Controlling Salinity

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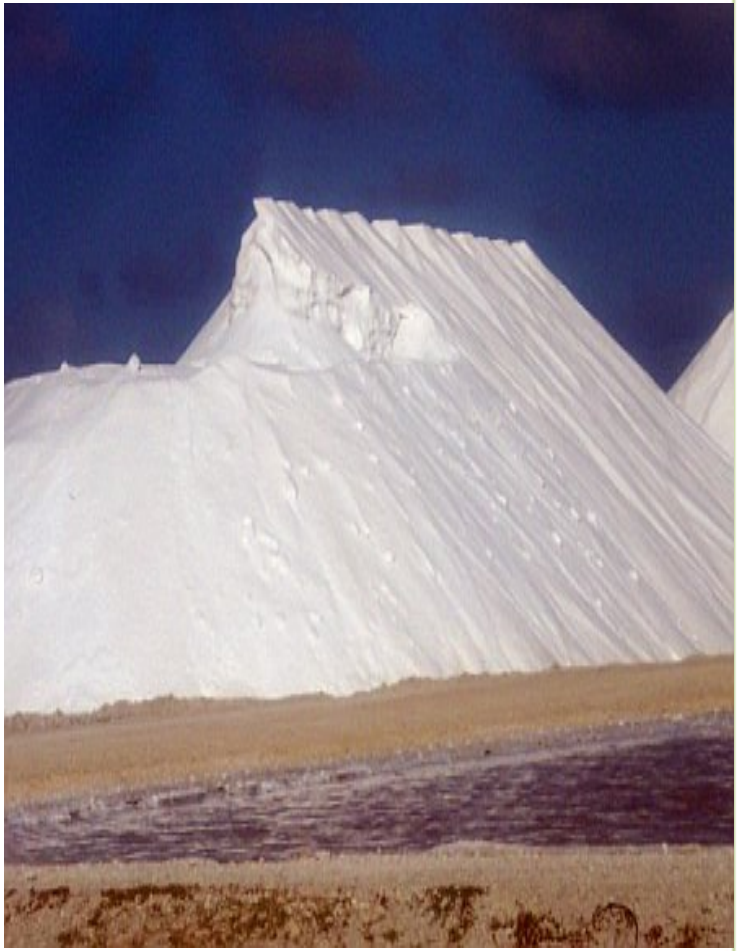
GREELEY AND HANSEN

What is Salinity?

Total Dissolved Solids (TDS):

- **Sodium**
- **Chloride**
- Hardness
- Sulfate
- Other inorganic trace minerals
  - (Si, P, K, B, etc.)



