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

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Project Objective

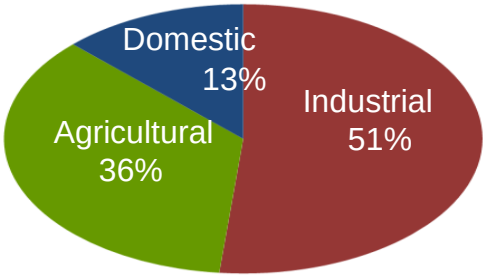
Background

- Water is vital to life and economy
- RO is the leading technology for water desalination and reuse
- US desalination uses over 9 TWh/yr electricity; 2x in 10 years
- Current water supplies will satisfy only 60% of global demand by 2030
- High performance membranes are key to reduce energy consumption

Project Objective

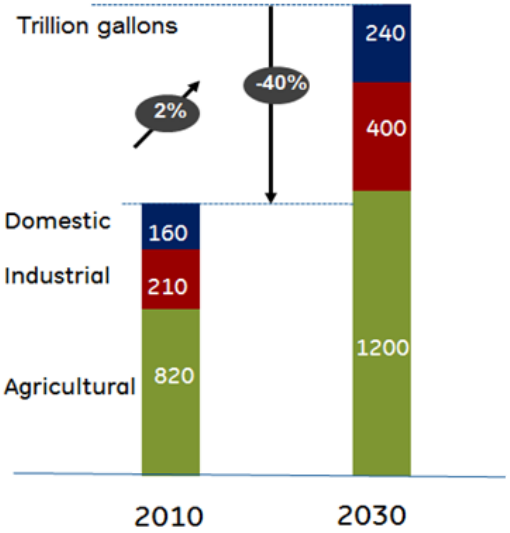
- Achieve 50% energy reduction in membrane processes through
  - Novel membranes & systems
  - Pilot manufacturing process
  - Techno-economic analysis

Total US water withdrawal (2010)



Total 355 billion gallons/day
130 trillion gallons/year
Source: USGS http://water.usgs.gov/watuse/wuto.html

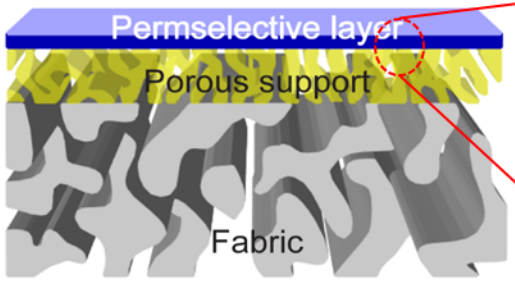
Total global annual water withdrawals

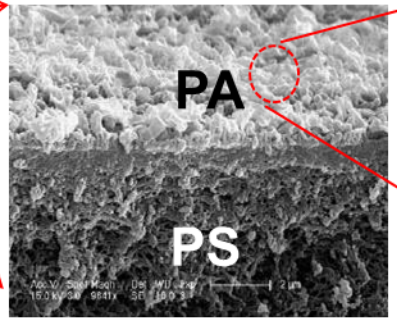


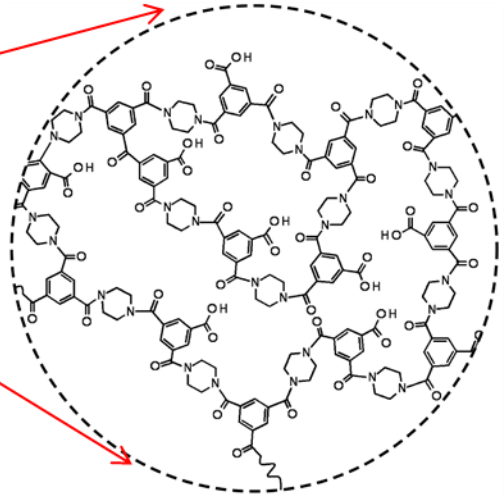
Source: Charting Our Water Future: Economic frameworks to inform decision-making
http://commdev.org/userfiles/Charting_Our_Water_Future_Final.pdf

