How Much Does Seawater Desalination Cost?

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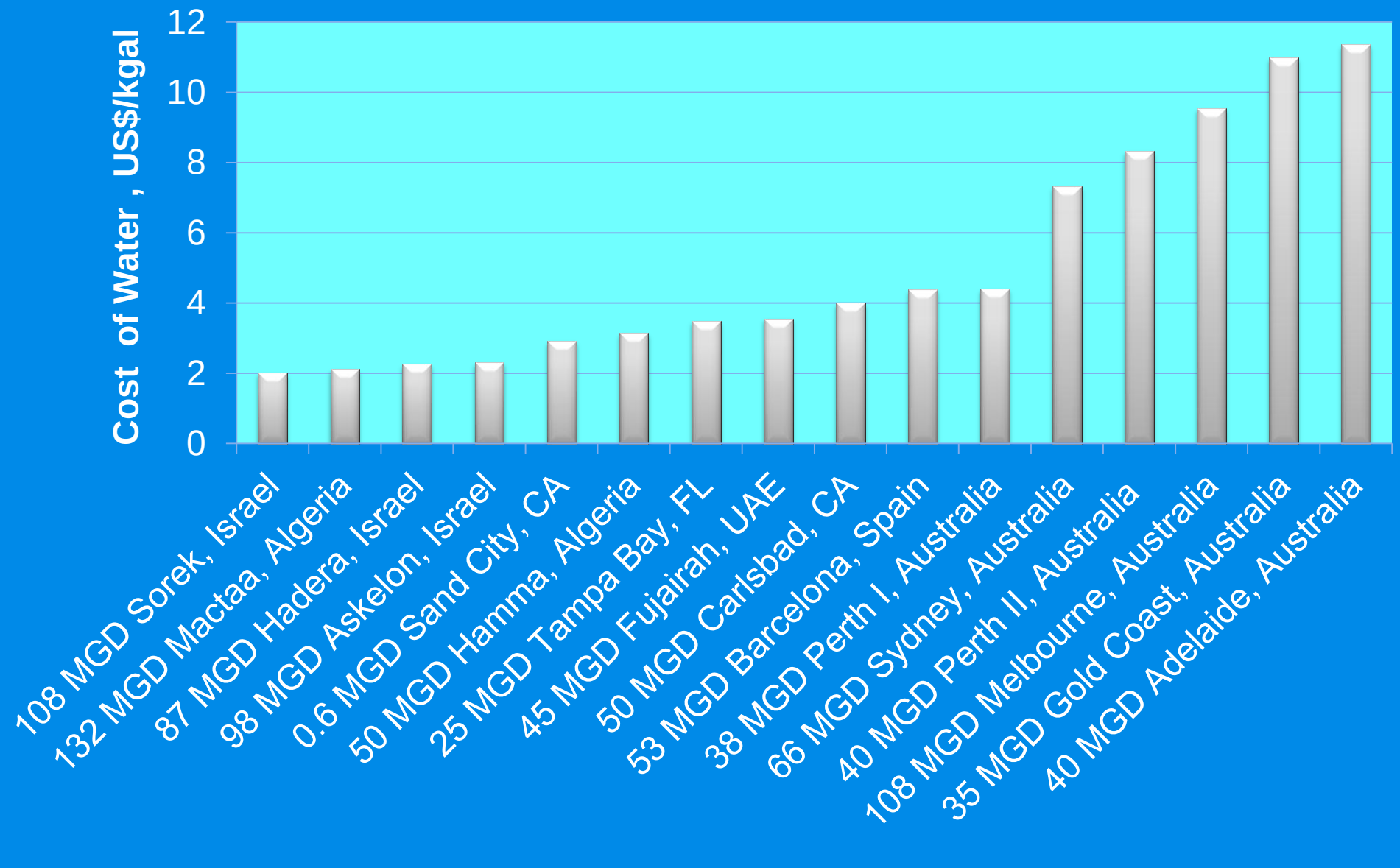
Presentation Outline

