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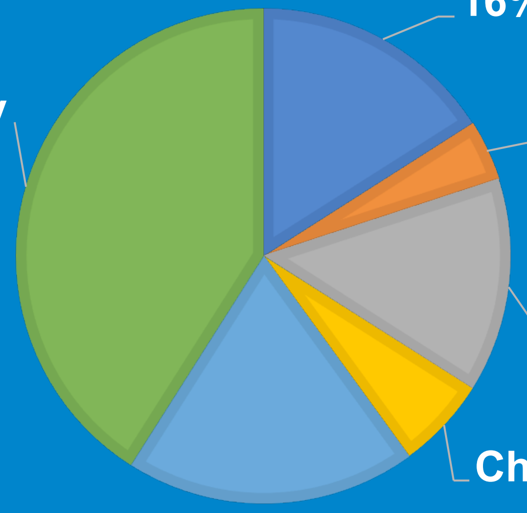
A Case for High Recovery, Low Energy, Low Cost Desalination with Twin Turbochargers

Introduction

- Total Water Cost (TWC)
  - TWC = CAPEX + OPEX
  - Does not include distribution costs

- TWC ranges between 0.8 - 2 USD/m^3

SEC is less than 20% of Total Cost of Water



Cosin C., Desalination Technologies and Economics: CAPEX, OPEX & Technological Game Changers to Come

Ghaffour N. et al., Desalination 309 (2013) 197–207

Reducing SEC made desal feasible – how do we make it available?

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Applying Known Principles

Today's RO design focuses on only one side of the equation.

$$\text{Horsepower} = \frac{\text{GPM} \times \text{PSI}}{1714 \times \%}$$

Low energy membranes

$$\text{ERD TRANSFER EFFICIENCY} = \frac{\text{Fluid Power Added to Feed Stream}}{\text{Fluid Power Taken from Brine Stream}}$$

Can we use ERDs and other devices to reduce feed GPM and HP?

A kilowatt saved beats 98% of a kilowatt recovered.

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Applying Known Principles

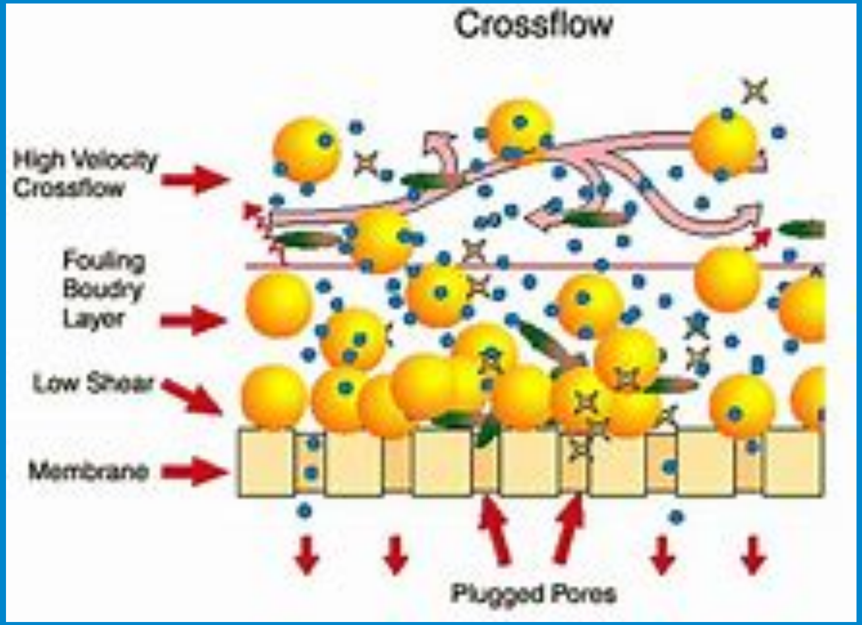
Limitations to increasing recovery?

