Experiences in construction & operation of Nuclear Desalination Demonstration Plant

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Acknowledgements

The details of work presented here are the result of dedicated and tireless efforts of a large number of desalination professionals involved in Research and Development, Design, construction, operation and maintenance of our Nuclear Desalination facilities

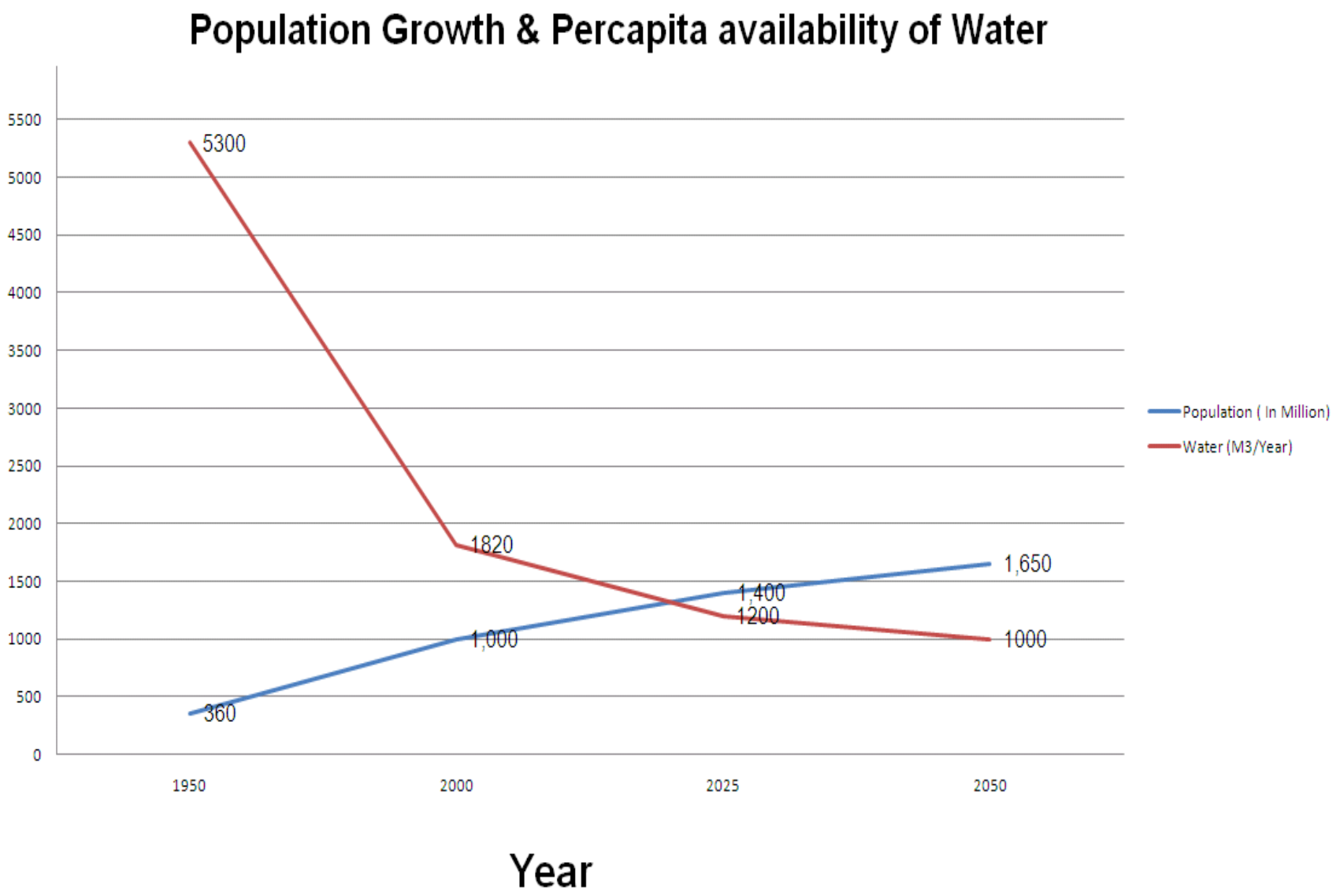
WATER SCENARIO - INDIA

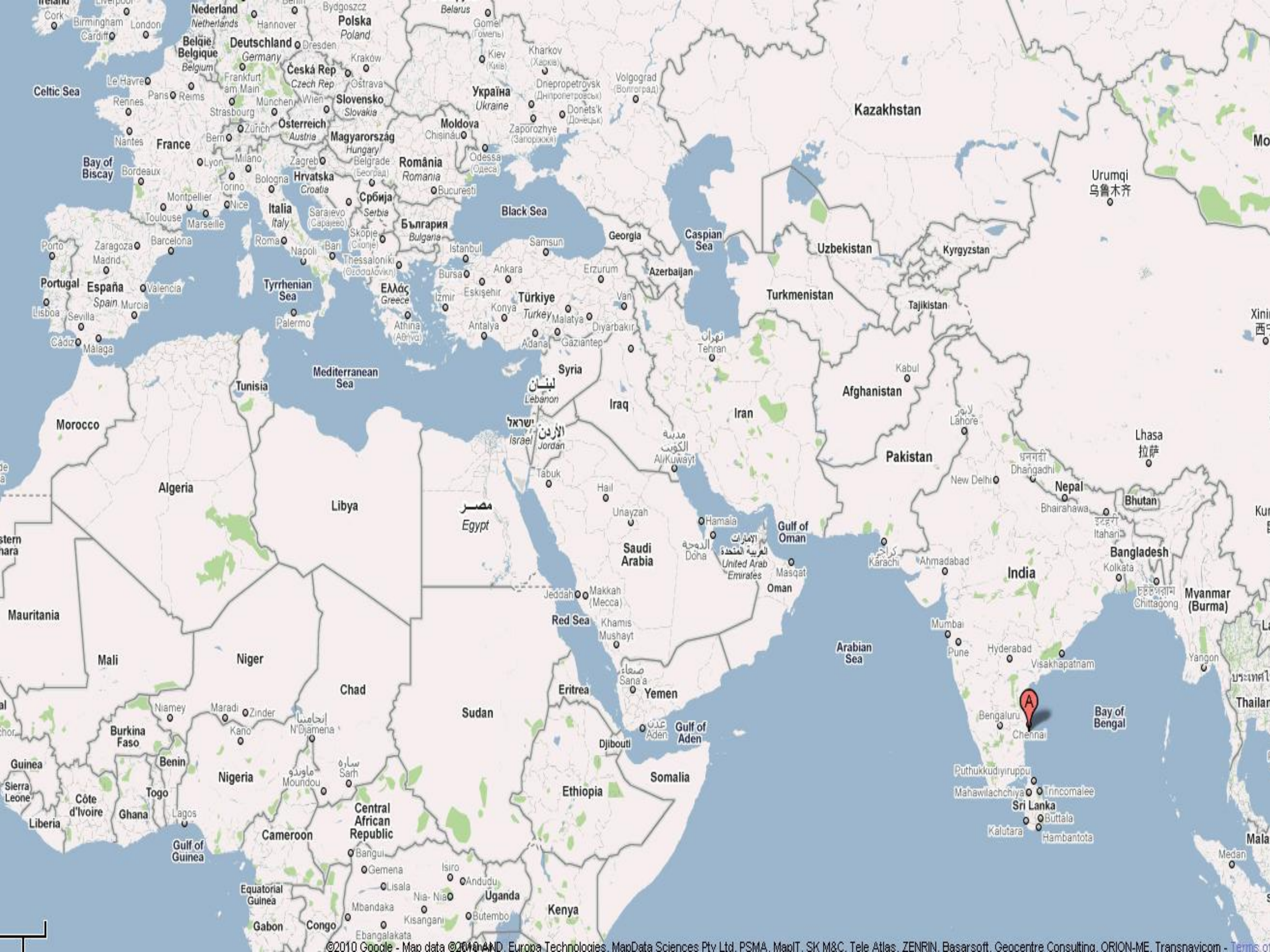
India receives abundant rains (4,000 cu.km) & only a small portion of this i.e about 1000 cubic Km is retained as ground and surface water sources and is available for consumption. Rest is lost as runoff to the sea.

Current water consumption in India for agricultural, industrial, domestic and commercial purpose is about 800km^3 and may touch 1000 km^3 in years to come.

India has 16% of global population but only 4% of global water resources.

