



DESOLINATION

**An innovative desalination concept
coupling concentrated solar for GCC
countries**

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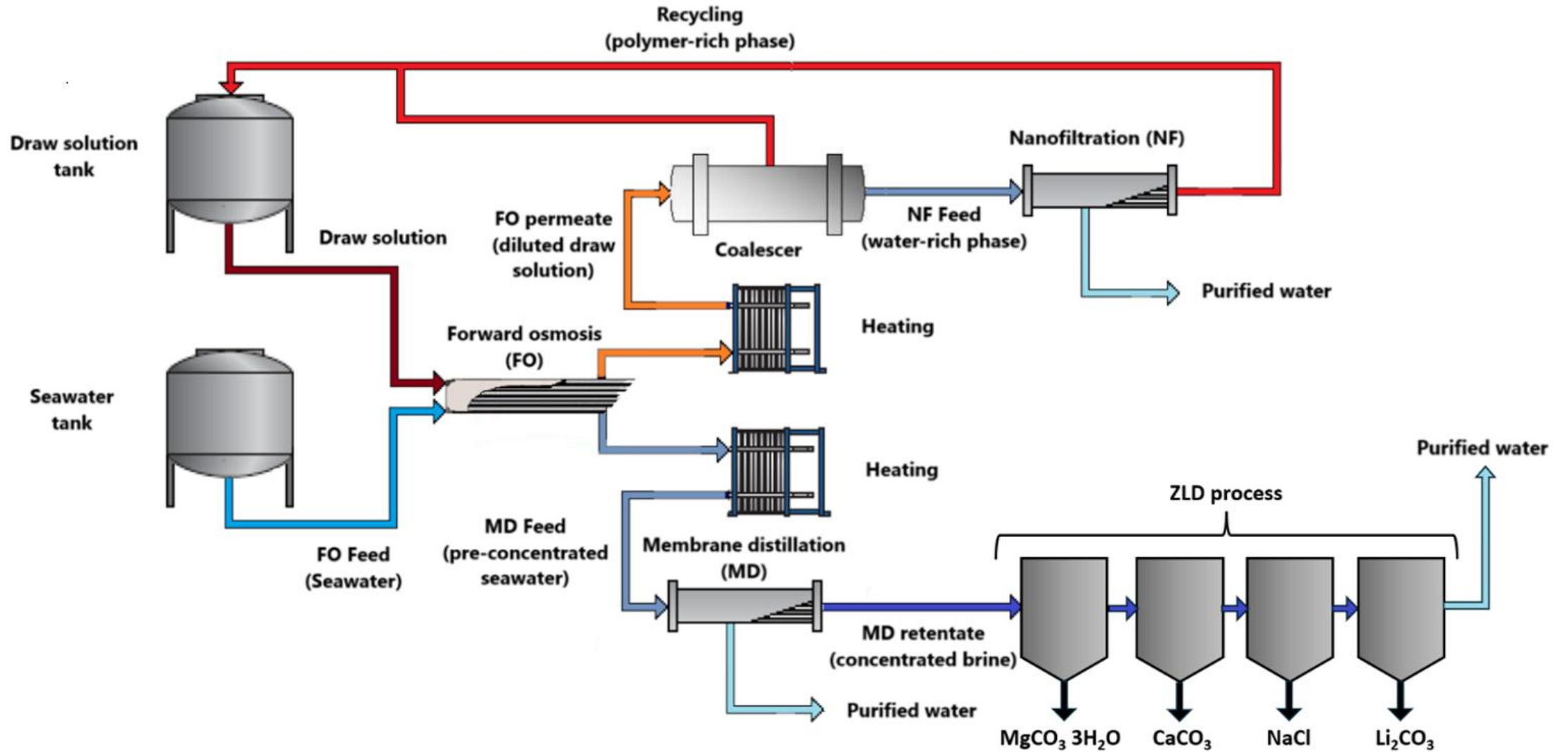


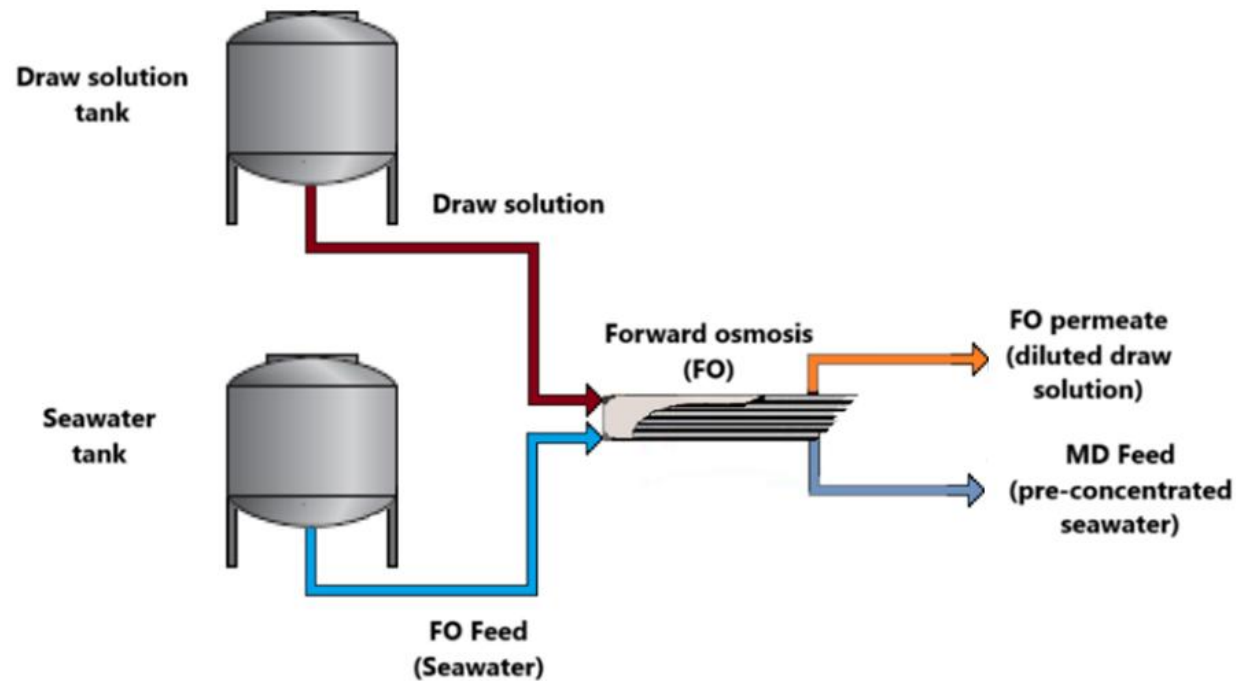
- **Water Scarcity Crisis:** By 2030, 40% of the world's population could face water shortages. With only 3% of Earth's water being freshwater, efficient water use is crucial.
- **Solar Energy:** A key player in reducing carbon emissions, accounted for 11% of global renewable energy in 2019 and has grown by 16% since 2020.
- **DESOLINATION:** The project integrates concentrated solar power (CSP) with advanced membrane processes and zero-liquid discharge (ZLD) technology to create a sustainable, zero-carbon desalination system.



