GLOBAL WATER INTELLIGENCE

A Global Desalination Perspective

Tom Pankratz, Water Desalination Report

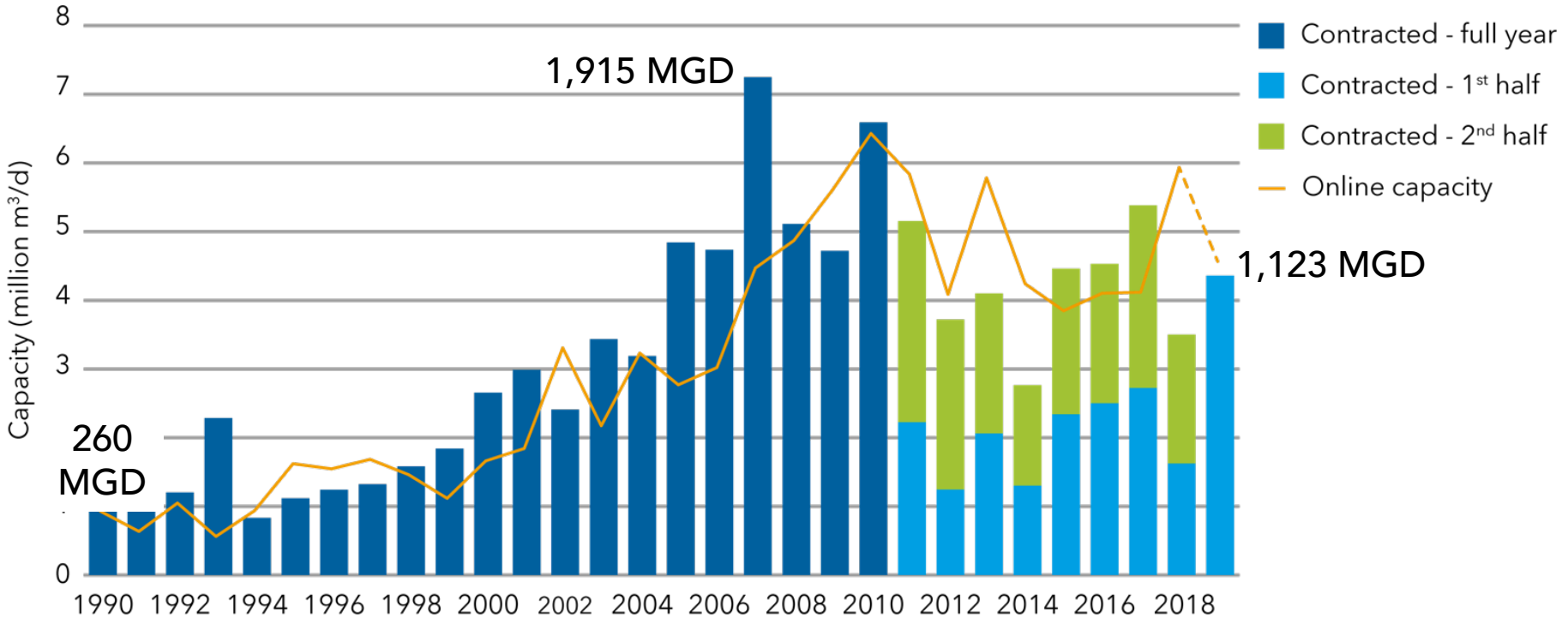
Topics

GLOBAL WATER INTELLIGENCE

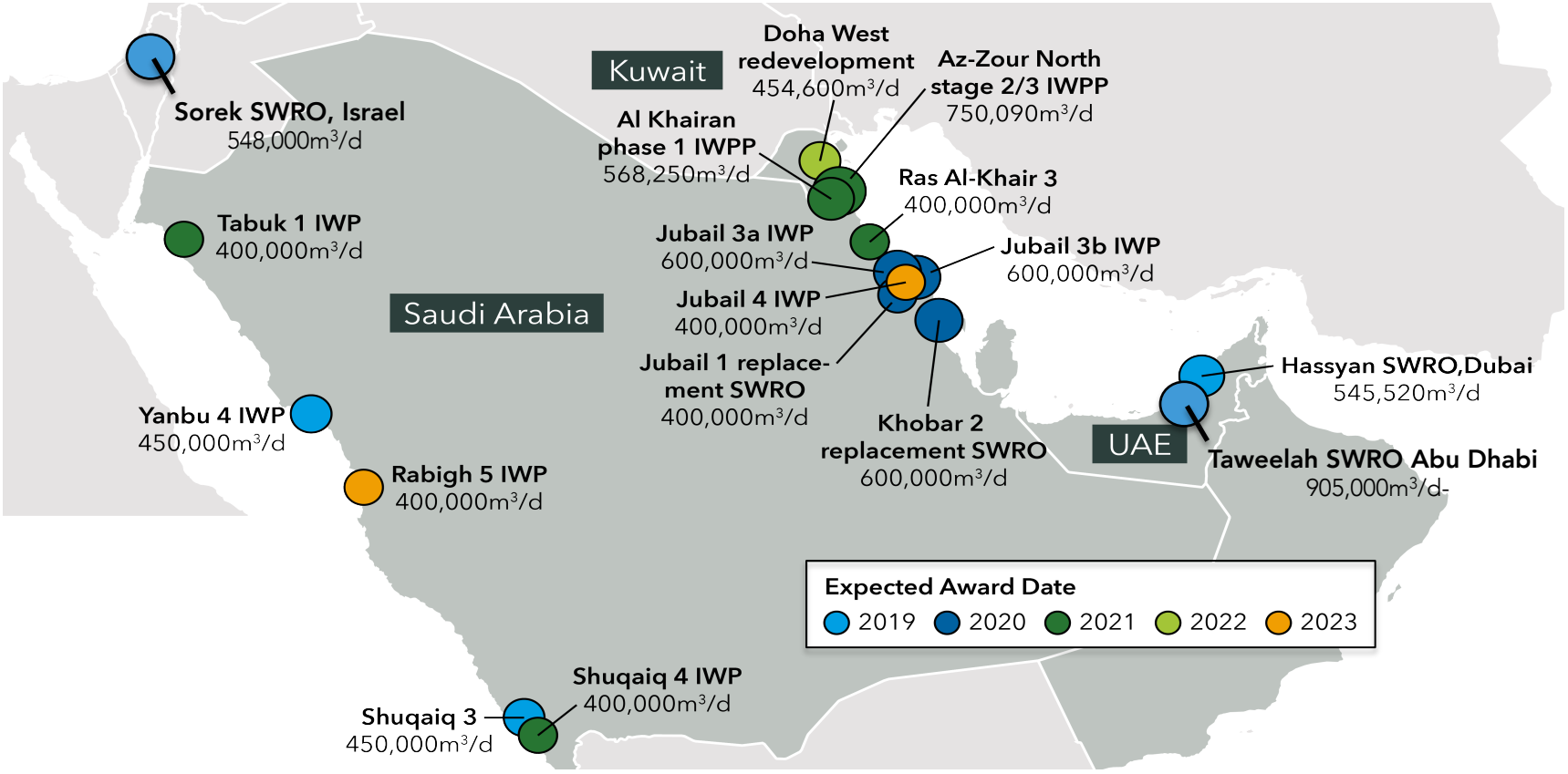
- Global desal market overview
- Membrane innovation timeline
- There's nothing wrong with incremental improvements
- There's more to desal than membranes
- Innovation's impact on the market
- Recommendations for researchers/reviewers
- Desal's greatest challenges

