

# **WATER DESALINATION AND POWER PRODUCTION**

**An Experience Based Vision for the  
Future**

BY

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# WATER DESALINATION:

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There are three processes of thermal desalination:

- Multi Stage Flash (**MSF**) is the workhorse of this industry for large and extremely large capacities of up to **giga liters**, per day productions;
- Multi Effect Distillation (**MED**) for medium capacities in **mega liters** per day productions; and
- Vapour Compression Distillation (**VCD**) is suitable for capacities in **kilo liters** per day productions.

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### **Other technologies are Sea Water Reverse Osmosis (SWRO)**

- Brackish Water Reverse Osmosis (**BWRO**);
- They are found suitable everywhere for medium to large capacities;
- Electro Dialysis (**ED** and with Reversal-**EDR**) is another permeation process;
- Both **ED & EDR** are found to serve small capacities particularly when industrial water is the prime requirement; and
- In such cases, Ion Exchange Desalination (**IED**) that utilizes special resins could also be used.

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For the future, the Arab World should spare no effort in developing other processes.

- These are the combination of **solar ponds** heat recovery and **solar distillation** specifically for remote areas;
- Last yet quite valuable is a call for the development of stand-alone and/or combined hybrid applications;
- Such as the utilization of selective species separation membrane processes; &
- Concentrated efforts in such development are to be directed towards **Ultra & Nano (UN) Filtration** techniques.

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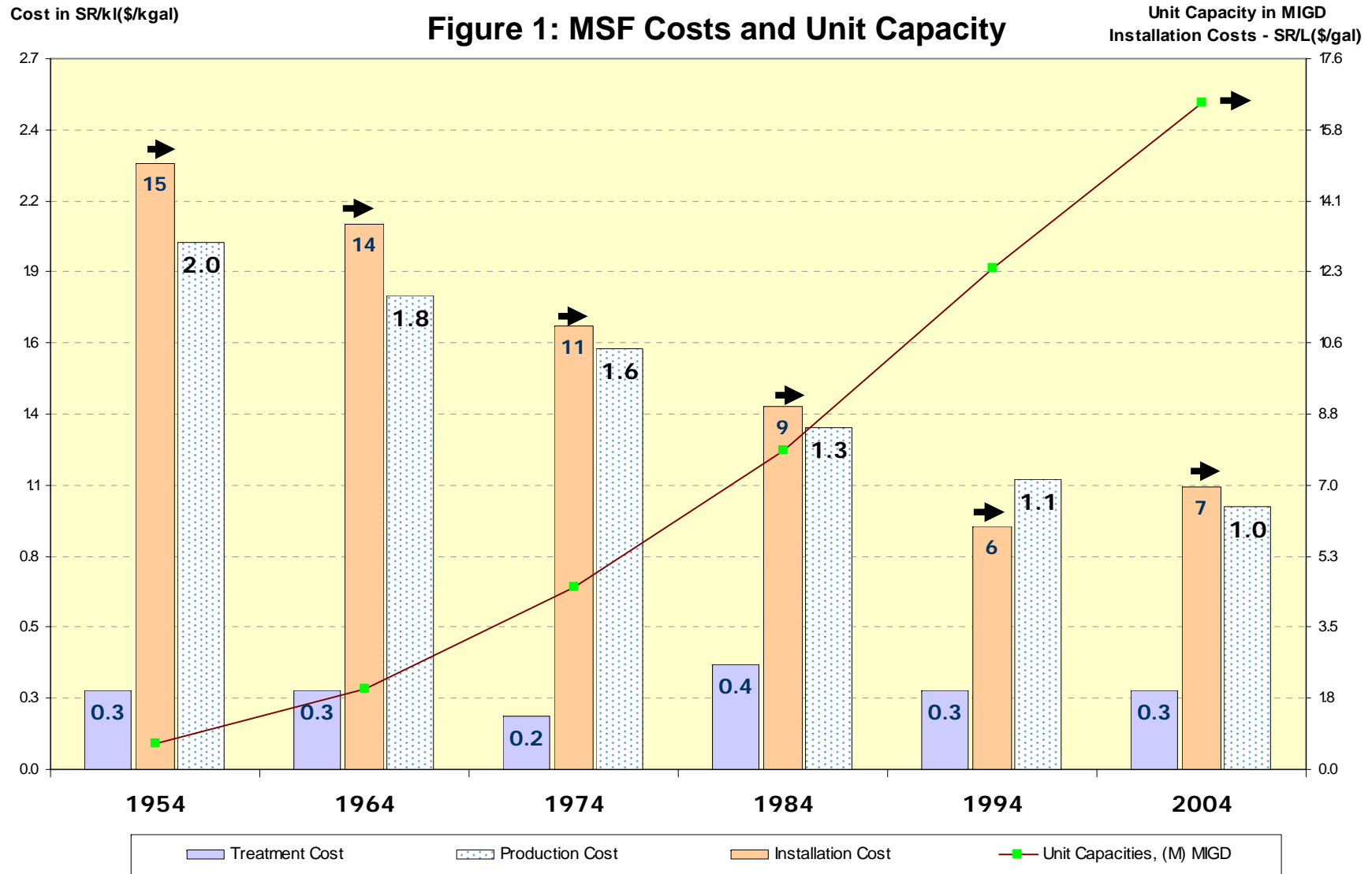
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Future work required to develop MSR are:

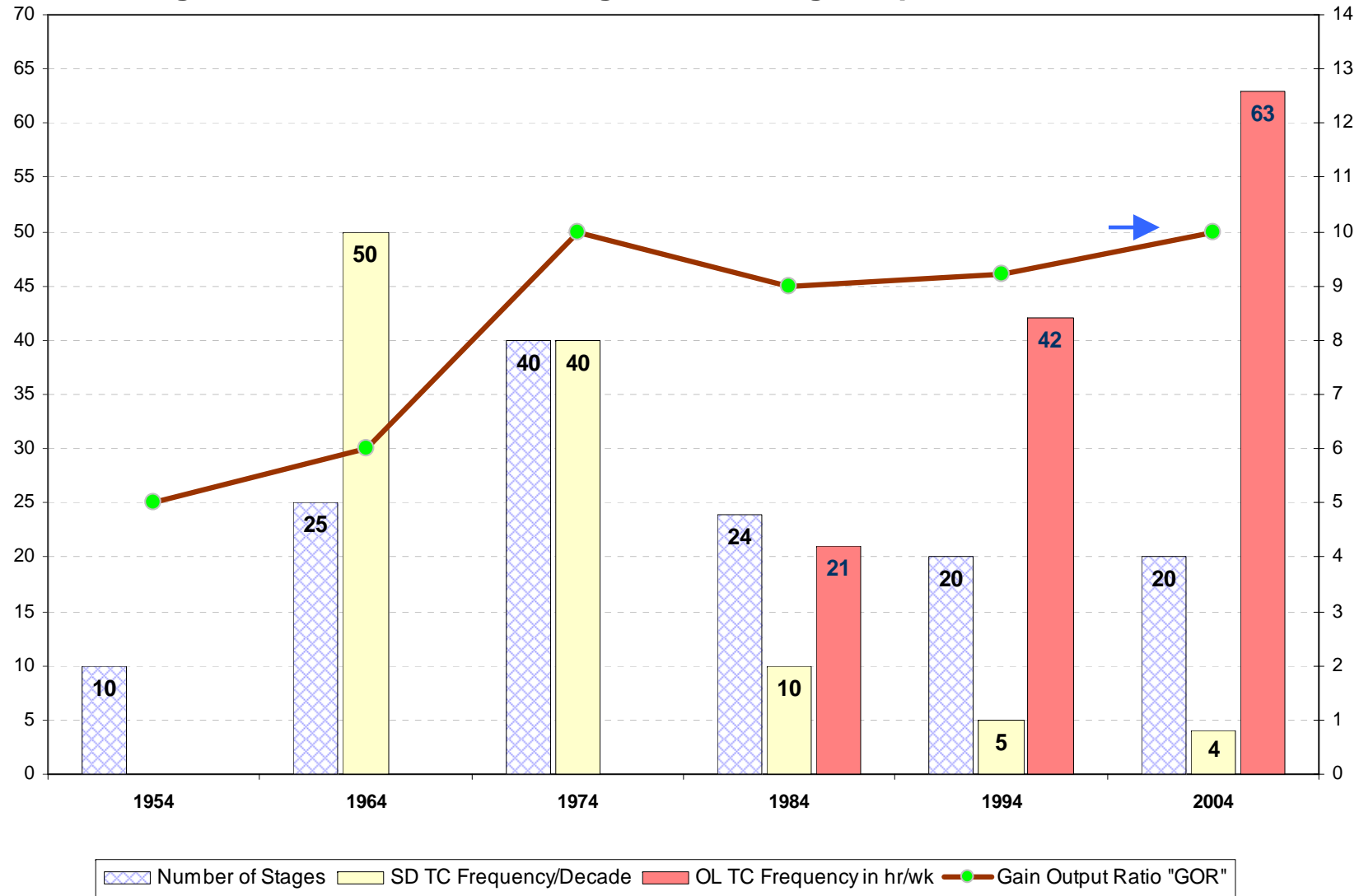
1. Unit capacity growth pattern;
2. Process efficiency to maximize energy utilization [Gain Output Ratio (GOR)];
3. Intake design to maximize feed utilization [Recovery Ratio (RR)];
4. Capital (installation) cost per unit output;
5. On-stream factor, as expressed by availability and reliability;

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Figure 2: MSF Number of Stages, Descaling Frequencies & GOR



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6. Understanding of scaling potentials and prevention mechanism;
7. Corrosion resistant materials that are most suitable for seawater & desalination;
8. Electronic measurement, monitoring and control, i.e., instrumentation.



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### 9. Mathematical modeling and simulations

to prevent:

- a) Stage pairing;
- b) Mist carry-over; and
- c) Non-Condensable accumulation through improved:
  - i) Bundle design;
  - ii) Vent off Take locationing; and
  - iii) Reduction in vapour losses.

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### 10. Demister design to:

#### a) Reduce scale build up through:

- i) Self draining configuration(s); and
- ii) Insitu salt removal by distillate jet flushing.

#### b) Assembly/mounting techniques in order to:

- i) Retard mist carry over through tighter sealing; and
- ii) Simplify as well as affect expedient installation & removal.

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11. Staggered Venting, i.e.,
  - a) Directional flow of non-condensables and;
  - b) Creation of counter flow of gases around the bundles.

N.B. This needs to be done in conjunction with item 9 above.

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## 12. Hybridization/Integration

a) Process hybridization

i) MSF/MEC

ii) MSF/MEC feed

treatment (De-hardening/  
Separation)

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## b) Integrated Production

- i) Simple Power Cycle(s), i.e., BTG or GTG;
- ii) Combined cycle of GTG/HRSG/STG; and
- iii) Variable back pressure, STG design.

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13. Carbon dioxide recovery improvements through:
  - a) Analytical laboratory chemical equilibrium assessment to clearly understand where CO<sub>2</sub> is being released in the process;
  - b) Prototype and pilot plant evaluation to verify the reality of the above analytical results; and
  - c) Stage-wise simulation & mathematical modeling to quantify off takes.