WATER AVAILABILITY





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A
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NDDP Pump House
CWMF Discharge
500m
NDDP
MSF Unit
SWRO Unit
MAPS Intake
Image © 2007 DigitalGlobe
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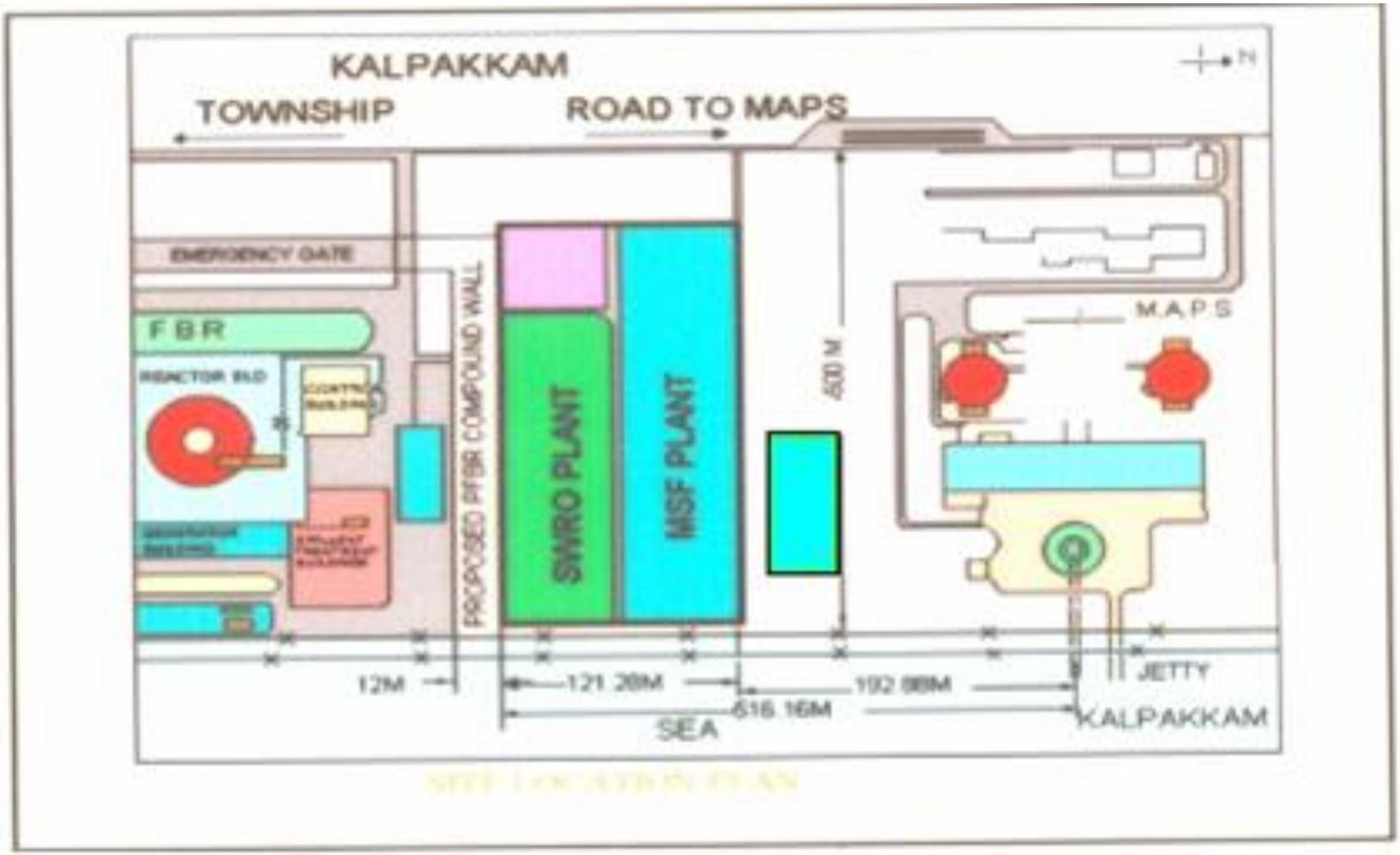
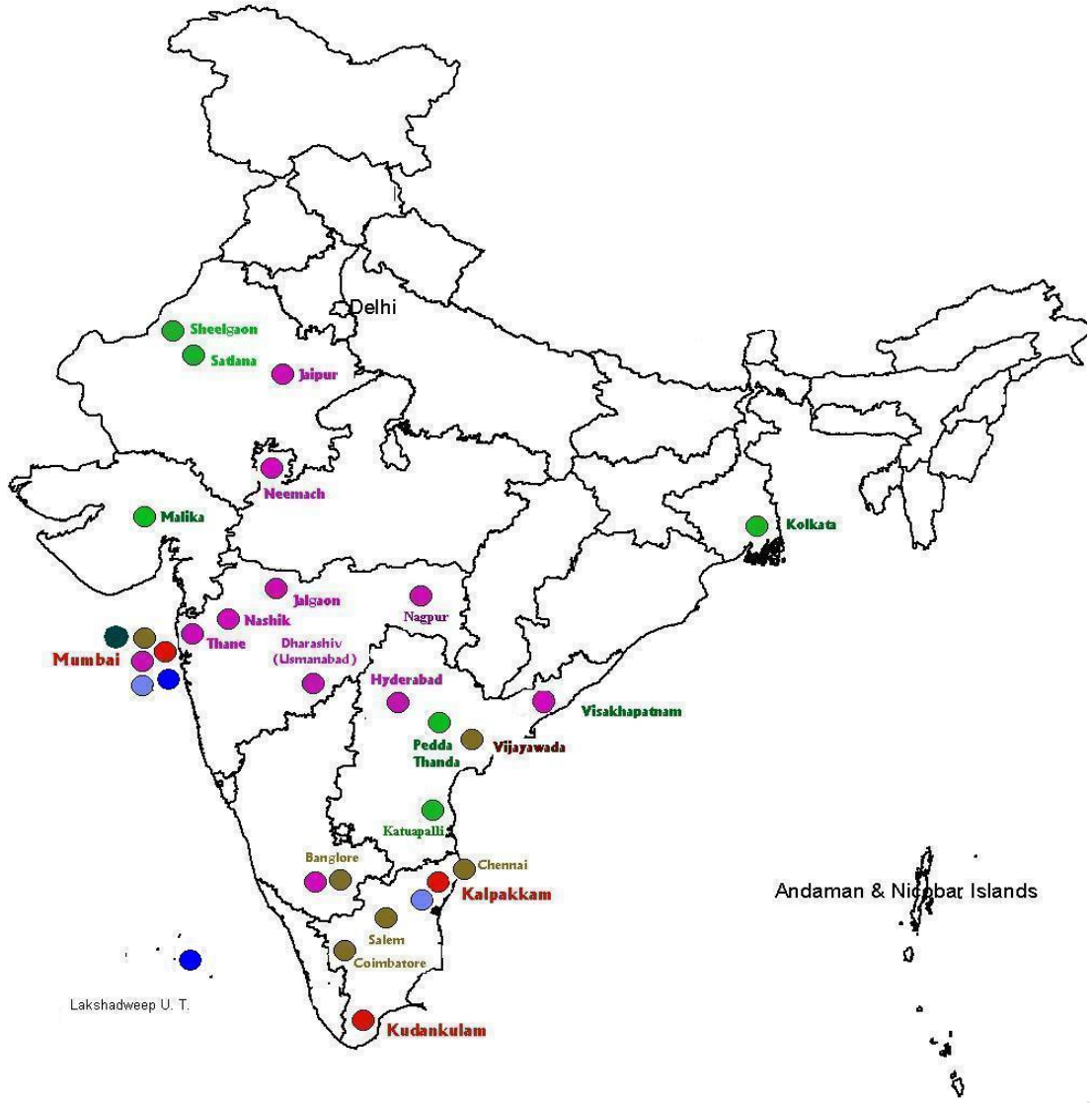
Kalpakkam Atomic Reprocessing Plant (KARP)/(IGCAR).
Pointer 12°33'26.61" N 80°10'36.35" E
Streaming 100%
Eye alt 2876 ft


KALPAKKAM
TOWNSHIP
ROAD TO MAPS
N
EMERGENCY GATE
FBR
REACTOR BLD
PROPOSED FFBR COMPOUND WALL
SWRO PLANT
MSF PLANT
400 M
MAPS
JETTY
12M
121.28M
192.88M
616.16M
SEA
KALPAKKAM

