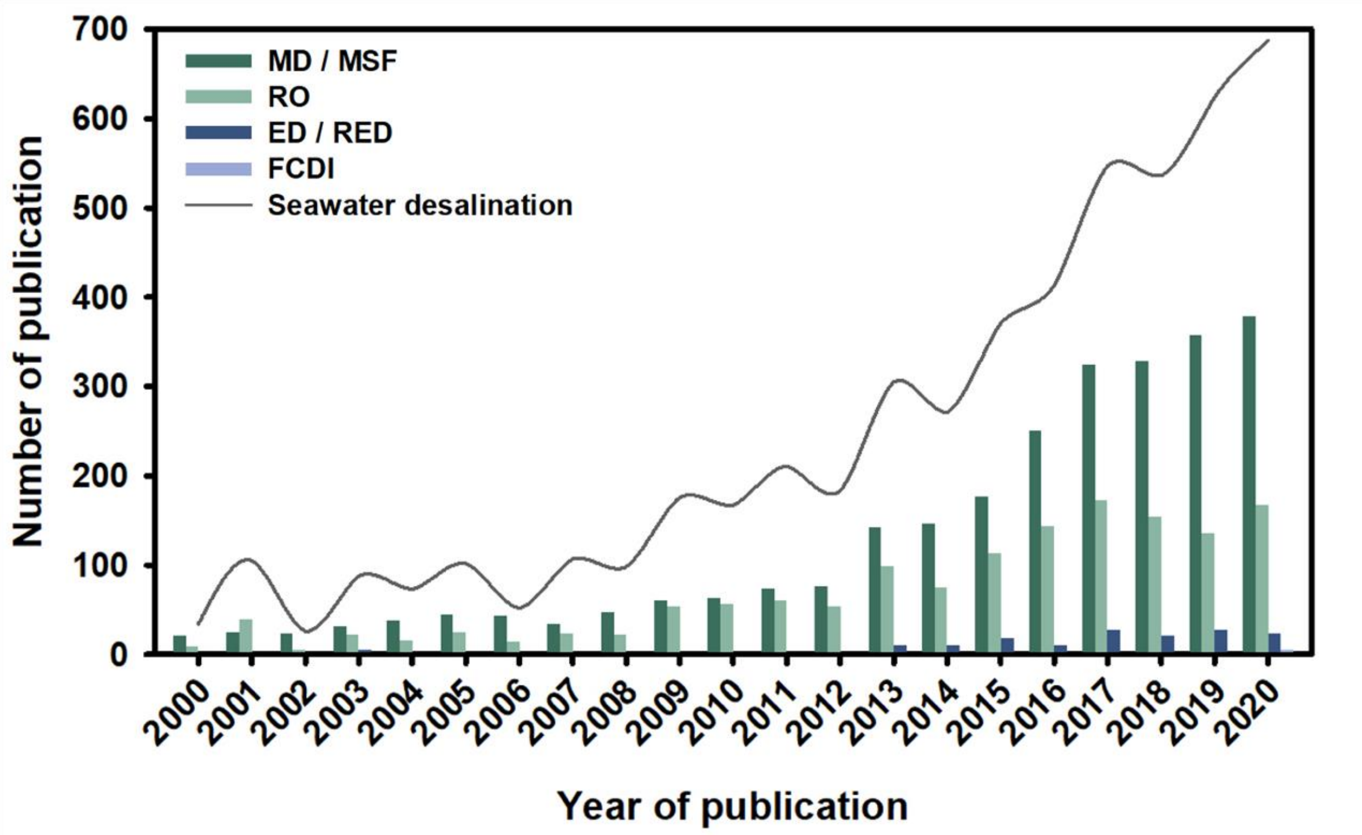
Conventional Desalination Technologies



Timeline of Desalination Technologies



Advanced Technologies of Seawater Desalination



Membrane Distillation (MD)

□A hybrid process

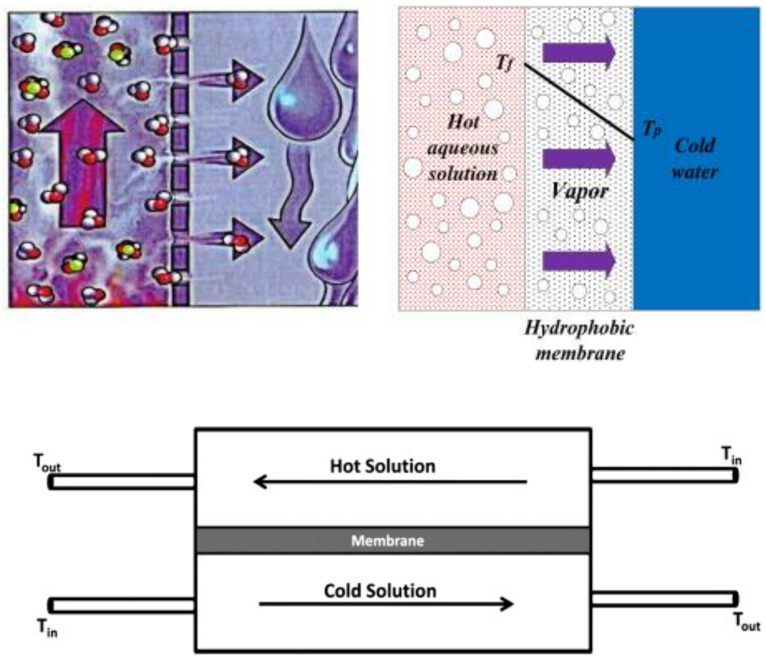
- Combination of the thermal distillation and the membrane technology
- Based on the principle of the liquid–vapor equilibrium

□Operation

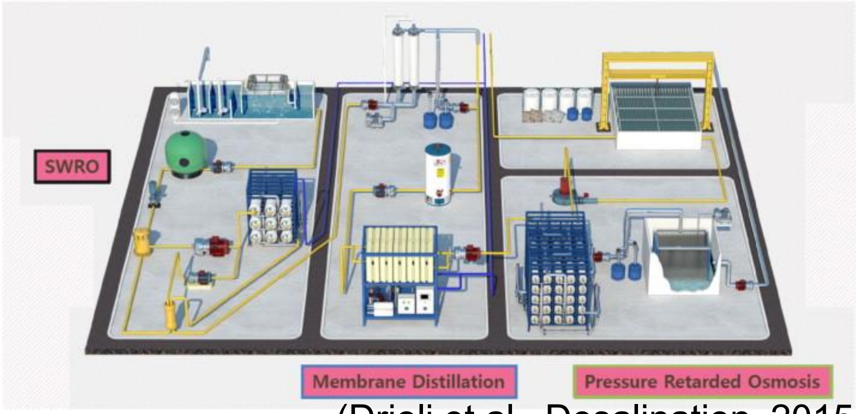
- Lower operating temperatures
- Lower hydrostatic pressure
- Lower fouling problem

□Process configuration

- Direct contact membrane distillation (DCMD)
- Air gap membrane ddistillation (AGMD)
- Sweeping gas membrane distillation (SGMD)
- Vacuum membrane distillation (VMD)



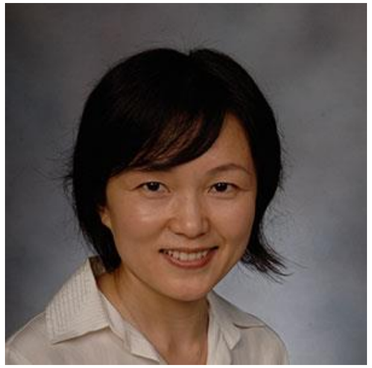
Membrane configuration: DCMD



(Drioli et al., Desalination, 2015)

Nanophotonics-Enabled Solar MD (NESMD) Reactor

Solving fit-for-purpose water treatment needs by applying nanoscale science and engineering

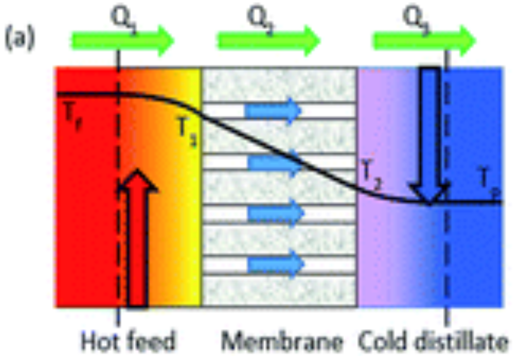


Prof. Qilin Li
(Rice Univ.)

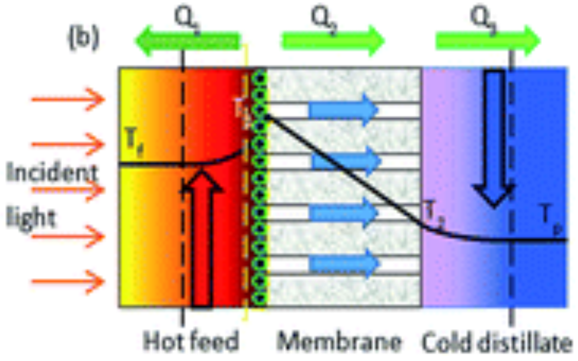
☐NESMD

- A direct solar method for desalination that utilizes nanoparticle-assisted solar vaporization in a membrane distillation geometry.
- Membranes coated with carbon black nanoparticles or SiO_2/Au nanoshells.

(Wu et al., J. Mater. Chem. A, 2017)



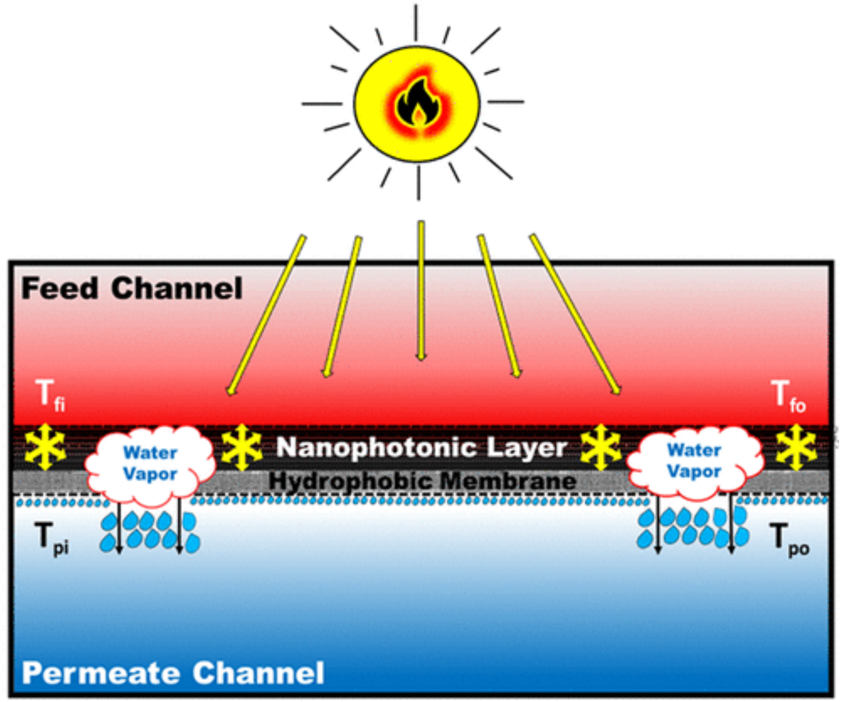
Conventional DCMD

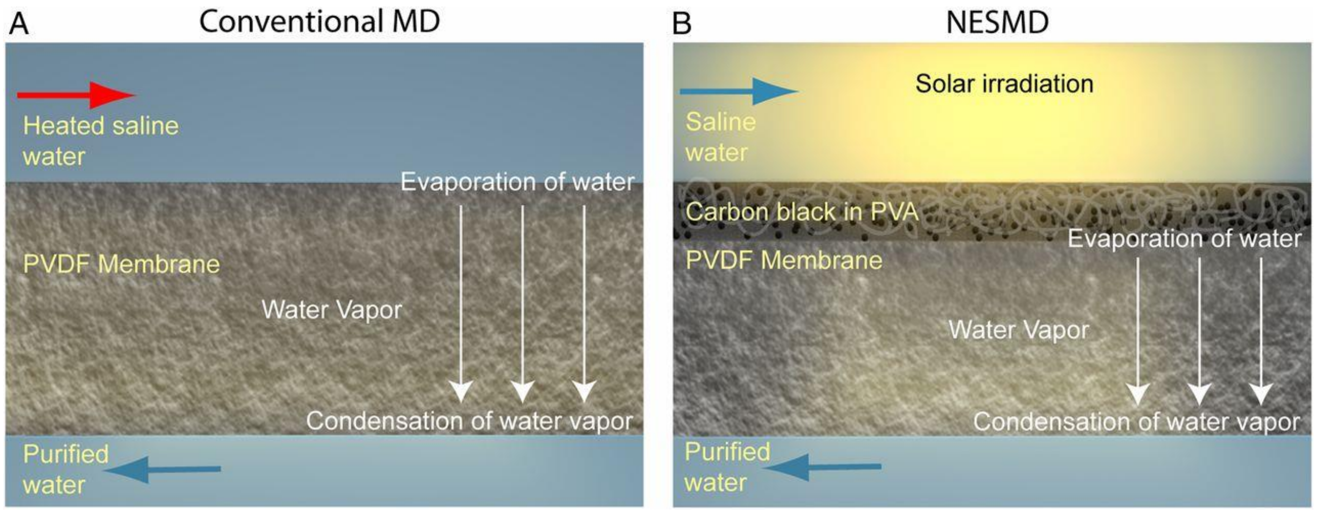


Photothermal DCMD with a nanomaterial coating and localized heating at the membrane surface

