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Creating Water Resources Through On Site Reverse Osmosis

Track: Water Session No: 3 Date: August 16, 2010

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Overview

- Introduction
- Objective
- Water Basics and Definitions
- Design Factors
- Case Studies
- RO Facility Planning Process
- RO Plant Options

Introduction

- Background
  - Work for NAVFAC Engineering Service Center, Port Hueneme, CA
  - Registered Mechanical Engineer, California
  - 18 years experience with water treatment, reverse osmosis
  - Manage the Navy's Seawater Desalination Test Facility, Port Hueneme, CA

Seawater Desalination Test Facility (SDTF)
Port Hueneme, CA

Naval Base Ventura County
Port Hueneme, CA

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Presentation Objective

- Provide background on water treatment terms
- Discuss Reverse Osmosis plant components and design factors
- Discuss steps in RO Facility Planning Process
- Provide examples and case studies of RO plants
- Increase awareness of issues and challenges with RO

Water Terms and Definitions

- **Feed:** raw water to be treated
- **Permeate:** filtered water
- **Brine:** concentrate, waste stream
- **Recovery:** ratio of permeate to feed
- **Flux:** amount of water per unit membrane area per unit time (gallons per square ft per day, GFD)
- **Rejection:** amount of salt rejected by membrane
- **Turbidity:** clarity of water

Water Terms and Definitions

- **Osmosis:** movement of water molecules across a membrane
- **Reverse Osmosis (RO):** method to desalinate water, requires external pressure, removes salt from water through membrane
- **Conductivity:** ability of water to conduct current
- **Total Dissolved Solids (TDS):** amount of ions per unit volume seawater : 35,000 mg/L
- **Osmotic Pressure:** approx. 1% of TDS, must be overcome to push water through membrane
- **Filter:** removes suspended particles through porous media, traps particles, 100% flow through
- **Membrane:** can provide absolute filtration, only portion of water is used, can remove dissolved substances in some cases

Water Types

- **Fresh :** typically less than 1000 mg/L
  - Ponds, rivers, lakes, groundwater
- **Brackish:** 2000 to 15,000 mg/L
  - Groundwater, near coastal regions
- **Saline:** greater than 15,000 mg/L
  - Seawater (35,000 mg/L)
  - Persian Gulf (45,000 to 60,000 mg/L)
- **Greywater/Blackwater**
  - Recycle/reuse water

RO System Components

- Intake System
- Pretreatment System
- High Pressure Pump/Reverse Osmosis System
- Energy Recovery System
- Air System
- Chemical System/Disinfection
- Postreatment/Distribution
- Control System/Instrumentation

Factors that Effect RO System Performance

- Membrane Flux
- System Recovery
- Water Quality
- Feedwater Salinity
- Feedwater Temperature
- Materials of construction
- Feedwater Oxidant Concentration
- Maintenance Requirements

Energy Recovery and RO

- Why is RO energy intensive
  - Must overcome osmotic pressure to make freshwater from saltwater
  - Seawater osmotic pressure : 350 to 400 psi
- Typical operating pressures
  - Most seawater plants operate between 800-900 psi to get reasonable flowrates through membrane
- Energy Recovery
  - Recycle energy that would otherwise go to waste. Recovery ratio is key. Methods to harness energy in brine stream to boost pressure and reduce energy requirements

