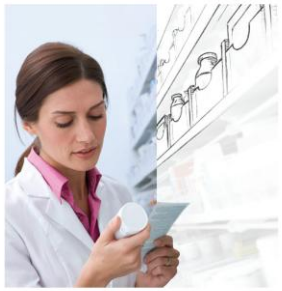
Dow Water and Process Solutions: Purifying Essentials for Life



Energy-Water Nexus: Furthering Technological Innovation

Panel I: Optimizing Current Technologies

George Barclay
Global R&D Director DW&PS

May, 2014

With So Much Water on Earth, Why Are We So Thirsty?

- Growing competition for water resources
- Water-energy nexus
- Value from first generation water efficiency efforts largely captured
- Outdated policy frameworks
- Aging or missing infrastructure

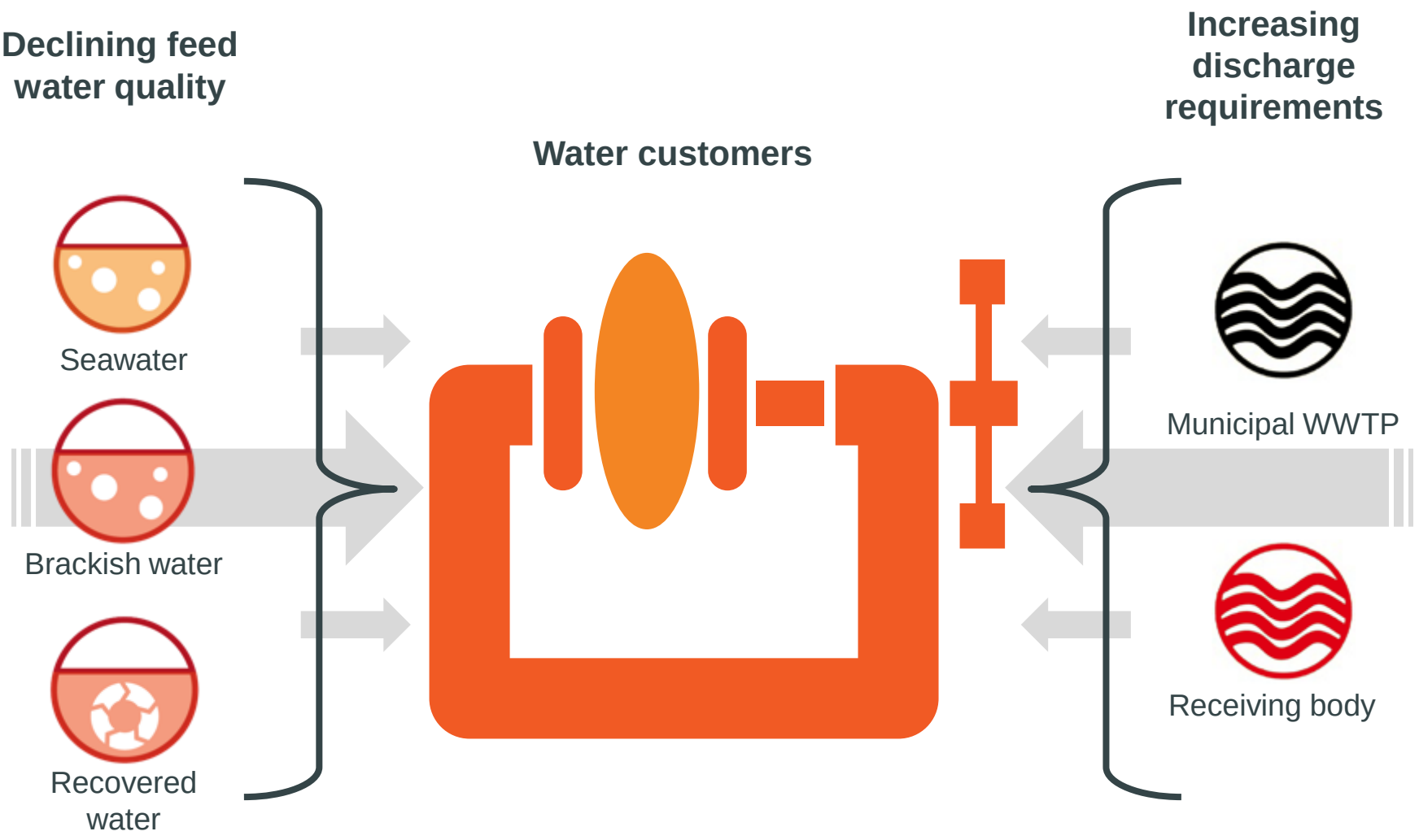
Tomorrow's Needs Will Be Even Greater

By 2030*, we will need:

- 30% more water
- 40% more energy
- 50% more food

*Source: World Business Council on Sustainable Development

Water Customers Are Being Squeezed on Both Ends



The Question Is Simple. The Challenges Aren't.