DEVELOPMENT AND DEPLOYMENT OF DESALINATION TECHNOLOGIES BY DAE



Seawater RO Plant

Brackish Water RO Plant

MSF Plant For Seawater Desalination

LTE Plant For Seawater Desalination

Waste Water Reuse Plant

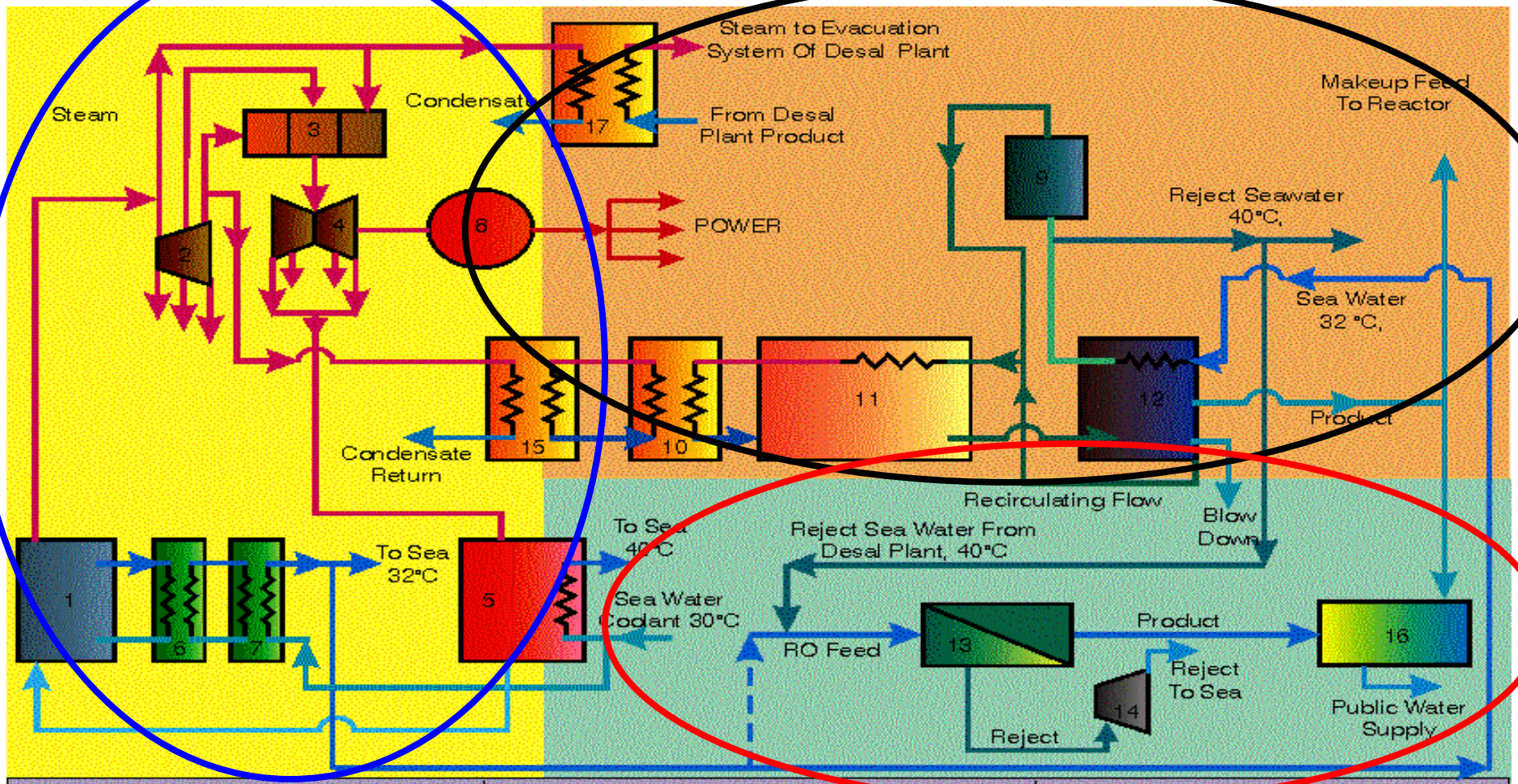
RO Technology Transferred

Domestic Water Purifier Technolgy Transferred

Objectives of 6300 m^3/d Hybrid Plant

- To establish the indigenous capability for the design, manufacture, installation and operation of Nuclear Desalination Plants.
- To generate necessary design inputs and optimum process parameters for large scale nuclear desalination plant.
- To serve as a demonstration project to IAEA welcoming participation from interested member states.

