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PRO and SWRO experimental synergy: a renewable nexus in the Caribbean

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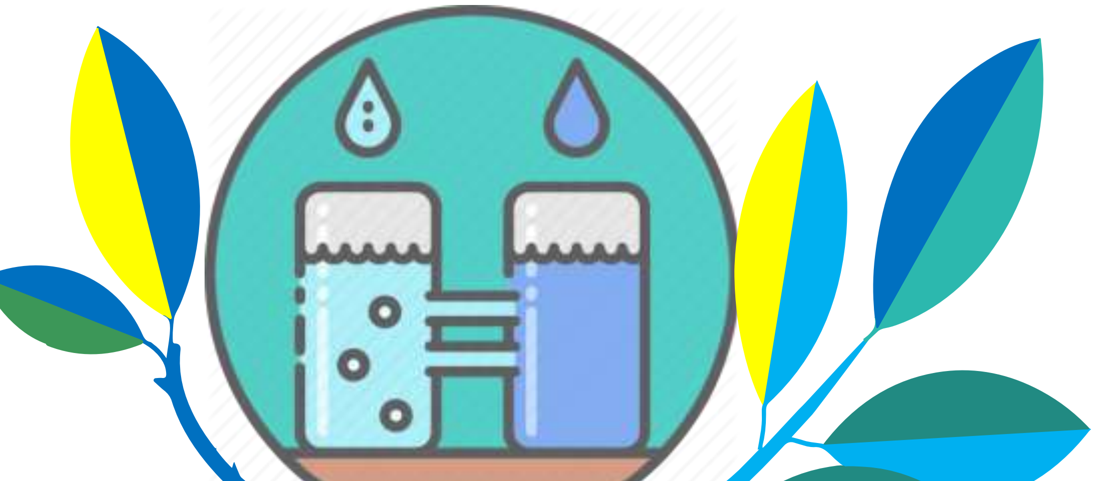
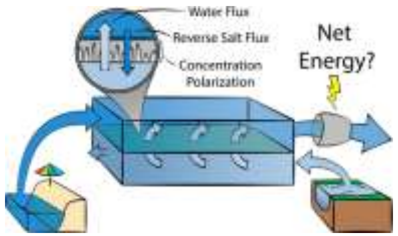
Barranquilla, Colombia – Jan 22, 2024



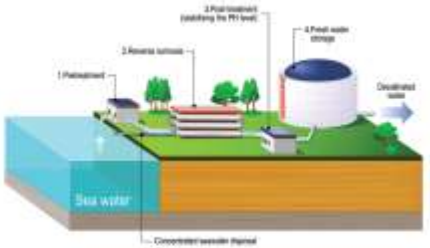
Introduction

Harvesting renewable energy and providing a second water alternative: a bridge between water desalination and electricity generation in the Caribbean blue revolution.

How?



Pressure Retarded Osmosis (PRO)
Magdalena River



Reverse Osmosis (RO)
Caribbean Sea

- Evaluate the potential of the area.
- Characterize waters.
- Adapt waters for operation (pretreatment).
- Exploration of technology configurations.
- Analyze and choose the configuration with the most significant synergistic benefits.

