



Challenges and Trends Forward in Desalination

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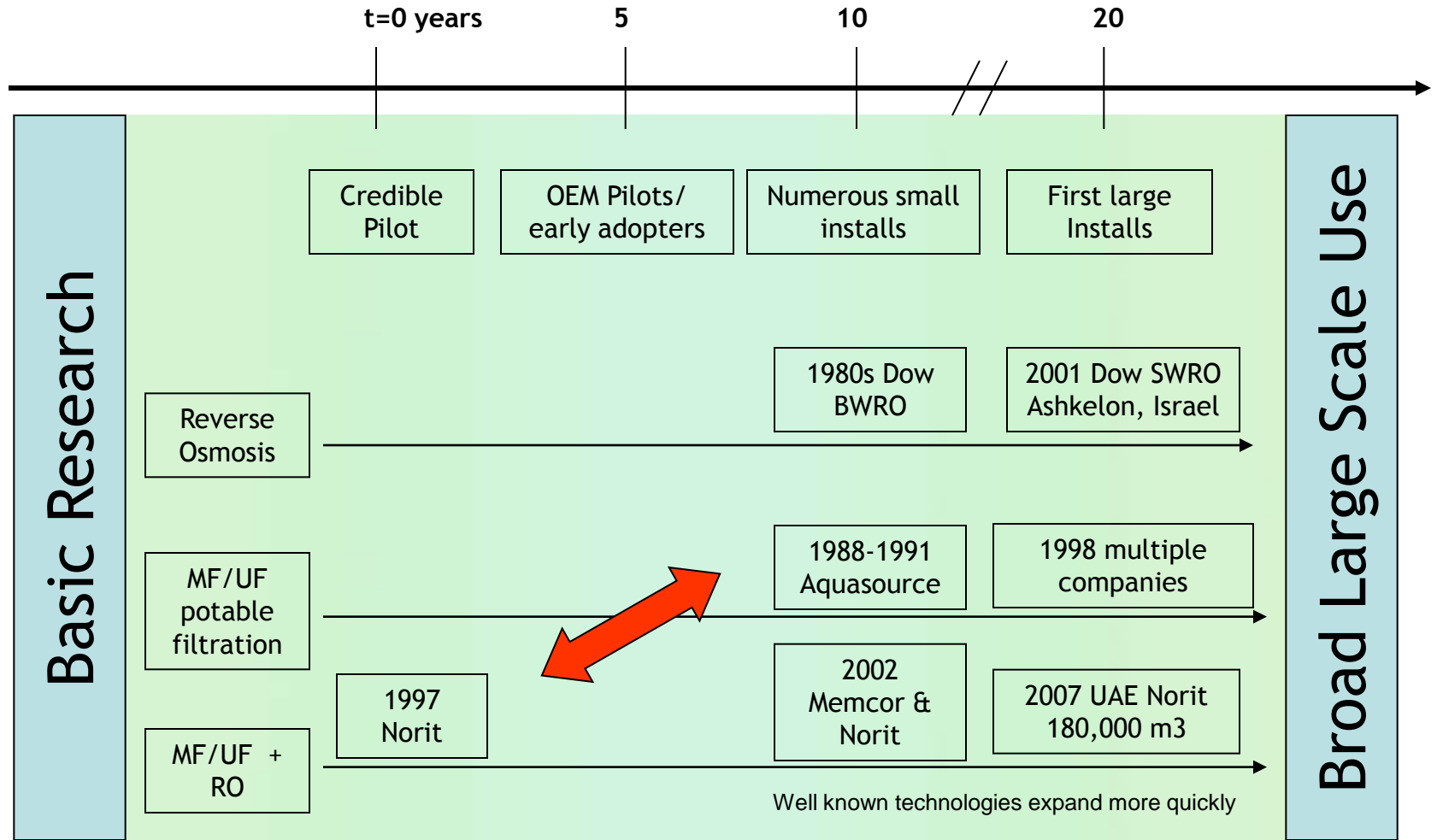
Overview

- Reverse Osmosis for 30 More Years
- Challenges With Alternative Technologies
- Reverse Osmosis Process Innovations
 - BWRO
 - SWRO