- **Integrated Membrane System:** Combines FO, NF, and MD with ZLD, including multi-crystallization for mineral recovery.
- **Advanced Membranes:** Develops and tests new membranes for FO, MD, and NF, exploring thermo-responsive polymers for FO.
- **Scaling Up:** The optimized system will be connected to the air Brayton cycle solar power tower at King Saud University, Saudi Arabia.

Overall process





FO Membranes:

Two high-flux polymeric concepts under development:

- Electrospun PAN plus layer-by-layer technique.
- Electrospun PS plus TFC.

Draw Solution:

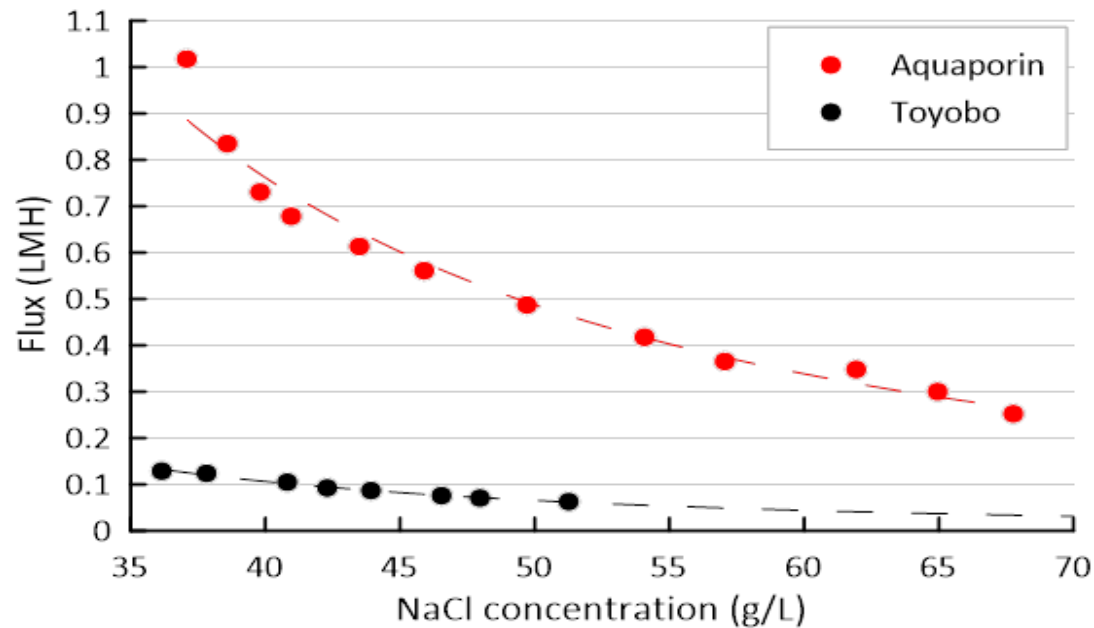
Thermo-responsive polymers are under investigation:

- Selection Criteria: Compatibility, viscosity, and osmotic pressure.

