

Novel Membranes and Systems for Industrial and Municipal Water Purification and Reuse

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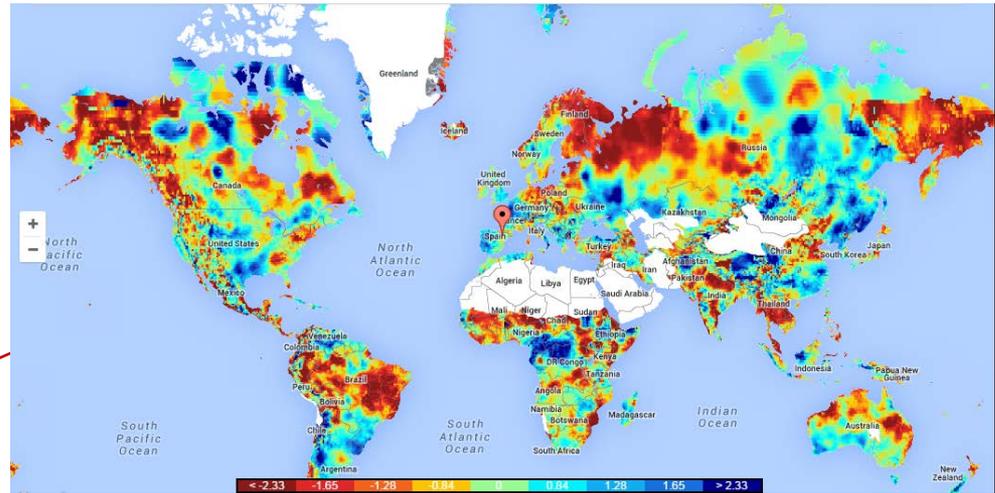
U.S. DOE Advanced Manufacturing Office Program Review Meeting

Washington, D.C.

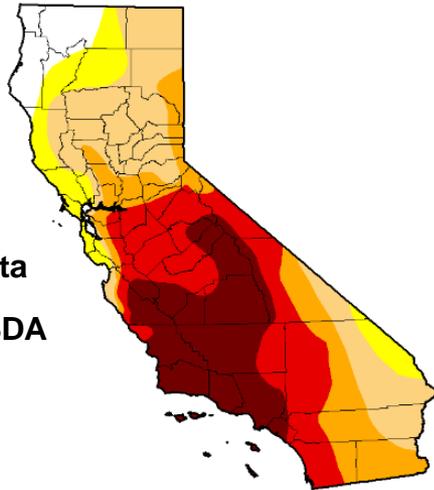
June 14-15, 2016

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Global Drought Map (April 2016)



Source: <http://sac.csic.es/spei/map/maps.html>



May 31, 2016 data

Brad Rippey, USDA

Source: <http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?CA>

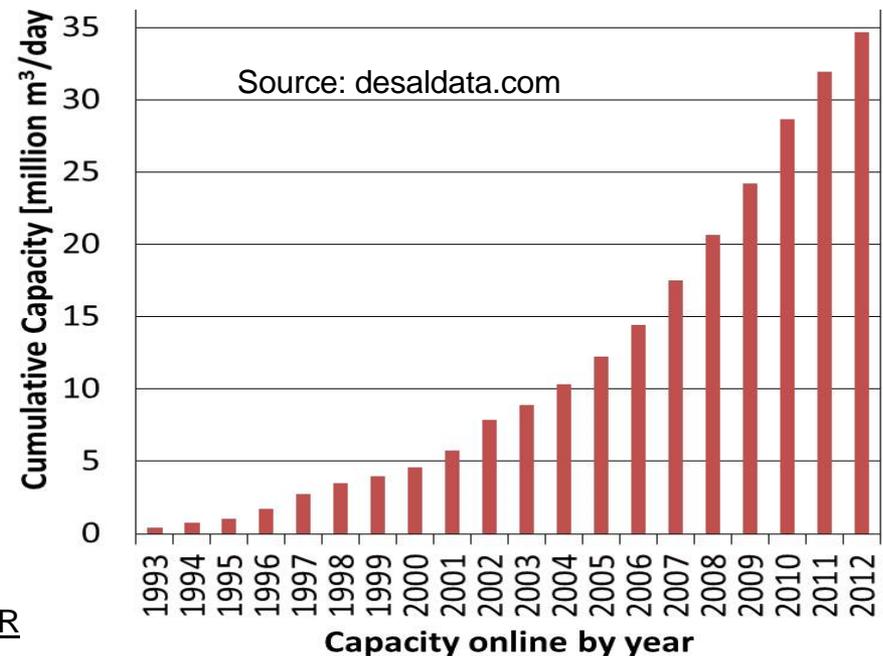
Project Objective

Achieve 50% energy reduction in membrane processes through

- Novel membranes & systems
- Pilot manufacturing process
- Techno-economic analysis