Market Adoption Timelines



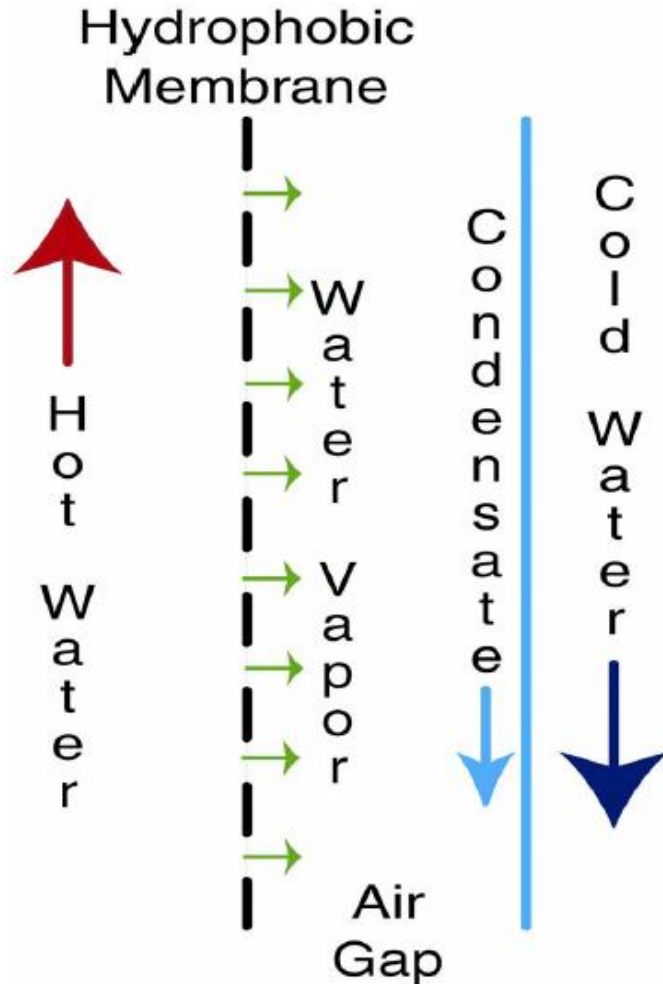


CAPEX Intensive Industries Change Slowly

- Need a credible CAPEX/OPEX story
- Risk avoidance
 - Requires long term demonstration
- Lack of trained field engineers



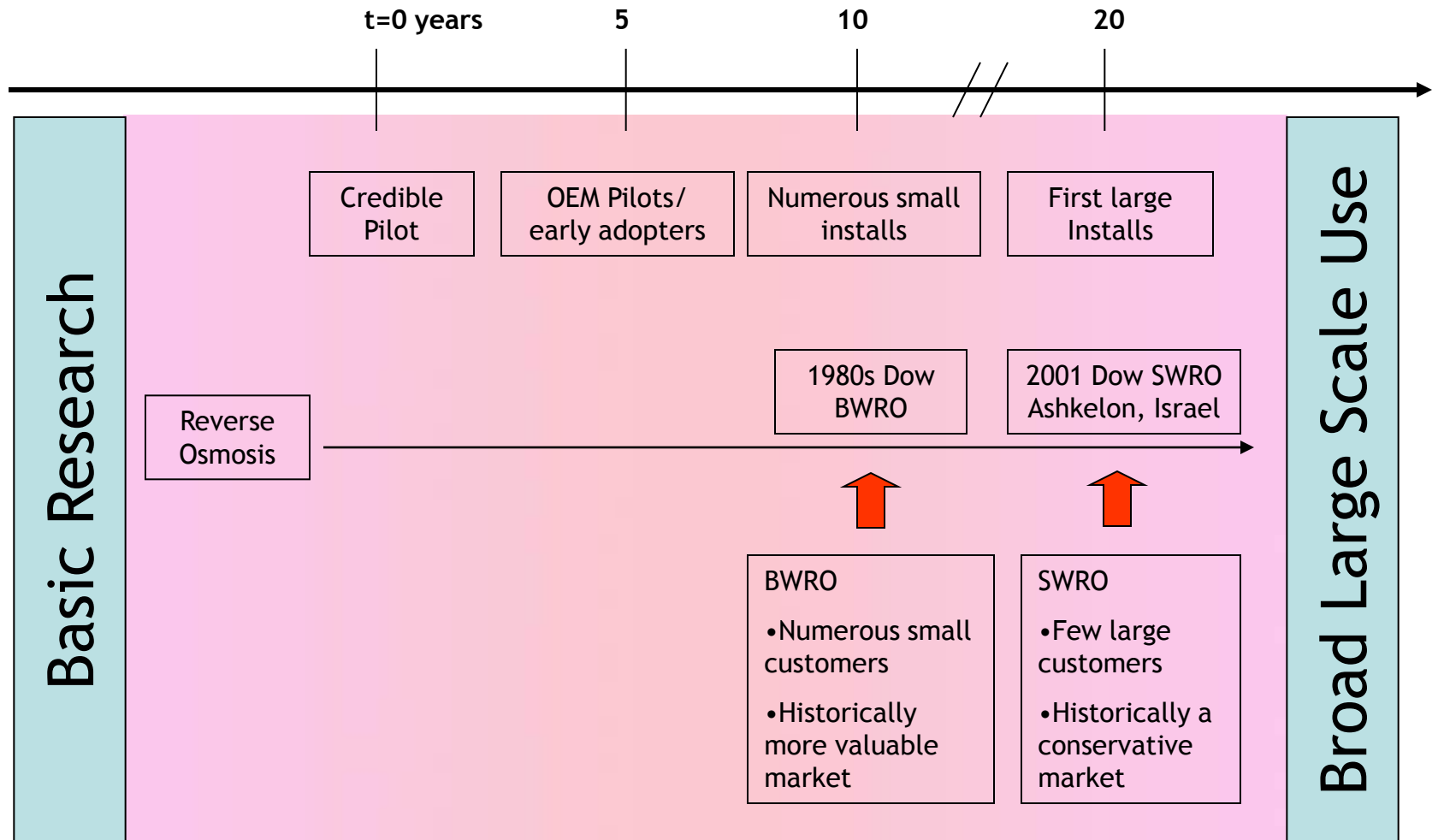
Membrane Distillation



- Reliance on waste or solar heat which limits the market
- Concern: “We just need a better membrane”
- Currently no credible pilot
- By history, needs at least 20 years after a credible pilot to become prominent