CHEMICAL & PETROCHEMICAL

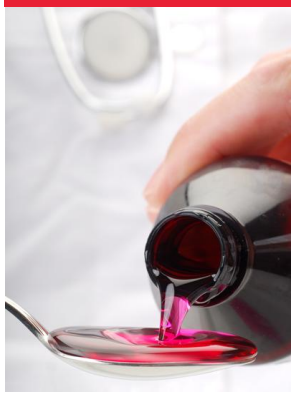
POWER GENERATION

MINING & HYDROMETALLURGY

PROCESSED FOODS

RESIDENTIAL & COMMERCIAL

HEALTHCARE



MUNICIPAL & DESALINATION

INDUSTRIAL WATER

WASTEWATER & REUSE

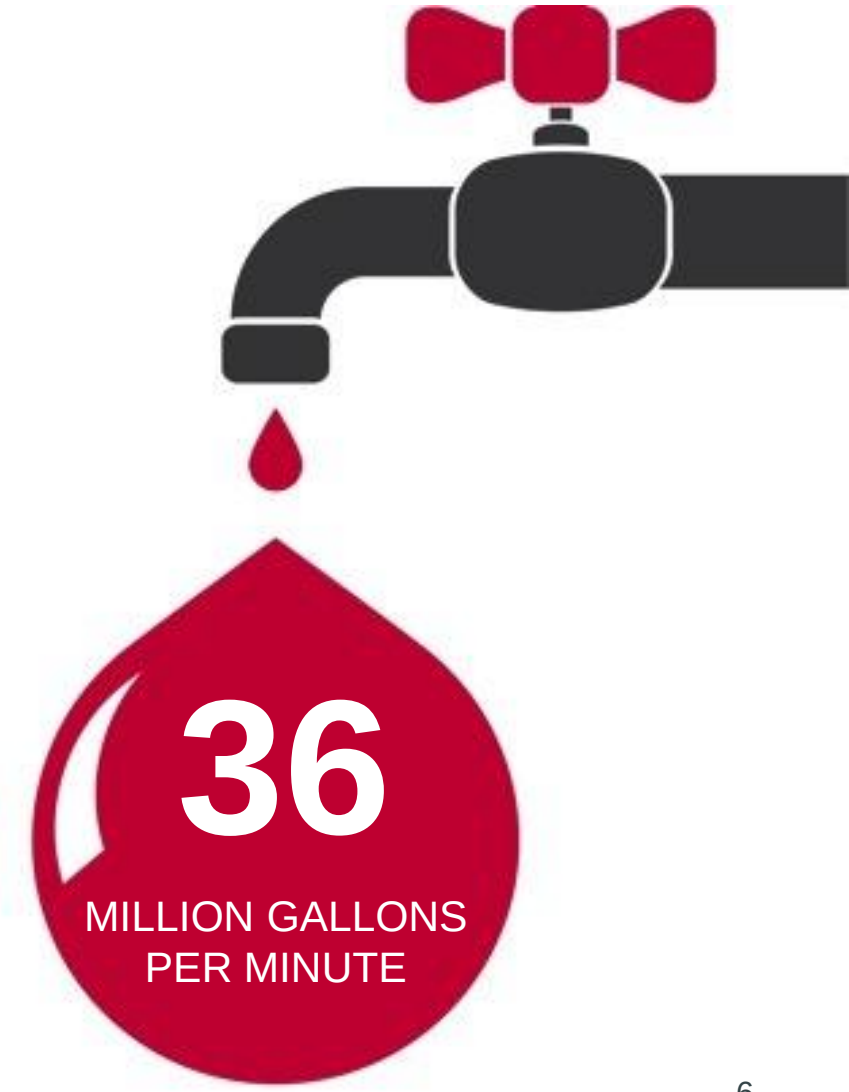
OIL FIELD WATER

We're combining the power of science and technology to passionately innovate what is essential to human progress

