

Sea Water Desalination

Economics of the Reverse Osmosis Desalination Technology

Author: Zeev Zimmerman, MBA, MSc., BSc.

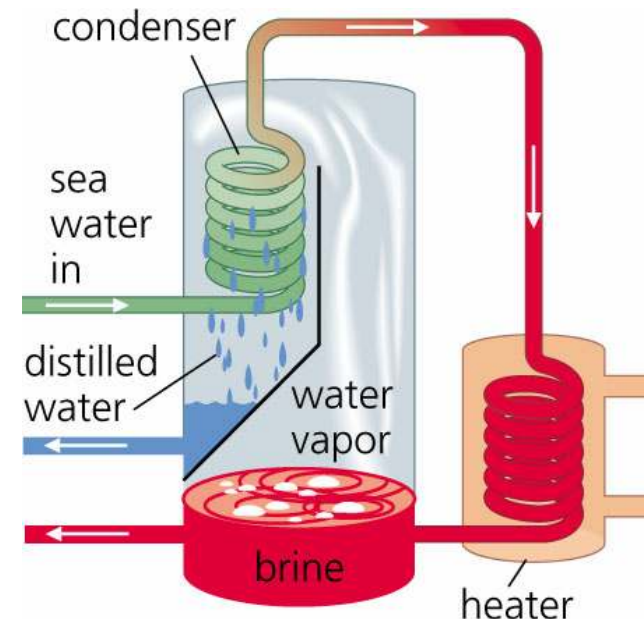
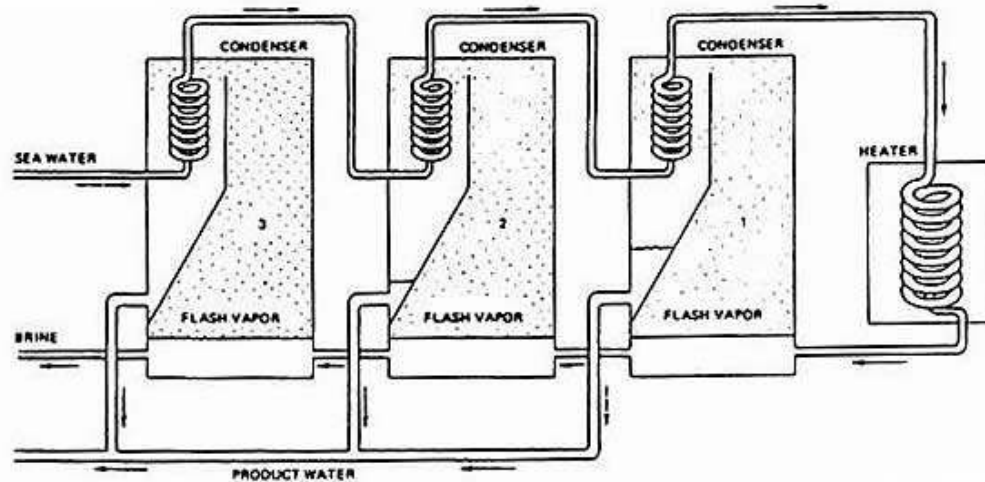
12 July 2009