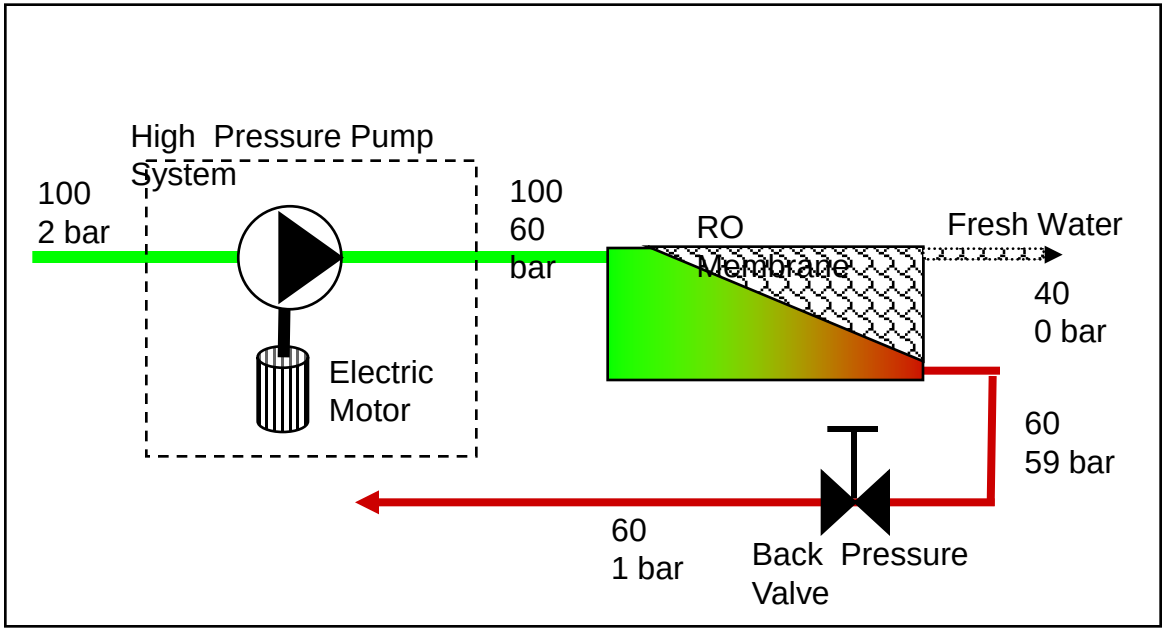
Energy Recovery Options

Turbo

Pelton

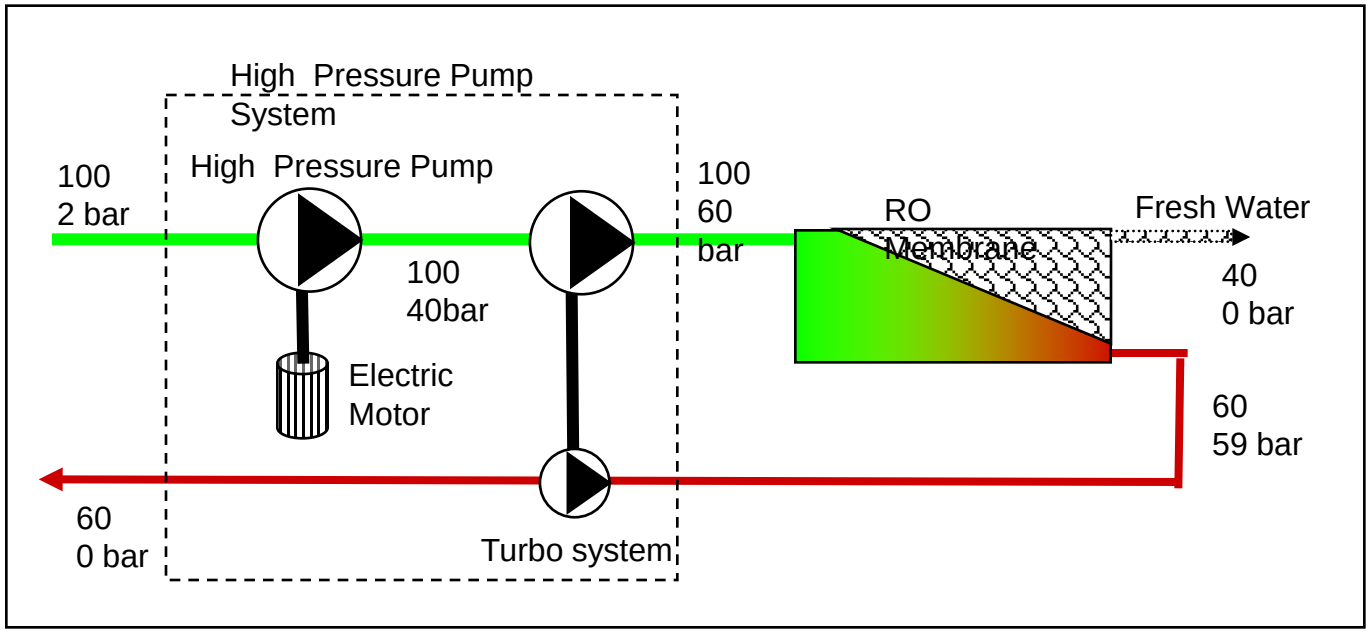
Pressure Exchanger

Original SWRO Osmosis System



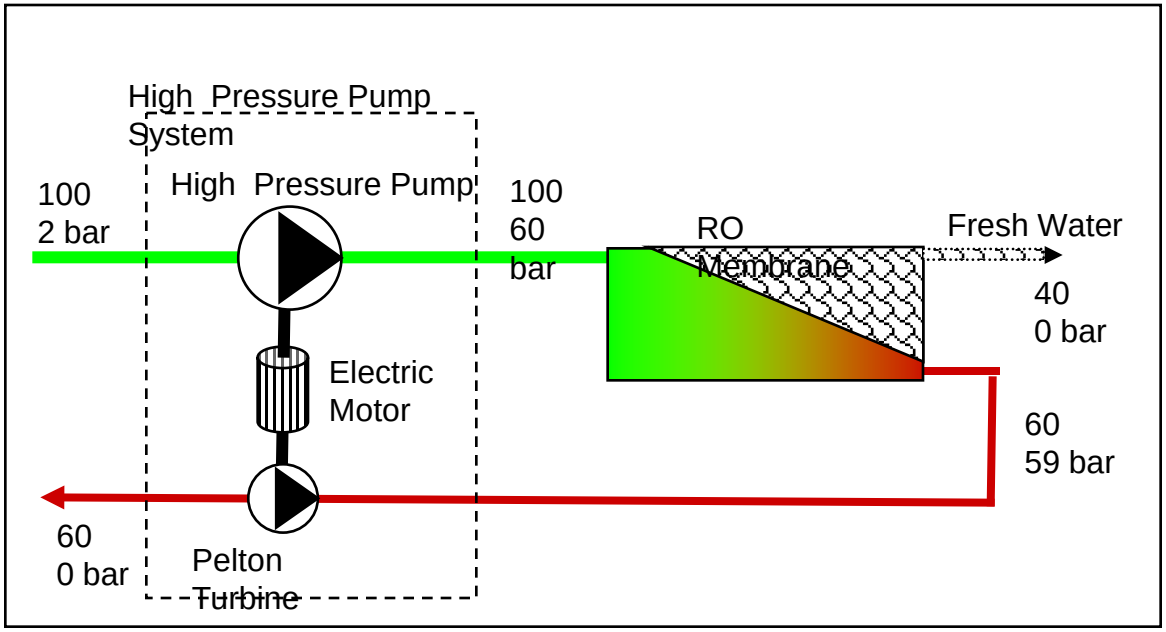
- 1980