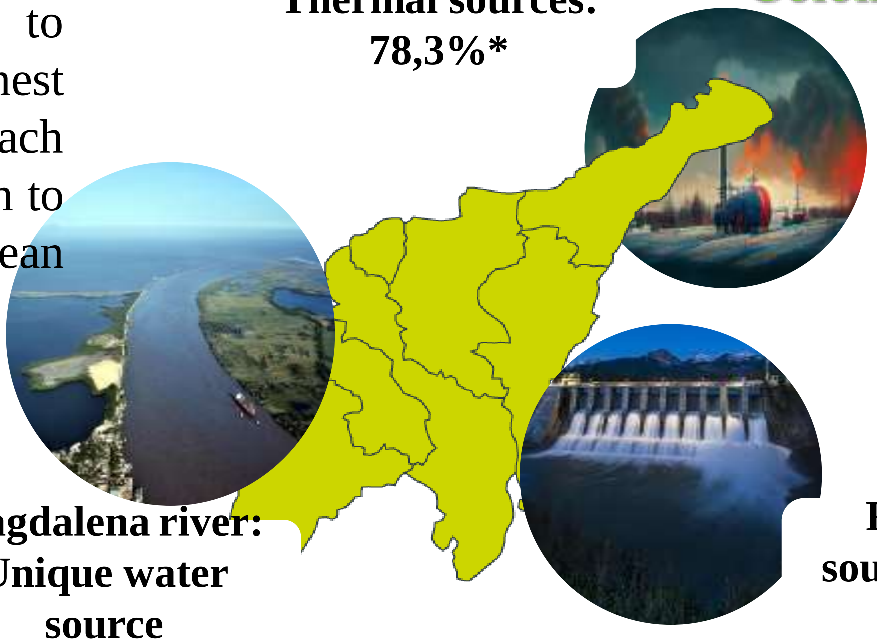
Specific capacity: 780 MW

Significant contribution to the region

Evaluate beyond conventional approaches by meticulously examining water quality along with energy production in RO-PRO hybrid systems. We unlock the potential not only to generate sustainable energy, but also to ensure the highest standards in produced water quality. This dual approach differentiates our research, offering a comprehensive solution to the water and energy challenges in the Colombian Caribbean region.

Colombia's Caribbean Region

Thermal sources: 78,3%*

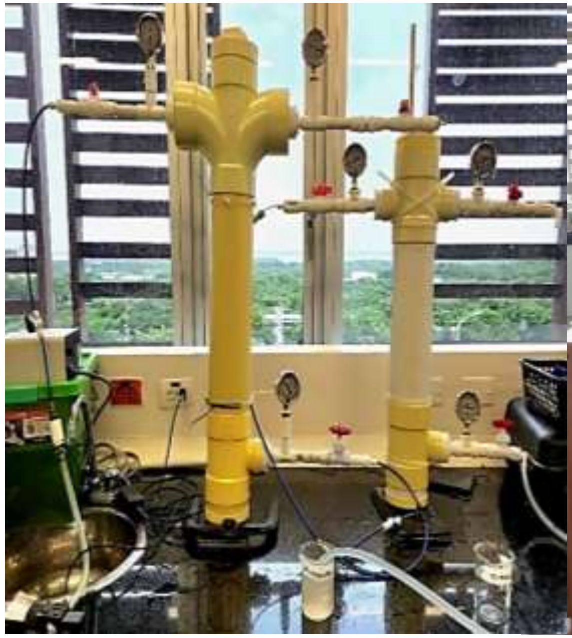


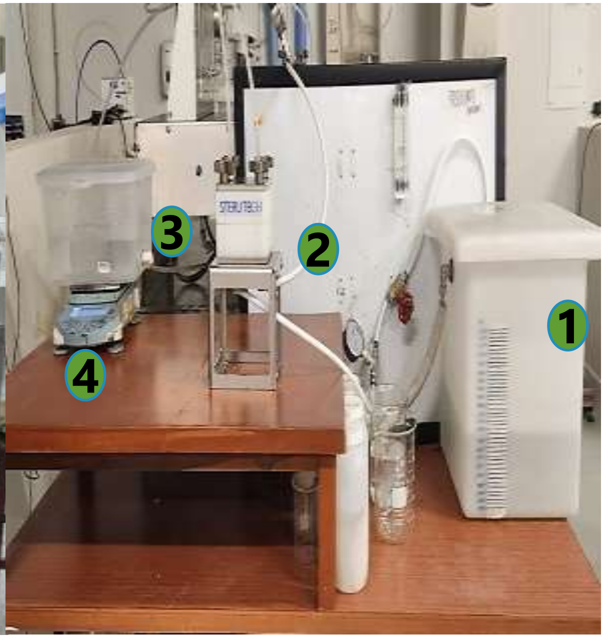
Magdalena river: Unique water source

Renewable sources:21,7%*

* According to the National Development Plan 2018-2022 report.