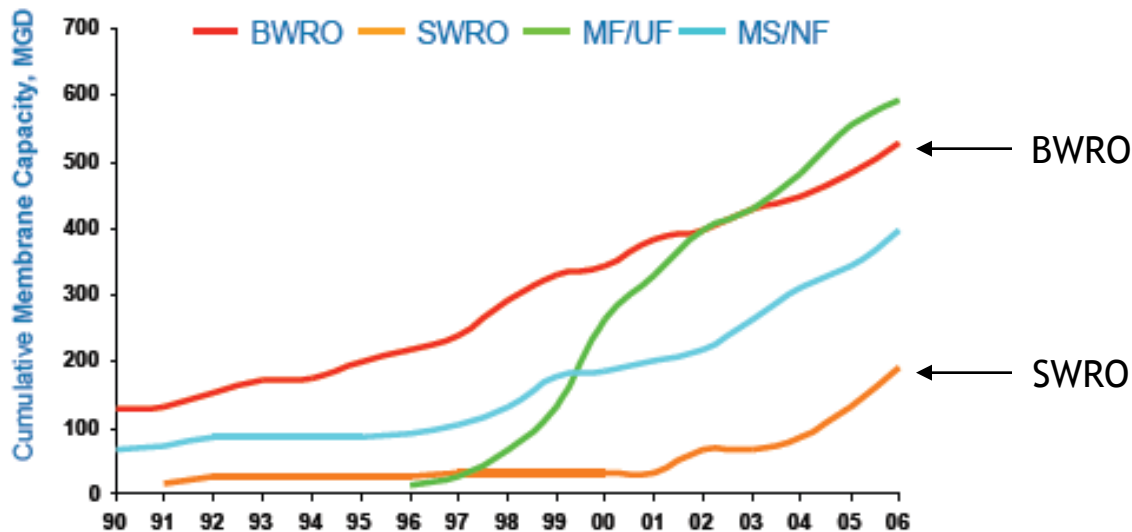
BWRO Adoption Always First





Global Desalination Capacity Mostly BWRO than SWRO

US Installed Membrane Capacity



Global Trend Is The Same

-Tom Pankratz, GWI
2009 Memphis Tenn AWWA Membrane Conference

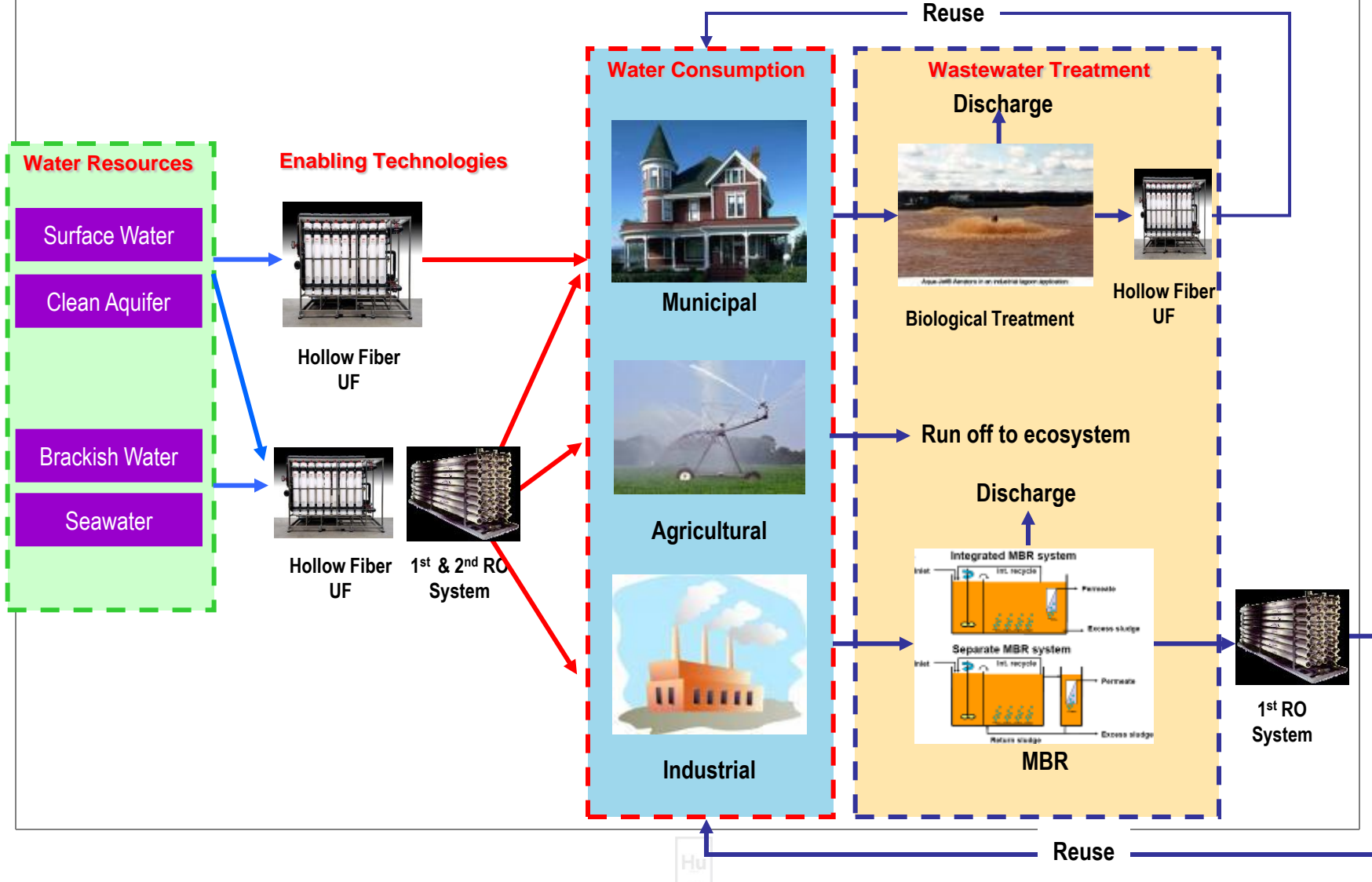
The market size for BWRO historically supported more R&D