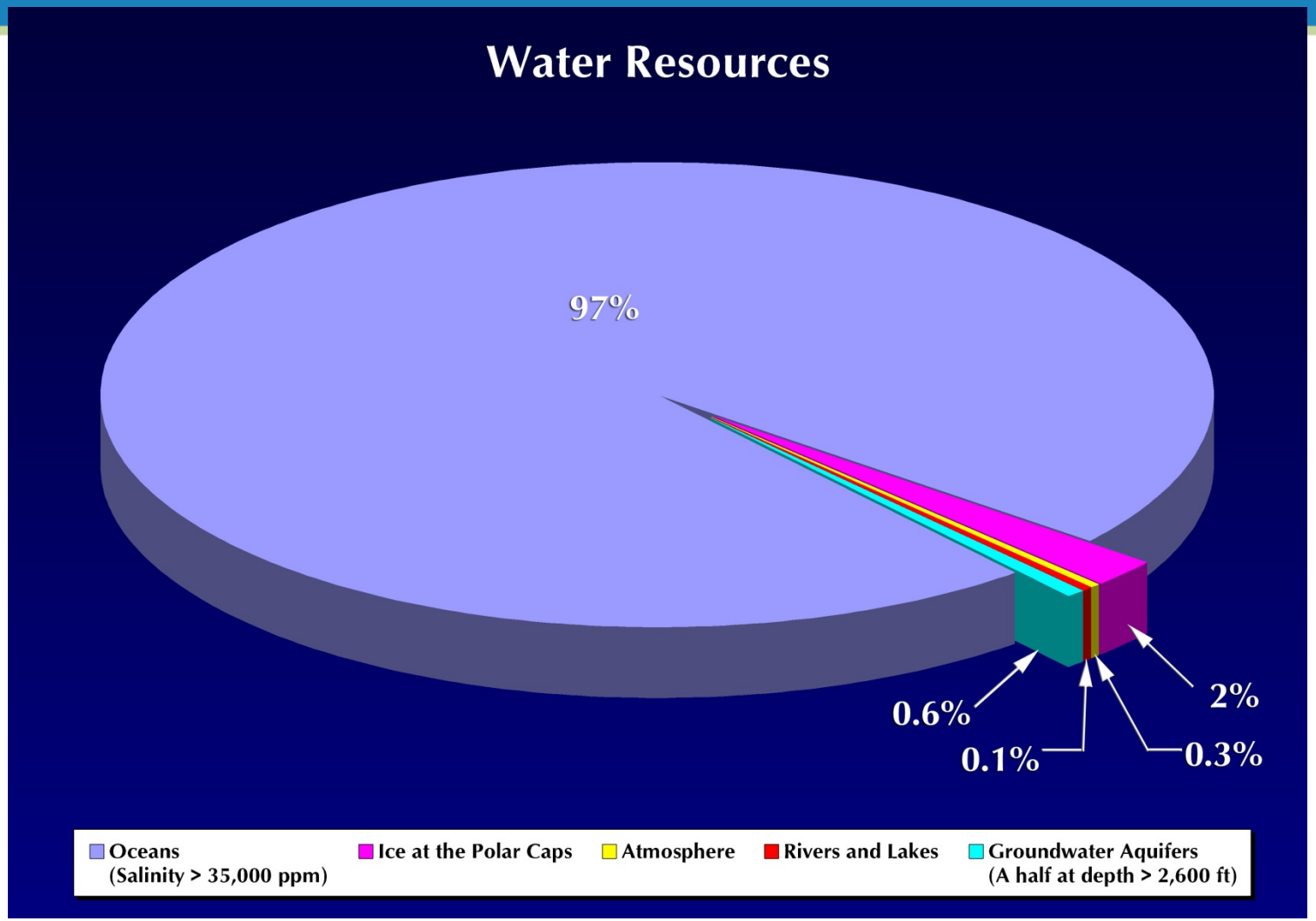
What is Salinity?