Precipitation

TDS limited by $CaCO_3$ & $CaSO_4$ to <90kppm

Pressure

Membranes limited to ~1200 psi (82.7 bar)



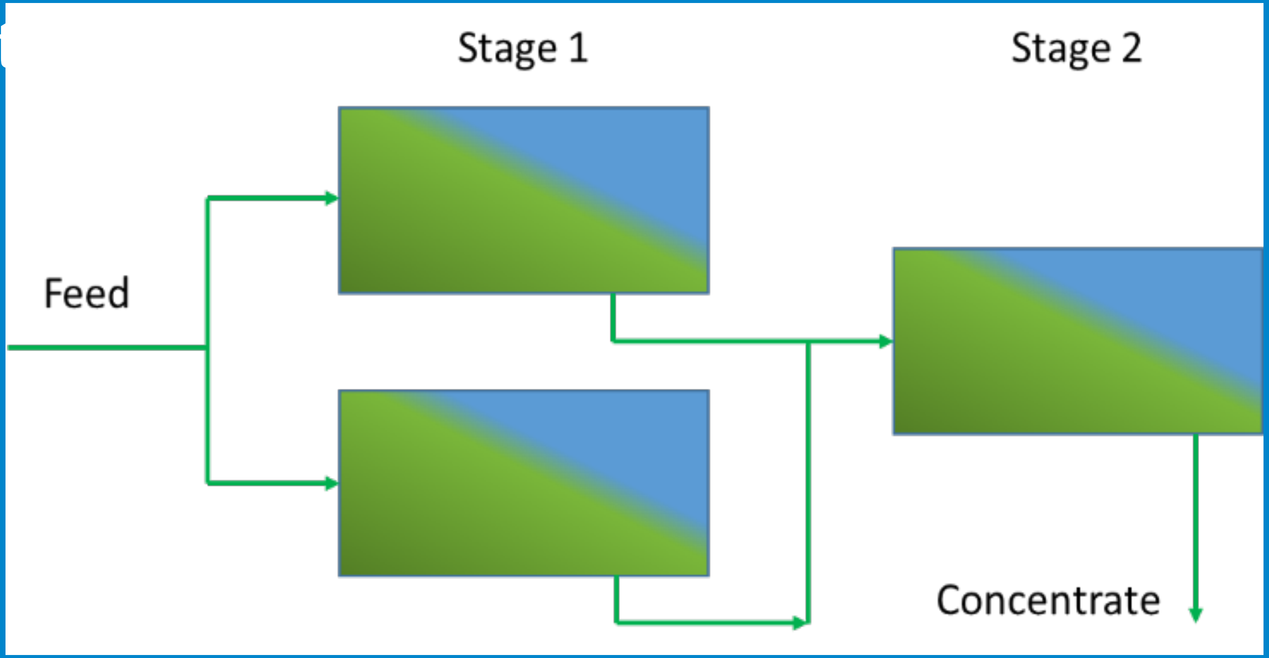
Process

Limits for lead element flux, element recovery, flow velocity

Applying Known Principles

Managing flow ***and*** pressure is common practice in BWRO systems

- Flow/Velocity — Staged RO vessels
- Pressure — Interstage boost

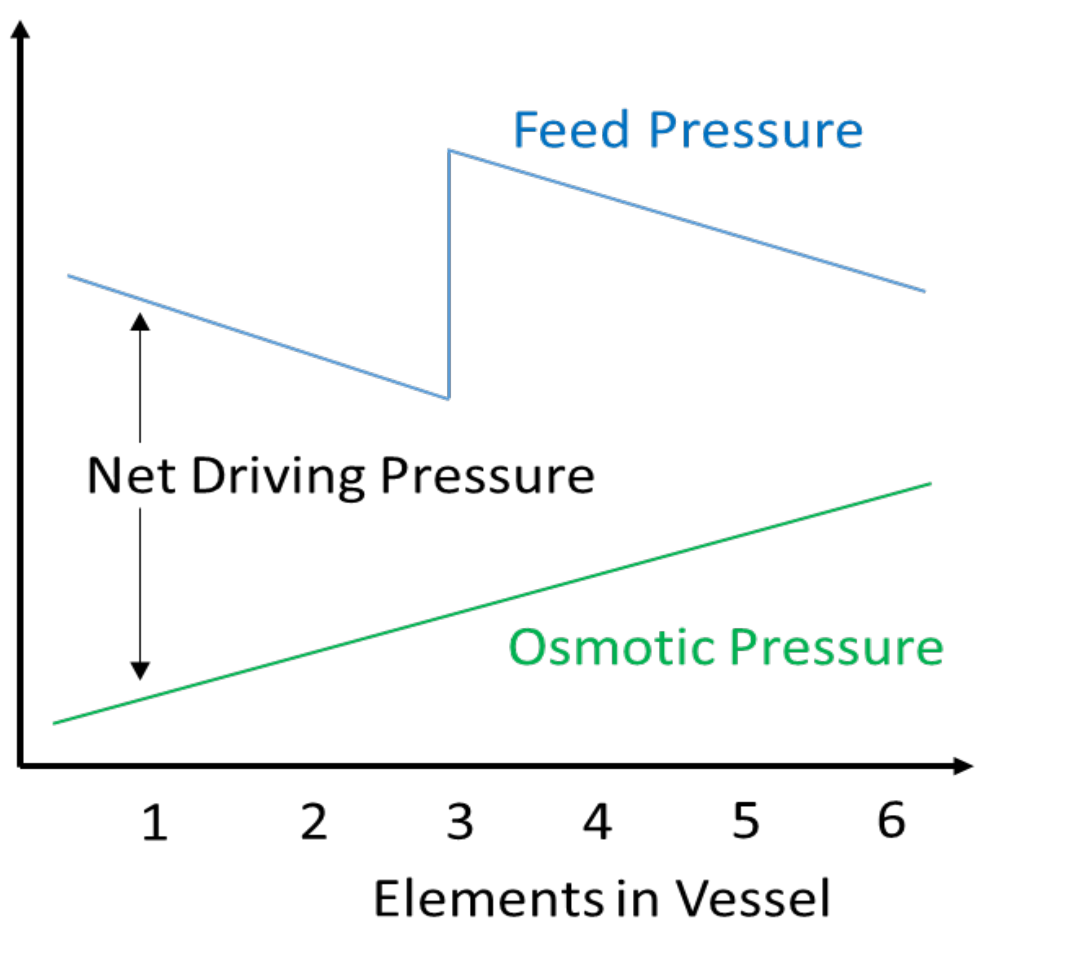


Flux Balancing → Managing Flow & Pressure

Applying Known Principles

Flux Balancing → increased average NDP and

- Manages Net Driving Pressure (NDP)
- Reduces energy consumption
- Improves flow velocity distribution
- Improves pressure distribution
- Distributes fouling → greater resistance
- Lower Beta and scaling potential



Improves membrane function and life when applied within manufacturers' limits

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Applying Known Principles

Previous Y2K-era experience with Brine Conversion Systems (BCS)

- Optimum 40%/33% recovery/stage manages salinity rise
- Ten (10) retrofit & newbuild plants
- Toray SU-820BCM

Plant	Recovery	Capacity m^3/d
Ehime, Japan	60 %	210
Mas Palomas Spain	60 %	270
Ibiza, Spain	60 %	270
Mas Palomas 1 Spain	60 %	4500
KAE Curacao 1 Caribbean	57 %	5700
KAE Curacao 2 Caribbean	57 %	5700
Mas Palomas 2 Spain	60 %	4500
Mas Palomas 3 Spain	60 %	4500
Tortola Caribbean	60 %	690
Muroto Japan	60 %	480

Moch, Jr., I., The Case and feasibility of very high recovery Sea Water Reverse Osmosis Plants, Proceedings, ADA North American Biennial Conference & Exposition, South Lake Tahoe, NV, August 2000

