WATER DESALINATION

BY

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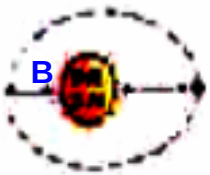
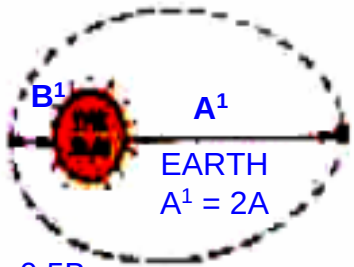
Mankind's knowledge did not stop at appreciating the secrets of water but merged in his endeavors to imitate what happens in nature. Late Professor (of Desalination) Robert Silver once said that, "***Earth is the largest distillation unit***".

WATER DESALINATION



A = APEX



EARTH
$A^1 = 2A$

$B^1 = 0.5B$

1

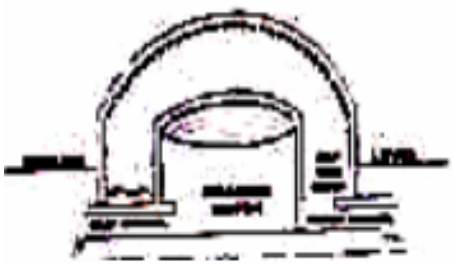
SEA WATER

SAND BASIN

FRESH WATER

2 AL-GHUMSAH

3 AN ANCIENT SAMAWAR
3RD MILLENNIUM B.C.



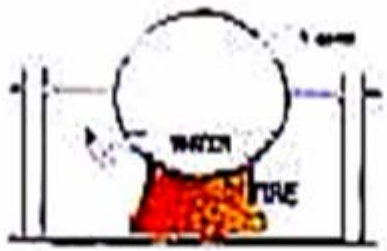
4 DOUBLE WALLED WATER
CAVERN 3RD MILLENNIUM B.C.

5 DISTILLATION ABOARD
SHIPS 2ND MILLENNIUM B.C.

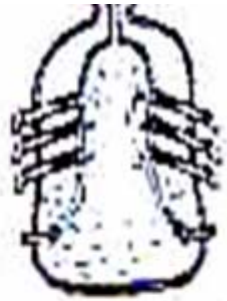
6 ARISTOLS CITATION
1ST MILLENNIUM B.C.

WATER DESALINATION

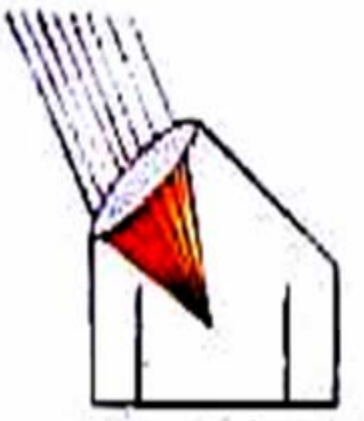
7 THE HOLLOW WAX BALL
1ST MILLENNIUM A.D.



8 THE OLDEST ANCESTOR OF DAULL PRODUCTION OF HERIO
1ST MILLENNIUM A.D.



9 PERFUM DISTILLATION OF ARABIAN CIVILIZATION
1ST MILLENNIUM A.D.



10 DESALINATION USING DAMASQUAIN GLASS
2ND MILLENNIUM A.D.

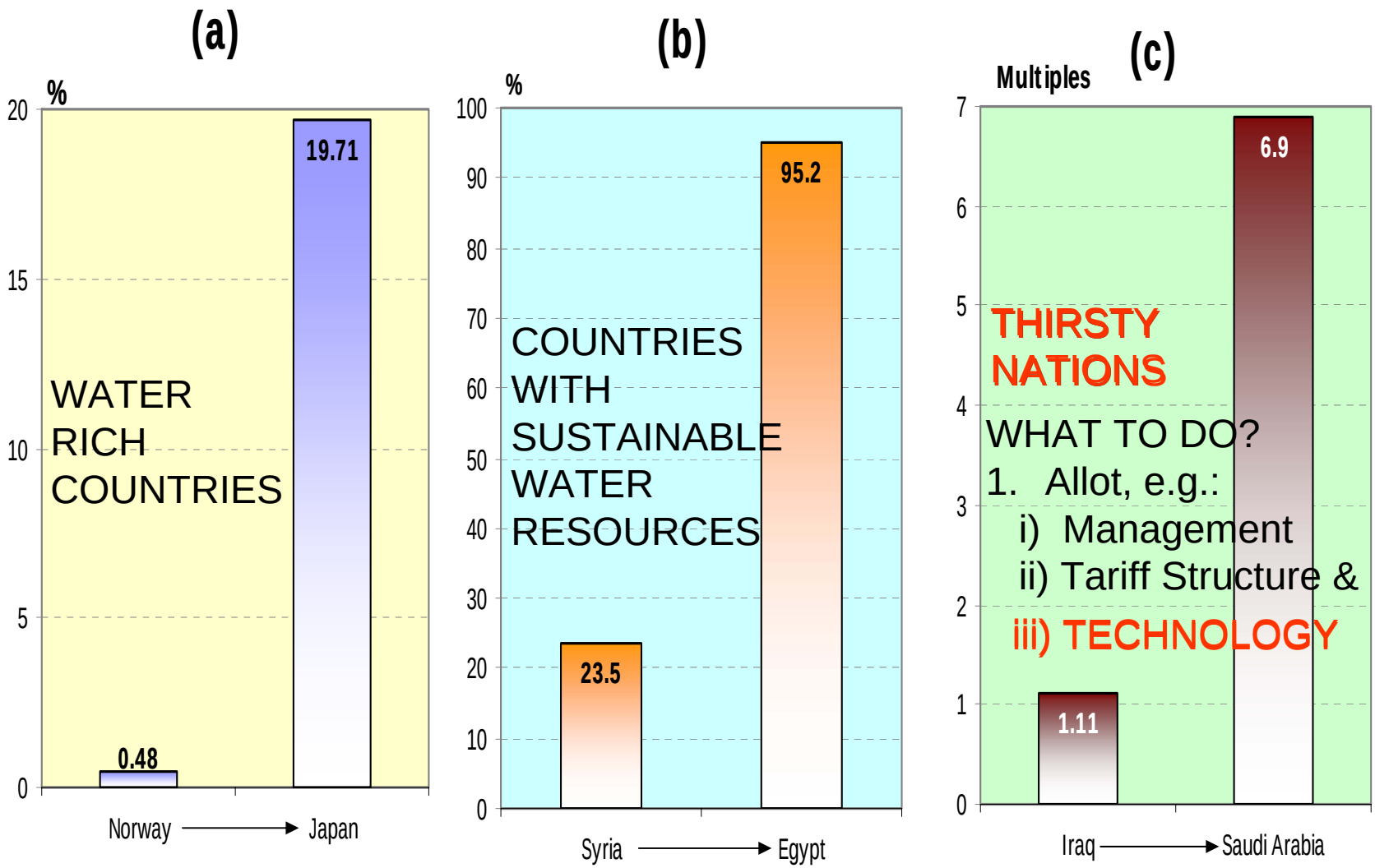
11 LEONARDO D'VINCI CITATION
2ND MILLENNIUM A.D.

12 THE TALE OF DANIEL DAVO
2ND MILLENNIUM A.D.

WATER DESALINATION

Today the Arab World desalinates more water than all other parts of the globe combined. Saudi Arabia by itself represents about **one-fourth of the total world's capacity.** Petroleum wealth has been the prime force behind this paramount growth in desalination capacity in more than one way. Oil booms have led to escalating rises in demand, the oil wealth provided capital funding for this growth and above all energy availability supported such high production rates of desalinated water. Some of the highest per capita desalination production rates are in **Qatar and United Arab Emirates (UAE).**

WATER DESALINATION



Consumption Divided by Renewable Water Resources

NOTE: Surface water would also provide renewable electricity.

Desalination Processes

As known today: 1a-3a, or as could be thought of: 3b

Desalination processes can be divided into:

1. Physical processes of phase change:

a. Solar distillation, stands half-way between nature & MSF.

b. Multi-stage flash (MSF) distillation

c. Multi-effect distillation (MED)

d. Vapor-compression distillation (VCD)

→ ***REHEAT*** ←

e. Pervapouration*

f. Freezing

** A process of vaporization and vapour permeation.*

Desalination Processes (Cont'd.)

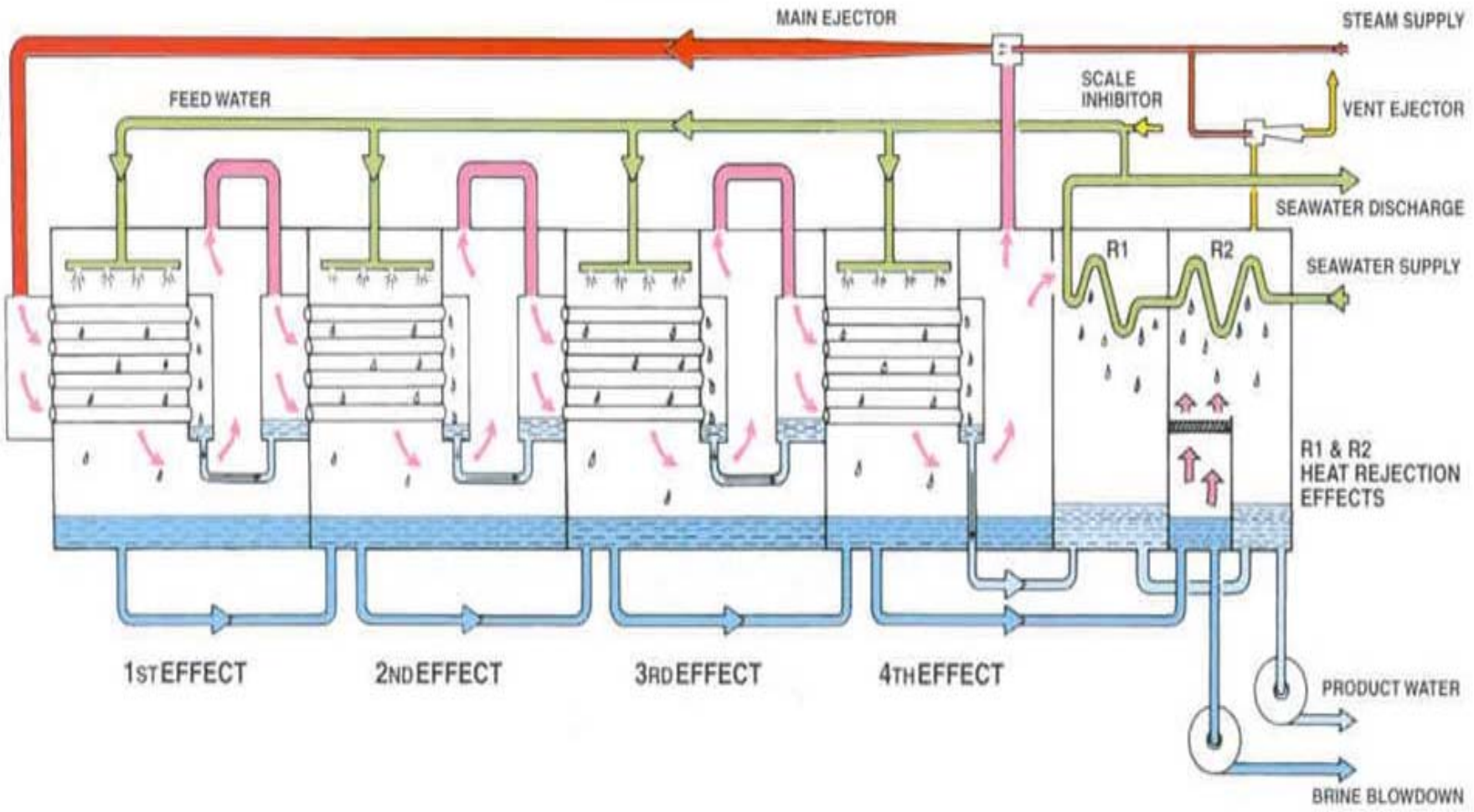
2. Physical processes of ionic change:

a. Reverse Osmosis (RO)
b. Electrodialysis (ED)
c. Inoexchange
d. Hydration
e. Electromagnetic
f. Chelation

3. Processes of chemical change:

a. Precipitation
b. Bio-Desalination

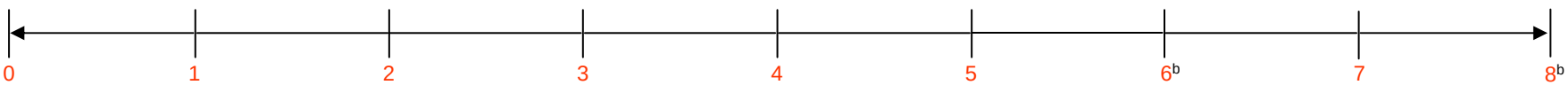
Performance of MED/TVC is Highly Influenced by Scale Formation



4-EFFECT REHEAT PROCESS FLOW DIAGRAM

Salient Features of MED

- High heat transfer rate (thin film boiling and condensation).
- Maximum temperature operation 65 °C to limit scale formation.
- Higher frequency of acid cleaning. Tube configuration is not suitable for sponge ball cleaning.
- Higher Gain output (GOR)*[a]
  MED GOR = N-1
- MSF GOR = N/2
- Low power consumption* (2 kWh/m3)[a]
- Small to medium capacity size plants* in MIGD range of:



**** These numbers are based on:***

a) Different steam grade than that required by MSF thus: GOR & Power Consumption are fictitious references, as they are used by many; yet the use of PR will give more realistic references.

b) Unit capacities of over three are achieved by duplicate(s) of parallel ejectors and distillation stages.