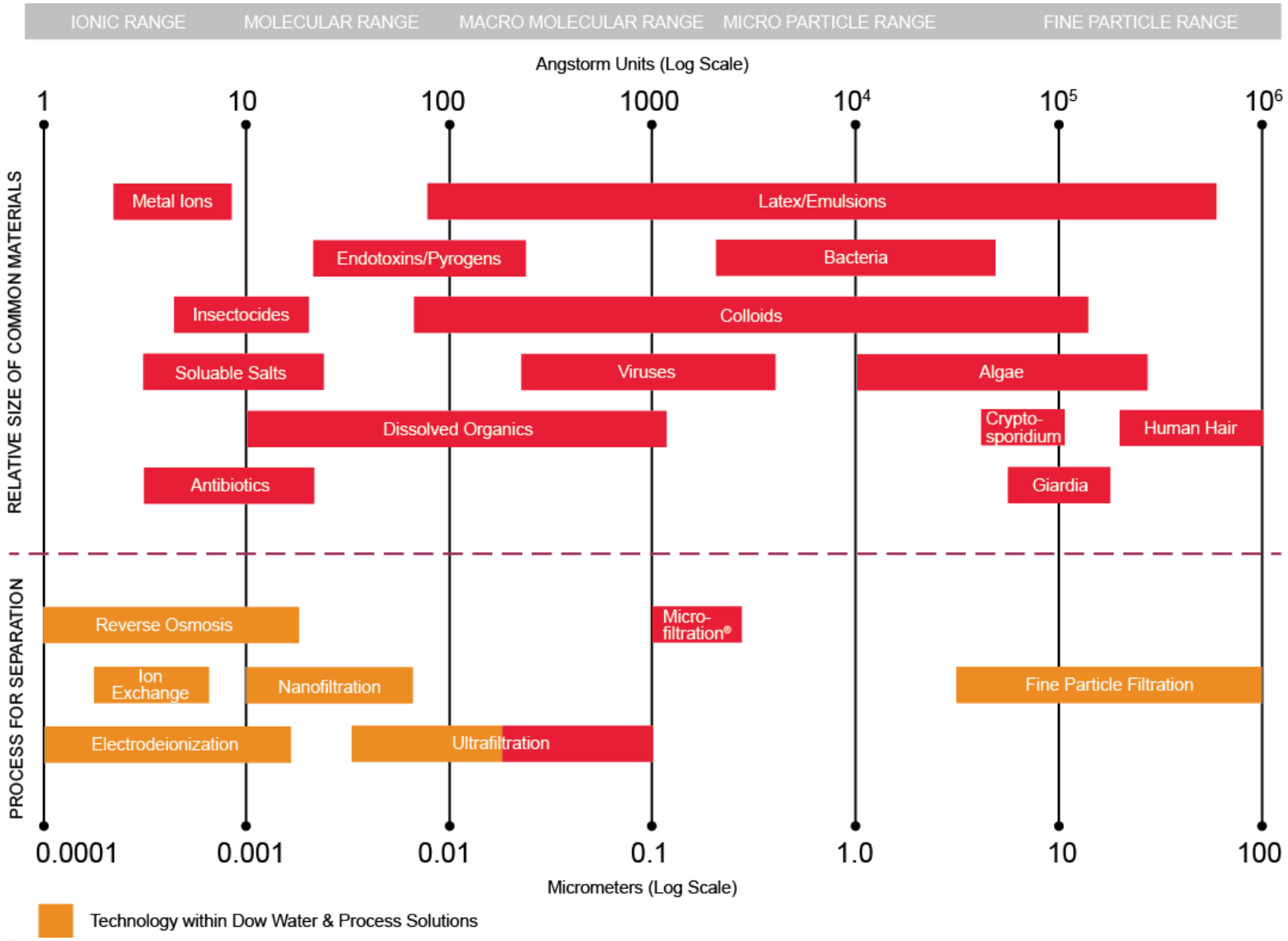
70+ Years Experience in Separations Technology

Dow technologies process **36 million gallons** of water every minute.

That equals more than **7 gallons** a day for every man, woman and child in the world.