Contracted Desalination Capacity

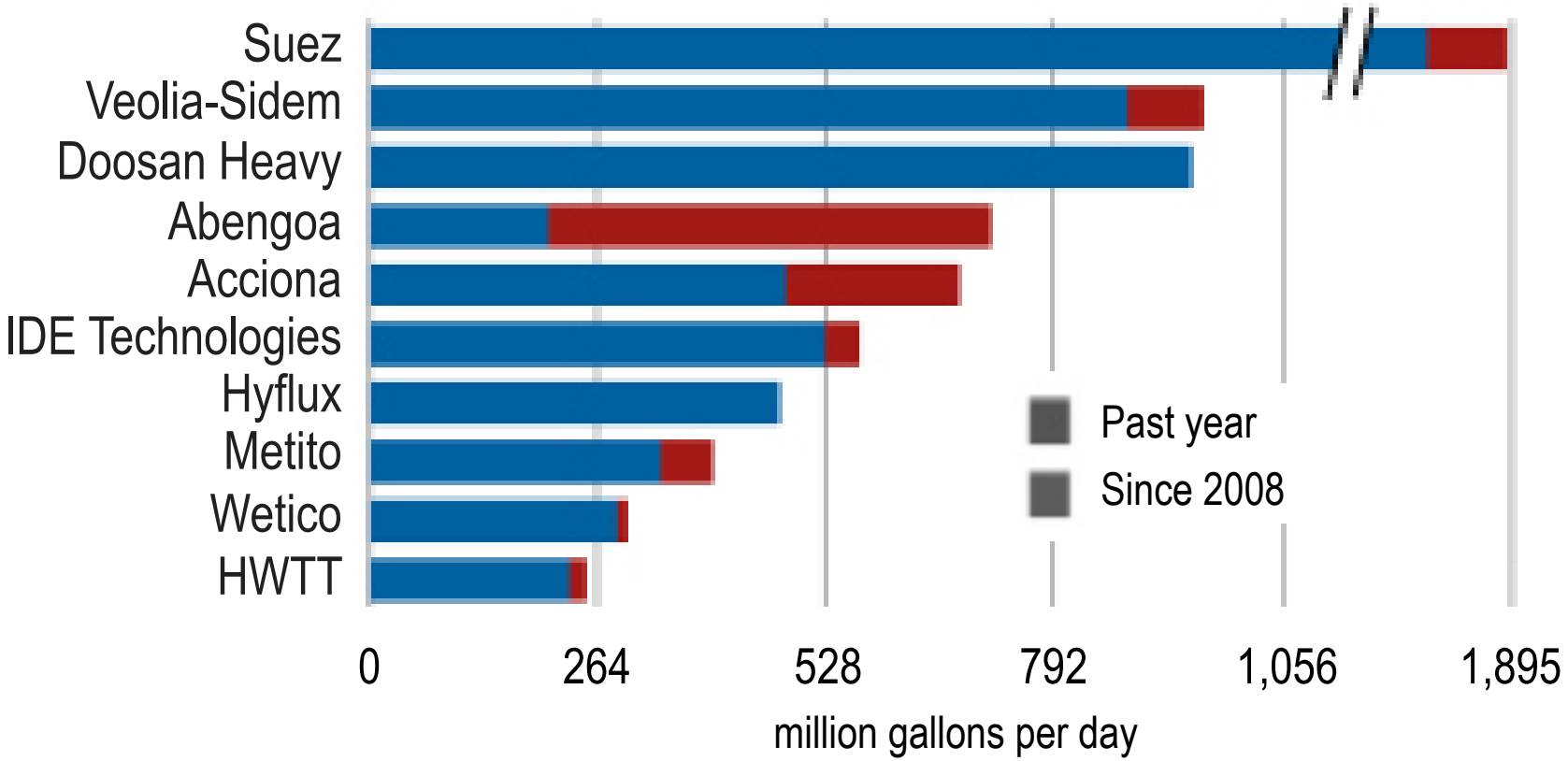
GLOBAL WATER INTELLIGENCE



2019-2023 Mid East Forecast: 2,343 MGD

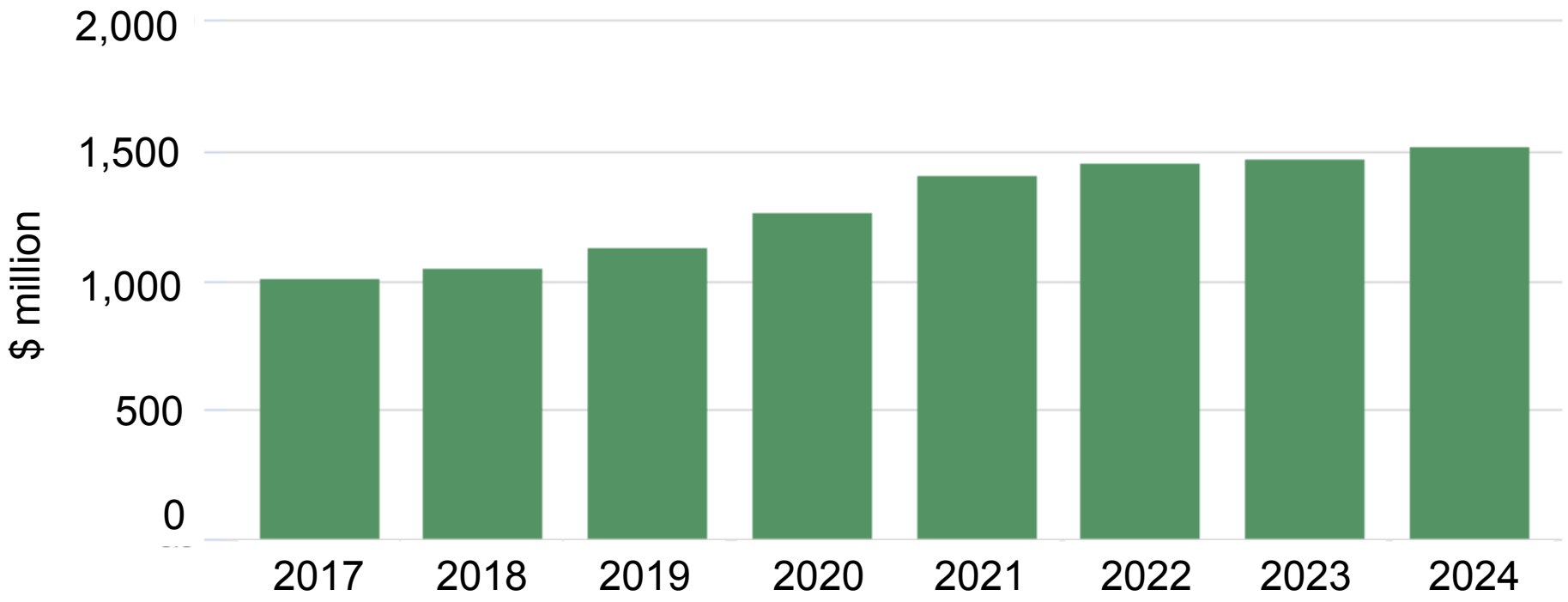


Suppliers by Contracted Capacity



North American Desal Forecast

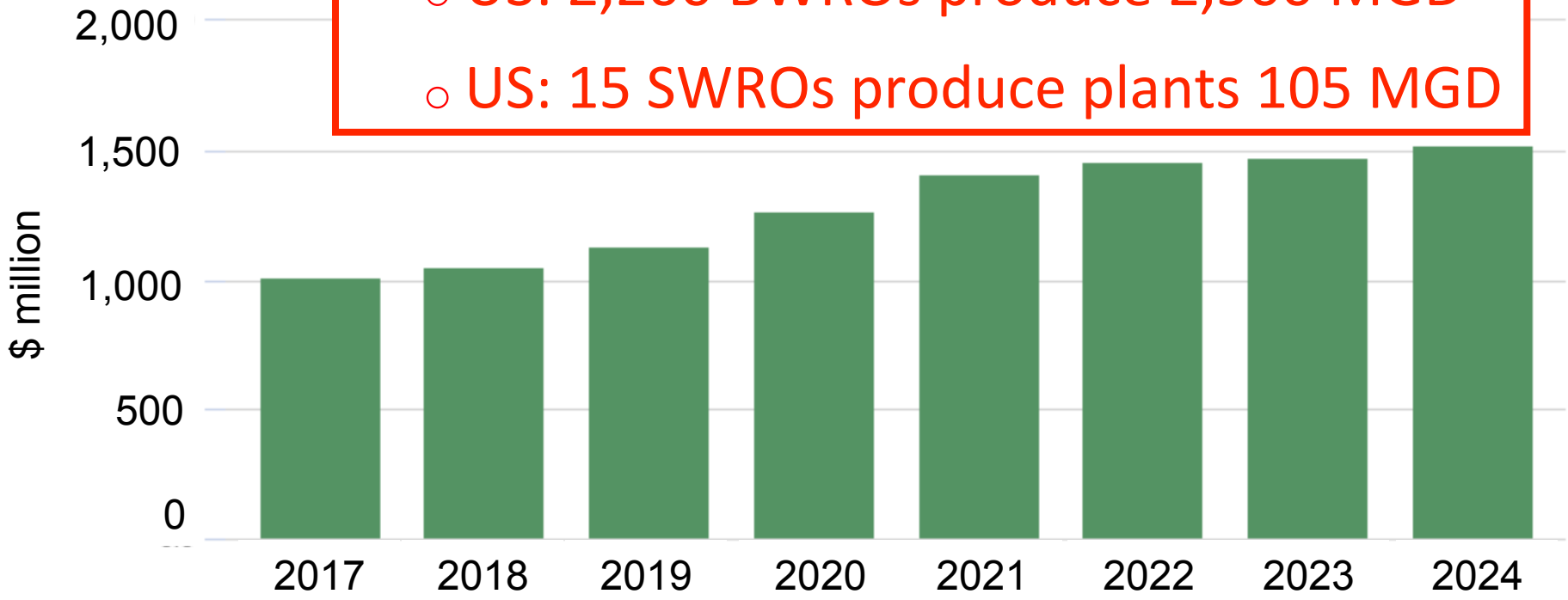
GLOBAL WATER INTELLIGENCE



North American Desal Forecast

GLOBAL WATER INTELLIGENCE

- US: 2,200 BWROs produce 2,500 MGD
- US: 15 SWROs produce plants 105 MGD



Desal's Strategic Cost Goal: Pipe Parity

GLOBAL WATER INTELLIGENCE

Pipe Parity: The the cost to deliver desalted water with an economic and energy/carbon cost equal to traditional water supplies.