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SWRO has proved itself worthwhile in recent years, but needs further development in four areas, which are:

- 1) Intake and Feed pretreatment systems.
- 2) Better understanding and prevention of membrane fouling and deterioration.
- 3) Improving membranes for higher flux.
- 4) Reduction of its multiple-flow streams.

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One basic upgrading requirement that MEC industry is to come up with is the design of larger thermal (steam) ejecto-compressors.

In this respect, reference can be made to a proposal put forward for a 75 MGD<sup>2</sup> (283.5 MLPD) MEC of 30 vertically stacked stages designed as a column.

The said design was based on multi ejectors and 6 parallel flow streams rather than larger components, since larger ejectors are still not available to the desalination industry.

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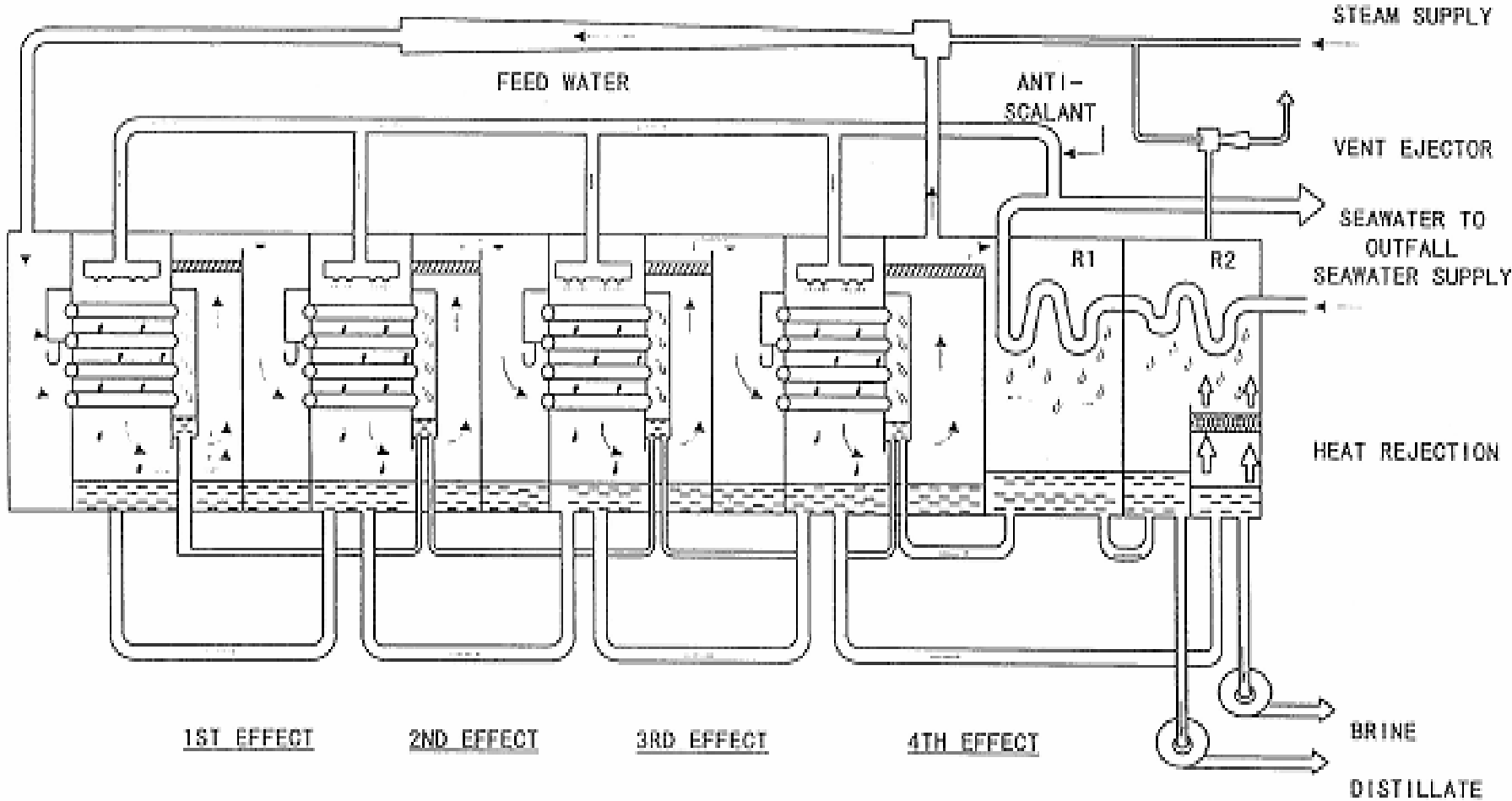
<sup>2</sup> MGD stands for Million US Gallon per day (approximately 3.78 liters per US Gallon)