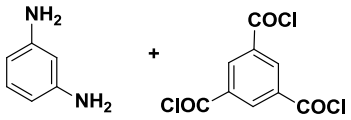


Current Technology Roadmap

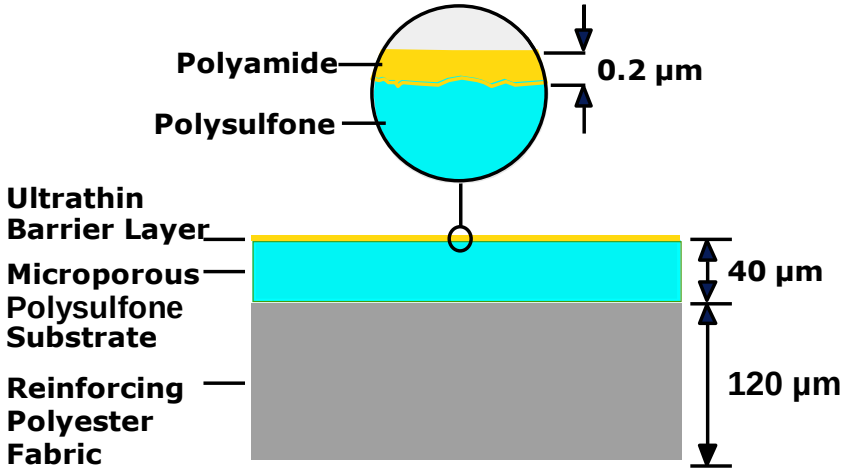


Basics of reverse osmosis

Chemistry

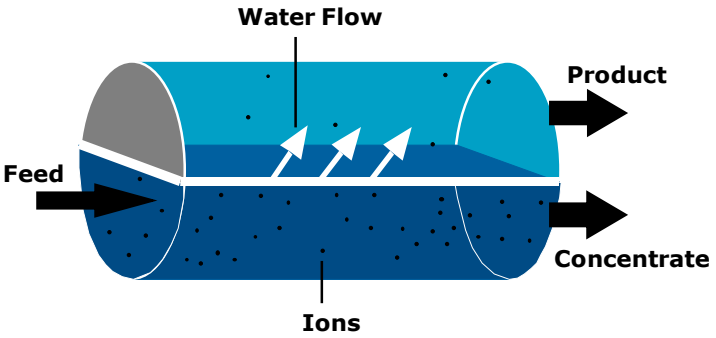


Tailored Polyamide

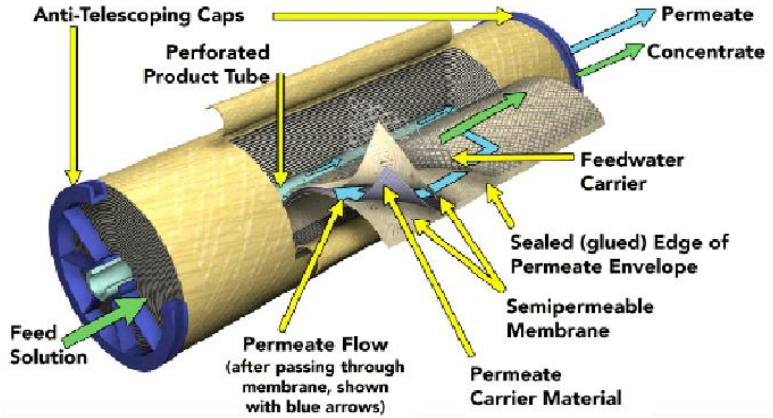


Membrane

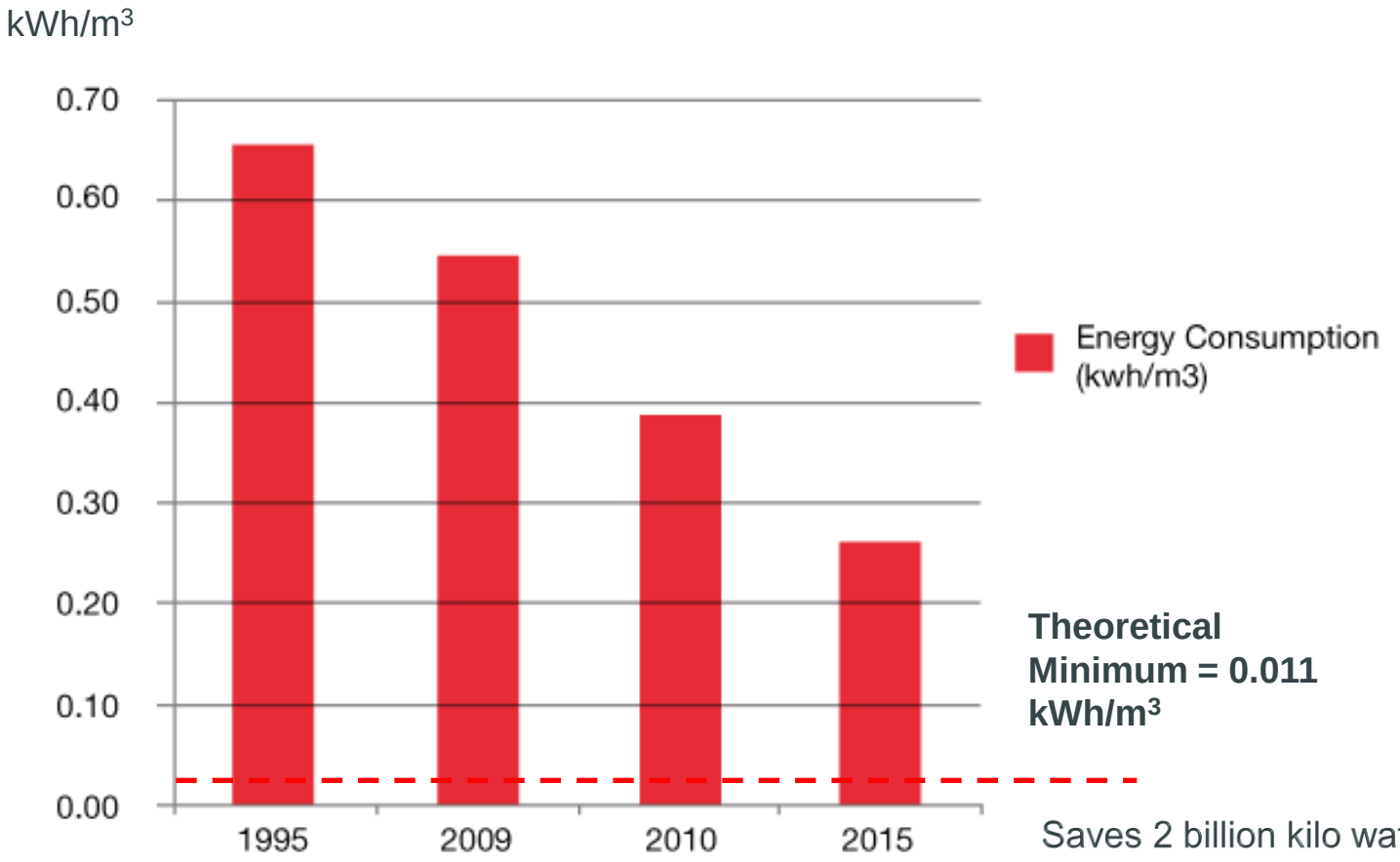
Technology



Product



Significant Drops in Energy Consumption with Each RO Product Generation



Saves 2 billion kilo watts of energy and reduces 1.5 million metric tons of CO2 emissions over 10 year of period