Avg freshwater cost: $0.50/m^3 ($1.90/kgal)
to extract, treat, convey

Avg energy required: 0.29 kWh/m3 (1.10 kWh/kgal)

SWRO Bid Submissions < $2.08/kgal

GLOBAL WATER INTELLIGENCE

Project (Bid Date)	Team	Price, $/m³ ($/kgal)
Rabigh 3, KSA (July 2018)	ACWA Power/Saudi Brothers	$0.531 ($2.01)
	Marubeni/Acciona/ALJ/Rawafid	$0.539 ($2.04)
Suqaiq 3, KSA (Sept 2018)	Marubeni/Acciona/Almar/Rawafid	$0.521 ($1.97)
	Engie/Mitsubishi/Metito/SSEM	$0.524 ($1.98)
	ACWA Pow/Saudi Bros/AlBablain	$0.525 ($1.99)
	Veolia/Marafiq/Amwal/ Al Khaleej	$0.525 ($1.99)
	Aqualia/HAACO/Nesma	$0.539 ($2.04)
	Cobra/Orascom/ Alblagha	$0.552 ($2.09)
Taweelah IWP, UAE (Nov 2018)	ACWA Power	$0.495 ($1.87)
	Engie/Marubeni	$0.516 ($1.95)
Sorek 2, Israel (Sept 2019 shortlist)	IDE Technologies	$0.455 ($1.72)
	Hutchison Water	$0.455 ($1.72)
Yanbu 4, KSA (Oct 2019)	Low bidder not identified	$0.450 ($1.70)

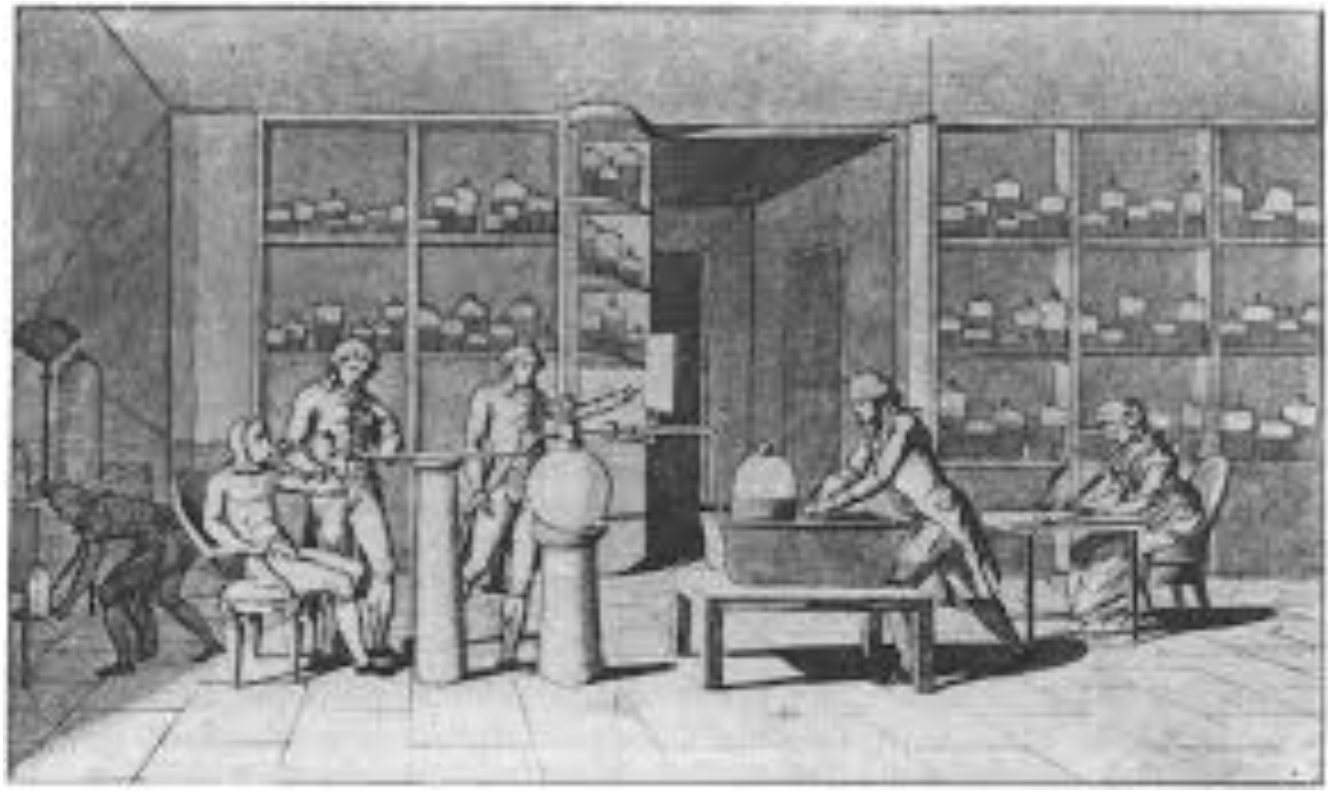
* unofficial

RO Membrane Innovation Timeline

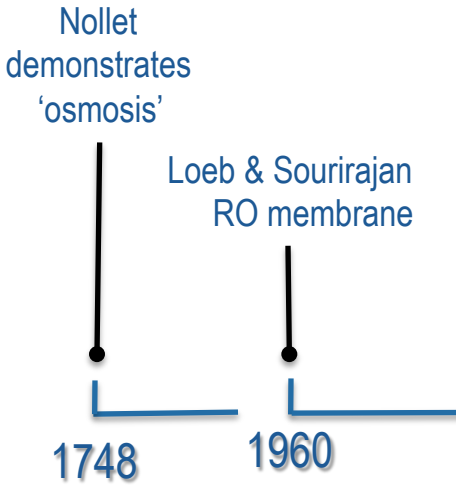
GLOBAL WATER INTELLIGENCE

Nollet demonstrates 'osmosis'