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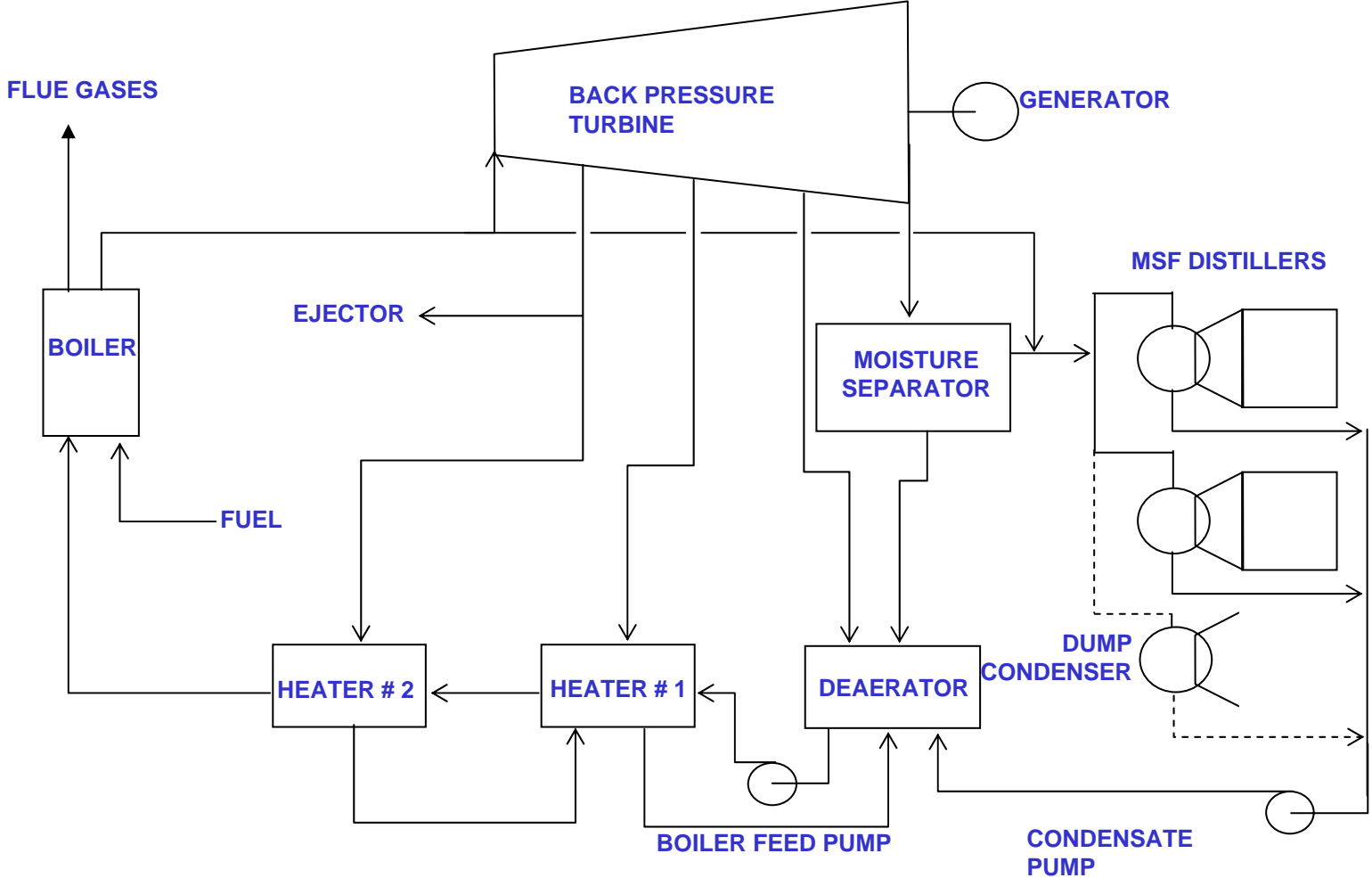
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Figure 3: Typical MEC



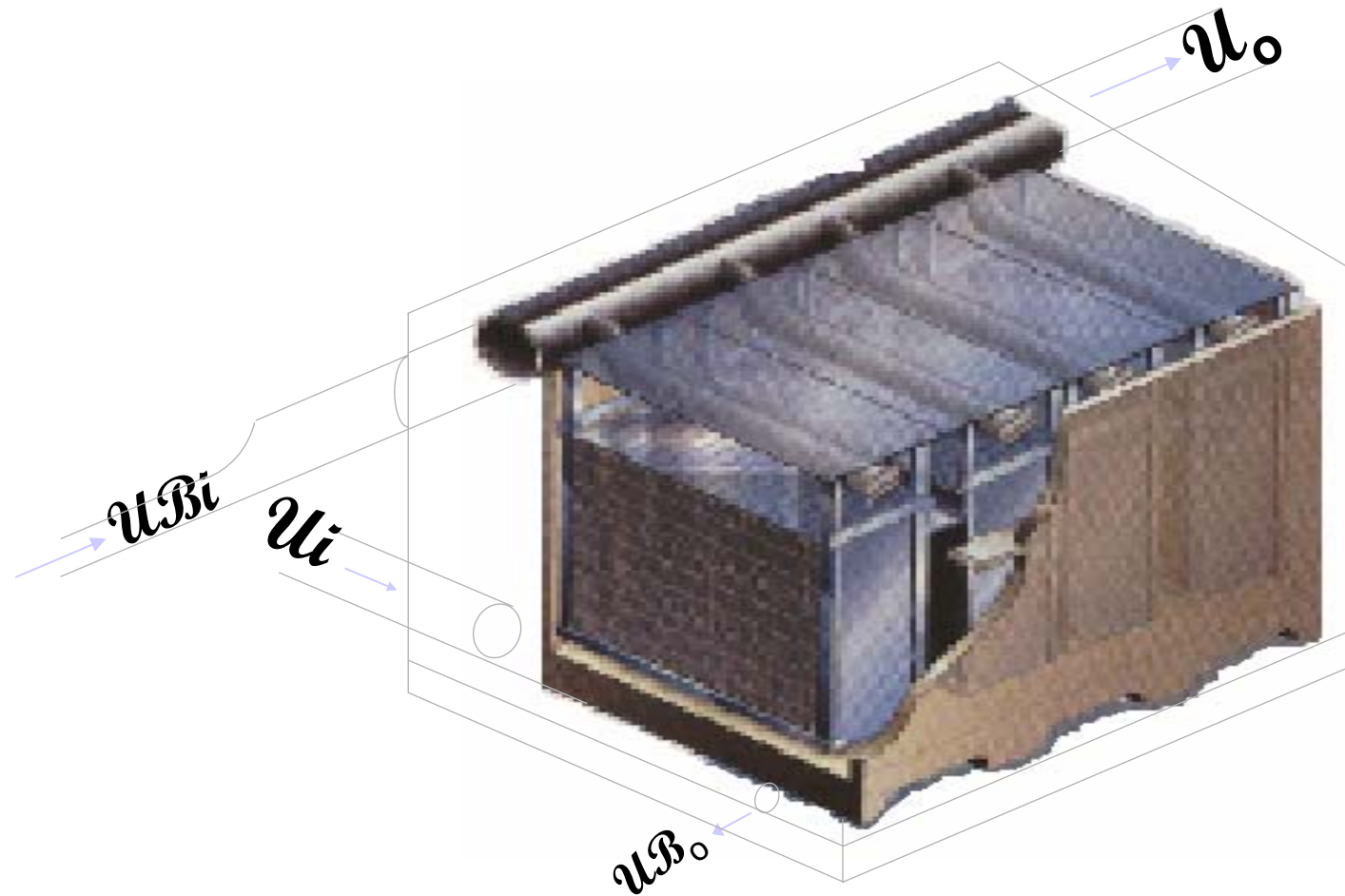
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Figure 4: Typical Dual Purpose Process