Chemical Formula: Na^{-} + Cl^{+} = NaCl

Atomic Weight: 22.99 + 35.45 = 58.44

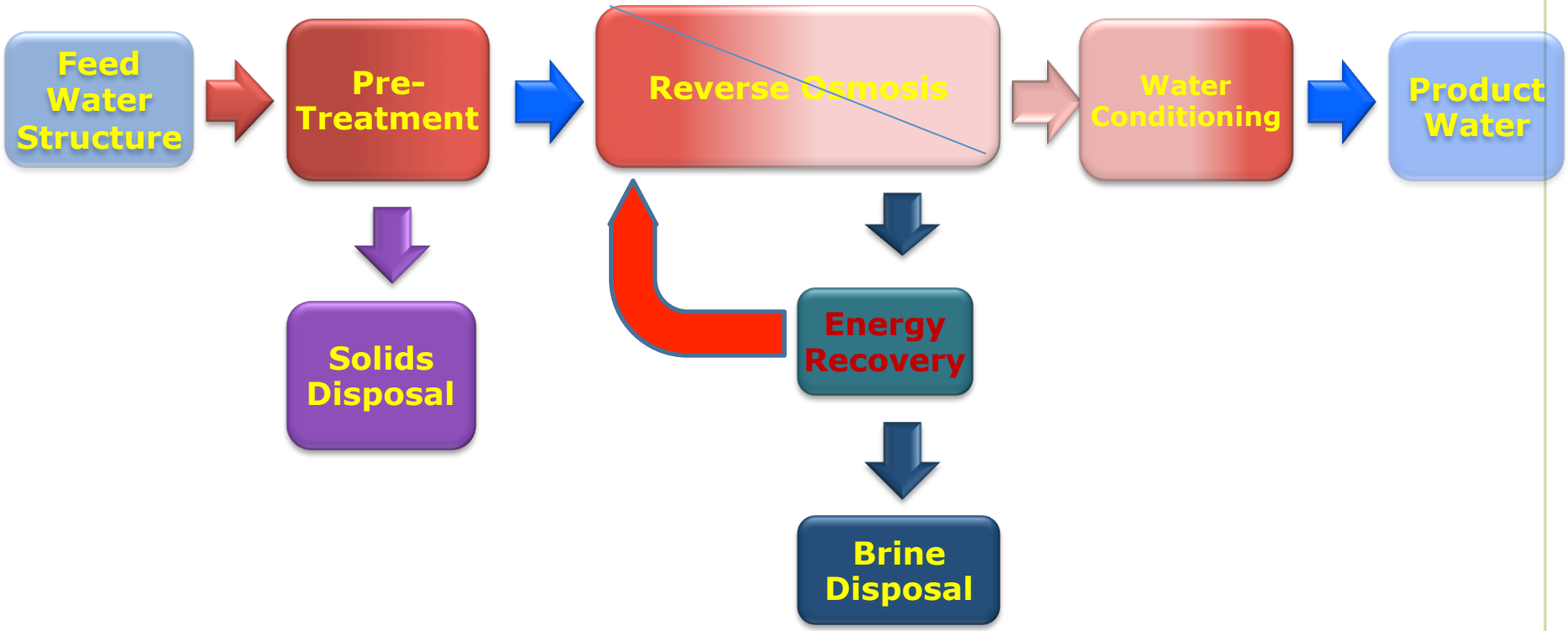
Low Sodium – Na < 50 mg/l
Low Sodium – NaCl < 50/22.9 x 58.44 < 127.1 mg/l
Low Sodium – TDS < 180 mg/l (assuming NaCl ~ 70% of TDS)
WHO Standard Drinking Water TDS < 500 mg/l

Do we need to control salinity ?



