A SOLUTION FOR EGYPT WATER SHORTAGE

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Introduction

Major plants designed by Egyptians numbered over 420 around the world in Spain, North America, Japan, China, North Africa, Middle East, Gulf countries, Indonesia & South Africa.

The total capacity is over 5 million cubic meters of desalination potable water of international quality standard. Judging by European per capita consumption (say 100 litres per capita/day) This would suffice the needs of 50 million. In contrast, by some African country consumption figures (20 litres/capita/day) this would serve 250 millions.

Current Alternatives For Sources Of Raw Water

Source for desalination plants can be:

- Nile Water (Surface Water) – Main
- Groundwater (TDS < 1000)
- Re-use of Irrigation Wastewater (TDS < 2000, future potential)

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- Re-use of Sewerage Waste (future potential)
- Desalination of Sea Water & Saline Groundwater

Why Desalination for Drinking Water

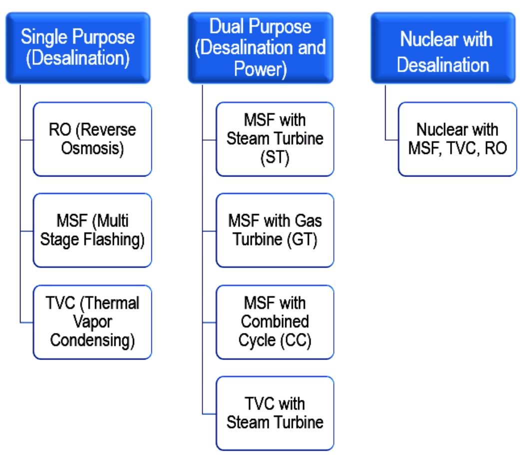
- Municipal Drinking Water Costs have escalated
- Transportation costs have high CAPEX & OPEX and long execution periods. For example: Alexandria – North Coast
  Maadi – New Cairo - Suez
  Qena – Safaga
  Cairo – Suez
- Municipal Network Losses are high (say 60%)
- Water Quality inconsistent
- Energy Costs escalation
- Desalination Technologies Proven Worldwide

Features of First Thermal MSF

- Used Associated Gas from Oil Wells (Waste Energy recuperation)
- Dual Purpose Steam plants (Cycle efficiency raised from 30% to 70%)
- Energy Cost minimal
- Product Quality High
- Sea Water as raw material was abundant
- Established WED in Kuwait (later MEW)
- Established Central Workshops for heavy maintenance work
- Saving the to & fro for repairing spares

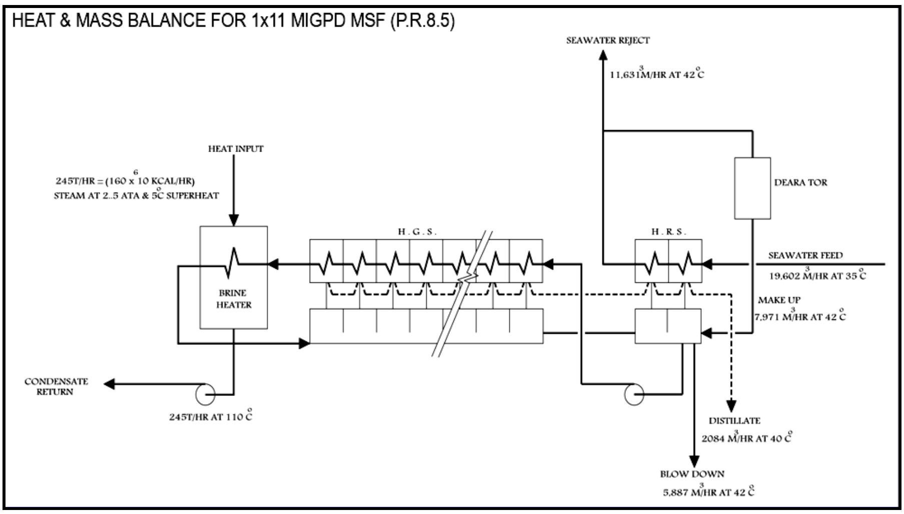
Classical Desalination Sectors

The main desalination running plants are classified as follows:

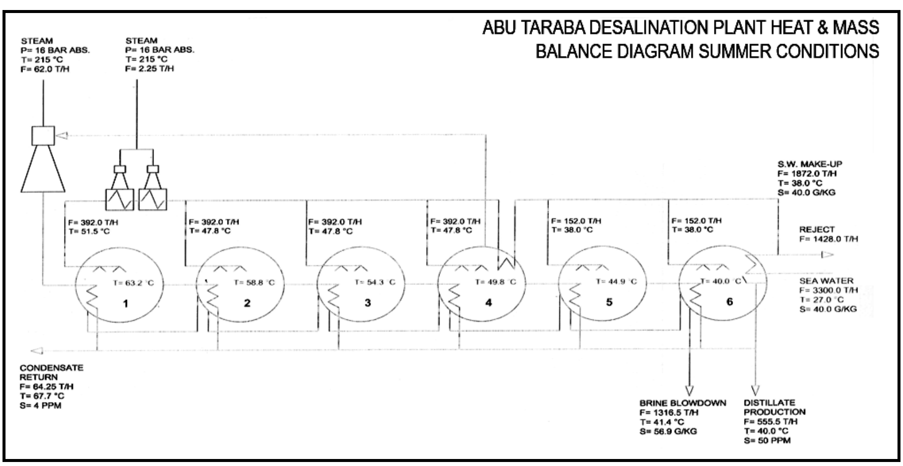


The most reliable type is the MSF process. It has shown resilience in practice. Further it has sustained water for development of water scarce countries for over 60 years. The Multi-Effect Thermal vapour compression (TVC) has become on of the most economical processes and has been functioning in the past 30 years.

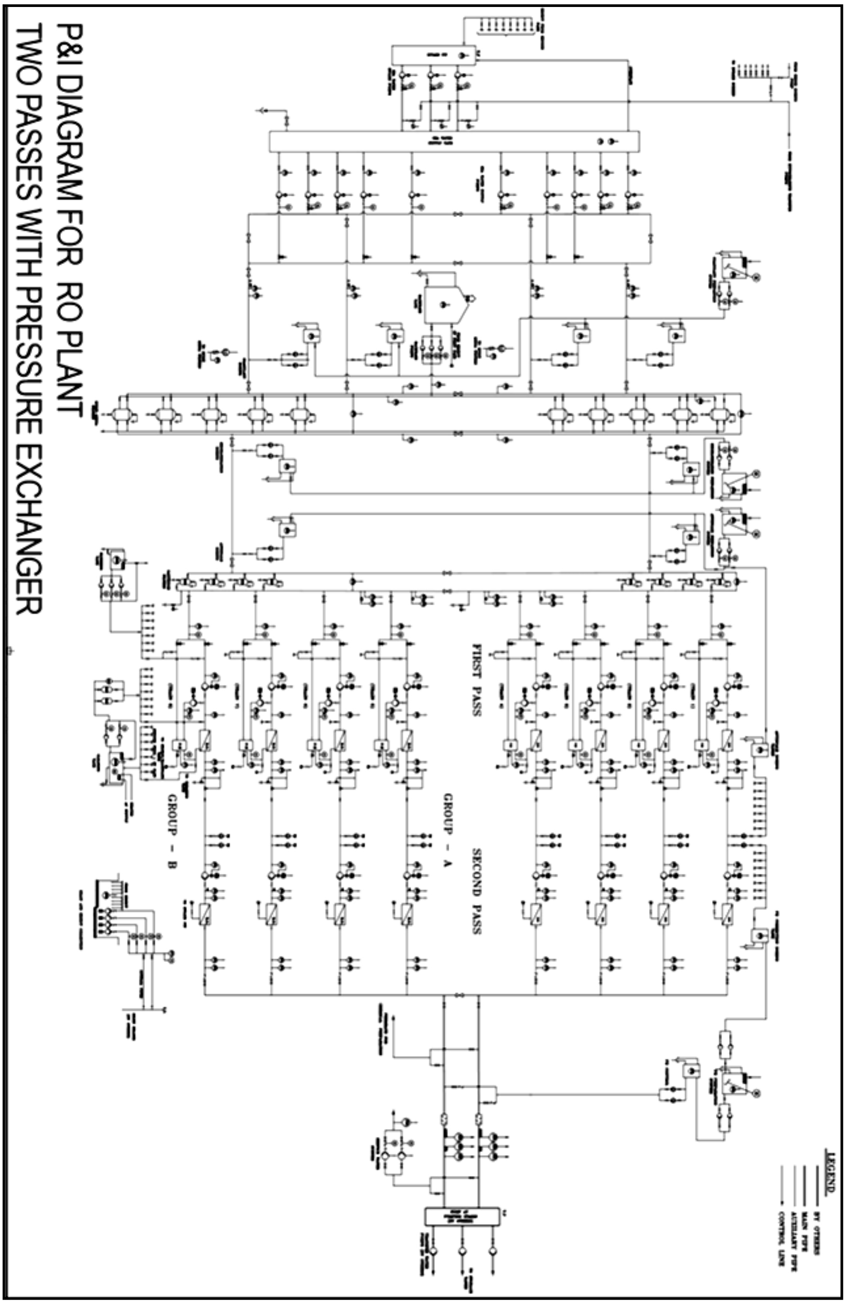
More recently, sea water RO (Reverse Osmosis) has become a favourite process especially at lower sea water salinities. Its electrical consumption has been dramatically reduced by the advent of the pressure exchangers.