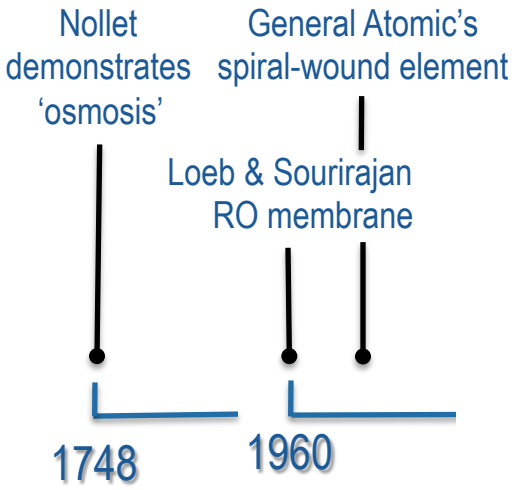
1748



RO Membrane Innovation Timeline

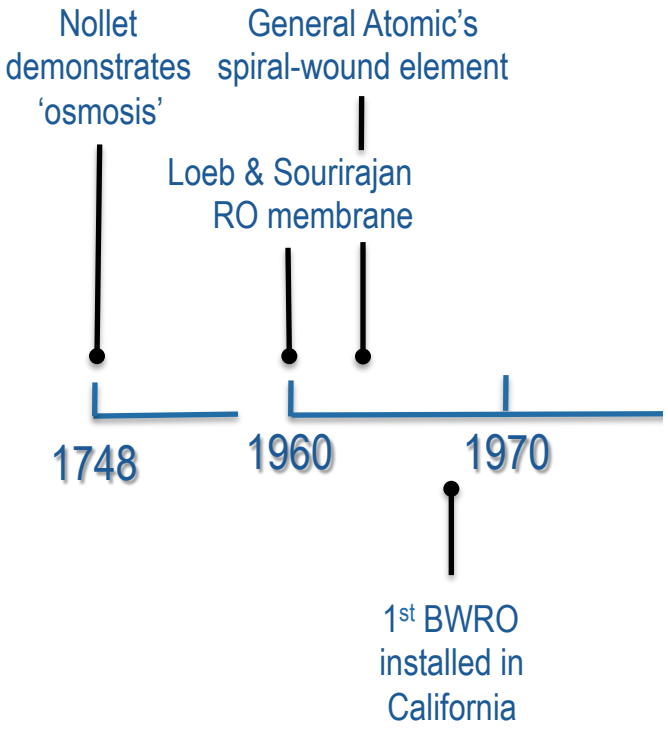


RO Membrane Innovation Timeline

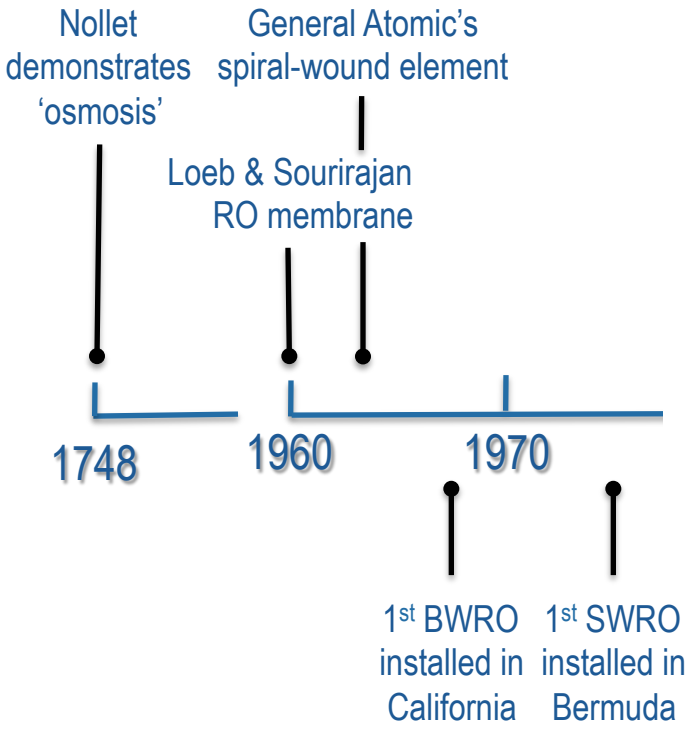


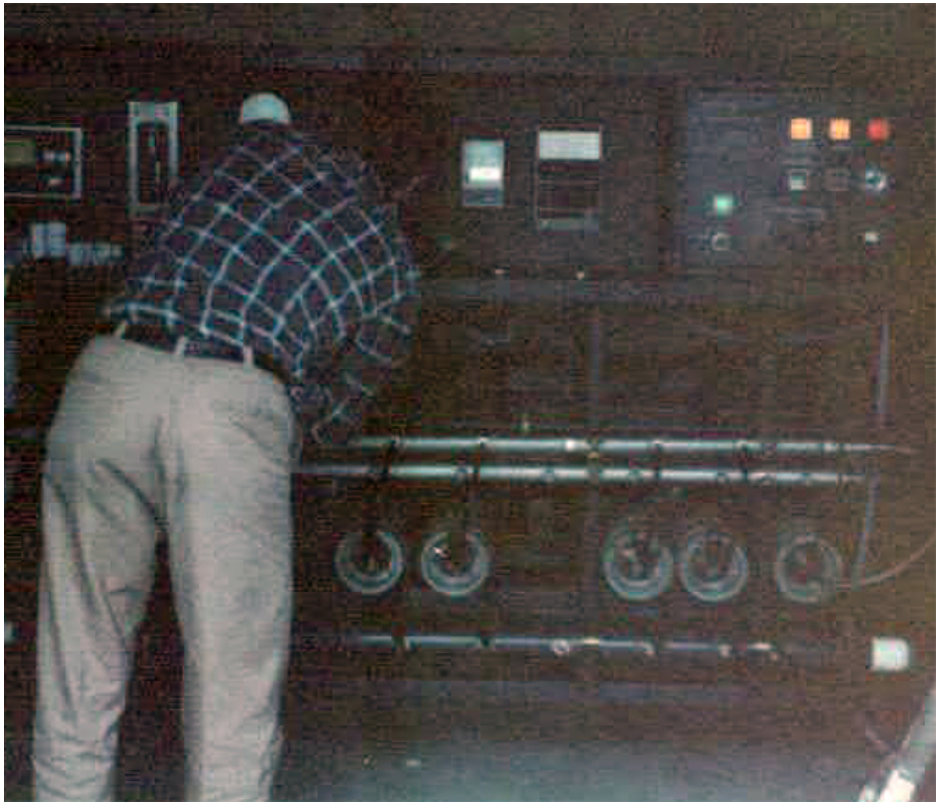
RO Membrane Innovation Timeline

GLOBAL WATER INTELLIGENCE

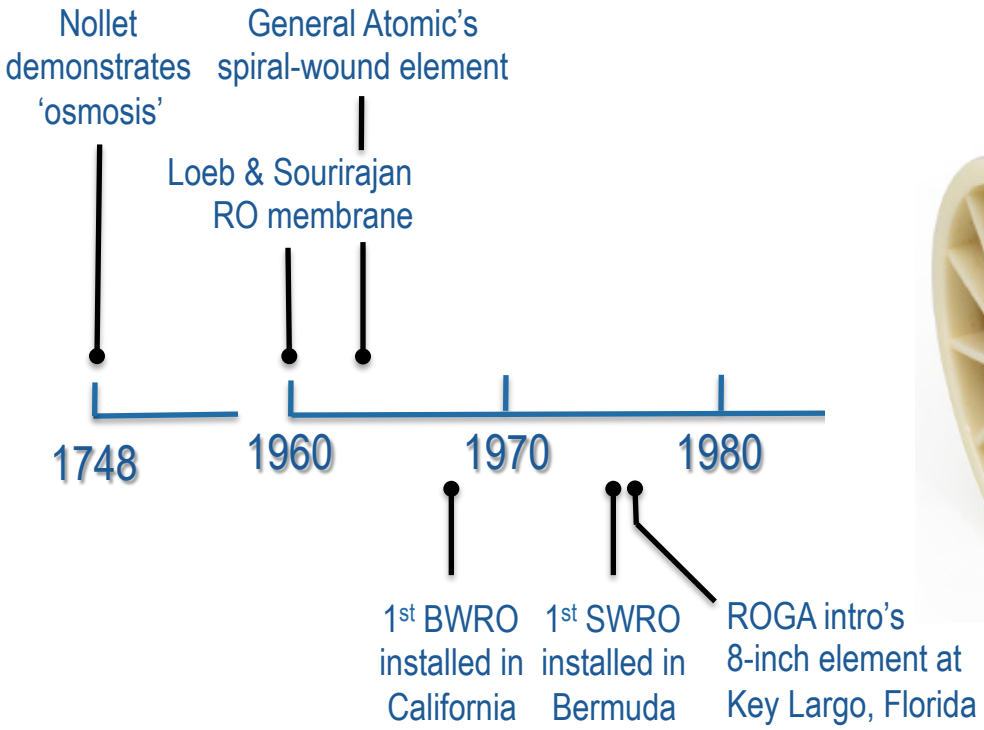


RO Membrane Innovation Timeline

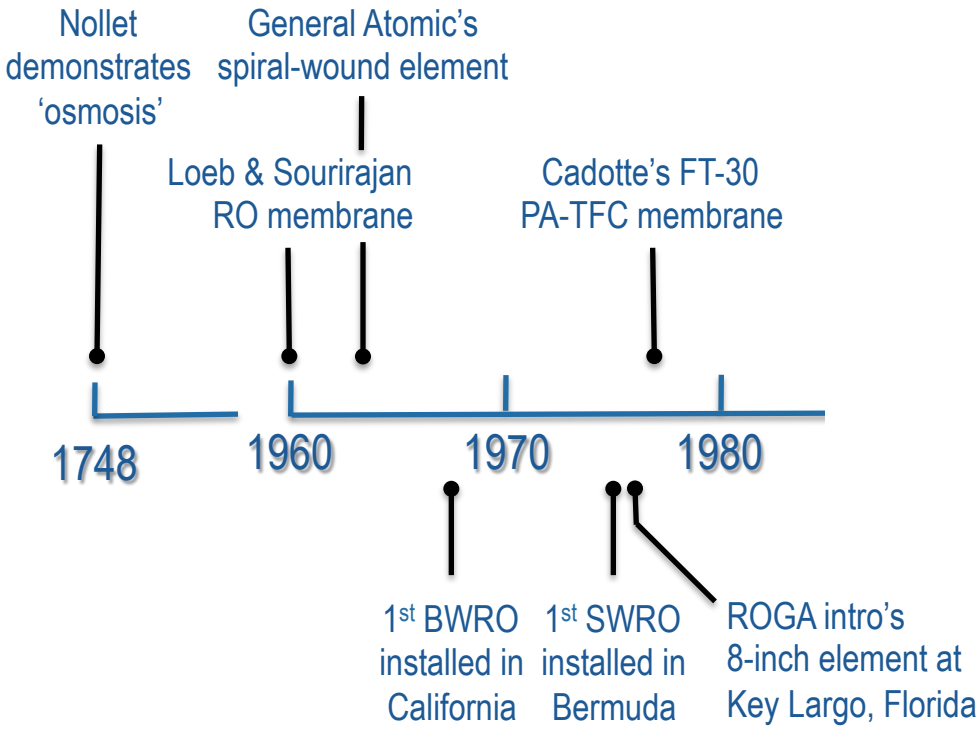


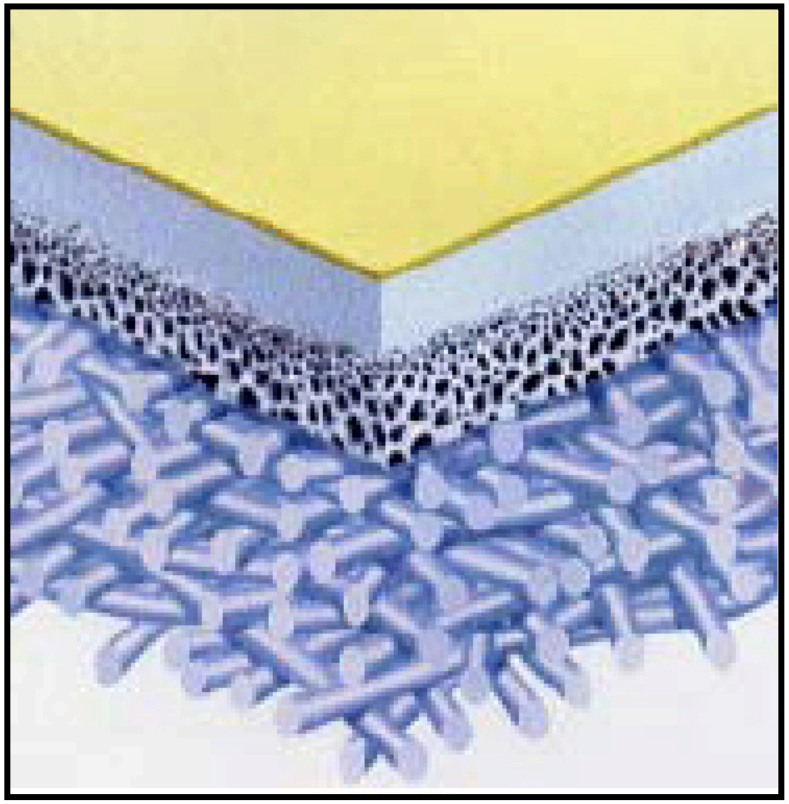


RO Membrane Innovation Timeline

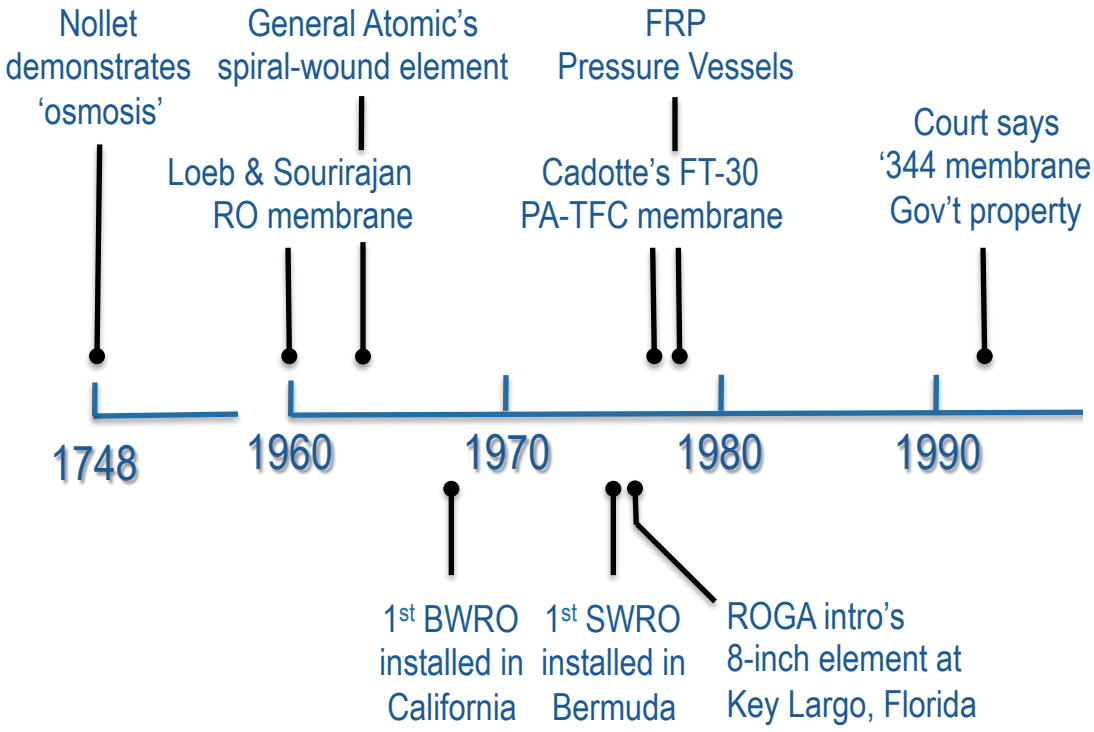


RO Membrane Innovation Timeline





RO Membrane Innovation Timeline



Significant 'incremental" improvements:

1985 – NF SRP membrane (Fluid Systems)
1990 – Side-ported FRP vessel
2002 – 18" dia RO (Koch Membranes)
2004 – 16" large dia RO standard (BoR)
2002 – 400 ft^2 8-in membrane area/element
2006 – TFN membrane (UCLA)
2006 – Automation
2012 – 440 ft^2 membrane area/element
2013 – 16" vertical RO (IDE)
2014 – Aquaporin impregnated RO
2018 – Printed spacers (Aqua Membranes}
2019 – 3D-printed TFC demonstrated (UConn)