Water & Process Solutions

BWRO Trends

Municipal Prioritized, Industry Reuses First





BWRO Reuse Large Plants

Year	Location	RO Permeate (m3/day)
2003-2010	NEWater, Singapore	>200,000
2005	Sulaibiya, Kuwait	320,000
2008	Luggage Point, Australia	66,000
2008	Orange County, USA	252,000
2010+	West Basin, CA	62,000

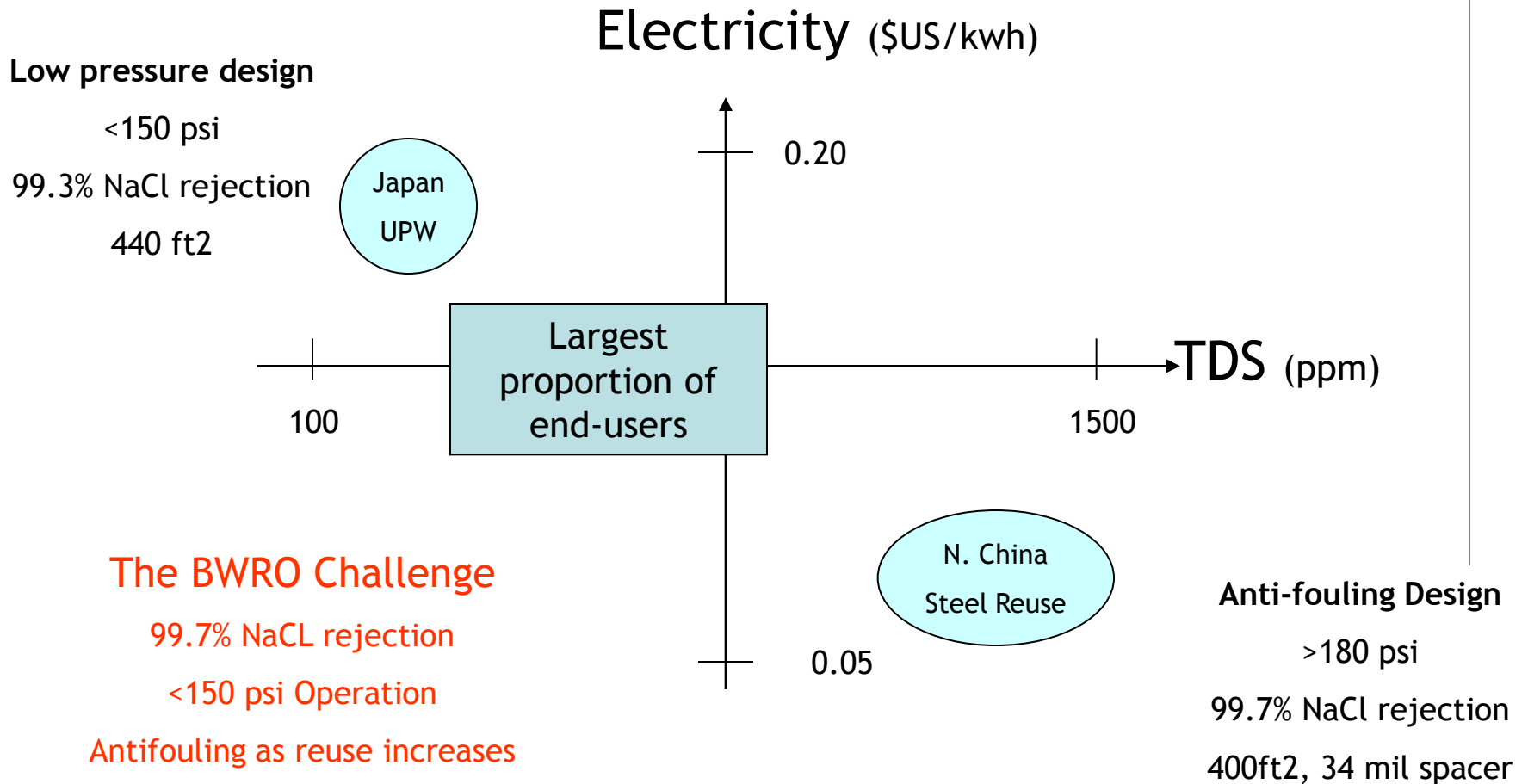
- Large BWRO plants imply a large number of smaller installations.
- Unlike SWRO plants which are mostly large, reuse plant are mostly small and provide a large number of early adopters for new technologies.