- Overview of Current Desalination Cost Trends
- Low-Cost Bracket Desalination Projects – Key Features
- High-Cost Bracket Desalination Projects – What Factors Drive the High Costs?
- Key Cost Components
- Main Factors Impacting Costs

Cost of Water of Recent Desalination Projects



Costs of Recent US SWRO Projects

Project	Status	Capital Cost (US$)	Annual O&M Cost (US$/kgal)	Cost of Water (US$/kgal)
0.6 MGD Sand City, CA	In Operation since 2010	US$11.9 MM	US$1.15/kgal	US$2.91/kgal
25 MGD Tampa Bay, FL	In Operation since 2008	US$138 MM	US$1.54/kgal	US$3.48/kgal
50 MGD Carlsbad, CA	In Financing	US$350 MM	US$1.75/kgal	US$4.00/kgal
2.5 MGD Santa Cruz, CA	In Planning	US$59-64 MM	US$3.94/kgal	US$7.6-8.0/kgal
2.5 MGD Brownsville Demo Project, TX	In Planning	US$22.5 MM	US$2.80/kgal	US$4.38/kgal
25 MGD-80 MGD Coquina Coast, FL	In Planning	US$180 MM - US$560 MM	US$1.99/kgal	US$4.47/kgal (US$5.35-US$6.10 w/ conveyance)

Typical Cost and Energy Ranges
(Medium & Large SWRO Plants)

Classification	Cost of Water Production (US$/kgal)	SWRO System Energy Use (US$/kgal)
Low-End Bracket	2.0 - 3.0	9.5 – 10.5
Medium Range	3.5 – 5.0	11.0 - 12.0
High-End Bracket	6.5 - 11.5	12.5 – 14.0
Average	4.0	11.5

Common Features of Low-Cost Desalination Projects

- Low Cost HDPE Open Intakes or Beach Wells;
- Near-Shore/On-Shore Discharges w/o Diffuser Systems or Co-discharge w/ Power Plant of WWTP Outfalls;
- Point of Product Water Delivery within 5 Miles of Desalination Plant Site;
- RO System Design w/ Feed of Multiple Trains by Common High Pressure Pumps and Energy Recovery Systems;
- Turnkey (BOOT, BOO) Method of Project Delivery.