WATER DESALINATION

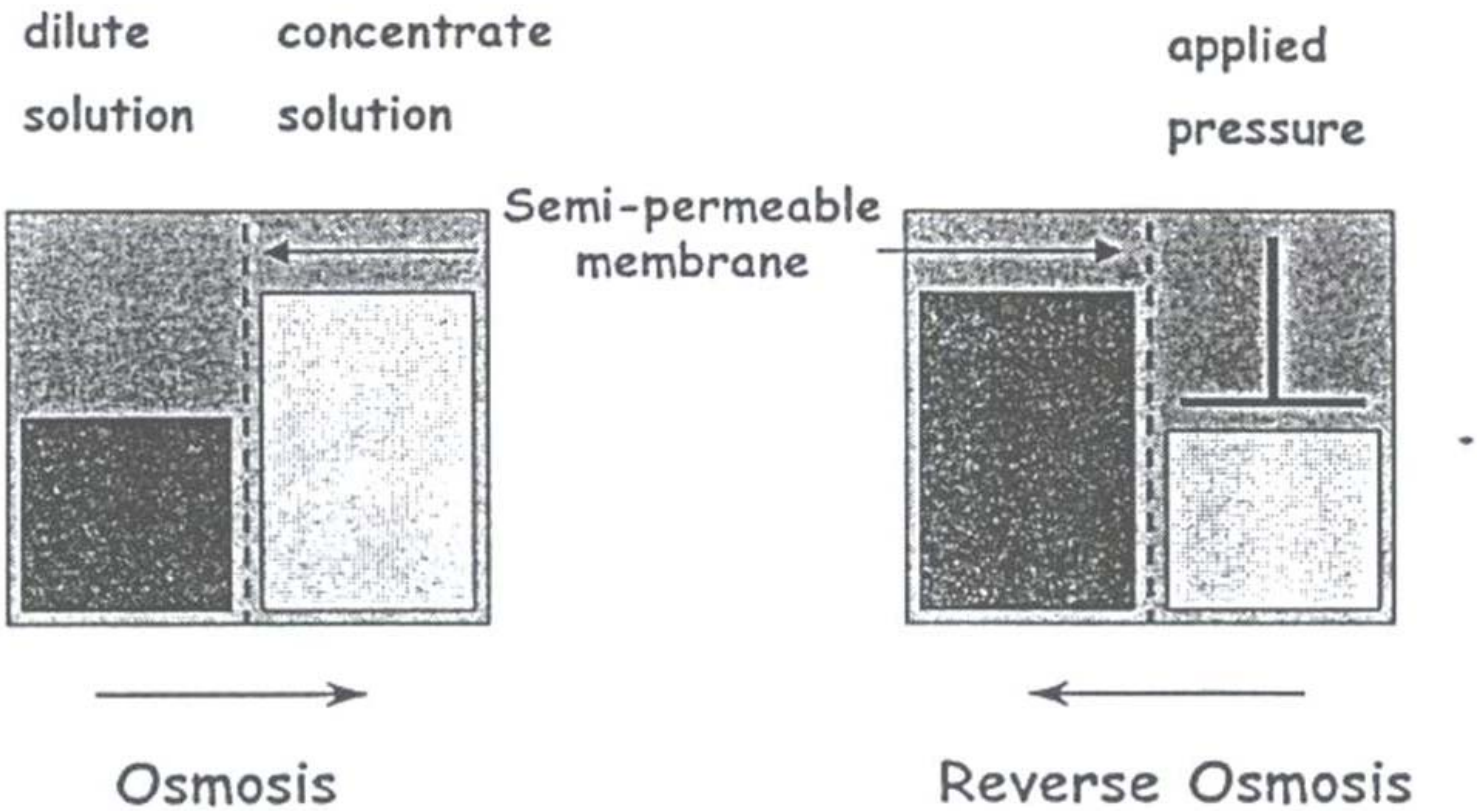
BREAK THROUGH IN SEA WATER DESALINATION

WORLD RECORD 5 MIGPD PER UNIT

Multiple effect Distillation with thermal vapour compression

MED TVC 22.700 m3/day – Commissioned in 2001

Osmotic Pressure



The direction of water flow is determined by the pressure, temperature & concentration of dissolved solids (e.g.salts)

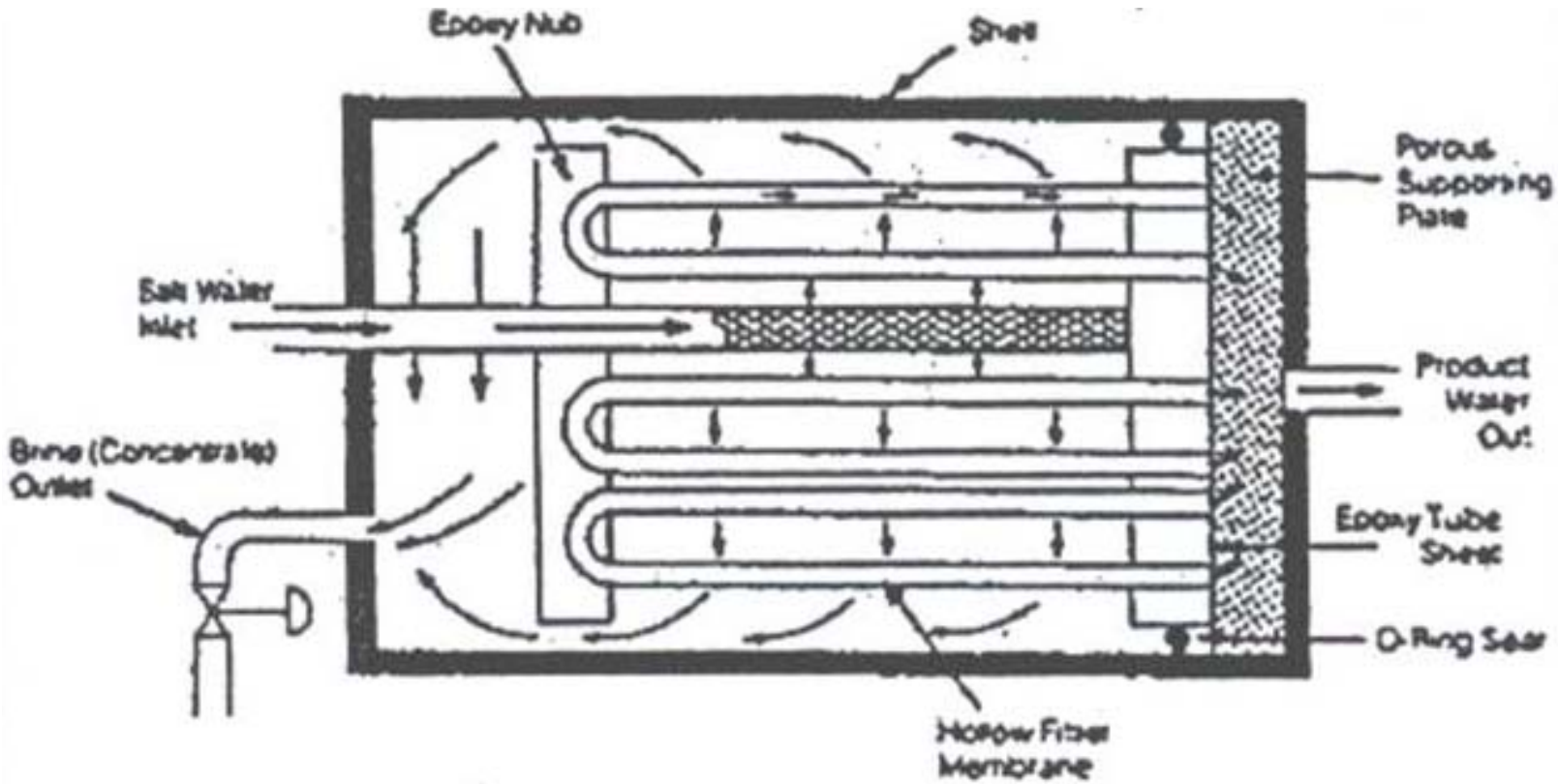
WATER DESALINATION

TABLE A

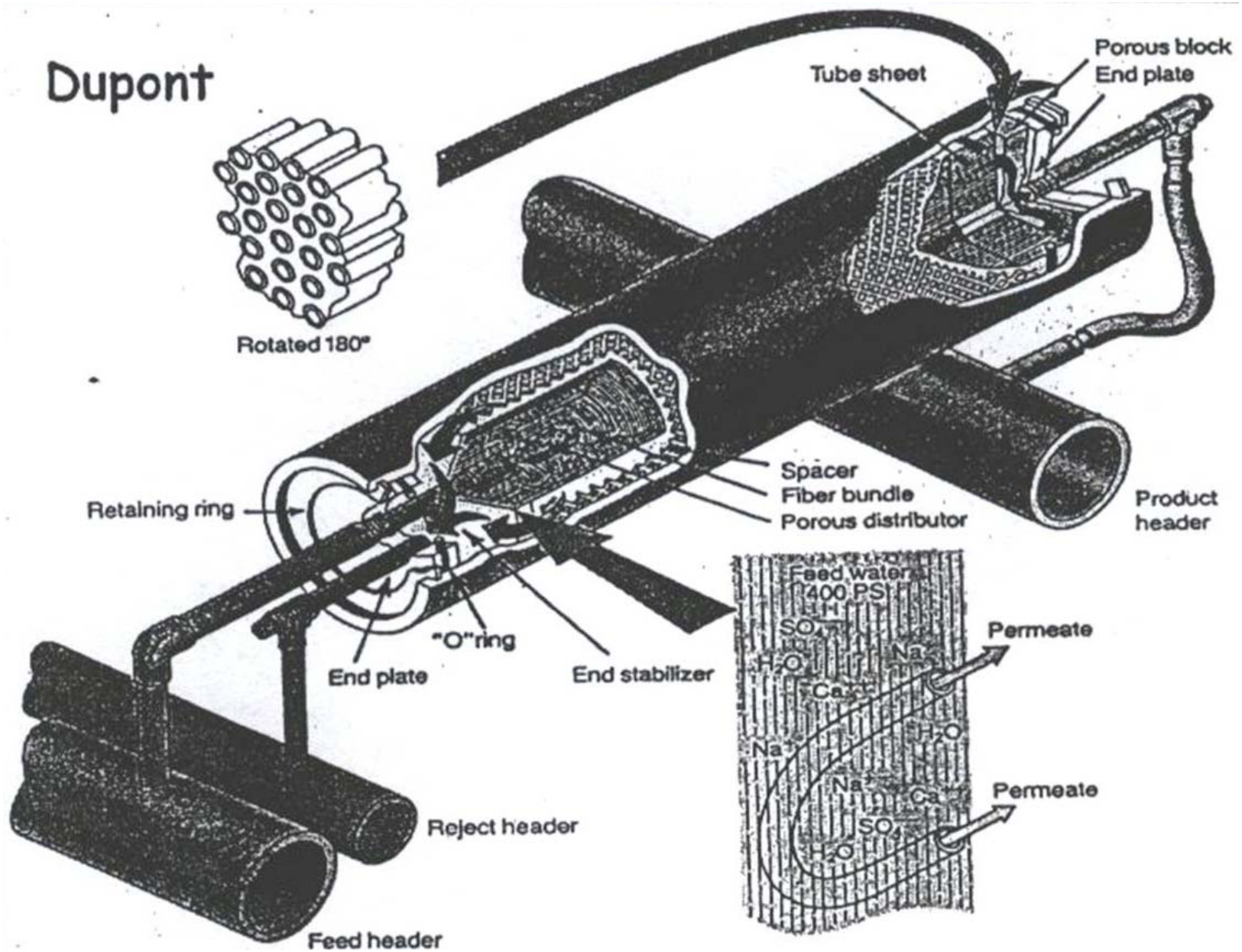
Membrane Area Per Unit Volume

(Ft2 membrane per Ft3 module)