Technical Approach

Conventional RO membrane Structure

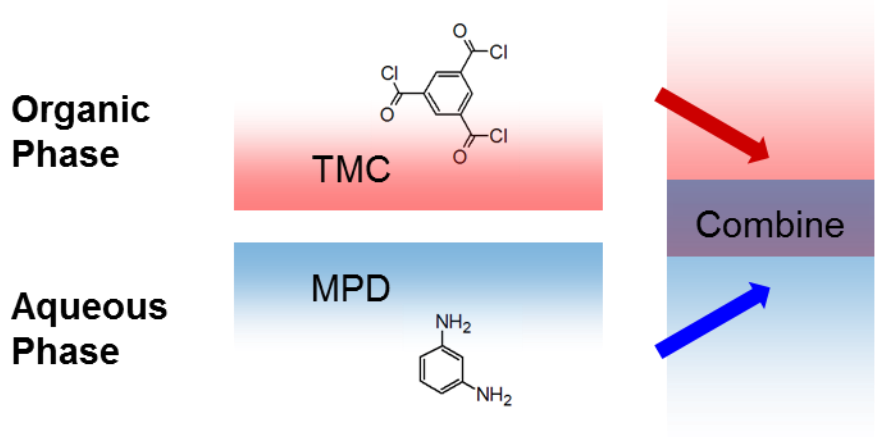






- Thick selective layer
- Lack control

Conventional Interfacial Polymerization of Polyamide

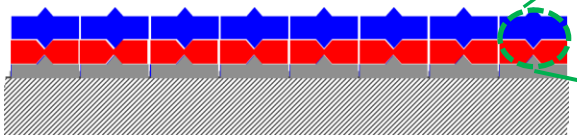


Water flux $J_w \cong \frac{D_w K_w}{h}(\Delta p - \Delta \pi)$

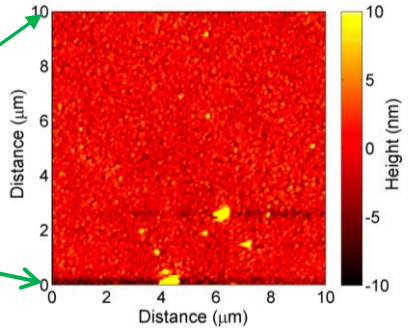
Salt flux $J_s \cong K_s D_s \frac{\Delta C_s}{h}$

Selectivity $\alpha = \frac{J_w}{J_s}$

Technical Approach (continued)

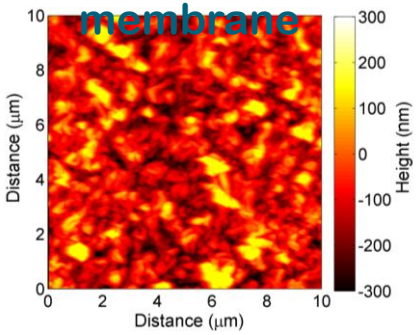


Novel membrane



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

vs. Conventional membrane

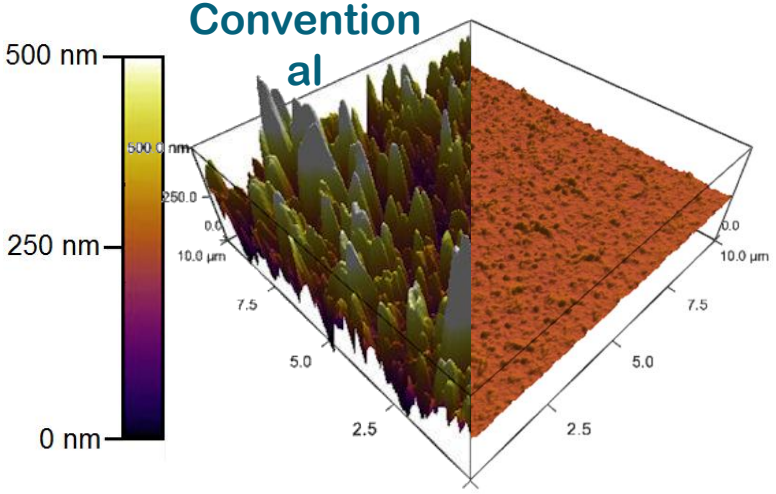


- Thick (~200 nm)
- Rough (rms = 129 nm)