Core RO system development

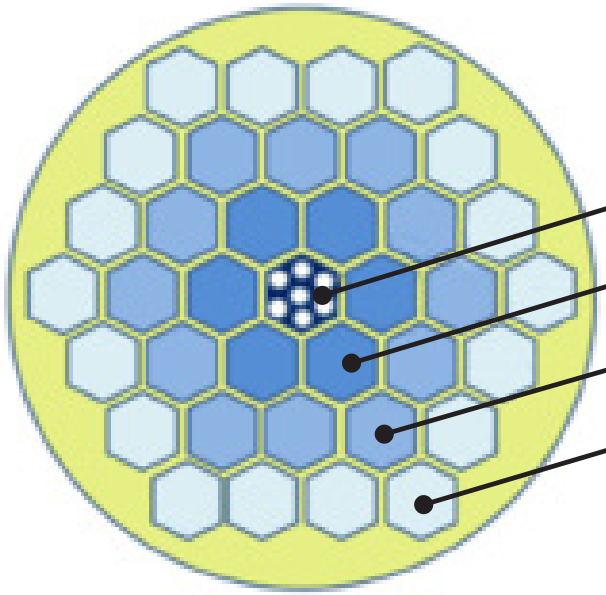
GLOBAL WATER INTELLIGENCE

1990s

Today

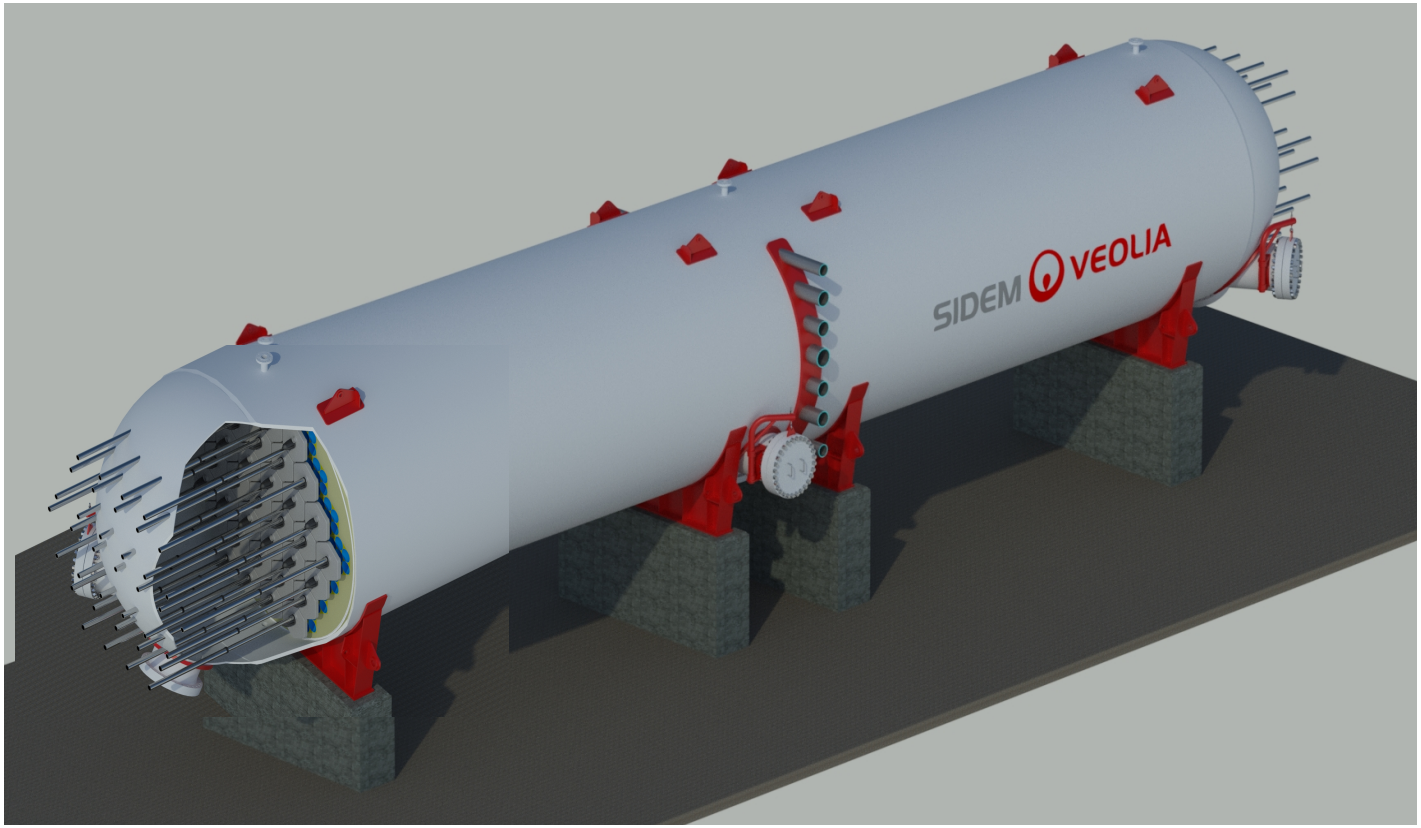
The 'Barrel'