Experimental Runs



Pretreatment
First stage: Conventional multimedia filtration
Type: Fractional factorial
Runs: 60
Second stage: Ultrafiltration
Type: Factorial 2^3
Runs: 32
OBJECTIVE: Turbidity, TOC, and SDI.

Coupled process
Type: Fractional 2X3
Runs: 36
OBJECTIVE: Power density and conductivity.

DoE

10 STAGES → Pretreatment / Coupled process

- ✓ Bibliographic review and collection
- ✓ Water sampling and characterization
- ✓ Conceptual design and experimental setup
- ✓ Execution and analysis of configurations
- ✓ Energy measurement
- ✓ Configuration selection

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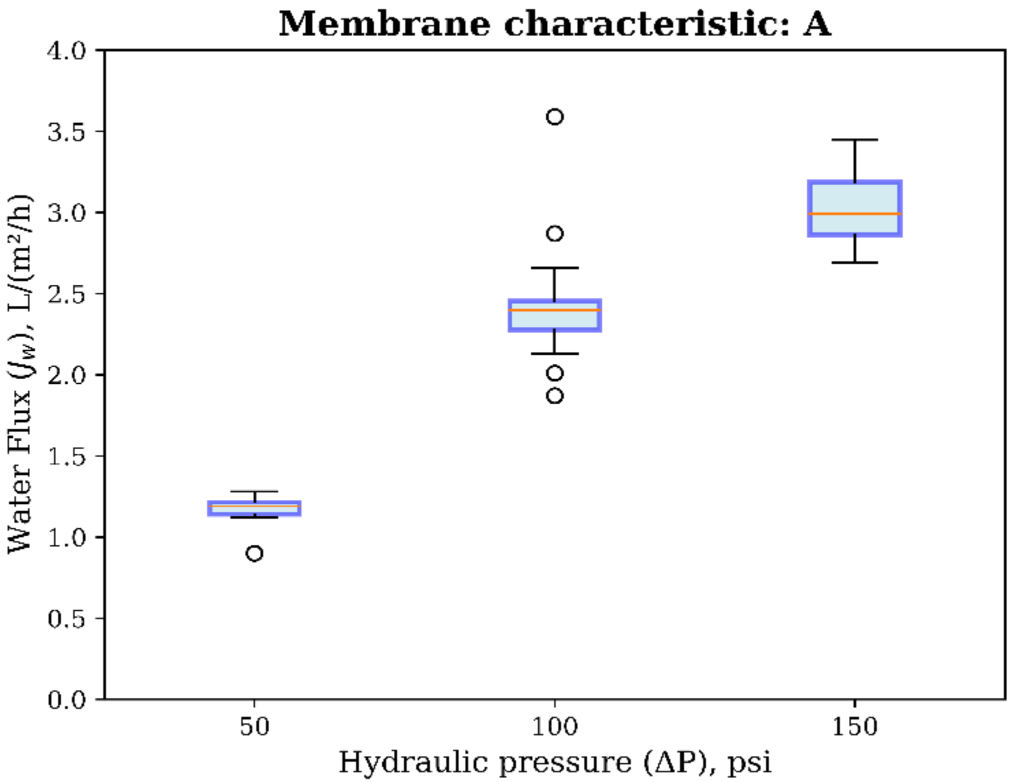
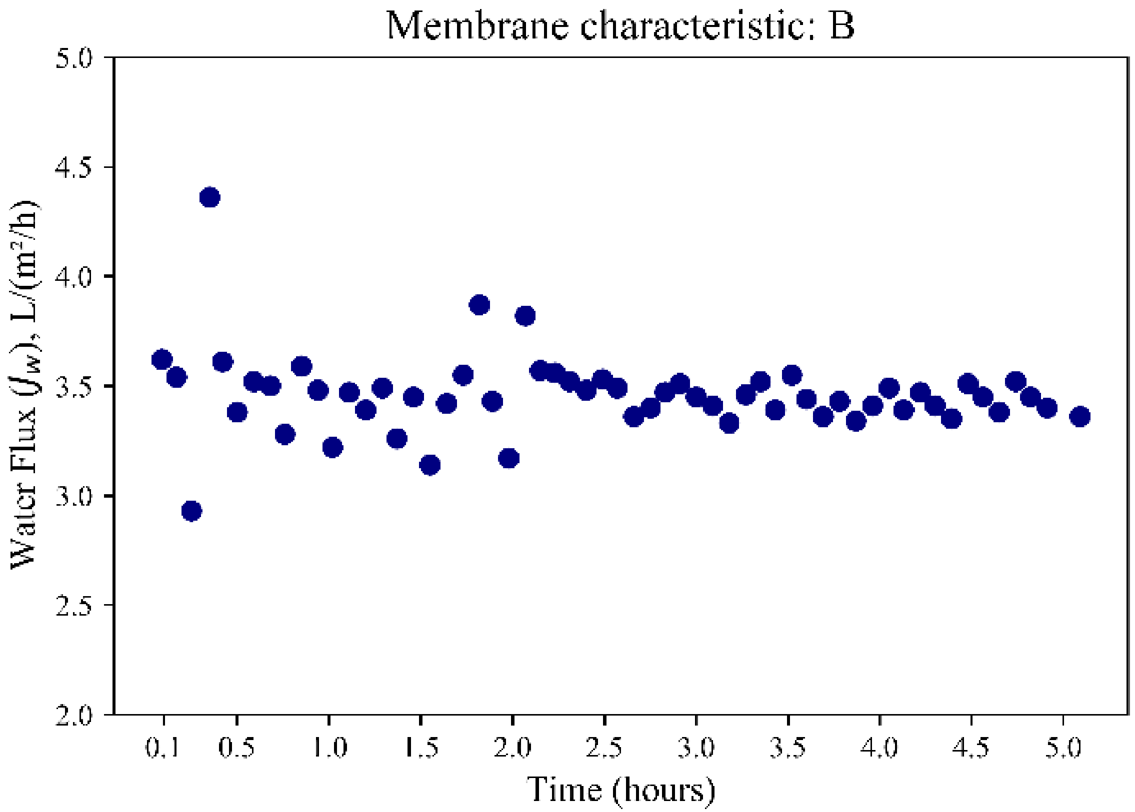
Experimental Runs