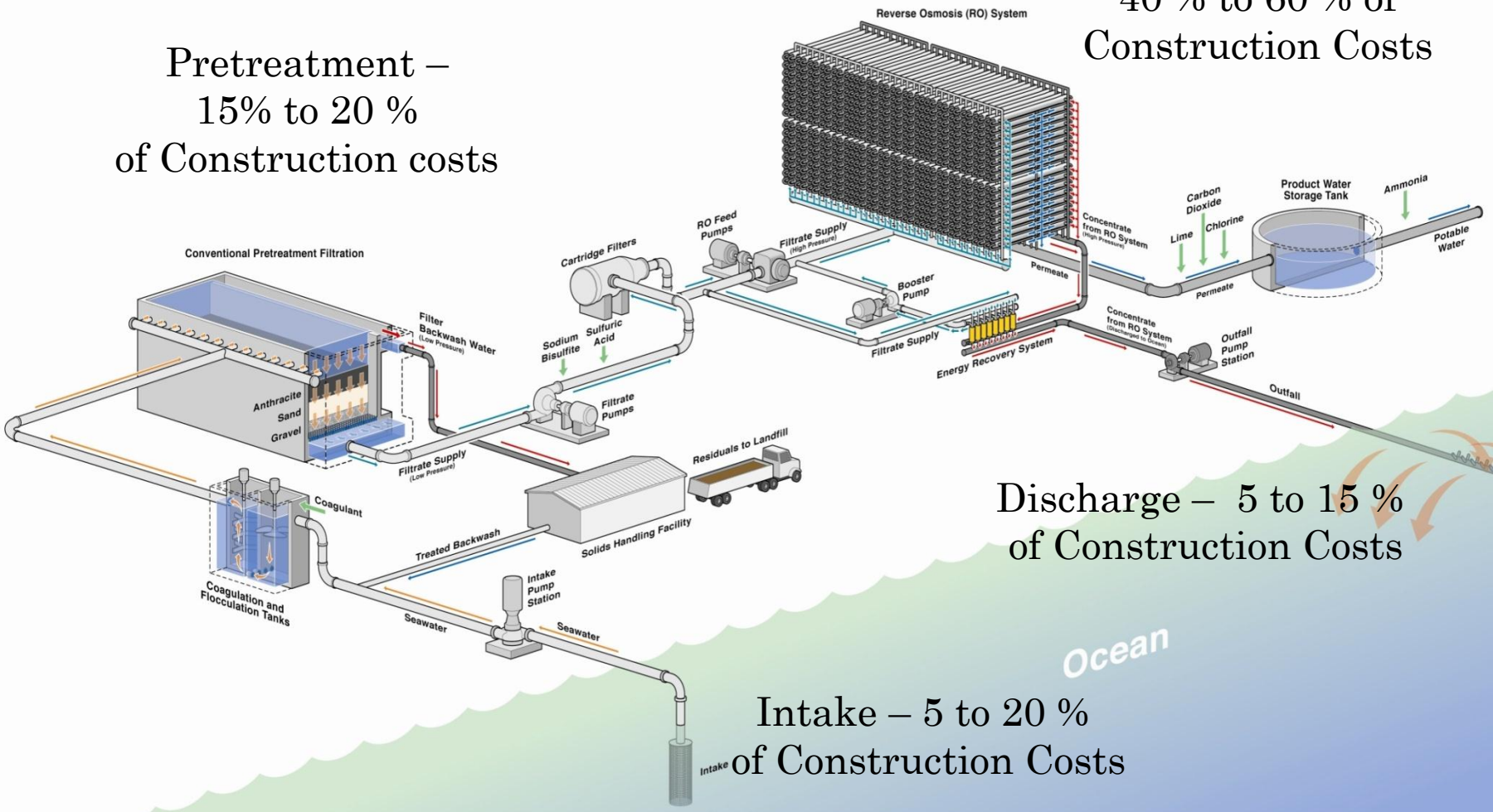
Key Reasons for Cost Disparity Between High-End & Low-end Cost Projects (US$2.0 – 3.0 vs. US$6.5-11.5/kgal)

- **Desalination Site Location** (NIMBI vs. Science Driven)
  - **Costly Plants Have Overly Long Product Water Delivery Pipelines**
    - 120 MGD Melbourne Plant – Cost of Plant/Delivery + Power Supply Systems = US$1.7 BB/1.1 BB (50 miles)
    - 66 MGD Sydney SWRO Plant – Cost of Plant/Delivery System = US$560 MM/US$490 MM (10 miles of underground tunnel under Botany Bay).
- **Environmental Considerations**
  - Complex Intakes & Diffuser Systems
- **Phasing Strategy**
  - Intake and Discharge System Capacity;
  - Pretreatment & RO System Design;
- **Labor Market Pressures**
- **Method of Project Delivery & Risk Allocation**

Seawater Desalination Plant – Construction Costs

RO System – 40 % to 60 % of Construction Costs

Pretreatment – 15% to 20 % of Construction costs



Discharge – 5 to 15 % of Construction Costs

Intake – 5 to 20 % of Construction Costs

Intake Construction Costs Key Factors

- Very Dependent on Source Water Quality
- Usually US$0.5 – 1.5 MM/MGD (up to 3.0 MM/MGD for Complex Tunnel Intakes)
- Beach Well Intakes Are Usually Less Costly
- Horizontal and Slant Wells Comparable to Open Intakes
- Infiltration Galleries Often are More Expensive than Open Intakes