Key issues to solve in RO membranes: energy and fouling

Dow's response:

DOW FILMTEC™ ECO RO Elements

40%
less salt passage

30%
less energy

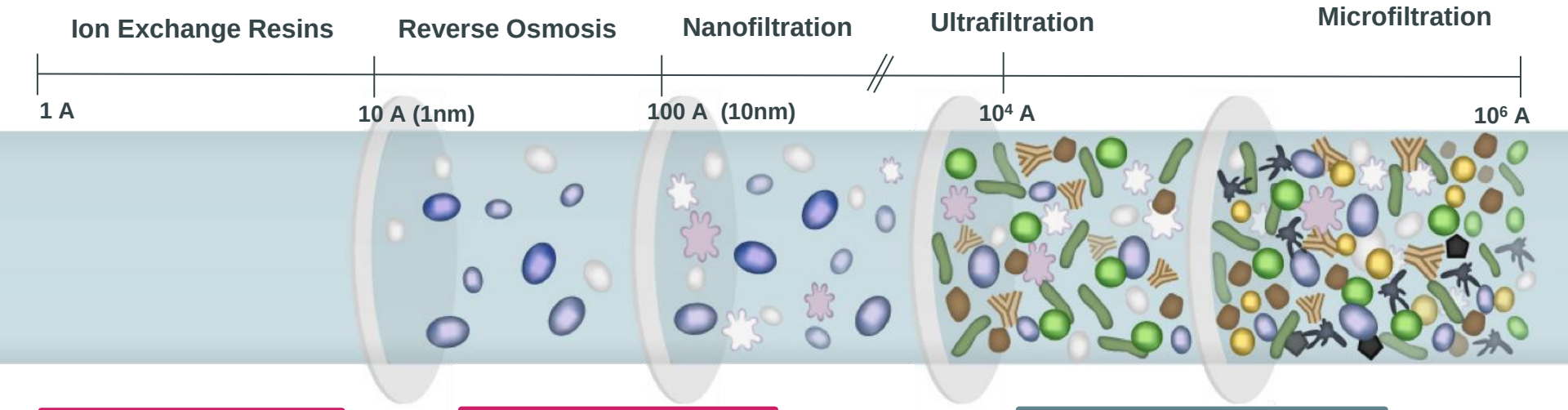
Dow's response:

THE NEXT BIG THING IN REVERSE OSMOSIS…

Reduce "Clean-in-place" frequency by 50%

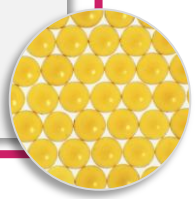
Reduced Energy
Reduced Chemical Use
Increased Water Availability

Partnership – Building a complete technology solution



Ion Exchange R&D

IER



Membrane R&D

RO/NF

Fine Particle Filtration

UF R&D

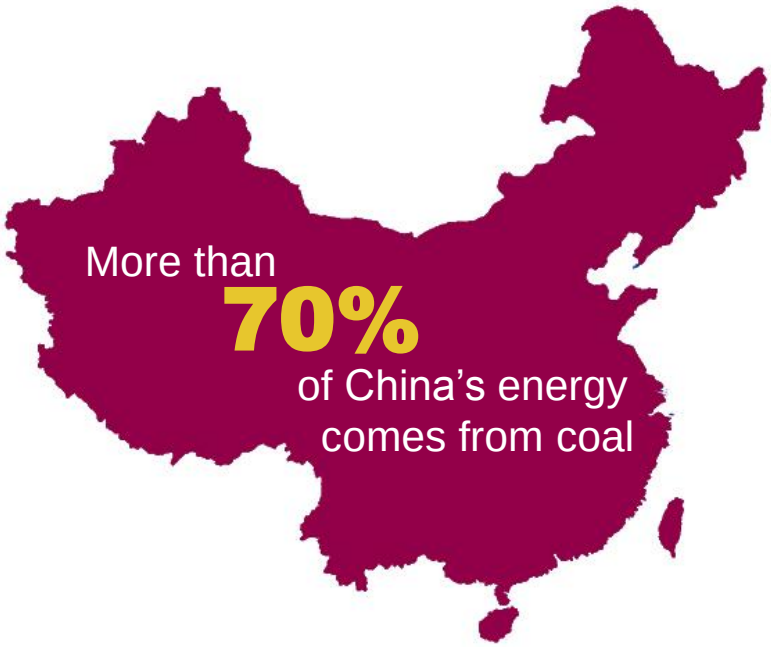
CFT R&D

Filtration

Addressing Challenges for Industrial Water

- WATER SCARCITY ISSUES – ECONOMIC GROWTH LINKED TO WATER FOR INDUSTRIAL USE
- WATER ENERGY NEXUS – RISING ENERGY COSTS
- INCONSISTENT FEEDWATER QUALITY
- INCREASING REGULATIONS AND COSTS
- OUTDATED SYSTEM DESIGN
- INCREASING COMPETITION
- NEED FOR PRODUCTION EXPANSION WITHOUT INCREASE IN WATER WITHDRAWALS