- 0% energy savings – 6 kWh/m3
- Variable recovery
- Complexity – low-medium

Turbo System



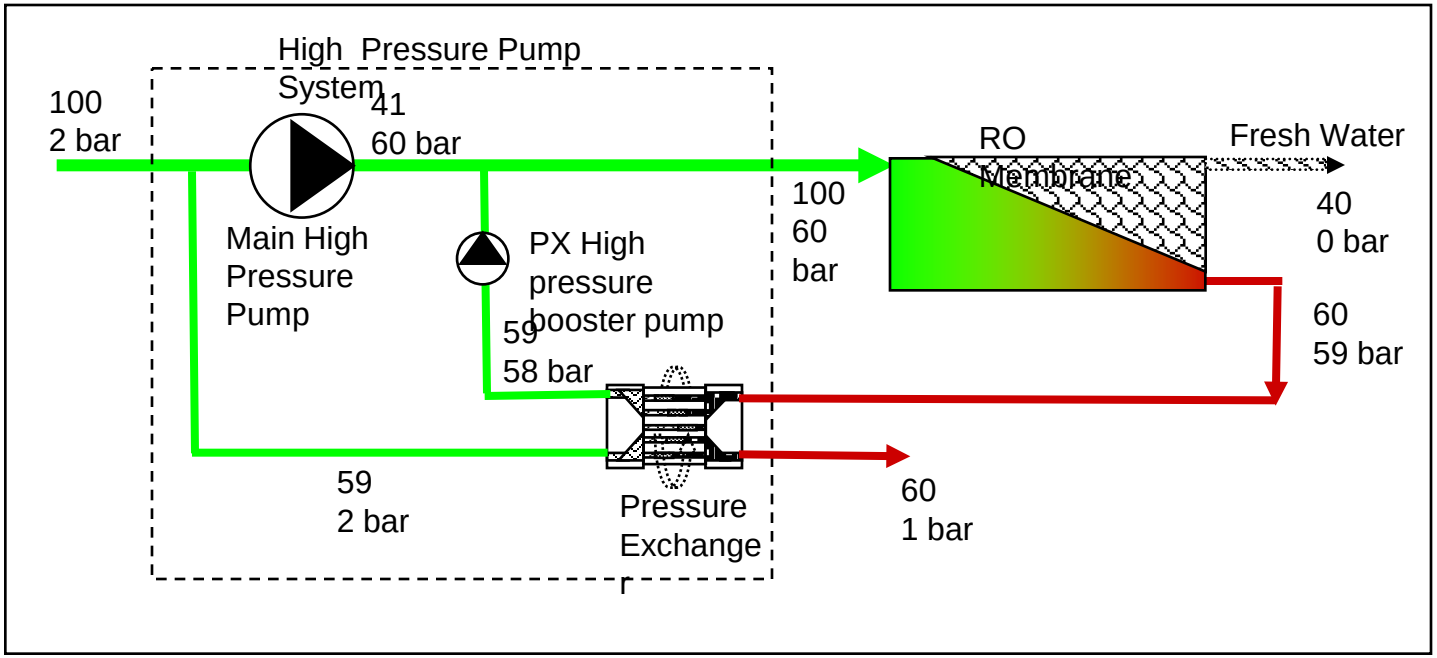
- 1980-2000
- ~30% energy savings ~4.2 kWh/m3
- Variable recovery
- Complexity – medium