Type of Desalination Processes

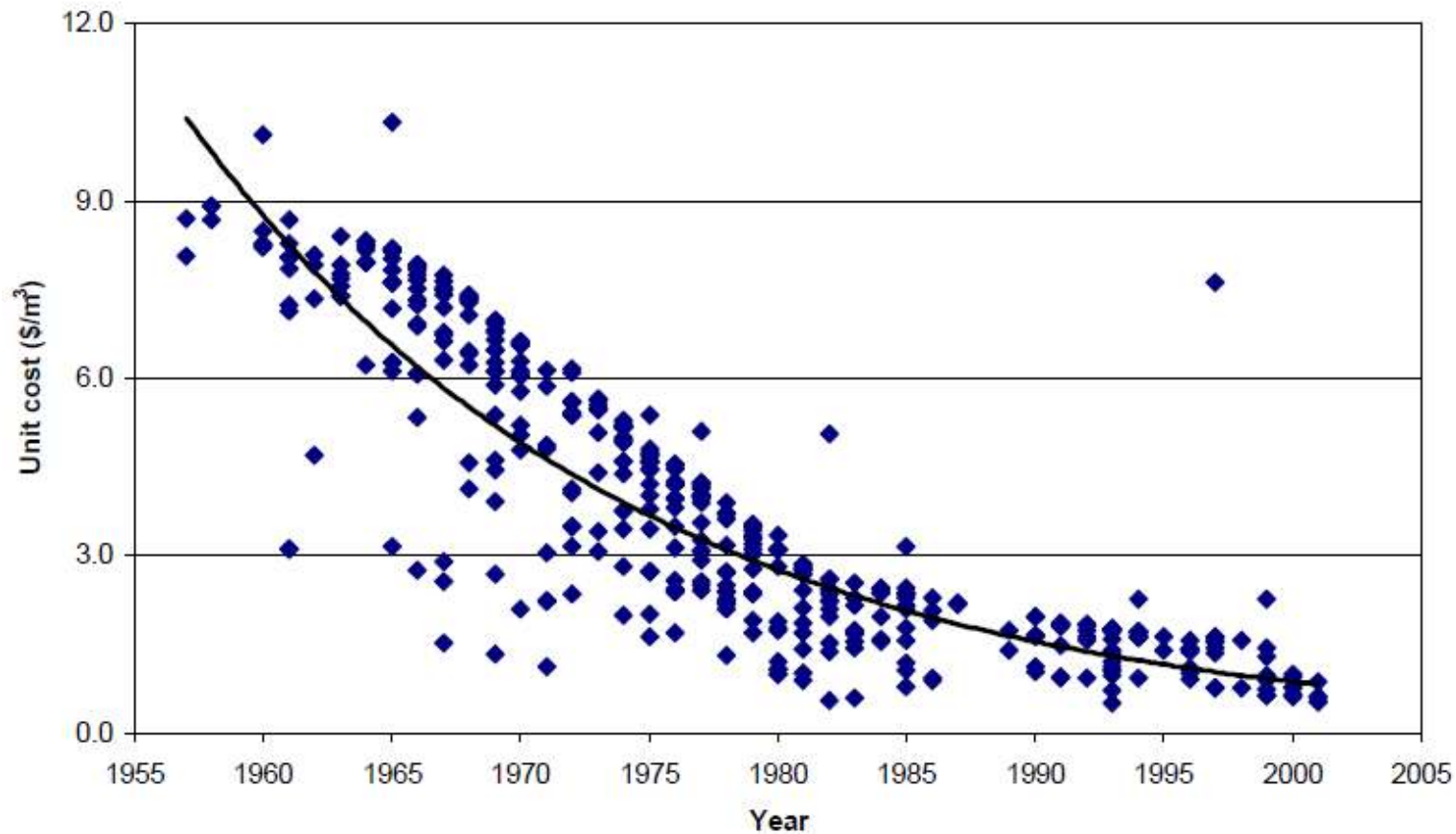
- Distillation
 - MSF - Multi-Stage Flash
 - MED - Multiple Effect Distillation
 - VC - Vapor Compression
- Membrane processes
 - SWRO - Sea Water Reverse Osmosis
 - BWRO – Brackish Water Reverse Osmosis
 - ED – Electro Dialysis