MSF Diagram



TVC Diagram

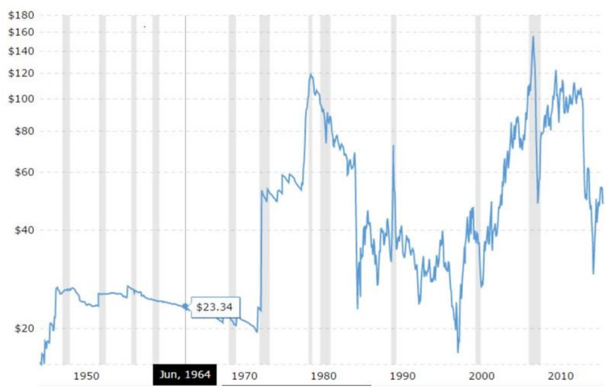

P&I DIAGRAM FOR RO PLANT
TWO PASSES WITH PRESSURE EXCHANGER
FIRST PASS
SECOND PASS
GROUP – A
GROUP – B
LEGEND

RO Diagram

Typical Energy Sources

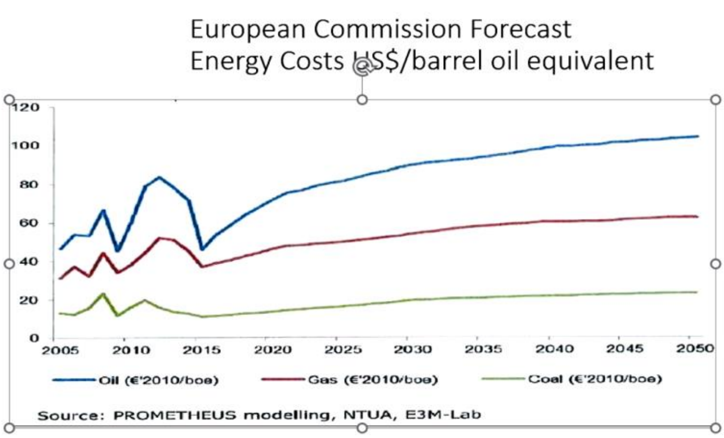
- Natural Gas (NG)
- Heavy Fuel Oil (HFO)
- Diesel Oil
- Coal
- Photovoltaics
- Concentrated Solar Power (Thermal)
- Wind
- Nuclear

Traditionally fossil fuels are susceptible to events such as wars and revolutions or strikes/unrest. The following figure demonstrates this principle.



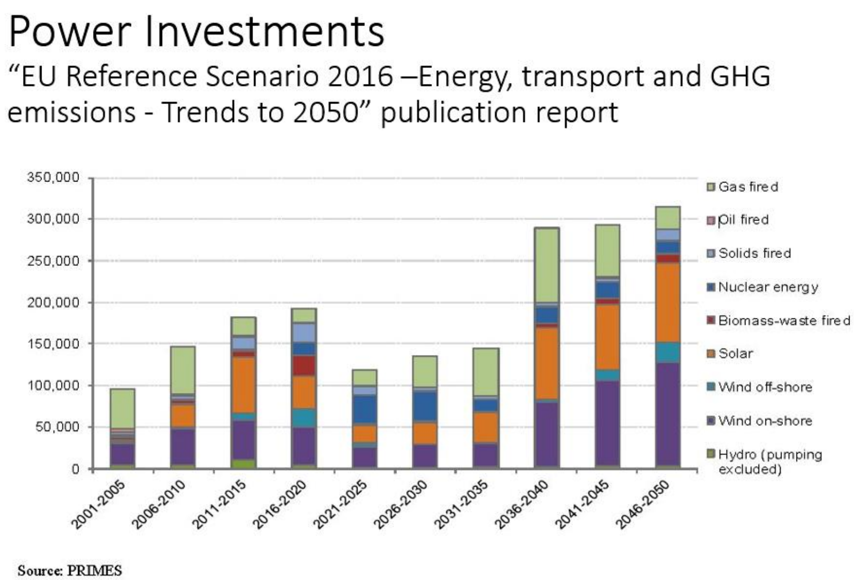
Oil Price Variation with Time

However trends for future energy prices have been predicted as given by EU Commission specialists as below.