Pelton Wheel System



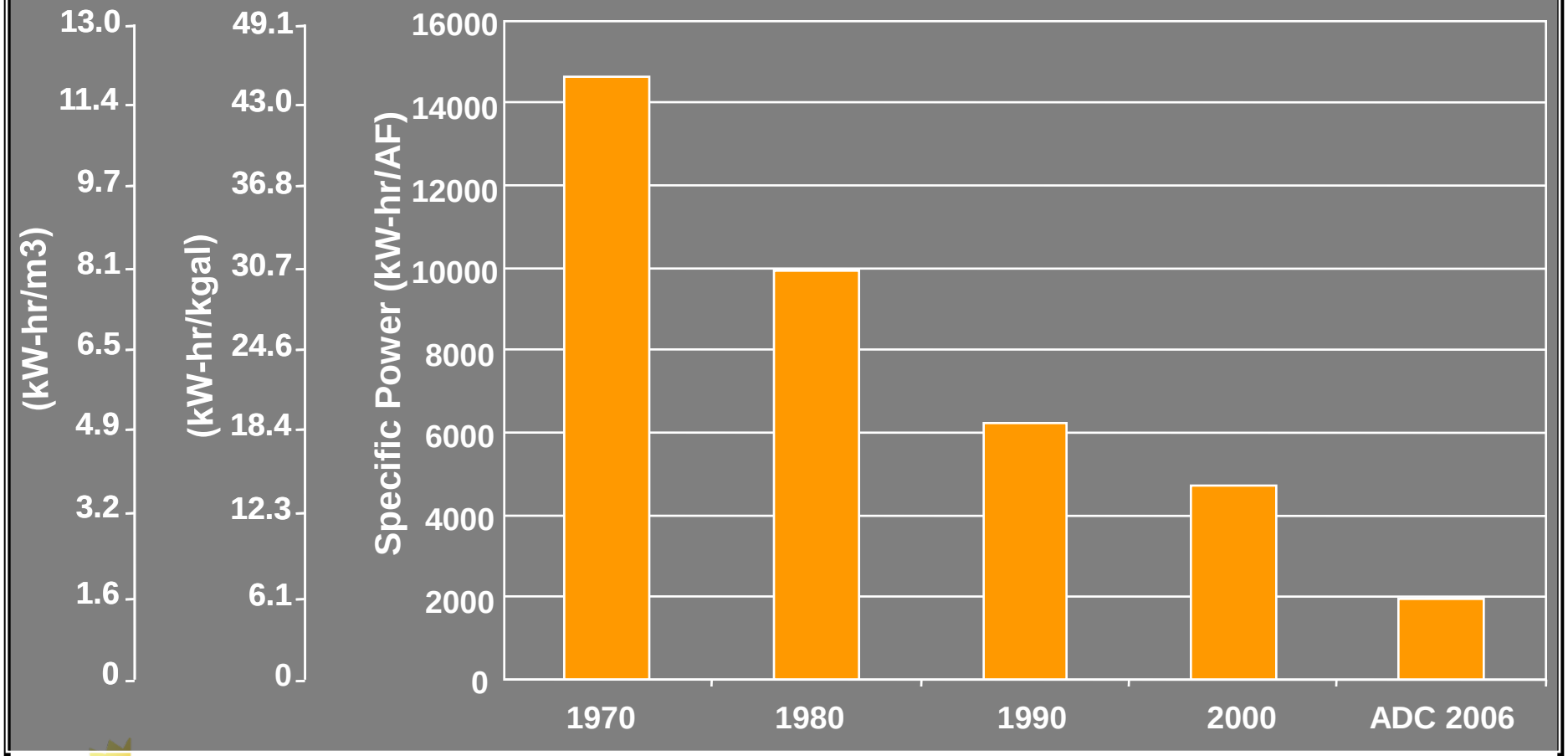
- 1980-2000
- 40% energy savings ~3.9 kWh/m3
- Variable recovery
- Complexity – medium