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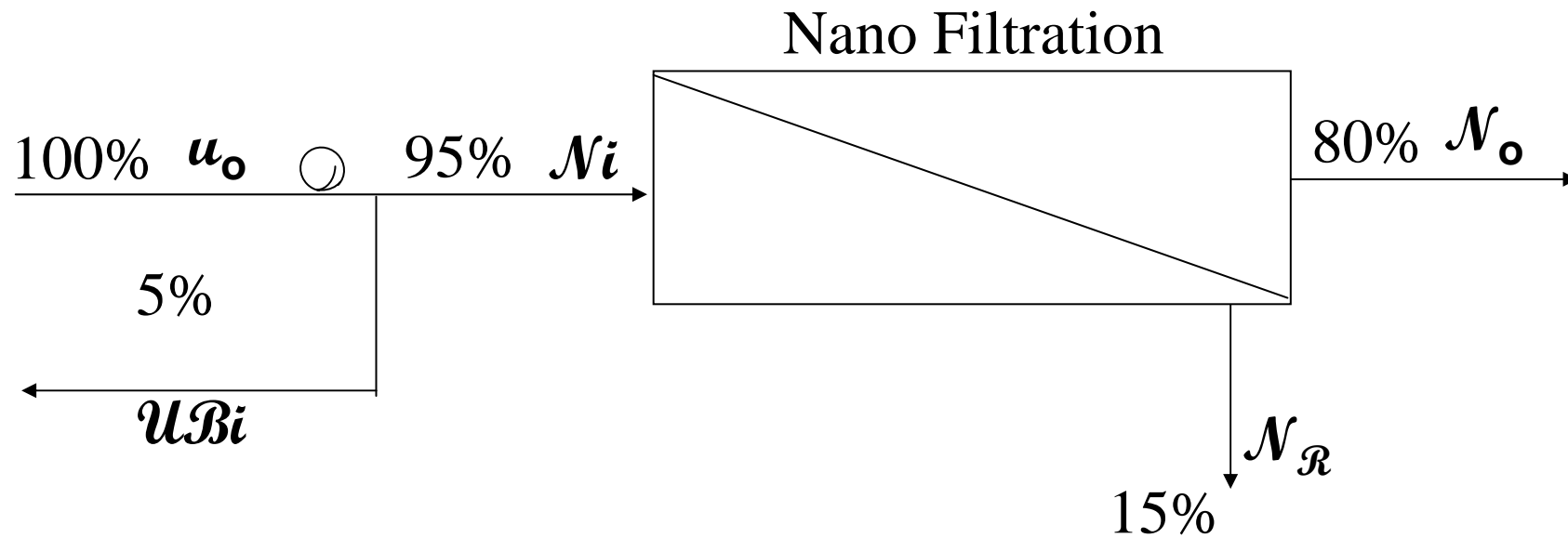
Figure 5: Ultra Filtration