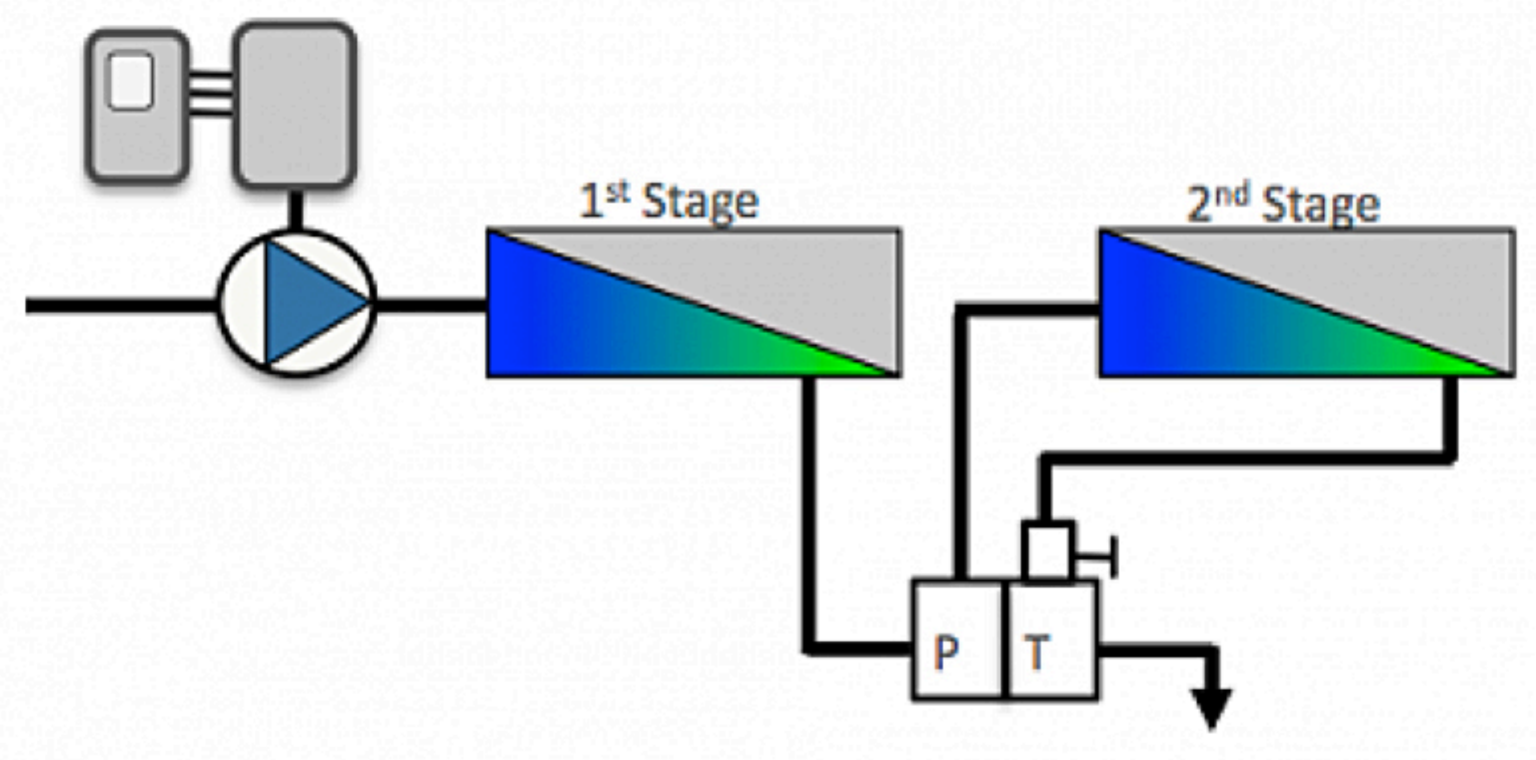
Application of Flux Balancing

Turbocharging
- Robust, reliable
- Low CAPEX
- Ease of maintenance

Center Port Vessels
- Managing flow and velocity
- Packaging efficiency

Application of Flux Balancing

Simple Interstage Turbo Booster Arrangement