MSF – Multi Stage Flash

- A portion of the water is flashed into steam in multiple stages



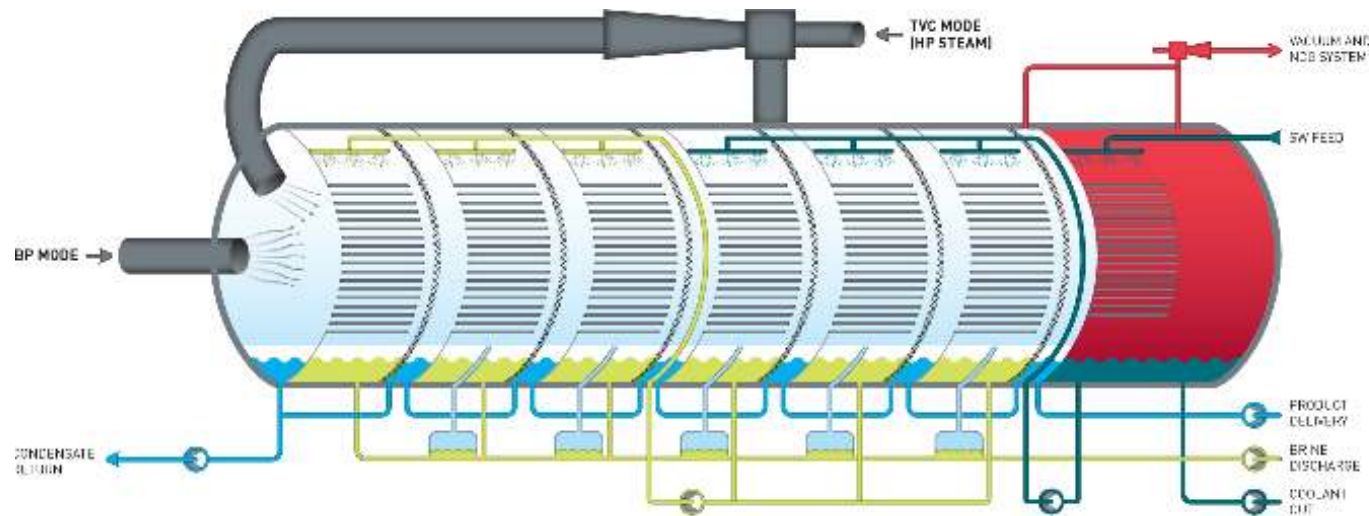
MSF – Water Unit Cost Variation



MSF current unit cost is around 1 \$/m³

LT MED – Low Temp. Multi Effect Distillation

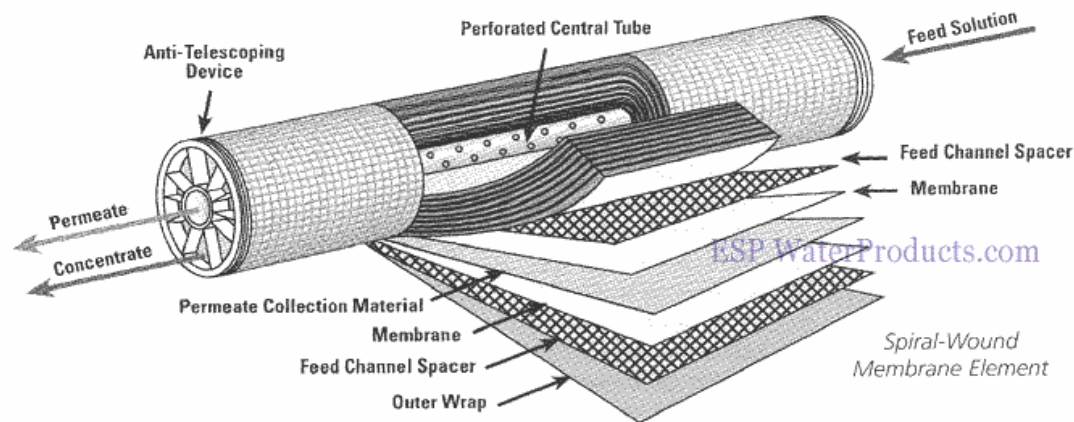
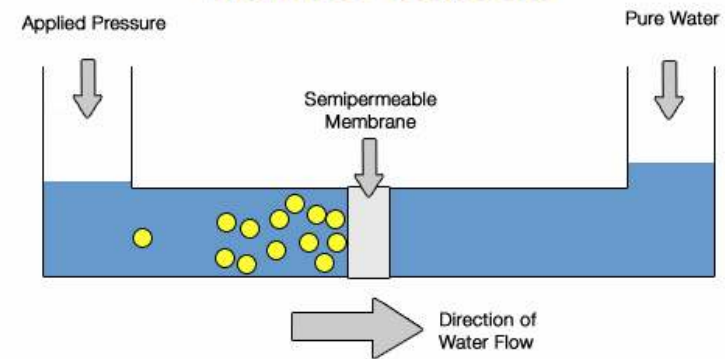
- The process comprised of a train of evaporative-condensers with a heat rejection condenser at the end. More efficient and minimal scaling.