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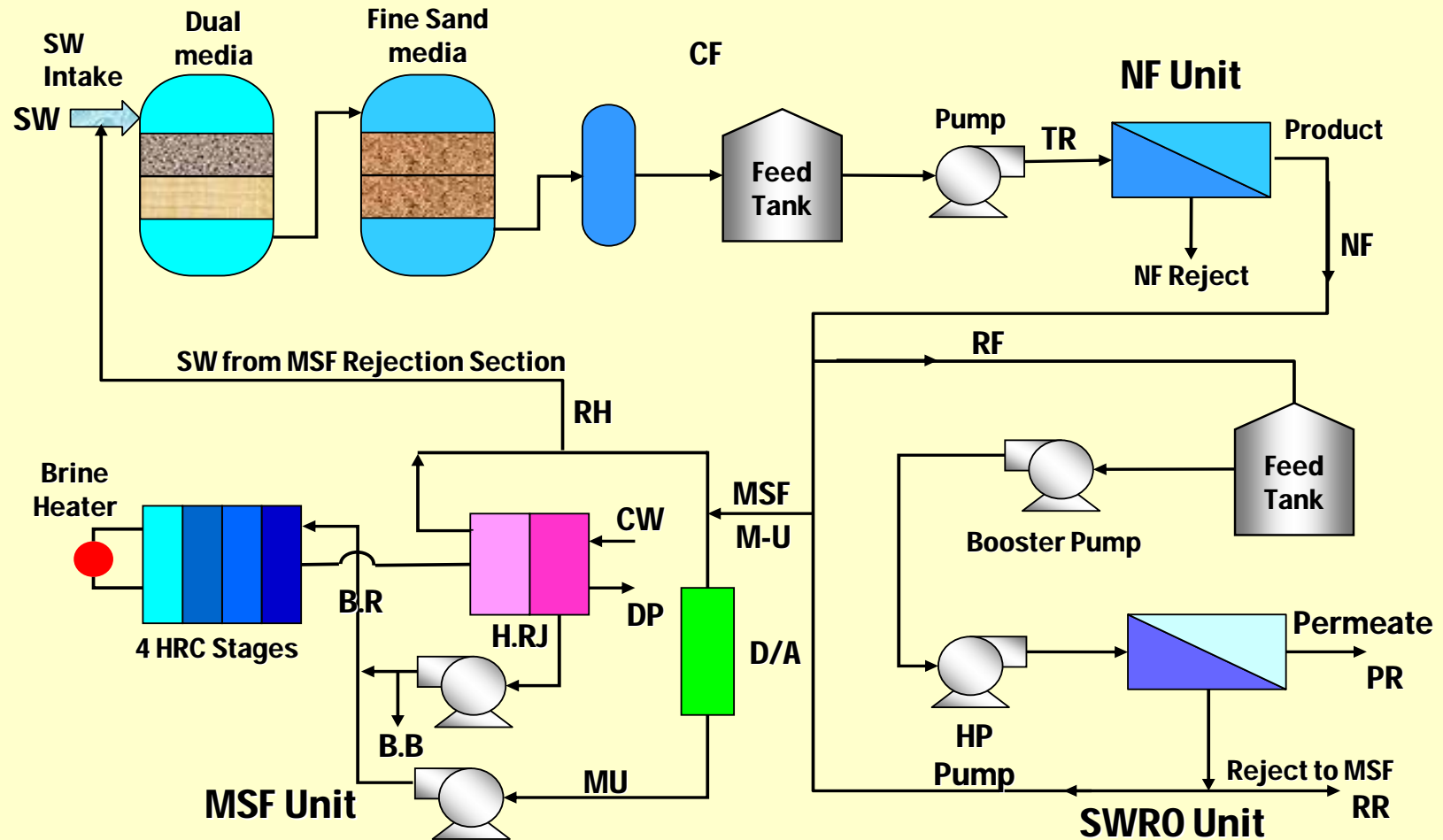
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Figure 6: Nano Filtration



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Figure 7: Schematic Flow Diagram of NF, SWRO and MSF



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This table shows that the scheme which is being heavily promoted these days; which is the combined cycle with desalination dual production schemes do not show as high energy (heat) utilization as Steam Cycle Back Pressure with desalination. It is felt that this stems out of higher efficiency fired boilers when compared to NRSB

PROCESSES	GTG	BTG	GTG-STG	GTG-STG (BP)	BTG (BP)
Power only	30 <sup>--</sup>	38	54 <sup>--</sup>	NA	NA
+MSF	65	75	NR	78	80
+MSF+SWRO	67	77	NR	80	81
+MEC	68	78	NR	81*	82*
+MEC+SWRO	69	NR	NR	83*	86*
+MSF+MEC	72	NR	NR	85*	88*
+MSF+MEC+SWRO	75	NR	NR	87*	90*

### NOTES:

NA= *Not Applicable*

NR = *Not Recommendable*

\* = *Lower Back Pressure*

\_\_ = *Lower Heat Utilization due to Ambient Temperatures*

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### **Commercialization of Suggested and Innovative Schemes**

The future of desalination will very much depend on developmental work to reduce production cost. New frontiers are to be explored by spending time and money to check the viability of some of the following options of suggested and innovative processes such as:

1. Unconventional High Temperature MSF (HTF);
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);

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6. Hydration;
7. Freezing;
8. Chemical Reaction, Salt Precipitation;
9. Combined Membrane Processes of Electro-Dylitic, Osmotic & Ion Exchange (ED, RO, IX);
10. Biodesalination, Anion/Cation Bacterial (oxi-re); and
11. Nuclear Energy Utilization.



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Solar energy deserves further developmental work in a stage wise pattern. The proposed stages are:

- 1) Literature review;
- 2) Proposal development;
- 3) Mathematical analysis and modeling;
- 4) Prototype construction and analyzing of results; and
- 5) Development of pilot plant(s).

