Hazen

High Recovery Desalination and Water Treatment

Kevin Alexander, P.E., Vice President, Hazen and Sawyer

National Academy of Engineering -
2016 US Frontiers of Engineering Symposium


Hoover Dam

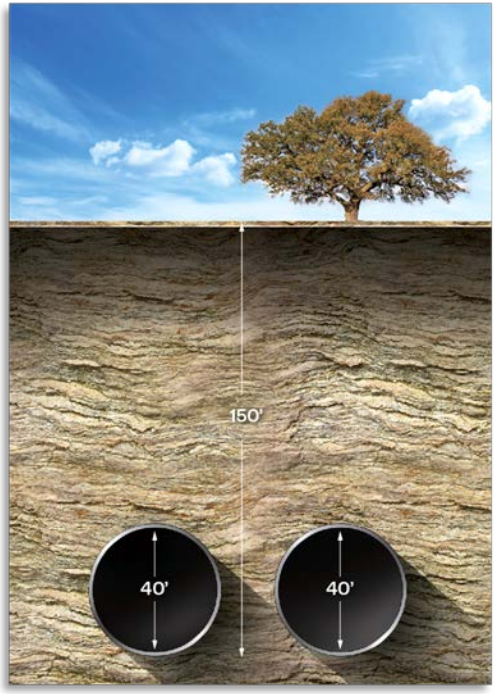
What did the Hoover Dam Solve?