TUBULAR	SPIRAL WOUND	HOLLOW FIBER
~ 100	~ 300	~ 5000



WATER DESALINATION



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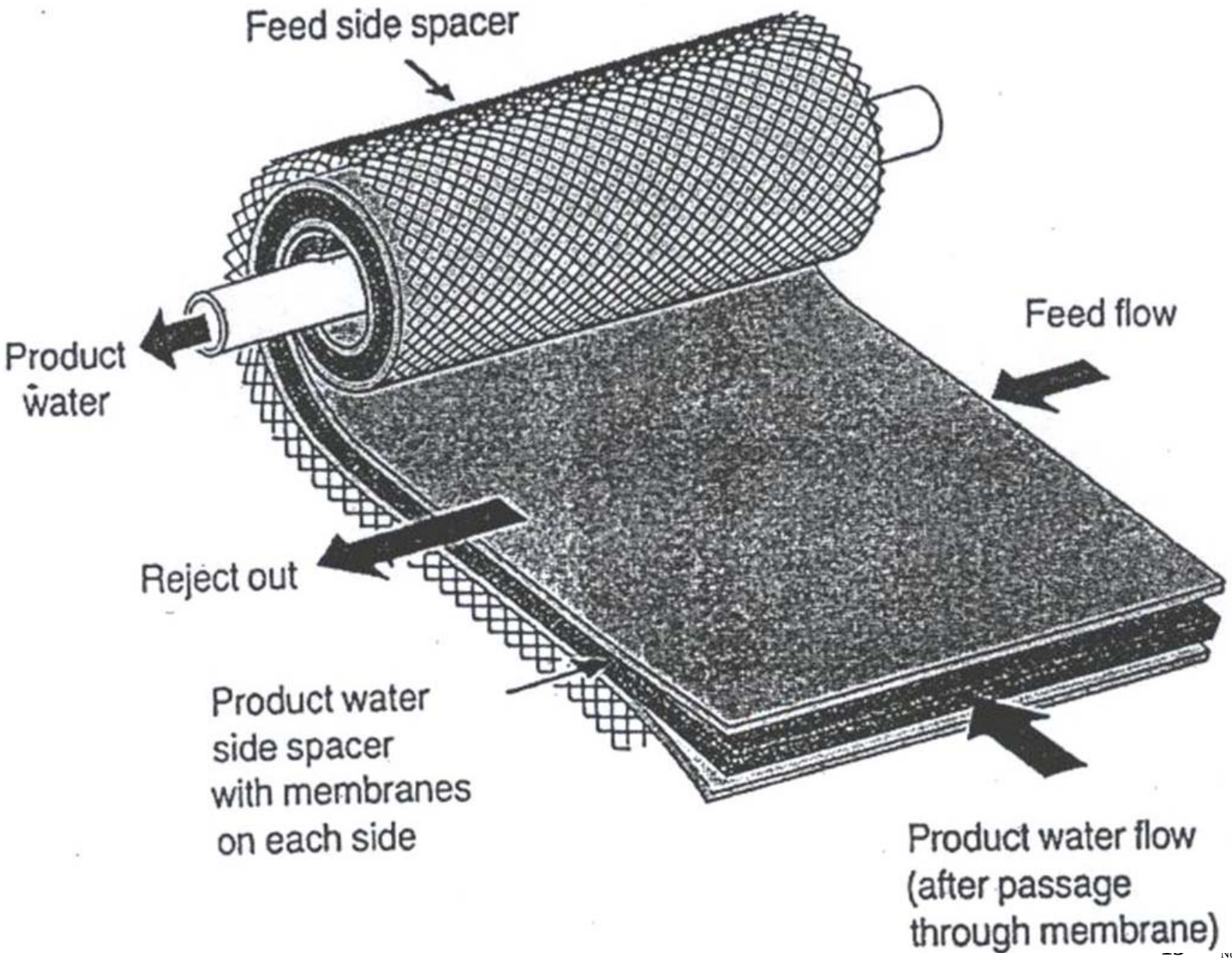

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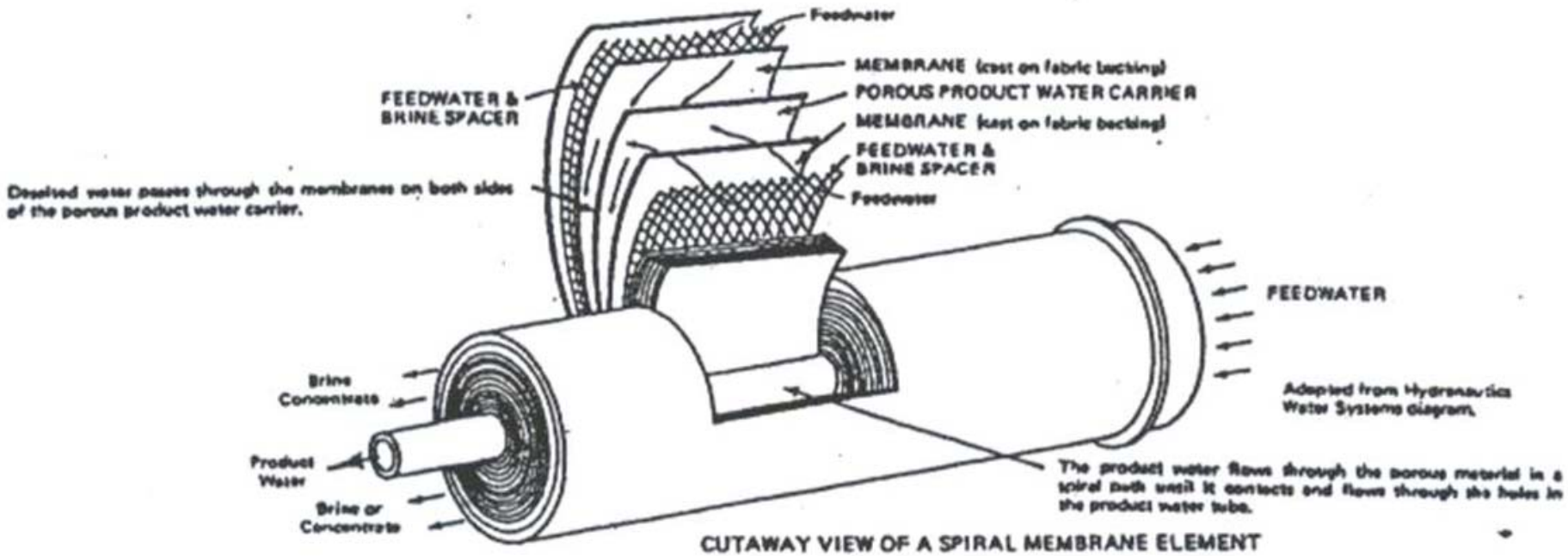
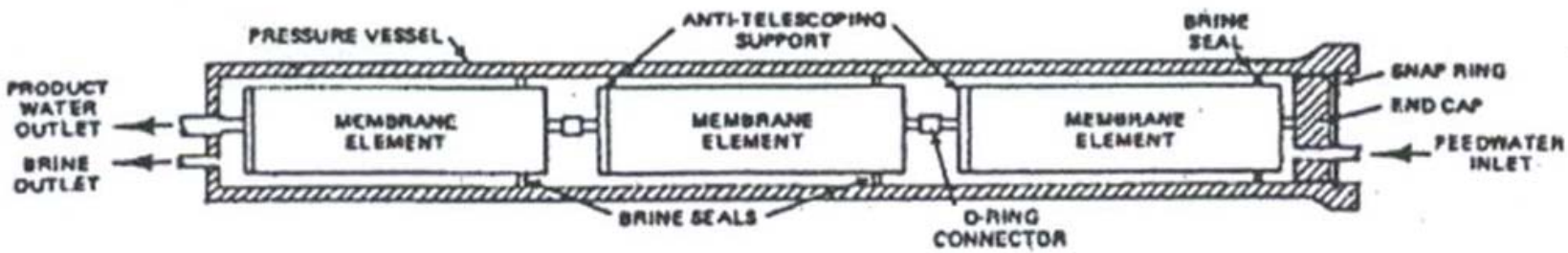
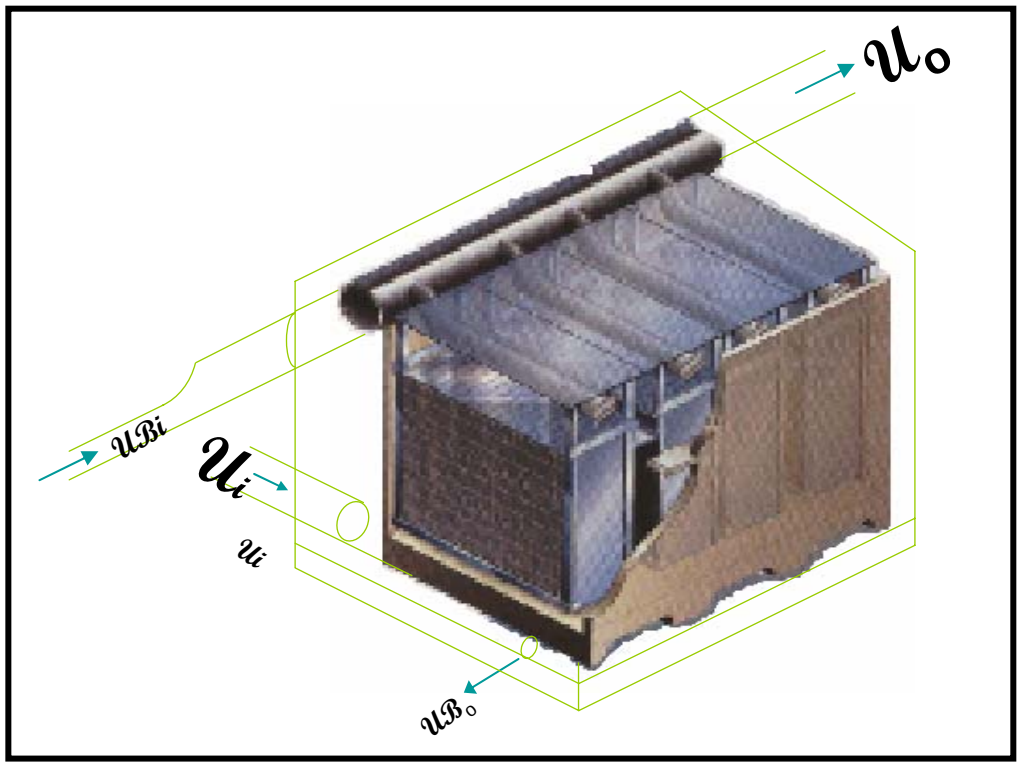


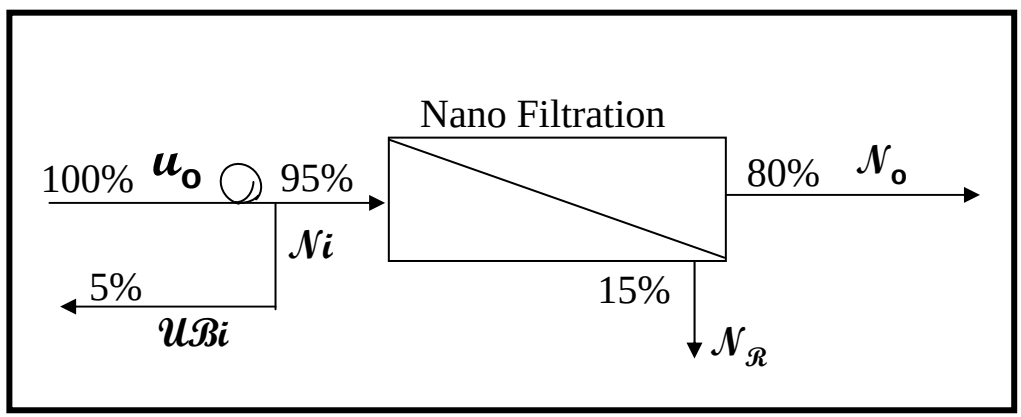
CUTAWAY VIEW OF A SPIRAL MEMBRANE ELEMENT