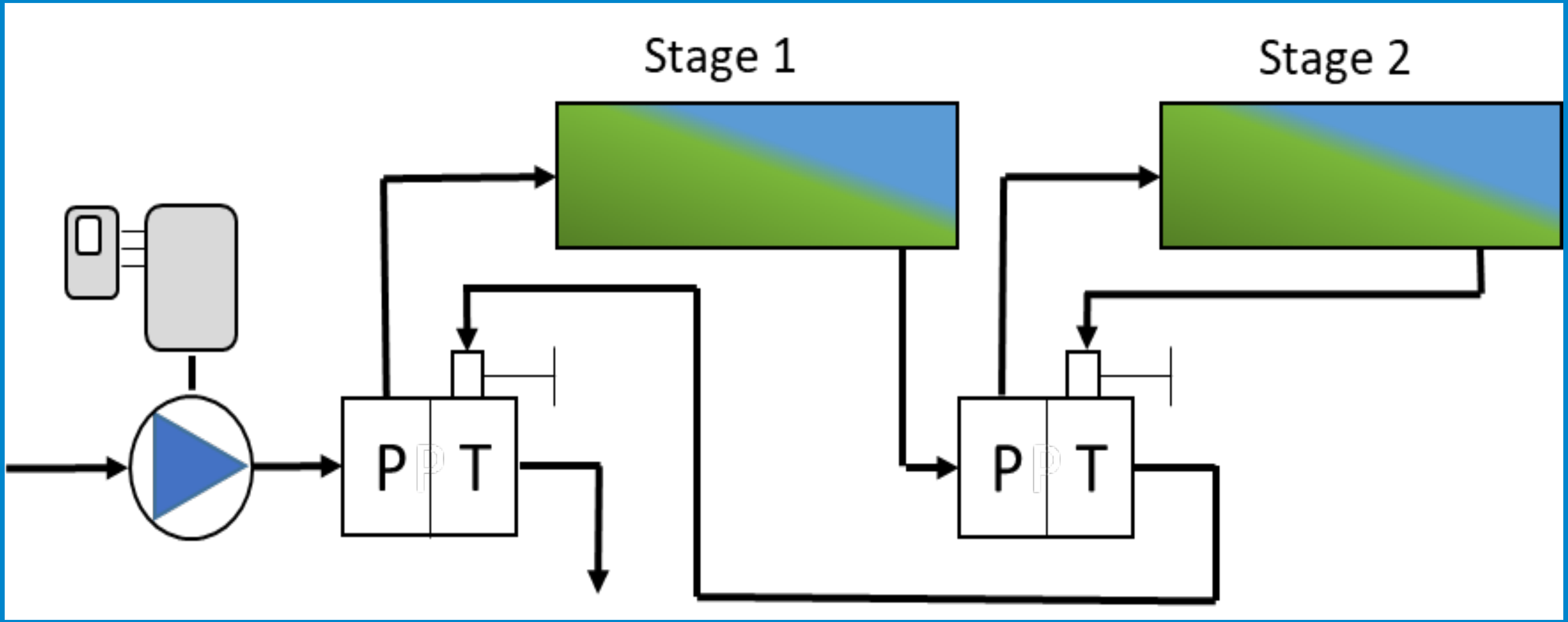


- Simple, robust design
- No additional components
- Ideal for small systems
- Low CAPEX

Application of Flux Balancing

Multi Stage / Dual Turbo (MSDT) Arrangement

- Efficient use of brine energy
- Reduce energy consumption
- Flexible flow and flux