Energy

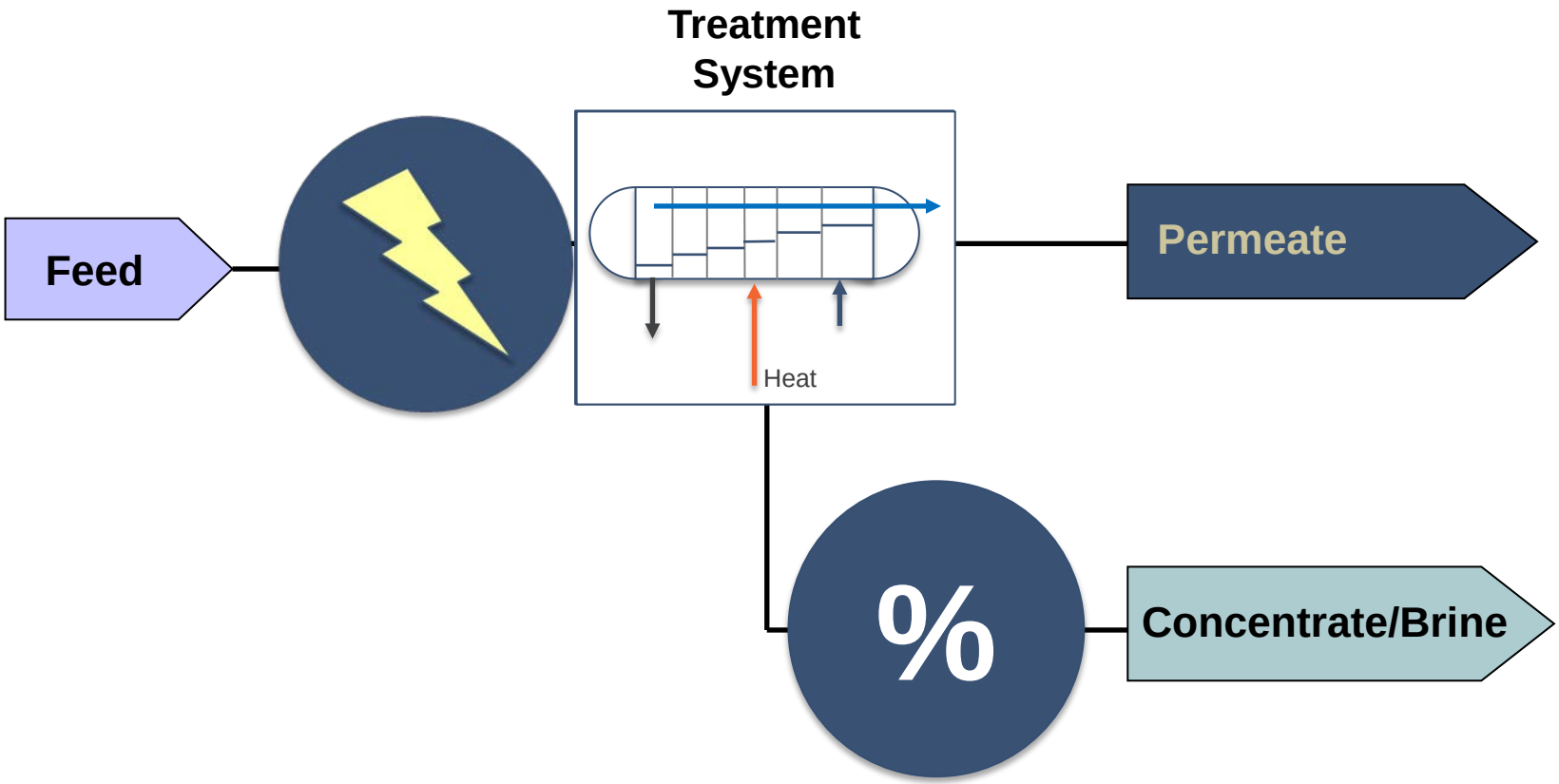
Water

Economic Downturn

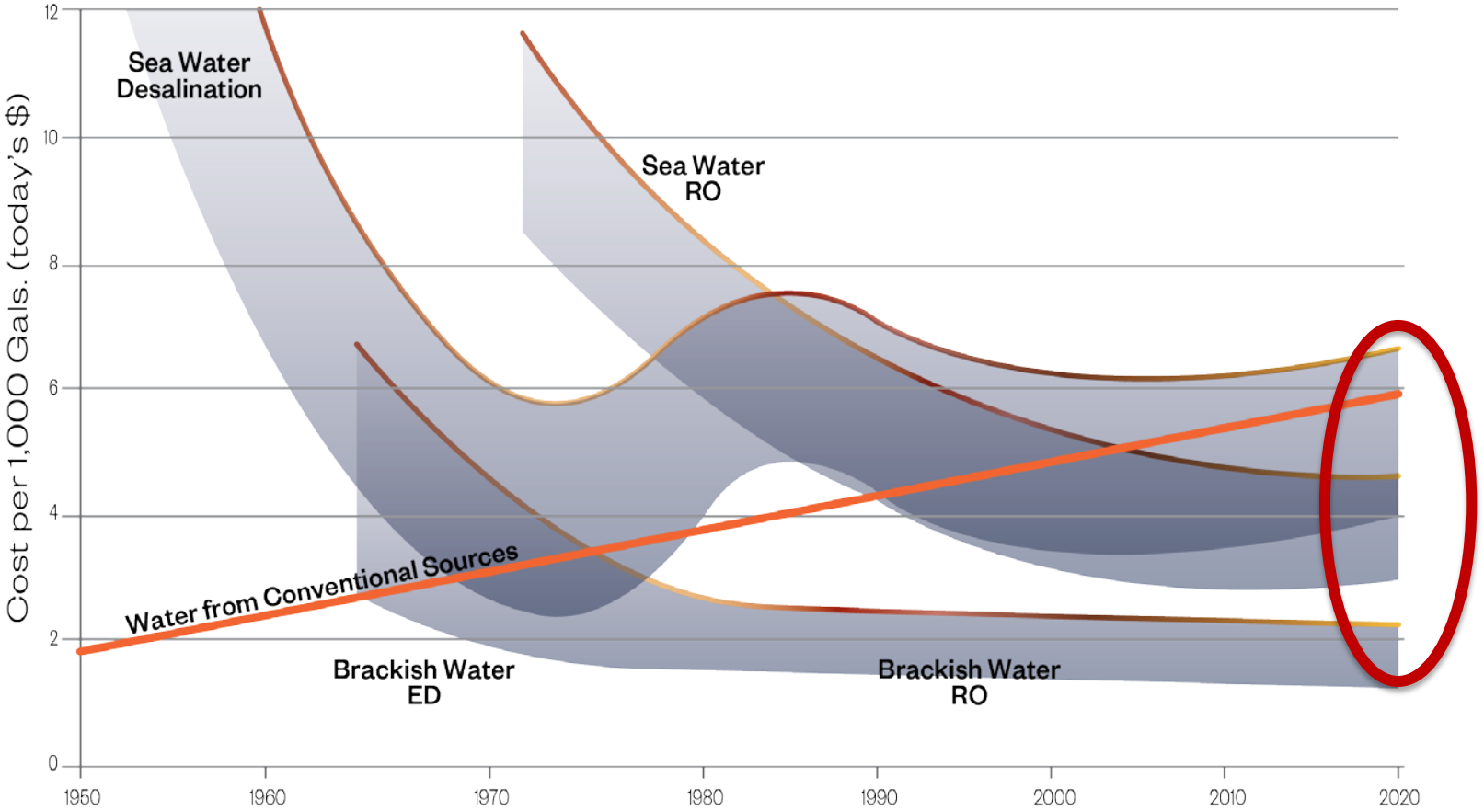
What is the Vision for the Next 100 Years?



Desalination Technologies have similarities to consider?



Cost of Desalination Approaching Theoretical Limits