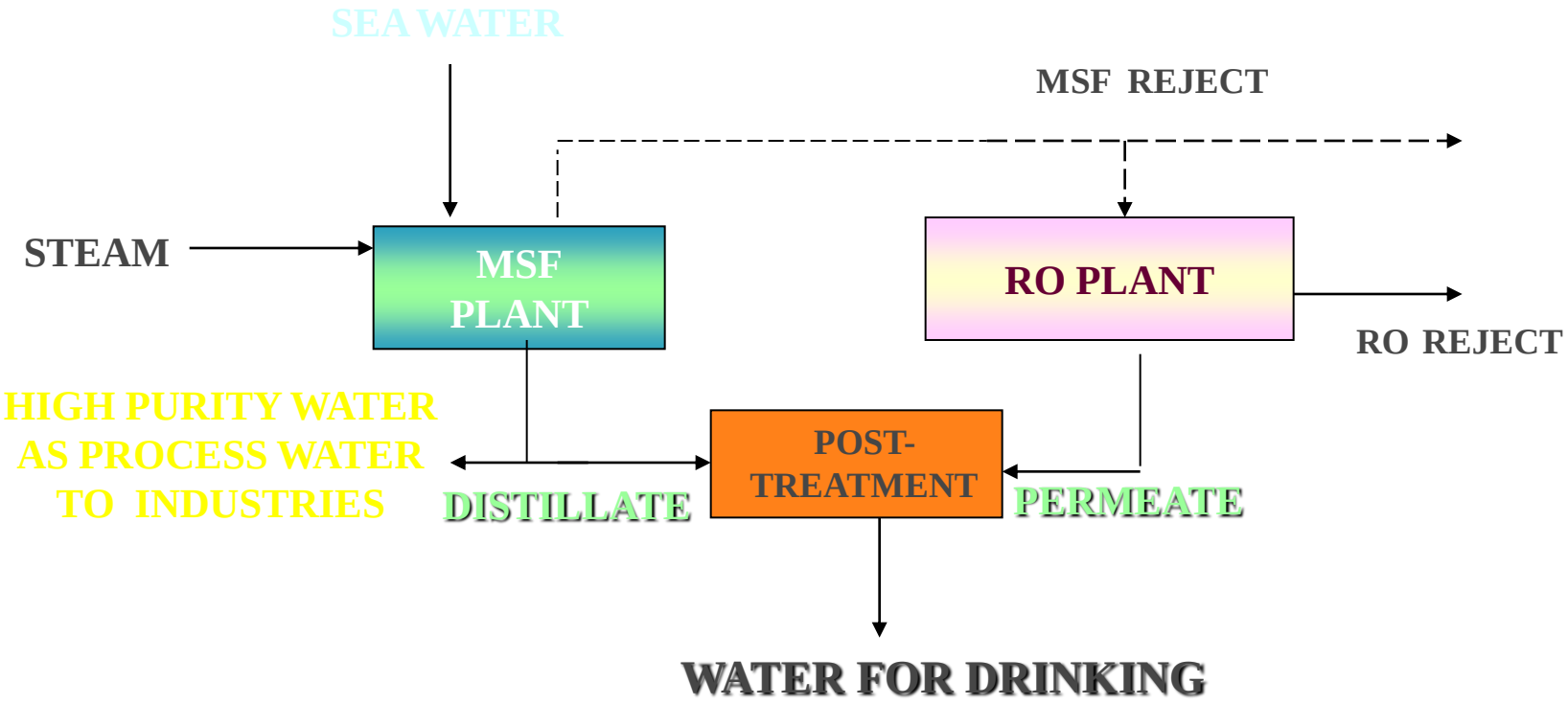
HYBRID NUCLEAR DESALINATION PLANT



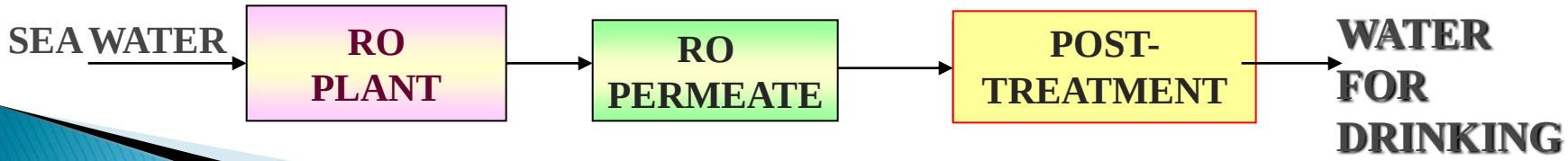
1. Nuclear Reactor
2. HP Turbine
3. Moisture Separator/Reheater
4. LP Turbine
5. Power Plant Condenser
6. Moderator - DM Water Cooling Loop
7. DM Water - Sea Water Cooling Loop
8. Generator
9. MSF Plant Chemical Pretreatment Section
10. MSF Plant Brine Heater
11. MSF Plant Heat Recovery Section
12. MSF Plant Heat Reject Section
13. RO Plant
14. RO Plant Energy Recovery Turbine
15. LP Isolation Heat Exchanger
16. Product Storage/Post Treatment System
17. HP Isolation Heat Exchanger

ADVANTAGES OF THE HYBRID PLANT

CASE I : POWER PLANT IS IN OPERATION ---



CASE II : POWER PLANT IS NOT IN OPERATION --