7-tube building block

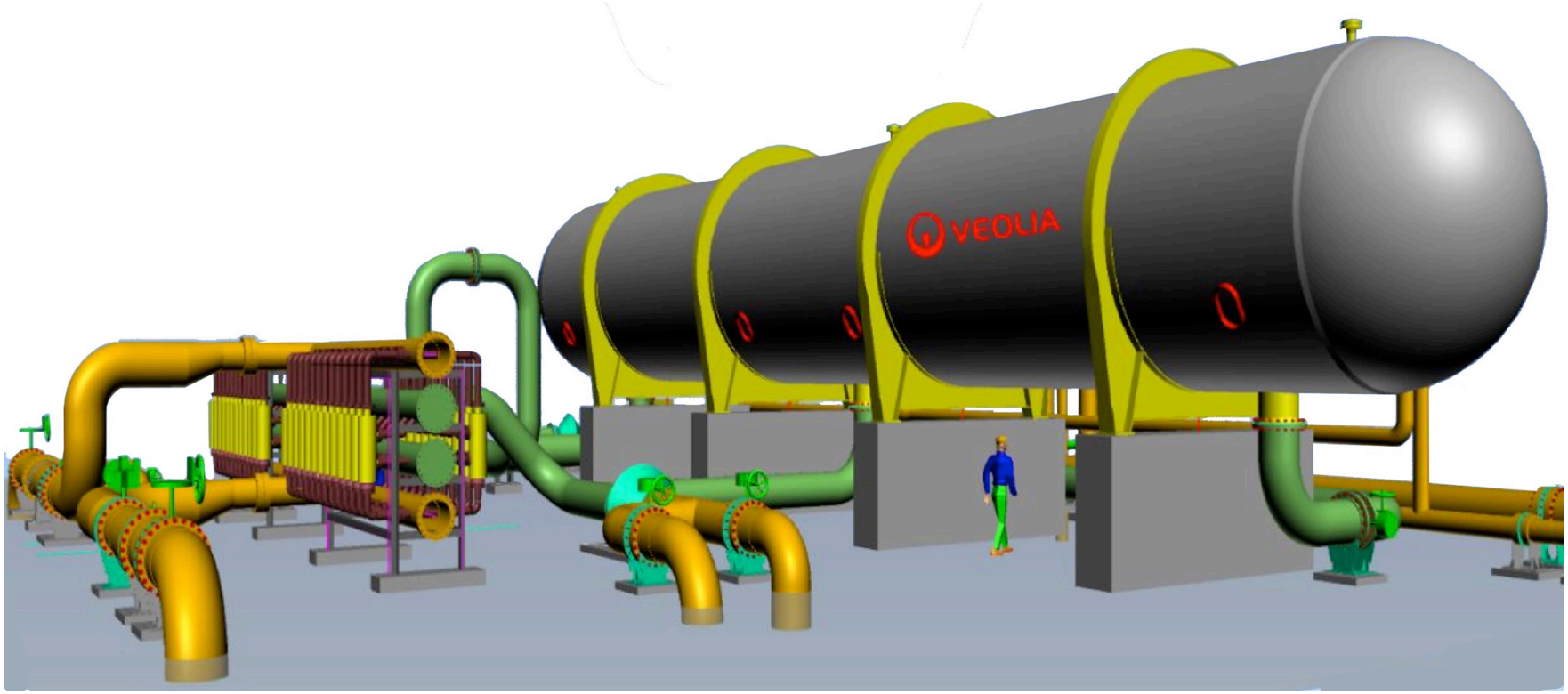


Cross-section illustrating multi-bundle options

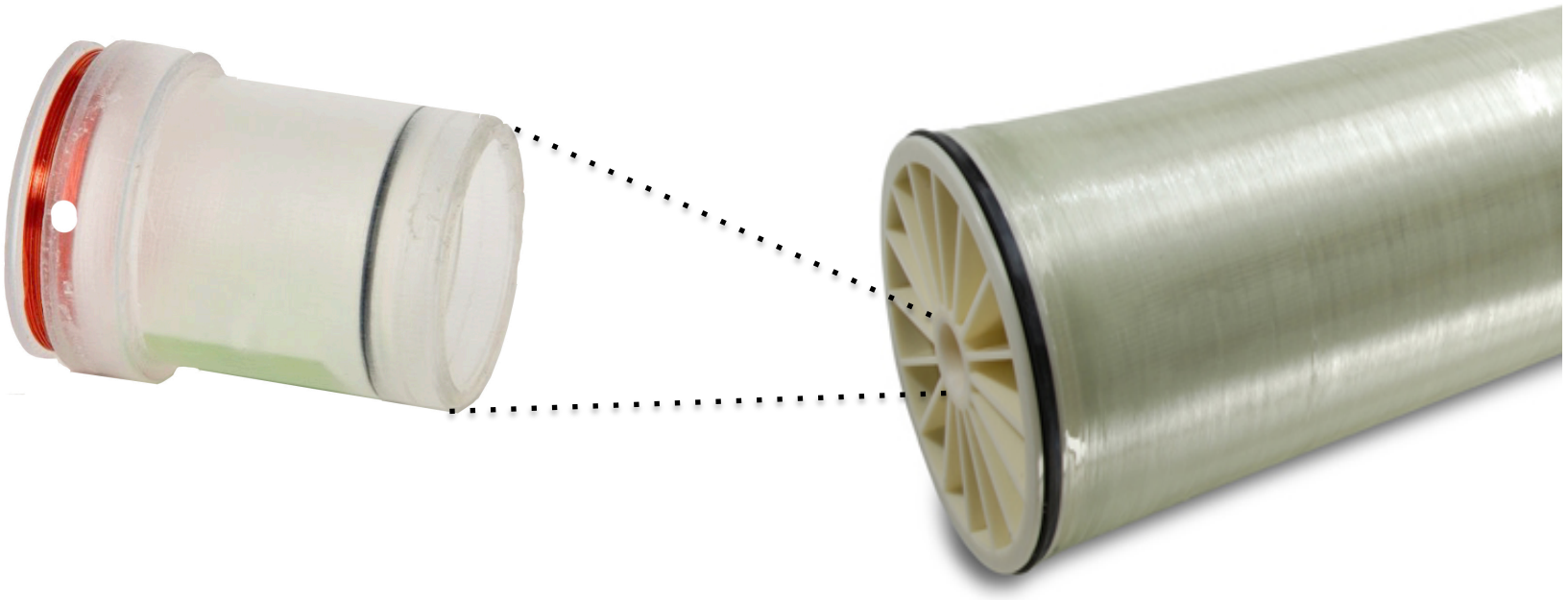
The Barrel



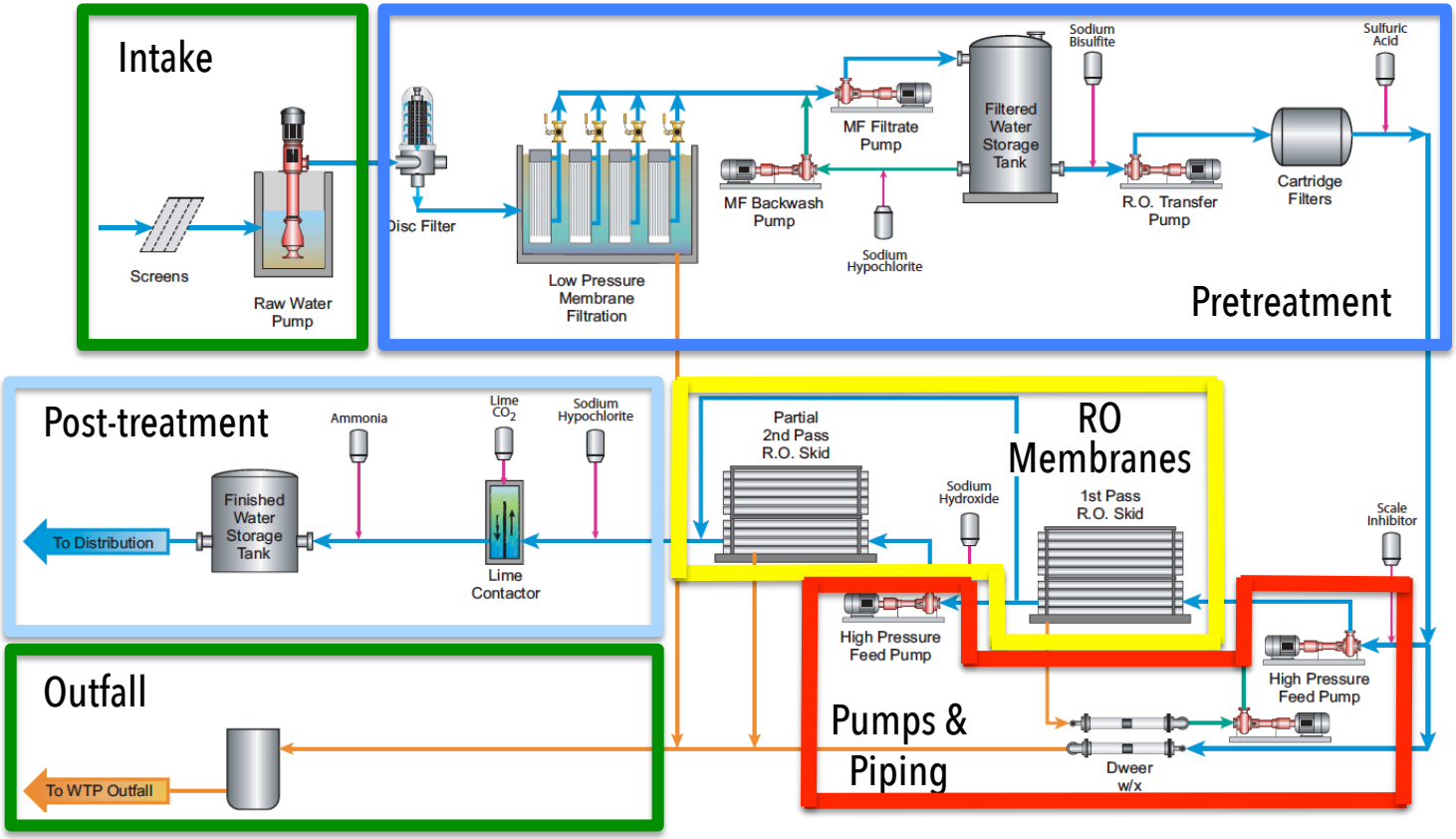
Barrel Installation



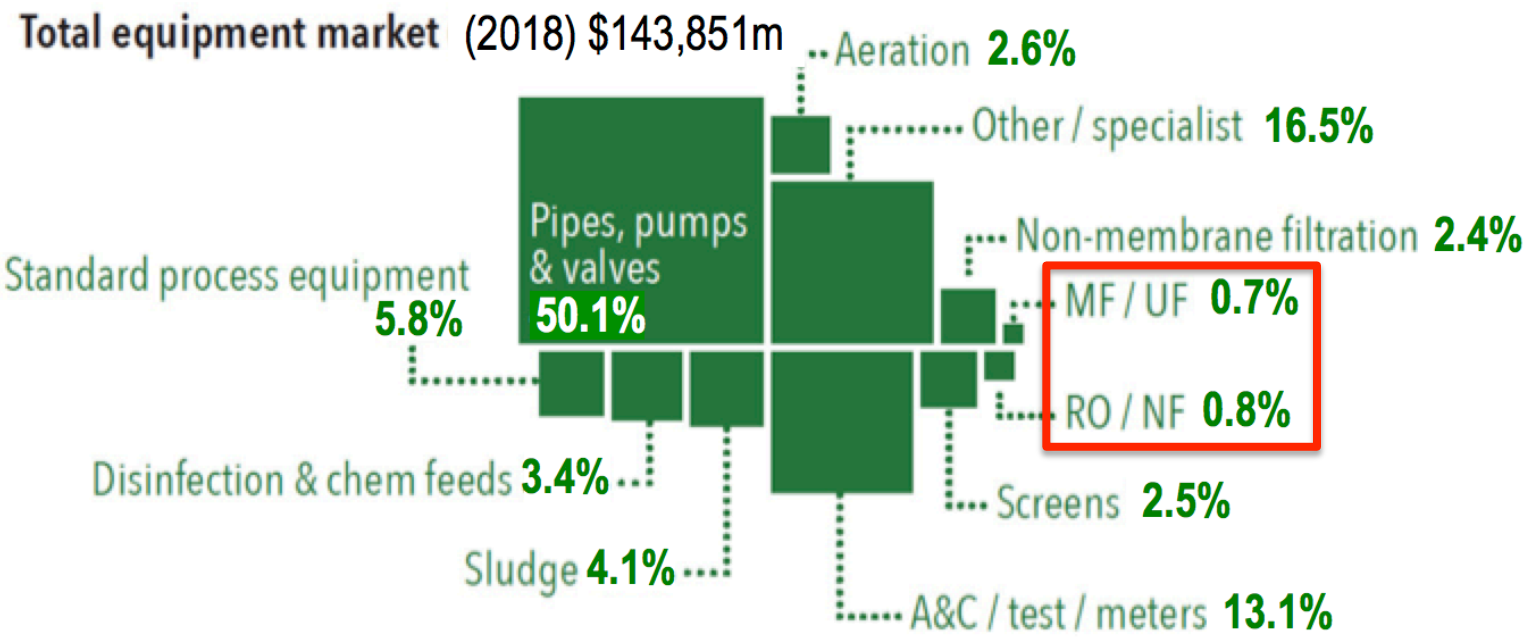
Smart Sensor



Desal is more than just membranes



Global W & WW Equipment Market



Suggestions for Researchers

GLOBAL WATER INTELLIGENCE

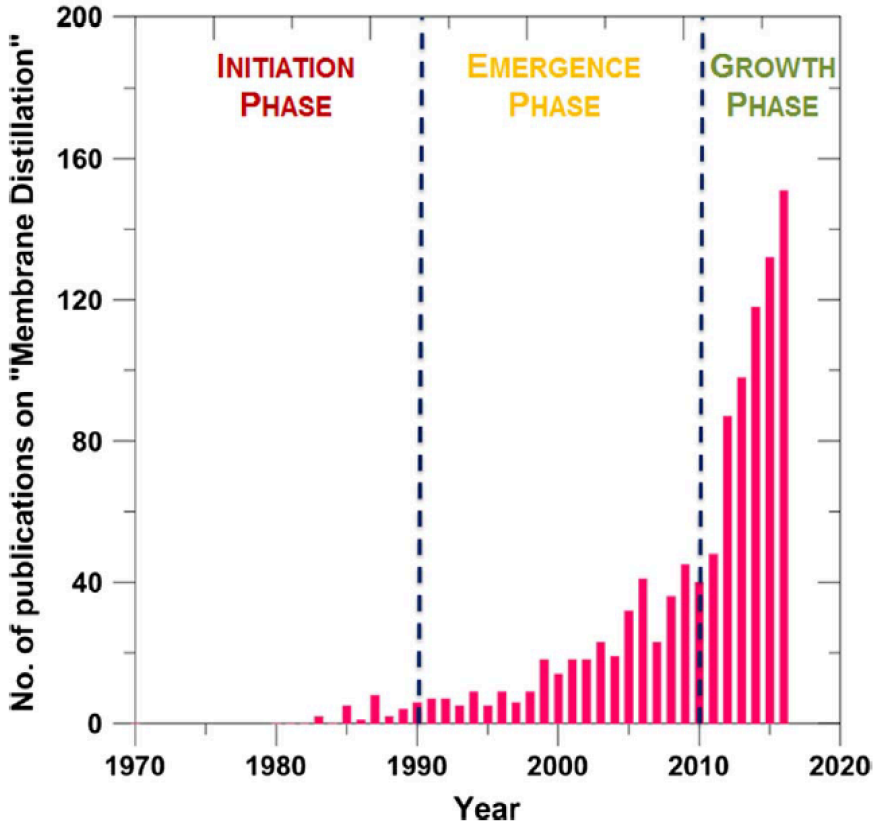
- Visit a desalination plant

Suggestions for Researchers

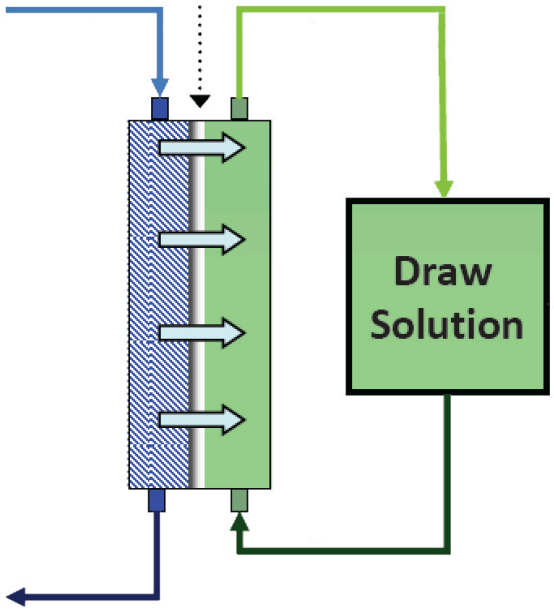
GLOBAL WATER INTELLIGENCE

- Visit a desalination plant
- There's no such thing as waste heat