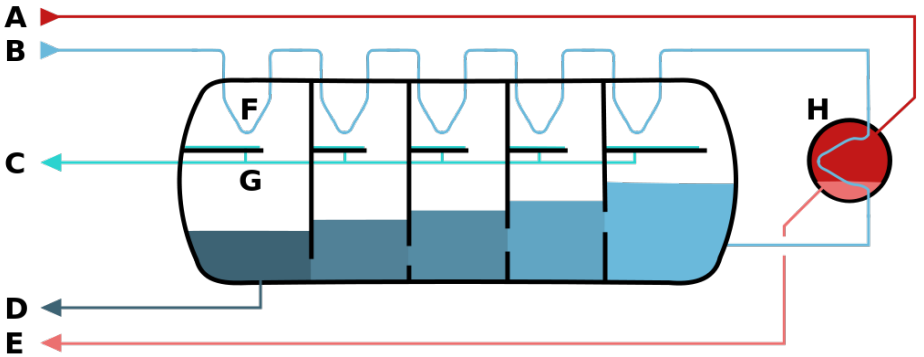
Multistage Flash and Multieffect Distillation Processes

Boilers from Australia Gold Mines - early 1900s

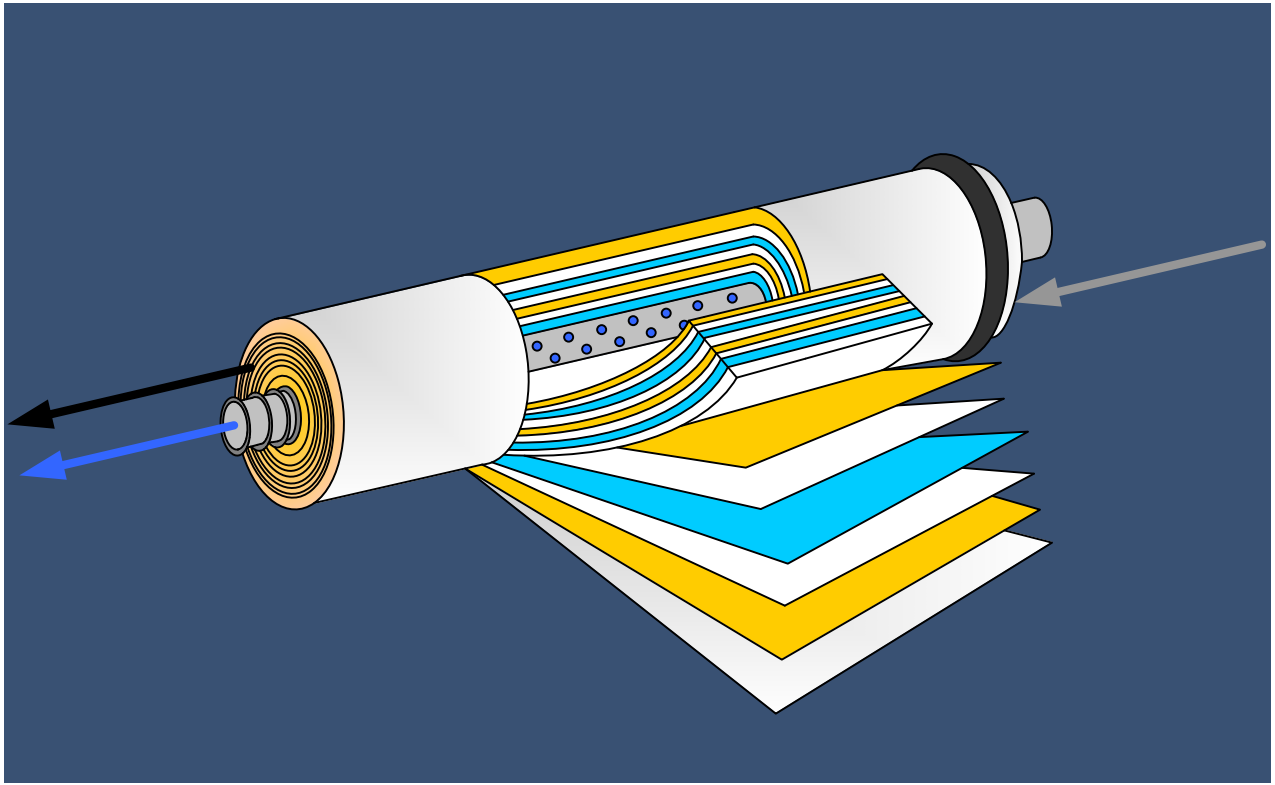
1960s Vacuum Freezing Technology Origins