Flux Balancing → Managing Flow & Pressure

Effect on Total Cost

Energy and amortization account for 60% of the Total Cost of Water

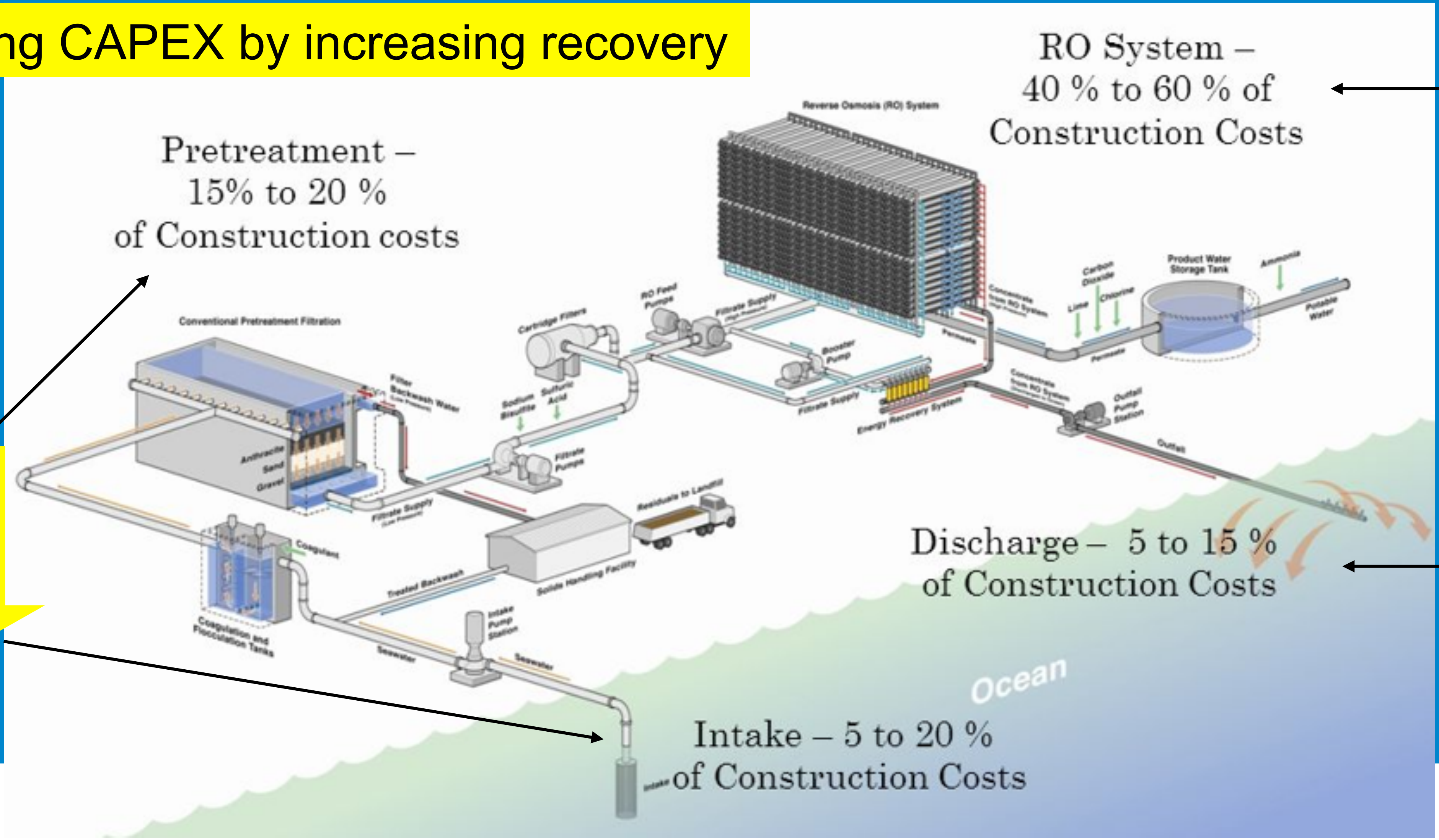
- Energy cost
  - Directly related to system flux and recovery
- Capital cost
  - Directly related to system flux and recovery
  - Amplified by maintenance and long-term borrowing costs

Ghaffour N. et al., Desalination 309 (2013) 197–207

Flux balancing with MSDT reduces Total Cost by increasing recovery

Effect on Total Cost

Reducing CAPEX by increasing recovery



600#
First
Stage
?

