

An Update on Desalination Technologies

Tom Pankratz, Water Desalination Report

RO Milestones



- 1959 – Loeb & Sourirajan invent RO membrane

RO Milestones



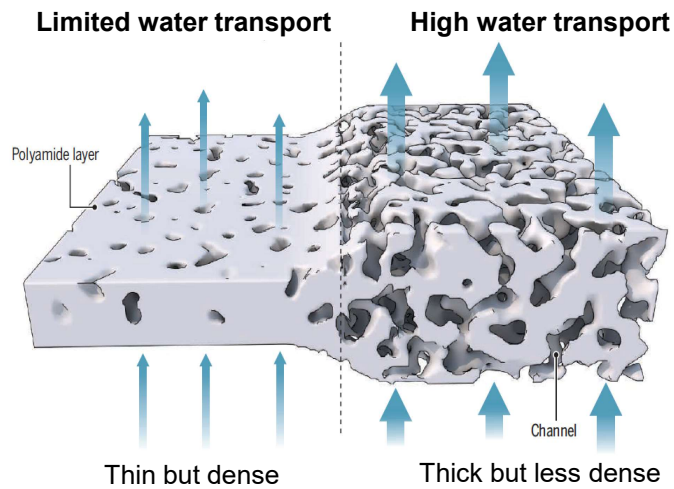
- 1959 – Loeb & Sourirajan invent RO membrane
- 1965 – Fluid Systems' patents multi-leaf spiral element

RO Milestones

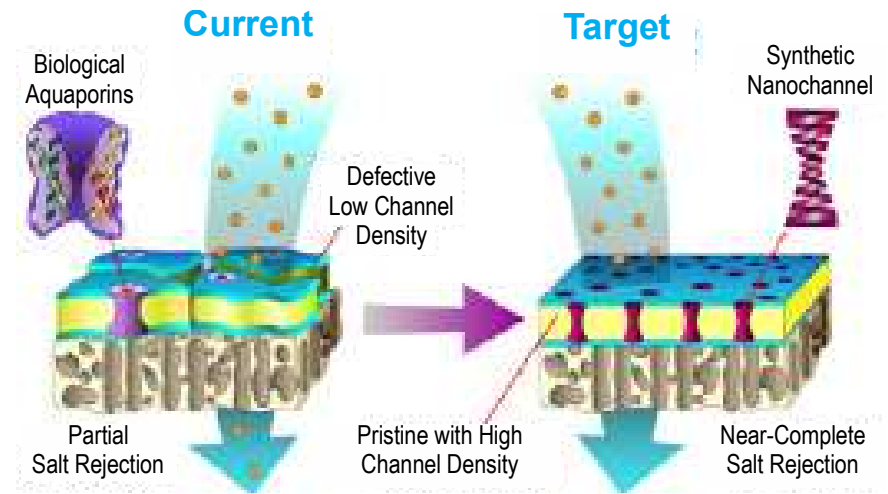
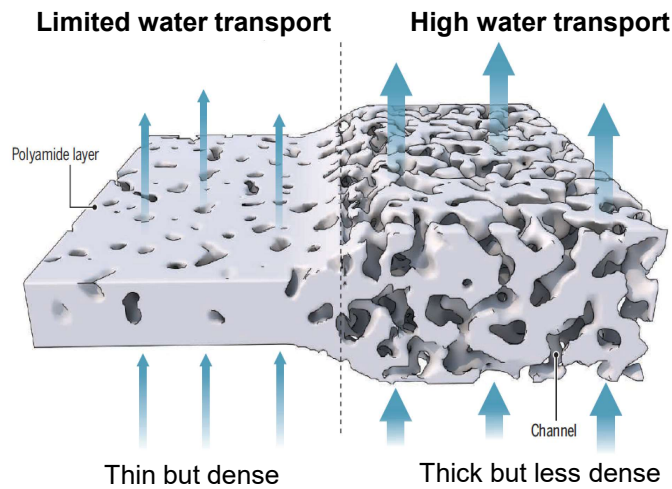


- 1959 – Loeb & Sourirajan invent RO membrane
- 1965 – Fluid Systems' patents multi-leaf spiral element
- 1977 – Cadotte develops thin-film composite membrane