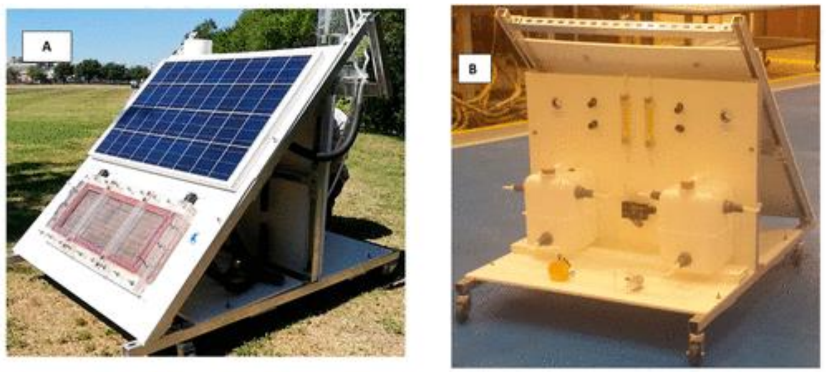
Demonstration of NESMD: No Additional Heat Source

- **NESMD greatly reduces the operation cost of MD by using sunlight**
  - Highly localized photothermal heating induced by solar illumination alone drives the distillation process, entirely eliminating the requirement of heating the input water.





(Dongare et al., PANS, 2017)

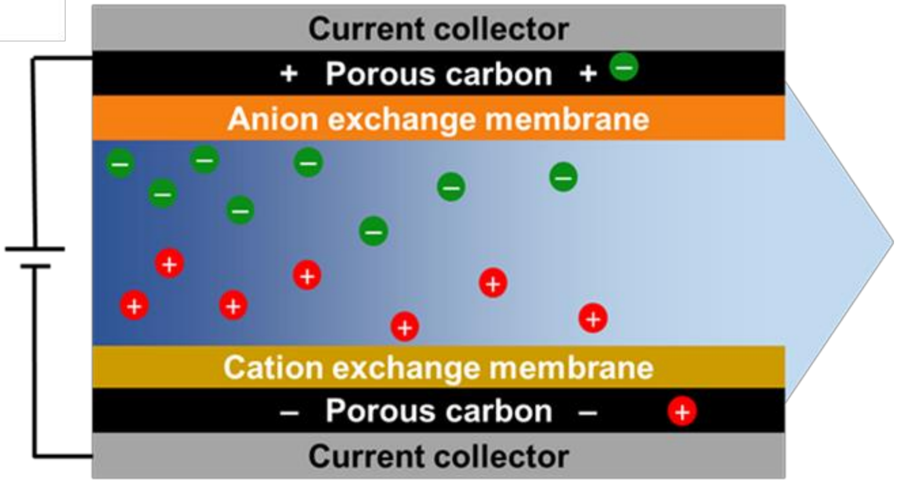


(Said et al., Ind. Eng. Chem. Res. 2019)

Membrane Capacitive Deionization (MCDI)

Electrosorption of ions

- Highly porous carbons for electrical double-layer (EDL) charging
- Placing ion-exchange membrane in front of the carbon electrodes



Operation

- High charge efficiency
- High water recovery
- Low chemical usage
- Environmental friendliness

Pilot study for water reclamation of WWTP effluent

Redox Flow Battery: Energy Storage

□Mechanism

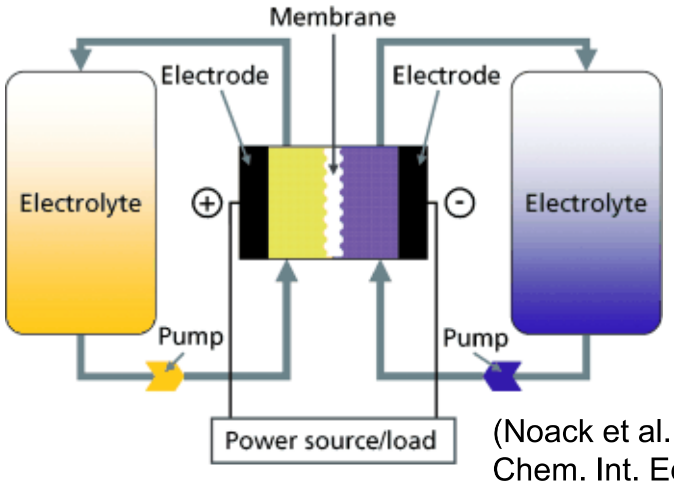
- Oxidation: $V^{2+} \rightarrow V^{3+} + e^-$
- Reduction: $VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$

□Operation

- Flexibility in power generation and distribution
- Enormous scalability
- Rapid response
- Long cycling lifetime

□Applications

- Energy storage
- Load levelling
- Electric vehicles



(Noack et al., Angew. Chem. Int. Ed. ,2015)

(Sumitomo Electric Industries, Ltd.)

Flow Battery Desalination (FBD)

Redox-flow batteries

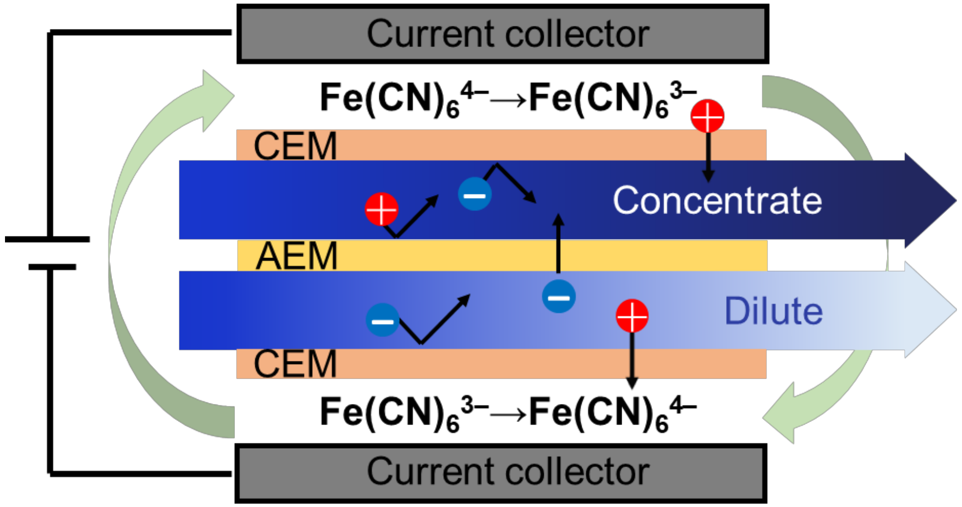
- Redox couples (e.g. $Fe(CN)_6^{4-}$ / $Fe(CN)_6^{3-}$)
  - Oxidation in anode chamber
  - Reduction in cathode chamber