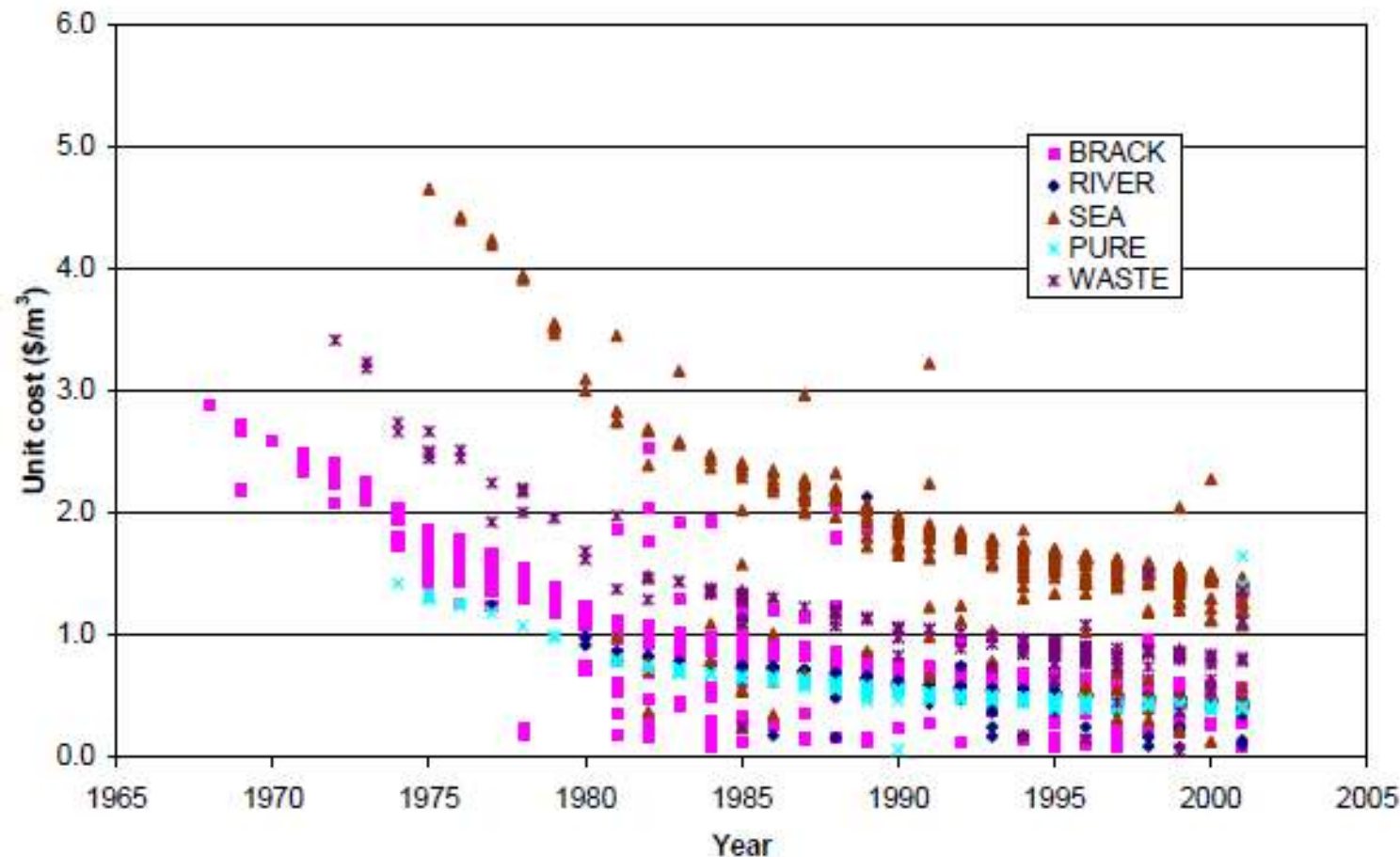
SWRO – Sea Water Reverse Osmosis

- The Process is a membrane-technology method that removes many types of large molecules and ions from solutions by applying pressure to the solution