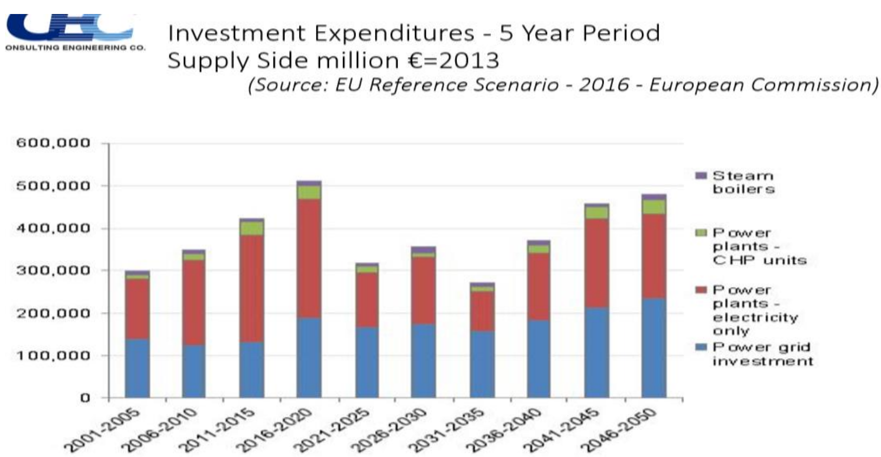


The abundance of coal rendered it a low cost fuel. Other fossil fuels are expected to rise in cost following a non-sustainable future.

The investments in future energy for power is depicted by EU commission forecast as shown.

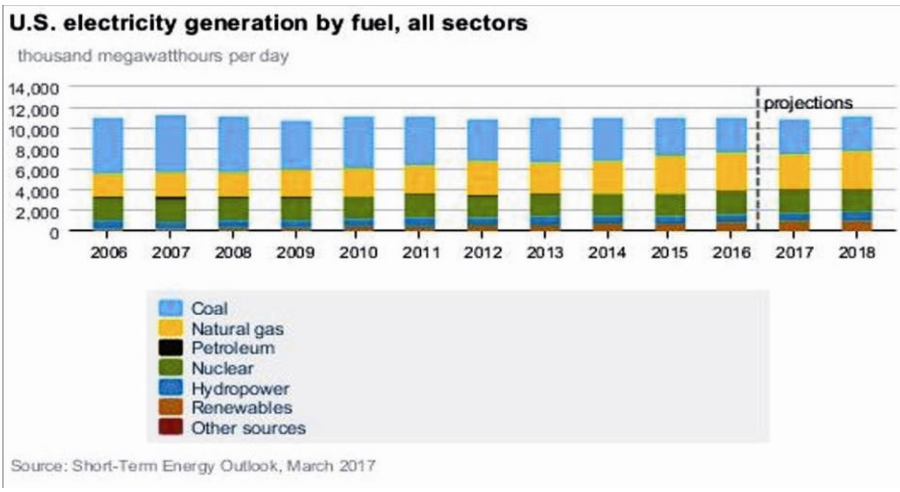


It is clear that since EU natural energy sources are scarce, the drive for renewables is accelerated in the EU forecast. The energy mix shifts towards renewables in near future.