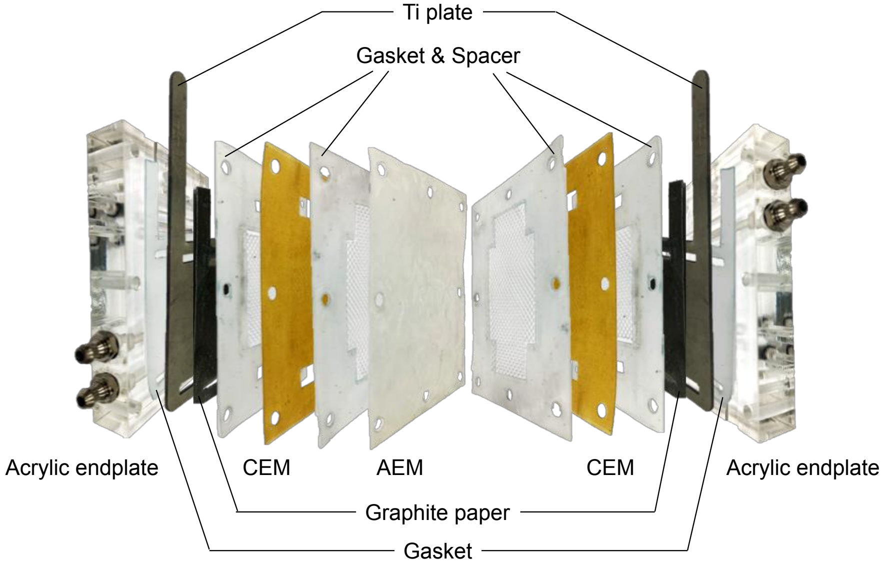
Operation

- Unlimited continuous operation for salt removal
- Wide salinity working range

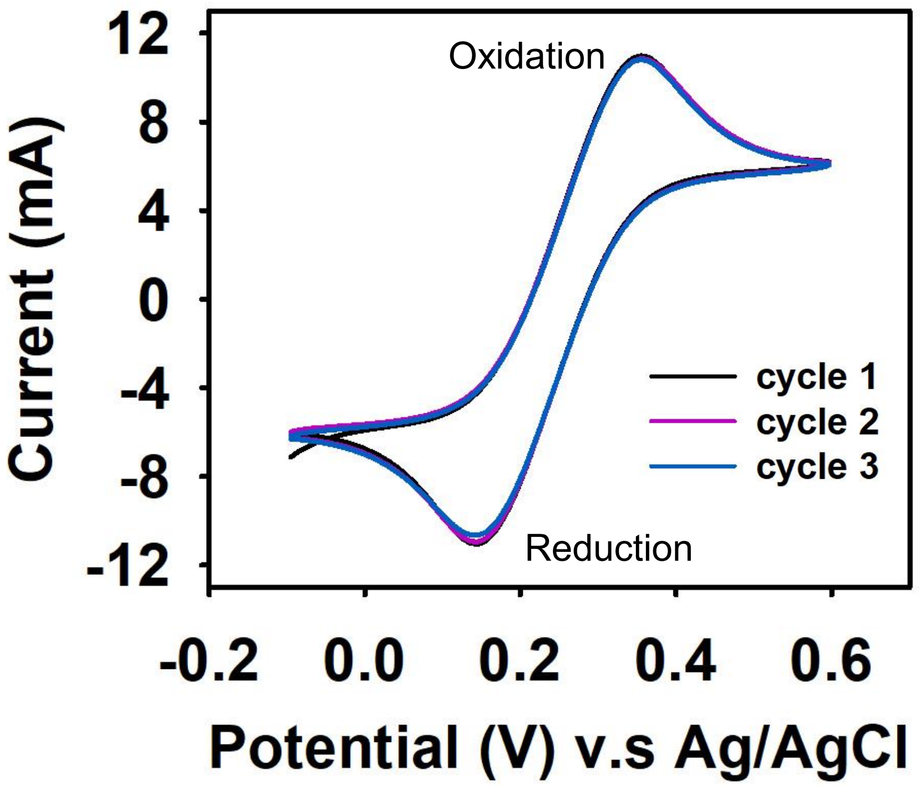
Applications

- Seawater desalination
- Concentrated brine
- Toward zero liquid discharge





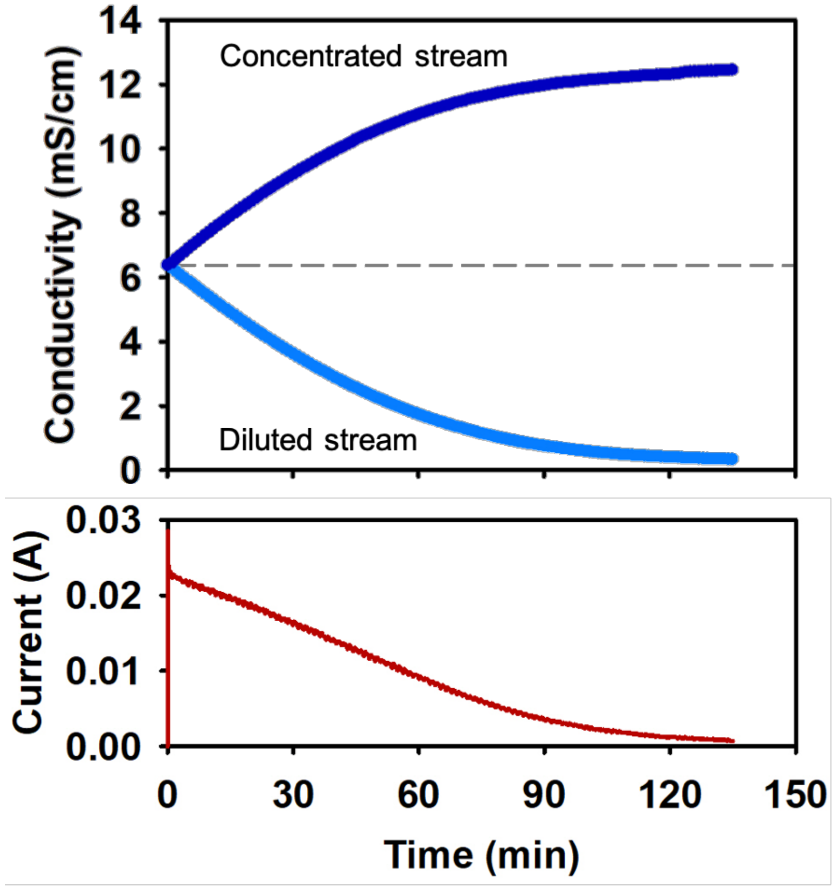
Electrochemical Analysis & Performance



Oxidation: $Fe(CN)_6^{4-} \rightarrow Fe(CN)_6^{3-} + e^-$

Reduction: $Fe(CN)_6^{3-} + e^- \rightarrow Fe(CN)_6^{4-}$

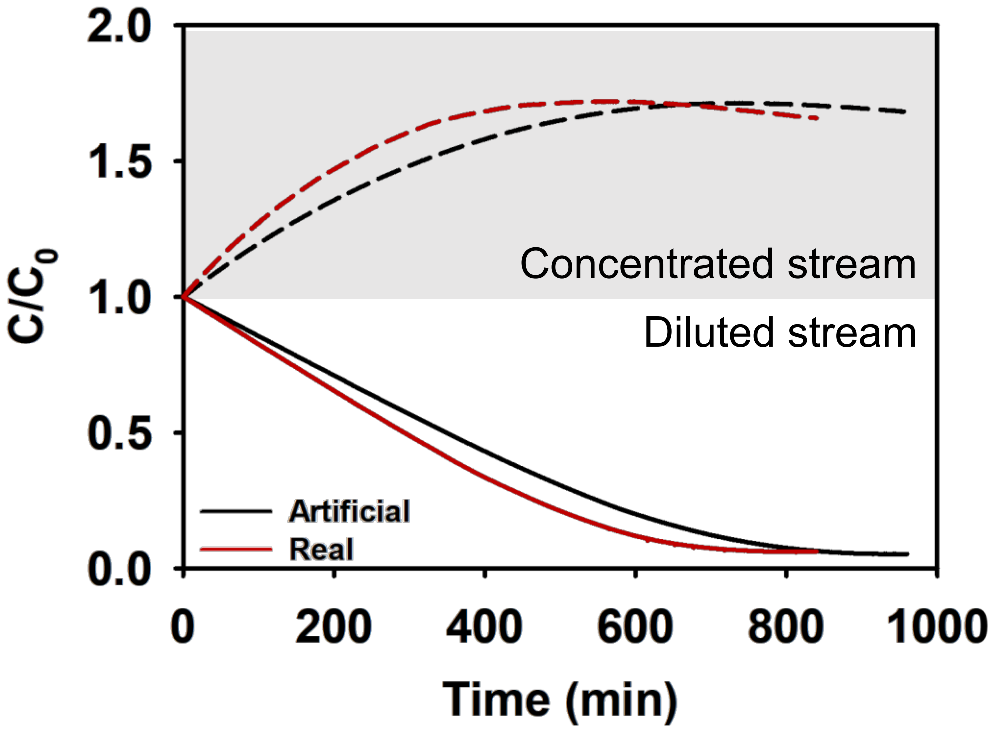
(Cheng et al., Desalination, 2022)

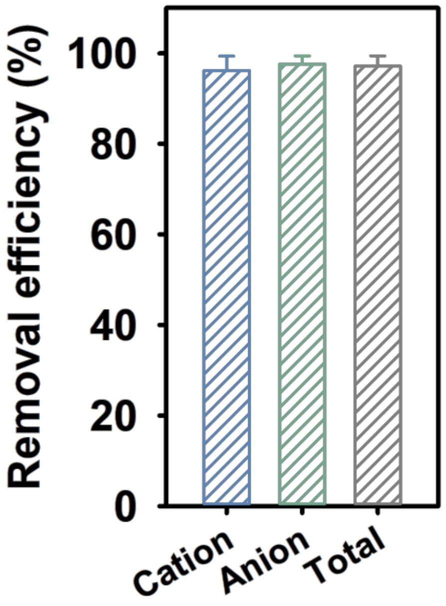


Applied voltage: 0.2 V
Anolyte/catholyte: 100 mM
Initial NaCl concentration: 3000 mg/L
Flowrate: 5 mL/min

FBD for Desalination of Real Seawater

□FBD exhibits potential for real seawater desalination.



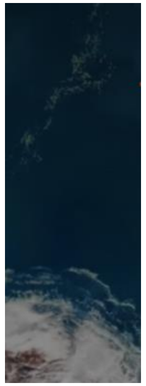


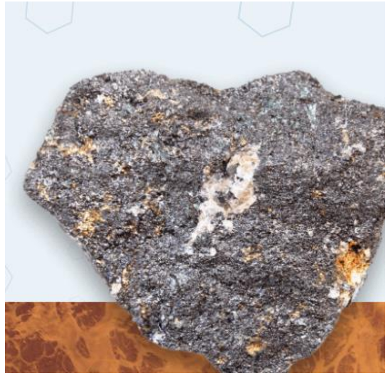
Item	Unit	Initial	Diluted
EC	mS/cm	51.19	3.741
pH	–	8.23	8.09
TDS	mg/L	39200.3	1840.5
Cations			
Ca^{2+}	mg/L	444.1	0.4
Mg^{2+}	mg/L	1884.8	0.7
Na^{+}	mg/L	10442.2	418.3
K^{+}	mg/L	487.6	374.3
B	mg/L	9.3	4.6
Sr^{2+}	mg/L	8.5	N.D
Anions			
Cl^{-}	mg/L	22849.4	1137.7
NH_3-N	mg/L	0.03	N.D
SO_4^{2-}	mg/L	3074.6	27.4

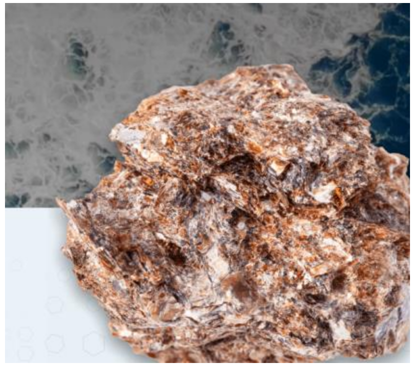
(Cheng et al., Desalination, 2022)

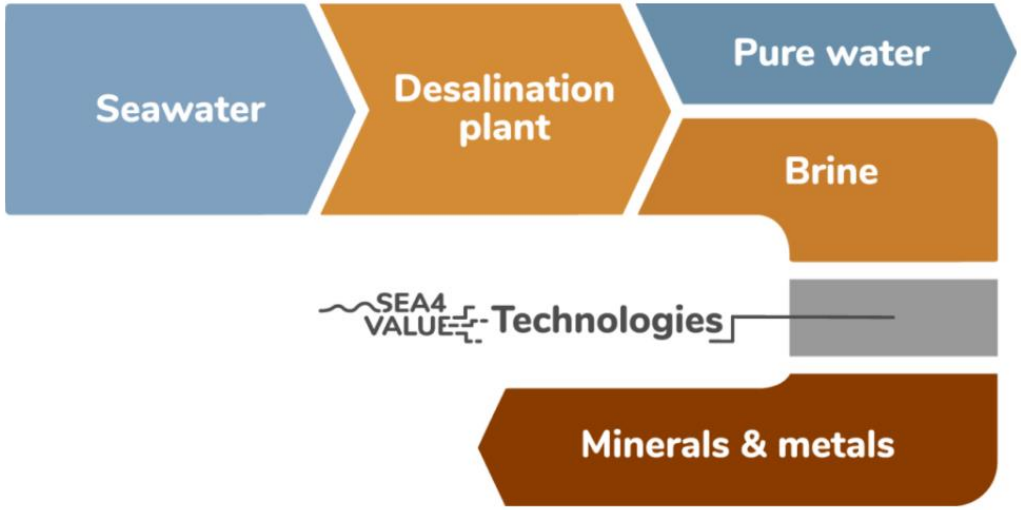
- □ FBD delivered 90% salt removal for real seawater desalination with an ASRR of 63.1 μs/min/cm². and with an energy consumption of 3.34 kWh/m³.

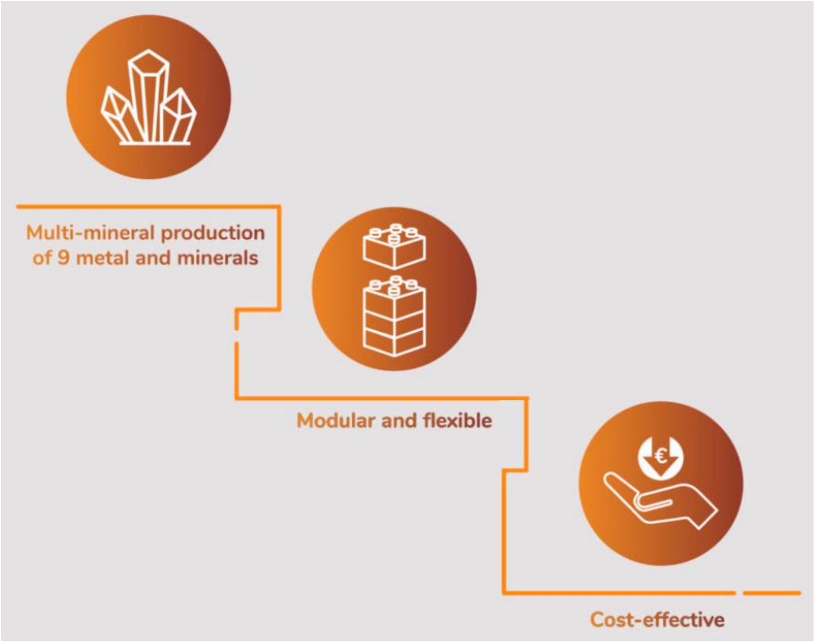
Lithium (Li) Recovery from Seawater Brine