New MEMBRANES



New MEMBRANES



New MEMBRANES

- Chlorine resistant membranes

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**POSSIBLE MEGA RESEARCH
FIELDS FOR REDUCING COST OF DESALINATION**

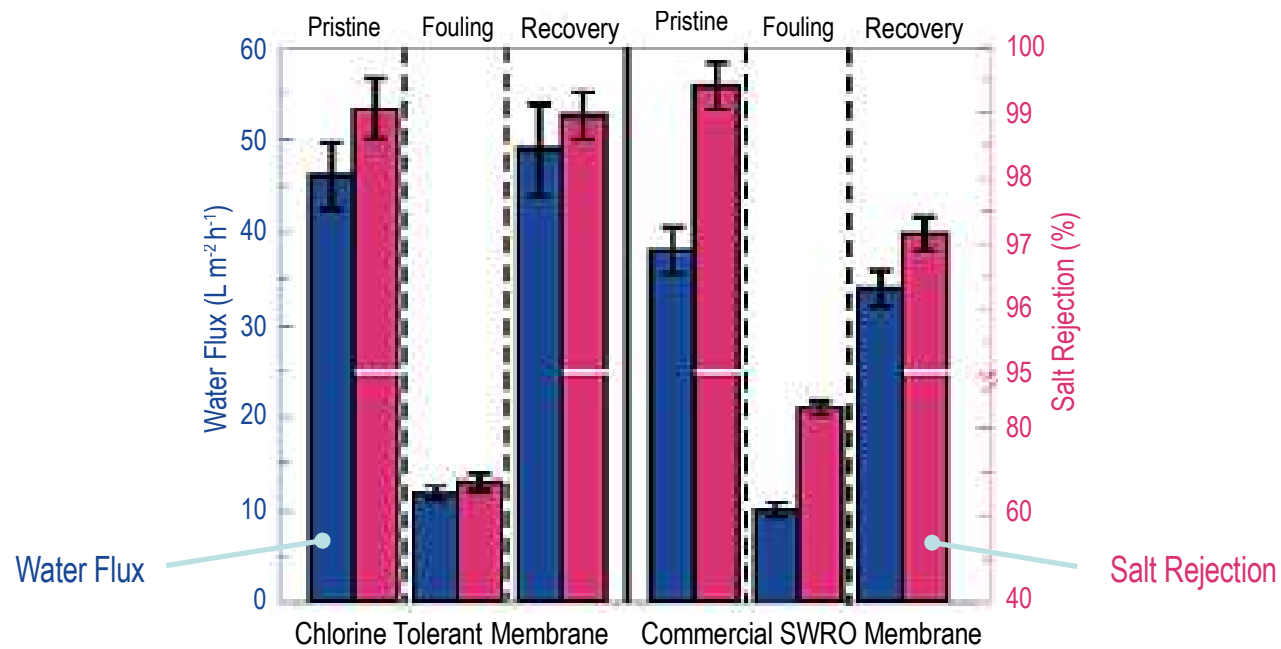
Fields of Research:	Priority (Percentage)*	Likely Cost Reduction (Percentage)	Time Required Years	Research Man/Month (Experts only)
A. DISTILLATION				
1. Scaling prevention techniques for film evaporation	100	+ 25%	3-5YR	6-10 MAN YRS + TECHNICIANS
2. Corrosion reduction including cost reduction of corrosion resistant materials for moving & non-moving parts.	25	+ 10%	2YR	2 MAN YEARS
3. Heat transfer improvement	10	+3-3%	—	DONE
4. Computer modelling for plant design	—	0%	—	DONE
5. Large-scale capacity increase *	5	VARIABLE	5-10YR	?
6. Computer control of processes	—	0%	—	DONE
7. Flexibility of water/electricity production	5	∇ 5%	1-3YR	1 MAN YR
B MEMBRANE PROCESSES				
1. Chlorine resistant sea water membrane	5	+ 3%	3-5YR	UNSURE
2. Feed water disinfection, alternative strategies, e.g. ozone	5	∇ 2%	3-5YR	UNSURE
3. Fouling and scaling mechanisms	25	+ 10%	3-10YR	LOTS
4. Membrane performance in typically variable chemical environments	25	∇ 10%	2-10YR	DEPEND ON NO. OF VARIABLES STUDIED