Uses waste heat from power plants

Common in middle east



Spiral Wound RO/NF Membrane Elements Construction



Reverse Osmosis Advancements

Membrane Materials –
Polyamide Composite

Membrane Manufacturing –
Automated Rolling

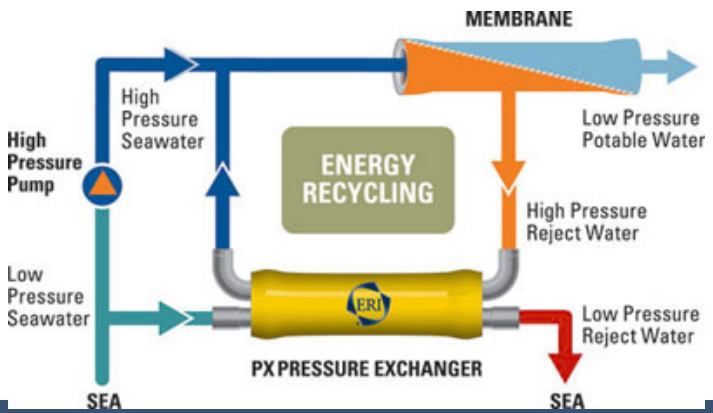
Membrane Packaging
16 inch diameter

Improved Energy Recovery using mechanical devices

RO System Configurations consider Energy Optimization

Lower Pressure Recovery Devices

- Pressure Exchangers
- Pump Engineering
- Fedco Energy Recovery
- DWEER

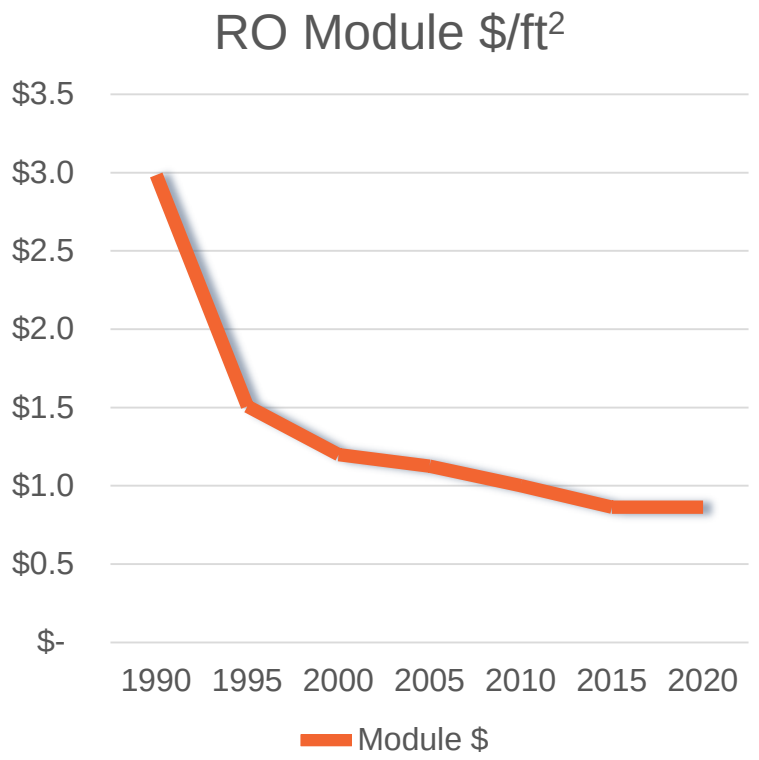


Improvements reduce costs of RO

Improved Membrane Manufacturing

Membrane Competition – 7 Manufacturers - LG, Lanxess, CMS, Koch, Hydranautics, Toray, Dow