25%

50%

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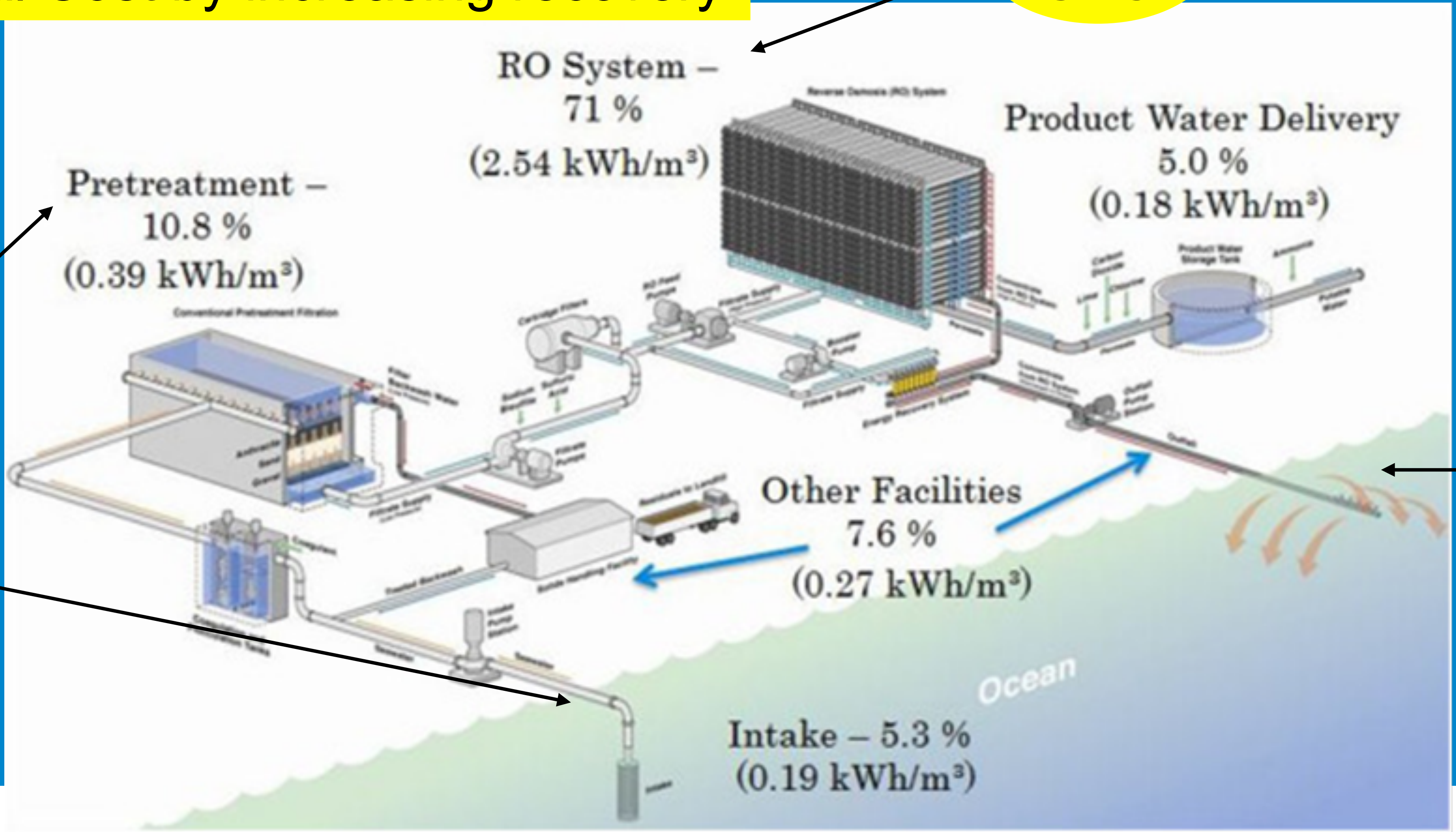
Effect on Total Cost

Reducing Total Cost by increasing recovery

Best SEC



25%

50%

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Effect on Total Cost

Case Study	Expected savings
FEDCO	10 - 20 %
Irving Moch, ADA Conference (2000)	10 - 20 %
Meyer- Steele S., et al., Suez, TP1029EN	16%

%	1 Stage	2 Stage
Capital Cost	46%	37%
Electricity	36%	30%
Membrane Replacement	5%	6%
Chemicals	4%	2.5%
Other	9%	8.5%
(Labor, maintenance, etc.)		
Savings	—	16%

Meyer-Steele S. et al., Seawater reverse osmosis plants in the Caribbean recover energy and brine reduce costs (SUEZ - Technical Paper TP1029EN)
Moch, Jr., I., The Case and feasibility of very high recovery Sea Water Reverse Osmosis Plants, Proceedings, ADA North American Biennial Conference & Exposition, South Lake Tahoe, NV, August 2000

Whether it's CAPEX or OPEX,
a penny saved is still a penny earned.