CROSS SECTION OF PRESSURE VESSEL WITH 3 MEMBRANE ELEMENT

WATER DESALINATION



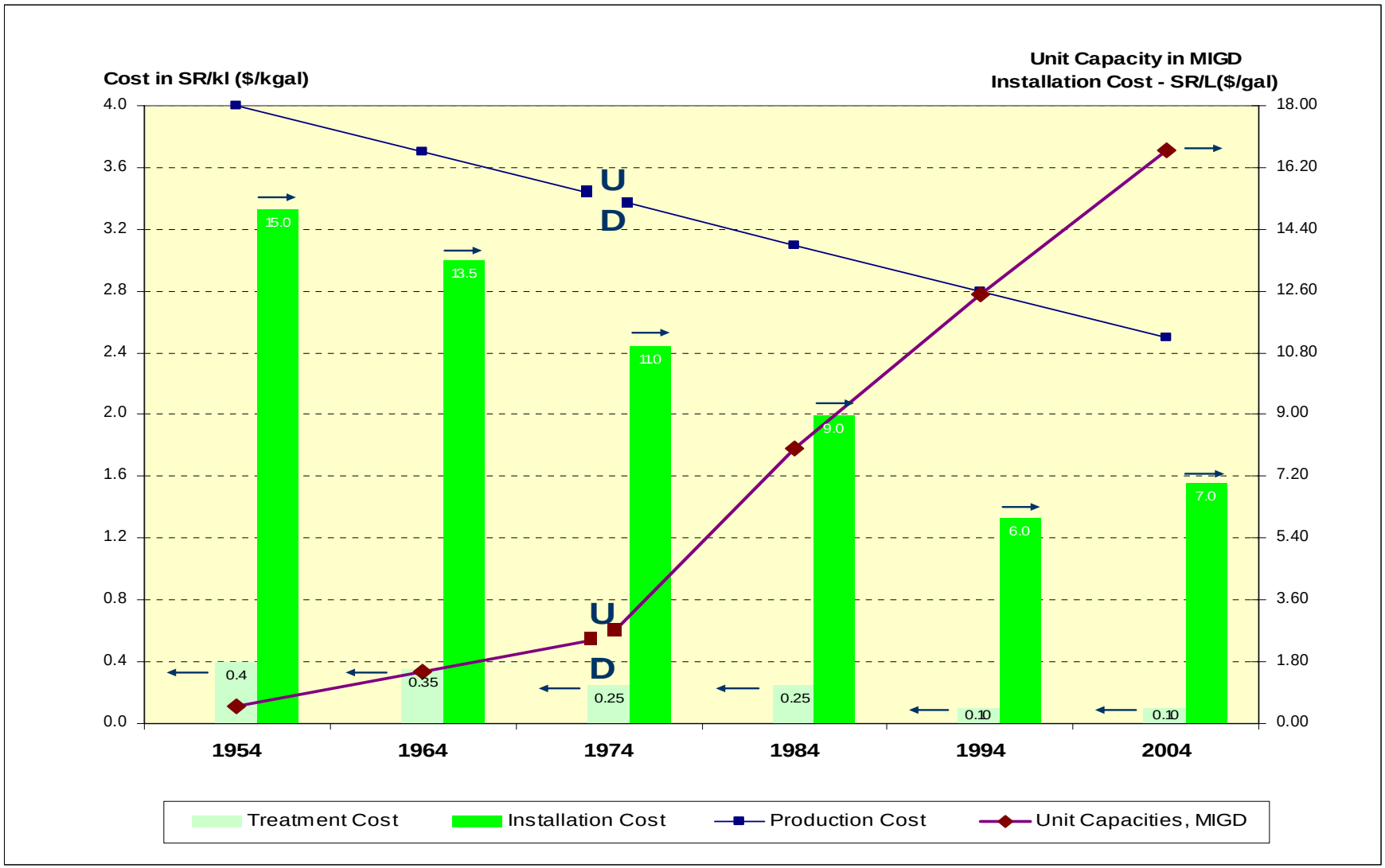


Features of New MSF Plants

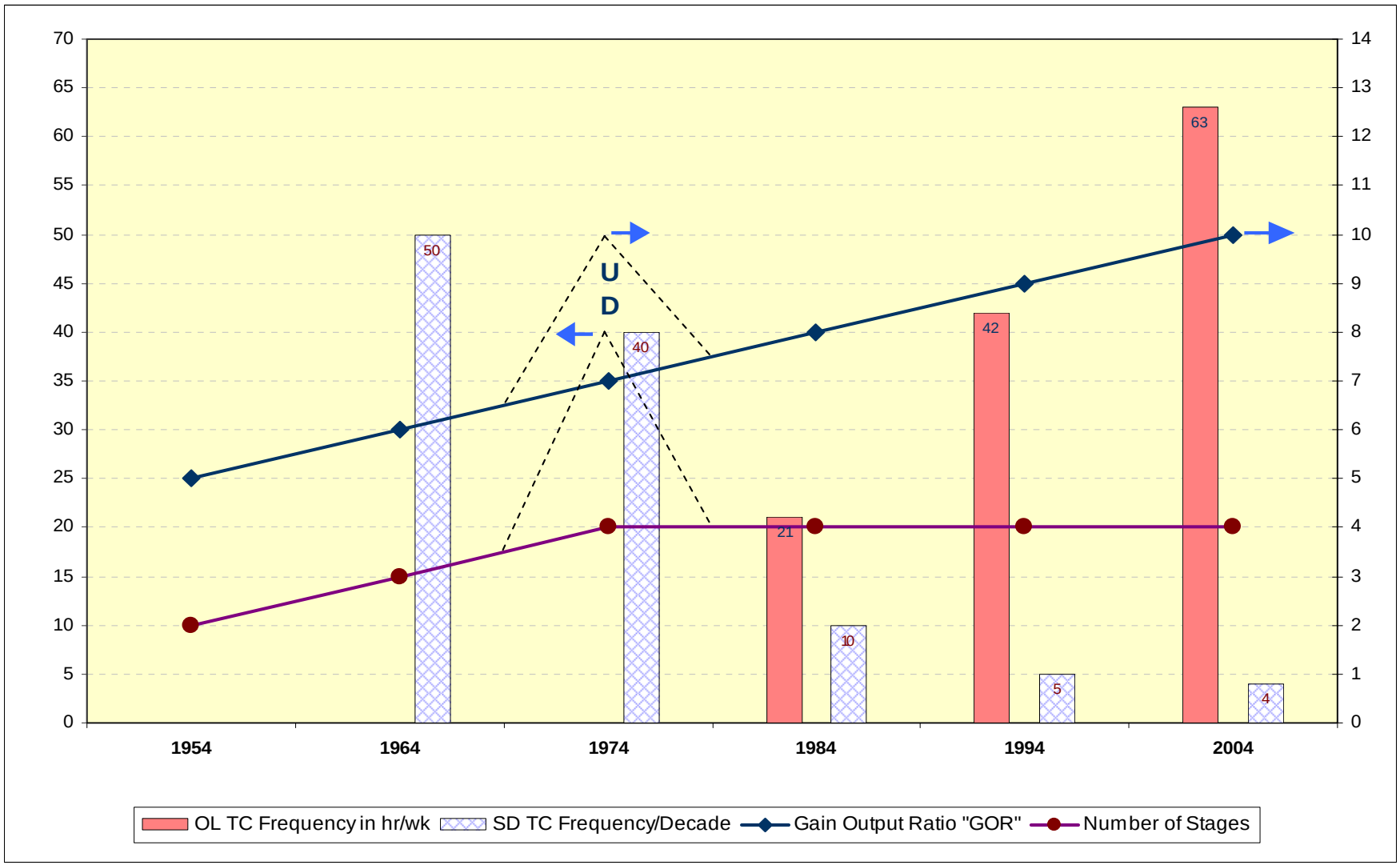
- Very high production per unit size.
- High performance ratio.
- Optimized heat exchange surfaces.
- Optimized design parameters.
- Reduced loses.
- Reasonable construction time.

WATER DESALINATION

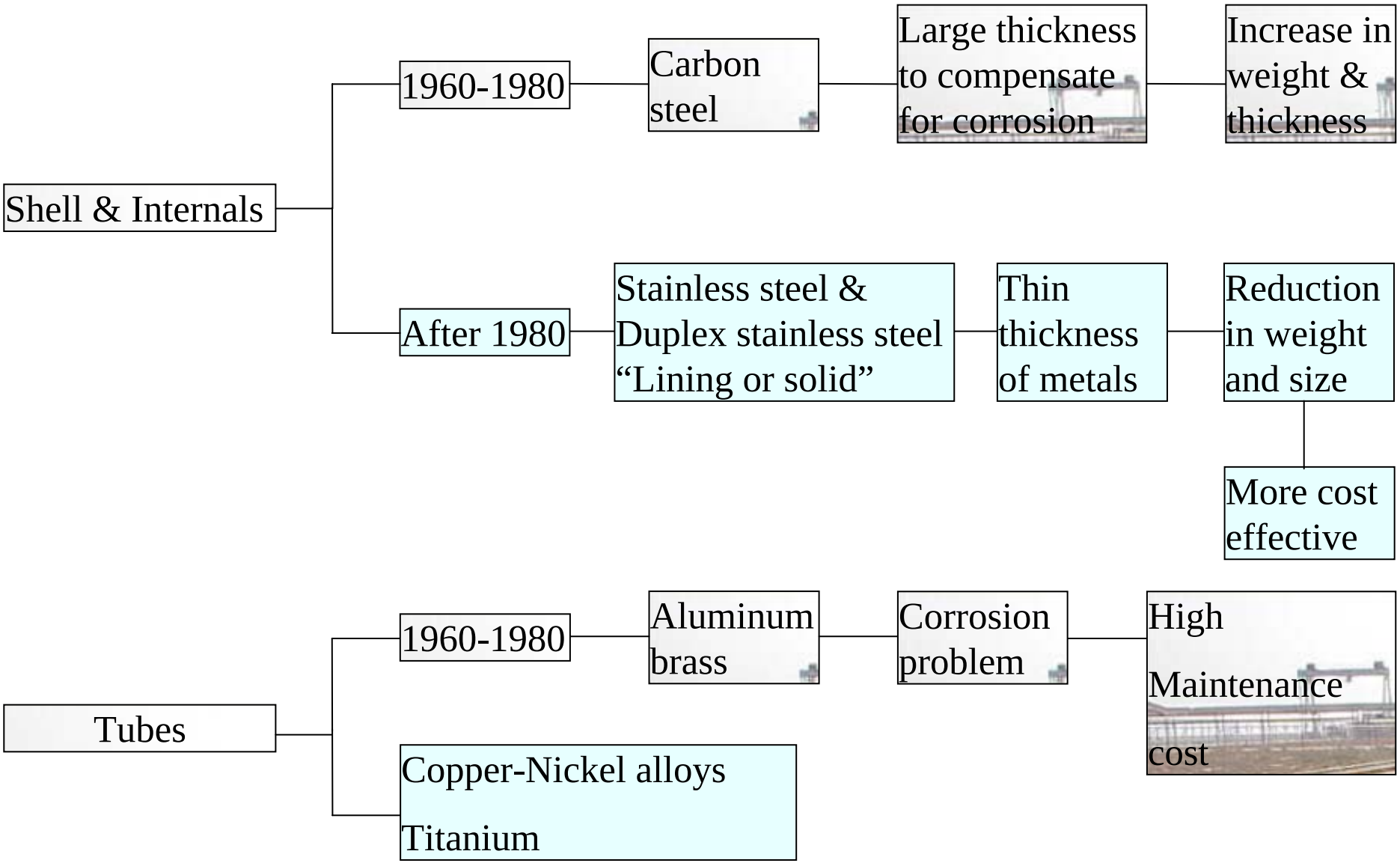
MSF Costs and Unit Capacity



MSF Number of Stages, GOR & Descaling Frequencies



Developments in Materials Selection



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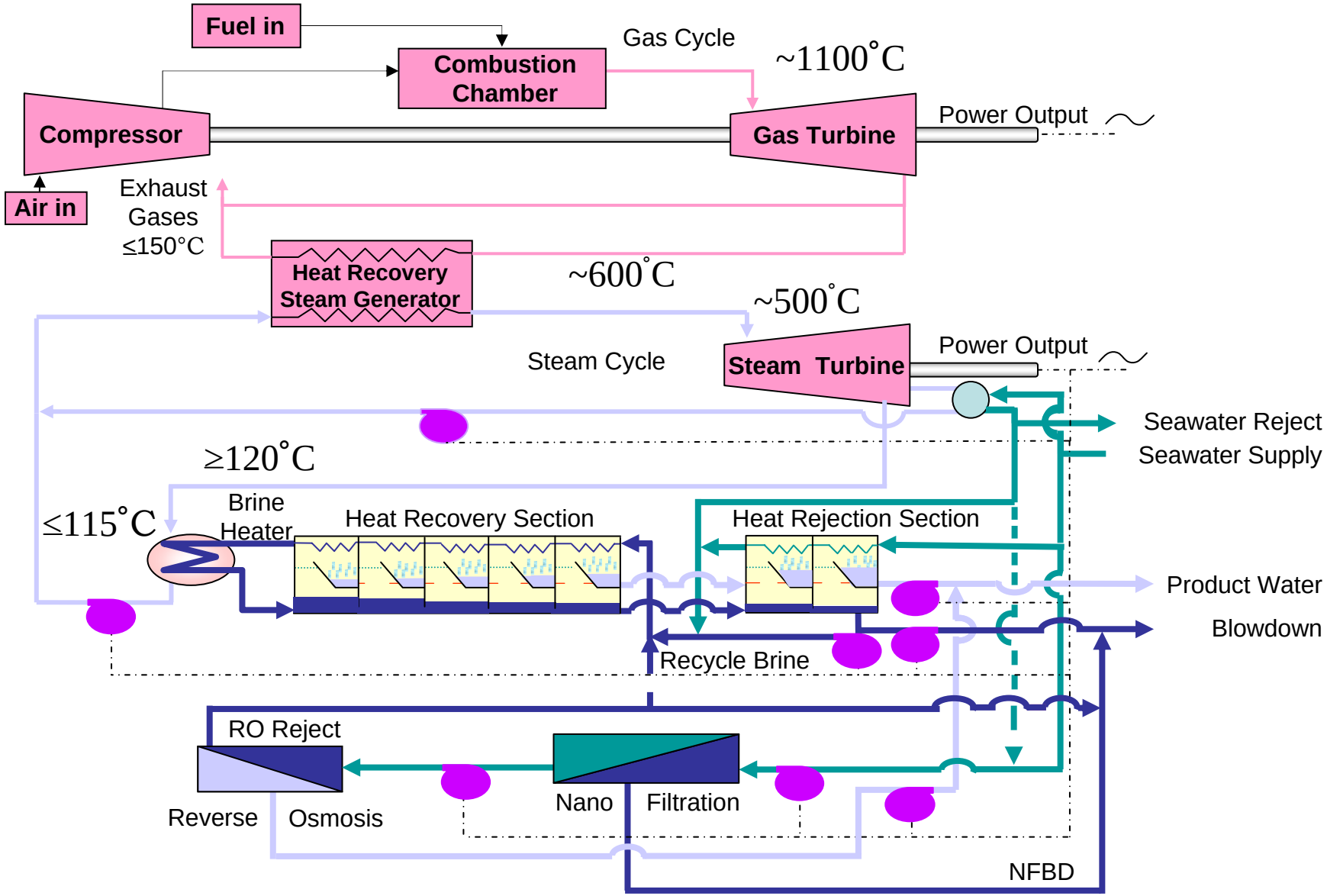