Reverse Osmosis

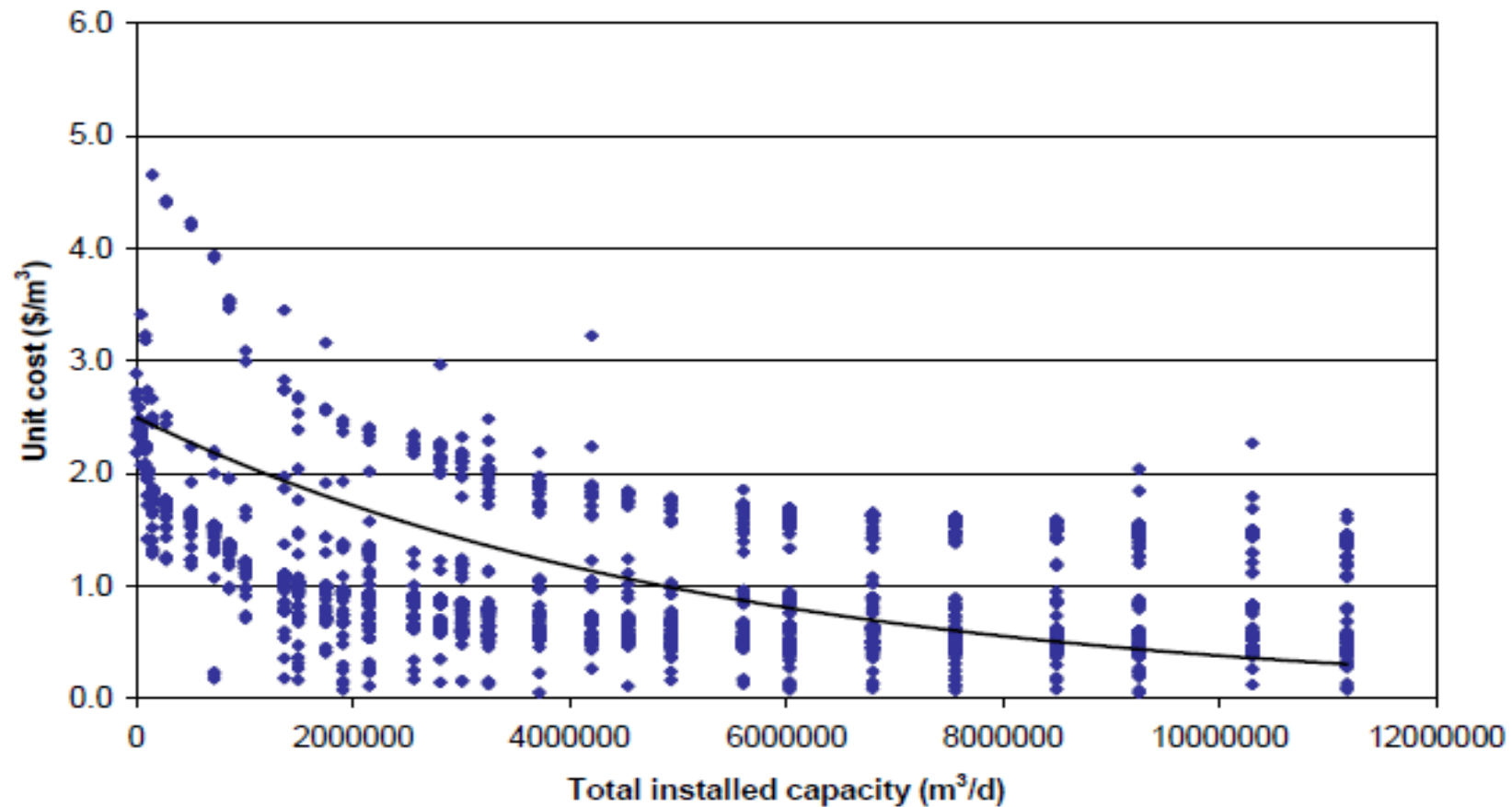


RO – Water Unit Cost Variation - years

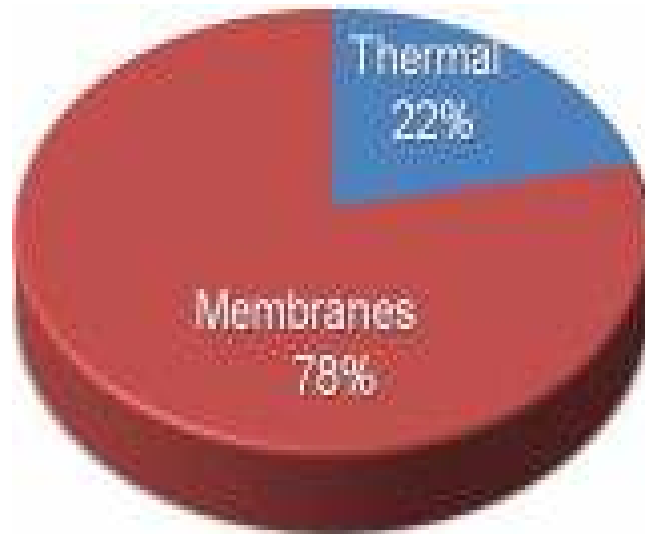


SWRO current unit cost is around 0.5 \$/m³

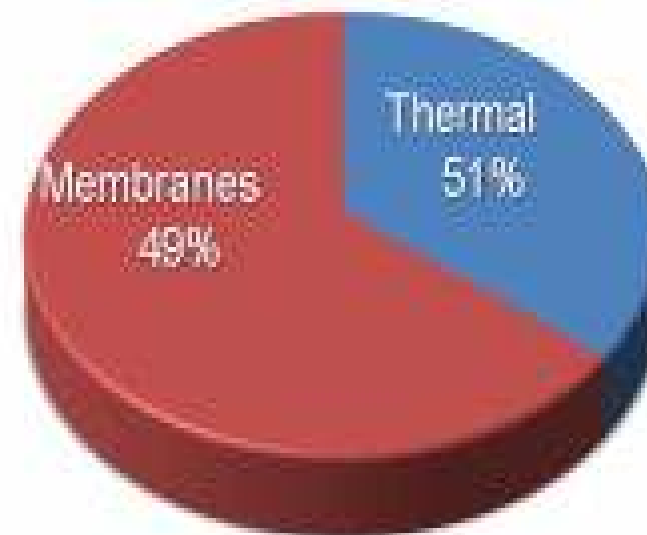
RO – Water Unit Cost Variation - Capacity



World Plant Distribution - Process