Salient features of 1800 m^3/d SWRO plant

- Cooling reject water of MSF plant at about 40^0C after appropriately mixing with raw sea water is the feed to the SWRO Plant.
- Clarification followed by filtration is adopted for pretreatment of feed sea water.
- RO section is designed at 35% recovery with 14 lmh flux.
- RO section consists of 2 x 50 % streams each having production capacity of 37.5 cu.m/hr.
- Reverse running type energy recovery device is deployed for reducing energy consumption by 30%.
- Lime stone alkalization is adopted to make RO permeate potable, palatable and passive.

RO SYSTEM Basic Components

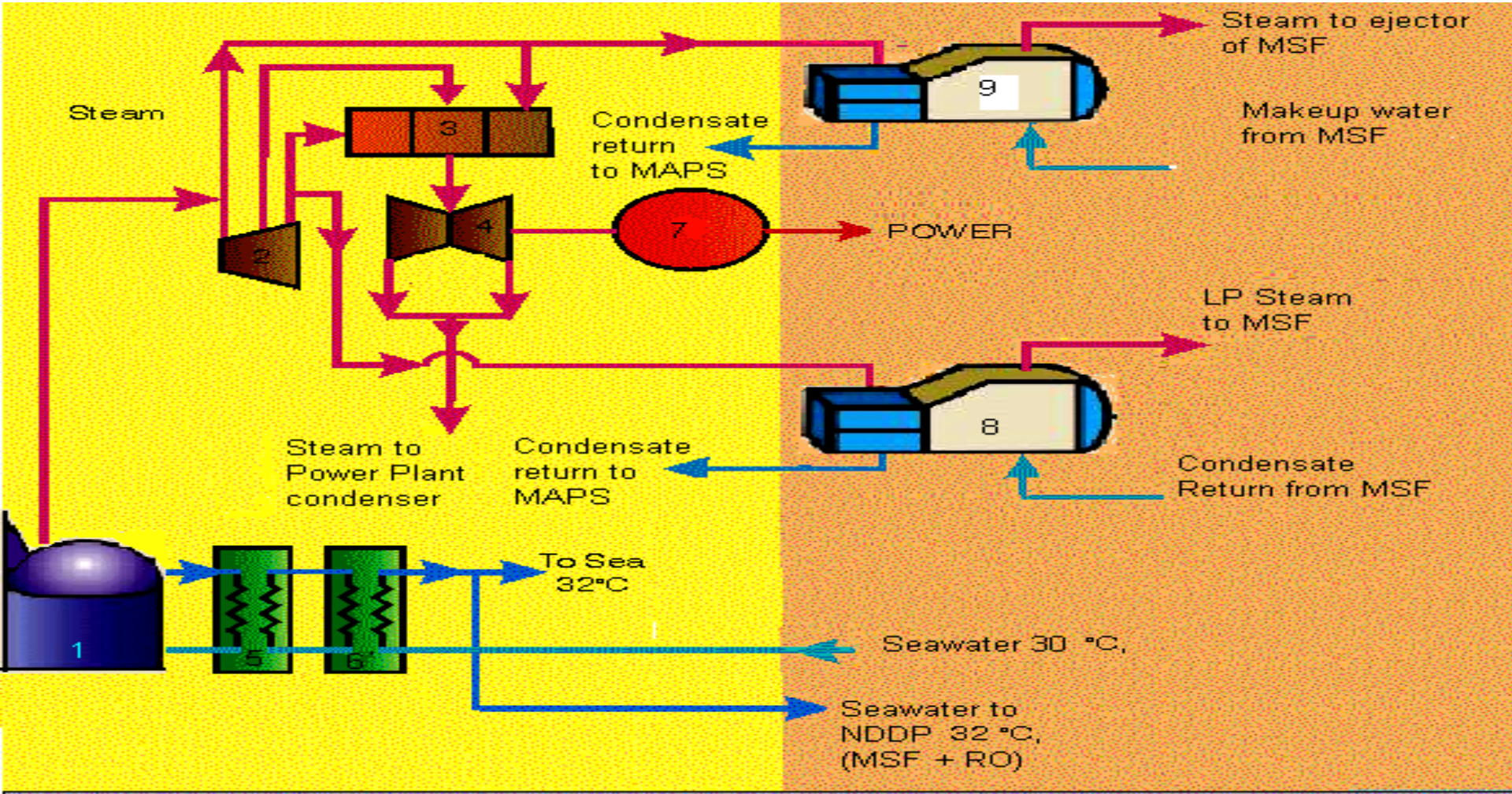
- Sea Water Intake
- Pretreatment
- High pressure pump
- Membrane assembly
- Post treatment