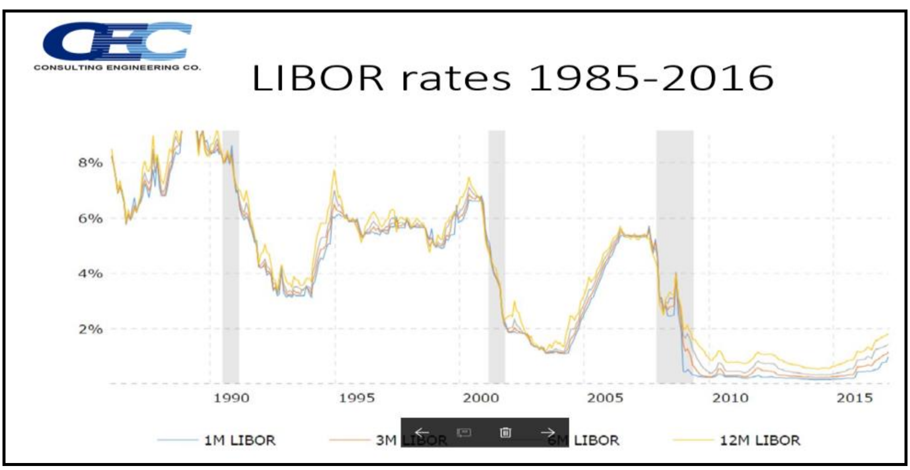


The investments in securing power to plants includes transmission and distribution of electricity required for desalination. Hence the capital needed for generation needs to allow for T & D costs which are equal or greater than the generation plants themselves.

On the other hand US has a different strategy due to the vast fossil energy reserves.



Hence, the rate of renewable share increase shows a much slower pace. Further the recent lowering of LIBOR rates (as a result of 2008 crisis) has been a major factor to reduce inflation and increase spending to redress the economic balance needed to promote growth.



Comparison of Different Desalination Processes

The following table shows a comparison of pros & cons of the different types of desalination process.

Comparison for Seawater (38-42 g/l) between Thermal & RO Plants for Capacity 20,000m3/Day

	ITEM	*THERMAL DESALINATION PLANTS*		*RO PLANTS*
		MSF	*TVC*	
1	Raw Water m^3/ m^3 Product Factor	7-12	6	2.5-3
2	Raw Water Pretreatment	Normal	Normal	Extensive pretreatment
3	Capital Cost Millions US$	30	28	22-26
4	Required Steam	Requires steam from waste heat (e.g. in combination with gas turbines, steam turbines, APG, NPP, CSP OR CC) for better Economy	Requires steam from waste heat (e.g. in combination with gas turbines, steam turbines, APG, NPP, CSP OR CC) for better Economy	Not Required
5	Power KWH/m^3 Product	3-3.5	1.5-2	4-6
6	Spare Parts	Wear & Tear Parts	Wear & Tear Parts	- Less Wear & Tear Parts - Membrane Replacement (high cost)
7	O&M	Normal	Normal	Chemist is required continuously
8	Reliability	Excellent	Good. Care not to precipitate salts outside tubes	Operation errors present high risk

Brackish Water Desalination

Factors related to lower salinity "brackish" water can be summarised as follows:

- Examples:
  - Madinaty 5000-6000 mg/L
  - Cairo Festival City 8000 mg/L
- Geophysical & Geological Studies
- Brine disposition
- Water cost 25-40 cents per cubic meter
- Construction Time Low for an RO plant

Remote Areas Desalination

- Desert Conditions
- Far Coastal Areas

Solutions

- TVC with diesel power
- RO with diesel power

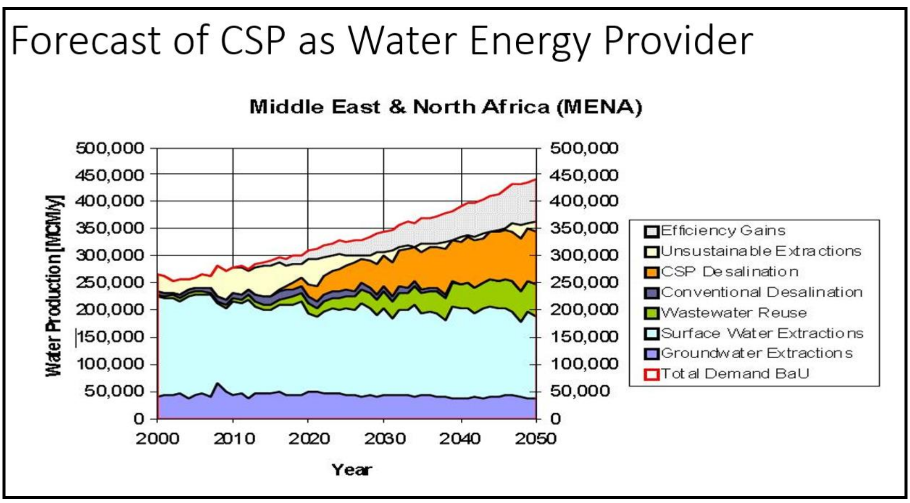
- TVC with CSP (TBP)
- RO with PV (disadvantages)