Membrane Models and Options

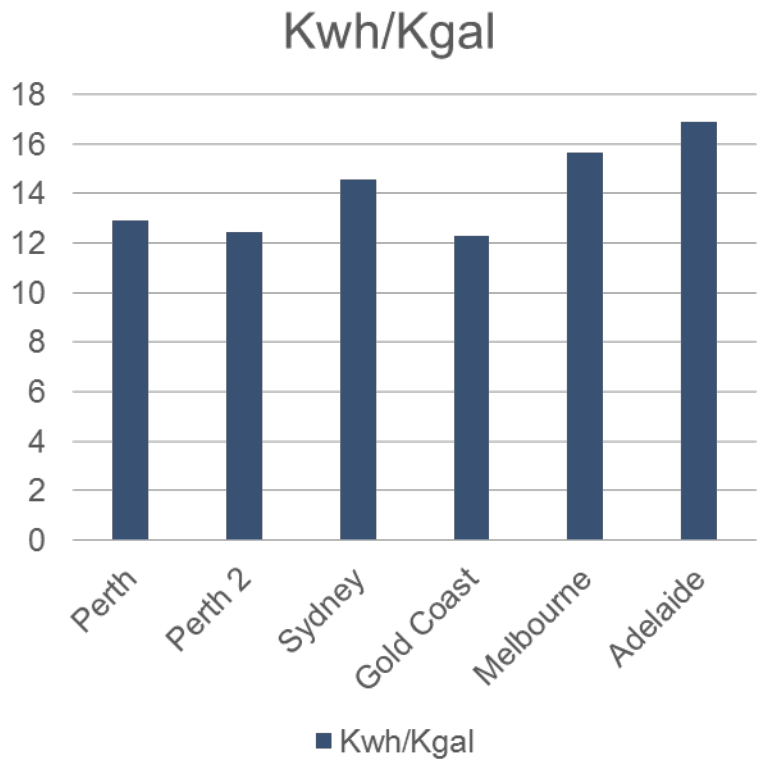


RO Seawater Desalination Energy per 1000 Gallons

Theoretical Minimum is 2.65Kwh/kgal

Dependent on many factors – Boron and Temperatures

Affordable Desalination Coalition proved 8-11 Kwh/Kgal

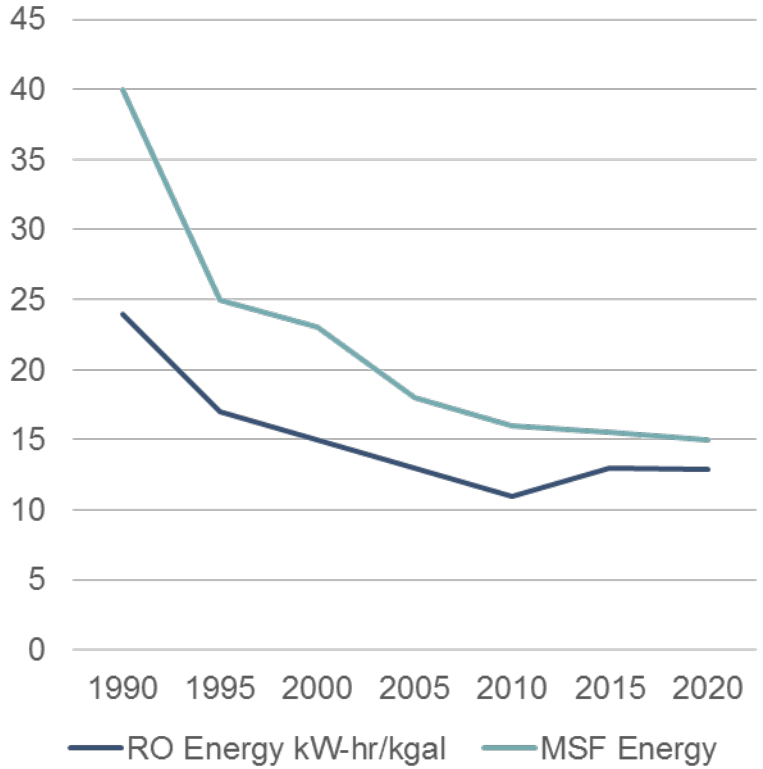


Energy Continues to Drop for Seawater Desalination

Energy Recovery and Boron Levels affect overall energy

Energy of MSF Reduced

Costs Vary with Petroleum and Waste heat



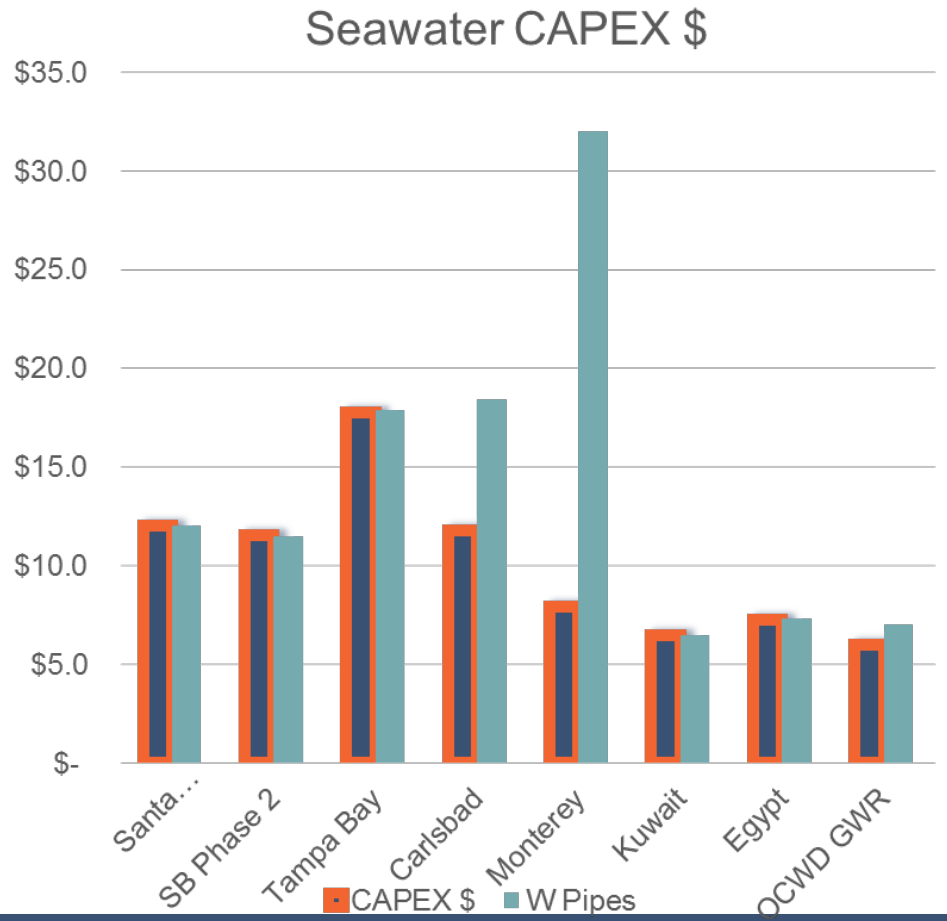
Capital Costs of Desalination Plants vary widely