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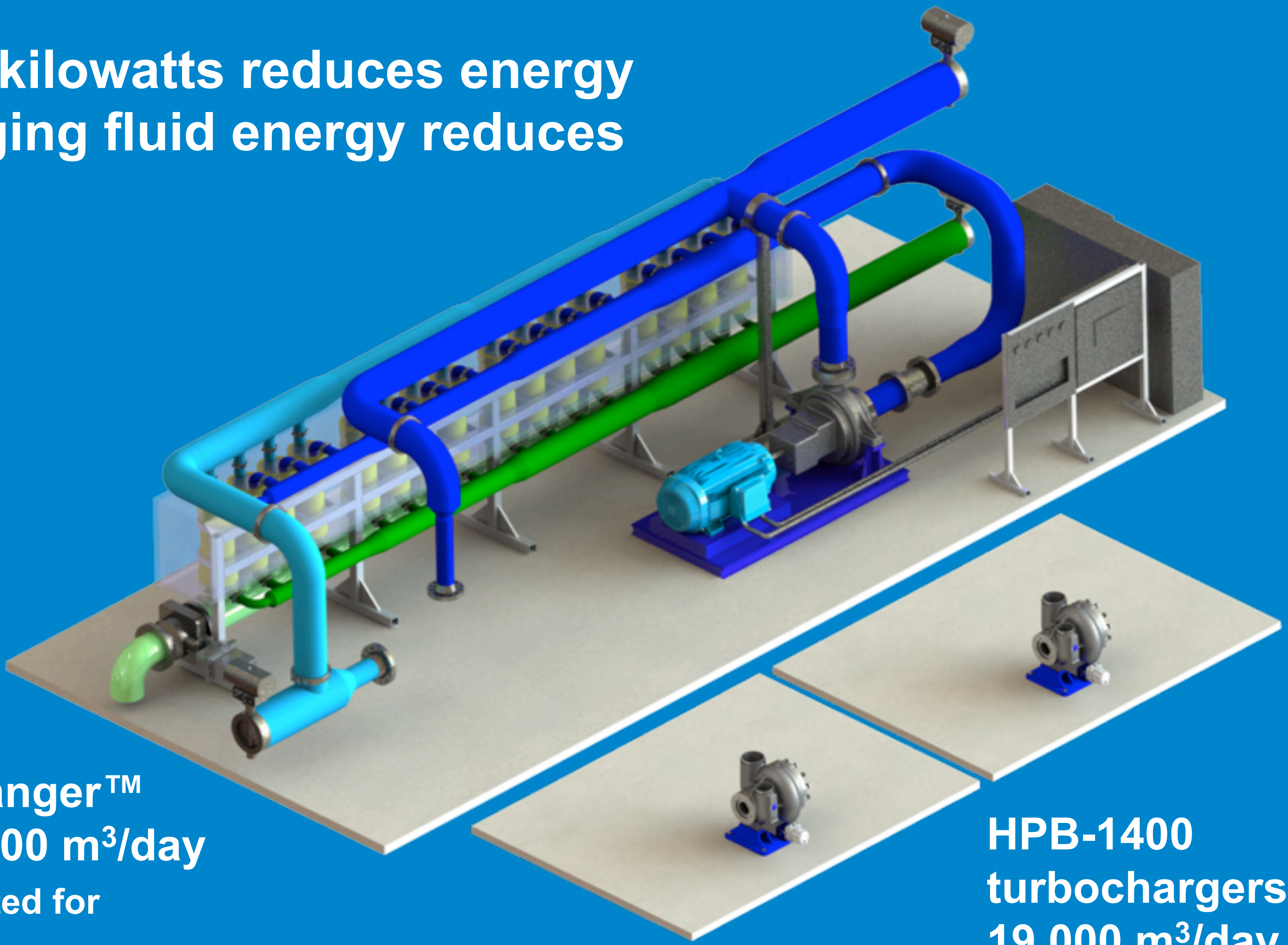
Transferring kilowatts reduces energy cost. Managing fluid energy reduces everything.



Pressure Exchanger™ System for 19,000 m^3/day train (details omitted for clarity)

HPB-1400 turbochargers for 19,000 m^3/day train

FEDCO Turbochargers - A robust solution with superior system availability for reduced Total Cost of Water

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