RO System

Reverse Osmosis Desalination Process Schematic

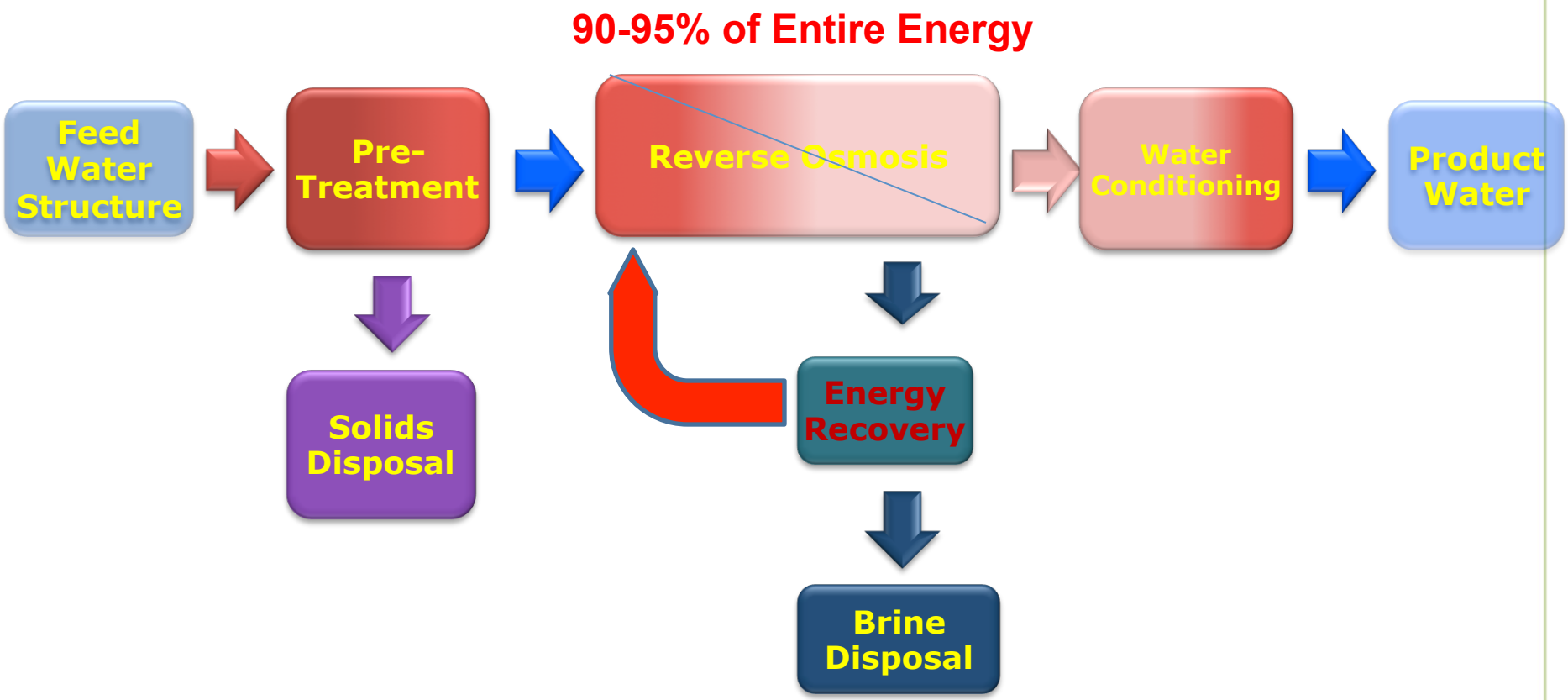


Energy Consumption by Desalination

Desalination

Energy

Reverse Osmosis Desalination Process Schematic



Typical Breakdown of Desalination Cost, %

	Seawater	Brackish water
Fixed costs	35 %	50 %
Energy	45 %	15 %
Labor	5 %	10 %
Membrane s replacement	5 %	5 %
Maintenance	7 %	10 %
Consumables	3 %	10 %

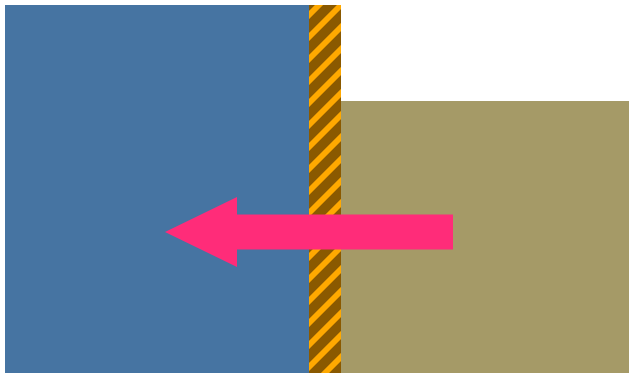
Energy Consumption by RO

- **Kinetic** energy for desalination process caused by membrane losses
- **Kinetic** system energy losses
- **Kinetic** energy losses caused by membrane fouling
- **Osmotic** energy

Osmosis

Pacific Ocean
TDS = 35,000 mg/l
Osmotic Pressure = 350 psi

No external pressure



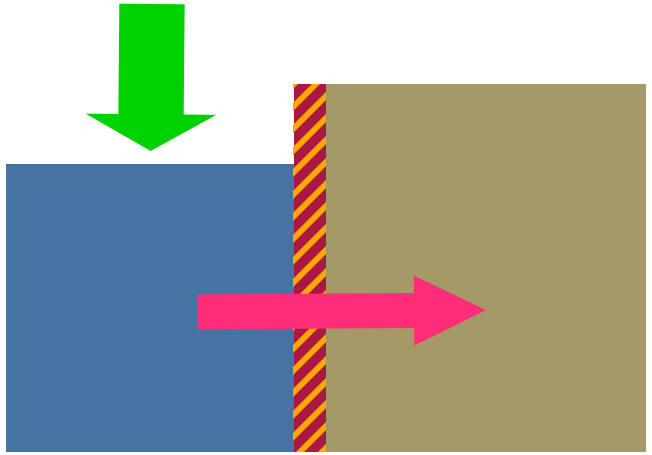
Concentrated Solution

Diluted Solution

Reverse Osmosis

RO reject at R=50%, TDS = 67,000 mg/l
Osmotic Pressure = 670 psi
Operational Pressure = 750 - 850 psi