US costs are impacted by Permitting/Environmental

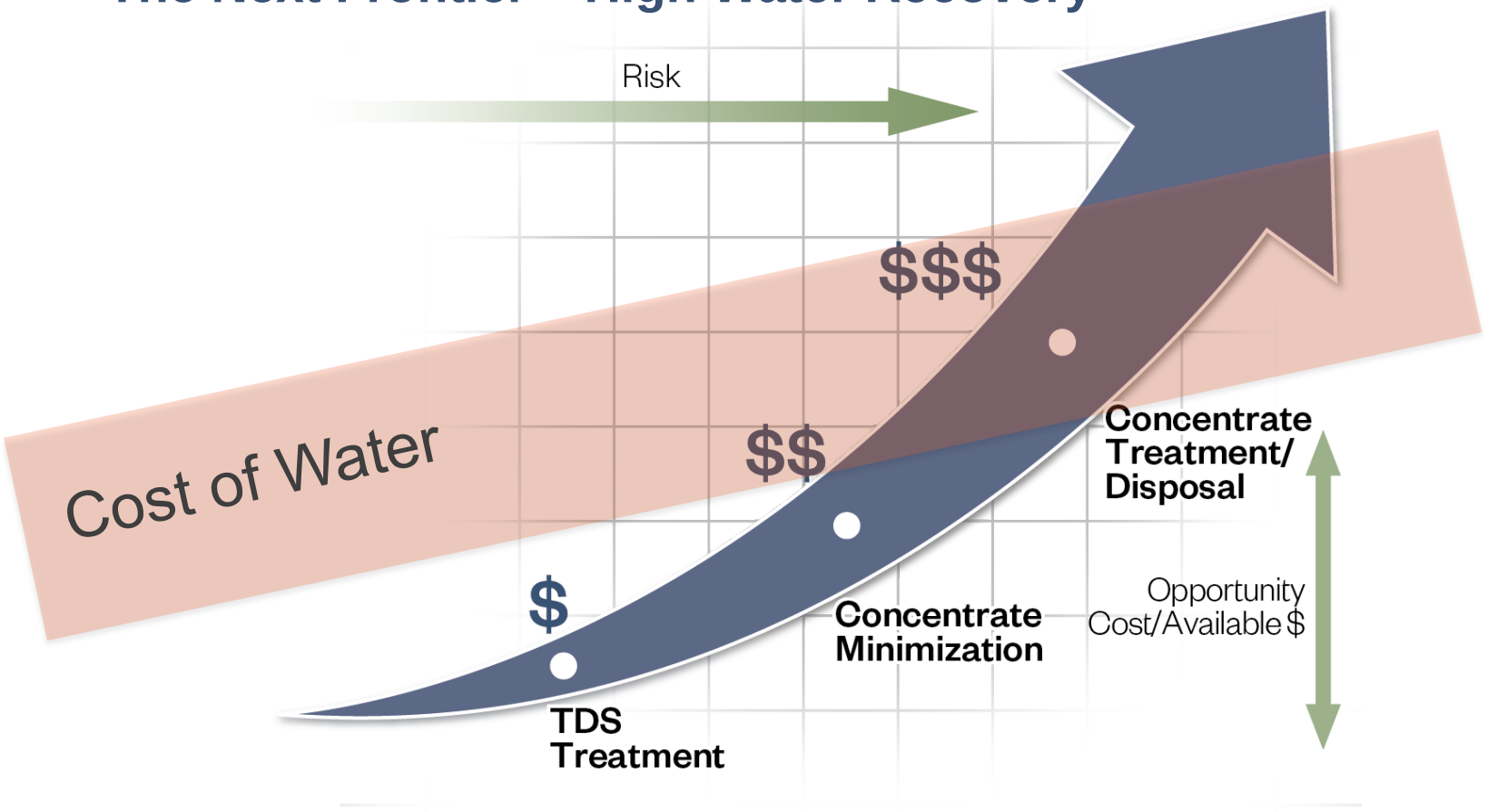
Desalination Costs in Other Countries 1/3 of US

Desalination Costs are site specific

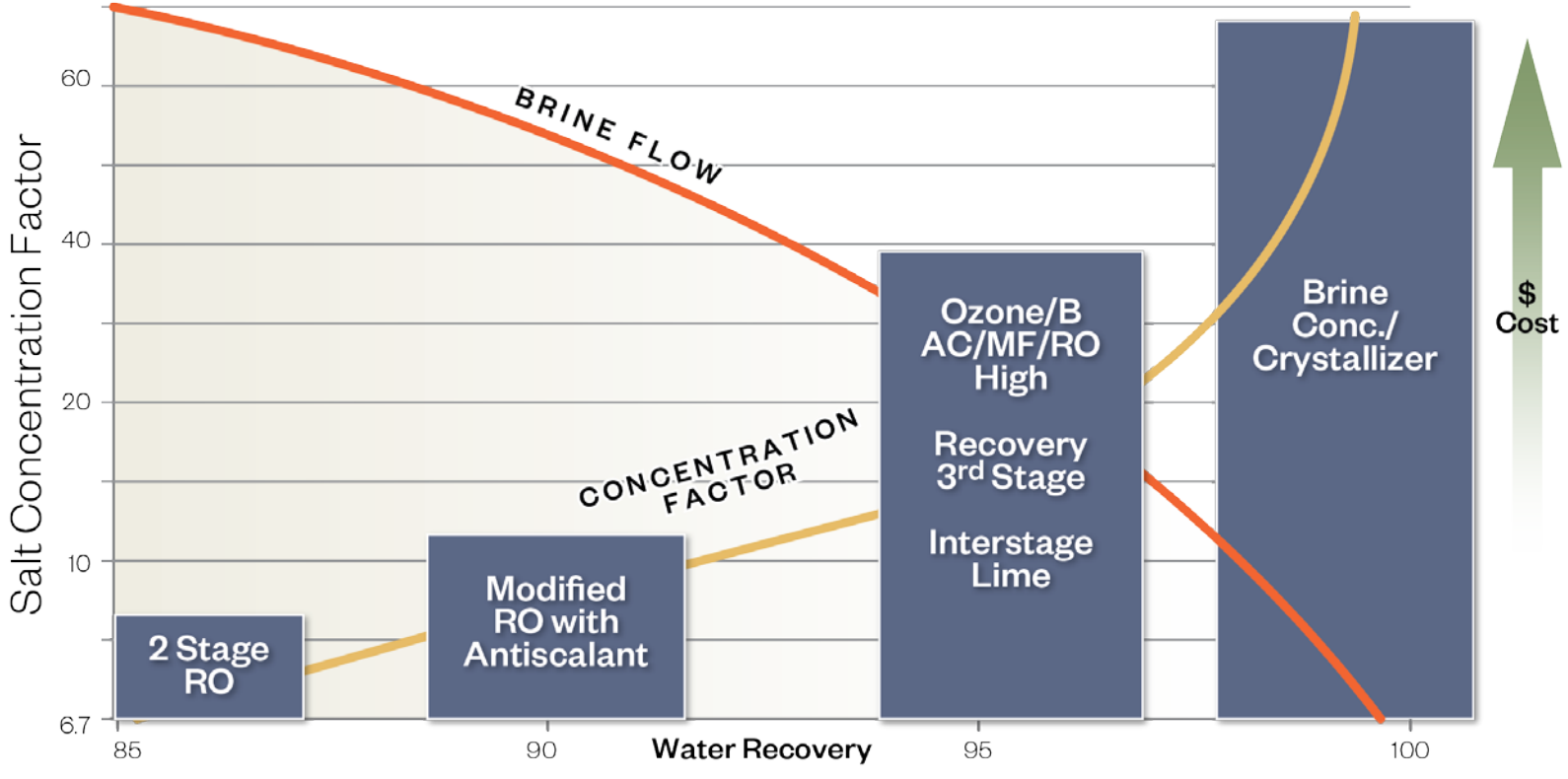
Desalination as compared to Advanced Water Treatment