Case in point: coal production in China



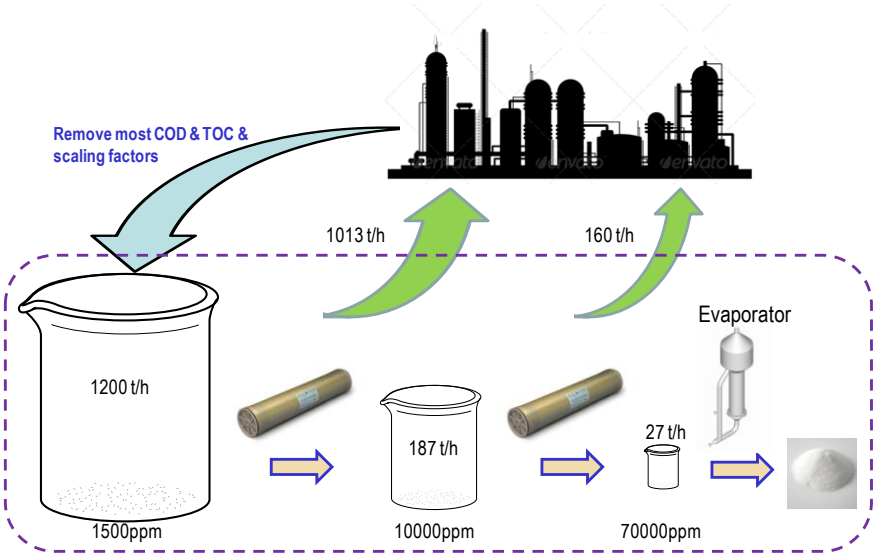
Coal resources are located in the North part of China – **its most water-stressed region**

90% coal resource but

21% water resources

Producers must reuse and recycle water. = ↑ **FOULING** = ↑ **COST FOR WATER TREATMENT**

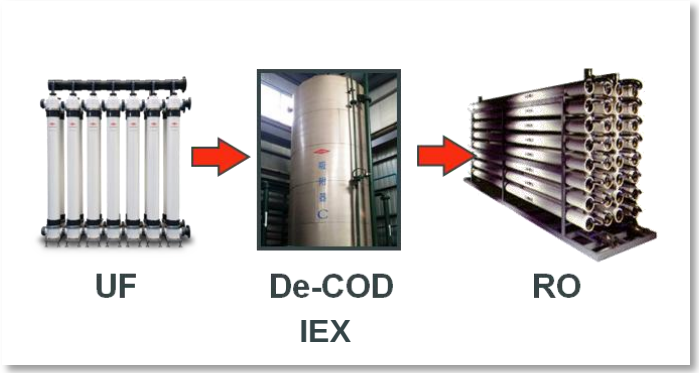
Coal to Chemical – Zero Liquid Discharge



COD_{cr}	2000-4000mg/L
BOD_5/COD_{cr}	0.25-0.35
Total phenol	300-1000mg/L
Volatile phenol	50-300mg/L
NH_3-N	100-250mg/L

Typical wastewater of coal gasification

Dow Solutionism – Combining Technologies



Addressing Challenges in the Oil and Gas Industry

- DECLINING PRODUCTION AND INCREASING WATER CUT FROM AGING RESERVOIRS
- WATER-INTENSIVE PROCESSES TO DEVELOP NEW RESOURCES (GAS AND OIL FROM SHALE FORMATIONS)
- LIMITATIONS IN WATER AVAILABILITY AND DISPOSAL OPTIONS
- ENVIRONMENTAL IMPACT AND REGULATIONS
- SPACE AND WEIGHT CONSTRAINTS OFFSHORE
- INCREASING CAPEX AND PROJECT RISK

Unconventional Oil & Gas

Waters Associated with Shale Development & Production

Frac Flowback

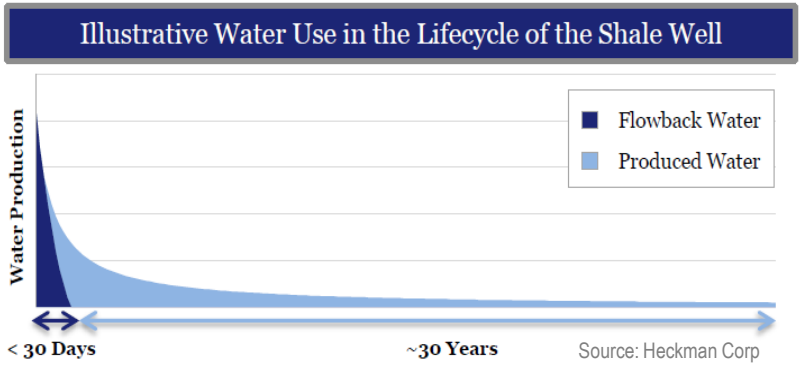
The portion of injected **frac fluids** that return to surface before production.