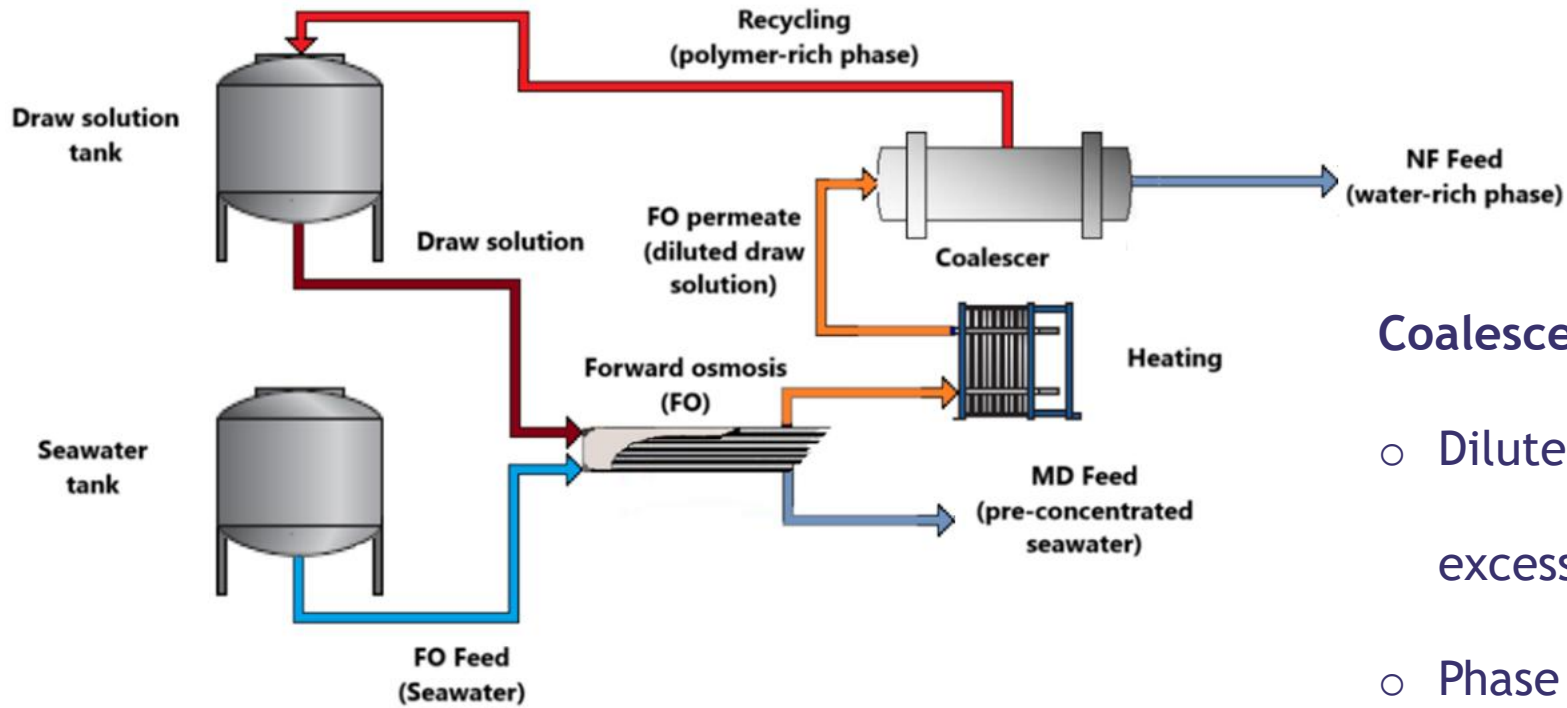
Selection of a Commercial membrane

	Aquaporin	Toyobo
Material	PA + Aquaporins	Cellulose triacetate
Type	Hollow fibre module	Hollow fibre module
Area (m ²)	2.3	31.5

	Draw (Unilube50MB-26)	Feed (NaCl)
Concentration	75 % w/w	3.5 % w/w
Mode of feed	Single pass	Circulating
Position of feed	Shell	Bore

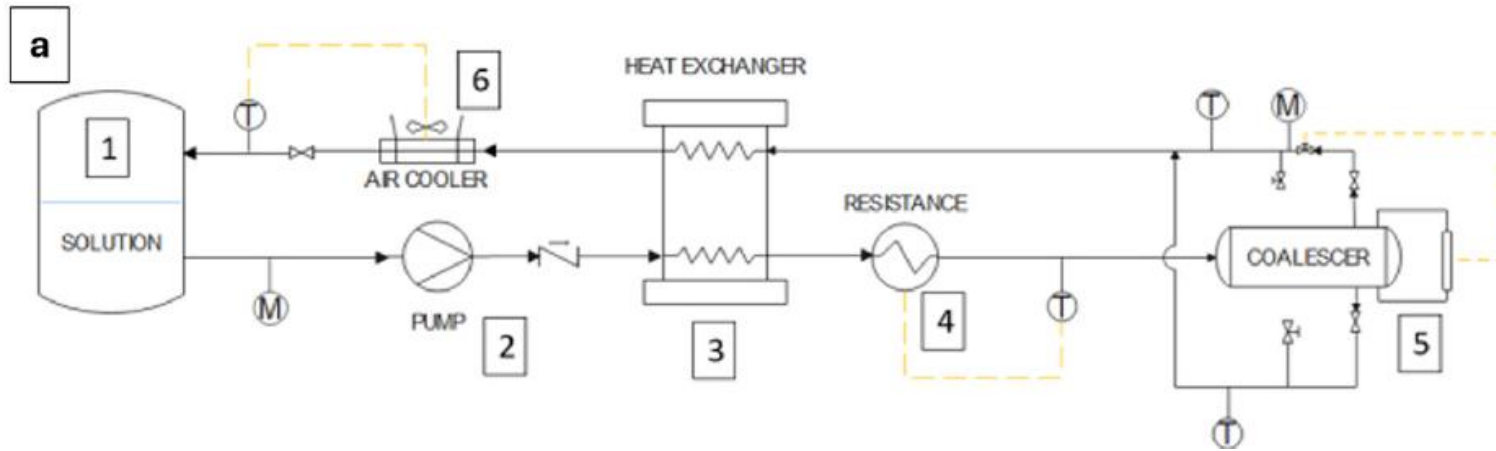


FO pilot unit (LUND)



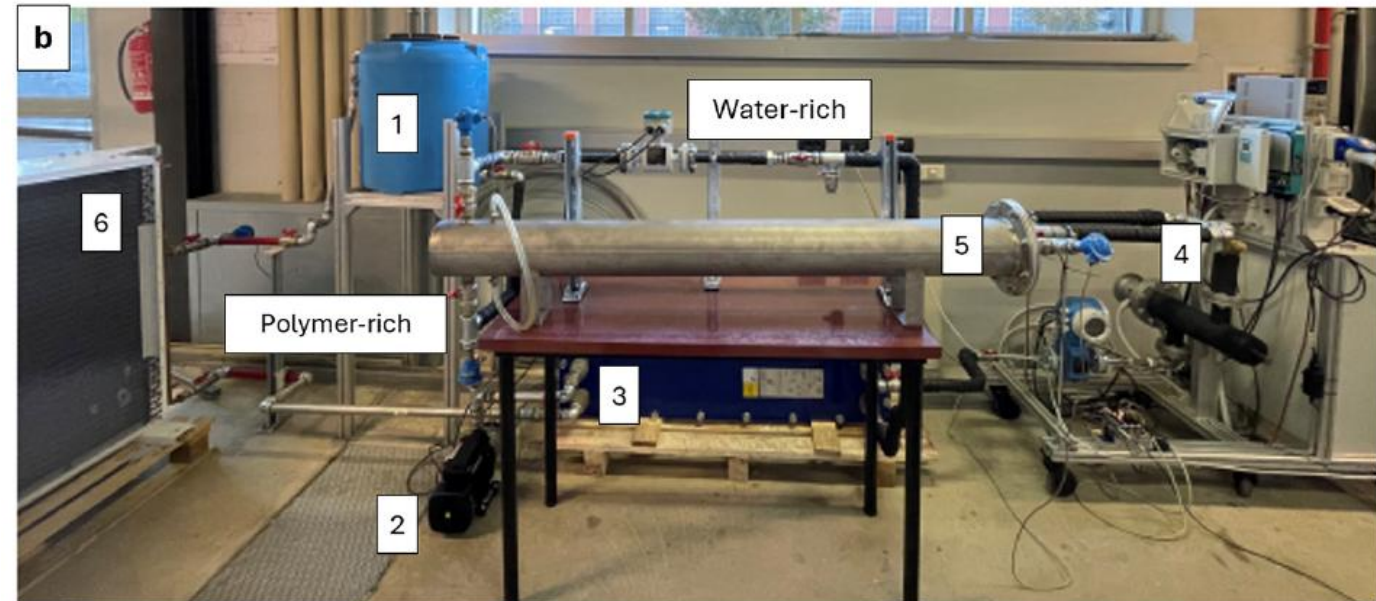
Coalescer:

- Diluted draw solution is heated using excess heat from the Brayton cycle.
- Phase separation in coalescer results in a polymer- and in a water-rich phase.