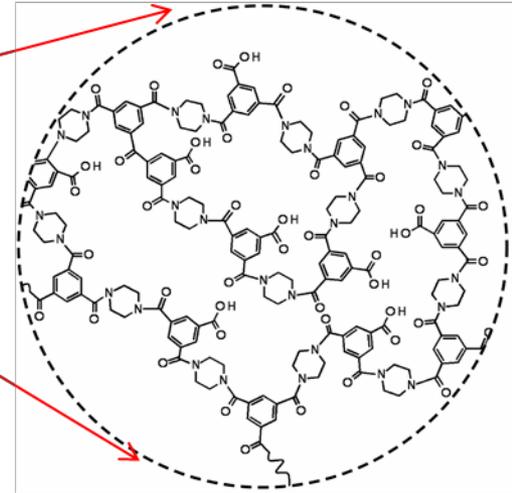
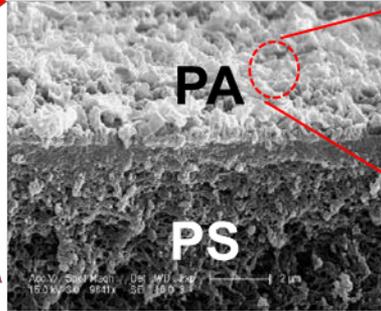
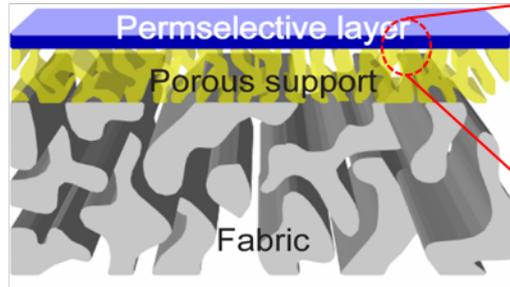
Source: WDR