Pretreatment Construction Costs

- Very Dependent on Source Water Quality & Type of Treatment Technologies
- Usually US$0.5 – US$1.5 MM/MGD
- High Quality Well Water Sources Require Only Cartridge Filtration (Low Cost Pretreatment)
- Single-stage Granular Media Filtration Usually is Less Costly than Membrane Pretreatment

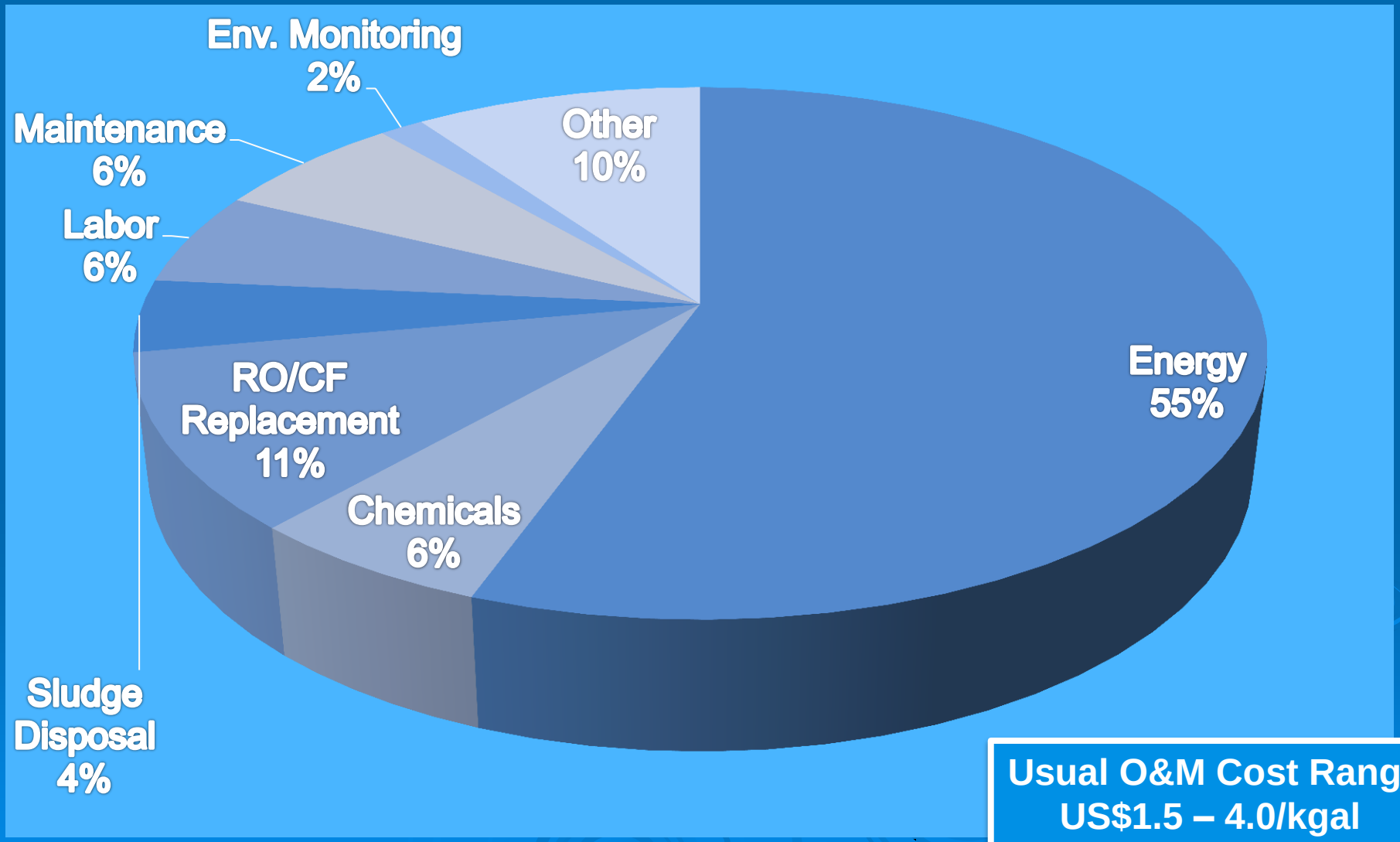
SWRO System Construction Costs

- Dependent on Source Water Quality & Target Product Water Quality
- Usually Between US$1.5-4.0 MM/MGD