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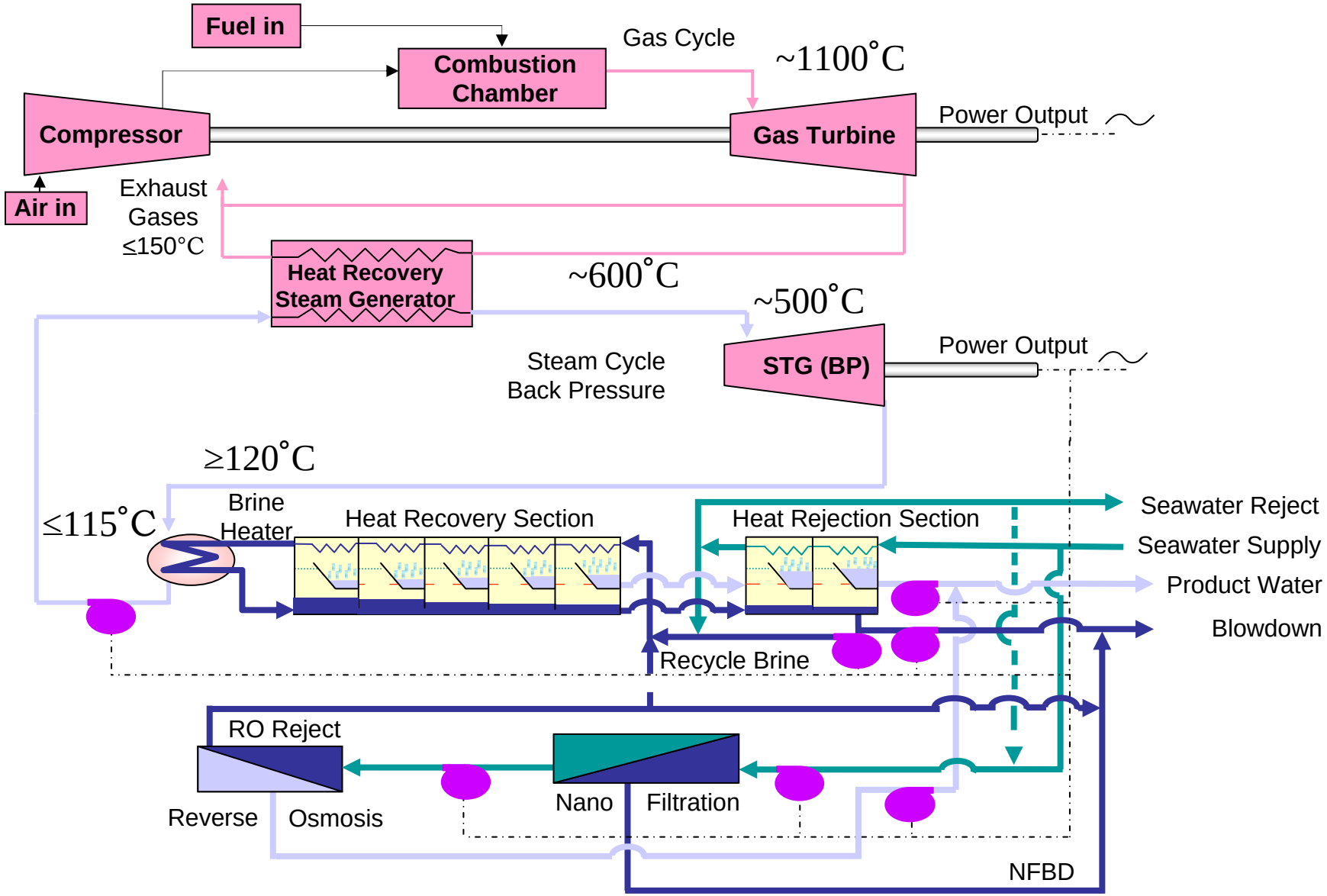
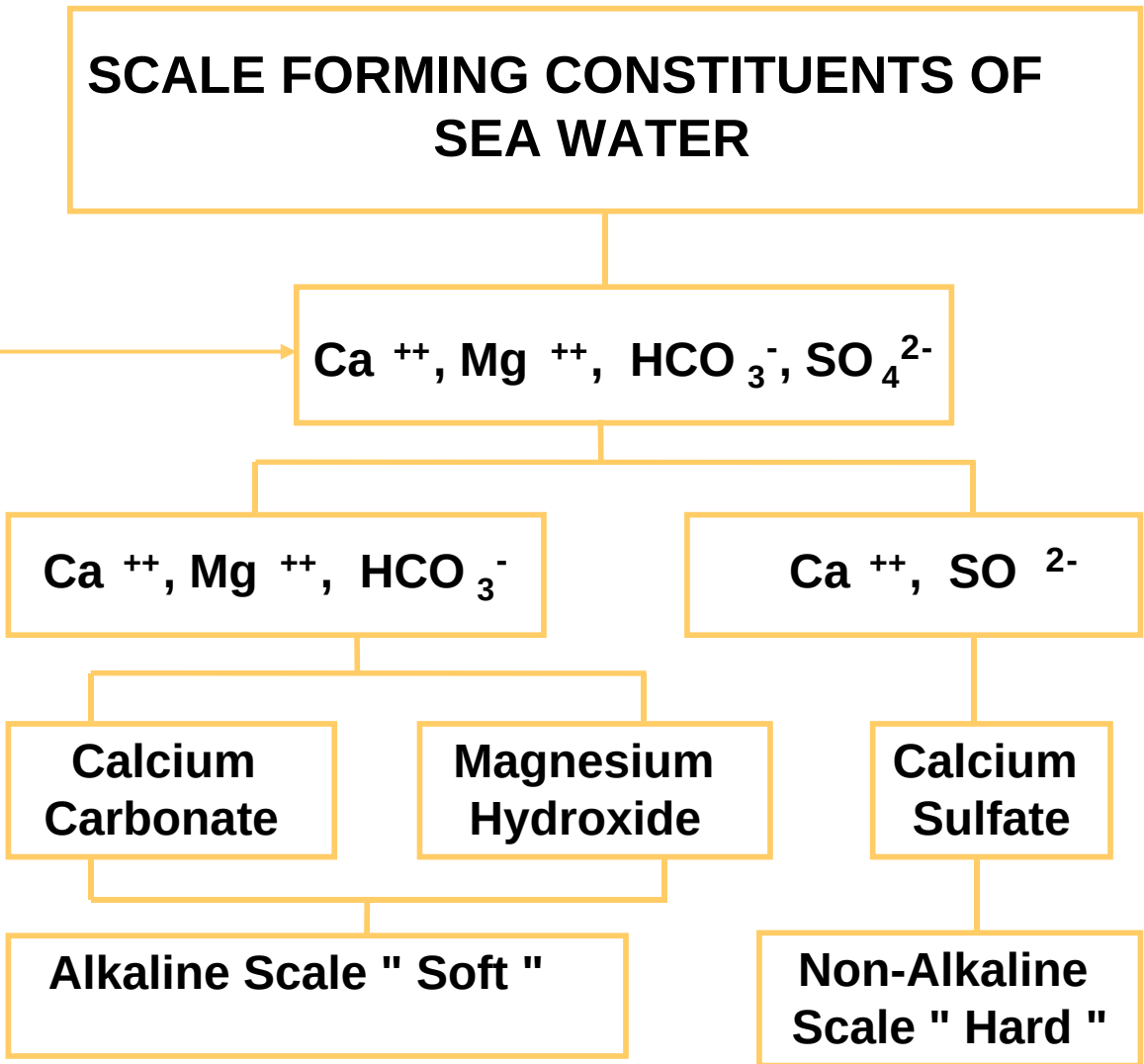


WATER DESALINATION

Typical Composition of Gulf Sea Water

Cations	**ppm**
Sodium	13630
Potassium	437
Calcium	**481**
Magnesium	**1608**
Traces of ions Copper, Boron, Strontium	
Anions	
Chloride	24040
Sulfate	**3200**
Bicarbonate	**128**
Bromide	76
Traces of Fluoride & Silicon	

Total dissolved salts = 44000



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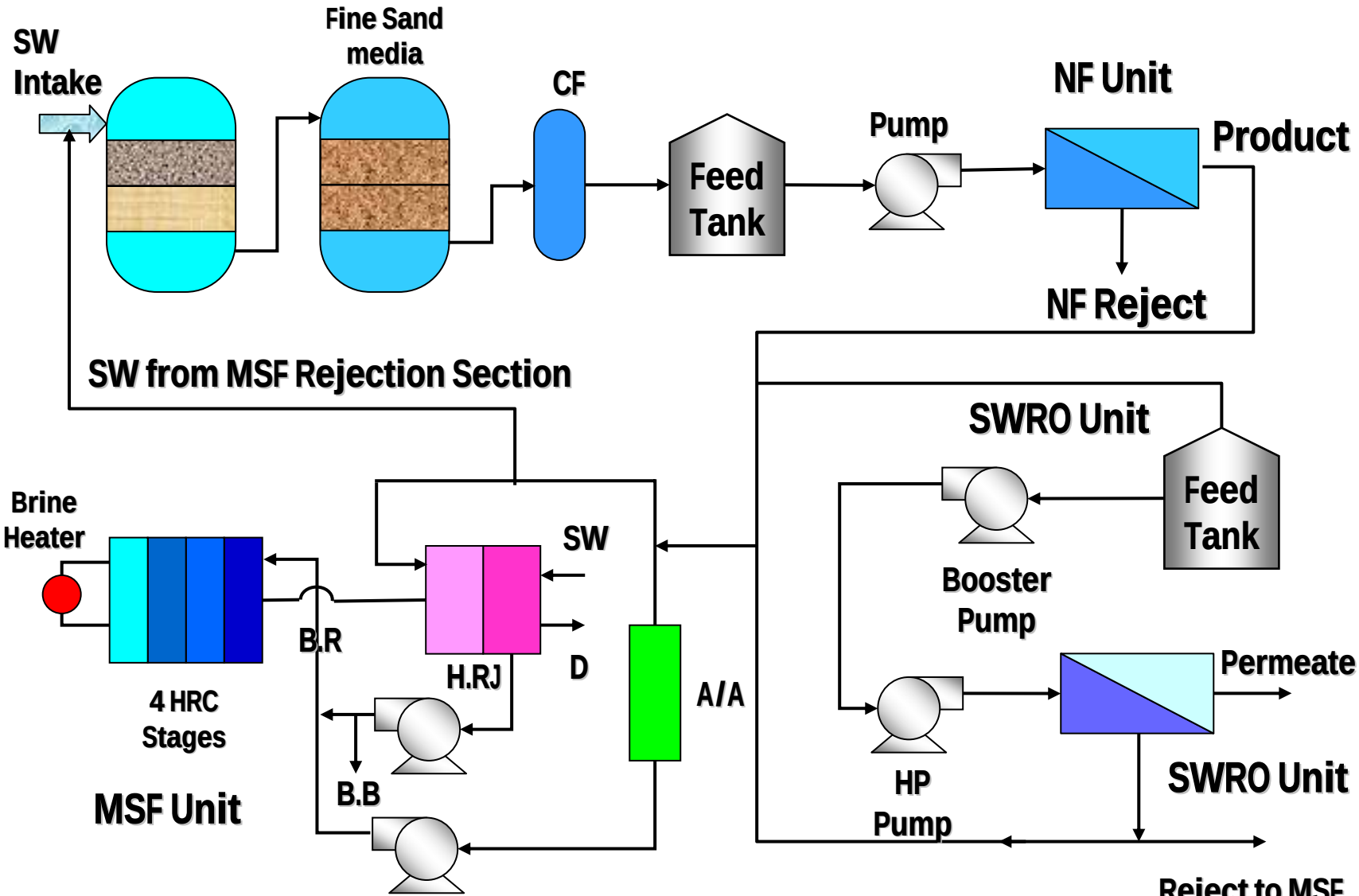
Schematic Flow Diagram of NF, SWRO and MSF Pilot Plants Used to Evaluate Di or Tri Seawater Desalination Hybrids