MAY 9 1995

Call me about it. #MMP amay 95

New MEMBRANES

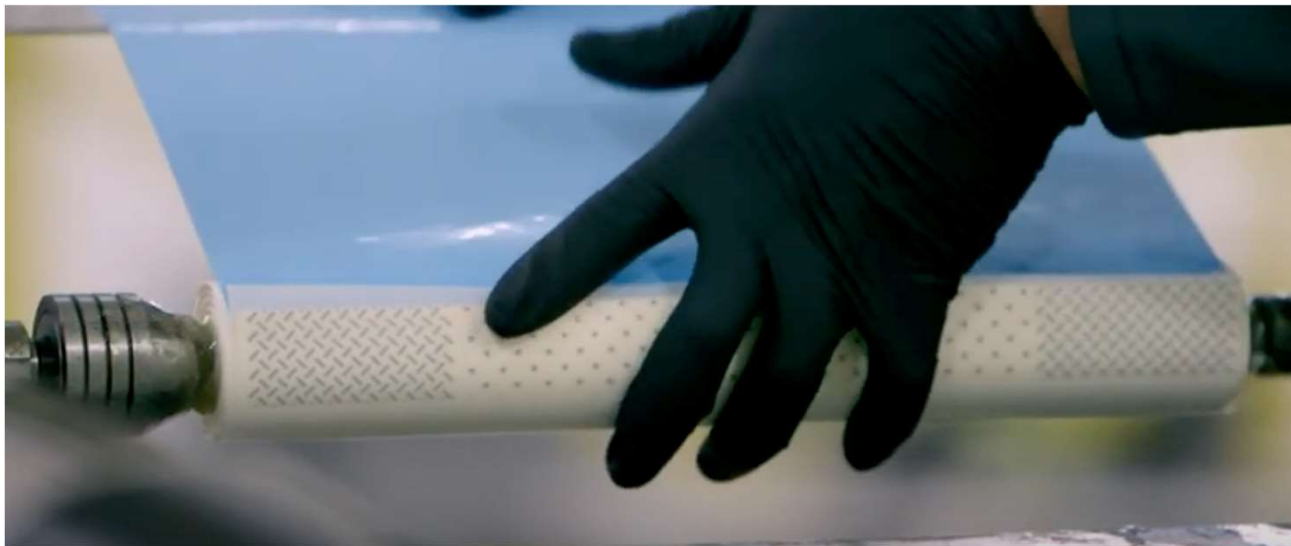
- *Chlorine resistant membranes*



source: Yale University

New MEMBRANES

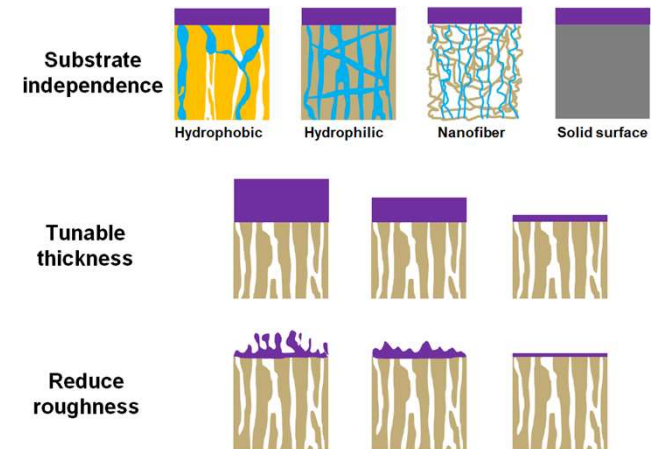
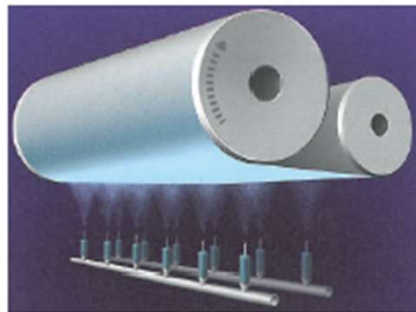
- *Chlorine resistant membranes*
- *3D-printed membrane spacers*



source: Aqua Membranes

New MEMBRANES

- *Chlorine resistant membranes*
- *3D-printed membrane spacers*
- *3D-printed membranes*