PRO: Membrane characteristic





A= 5,86799x10^{-9}

B =6.13474x10^{-8} m/s

k = 9.17 x10^{-4} m/s

D = 1.51x10^{-9} m^2/s

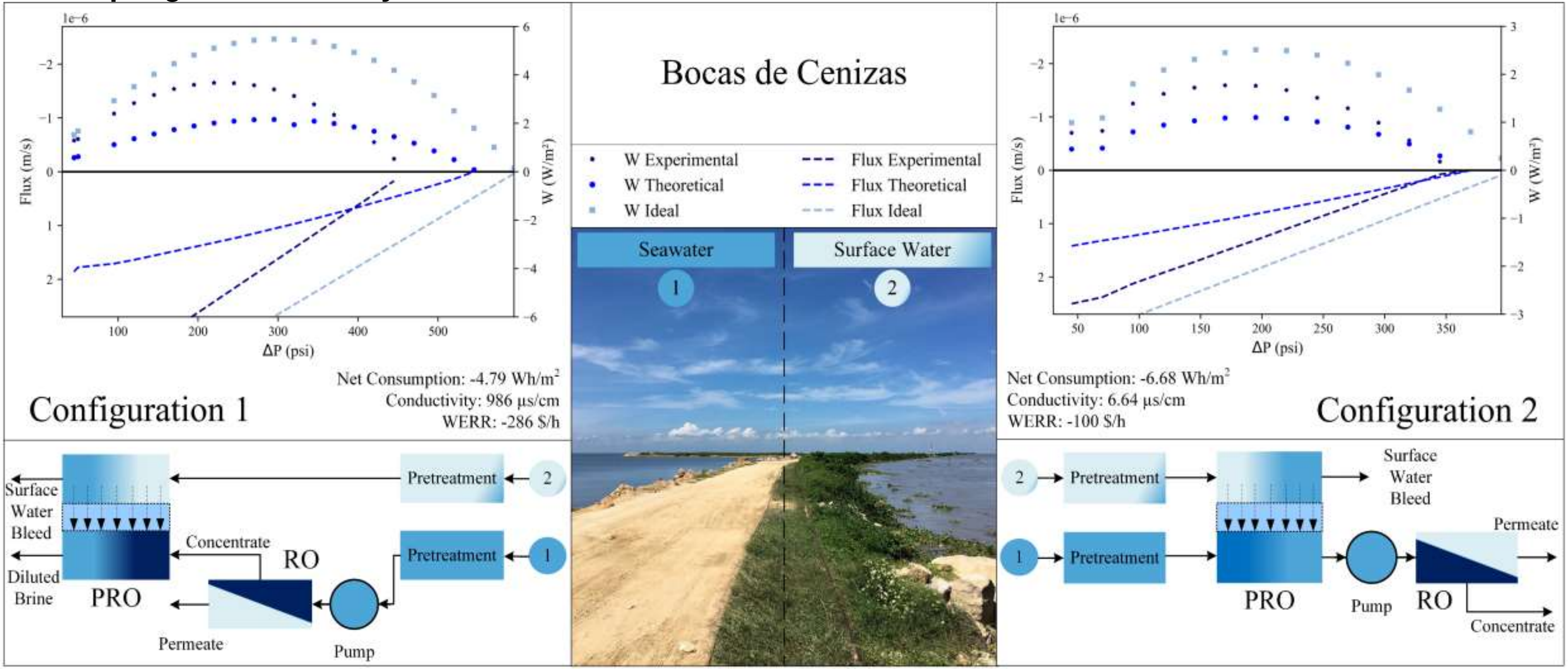
tτ/ε = 2.32 x10^{-3}

K =1.54 x10^{6} s/m

A: Water permeability coefficient
B: Salt permeability
k: Mass transport coefficient
K= *R*esistivity
tτ/ε: The thickness, tortuosity, and porosity
D: Diffusion coefficient

Results

1. Coupling Process Analysis



Results

2. Coupling Process Analysis

Technical PRO component

An indicator prioritizing higher net energy consumption in PRO compared to conductivity in produced water.

Water quality components produced at RO

Penalizes conductivity above 1000 µs/cm in produced water, the drinking water limit (Res. 2115, 2007 – COL).

Synergic Coupling Component

is measured by WERR, representing the commercial value conversion of water from RO and energy from PRO.

Configurations		**Technical Component**		**Water Quality Component**		**Synergic Component**		**Total**
		Net Consumption	Score	Conductivity	Score	WERR	Score	Score
No.	Description	Wh/m^2	0.3333	µs/cm	0.3333	$/h	0.3333	1
1	RO in the first stage + PRO in the second stage	-4.79	1.20	986	7.72	-286	1.12	3.43
2	PRO in the first stage + RO in the second stage	-6.68	0.50	6.64	9.97	-100	3.45	4.67

Key Findings

1.Effective Pretreatment: Achieved up to 99.63% reduction in turbidity, 91.00% in TOC for river and seawater and SDI<5.

2.FTSH₂O Membrane: Vital coefficients obtained, including linear water flux increase.

3.Statistical Analysis: Highly significant impact on power density ($R^2 = 0.955$), with ΔP (psi) and C extraction (mg/L) influencing the response.