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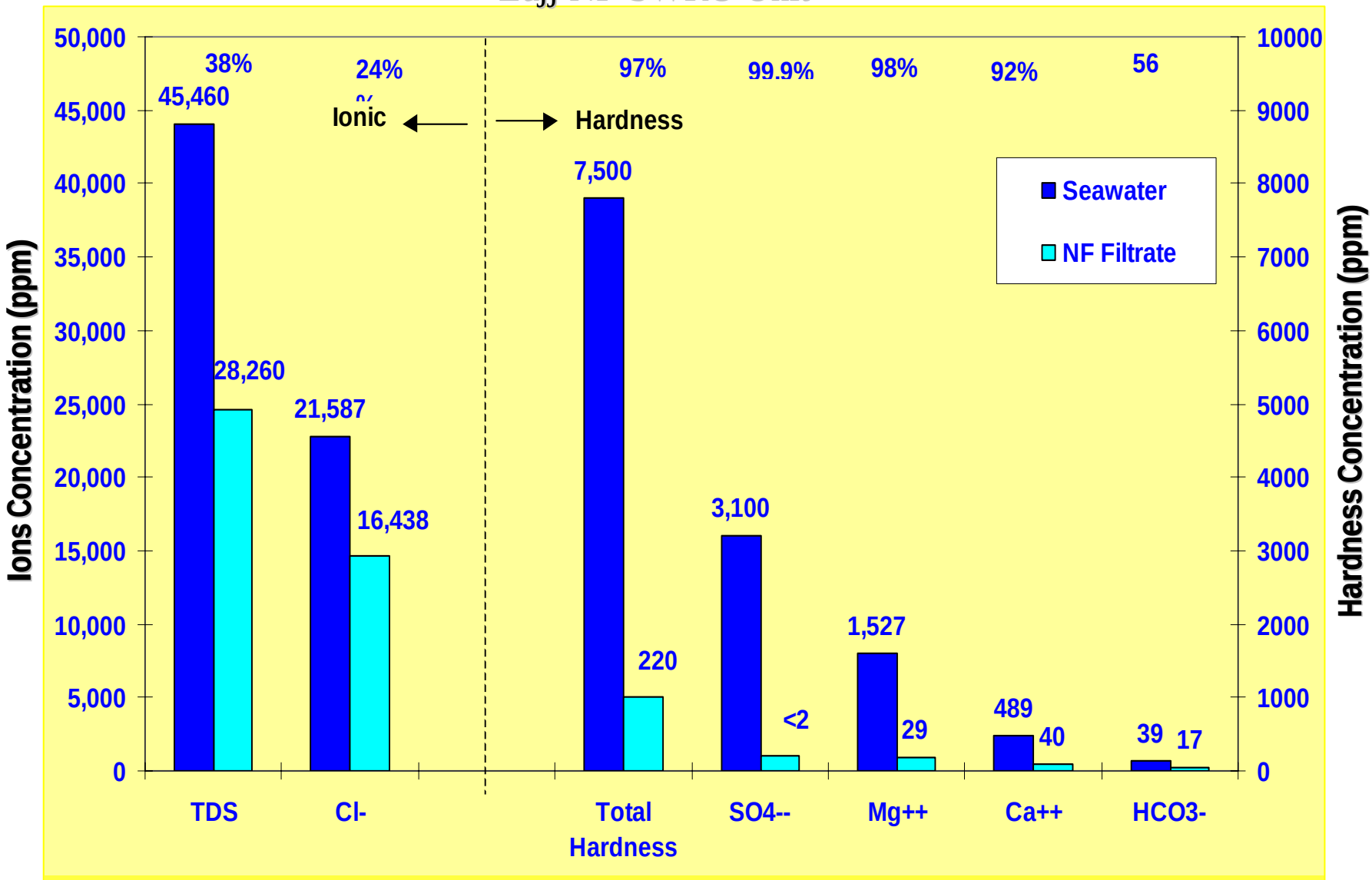
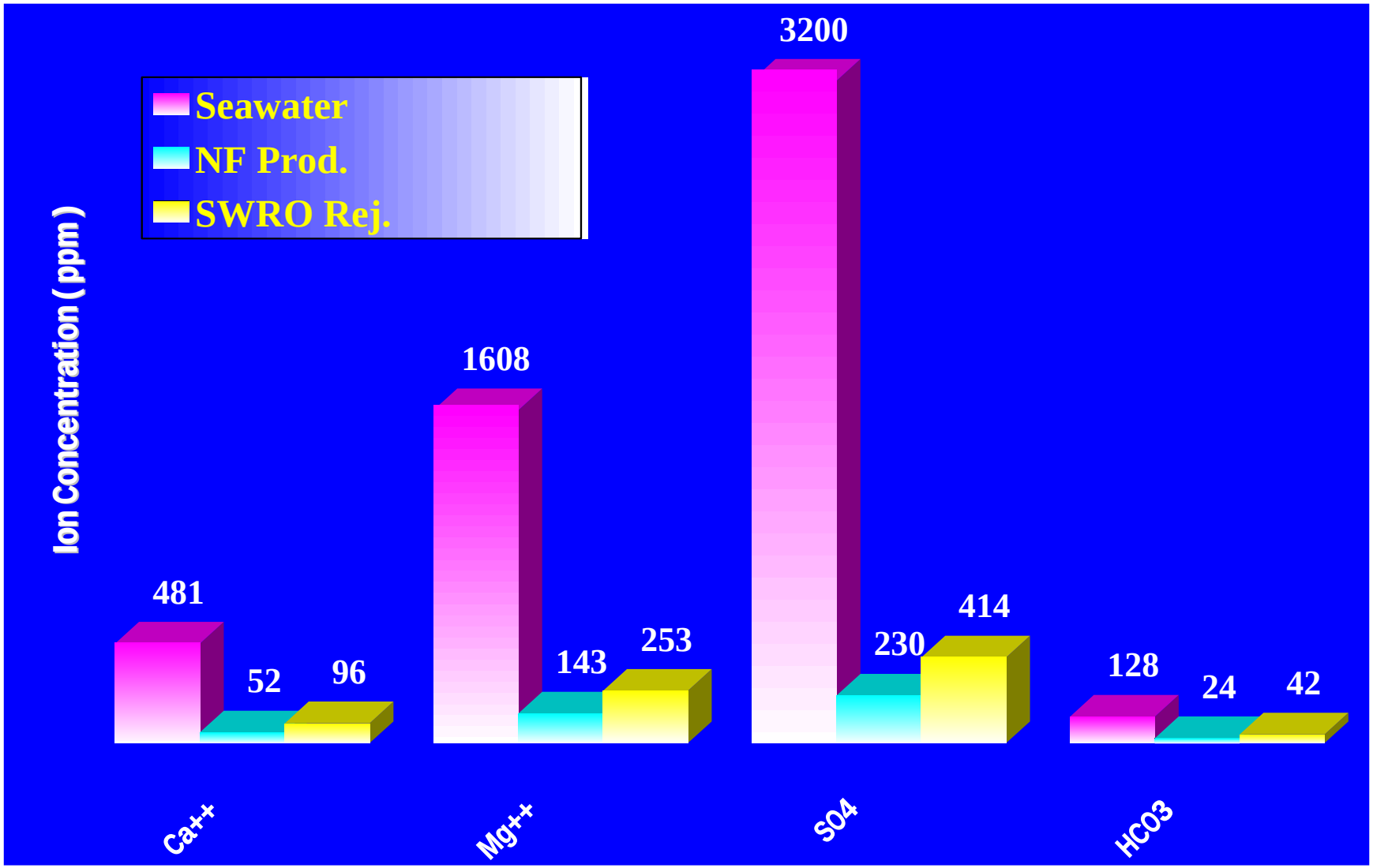
Effect of New NF Pretreatment Process on Removal of Hardness Ions and TDS at Umm Lujj NF-SWRO Unit



WATER DESALINATION

Operation of SWRO Unit on NF Product Produces High Quality SWRO Permeates Void of Hardness Ions and SWRO Reject Containing Very Low Hardness Ions



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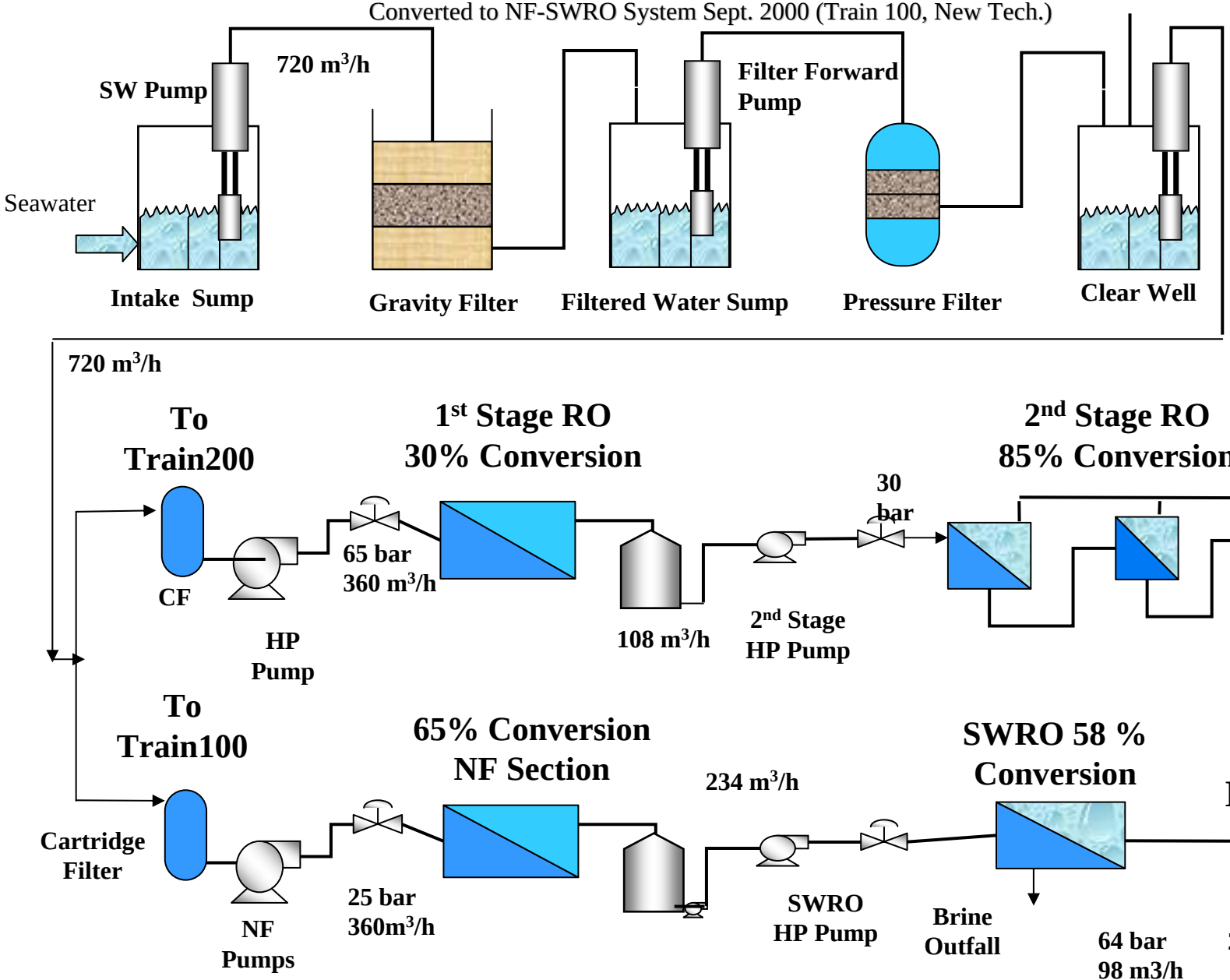
Umm Lujj SWRO Plant Flow Diagram a. SWRO Arrangement as Built in 1986 (Train 200, Control) b. NF-SWRO Arrangement as Converted to NF-SWRO System Sept. 2000 (Train 100, New Tech.)