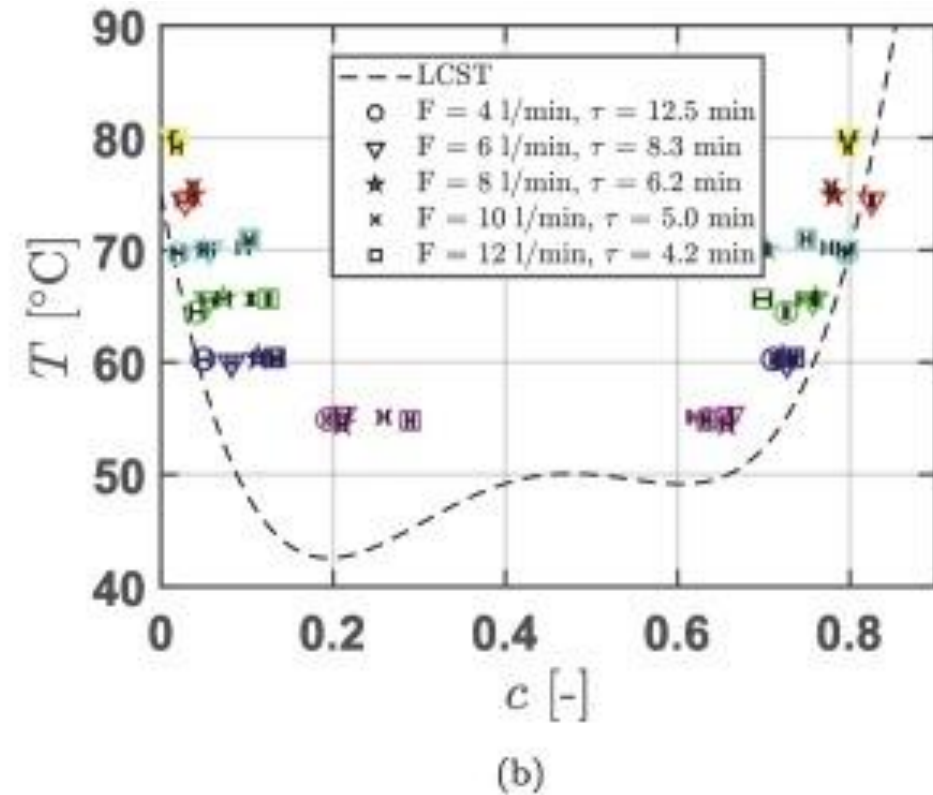
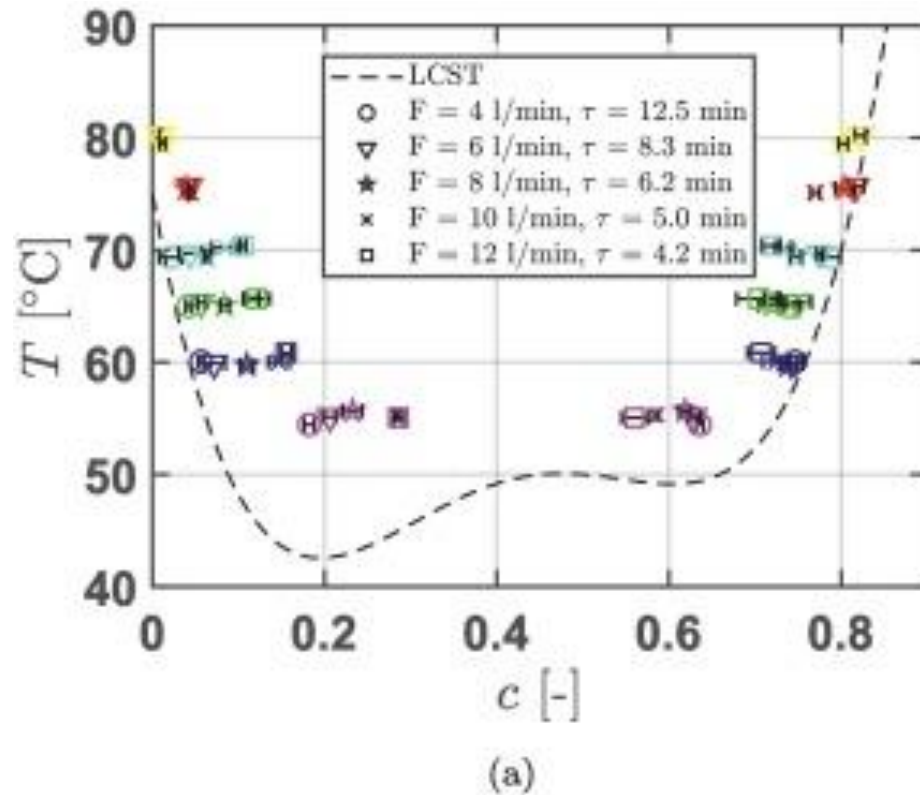
Coalescer pilot unit (Politecnico di Milano)

Optimisation of process conditions:
Concentration, temperature and flow rate.