Growth in Global SWRO Capacity



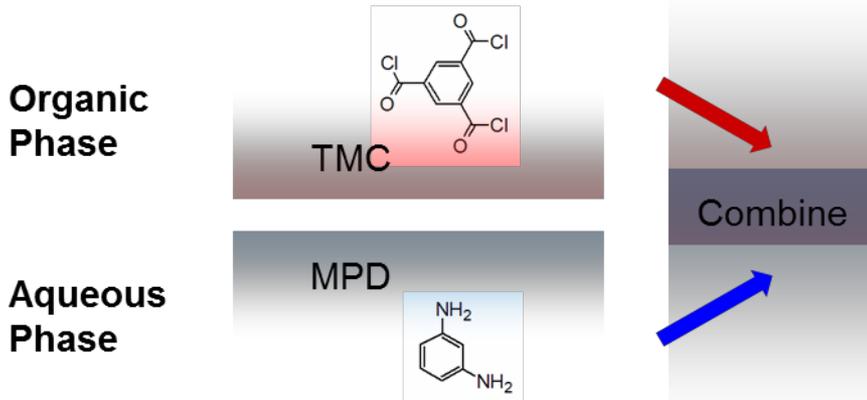
Technical Approach

Conventional RO membrane Structure



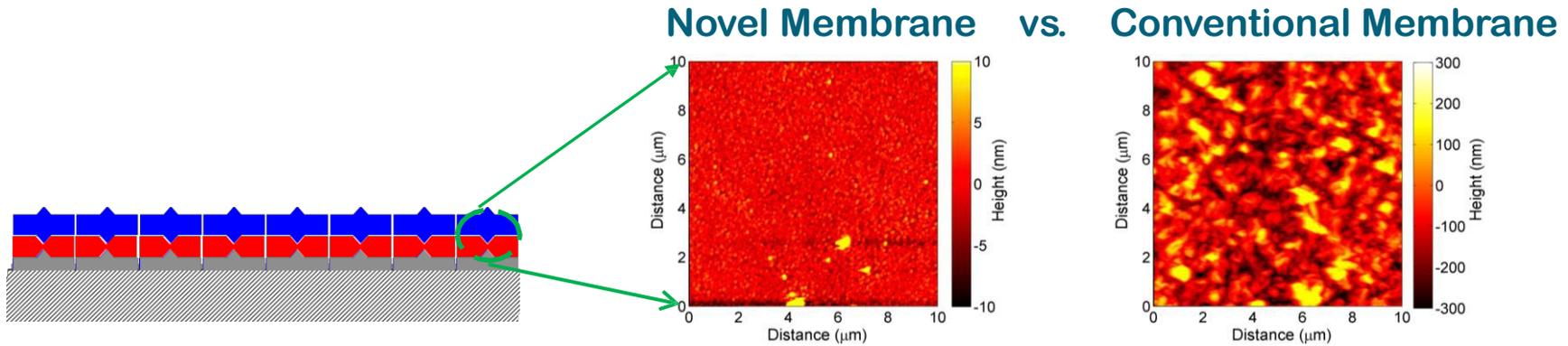
- Thick selective layer
- Lack control

Conventional Interfacial Polymerization of Polyamide



- Water flux $J_w \cong \frac{D_w K_w}{h} (\Delta p - \Delta \pi)$
- Salt flux $J_s \cong K_s D_s \frac{\Delta C_s}{h}$
- Selectivity $\alpha = \frac{J_w}{J_s}$

Technical Approach (continued)

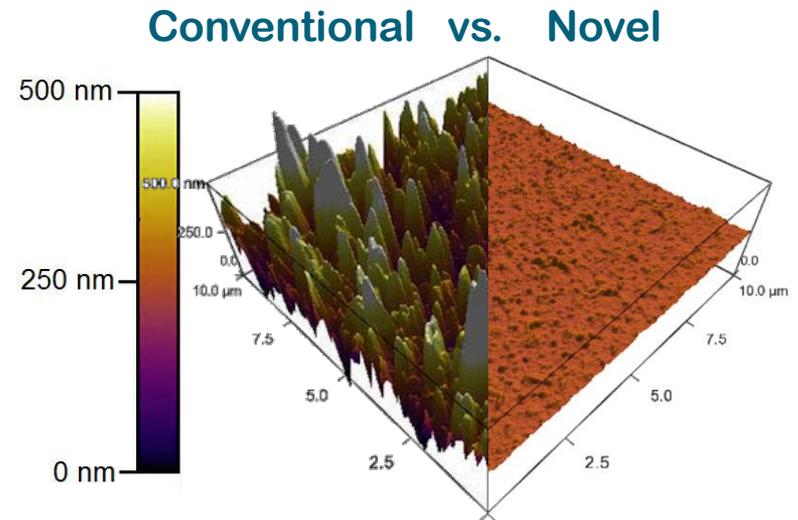


- “Dial-in” film thickness
- Smooth (rms = 3.5 nm)

- Thick (~200 nm)
- Rough (rms = 129 nm)

Novel Approach

- Molecular level control
- Precise thickness & chemistry
 - Thinner
 - Smoother
 - Lower fouling



Transition and Deployment



Impacts to broad sectors

- Industrial (e.g. power, oil & gas, chemical)
- Domestic (municipal, water reuse)
- Agricultural (irrigation, aquifer recharge)
- Energy savings & environmental benefits

Direct impacts to membrane industries

- \$1.4 B RO membranes & elements
- \$5 B RO systems

Transition and Deployment (continued)

Lab-scale development



Pilot-scale mfg. process



Module validation
Techno-economics



NTI & NPI



Sell
Products



DOE Project Scope



GE New Technology/Product Introduction



Measure of Success

Near term

- Achieve technical objectives & milestones
- Demonstrate techno-economic feasibility



Medium term

- Develop commercialization strategy
- Field piloting & demonstration
- New technology/product introduction



Long term

- Commercialization & product sales

Energy savings & economic impacts

- 9 TWh electricity savings potential
- Markets: \$1.4 B membranes & elements, \$5 B systems



Project Management & Budget

Project duration:

34 Months

Dec. 2014 – Oct. 2017

Project Task Structure (simplified)

1. Membrane material development
2. Pilot mfg process development
3. Module performance validation
4. System design optimized
5. Techno-economic analysis
6. Energy savings validation

Total Project Budget

DOE Investment (80%)	\$2,000,000
GE Cost Share (20%)	\$500,000
	\$2,500,000

BP	Status	Major Milestones
BP 1	✓	Q2: Novel thin film materials demonstrated
	✓	Q4: Composite membranes demonstrated
	✓	Q5: Membrane performance specs met (go/no-go)
BP 2		Q7: Roll-to-roll pilot line assembled
		Q9: R2R membrane fab process
		Q9: Technology competitiveness
BP 3		Q10: RO module performance validated
		Q10: RO module performance validated
		Q10: RO module performance validated

Results and Accomplishments

Project Status

- Completed milestones:
Demonstrated novel RO materials
 - linear growth rate & precise thickness control
- Demonstrate composite membrane performance

Work to be completed

- Demonstrate pilot manufacturing process (BP 2)
- Demonstrate module performance
- Validate energy savings (BP 3)

Results