Pressure Exchanger System



- 2000-Present
- ~54% energy savings ~2.4 kWh/m3 (100 gpm 380 l/m)
- ~55% energy savings ~2.8 kWh/m3 (460 gpm 1700 l/m)
- Variable recovery
- Complexity – highest

Desalination Energy Requirements



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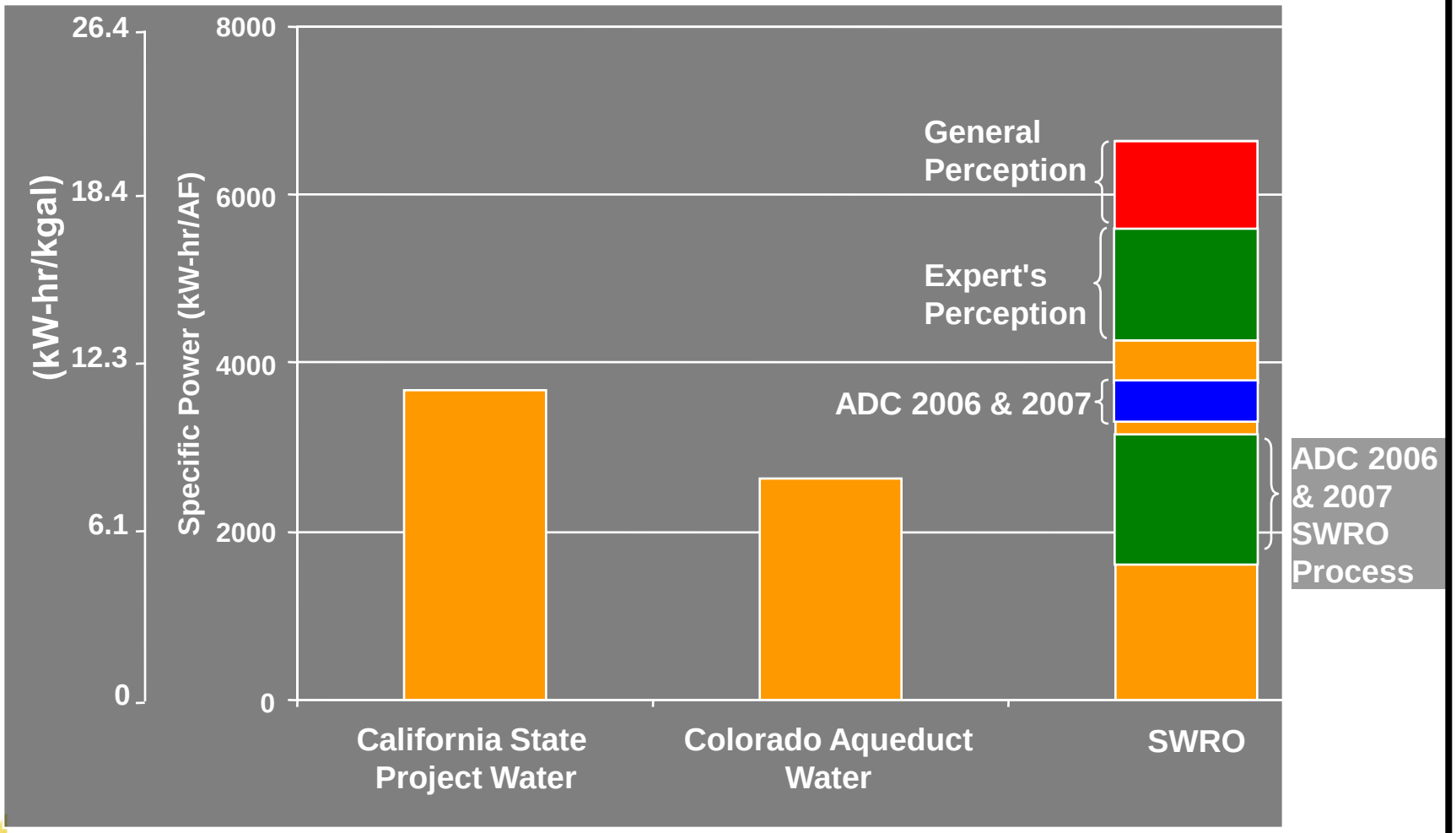
Case Study-Affordable Desalination Collaboration (ADC)