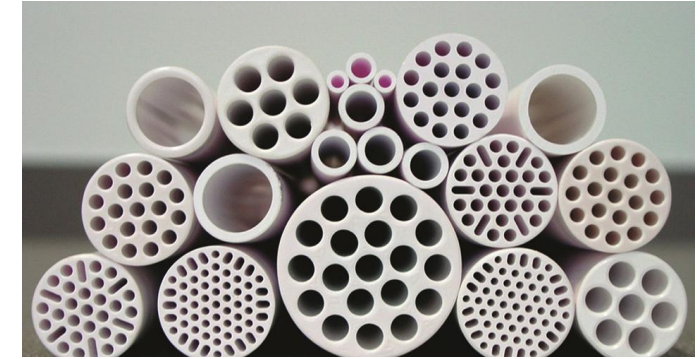
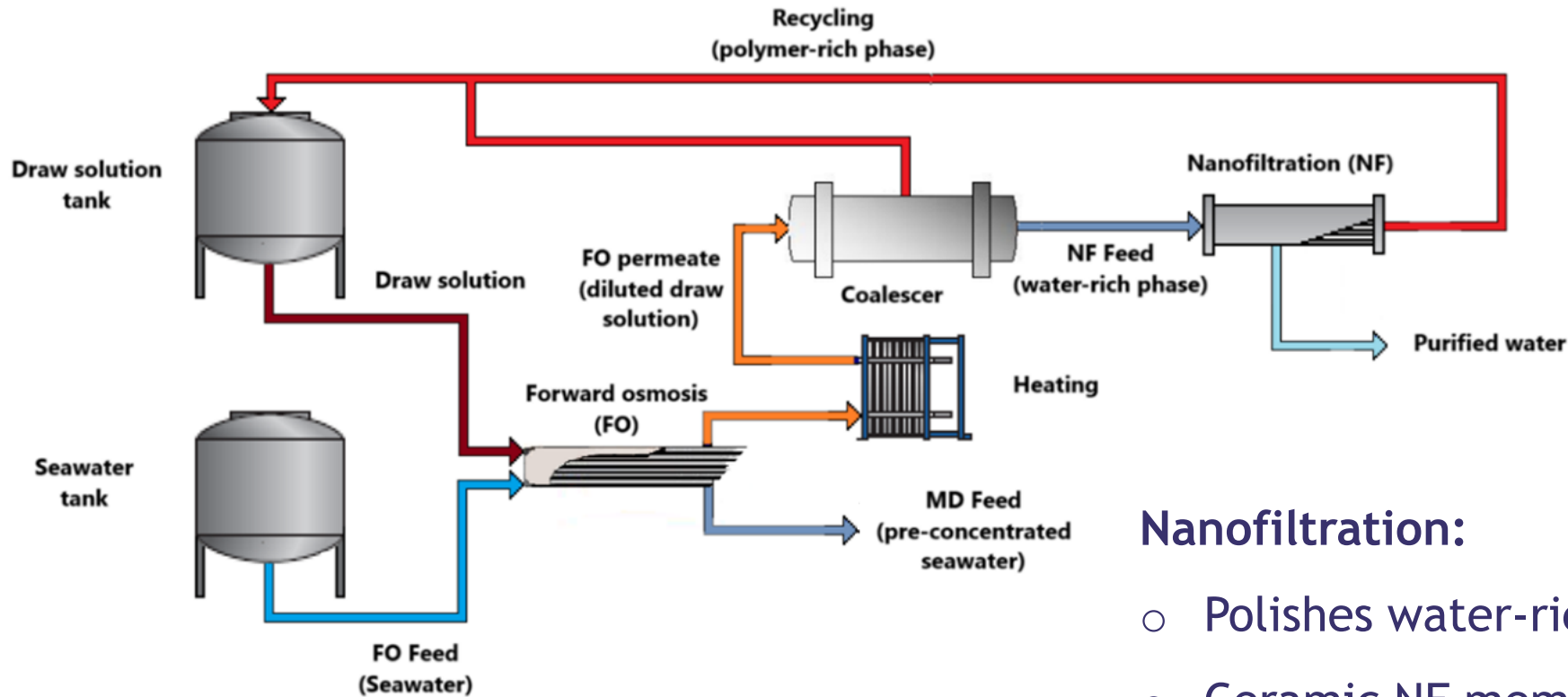


Source: Desalination Volume 5861 October 2024 Article number 117840

Lower Critical Solution Temperature (LCST) for PAGB2000



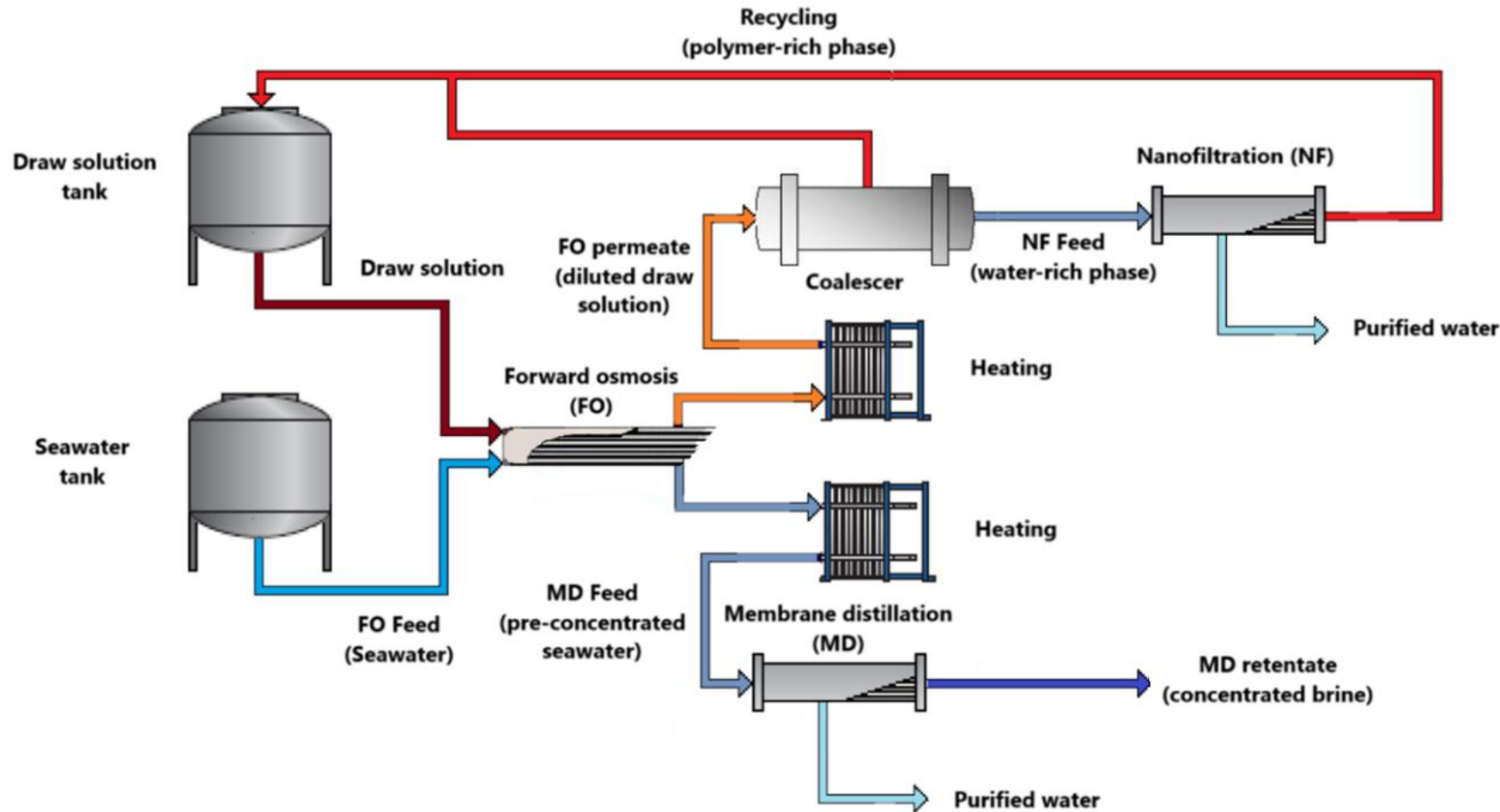
Influence of regeneration temperatures, residence time (τ), initial draw concentration: 0.50 (a) and 0.60 (b)