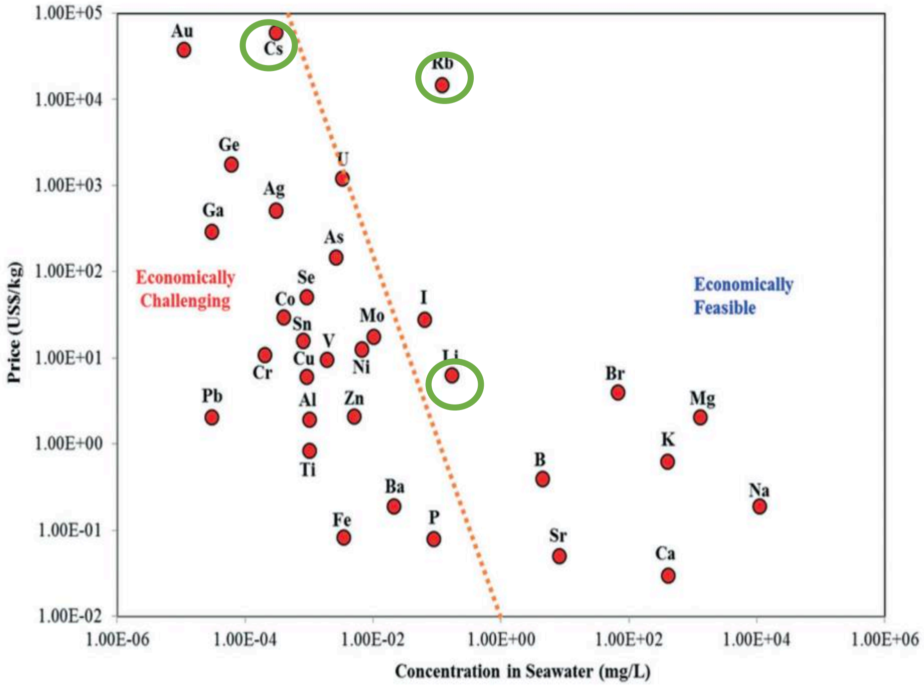




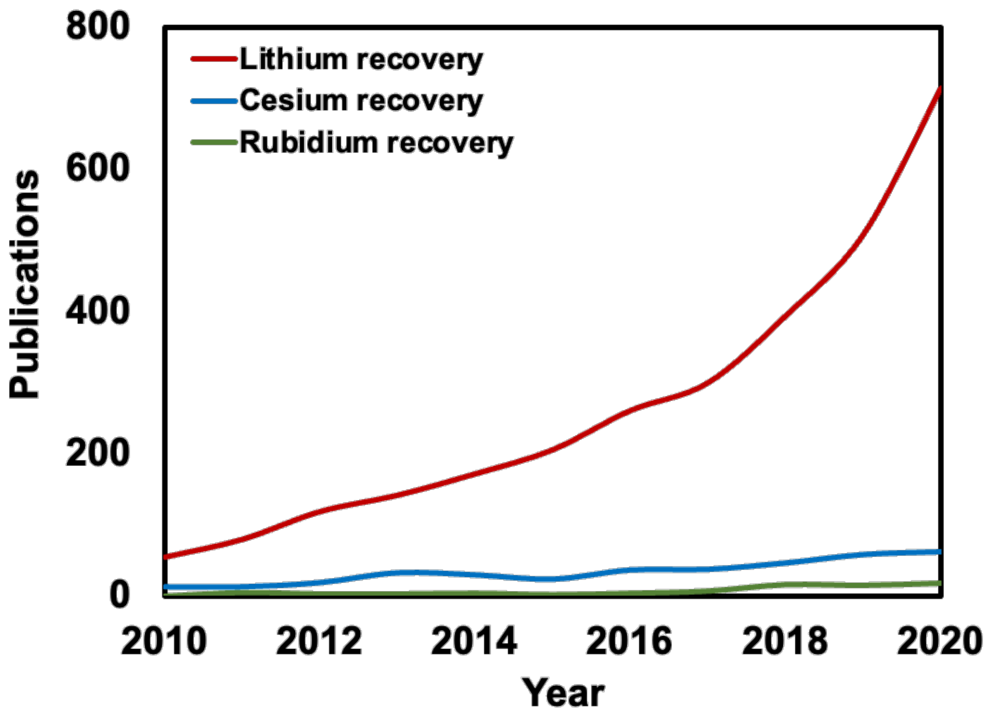
Sources: https://sea4value.eu/

Perspectives of Screening Valuable Minerals

- **Economic gains obtained by extracting minerals depend on**
  - The concentration of minerals in seawater
  - The market price of these minerals
- **Lithium(Li), Cesium (Cs), and Rubidium (Rb)** are potentially attractive for extraction.



(Loganathan et al., 2017)



Ion Composition of Seawater and Seawater Brine

Elements		Seawater (mg/L)	Seawater brine (mg/L)
Major elements	Cl^-	18980-19400	39583-43790
	Na^+	10556-10800	22800-25237
	SO_4^{2-}	2649-2790	5693-6050
	Mg^{2+}	1262-1295	2632-2900
	Ca^{2+}	400-416	839-960
	K^+	380-392	781-918
Minor elements	Li^+	0.17-0.18	0.27-0.41
	Sr	8.1-13.0	14.5-17
	Rb	0.12-0.24	0.19-0.24
	Cs	0.0002-0.0003	0.0006-0.0008
	Br	65-67.3	120-147
	B	4.4-4.7	4.45-9.3

(Zhang et al., 2021; Najid et al., 2021; Wang et al., 2019; Naidu et al., 2018; Quist-Jensen et al., 2016)

Principles: Selective Recovery

☐ Pretreatment

- Monovalent and multivalent ions separation (Nanofiltration membranes)
- Selectrodialysis (SED)

☐ Concentration

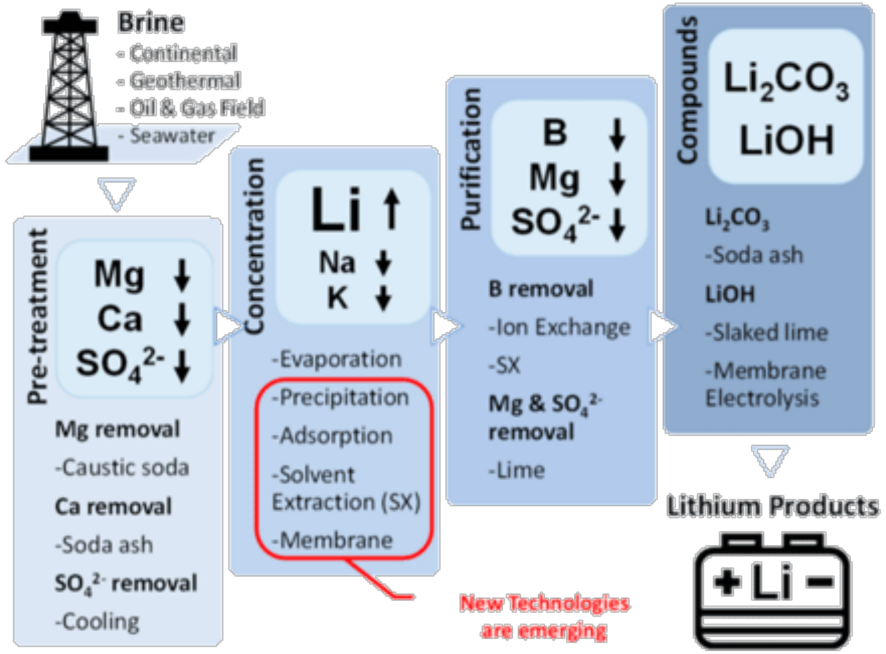
- Membrane distillation (MD)
- Advanced multi-effect distillation
- Advanced membrane crystallization (MCr)

☐ Purification

- Ion exchange
- Chemical addition (Lime)

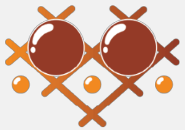
☐ Compounds

- Precipitation by Na_2CO_3



Sea4Value: Technologies

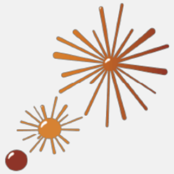
Pretreatment



Nanofiltration membranes for monovalent and multivalent ions separation

Concentration

Advanced multi-effect distillation

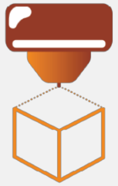


Advanced membrane crystallization

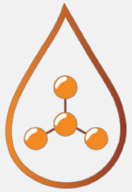
Selective recovery

Ion-selective polymer inclusion membranes
→ **Ga, Ru**

Electrodialysis with bipolar membranes
→ **B**

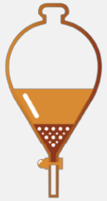


3D-printed adsorption modules
→ **B, In, V, Mo, Sc**



Ionic liquid solvent Extraction
→ **In**

Binary extractant solvent extraction
→ **Mg**



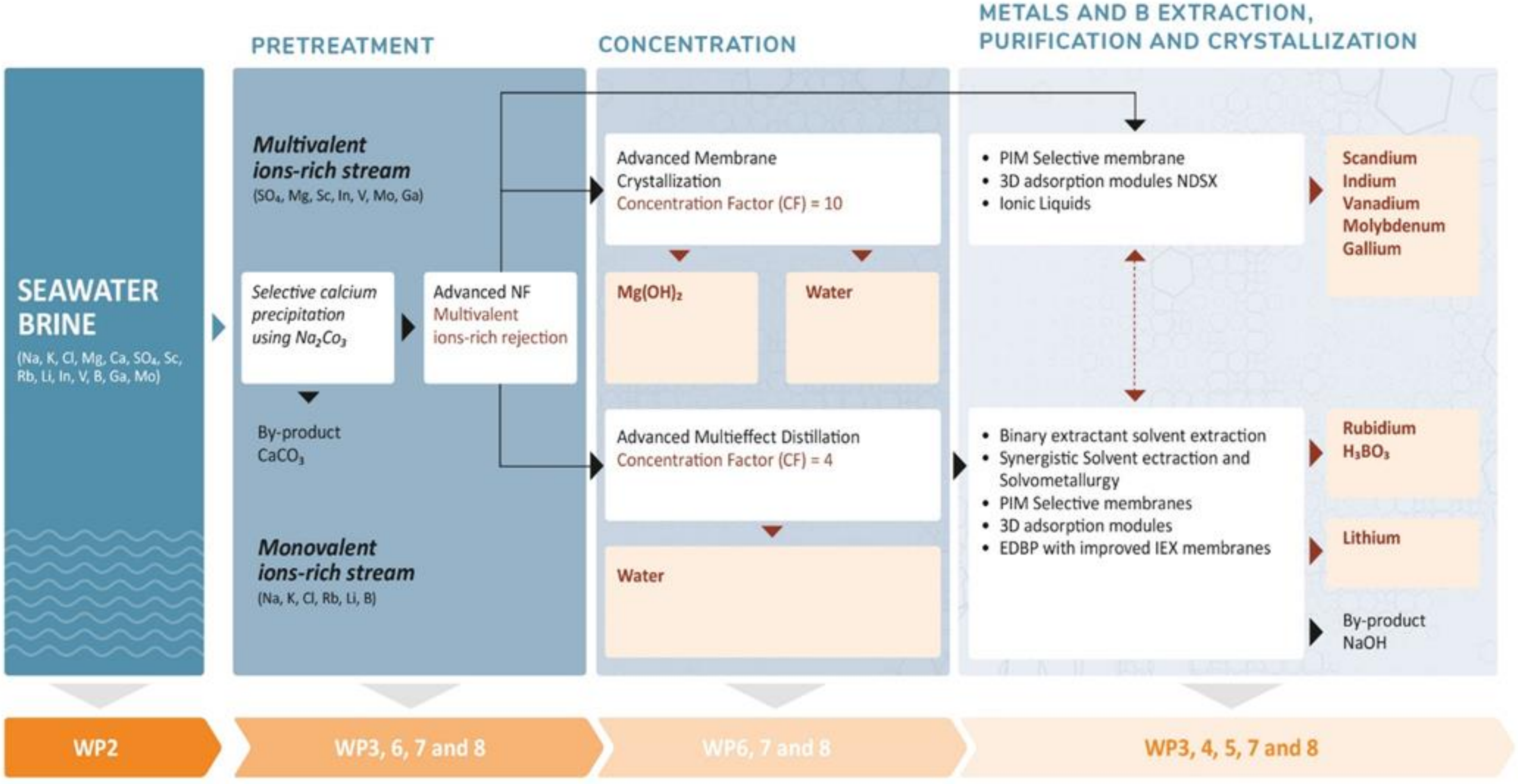
Synergic solvent extraction combined with Solvometallurgy
→ **Li**

Non-Dispersive solvent extraction
→ **In, V, Mo**

This project has received funding from the European Union's Horizon 2020 research and innovation programme

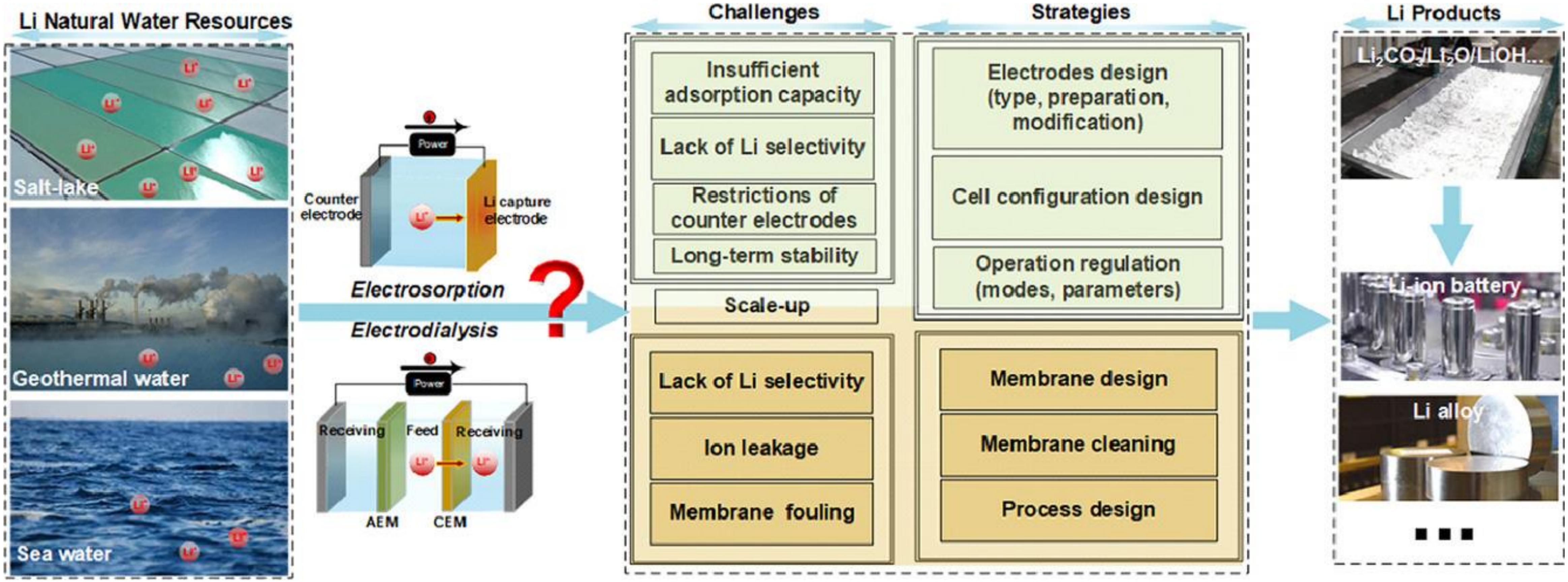
Sources: https://sea4value.eu/

SEA4VALUE: Multi-Mineral Brine Mining Process



(Source: https://www.chemistryviews.org/)