Specifications - 1800 m^3/d SWRO Plant

1.	A.	Product water output	75 m^3/hr
	B.	Product quality	500 ppm TDS
2.	A.	Sea Water Required	215 m^3/hr
	B.	Sea Water TDS	35,000 ppm
3.	% Recovery		35%

The plant is operating as per design intent supplying potable water to nearby areas.

Coupling arrangement of NDDP with MAPS



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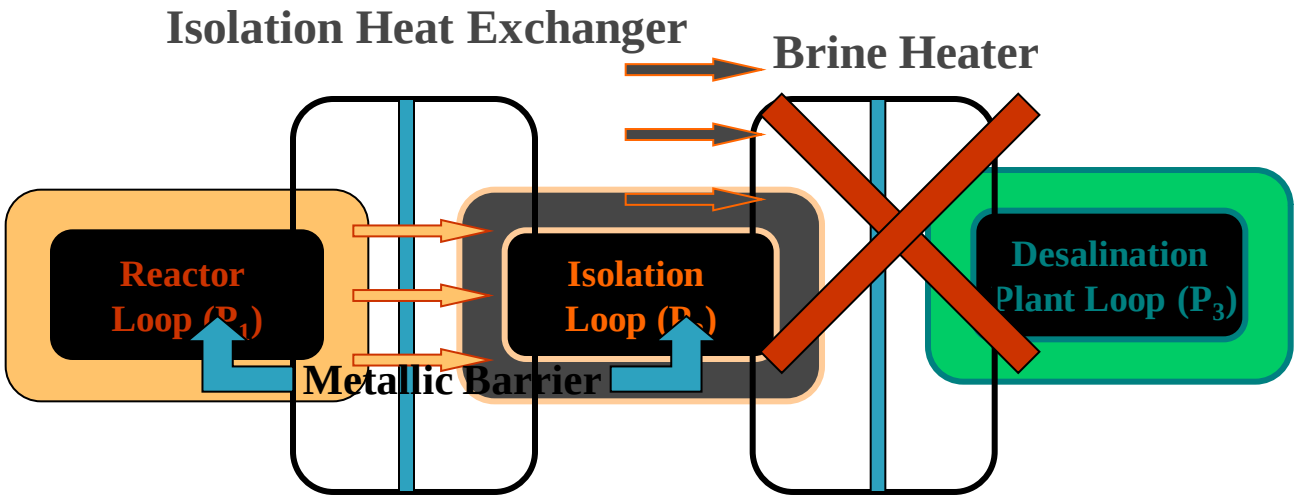
9. HP Isolation Heat Exchanger