Trends in BWRO

Antifouling, High Rejection, Low Energy



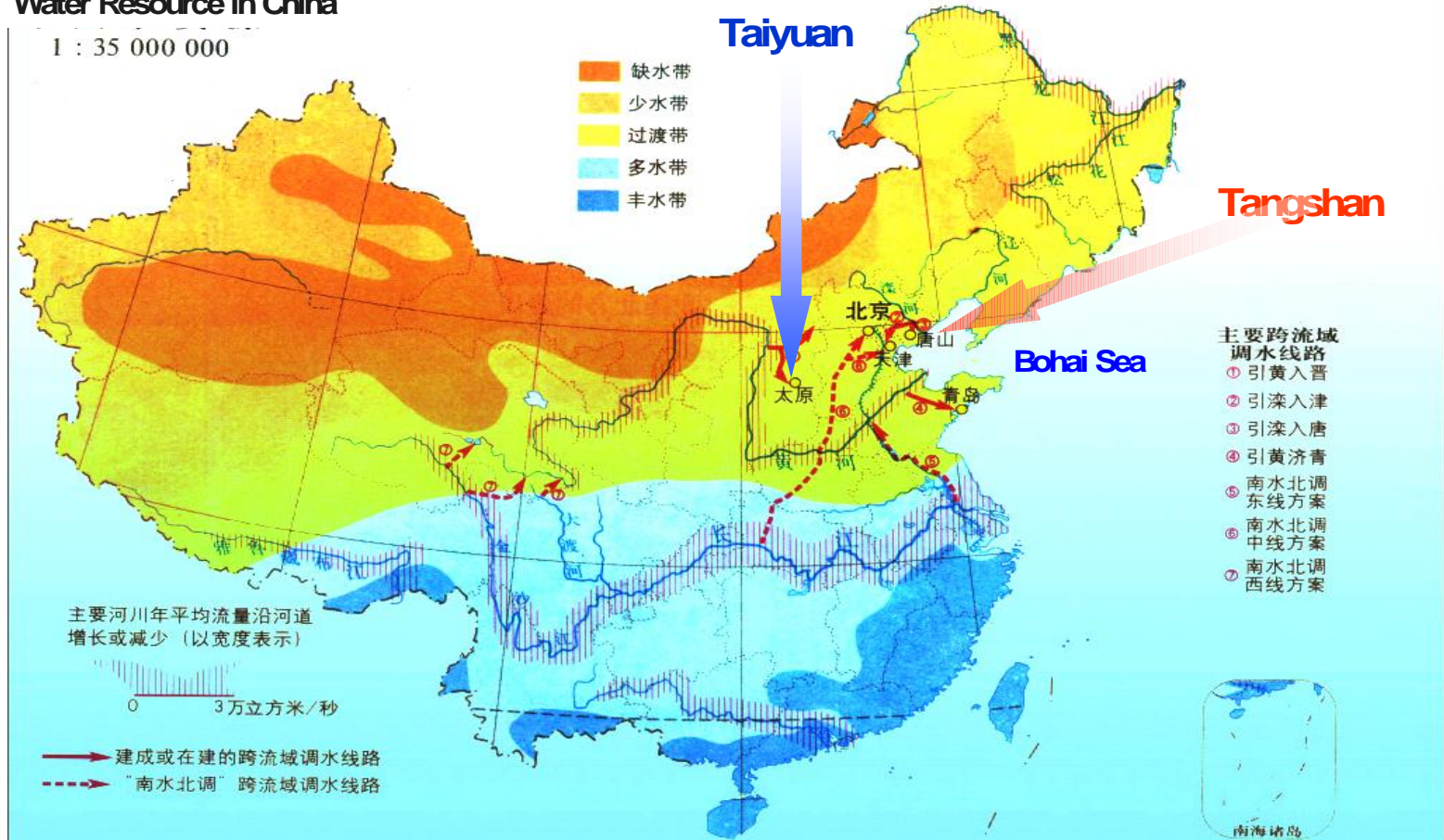


China's Water Scarcity

Example of BWRO Reuse

Water Resource in China

1 : 35 000 000



Note: The color change from light blue to red means that water scarcity is becoming more and more serious.