Different membrane geometries developed by IKTS.

Nanofiltration:

- Polishes water-rich phase from coalescer.
- Ceramic NF membranes from IKTS were chosen to reduce the need for cooling after the decantation process.

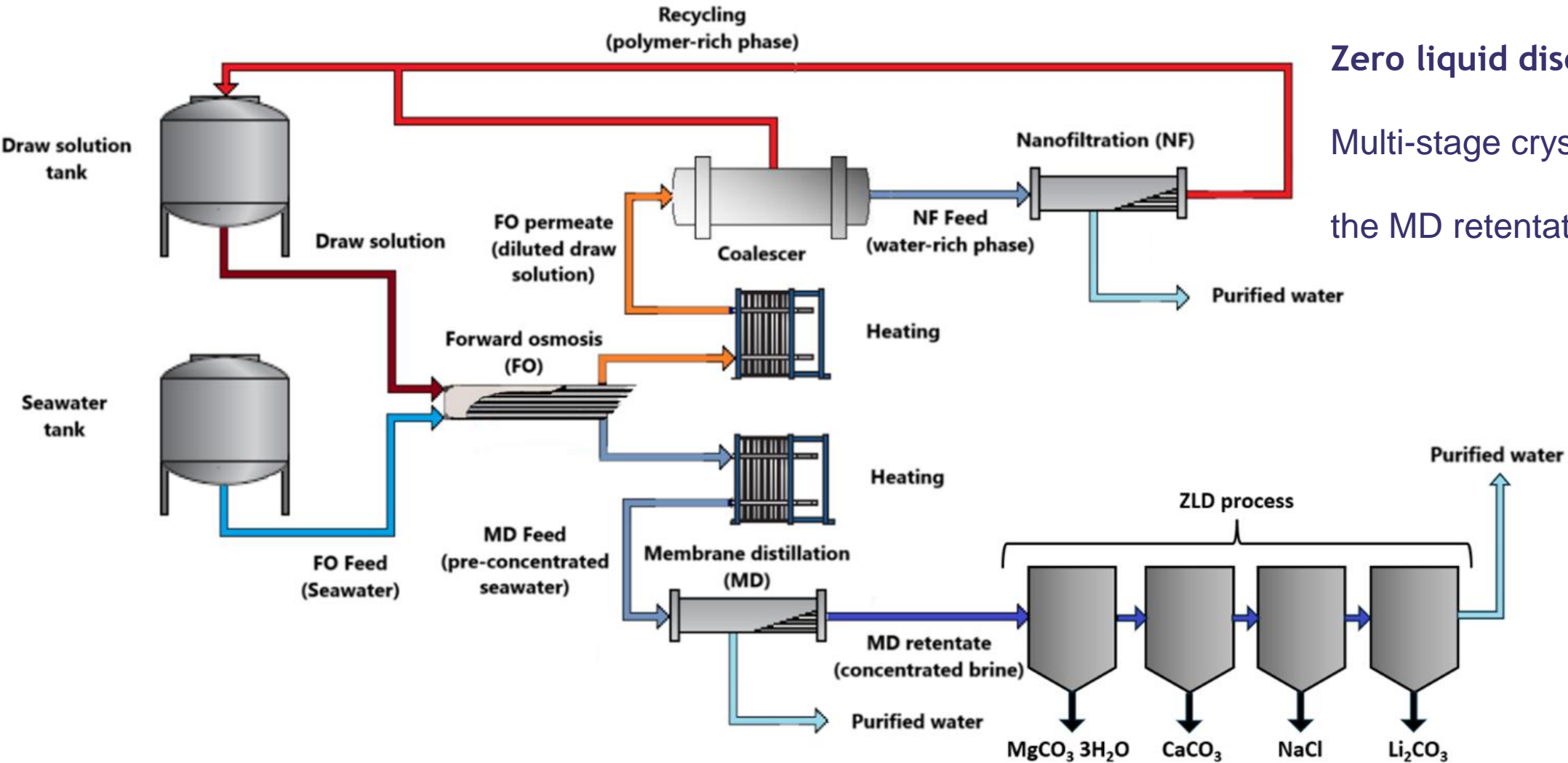


Membrane Distillation:

- Increase brine concentration and water recover.
- New superhydrophobic ceramic membranes for vacuum MD.
- Membranes use silane grafting.

Zero liquid discharge (ZLD)

Zero liquid discharge:
Multi-stage crystallizers to treat
the MD retentate.