source: University of Connecticut

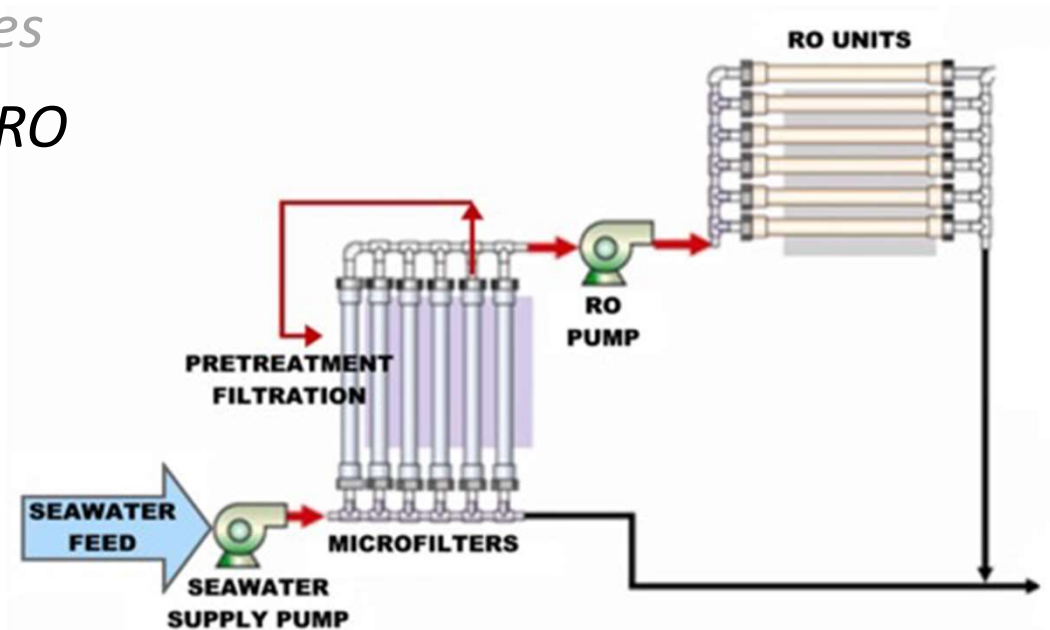
More effective PRETREATMENT



- *Low-pressure membranes*
- *Ceramic membranes*

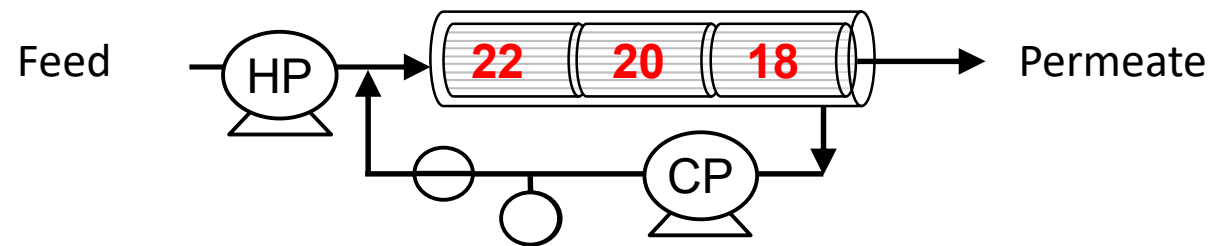
More effective PRETREATMENT

- *Low-pressure membranes*
- *Ceramic membranes*
- *Direct-coupled UF-RO*



New BRINE MANAGEMENT technologies

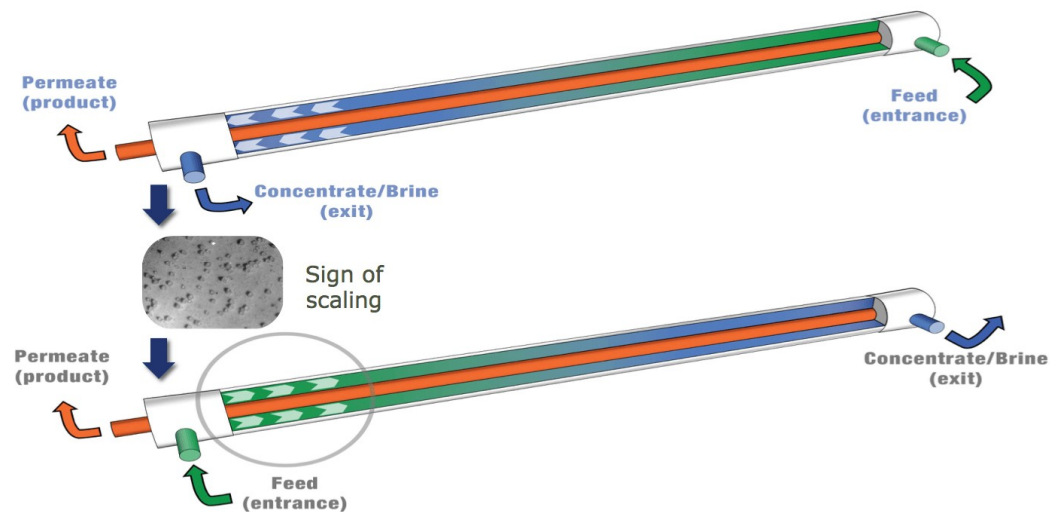
- *Semi-batch technologies*