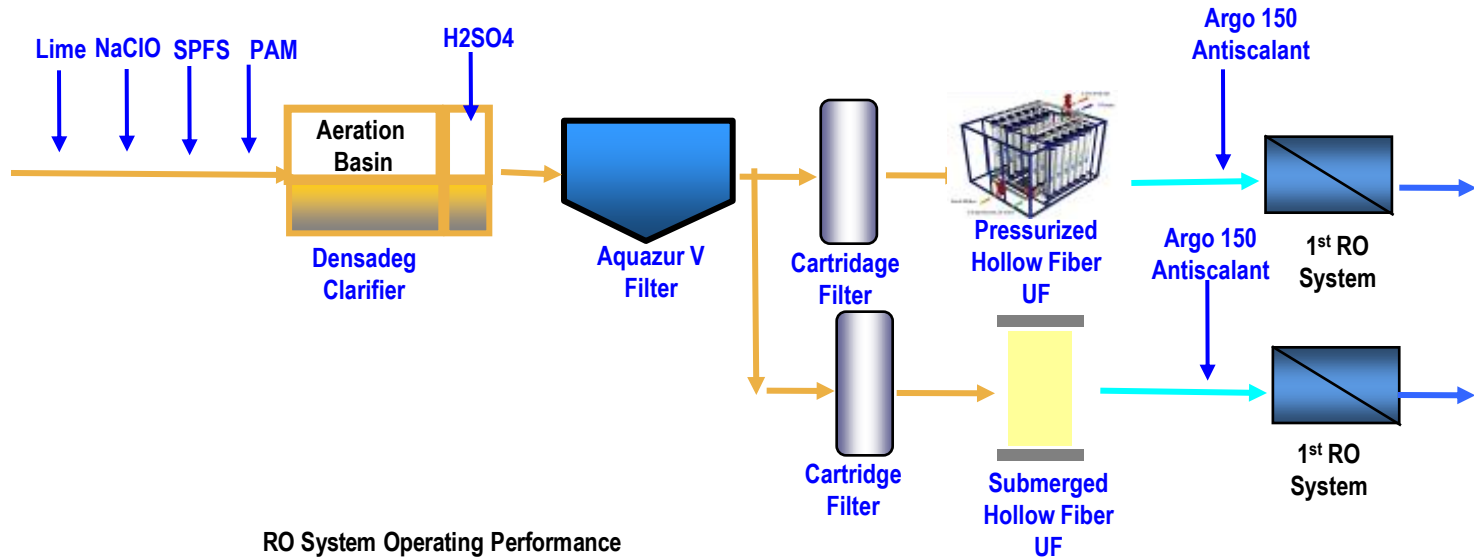
Prevalent Technology for WRU

Highest Reuse Industry in China

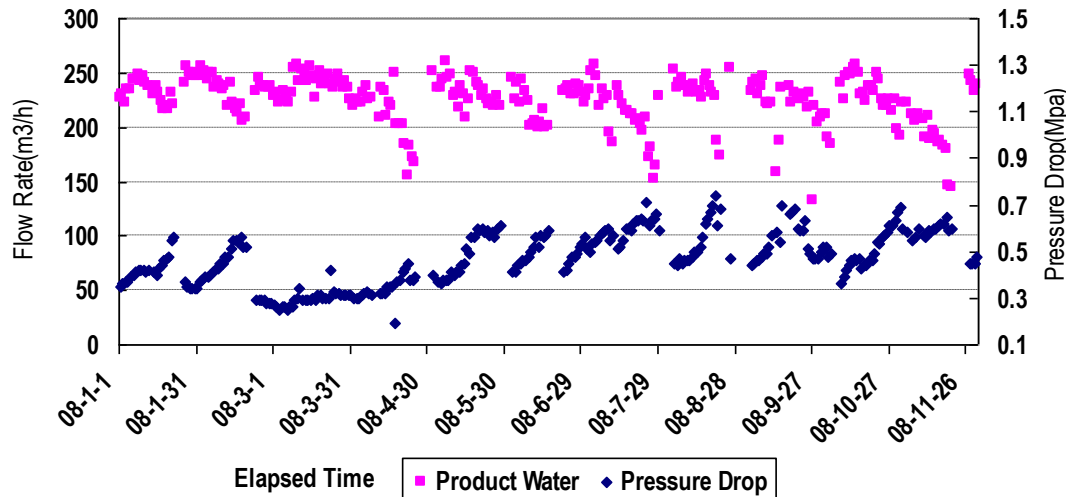
Plant name	Location	Capacity m ³ /day	Year	Pretreatment	RO Element
Taiyuan Steel	Taiyuan Shanxi	38,400	2003	Oxidization + Coag/ Floc+ MMF+ UF	Filmtec BW30-365FR BW30-400FR
Handan Steel	Handan Hebei	43,200	2005 2006	Clarifier + V Filter + UF	Filmtec BW30-400FR
Anyang Steel	Anyang Henan	14,400	2006	Clarifier + V Filter + MMF	Filmtec BW30-365FR
Shoudu Steel	BeiJing	12,000	2006	Clarifier + V Filter + UF	BW30-365FR
Anshan Steel	Anshan	14,400		Clarifier + V Filter + UF	BW30-365FR
TangShan Steel	Tangshan Hebei	14,400		MMF	Filmtec BW30-400/34i
Wukuang Yingkou	Yingkou Liaoning	14,400		UF	Filmtec BW30-400FR
Jinan Steel	Jinan Shandong	19,200	2007	UF	Filmtec BW30-365FR
Longda Steel	Zibo Shandong	2,880	2007	Clarifier + Gravity Filter + Fine Sand Filter	Filmtec BW30-400FR