- Partnership with state, local, federal, and private industry partners
- Focused on demonstration of energy efficient desalination
- 4 year study conducted between 2005-2009 at SDTF, Port Hueneme, CA .
- Demonstrated low energy consumption and created database for future planners

Energy Comparision



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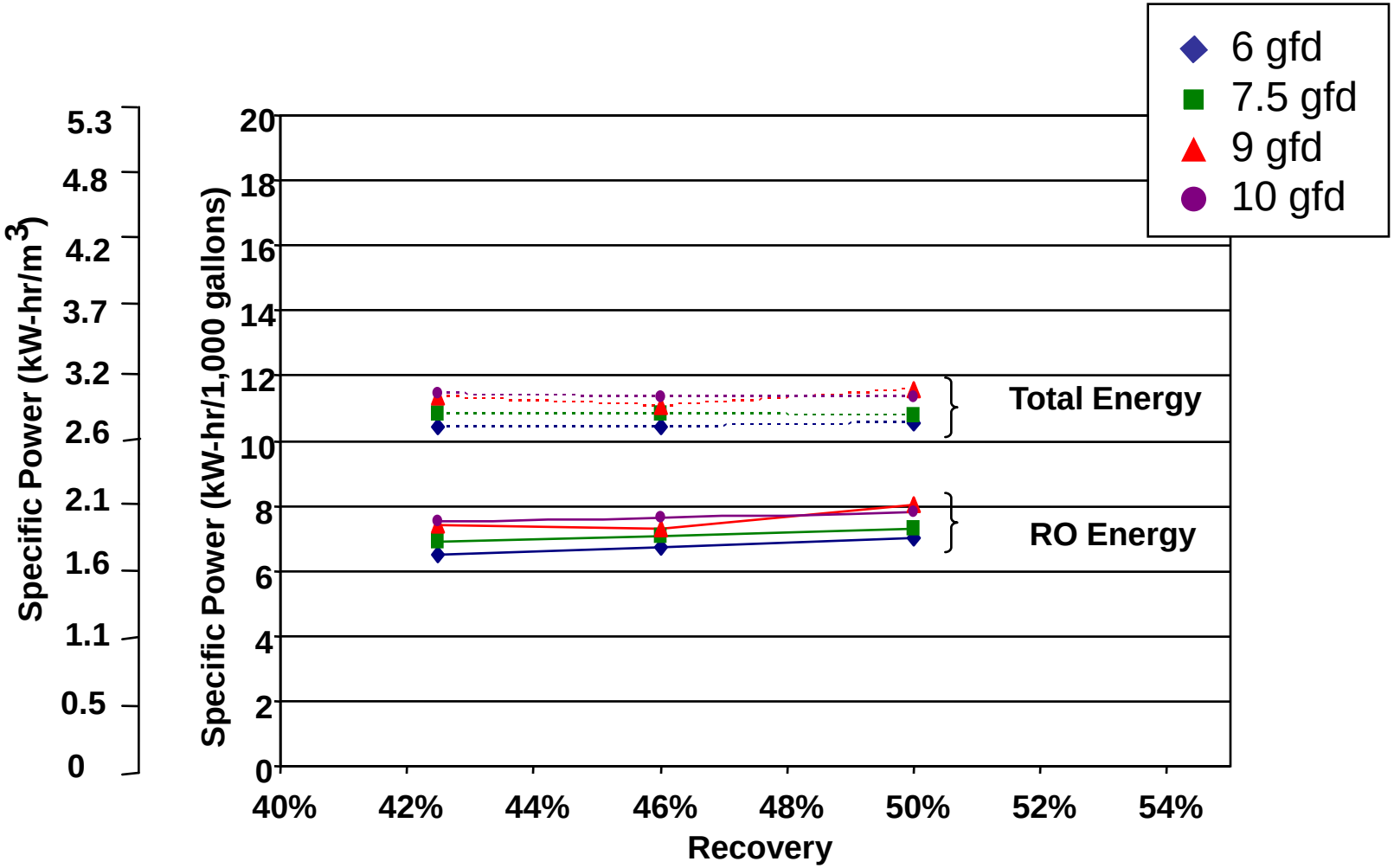
Specific Power Consumption