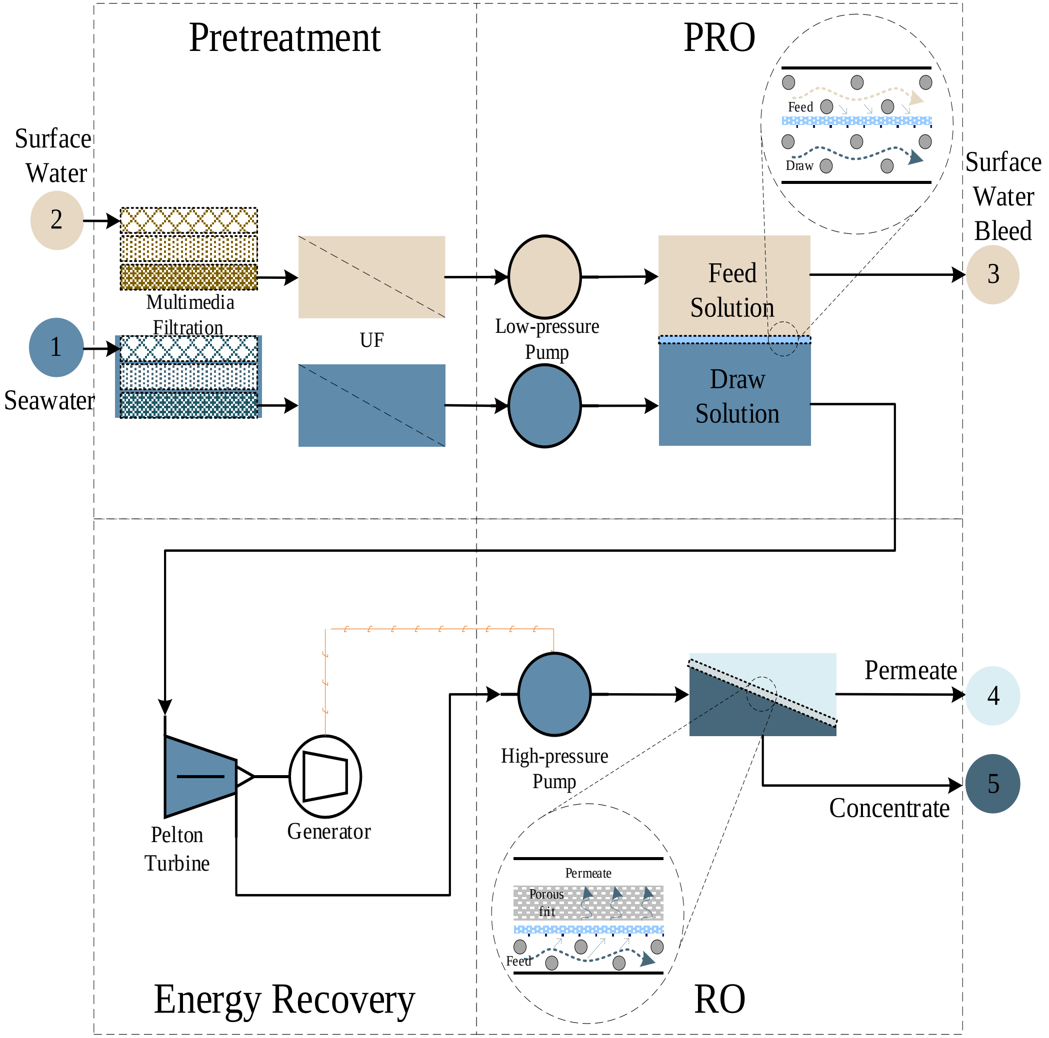
4.Experimental vs. Theoretical: Notable experimental outperformance, Configuration 1 achieving 3.66 W/m², Configuration 2 showing potential with 1.77 W/m².

5.Comparative Analysis: Configuration 2 is preferred due to lower conductivity, meeting water quality standards, and notable synergistic benefits.

6.Contextual Considerations: Caution in generalizing findings.

7.Gateway for Sustainable Processes: Encourages exploration of alternative couplings. Ongoing efforts focus on enhancing energy efficiency and analyzing larger-scale modules.

Configuration 2



Thanks

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