Biofouling – Still One of The Key Failure Modes



RO System Operating Performance



**Extreme Biofouling
Metal Scaling**

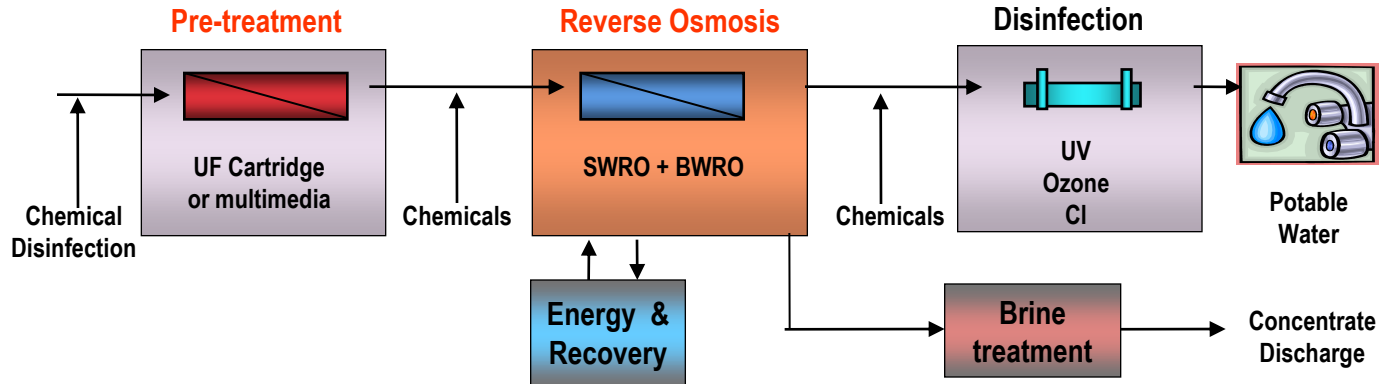


General Industrial Reuse BWRO Needs

- Industry specific solutions
 - Steel & Coking
 - Textiles
 - Pulp & Paper
 - Mining
 - Chemicals/Petrochemicals
 - Food Processing
- New types of chemically & biologically resistant membranes



SWRO Trends

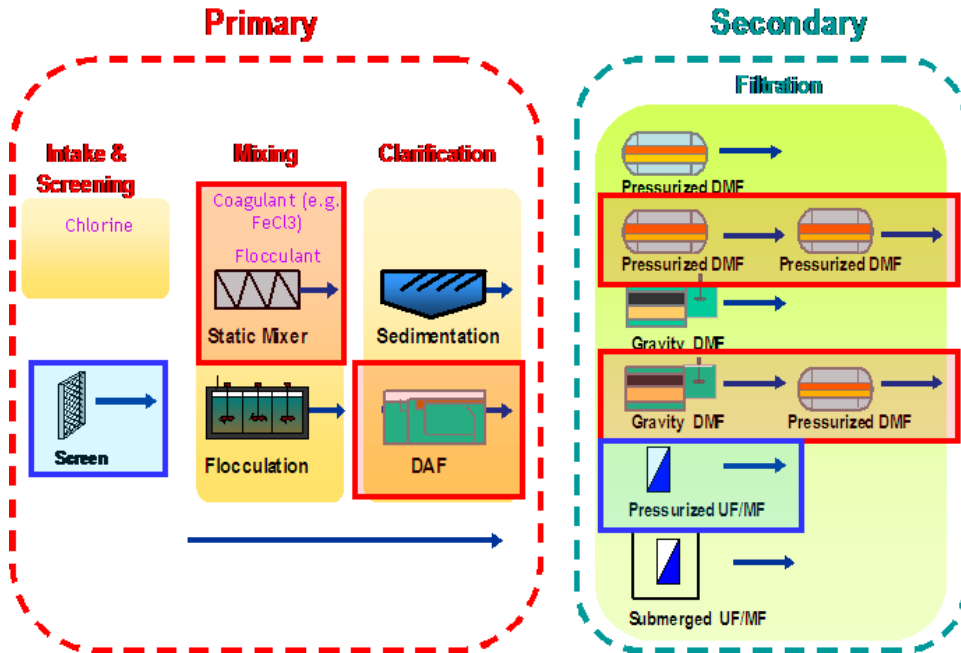


Every Unit Operation Has Major Changes Being Adopted!