- Single-stage/Single Pass SWRO System is Least Costly
- Additional Costs for Two-Pass/Two-Stage RO System May Vary Between 15 and 30 % of the These of Single Pass/Single Stage SWRO System

Concentrate Disposal Construction Costs

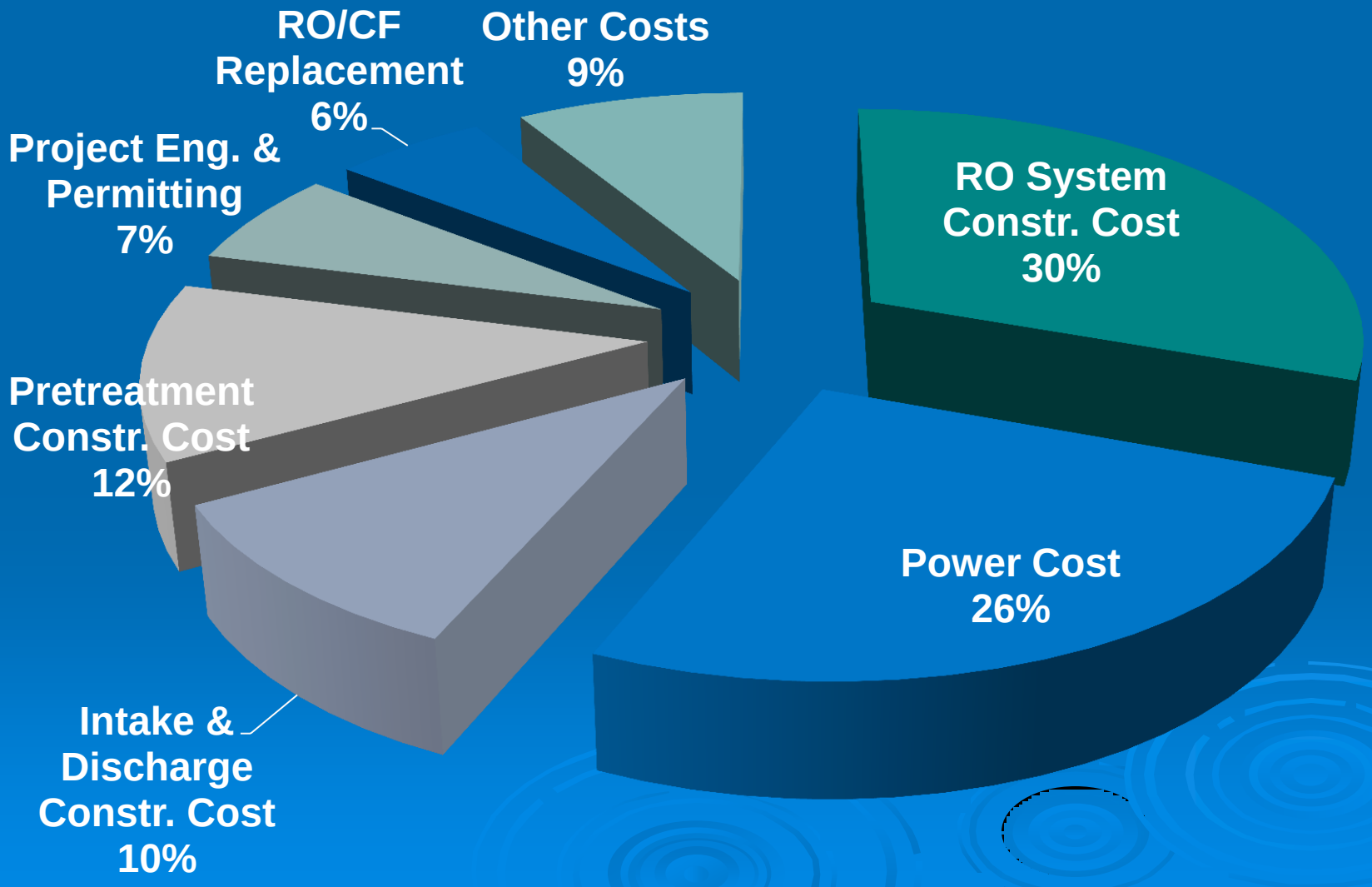
Disposal Method	Construction Cost (US$ Million/MGD)
New Outfall w/Diffusers	2.0 – 5.5
Power Plant Outfall	0.2 – 0.6
Sanitary Sewer	0.1 – 0.4
WWTP Outfall	0.3 – 2.0
Deep Well Injection	2.5 – 6.0
Evaporation Ponds	3.0 – 9.5
Zero-Liquid Discharge	5.5 – 15.0