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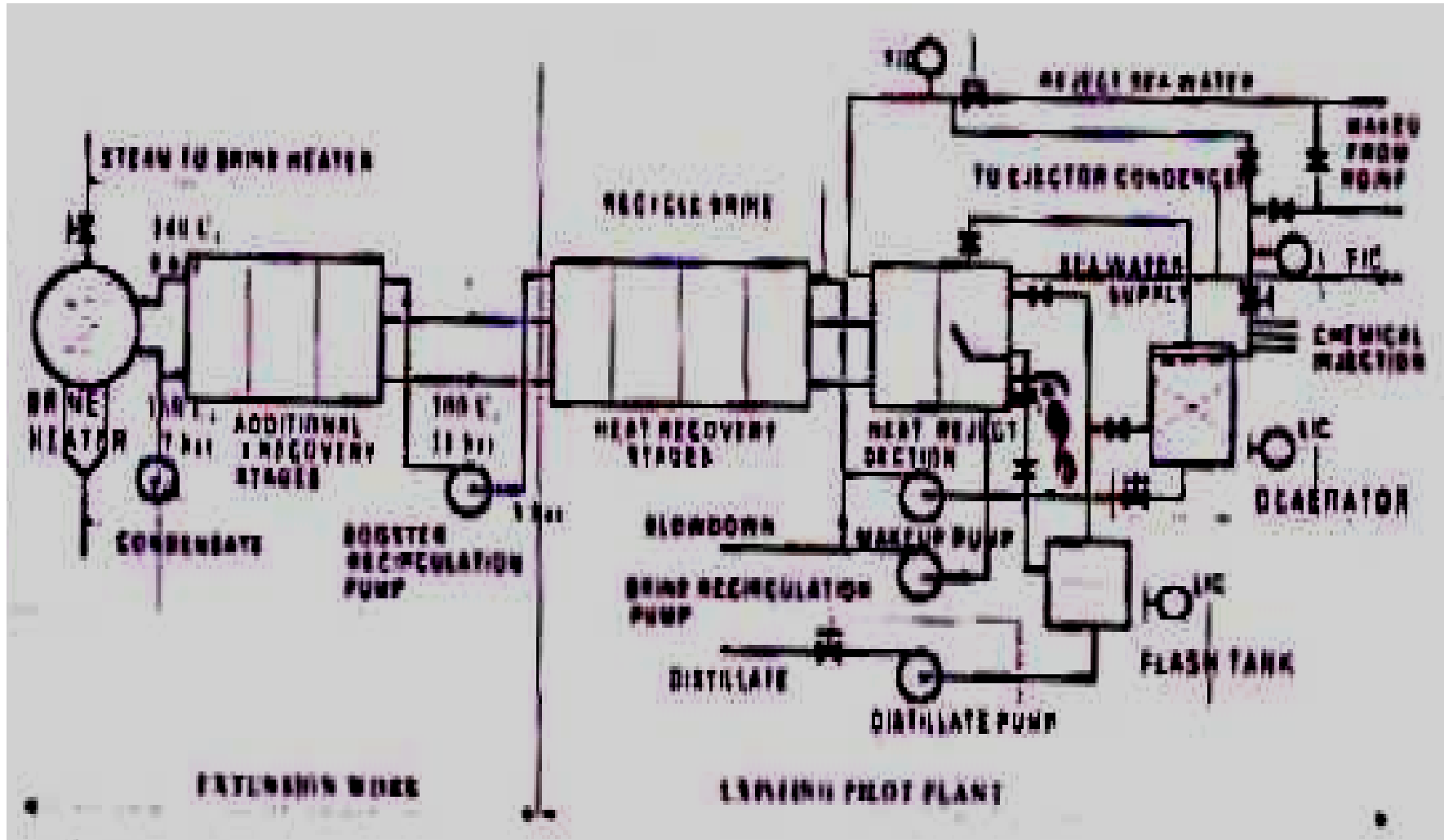
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Few options of direct and indirect solar energy utilization.

1. Multi-layered and convective solar stills.
2. Humidification/De-humidification
3. indirect utilization techniques
4. Solar ponds heat recovery for conventional distillation of segregated versus integrated MSF/MEC process(es).

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Figure 8: Proposed MSF Design Concept