Multiple barrier – Isolation Loop

Three loop concept



$P_1 > P_2 > P_3$

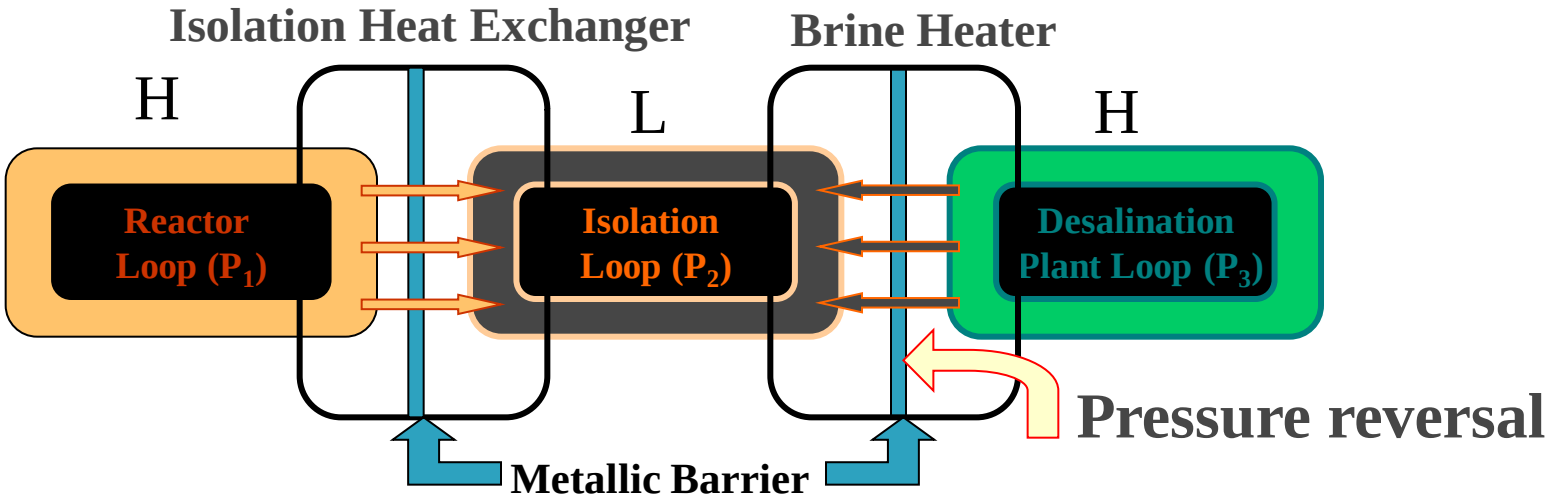
Coupling of the Desalination Plant to Nuclear Reactor by an Isolation Loop

Pressure Reversal is the solution

Engineered safety features – Pressure Reversal

H-L-H Configuration

The reactor loop pressure (P1) and the DP loop pressure (P3) are higher than the IL loop pressure (P2) **(H-L-H).**



Pressure reversal exists between the DP loop and the IL loop

Advantage of this configuration is that any leakage in the isolation heat exchanger will be directed to the IL and not to the DP loop.

Disadvantage is that the operating pressure in the DP loop is higher which is difficult to use as the pressure of the DP loop is dictated by the process and it is not very high

Salient features of 4500 M^3/D MSF plant

- Brine Recirculation type, saving of dosing chemicals
- Acid pretreatment – increase in top brine temperature (121^0C)
- More number of stages, Higher Gain Output Ratio (GOR)
- Long tube design, reduction in pumping power
- Incorporation of stage crossing chamber prevention of blow through stages.

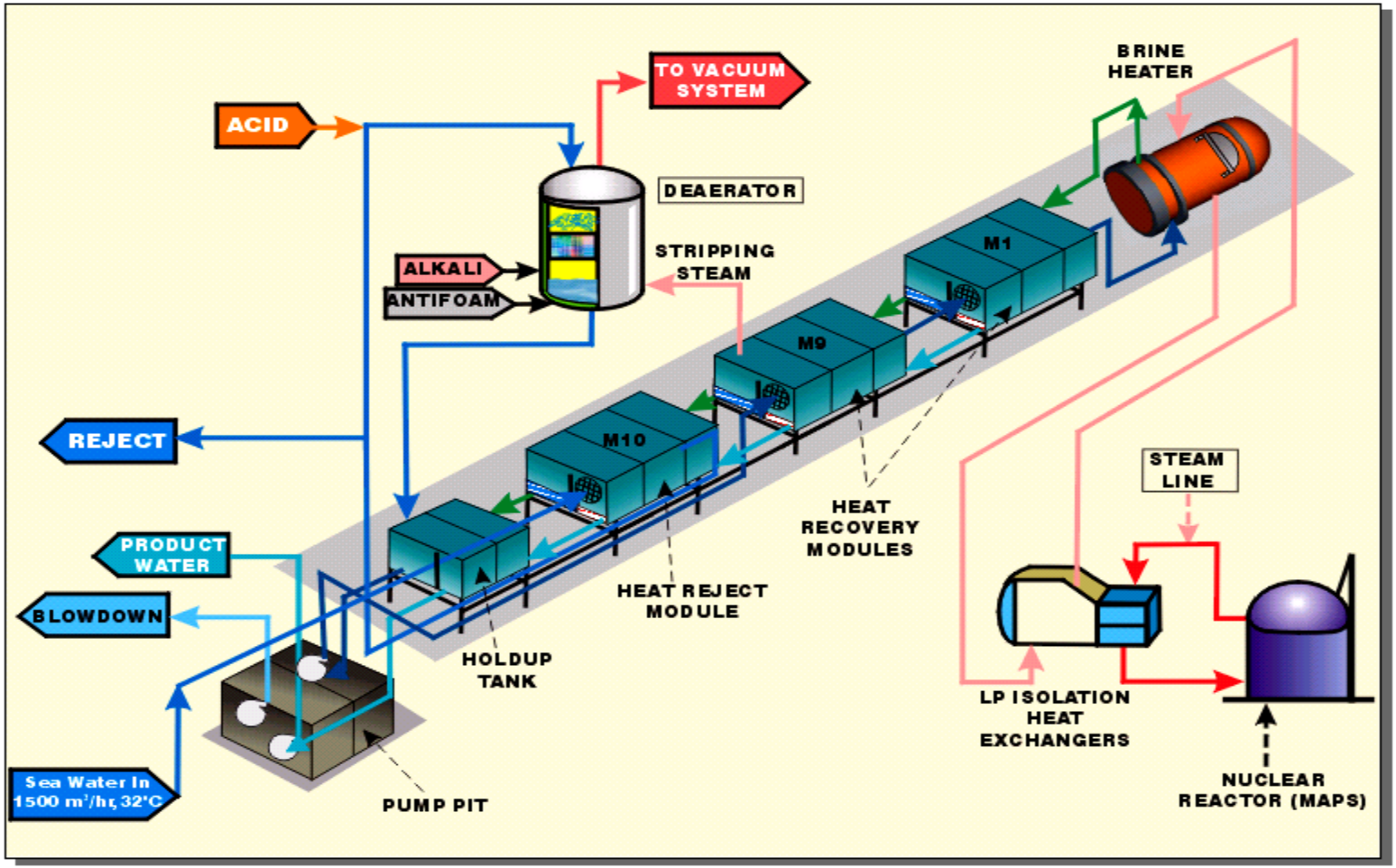
MSF Plant basic components

- Sea water intake
- Isolation heat exchangers
- Brine heater
- Evaporator modules
- Deaerator and dosing systems
- Steamjet ejectors
- Product storage & reject disposal