Lithium Recovery Using Electrochemical Technologies: Advances and Challenges

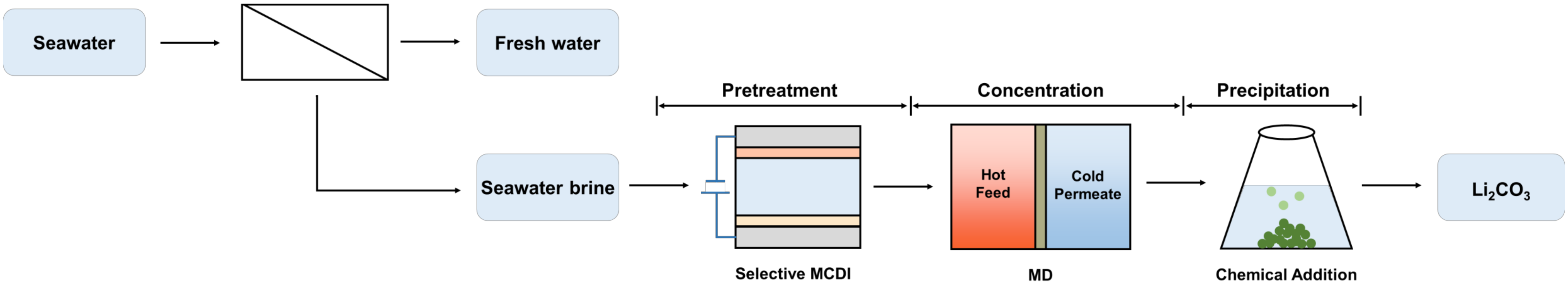


(Water Research, 21, 118822, 2022)

Novel Membrane-Based Process to Selectively Capture Li

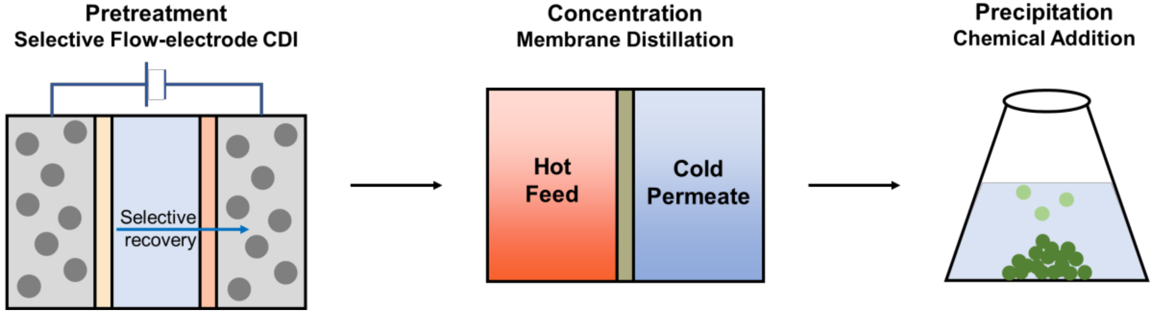
Advanced resource recovery system

- Selective membrane capacitive deionization (MCDI)
  - Pretreatment: selective separation between Li^+ and Ca^{2+}/Mg^{2+}
- Membrane distillation (MD)
  - Concentration: lithium concentrate (X 10 times)
- Chemical precipitation
  - Li-product: transform lithium concentrate into lithium compounds (Li_2CO_3)



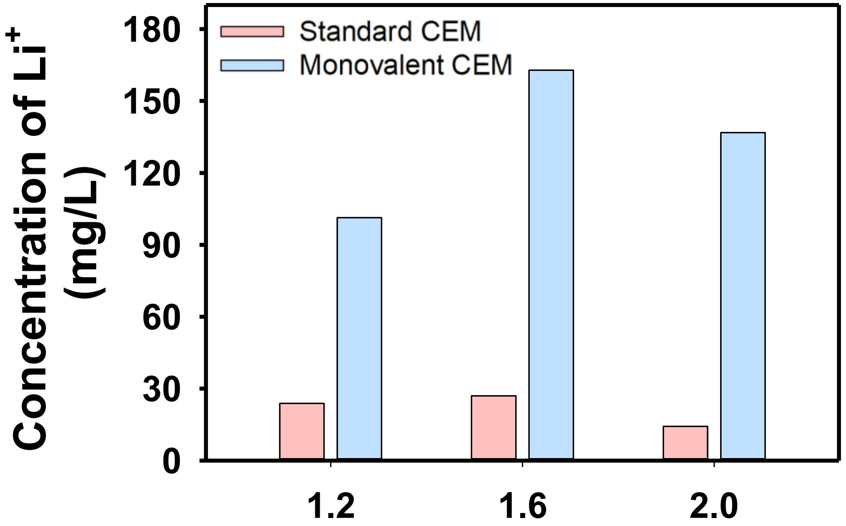
Selective Flow-electrode CDI for Lithium Recovery

☐ Lithium recovery from leachate of lithium-ion battery (LIB)



☐ Operational conditions

- Mode: Batch (100 mL)
- Monovalent-selective cation exchange membrane
- Solution: leachate of LIB (3.2 g/L Li^{+}, 7.9 g/L Co^{2+}, 7.5 g/L Ni^{2+}, 7.6 g/L Mn^{2+})
- Charging time: 300 min
- Voltage: 1.2, 1.6, 2.0 V



Selective flow-electrode CDI can be promising candidate for lithium recovery.

6th International Conference on Battery Deionization & Electrochemical Separation (BDI&E)

July 2 - 5, Taipei

NSTC 國家科學及技術委員會 National Science and Technology Council

經濟部水利署 Water Resources Agency, MOEA

內政部營建署 Construction and Planning Agency Ministry of the Interior

行政院環境保護署 Environmental Protection Administration Executive Yuan, R.O.C.(Taiwan)

國立臺灣大學 National Taiwan University

Thank you for your attention.

Environmental Aspects of Desalination – IDE's Considerations and Solutions

October 13, 2022

IDE Technologies Your Water Partners

台灣國際水週 Taiwan International Water Week

YOUR WATER CHALLENGES ARE OUR WATER CHALLENGES.

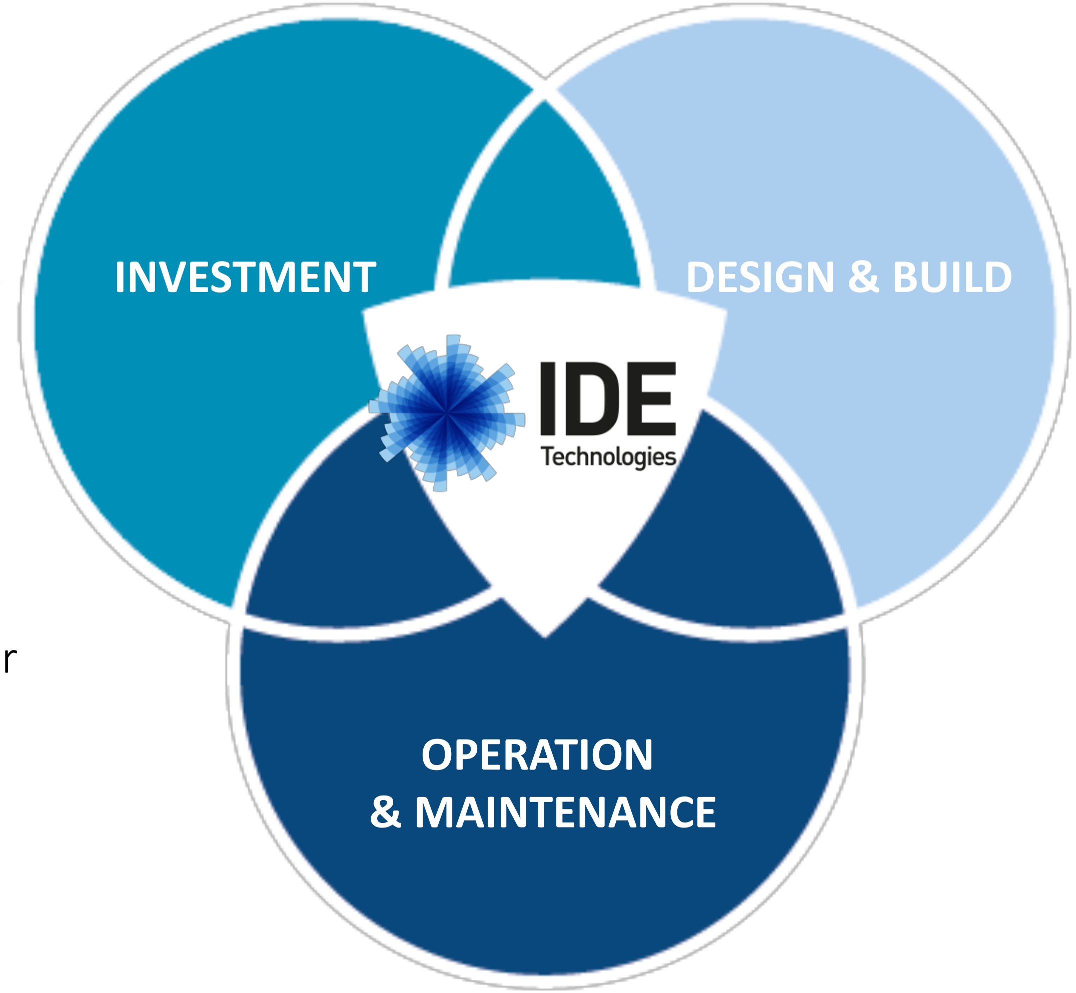
Let's solve them together.

Some water companies provide D&B. Others O&M. Investors manage the asset. This leads to competing agendas.

IDE provides the complete solution.

Sharing the risk AND responsibility in our water projects, from start to end is our philosophy.

Alignment of interest that provide comfort to our stakeholders That's true partnership.



TURNING THE DREAM INTO A REALITY

Our story begins in the young state of Israel, almost 60 years ago

Turning the desert into a lush land using desalination was the vision that dreamers such as Ben Gurion strove to realize

The Israeli desalination story intertwines with the birth of a new nation. It brings together forward thinking, state-of-the-art technology and a determined refusal to surrender to adversity

This turned Israel from a semi-arid country with scarce water resources into a flourishing, water-resilient nation, where 70% of potable water originates from desalination

Necessity and Ingenuity are the very foundations on which IDE Technologies was established

DELIVERING WATER SOLUTIONS FOR OVER 50 YEARS

Some of our flagship projects:

ASHKELON, ISRAEL

396 ML/Day

Winner of GWI's 2006 "Desalination Plant of The Year" award.