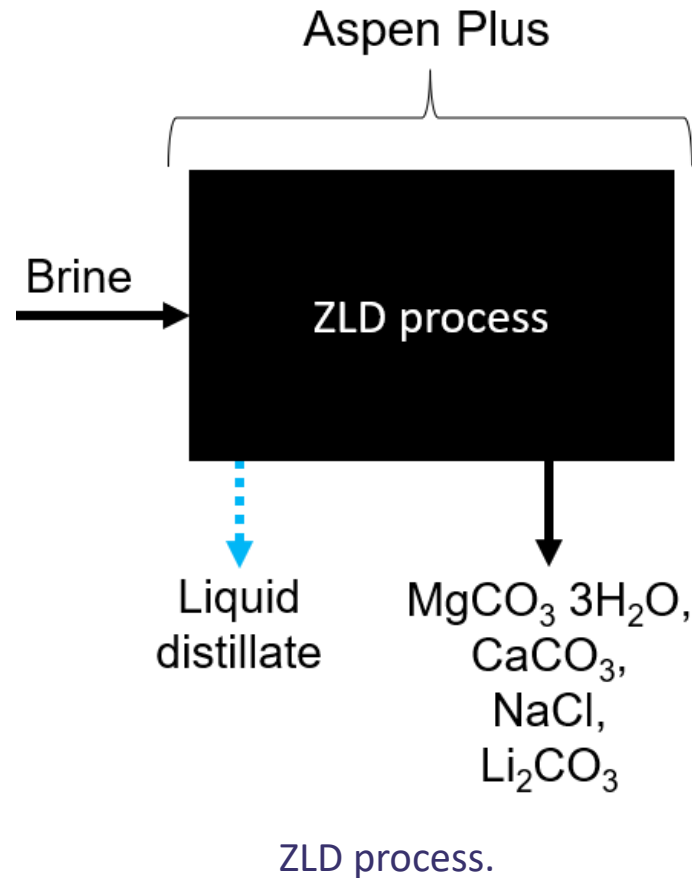




Brine mining

Simulations using Aspen Plus™ predict:

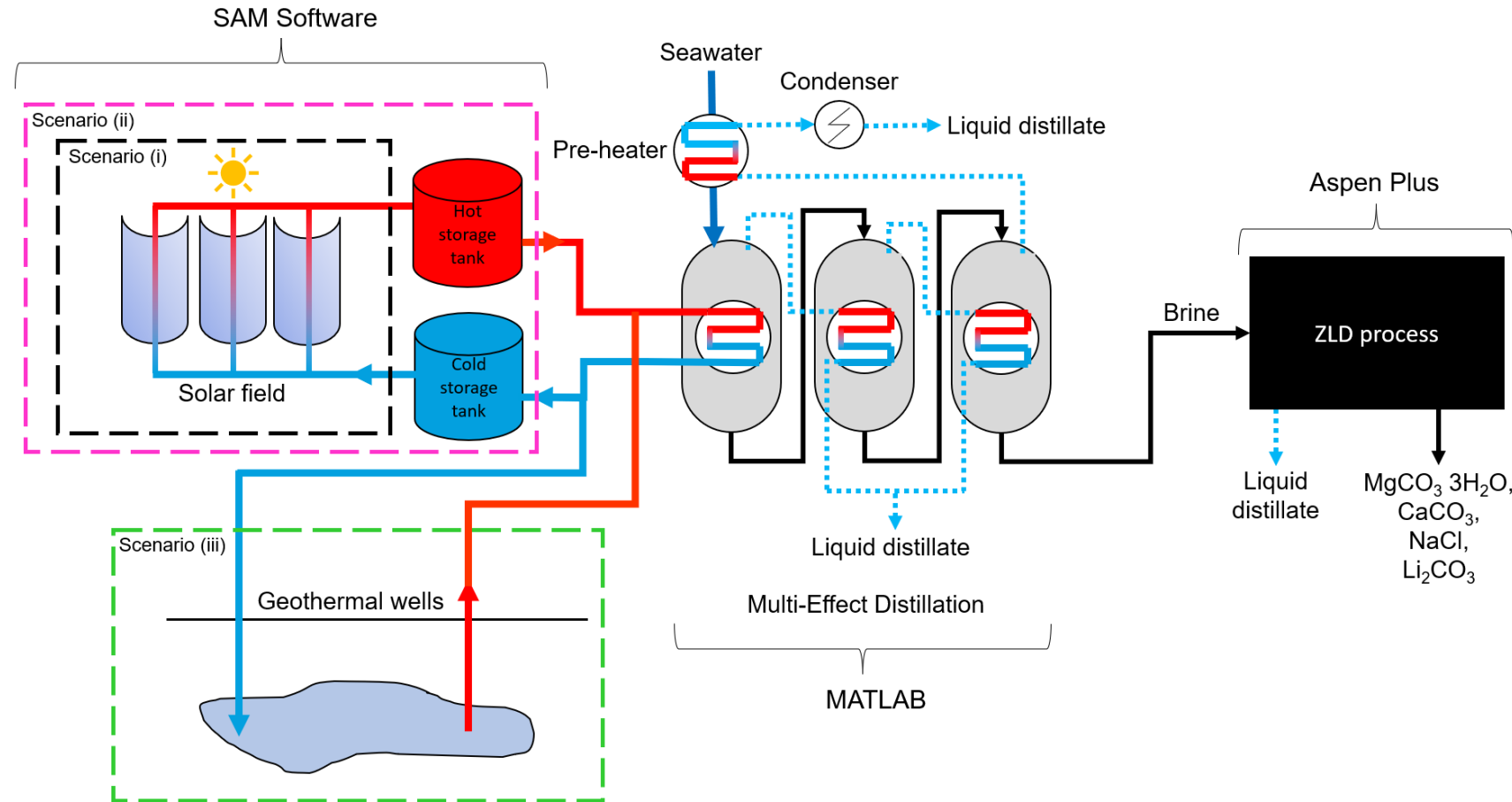
- Near 100% recovery of water from concentrated brines
- Recovery of:
 - 89% of Mg^{2+}
 - 99% of Ca^{2+}
 - 72% of NaCl
 - 80% of Li^+
- For each cubic meter of concentrated seawater brine, this ZLD method can produce:
 - 11.23 kg of $MgCO_3 \cdot 3H_2O$
 - 1.74 kg of $CaCO_3$
 - 29.64 kg of NaCl
 - 1.23 g of Li_2CO_3



Is Brine Mining profitable?