RO Combined with PV

- PV cannot provide 24 hour operation for RO
- Alternative power source is required
- Intermittent operation ages the membranes
- It is not a viable sustainable option
- *CSP Desalination Options (Can operate 24 hours with suitable storage and capacity*
- CSP energy can be used to provide the heat for thermal desalination
- Thermal utilization of concentrated solar power (40-50%) is higher than PV (10-20%)
- Lower temperature steam is required cf to generating power with higher T steam

CSP for Electrical Production

- Storage of 3 hours – USD 5200/kW (Nour)
- Storage of 8 hours – USD 5900/kW (Nour)
- Storage of 16 hours – USD 8000/kW
- Above for power production are viable alternatives and can match the daily load graph demands or in part.
- The third alternative allows 24 hour operation, suitable for desalination



Power Generation Typicals

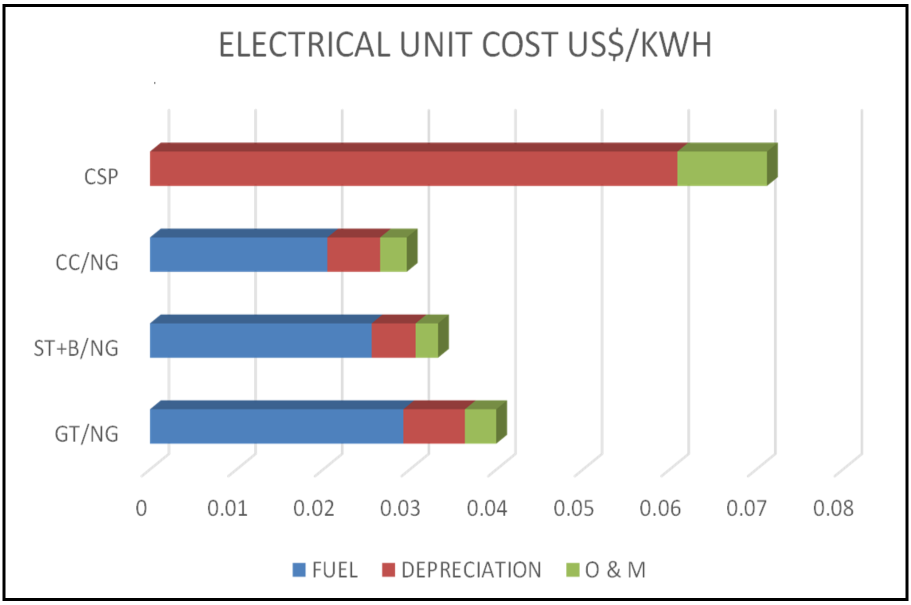
Type	Capital $/kW	Life (Y)	Efficiency %	Fuel Type	Fuel Cost US$/M-BTU
Steam	1000	30	40	NG	3
GT	800	25	33-35	NG	3
CC	900	25	50-55	NG	3
Coal	2500	30	36	Coal	3-4
CSP(including Storage)	8000	25	N/A	IR	-

Different Power & Water Alternatives

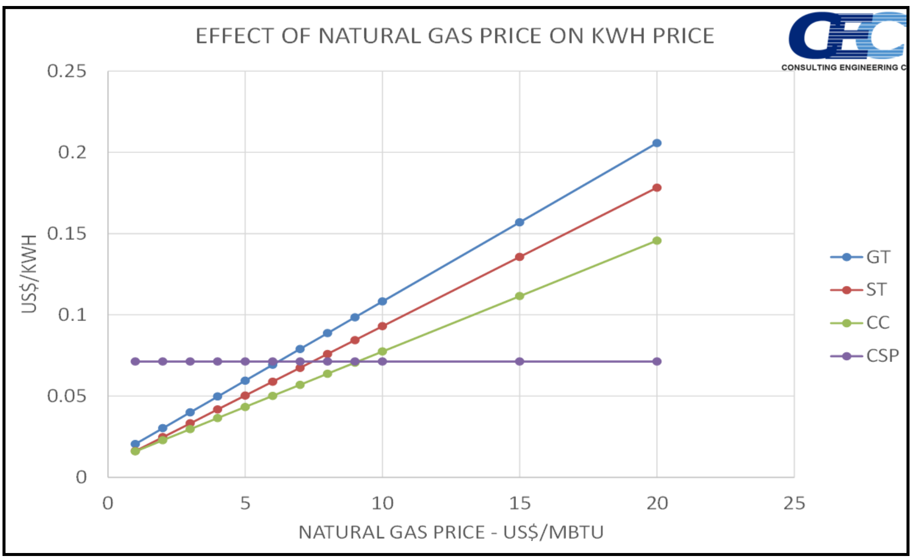
The *lifetimes* considered are 20 years for RO & TVC, 25 years for MSF, 30 years for ST, 15 years for GT, and 20 years for CC & CSP