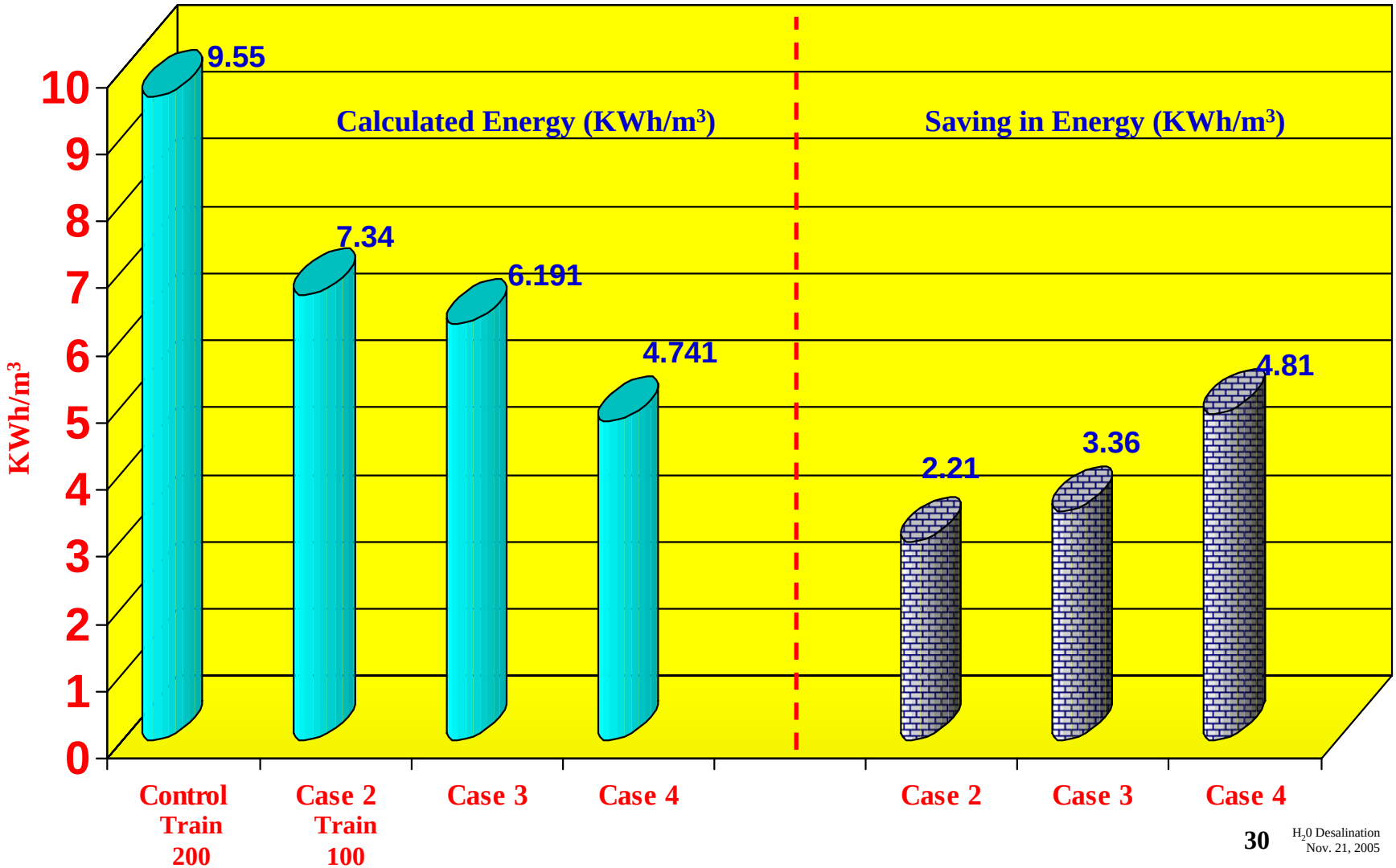
WATER DESALINATION

A Photo of the Final NF-SWRO Plant with NF Section in Front and SWRO Section in the Back

WATER DESALINATION

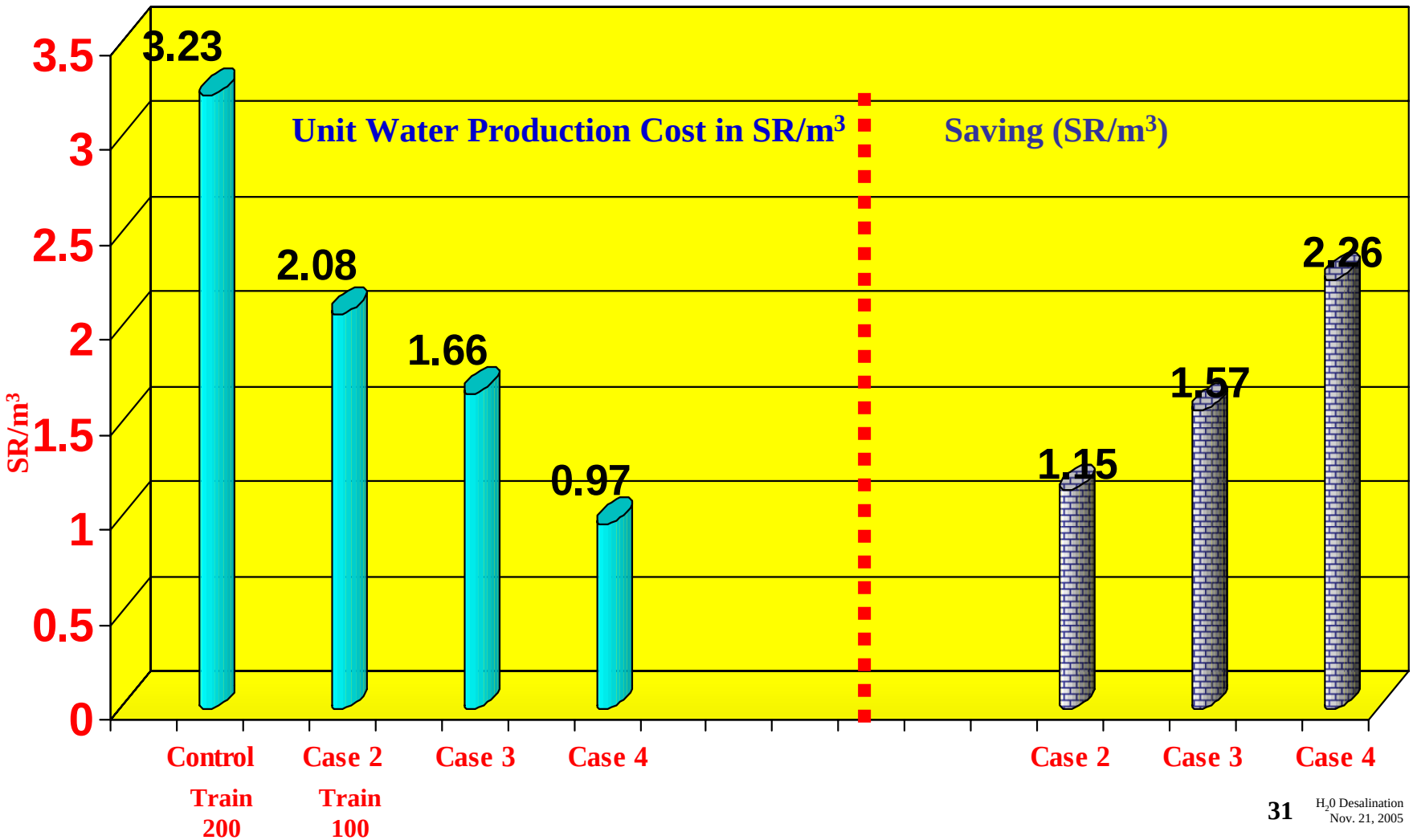
Calculated Energy Consumption for the Convention at Ummlujj SWRO Process as Built in 1986 and for the Various Conversion Cases of NF-SWRO

Case 2: Train 100 (NF-SWRO) Using Existing Pretreatment, Case 3 : Conversion of Two Trains to Full SWRO HP pump Capacity (360 m3/h) with Introduction of Additional Pretreatment, Case 4 : Same as Case 3 with Two Stage Operation of each of NF and SWRO and Energy Recovery Turbocharger in between.



Cost (without interest) of Added Water Production(SR/m3)

Case 2: Train 100 (NF-SWRO) Using Existing Pretreatment, Case 3 : Conversion of Two Trains to Full SWRO HP pump Capacity (360 m3/h) with Introduction of Additional Pretreatment, Case 4 : Same as Case 3 with Two Stage Operation of each of NF and SWRO and Energy Recovery Turbocharger in between.



Commercialization of Suggested and Innovative Schemes

1. Unconventional High Temperature MSF (HTF), see Figure 18
2. Solar Energy Utilization, especially through Solar Ponds.
3. Utilization of Other Renewable Resources, such as: Wind and Wave Energy.
4. Electrically Induced Separation.
5. Ion Exchange (IED).
6. Hydration, see Figure 19.

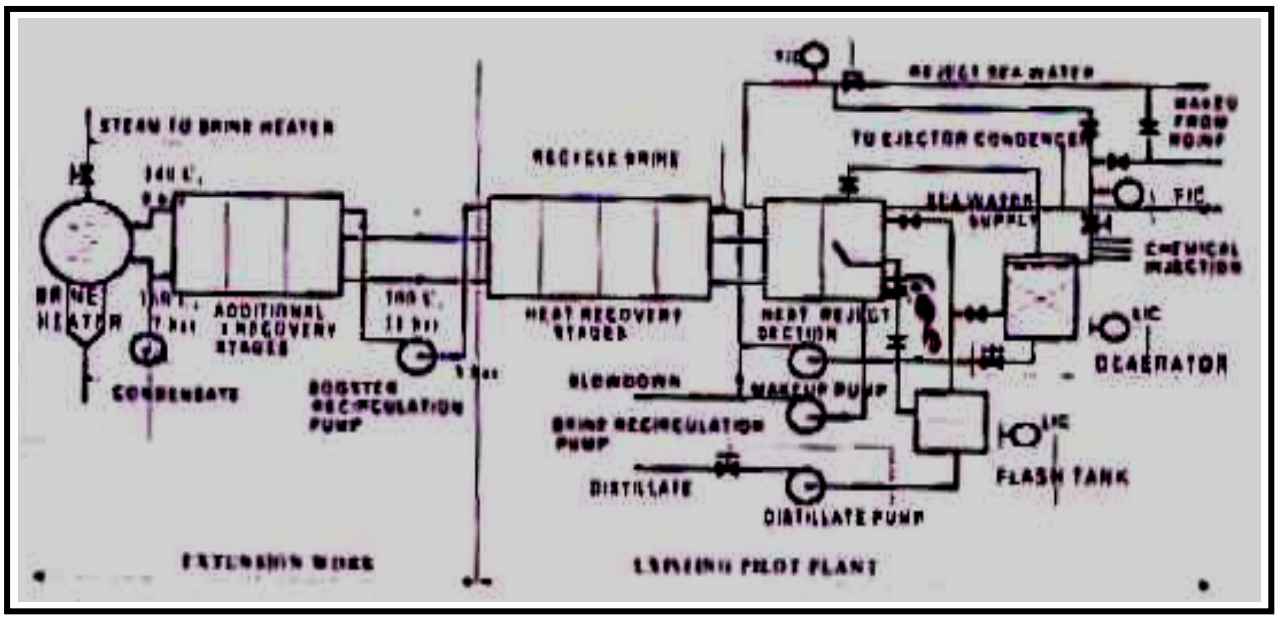


Figure 18

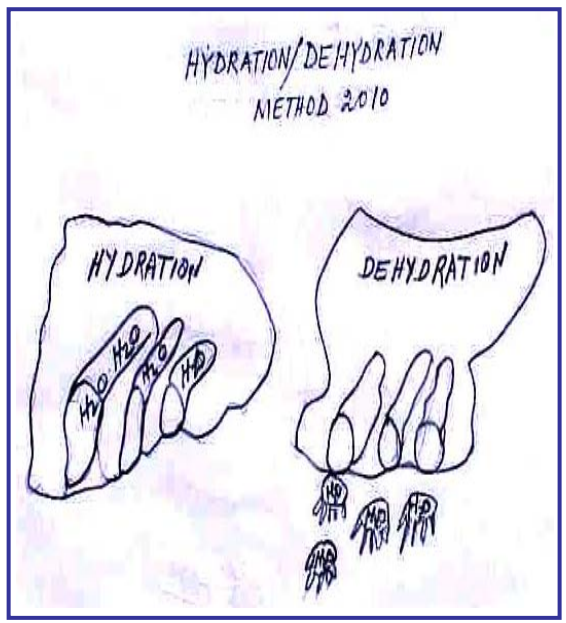


Figure 19

Commercialization of Suggested and Innovative Schemes (Cont'd.)

7. Chemical Reaction, Salt Precipitation, see Figure 20.
8. Biodesalination, Anion/Cation Bacterial (oxi-re), see Figure 21.