Successfully operating since 2005

RELIANCE, JAMNAGAR, INDIA

MED & SWRO **400 ML/Day**

One of the largest MED sites in the world, continuous successful operation for over 20 years

TIANJIN, CHINA

200 ML/Day

China's largest MED desalination facility

CARLSBAD, CALIFORNIA, US

204 ML/Day

Largest desalination plant in the western hemisphere, winner of GWI's 2013 "Desalination Deal of the Year" award

AND IN 40+ COUNTRIES

USA
Total Capacity
225,000 m^3/day

ISRAEL
Total Capacity
1,600,000 m^3/day

ITALY
Total Capacity
27,000 m^3/day

SPAIN
Total Capacity
78,000 m^3/day

LATIN AMERICA
Total Capacity
142,000 m^3/day

AUSTRALIA
Total Capacity
150,000 m^3/day

INDIA
Total Capacity
583,000 m^3/day

CYPRUS
Total Capacity
125,000 m^3/day

CHINA
Total Capacity
200,000 m^3/day

CENTRAL ASIA
Total Capacity
260,000 m^3/day

TRADITION OF EXCELLENCE

DESALINATION COMPANY OF THE YEAR 2022

GWI 2018
Desalination
Plant of the Year
(Carlsbad, USA)

GWI Global Water Summit 2019
Desalination
Plant of the Year
(Distinction)

GWI Global Water Summit 2020
Wastewater
Project of the Year
(Distinction)

GWI 2021
Desalination
Company of the Year

Fortune 2016
Companies that
Changed the
World Award

GWI Global Water Summit 2018
Desal R&D Olympics
Gold Medal

World Technology Award 2018
(Environmental)

THE ISRAELI DESALINATION REVOLUTION – FROM DEPENDENT TO INDEPENDENT IN A DECADE

Sorek B
(150M m³/y)

UNDER CONSTRUCTION by IDE

Hadera (127M m³/y)
since 12/2009, **by IDE**

Sorek A (150M m³/y)
since 8/2013, **by IDE**

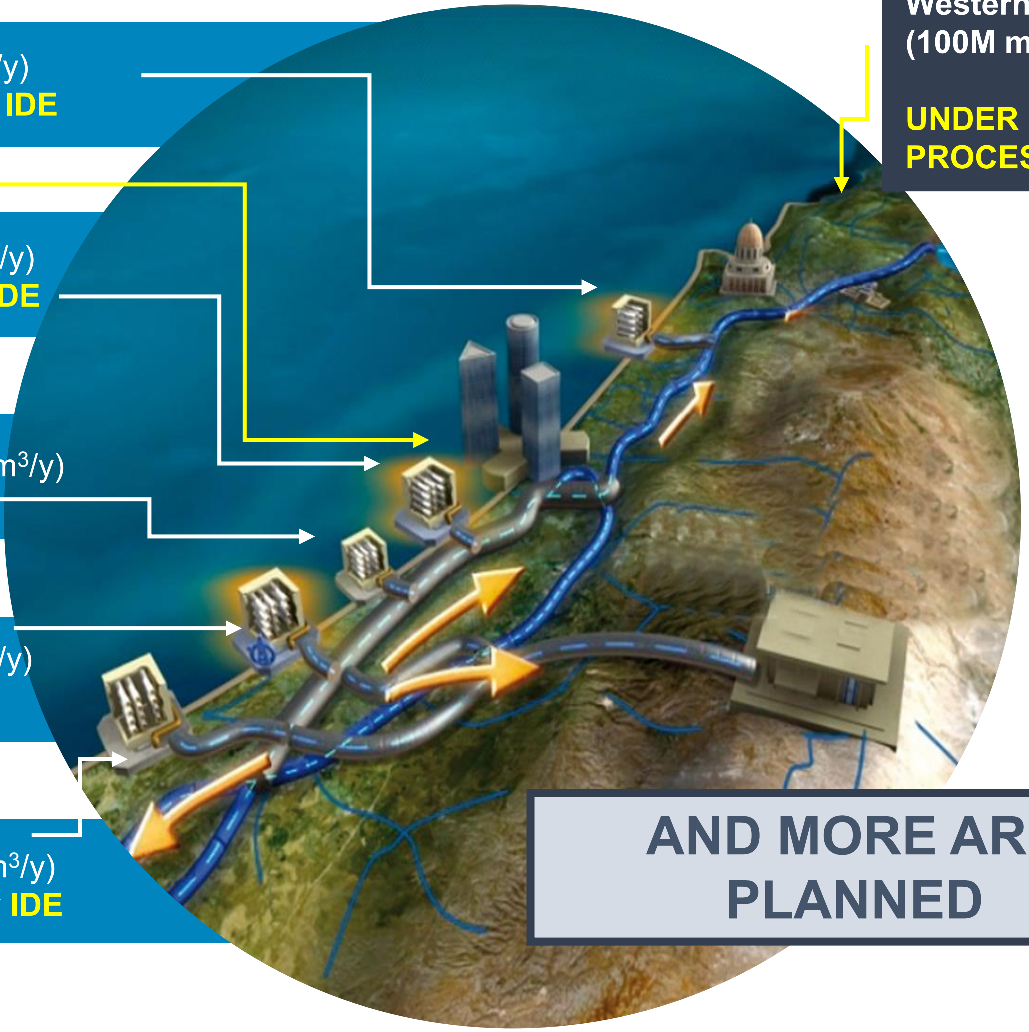
Palmachim (90M m³/y)
Since 6/2007

Ashdod (100M m³/y)
Since 12/2015

Ashkelon (120M m³/y)
Since 12/2005, **by IDE**

Western Galilee
(100M m³/y)