 - *Closed Circuit RO*



source: DuPont DesalTec

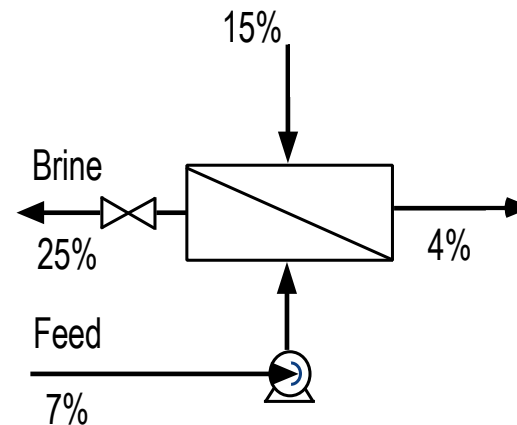
New BRINE MANAGEMENT technologies

- *Semi-batch technologies*
 - *Closed Circuit*
 - *Pulse Flow*
 - *Reverse Flow*



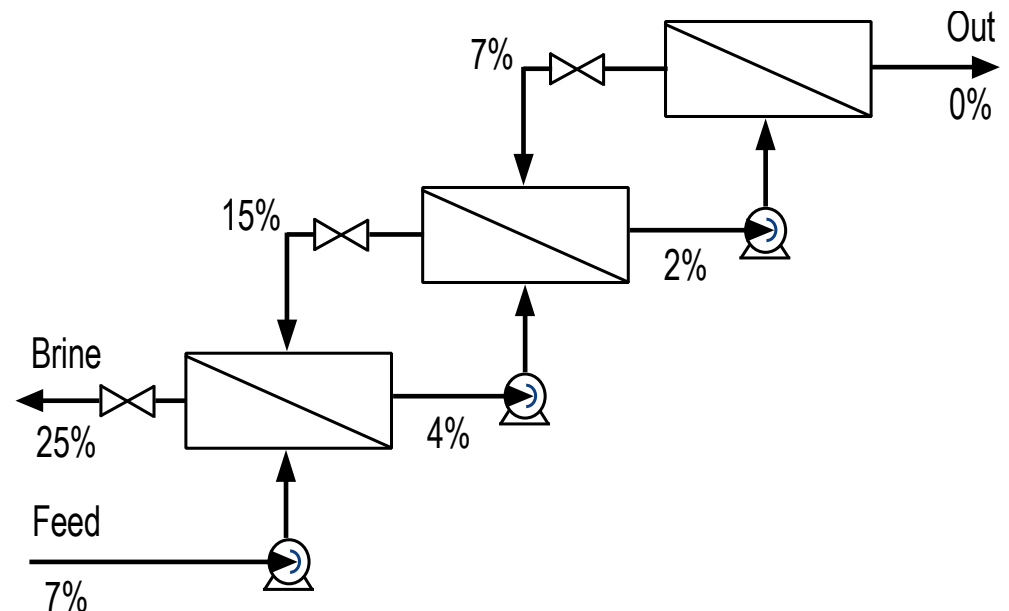
New BRINE MANAGEMENT technologies

- *Semi-batch technologies*
 - *Closed Circuit*
 - *Pulse Flow*
 - *Reverse Flow*
- *Crossflow RO*