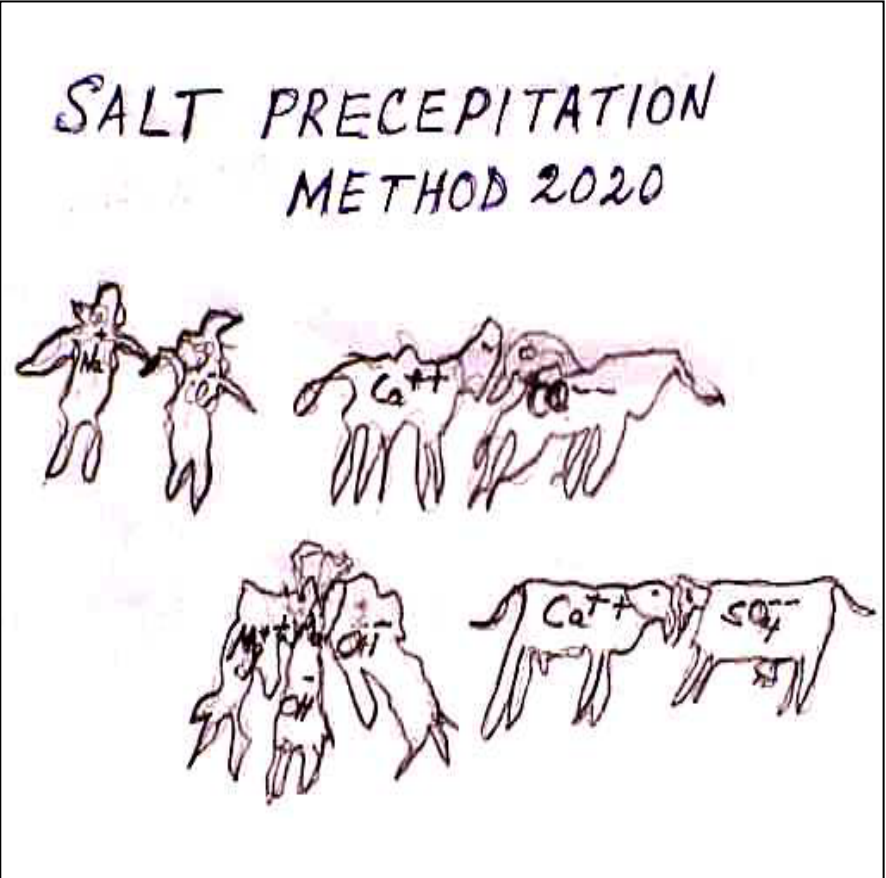


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Figure 9



Figure 10

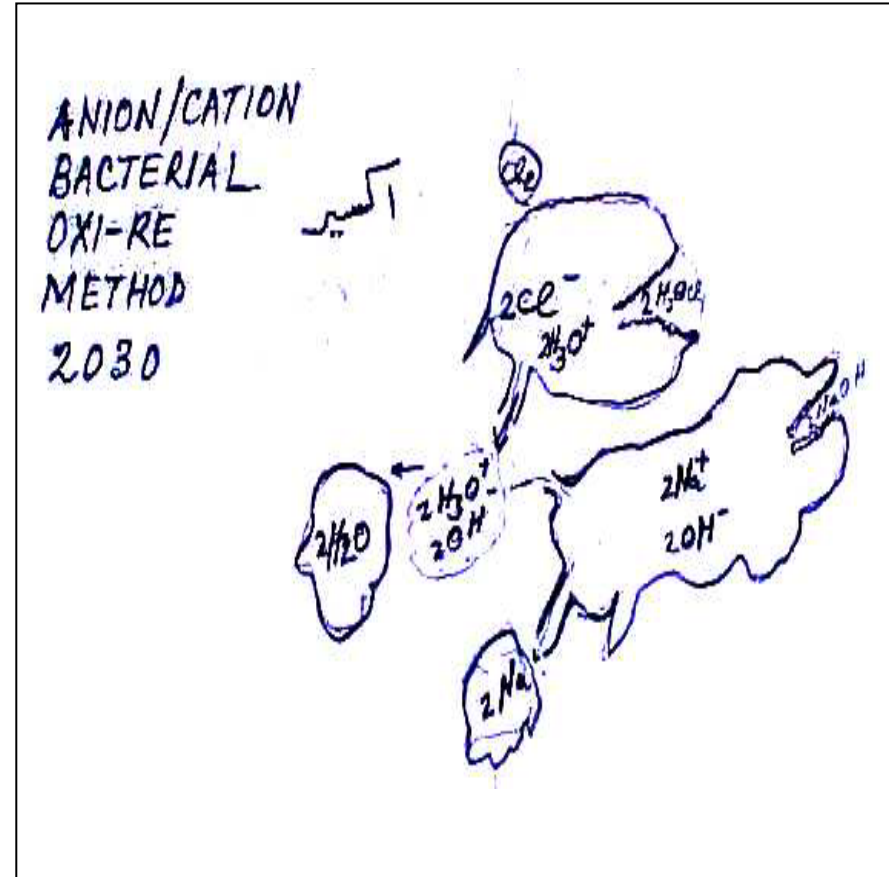


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Figure 11



Figure 12

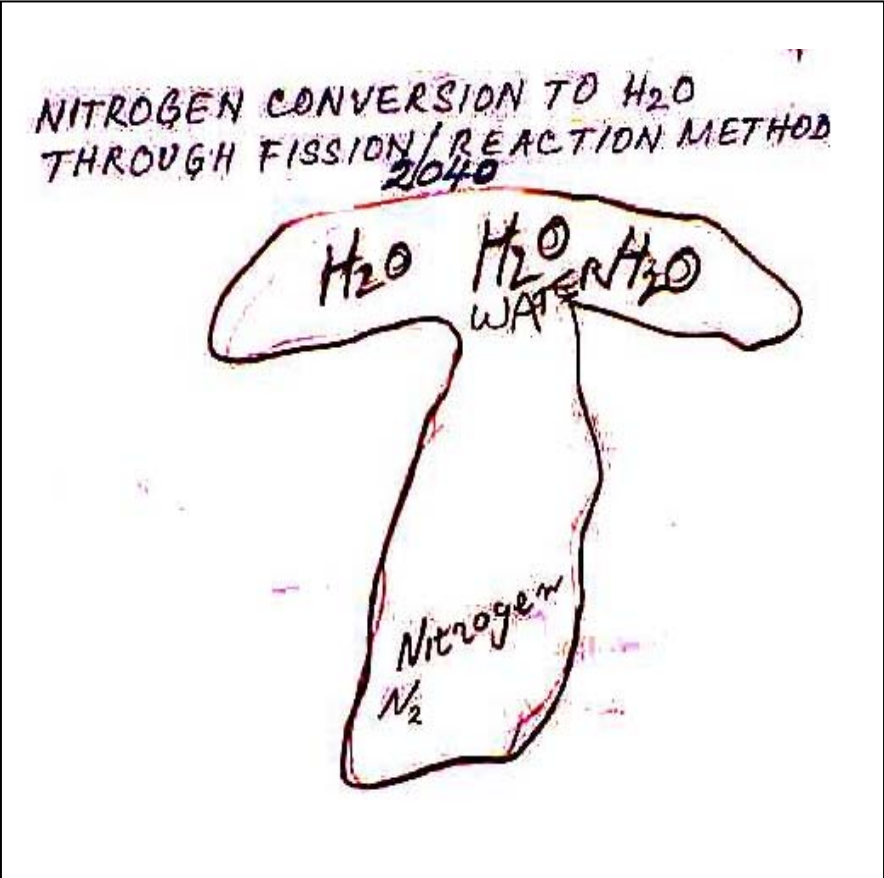


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Figure 13



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**Thank You**