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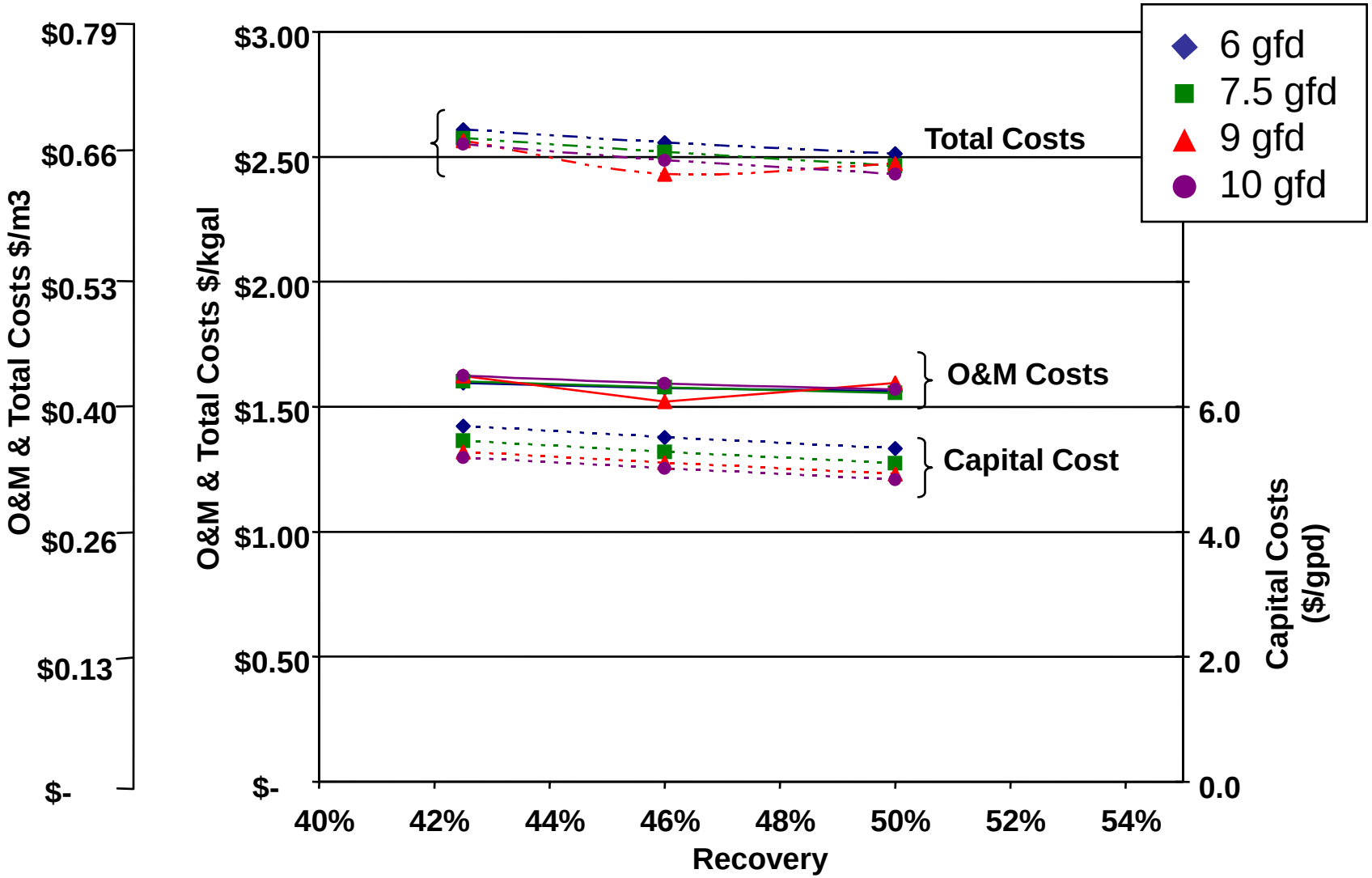
50 MGD Cost Model Results