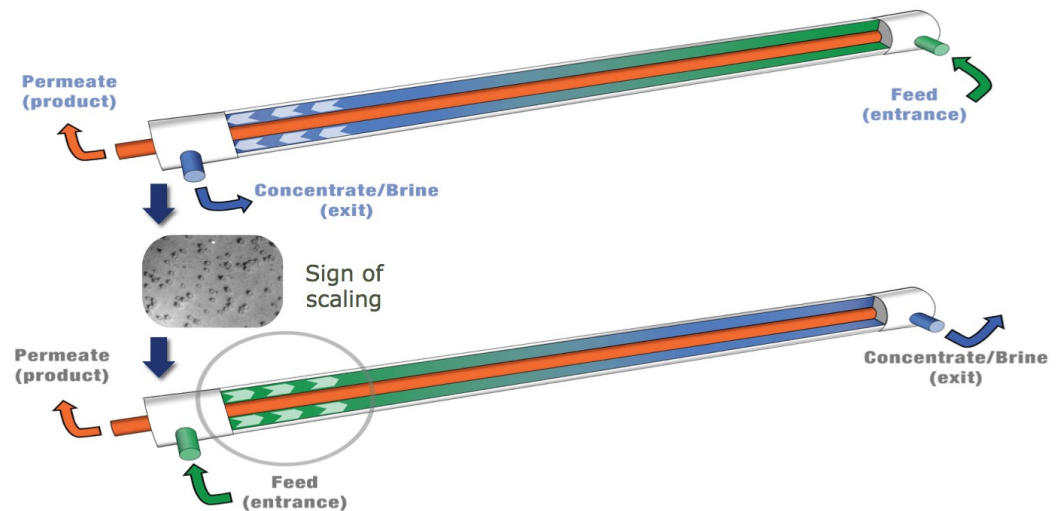
New BRINE MANAGEMENT technologies

- *Semi-batch technologies*
 - *Closed Circuit*
 - *Pulse Flow*
 - *Reverse Flow*
- *Crossflow RO*



New BRINE MANAGEMENT technologies

- *Semi-batch technologies*
 - *Closed Circuit*
 - *Counterflow RO*
 - *Pulse Flow*
 - *Reverse Flow*