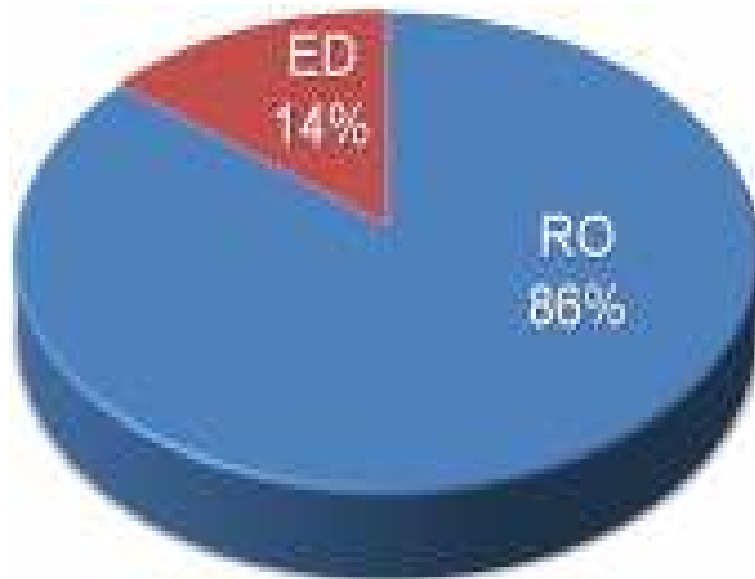


Plants 13600

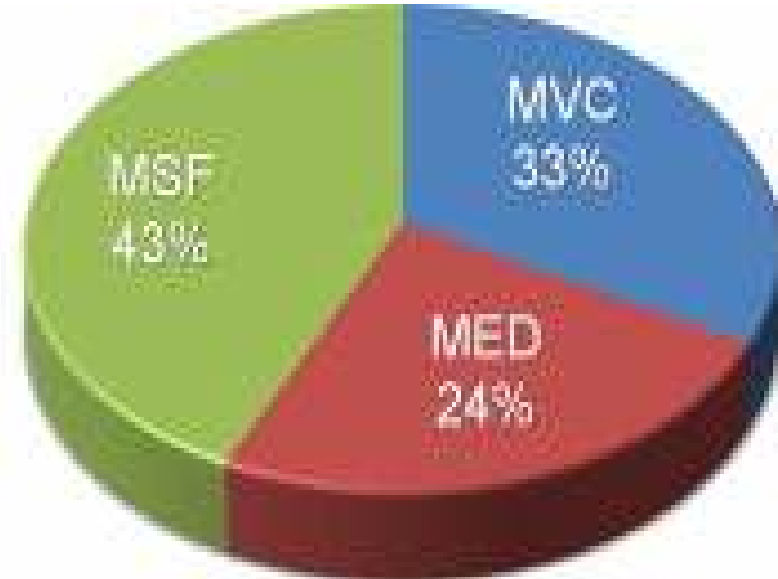


**Water Processed
7000 MGD**

World Plant Distribution - Technology



Membrane Processes



Thermal Systems

Factors Affecting Desalination Costs

In general, cost factors are site specific:

- Quality of Feed Water – Sea water TDS is around 36,000 ppm, brackish water TDS 5,000 ppm
- Plant Capacity – due to the economy of scale
- Site Characteristics – intake, land, pumping cost, storage
- Energy Availability – electricity, waste heat, etc.
- Regulatory Requirements – Drinking water standard, high purity, local permits & requirements

Desalination Implementation Costs

- Construction Costs
 - Direct Costs
 - Indirect Costs
- Operational and Maintenance Costs
 - Fixed Costs
 - Variable Costs

Construction Costs

- Direct Costs (Hard Costs)
 - Land
 - Submerged Water Intake
 - Process Equipment
 - Auxiliary Equipment, Water pumping & Buildings
- Indirect Costs (Soft Costs)
 - Freight & Insurance
 - Construction Manpower & overhead
 - Engineering, Procurement and Construction (EPC)
 - Financial Cost – loans, L/C, guarantees
 - Contingencies

O&M – Operational & Maintenance Costs

- Fixed Costs
 - Land Rental
 - Service Contracts, Local Taxes
 - Insurance
 - Equipment Amortization
 - Manpower
- Variable Costs
 - Electricity & Energy
 - Membranes & Cartridges
 - Chemical Costs
 - Maintenance

SWRO Water Costs Evaluation - Sample

			INPUT DATA:	Specific Cost
Annual Investment Costs				(Euro/m3)
1	Plant Capacity	m3/ day	18,000	
2	Annual Production (354 days/yr)	m3/yr	6,210,000	
3	Capital Investment			
	Desalination EPC	Euro	€ 13,550,000	
	Civil Works & Infrastructure	Euro	€ 5,500,000	
	Total Capital Investment	Euro	€ 19,050,000	
4	Financial Data			
	Interest rate (assumed)	% per year	6.24%	
	Period (assumend)	Years	25	
	Capex Factor rate	% per year	8.00%	
	Annual Cost of Investment =			
	19,050,000 X 8% =	Euro/year	€ 1,523,986	€ 0.245