The Next Frontier – High Water Recovery

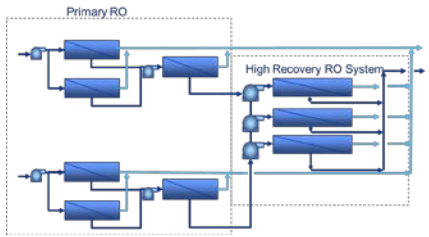


High Recovery Frontier – Concentrate Minimization



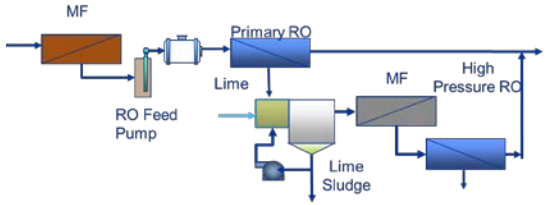
High Recovery Frontier – Other Brine Minimization Technology

Controlled Scaling RO - CSRO

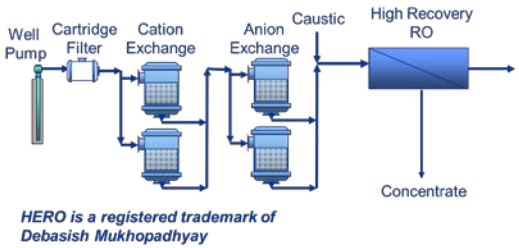


ZDD Technology

Interstage Lime

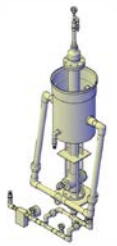


Hi Efficiency RO - HERO™

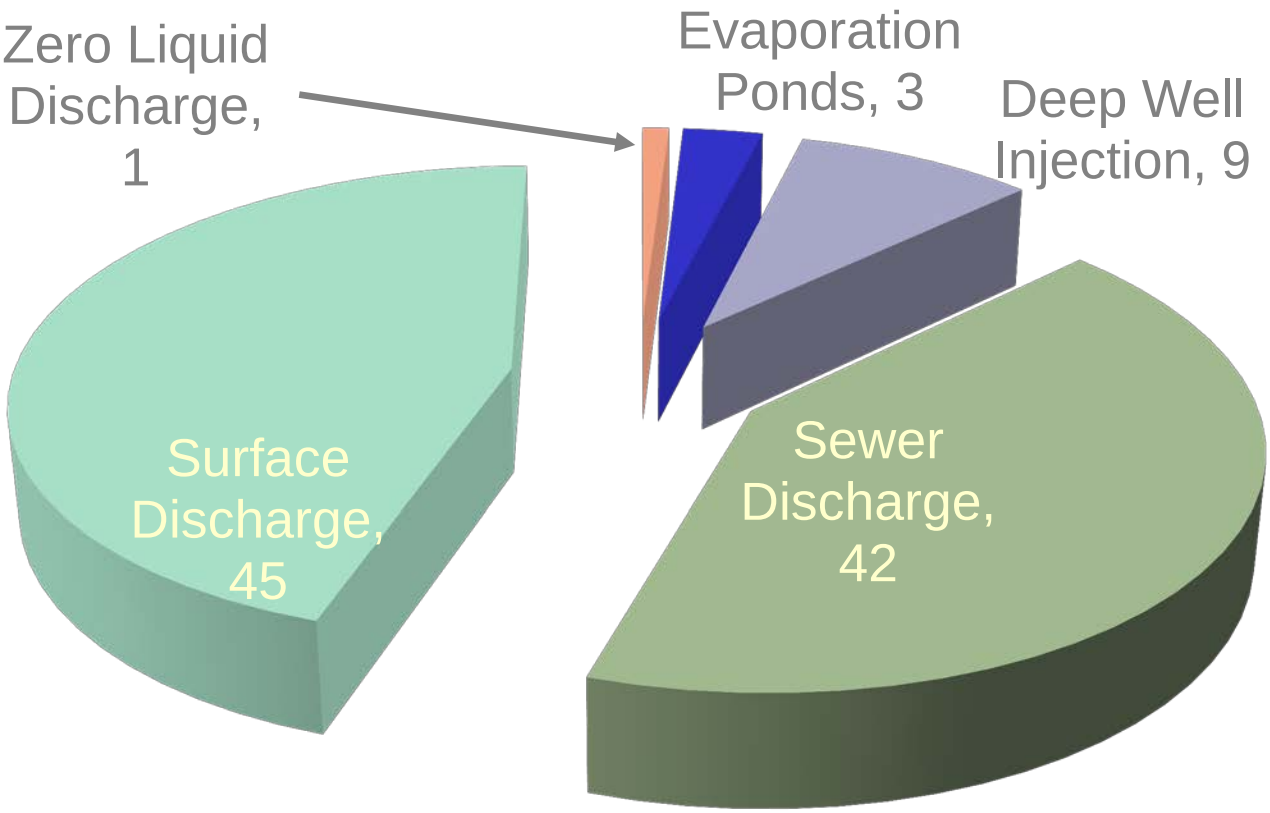


Desalitech - Closed Circuit Desalination

Brine Bulb



Concentrate Disposal – Zero Liquid Discharge



Mickley, 2008

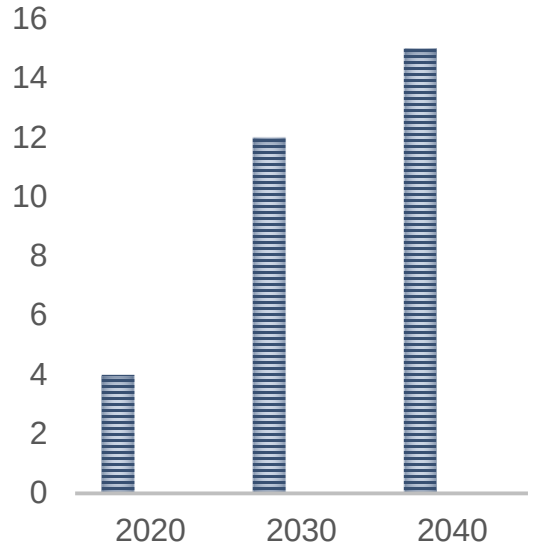
ZLD Cost considerations and site impacts vary