- Typically 10-30% returns in 7-14 days with a rapid decline in quantity & quality.

Produced Water

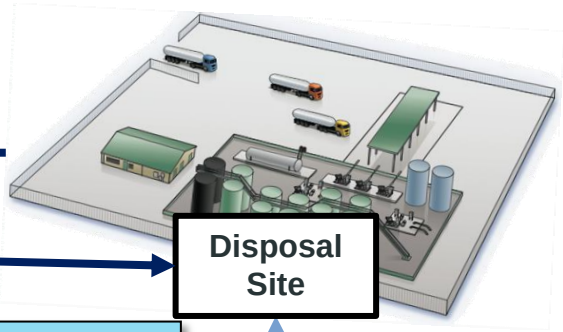
Shales - typically refers to water produced from the wells longer term…During production.

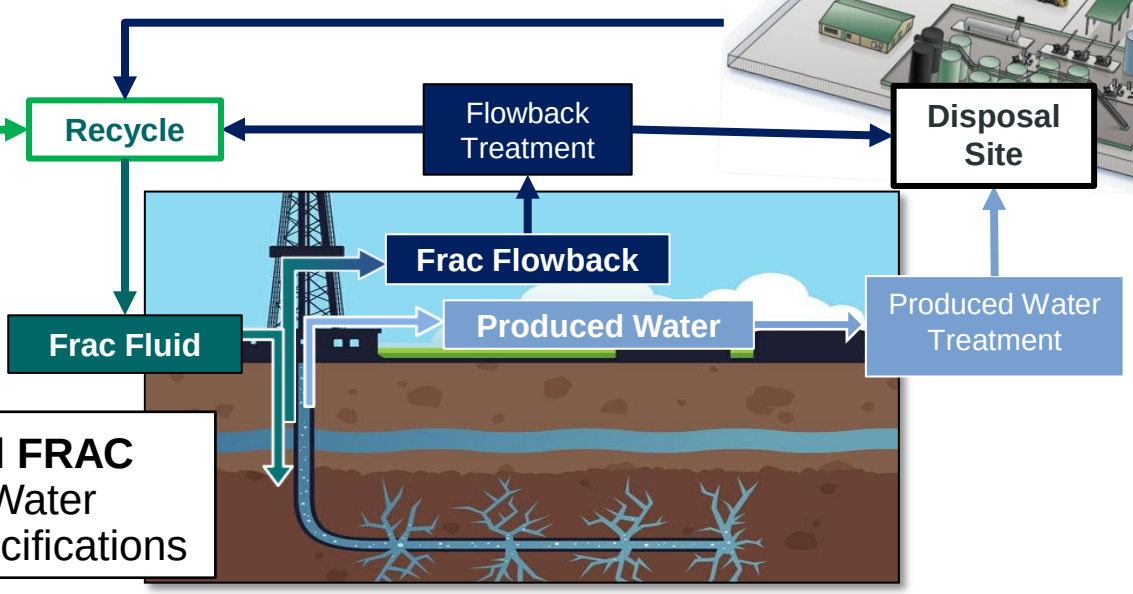
- Often significantly lower flow rates than flow back, and more consistent quality (after a while).



Make up Waters

- Surface Water (Fresh)
- Ground Water (brackish)
- Other produced waters
- Waste waters?





The WELL and **FRAC FLUIDS** drive Water Treatment specifications

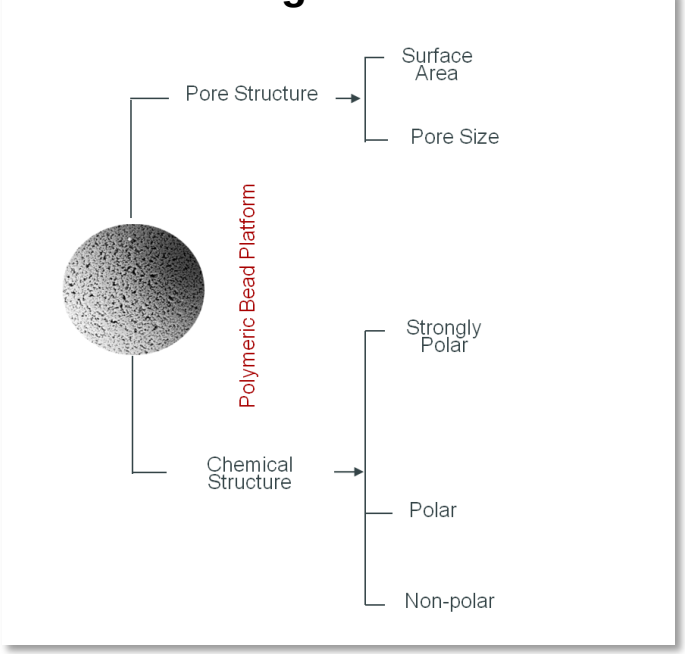
Residual Organics – Water Soluble Organics (WSO)