Case study of Tenerife Island

- Model and simulate a large-scale sustainable MED desalination plant under three scenarios.
- 100,000 m³/day seawater feed.
- Calculate levelised cost of water and payback period with/without ZLD.
- Assess techno-economic benefits of brine mining.
- Compare with state-of-the-art and commercial data.



Integrated MED-ZLD model. Scenarios (i), (ii), and (iii) are represented within the black, pink, and green dotted boxes respectively.

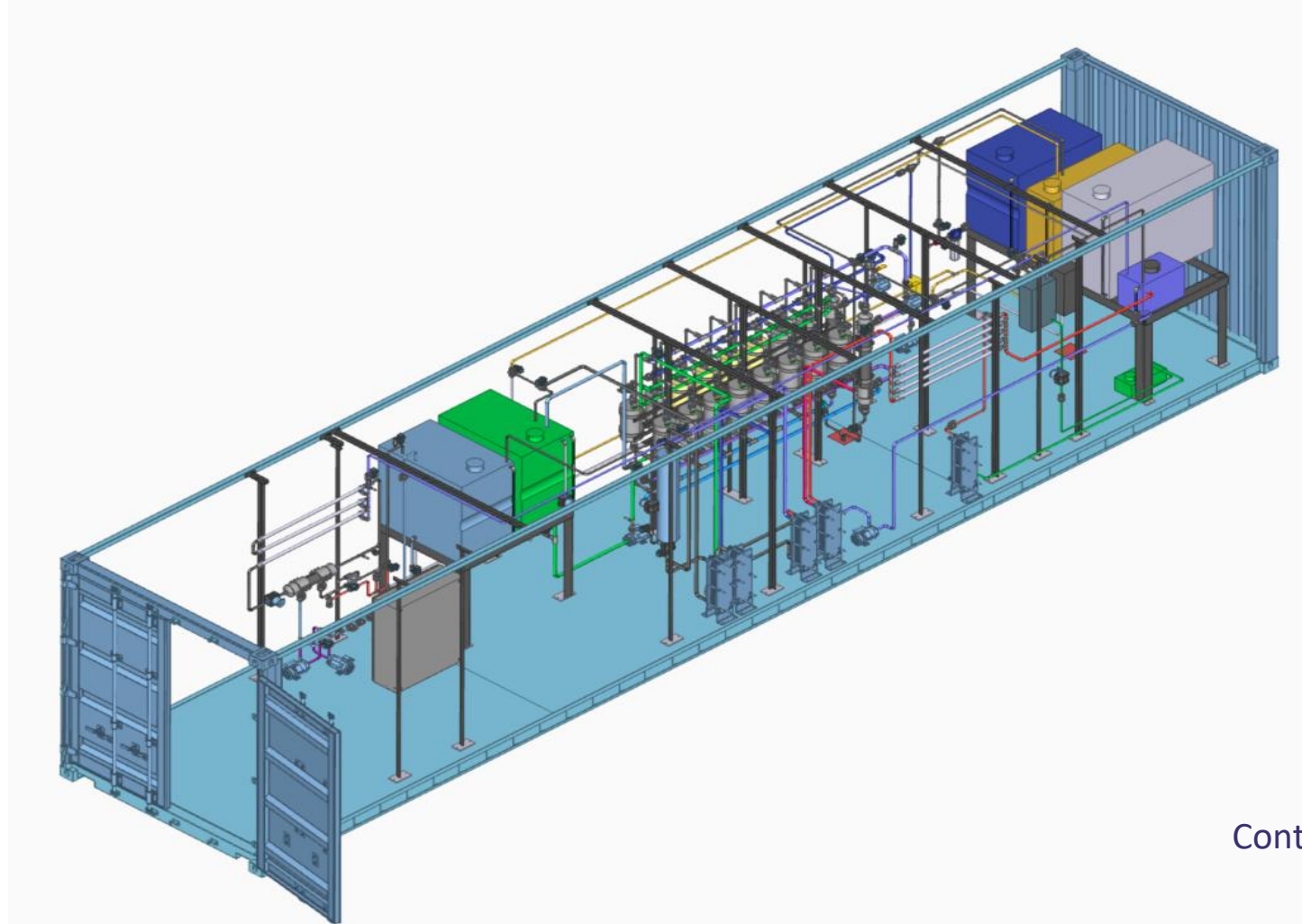


Without ZLD	With ZLD
Water recovery = 40%	Water recovery = 99.8%
Levelised Cost of Water: <ul style="list-style-type: none"> • (i) 6.08 \$/m³ • (ii) 2.74 \$/m³ • (iii) 1.54 \$/m³ 	Levelised Cost of Water: <ul style="list-style-type: none"> • (i) 16.97 \$/m³ • (ii) 6.54 \$/m³ • (iii) 5.09 \$/m³
Payback period: <ul style="list-style-type: none"> • (i) Non-profitable • (ii) 13.2 years • (iii) 5.3 years 	Payback period: <ul style="list-style-type: none"> • (i) 24.0 years • (ii) 6.9 years (47.7% drop) • (iii) 4.7 years (11.3% drop)
	Annual expenses increased: <ul style="list-style-type: none"> • (i) by 6.7-times • (ii) by 5.8 times • (iii) by 8-times • <u>Revenue increased by 9.4-times in all cases</u> • CO₂ emissions reduced by 26k-124k tonnes/year <p>➡ Brine mining improves profitability and sustainability</p>



- **DESOLINATION** provides a sustainable solution to water scarcity by integrating solar power with advanced desalination technologies.
- **Innovative membrane development:** FO, MD, and NF membranes, along with thermo-responsive polymers, enhance water recovery and reduce environmental impact.
- **Zero-liquid discharge integration** enables valuable salt recovery and achieves nearly 100% water recovery.
- **Sustainable and cost-effective:** Offers a viable solution for clean water production, particularly in water-scarce regions like the Middle East.





Container design (Protarget).

Large-scale pilot to be installed and started at King Saud University in Saudi Arabia in Sept 2025.





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Thank you for your attention.
Any questions?



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