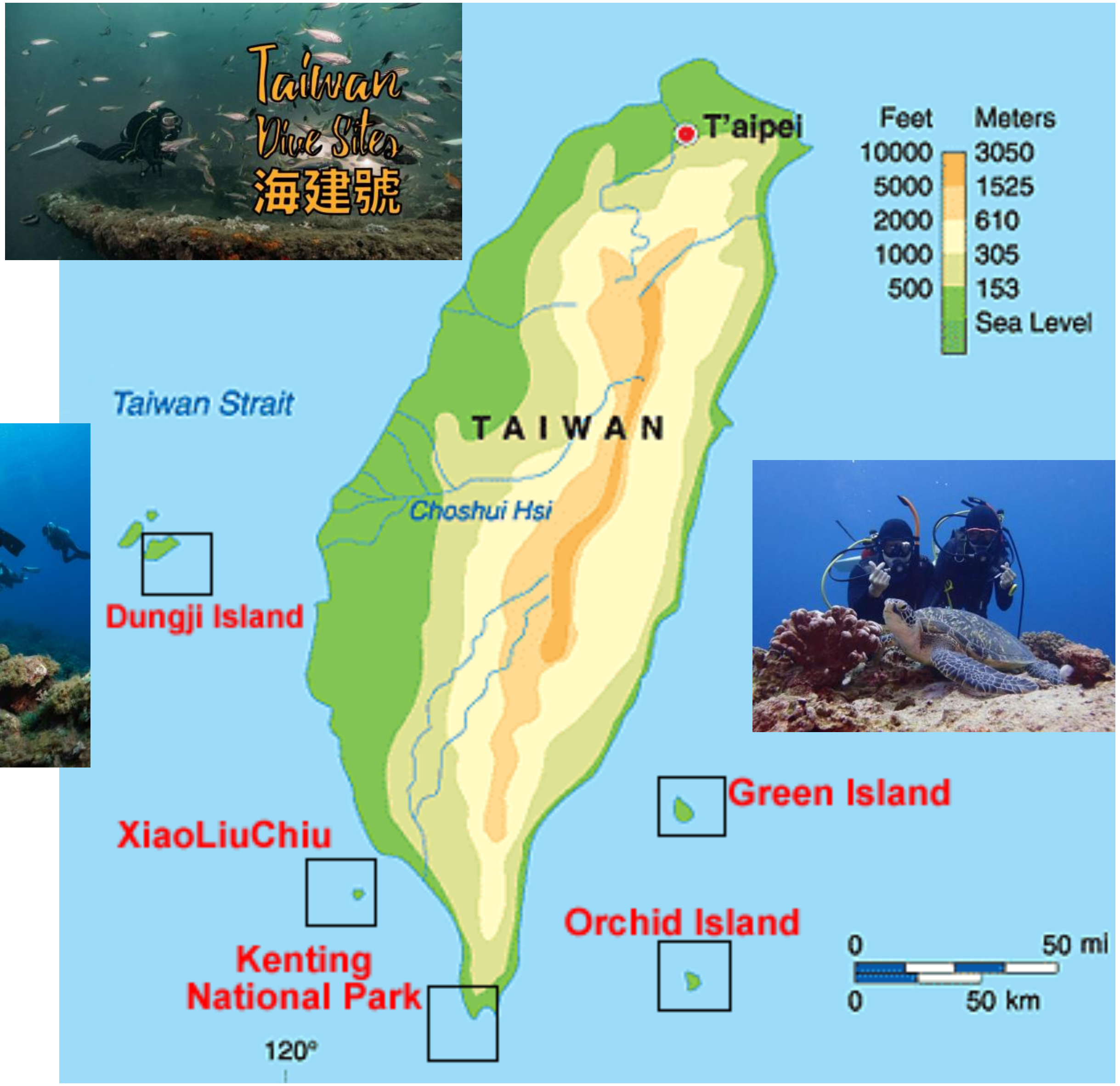
UNDER BIDDING PROCESS



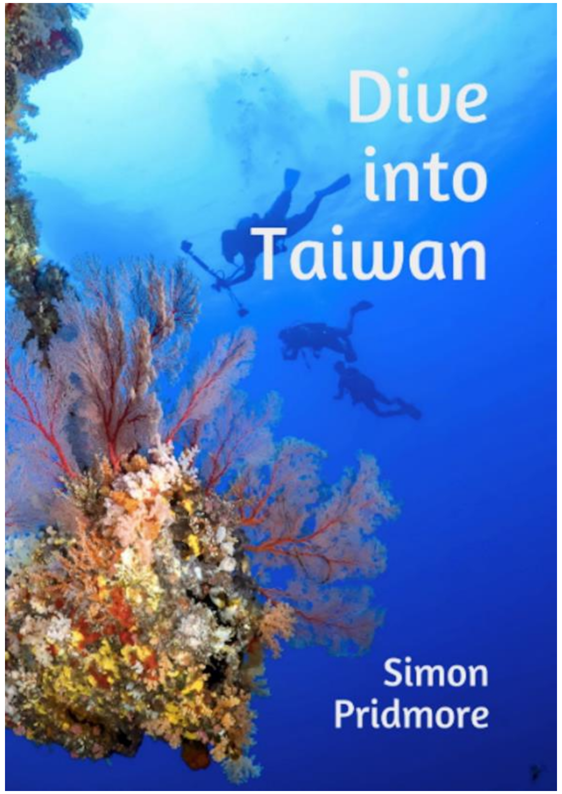
From Zero to
590M m^3/y
in a decade

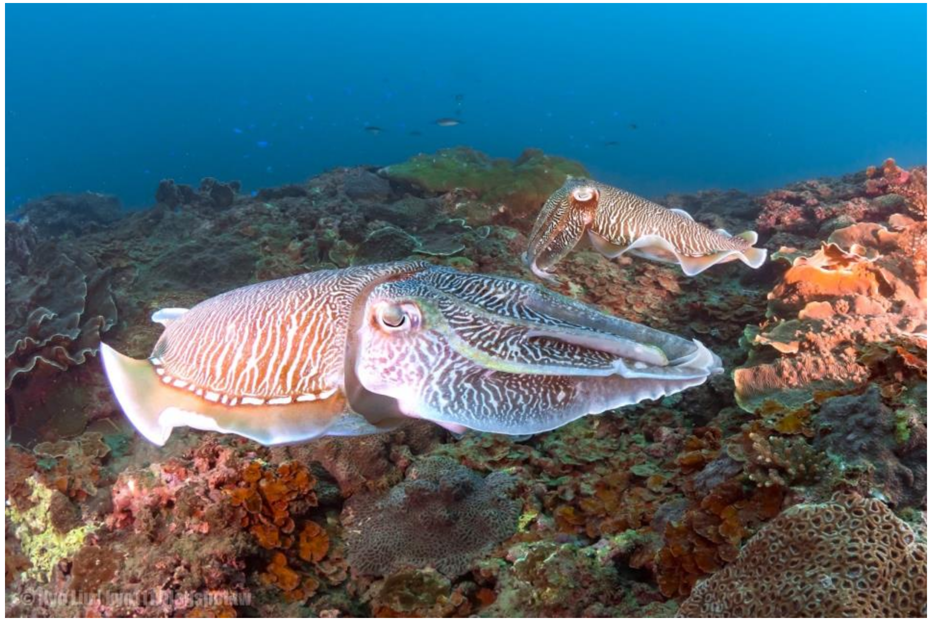
AND MORE ARE PLANNED

THE COASTAL ECOLOGY OF TAIWAN



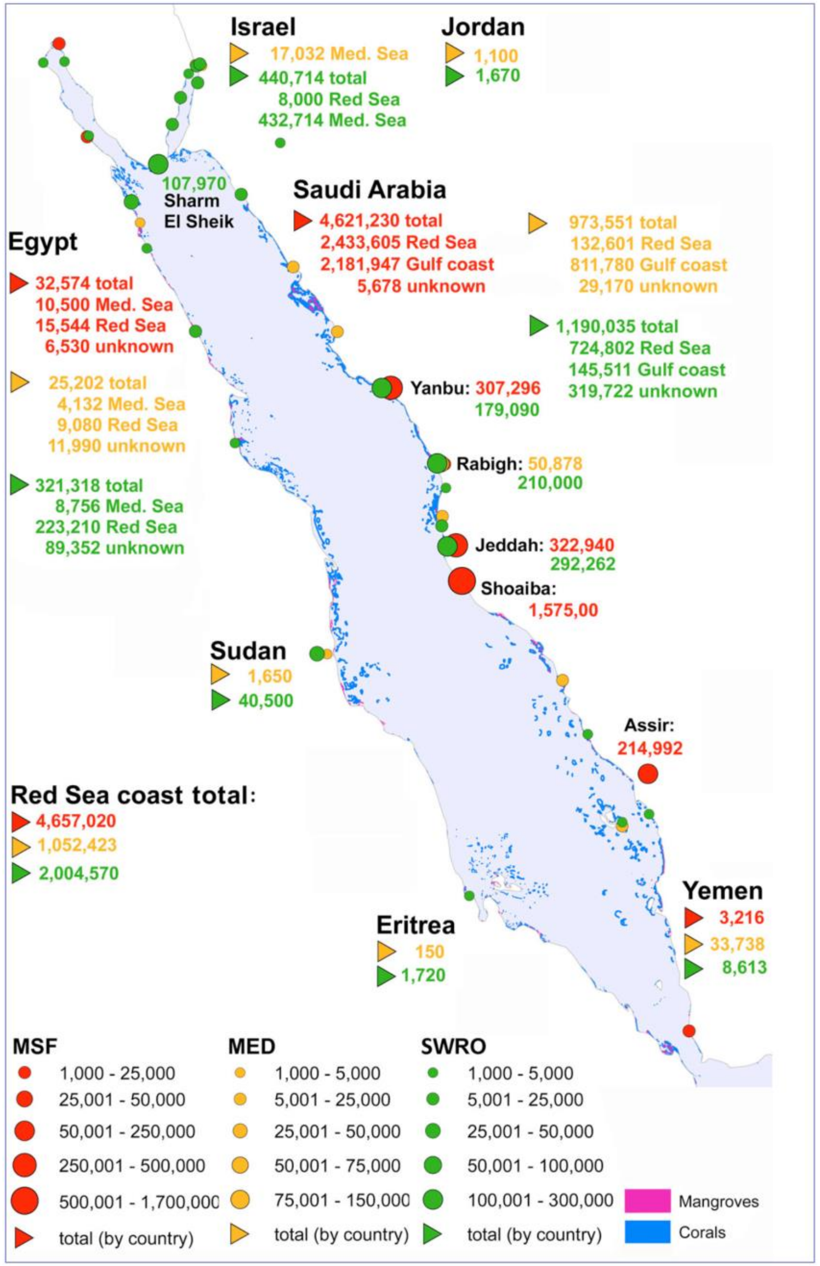
THE COASTAL ECOLOGY OF TAIWAN





SIMILARITY TO THE RED SEA CORAL REEFS

RED SEA MASSIVE DESALINATION PROGRAM



- The Red Sea is a very eco-sensitive marine environment, and the Coral Reef is ecologically fragile
- Yet, due to the need for freshwater, a massive desalination program is being in place, with a yearly production of 4,000,000 m^3
- Environmental aspects are an integrated part of the desalination plants design
- So, both exist side by side without interfering with each other

SO ENVIRONMENTAL ASPECTS ARE AN INTEGRATED PART OF THE DESIGN

- Preliminary environmental Survey (at the bid or development stage)
  - Looking forward to the construction and operation stages
- Potential impacts on the terrestrial environment (not to be elaborated at this presentation)
  - Including minimizing usage of chemicals and energy consumption
- Potential impacts on the **marine** environment form Intake & outfall
  - Intake system -
    - Piping, suction heads, screening system
  - Outfall system –
    - Piping, concentrate outfall RO Brine, diffusers

Environmentally and responsible desalination demonstrates the legitimacy of seawater as an alternative water source that can co-exist in harmony with the environment

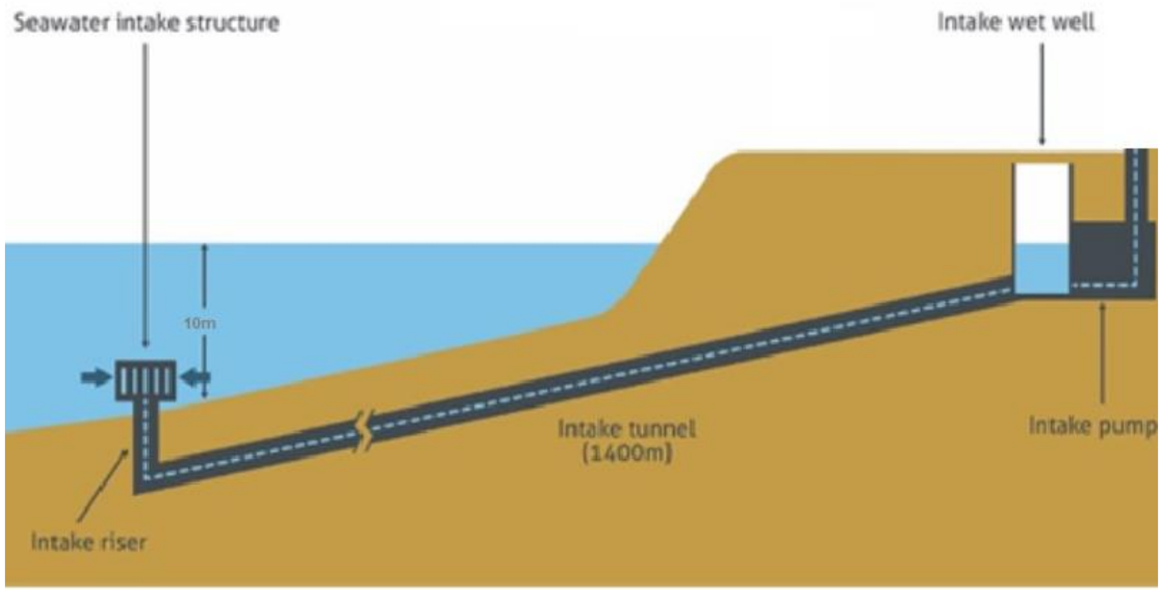
Near Shore Discharge - Hadera Desalination Plant

ENVIRONMENTAL ASPECTS – PIPEJACKING

Illustration of the Pipe-Jacking Method

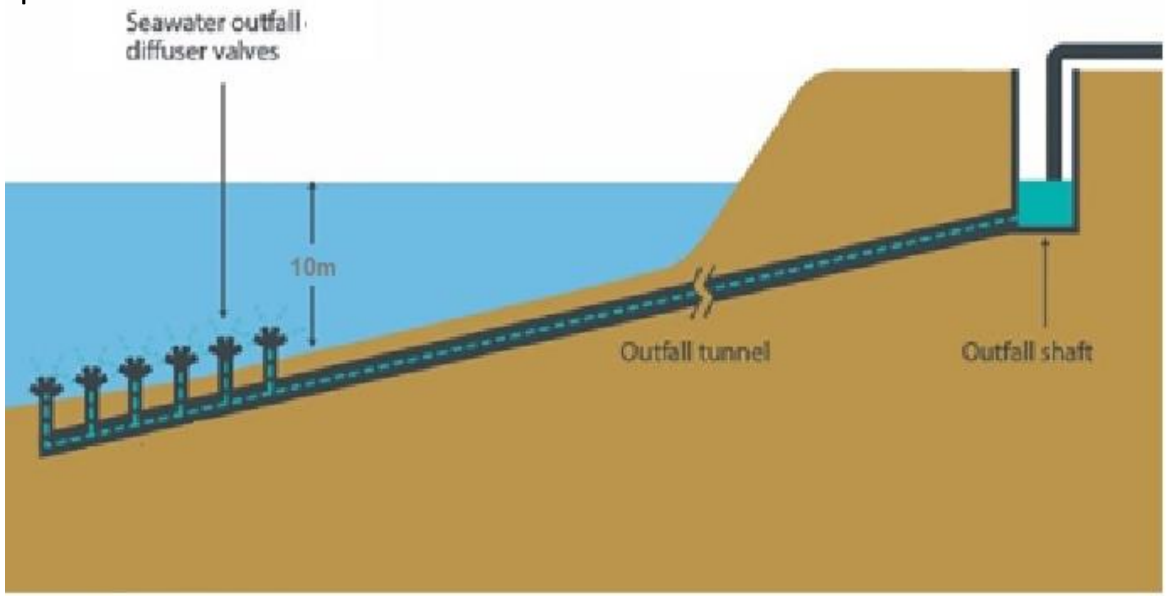
ENVIRONMENTAL ASPECTS – INTAKE SYSTEM

- Intake System with **zero impact** on seabed and marine life -
  - To be located in the proper water depth (~10m below sea level and above seabed)
  - No pumps in the sea
  - Water coming in by communicating vessels mechanism or gravitation
  - Low velocity water at intake head to avoid entrapment of even the smallest marine species
  - Pipejacking to avoid impact on the seabed



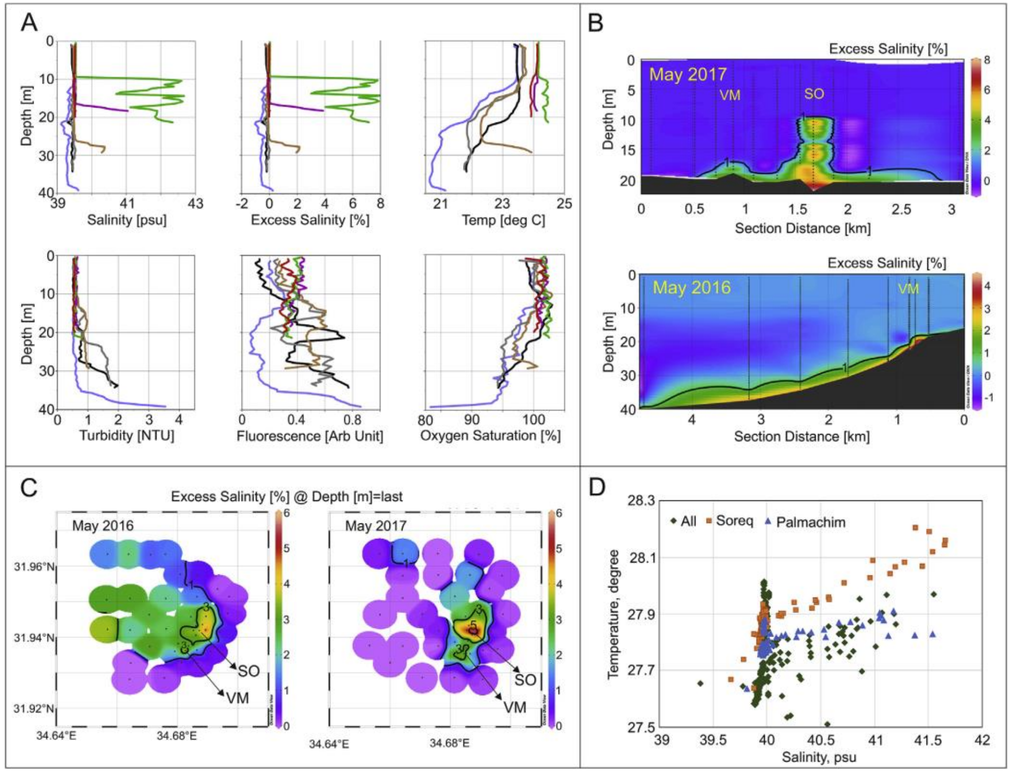
ENVIRONMENTAL ASPECTS – OUTFALL SYSTEM

- Outfall System
  - Properly modeled, designed and strategically located **outfall system with zero impact on seabed and marine life** will effectively mitigate discharge concerns and minimize potential impact
  - Design according to the local specific marine currents, high and lows etc.
  - **Outfall diffuser system** designed to enhance initial dilution of concentrate
  - Solid waste is separated, disposed off and is **not** returned to the sea