As Shale Production moves from Gas to Liquids to Oil…

Water Soluble Organics become a primary concern:

- Commonly Include:
  - Gasoline Range Organics (GRO)
  - Diesel Range Organics (DRO)
  - BTEX

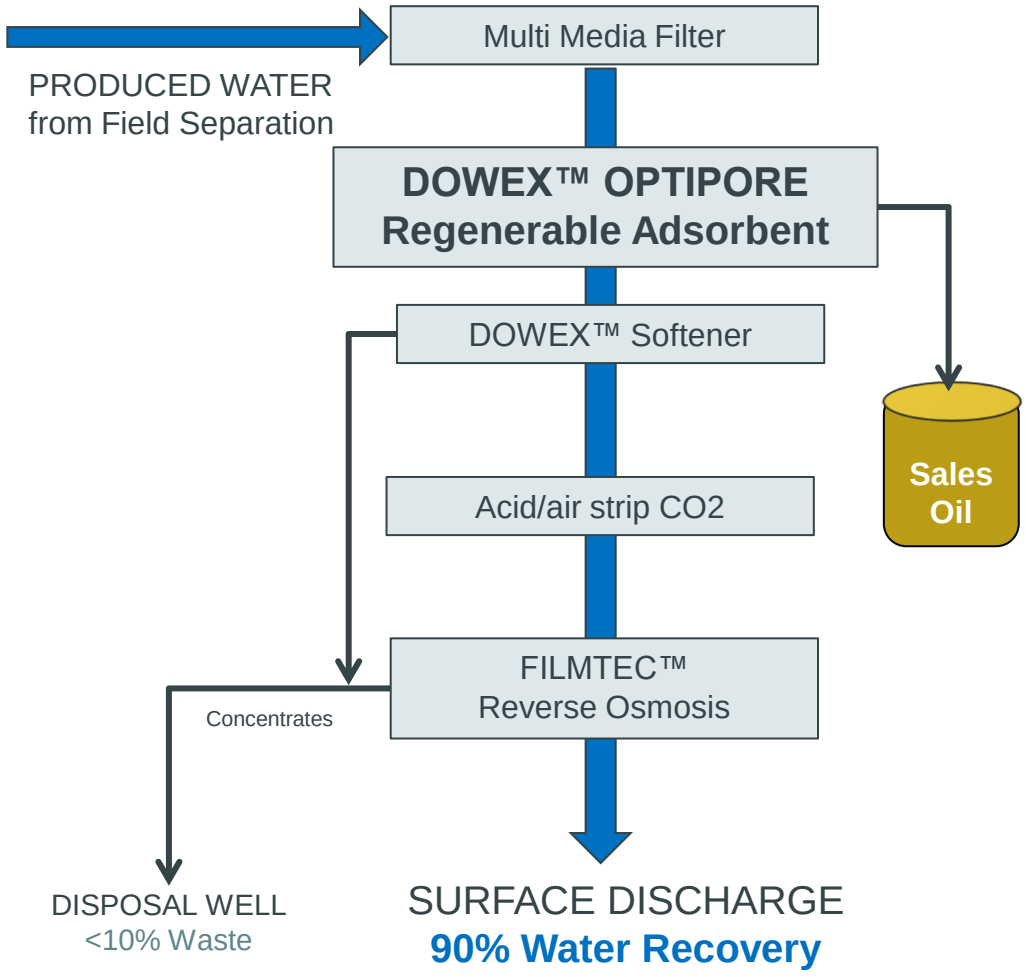
Portfolio of Organics Removal Media



DOWEX OPTIPORE BTEX removal and recovery system demonstration: *Raw Water (left), Clean effluent (middle) & Recovered Condensate (right)*

Neptune Produced Water Desalination Facility

First large-scale OPTIPORE™ Installation for Produced Water Treatment



Wind River Basin, WY

Ground Breaking: November 2013

Commissioning: June 2014

Capacity: 25,000 bwpd (about 1 MGD)

- Collaboration between
  - Dow
  - GE
  - Encana

Optimizing Current Technologies

Great progress is being made in optimizing current technologies

- Separations and Purification Technologies
- Membrane Technology
- Ion Exchange Technology
- Ultrafiltration Technology
- Fine particle Filtration

Bringing it all together takes partnership

- ✓ *Chemistry/Component Supplier : Dow*
- ✓ *Systems Engineering :*
- ✓ *End users : wide range of application from Industrial to Municipal*
- ✓ *Deep Application Knowledge*