- For thermal processes: don't forget the Sink
- Don't reinvent the flat tire
- Consider the Big Picture
- Keep strategic goals in mind
- Most improvements involve than one discipline
- Prepare a mass/energy balance

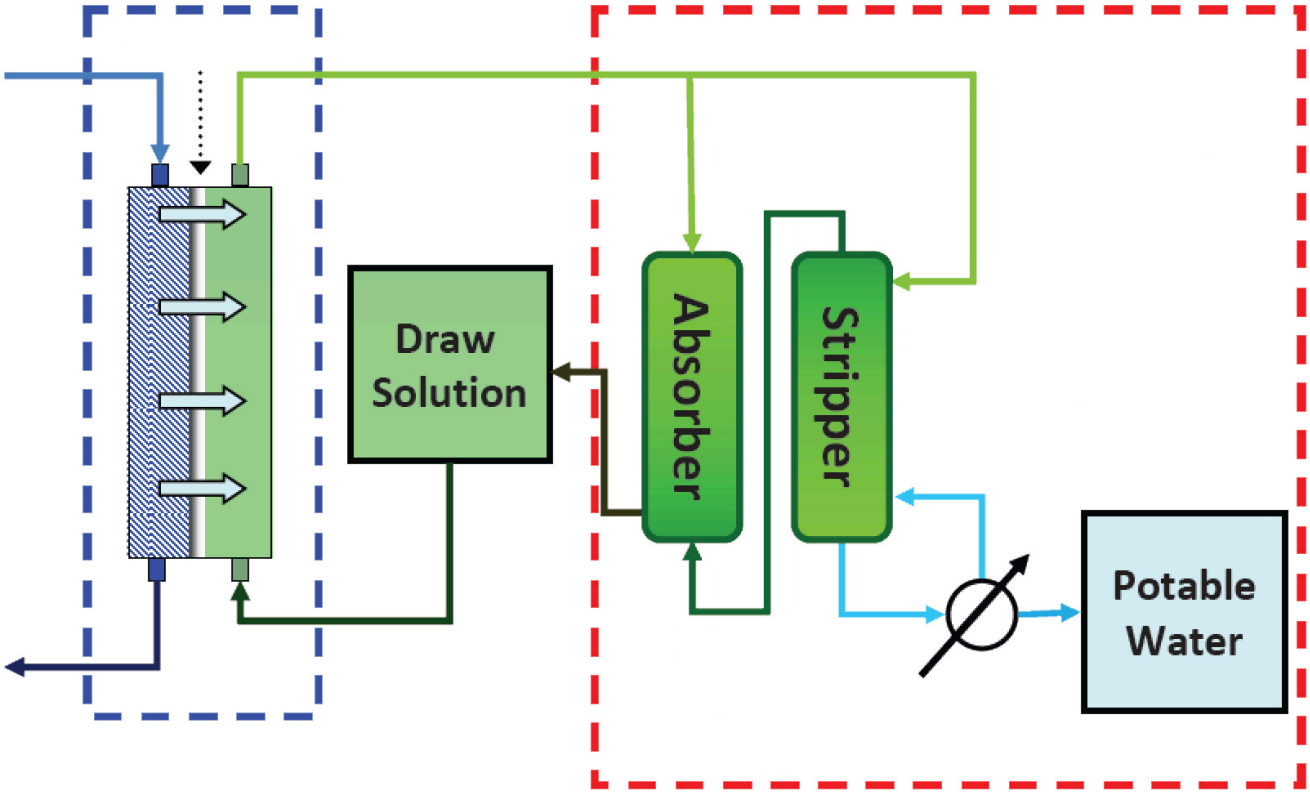
Membrane Distillation Publications



Forward Osmosis (FO) Simplified PFD



More Realistic FO PFD



Suggestions for Reviewers

GLOBAL WATER INTELLIGENCE

- Visit a desalination plant
- Require a full PFD
- Require a mass/energy balance
- Require a Techno-economic Analysis

Desal's Greatest Challenges

GLOBAL WATER INTELLIGENCE

- Membrane Biofouling
- Intake design
- Concentrate management