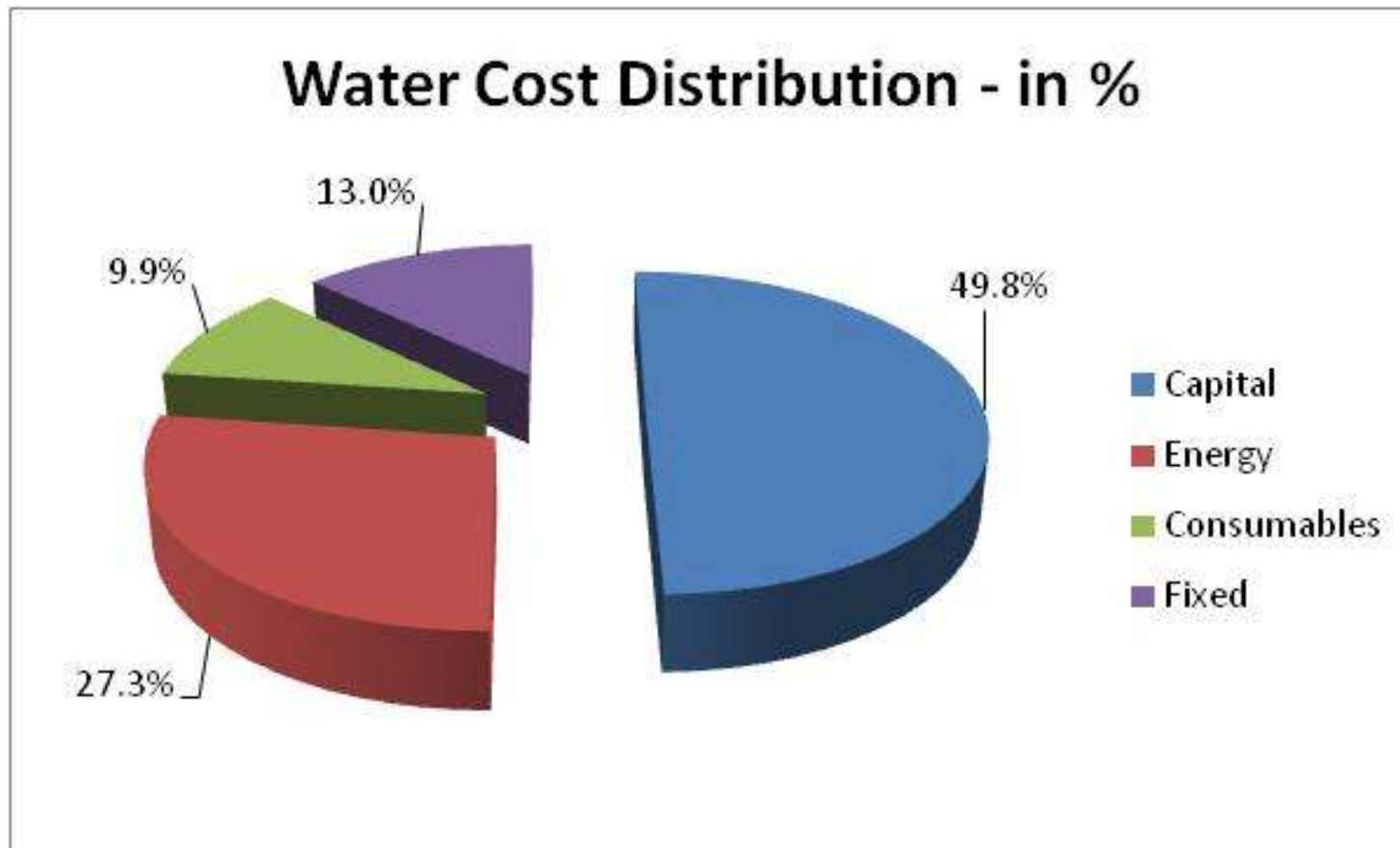
SWRO Water Costs – Sample (cont)

		INPUT DATA:	Specific Cost
Annual O&M Costs			(Euro/m3)
<u>Variable Costs</u>			
5	Energy Data		
	Energy Consumpt. 5 yr cycle	kWh/m3	3.500
	Electricity Tariff	Euro/kWh	€ 0.038
	Annual Cost of Energy = 3,600,000 X 3.5 X 0.077=		€ 836,000
			€ 0.135
6	Consumables		
	Membrane & Cartridges	Euro/yr	80,000
	Maintenance & Repairs	Euro/yr	130,800
	Chemicals & IX Resins	Euro/yr	92,000
	Total Consumables Costs	Euro/m3	€ 302,800
			€ 0.049
<u>Fixed Costs</u>			
	O&M Manpower	Euro/yr	216,000
	Municipal & local costs	Euro/yr	5,000
	General & Others	Euro/yr	110,000
	Insurance	Euro/yr	65,500
	Others	Euro/yr	0
	Total Fixed Costs	Euro/yr	€ 396,500
			€ 0.064
	Total Operational Costs		€ 1,535,300
			€ 0.247

SWRO Water Costs – Sample (cont)

	Annual Values:	Specific Cost
Total Annual Costs	(Euro)	(Euro/m3)
7 GRAN TOTAL RESULTS:		
Annual Investment Costs	€ 1,523,986	€ 0.245
Total Operational Costs	€ 1,535,300	€ 0.247
GRAN TOTAL RESULTS	€ 3,059,286	€ 0.493

SWRO Water Costs – Sample (cont)



Conclusions

- Desalination cost has decreased over the years due to technical improvements
- For desalination systems, the cost for seawater ranges from 0.5 \$/m³ (membrane) to more than 1.0 \$/m³ (thermal).
- The choice of desalination method affects significantly the water desalination cost
 - Thermal methods, MSF, MED are used mainly in medium and large size systems – where waste energy is available.
 - SWRO is currently the optimal choice and this technology is currently used by large, medium and low capacity systems
- In SWRO, the Capital investment and the Energy consumption account for about 75% of the total water cost.



THANK YOU