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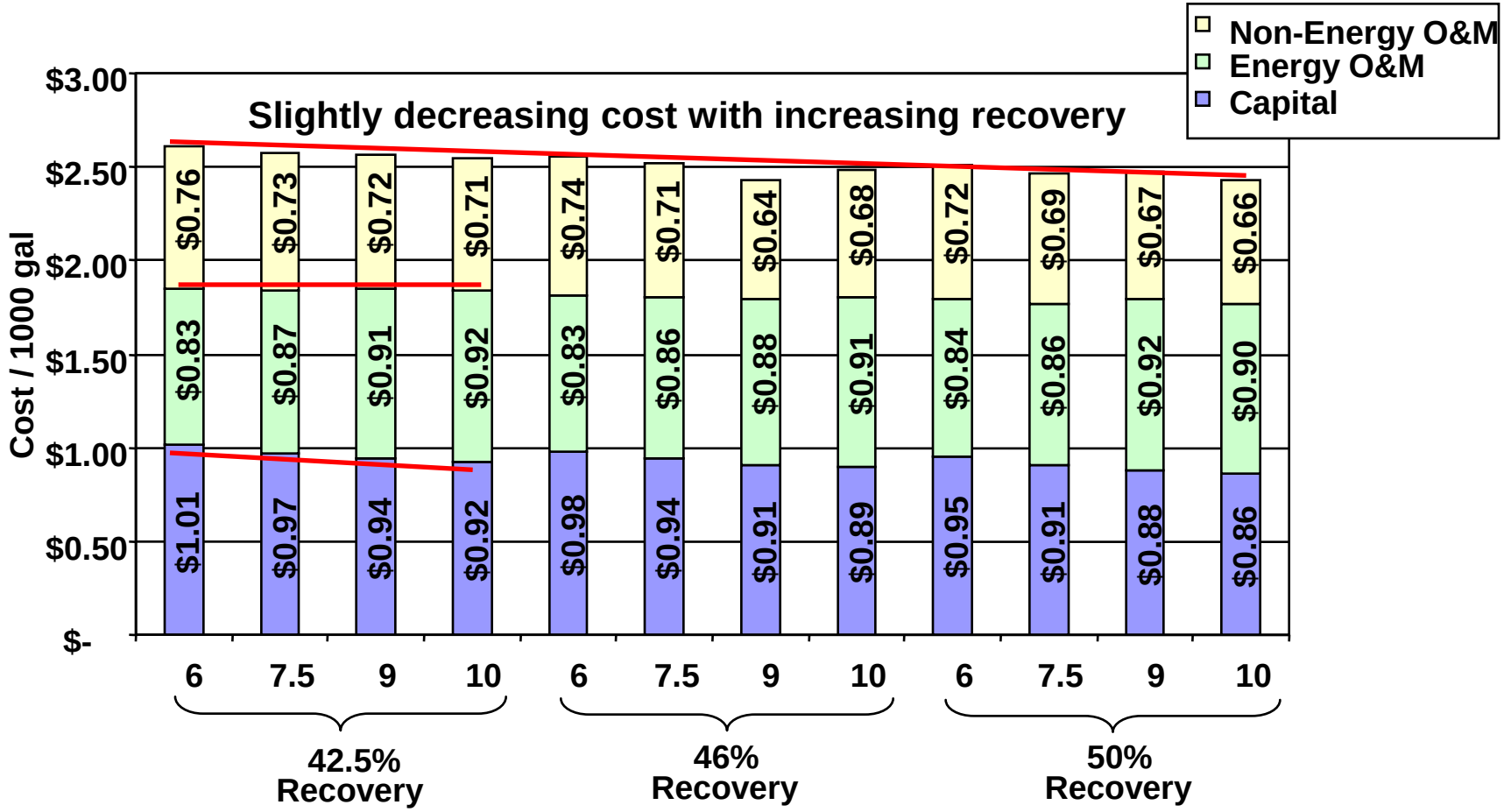
50 MGD Cost Model Results



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RO Facility Planning Steps

- Determine/define plant capacity (gal/day)
- Determine how water will be used
- Type of water to treat
- Identify/specify infrastructure/utilities
- Storage and distribution of water
- Legal/environmental permit issues
- Safety considerations, human interface
- Develop performance statement of work

RO Facility Planning Steps

- Develop preliminary design
- Specify system components
- Create economic cost model
- Conduct Water Analysis
- Setup and conduct pilot studies
- Optimize system variables and scaleup design
- Develop final design and statement of work
- Award contract to build facility

RO Plant options

- Custom Design-build to order
- Prepackaged plants
- Fixed Facility vs. Mobile
- Military Systems
- Lease
- Build/Own/Operate

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