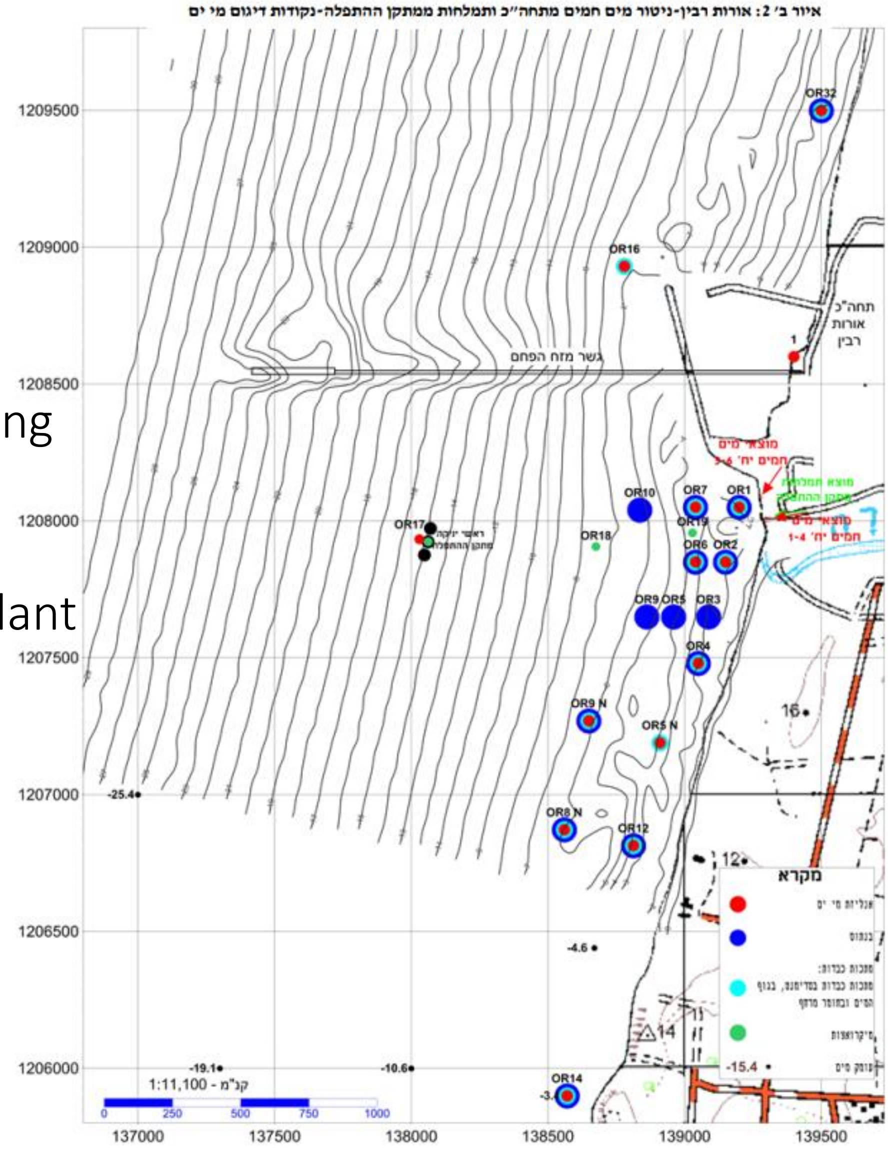
ENVIRONMENTAL ASPECTS – MONITORING

- Constant monitoring of dispersion analysis at specific locations by plant operators
- Daily, monthly and yearly reports to authorities
- Marine life and seabed constantly monitored



Depth profiles, depth sections, brine dispersion near the bottom and TS diagram - The Soreq and Palmachim outfalls

Marine Sampling Points for the Hadera Desalination Plant



ENVIRONMENTAL ASPECTS – MITIGATION SUMMARY

Potential Environmental Impact		Mitigation Measures
Impact	Source of Impact	
Alteration of the natural terrain (land area)	Earth and construction works	Pipe-jacking (tunnelling) for installation of onshore pipelines (seawater feed and brine)
		Measures for soil retention in plant area
Alteration of the seabed	Marine works	Pipe-jacking for installation of offshore pipelines (intake & outfall); precisely controlled dredging for installation of pipelines; covering of the pipelines and restoration of the original bathymetry
Sediment resuspension	Marine works	Minimal dredging activities; minimization of drifting and sweeping of dredger suction head by precise positioning control

ENVIRONMENTAL ASPECTS – MITIGATION SUMMARY

Potential Environmental Impact		Mitigation Measures
Impact	Source of Impact	
Marine habitat alteration and changes in sediment transport	Intake & outfall systems (piping)	Intake and outfall pipelines laid below the seabed
Entrainment and impingement of marine biota	Intake system (suction heads)	Intake heads designed for slow suction velocity
Accidental spillage or leakage of hazardous chemicals	Main plant (storage & handling of chemicals)	Safety measures for transportation, storage and handling of chemicals as prescribed in applicable legislation; placement of storage tanks for corrosive chemicals in secondary basins; chemical neutralization of any spill prior to disposal

DESALINATION PLANT SEAWATER INTAKE AND OUTFALL

Perth, Australia

ENVIRONMENTAL ASPECTS - DISCHARGE OF CONCENTRATE

ResearchGate

No detrimental effects of desalination waste on temperate fish assemblages

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ENVIRONMENTAL ASPECTS - DISCHARGE OF CONCENTRATE

No detrimental effects of desalination waste on temperate fish assemblages

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Water resources are becoming increasingly scarce due to population growth and global changes in weather patterns. Desalination plants that extract freshwater from brackish or seawater are already being used worldwide, with many new plants being developed and built. The waste product from the extraction processes has an elevated salt concentration and can potentially cause substantial impacts to local marine flora and fauna. The present study assesses the impact of saline waste from a 100 GL/year desalination plant on southern Australian temperate fish assemblages, using baited remote underwater video. The study compared four reference sites to the impact site (desalination outfall) and found no evidence that the saline waste was having a detrimental effect on fish assemblages in proximity to the outfall, with species diversity and abundance comparable to those observed at reference sites. However, species diversity and abundance varied across geographical location, protection from fishing pressure, and reef type. Our study is one of the few assessing the ecological impacts of saline waste discharged from a large desalination plant and shows no decrease in fish diversity or abundance, which is the response typically associated with the negative impacts of anthropogenic activities on fish assemblages.

Keywords: baited video, BRUVS, desalination, fish communities, impact assessment, marine protected areas

ENVIRONMENTAL ASPECTS - DISCHARGE OF CONCENTRATE

thermal distillation. The concentrated saline waste that results from these processes is then typically released back into the

details in the methods and/or experimental design rigour (Roberts et al., 2010). Advances in technology have, however,

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Discussion

Our study shows that the artificial habitat and protection provided by the ADP outfall were the only factors influencing fish assemblages, while the discharged saline waste did not negatively affect fish communities. Fish assemblages associated with the ADP showed no reduction in species richness or abundance despite the discharge of saline waste. The ADP site also had the strongest similarity to other artificial sites (NTR and GTR), thus rejecting our hypothesis that the desalination plant has a greater impact on fish assemblage than seasonal changes, structural changes, or localised fishing pressures.

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2018). Past issues with elevated water temperatures around the outfall and the use of toxic chemicals in treatment process have

d outfall area. While it
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with an artificial struc-
ture, at similar size, and depth, this could not be found in Gulf St Vincent.

ENVIRONMENTAL ASPECTS - DISCHARGE OF CONCENTRATE

World-first major desalination field study finds minimal marine impact

20 SEP 2018 | STUART SNELL

Highly saline flows from the Sydney Desalination Plant will not affect surrounding marine life as commonly believed, a major new study led by UNSW Sydney shows.

The research focused on six ocean sites near the desalination plant.

ENVIRONMENTAL ASPECTS - DISCHARGE OF CONCENTRATE

California's Environmental reports

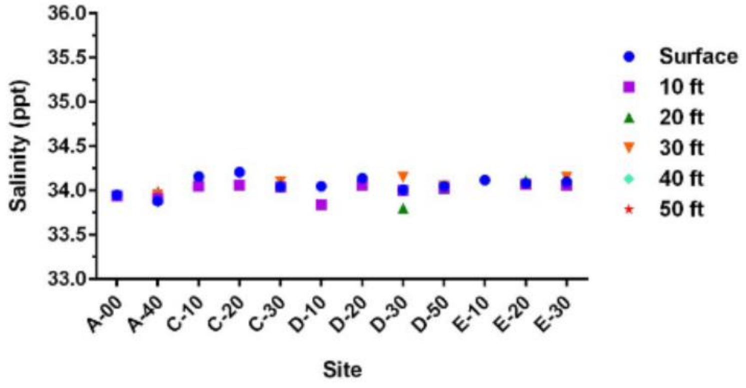


Figure 4. Salinity Depth Profiles

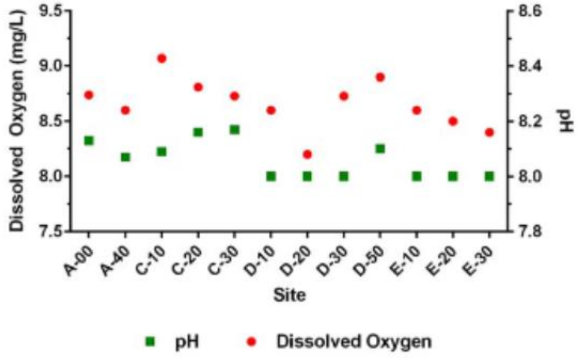


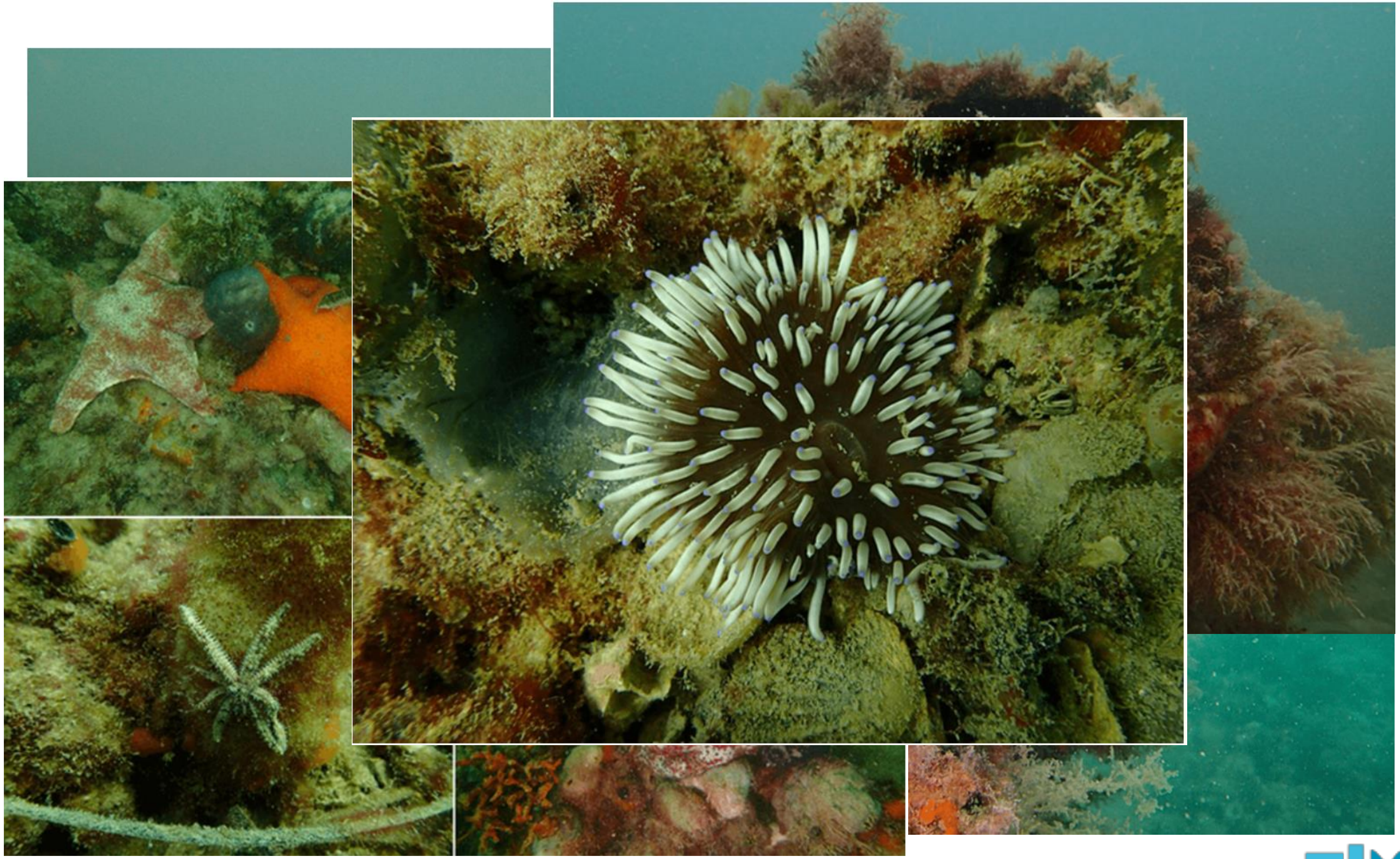
Figure 3. Surface Measurements of pH and Dissolved Oxygen

Offshore Water Quality Monitoring the IDE/Poseidon Desalination Plant in Carlsbad, CA. January 28, 2018

Ocean Receiving Water Monitoring Report for the IDE/Poseidon Desalinization Facility in Carlsbad, CA
January 28, 2018 Monitoring Event

ENVIRONMENTAL ASPECTS - DISCHARGE OF CONCENTRATE

Pictures from marine habitat around brine diffusers in Australia



DESALINATION PLANT BRINE DIFFUSERS

Adelaide , Australia

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