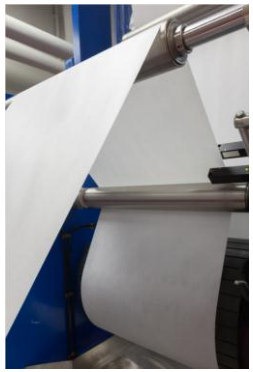
New Approach

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

New Conventional



Transition and Deployment



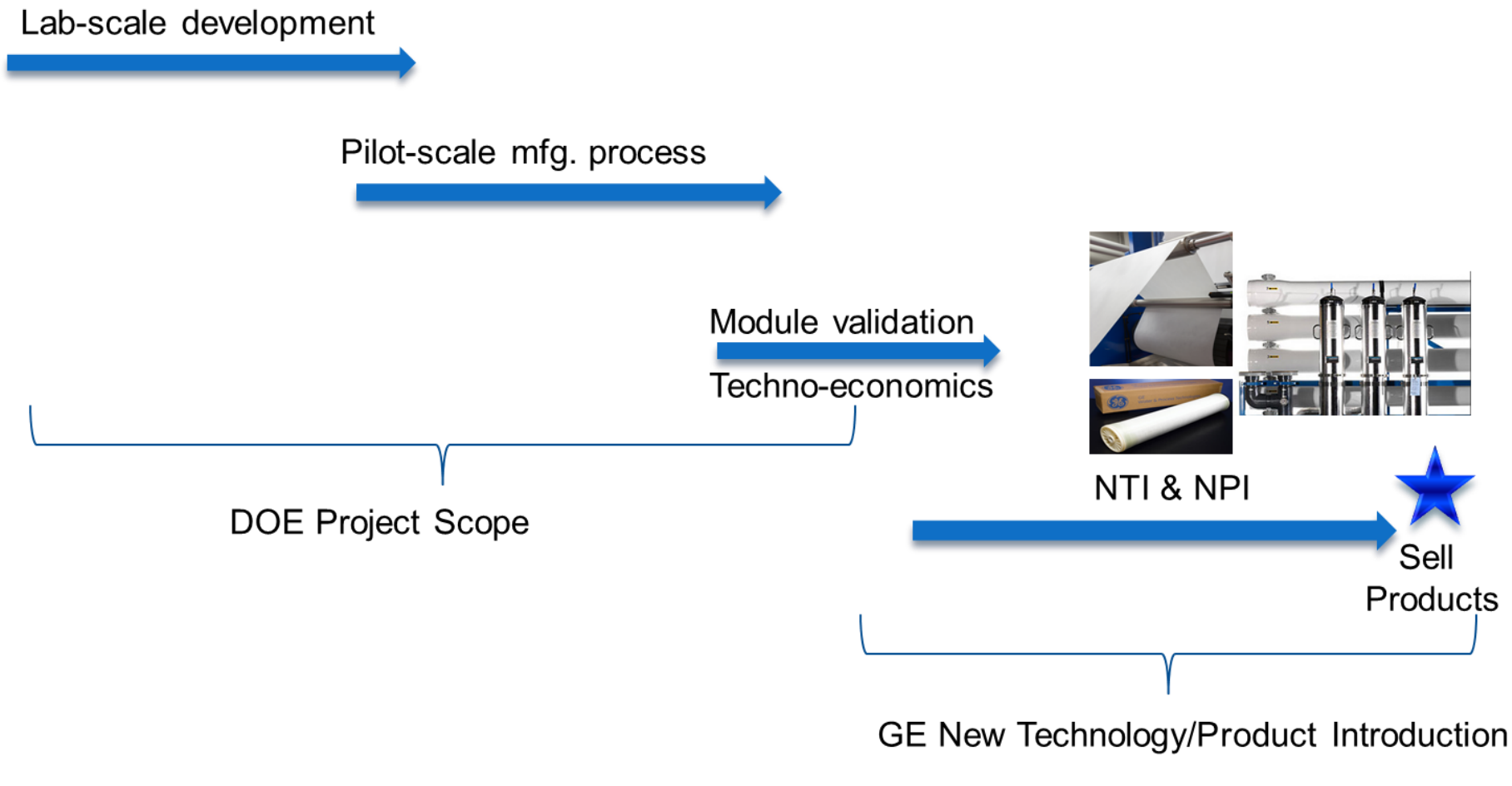
Impacts to broad sectors

- 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)



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.

Started on Dec. 2014

Project Task Structure (simplified)
1. Membrane material development
2. Pilot mfgr process development
3. Module performance validation
4. System design & simulation
5. Techno-economic analysis
6. Energy savings validation

Total Project Budget	
DOE Investment (80%)	$2,000,000
GE Cost Share (20%)	$500,000
Total	$2,500,000

	Status	Major Milestones
BP 1	✓	Q2: Novel thin film materials demonstrated
		Q4: Composite membranes demonstrated
BP 2		Q5: Membrane performance specs met (go/no go)
		Q7: Roll-to-roll pilot line assembled
		Q9: R2R membrane fab process optimized
		Q9: Technology competitiveness demonstrated (go/no-go)
		Q10: RO module performance validated
		Q10: System design/simulation completed
		Q11: Energy savings validated

Results and Accomplishments

Project Status

- Project kicked off in Dec. 2014
- Designed & built a robotic coater
- Designed & built a rotating drum reactor
- Completed milestones:

  Demonstrated novel RO materials
  - ➢ linear film growth rate
  - ➢ precise thickness control

Work to be completed

- Demonstrate composite membrane performance (BP 1)
- Demonstrate pilot manufacturing process (BP 2)
- Design RO system & validate energy savings (BP 3)

Results