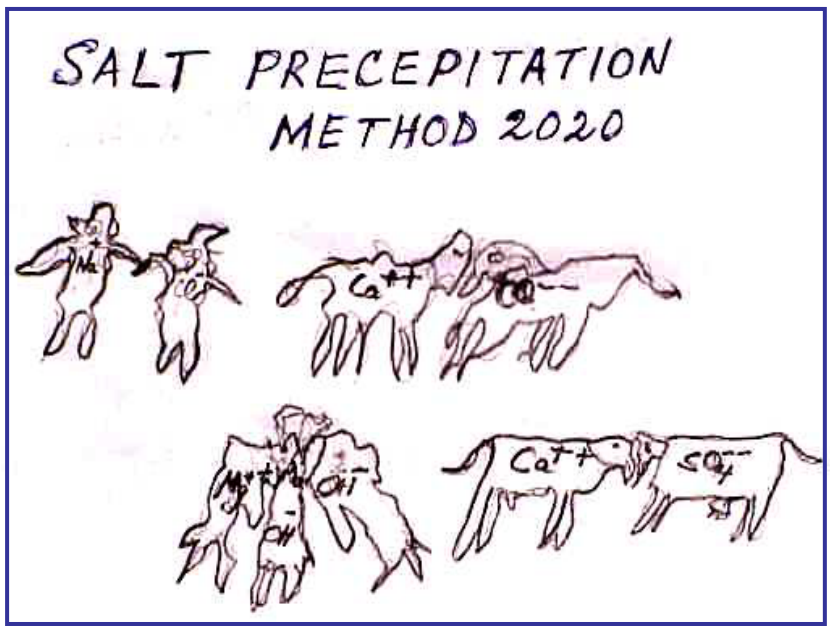


Figure 20

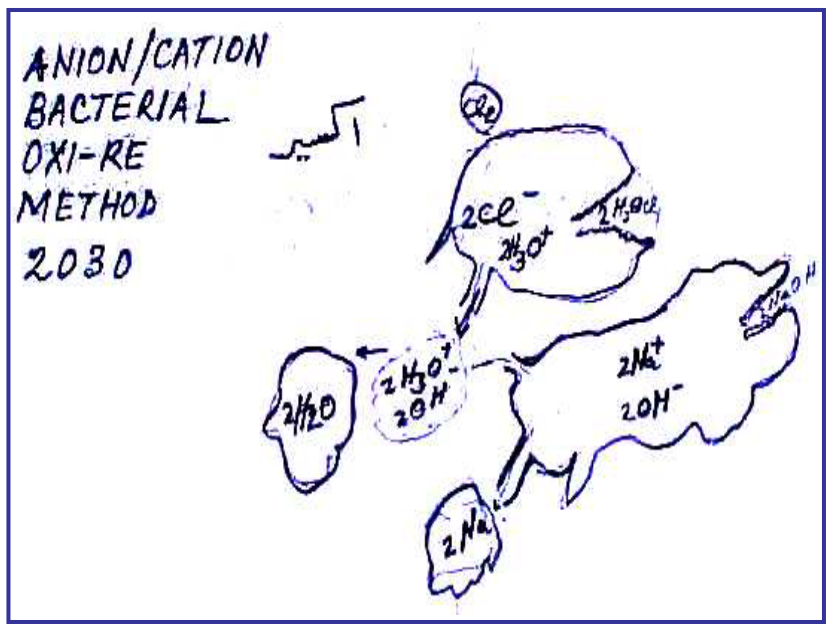


Figure 21

Commercialization of Suggested and Innovative Schemes (Cont'd.)

9. Freezing.
10. Nuclear Energy Utilization, see Figure 22.
11. Combined Membrane Processes of Dylitic, Osmotic & Ion Exchange (ED, RO, IX), see Figure 23.

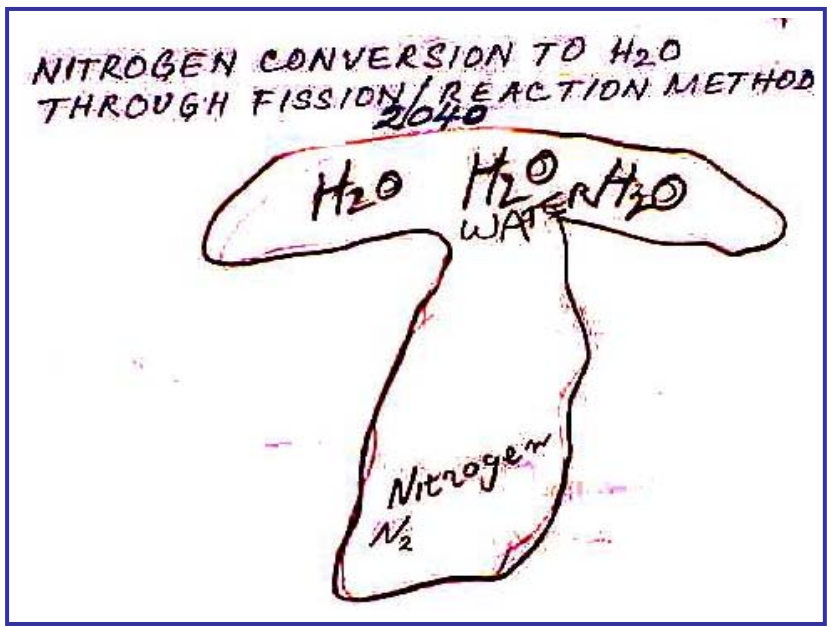


Figure 22

Figure 23

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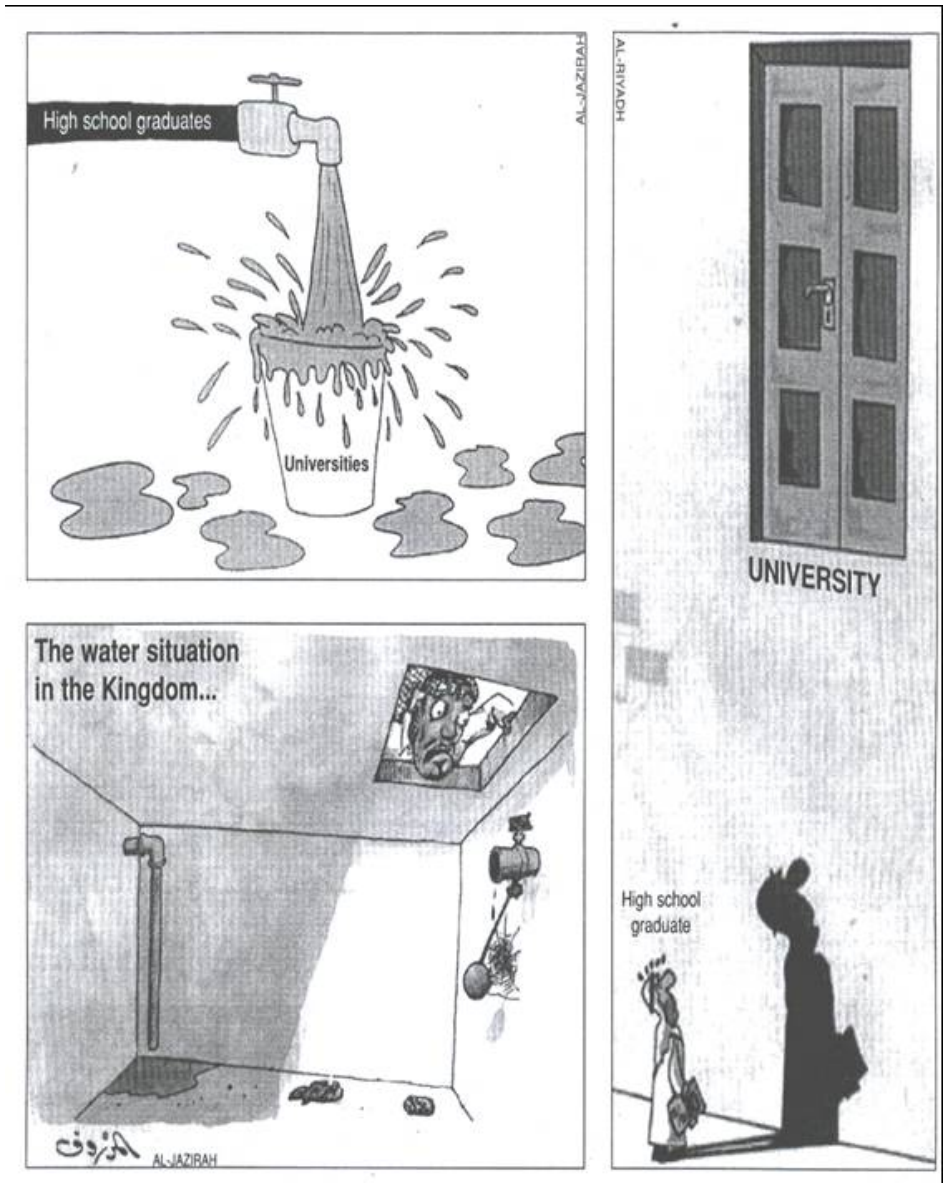

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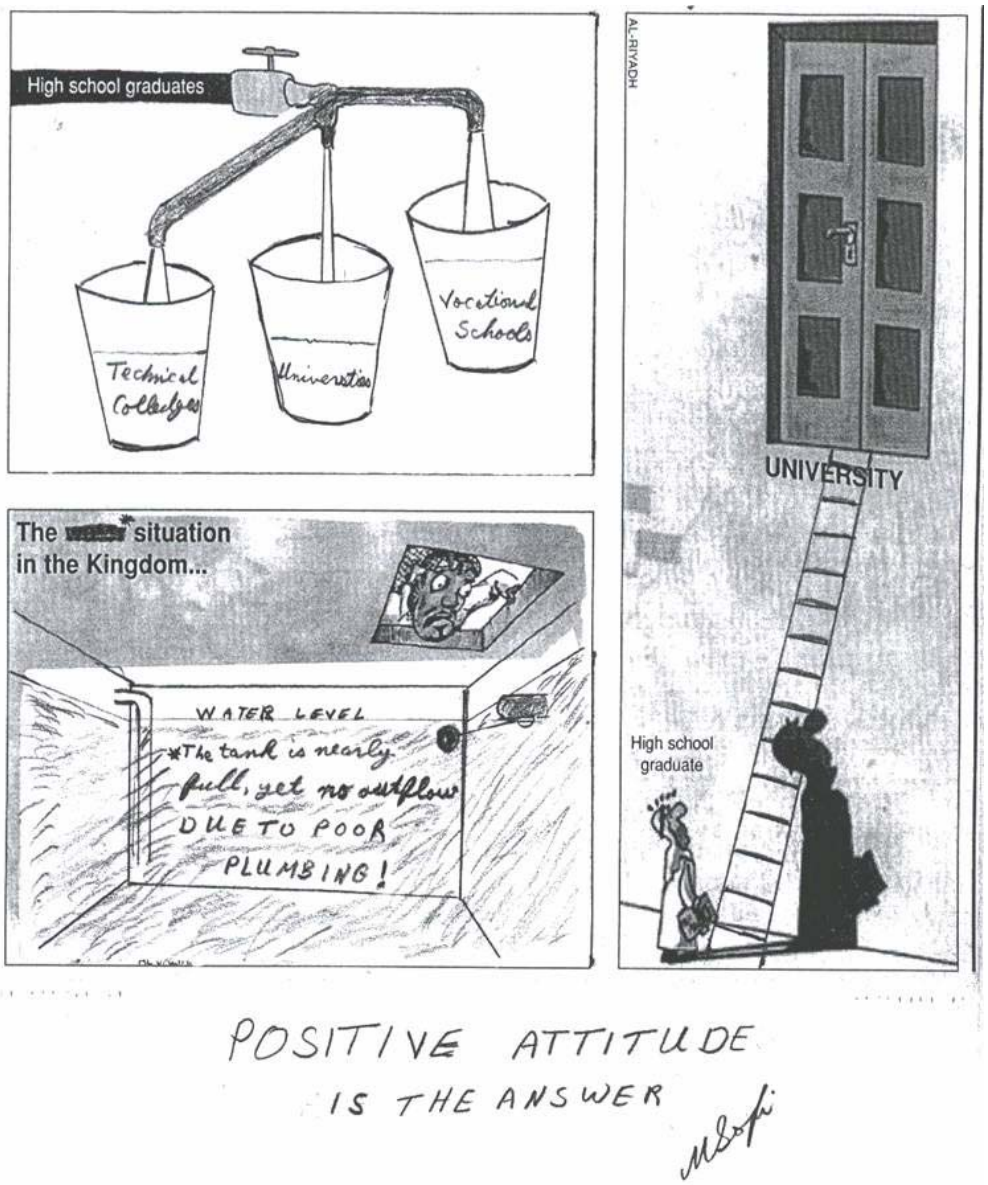

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Thank You