Location	Flow	Recovery	CAPEX Cost	OPEX Cost
Chino Desalter Authority	1.7 MGD	95%	$47.1M	$0.05/kgal
WRD of So. CA	1 MGD	93%	$5M	$1.5/kgal
Signal Hill	15 GPM	98%	$198K	$0.05/kgal
EMWD	2.3 MGD	85%	$18.2M	$1.05M/yr

High Recovery Desalination and Water Treatment

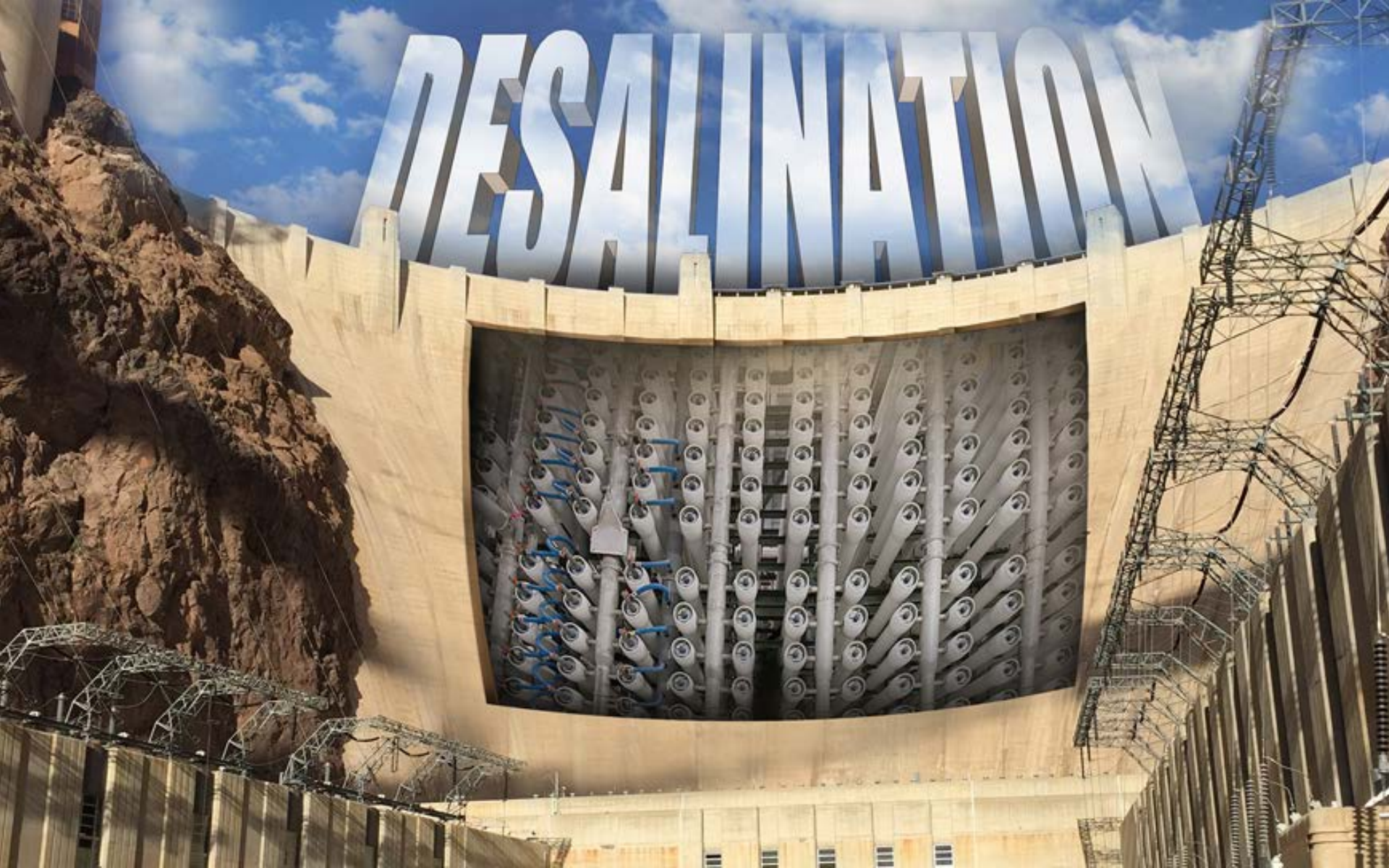
Energy

Water

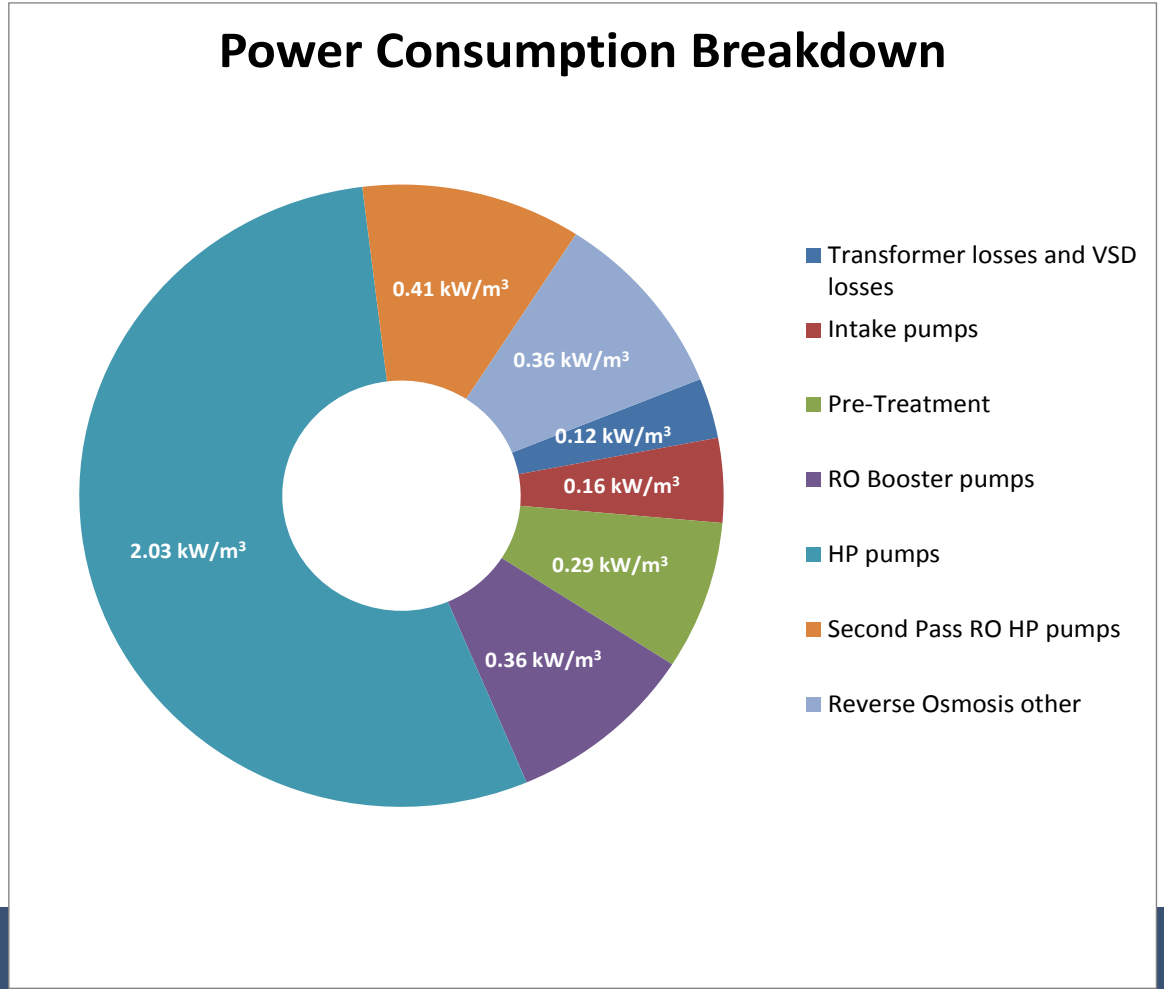


Economic Growth

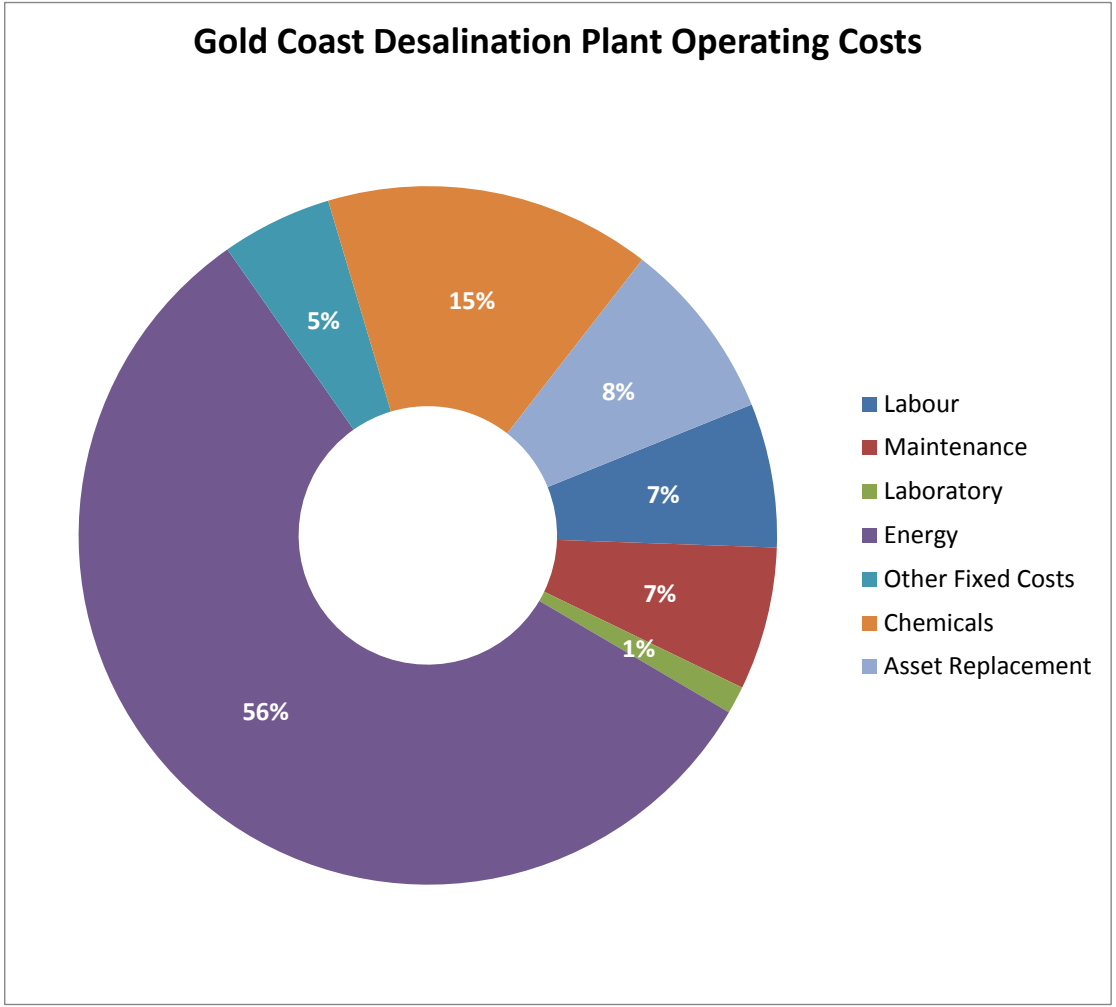
DESALINATION



Power


Power Consumption Breakdown
0.41 kW/m³
0.36 kW/m³
0.12 kW/m³
0.16 kW/m³
0.29 kW/m³
0.36 kW/m³
2.03 kW/m³
Transformer losses and VSD losses
Intake pumps
Pre-Treatment
RO Booster pumps
HP pumps
Second Pass RO HP pumps
Reverse Osmosis other

Maintenance Costs



Australian Seawater Desal Ops Cost