FUEL	P TYPE	D TYPE	FUEL ($/MBTU)	ELEC (KWH/M3)	$/KWH	$/M3
HFO	ST	MSF	9	3.5	0.084438337	0.538432521
HFO	ST	TVC	9	1.5	0.084438337	0.404934362
NA	GRID-H	RO	0	4	0.1	0.730843547
NA	CSP	RO	0	4	0.071232877	0.615775054
NG	CC	MSF	3	3.5	0.029641361	0.346643106
NG	CC	TVC	3	1.5	0.029641361	0.322738899
NG	GT	MSF	3	3.5	0.039973997	0.38280733
NG	GT	TVC	3	1.5	0.039973997	0.338237852
NG	ST	MSF	3	3.5	0.033253503	0.359285602
NG	ST	TVC	3	1.5	0.033253503	0.328157111
SUN	CSP	MSF	0	3.5	0.071232877	0.49221341
SUN	CSP	TVC	0	1.5	0.071232877	0.349747657
NA	GRID-E	RO	0	4	0.055	0.550843547
NA	PP-E	RO	0	4	0.03	0.450843547

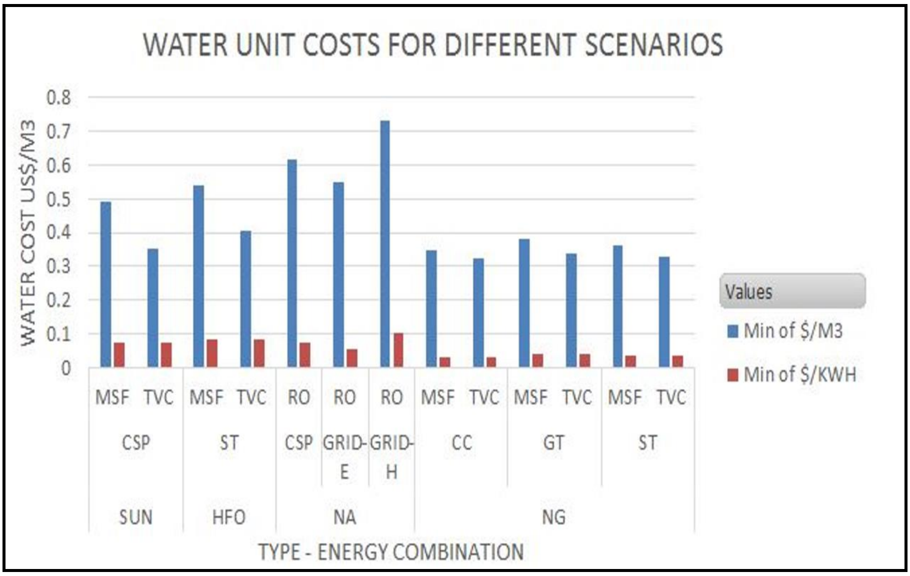
Typical electrical unit costs are given showing CAPEX and OPEX. CSP capital costs re expected to be reduced with technology optimization and economies of scale.



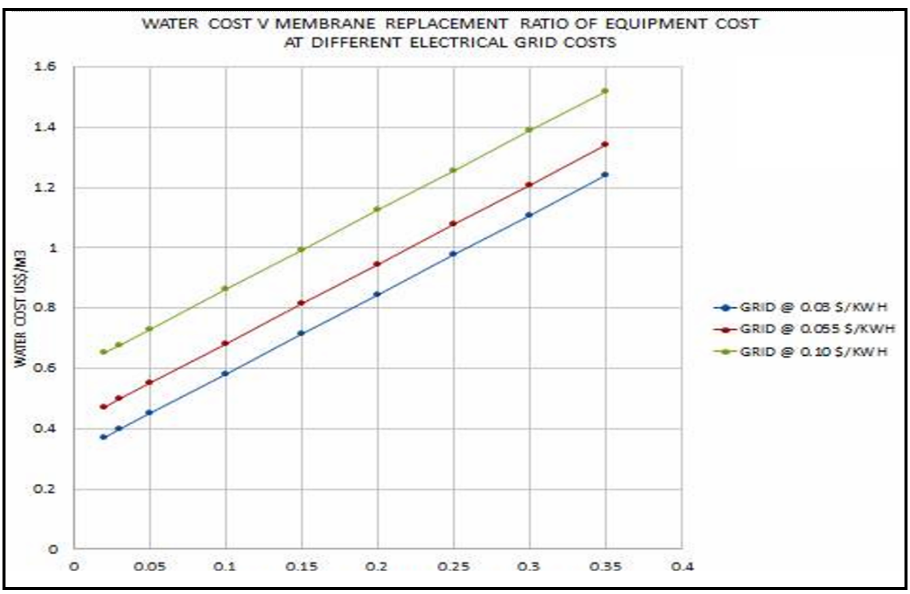
The sensitivity of gas price to produce electricity is shown in the next figure.