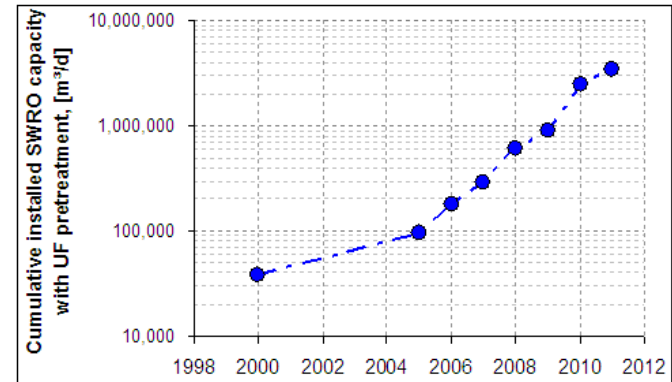
- Integrated Membranes Wide Adoption
- SWRO Advances
- Biofouling Control

SWRO Trends

Pretreatment Moves to Ultrafiltration



UF High CAPEX/Low OPEX



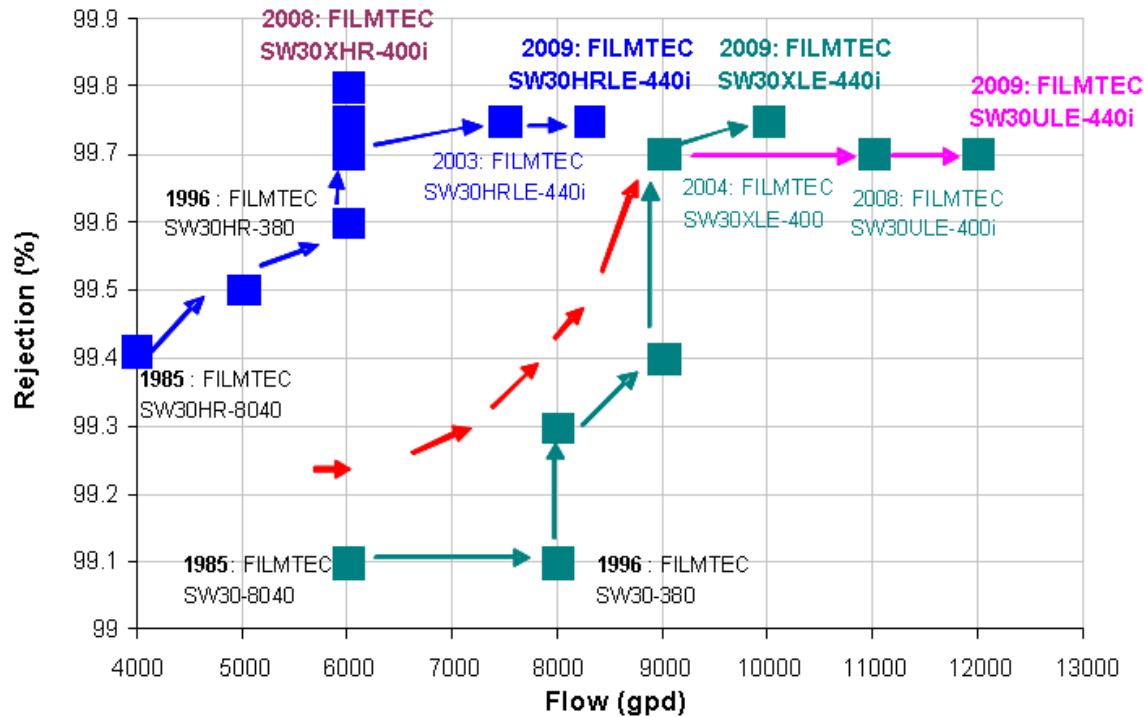
UF is Taking Off

Increased permeability membranes
Improved low chemical operations



SWRO Trends

SWRO Flow/Rejection Continues to Advance



More to come!



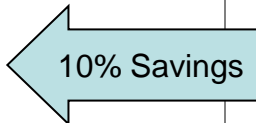
SWRO Trends

SWRO Large Format



Industry Adoption Just Beginning

	Millions of Dollars (\$)		
	8-inch	16-inch	Savings
UF Pretreatment	35.2	35.2	0.0
Seawater RO	70.9	59.6	11.3
Other Process	10.1	10.1	0.0
Infrastructure	32.6	29.4	3.2
Contractor Mark-Up	31.7	28.6	3.1
Contingency	36.1	32.6	3.5
Total	216.6	195.6	21.1



- U.S. Dept. of Interior, DWPR Report 114, "Industry Consortium Analysis of Large RO/NF Element Diameters", 2005.
- Cost Analysis by CH2MHill



SWRO

Biofouling Management

- Significant Research Opportunity
 - Pretreatment optimization
 - Selective organics removal
 - Process control
 - Optimized RO cleaning





Summary

Expectation for RO processes to continue to shave another 30% off the total cost of water.





Water & Process Solutions

Thank You!