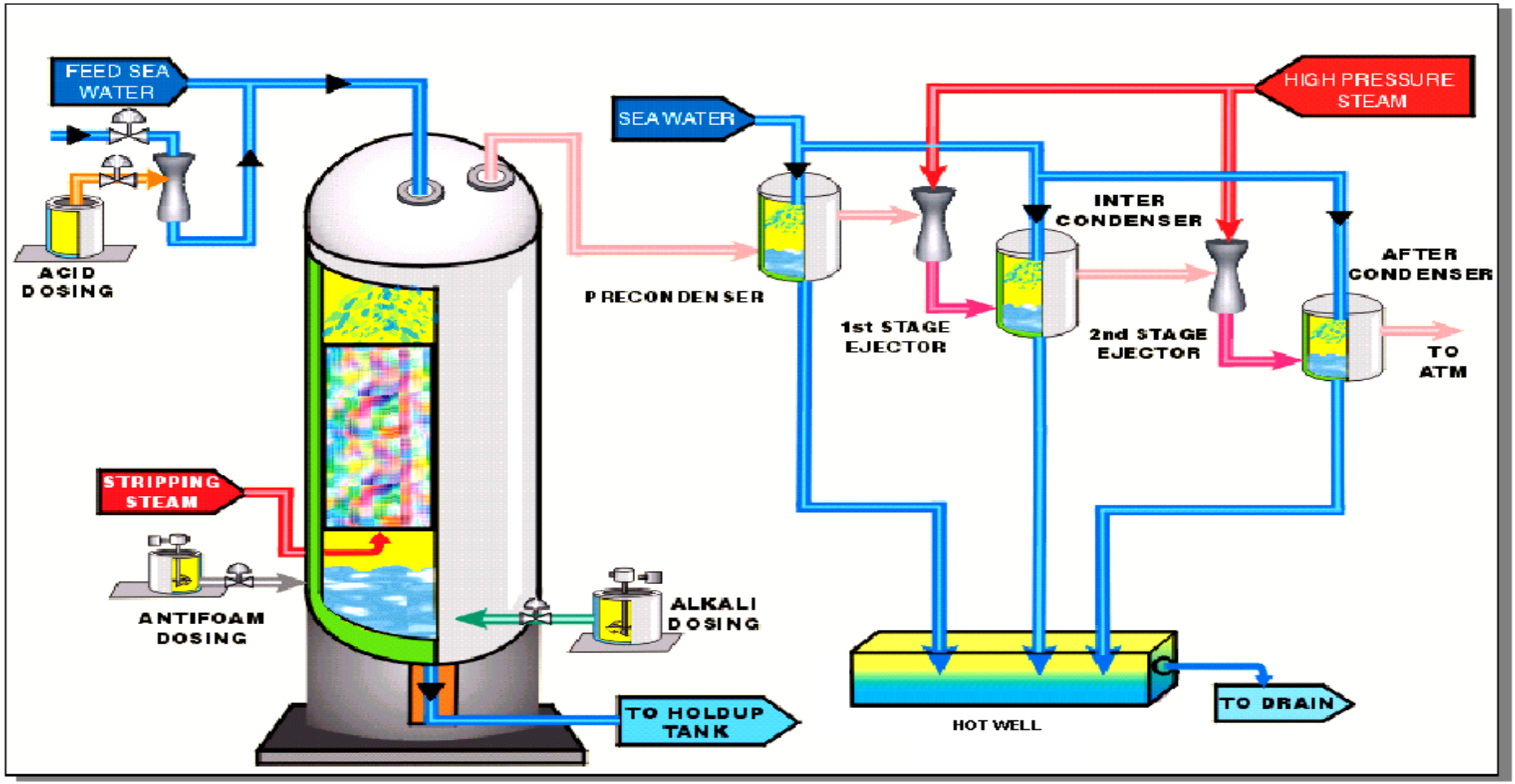
Specifications of 4500 m^3/d MSF Plant

1.	Product water output		187.5 m^3/hr
2.	Product water salt content		< 20 ppm
3.	Sea Water Requirement		
	3.1	Total (cooling)	1544 m^3/hr
	3.2	Make-up Feed (Part of 3.1)	375 m^3/hr
4.	Brine Temperature		
	4.1	Max. recirculation brine temperature	121°C
	4.2	Blow down temperature	40°C
5.	Concentration ratio		2
6.	Steam Consumption		
	6.1.	Heating in the brine heater	20.6 Te/hr (2.8 bar)
	6.2	Steam jet ejectors	400.0 kg/hr (7 bar)
7.	Gain Output Ratio		9
8.	Power Consumption		475 kWe

Layout of 4500 m^3/d MSF Desalination plant



Feed pretreatment & Vacuum system for MSF



Challenges during Construction

- Construction of brine circulation pump pit 15M X 15M X 7D
- Installation of deaerator vessel and its structure
- Control and instrumentation cabling without disturbing reactor operations
- Rains during heat treatment of modules
- Lifting of modules weighing about 140 tonnes and keeping on foundations.

Challenges during operation

- ACF Strainer plate seeing shut off pressure of pump
- Proper selection of pretreatment process and monitoring of SDI
- Snapping of cartridge filter tierod bushes.
- Seasonal changes in sea water quality
- High attrition rate of fabrication and operation personnel

SUMMARY

For successful management of project implementation & subsequent operation and maintenance, have “SMART” goals.

- SPECIFIC
- MEASURABLE
- ACHIEVABLE
- RELEVANT
- TIMELY

Thank You!