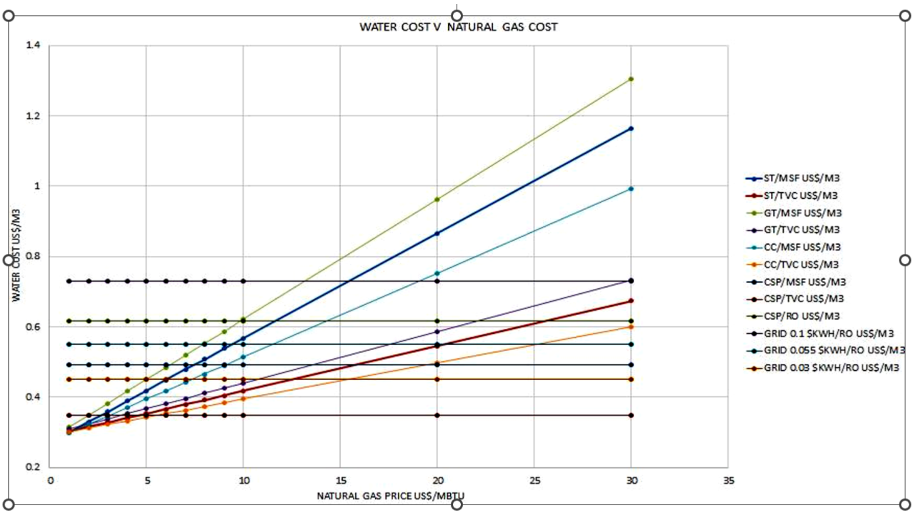
Different scenarios for the type of fuel, type of processes is shown below.



The effect of membrane change fraction shows a high sensitivity for RO. Hence this should be allowed for and monitored over the life of the plant.



Sensitivity for different options of fuel cost is given for the unit cost of water.



Strategy

- ABUNDENT ENERGY – CHEAPER THERMAL PLANTS (EGZOHR)
- COASTAL PLANTS TO BE ADOPTED EXTENSIVELY
- LOW TDS ACQUIFERS PROMOTE RO INLAND
- BRINE IS USED IN KUWAIT & UAE TO PRODUCE:
  - HCL; CAUSTIC SODA; HYPOCHLORITE; HIGH PURITY SALT
- POWER PLANTS ADJACENT TO DESALINATION SAVES ENERGY
- SPAIN IMPLEMENTS LAW TO USE DESALINATION ALONG COAST FOR IRRIGATION

Manufacturing Considerations

- Marine Shipyards are traditionally the most appropriate for thermal plants. (Not yet implemented.)
- Some attempts at manufacturing RO membranes and HP pumps locally. Commercial Production lines still to be implemented.
- Maintenance facilities lacking
- High grade metal components are imported

Finance - Who are the Stakeholders

Government

- Ministry of Finance
- Ministry of Housing
- Ministry of Irrigation

- Ministry of Agriculture
- Ministry of Electricity
- Ministry of Petroleum
- Ministry of Education
- Ministry of Defense

Research

- Desert Research Centre
- Hydraulic Research Institute
- Water Research institutes (many)
- Geophysics Institute (Helwan)
- National Research Centre
- Tebbin Metals Research Centre
- Universities (many)

Operation & Maintenance

- HCCW
- NOPWASD
- Private Construction Companies (many)
- Private Operation Companies (many)
- Pumps & Pipe Suppliers (many)
- Maritime Manufacturers
- Membrane Suppliers
- Chemicals Suppliers
- Instrumentation & Control Systems Suppliers