DIGITAL desalination

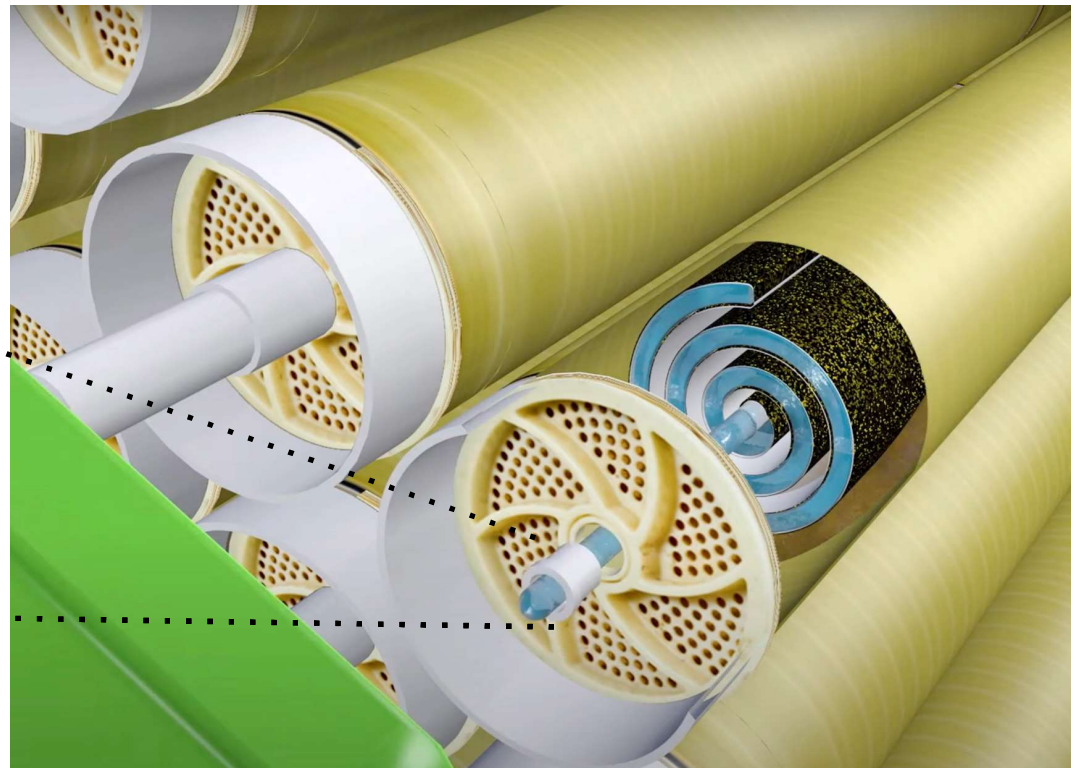


DIGITAL desalination

- *New Sensors*



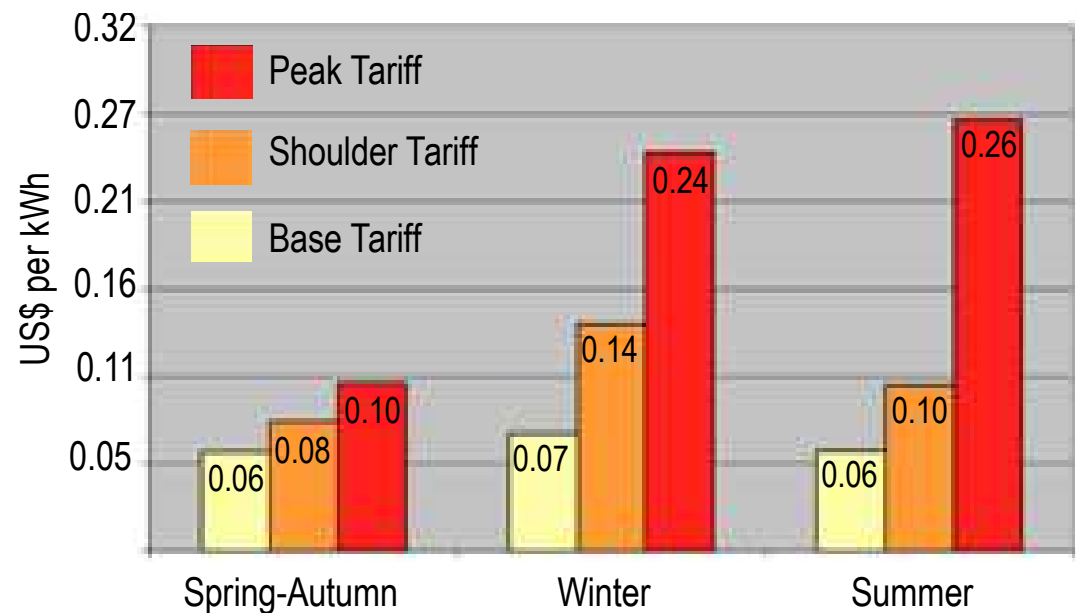
Smart Connector



source: Veolia

DIGITAL desalination

- *New Sensors*
- *Artificial Intelligence*
- *Machine Learning*



DIGITAL desalination

- *New Sensors*
- *Artificial Intelligence*
- *Machine Learning*
- *Digital Twinning*