Typical O&M Cost Breakdown



Usual O&M Cost Range
US$1.5 – 4.0/kgal

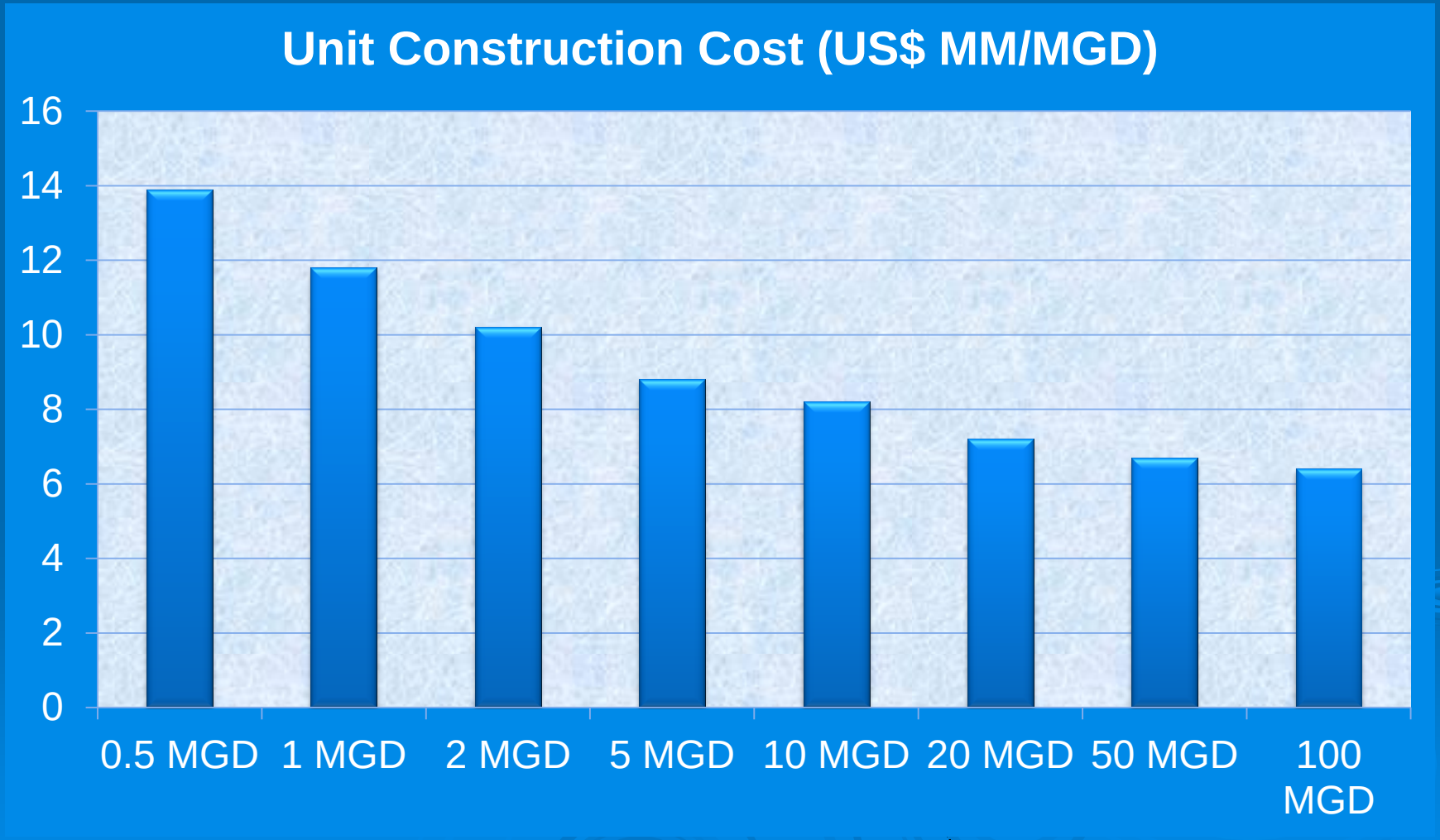
Cost of Water Breakdown



Key Factors Affecting Costs

- Plant Size – Bigger is Better
- Source Water Quality - TDS, Temperature, Solids, Silt and Organics Content.
- Product Water Quality – TDS, Boron, Bromides, Disinfection Compatibility.
- Concentrate Disposal Method;
- Power Supply & Unit Power Costs;
- Project Delivery Method & Financing;
- Other Factors:
  - Intake and Discharge System Type;
  - Pretreatment & RO System Design;
  - Plant Capacity Availability Target.

Desalination Plant Construction Cost as Function of Capacity



Product Water Quality & Costs

Target WQ	Constr. Costs	O&M Costs	Cost of Water
TDS/Cl = 500/250 mg/L; Boron = 1 mg/L.	1.0	1.0	1.0
TDS/Cl = 250/100 mg/L; Boron = 0.75 mg/L.	**1.15-1.25**	**1.05-1.10**	**1.10-1.18**
TDS/Cl = 100/50 mg/L; Boron = 0.5 mg/L.	1.27-1.38	1.18-1.25	1.23-1.32
TDS/Cl = 30/10 mg/L; Boron = 0.3 mg/L.	1.40-1.55	1.32-1.45	1.36-1.50

Where Future Cost Savings Would Come From?

"The Best" of Seawater Desalination Present Status & Future Forecasts

Parameter	Today	Within 5 Years	Within 20 Years
Cost of Water (2010 US$/kgal)	US$2.0-3.0	US$1.5-2.5	US$1.0-1.5
Construction Cost (Million US$/MGD)	4.5-8.0	4.0-6.5	2.0-3.5
Power Use of SWRO System (kWh/kgal)	9.5-10.5	8.0-10.0	5.0-6.5
Membrane Productivity (gallons/day/membrane)	6,500-12,500	9,000-15,000	25,000-40,000
Membrane Useful Life (years)	5-7	7-10	10-15
Plant Recovery Ratio (%)	45-50	50-55	55-65

Concluding Remarks

- Seawater Desalination is Economical Today and Will Become Even More Cost-Competitive in the Future;
- Typical Cost of Water is US$3.5 to US$5.0/kgal;
- The Future of Seawater Desalination Is Bright – 20% Cost of Water Reduction in the Next 5 Years;
- Long-term Investment In Research and Development Has the Potential to Reduce the Cost of Desalinated Water by 80 % In the Next 20 Years.

Seawater Desalination Costs

Questions?