Innovative FORM FACTOR

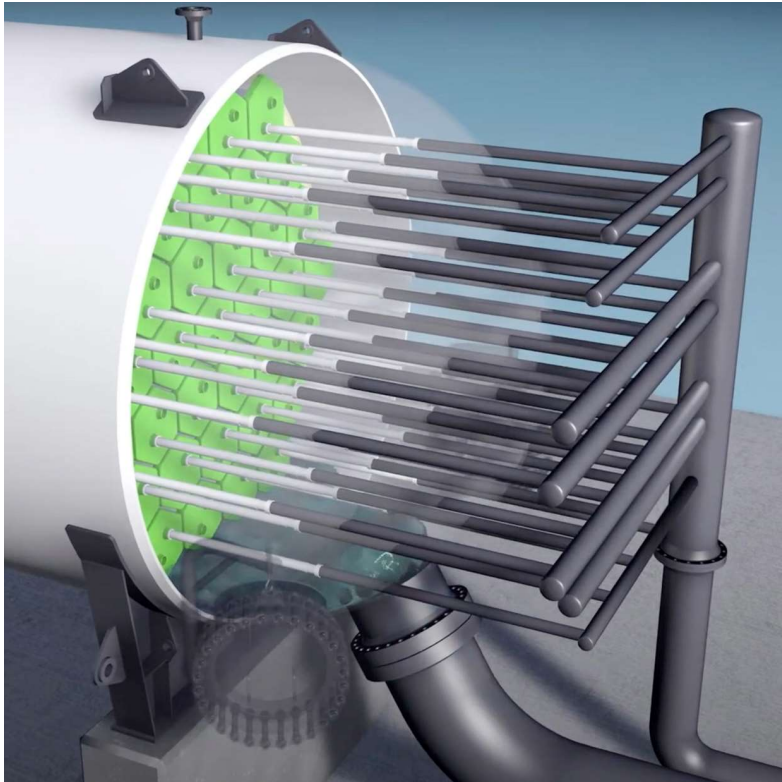


The Barrel



source: Veolia

The Barrel

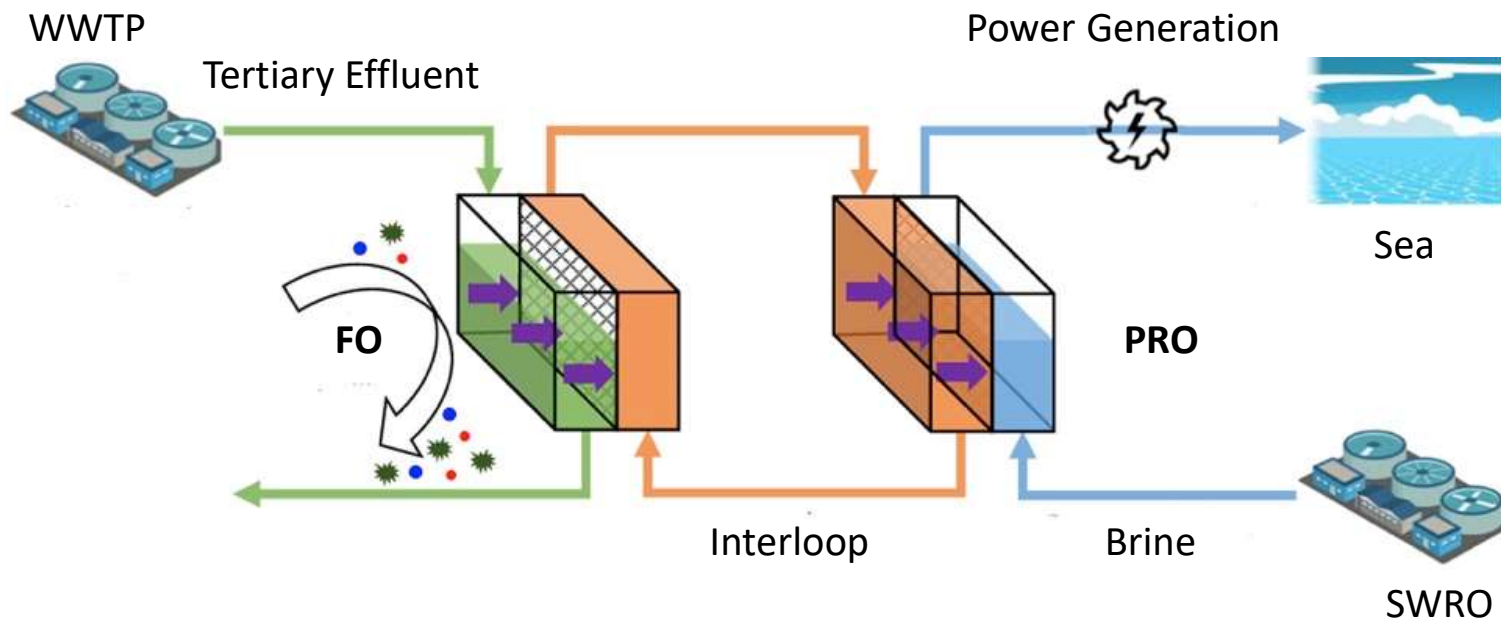


source: Veolia

HYBRIDIZED arrangements



Pressure Retarded RO – Osmotic Power



Other Innovations



- Electrochemical processes (>selectivity)
- Integrating renewables
- Procurement strategies (DB, BOTs)
- NGS