External pressure

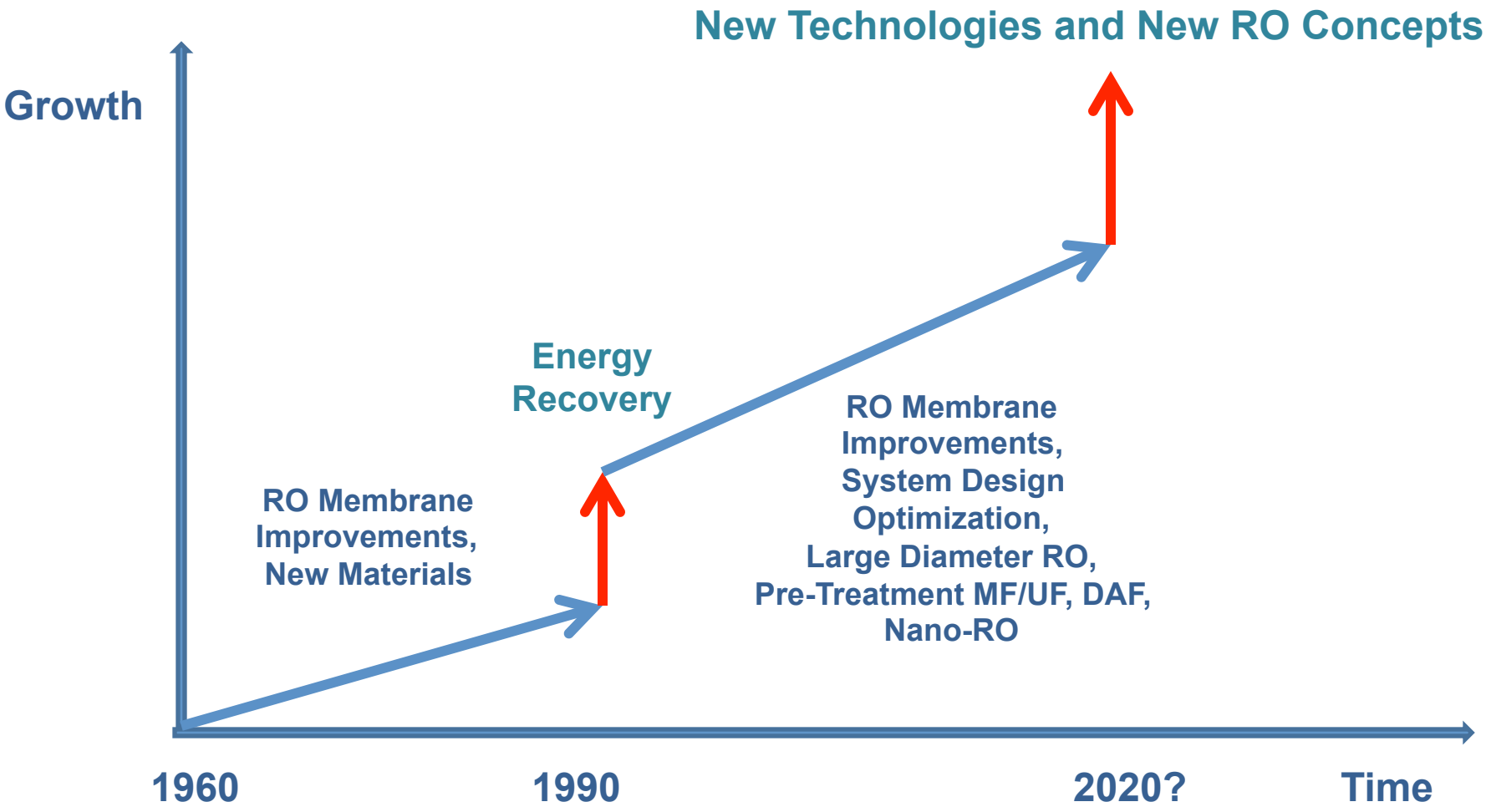


Concentrated Solution

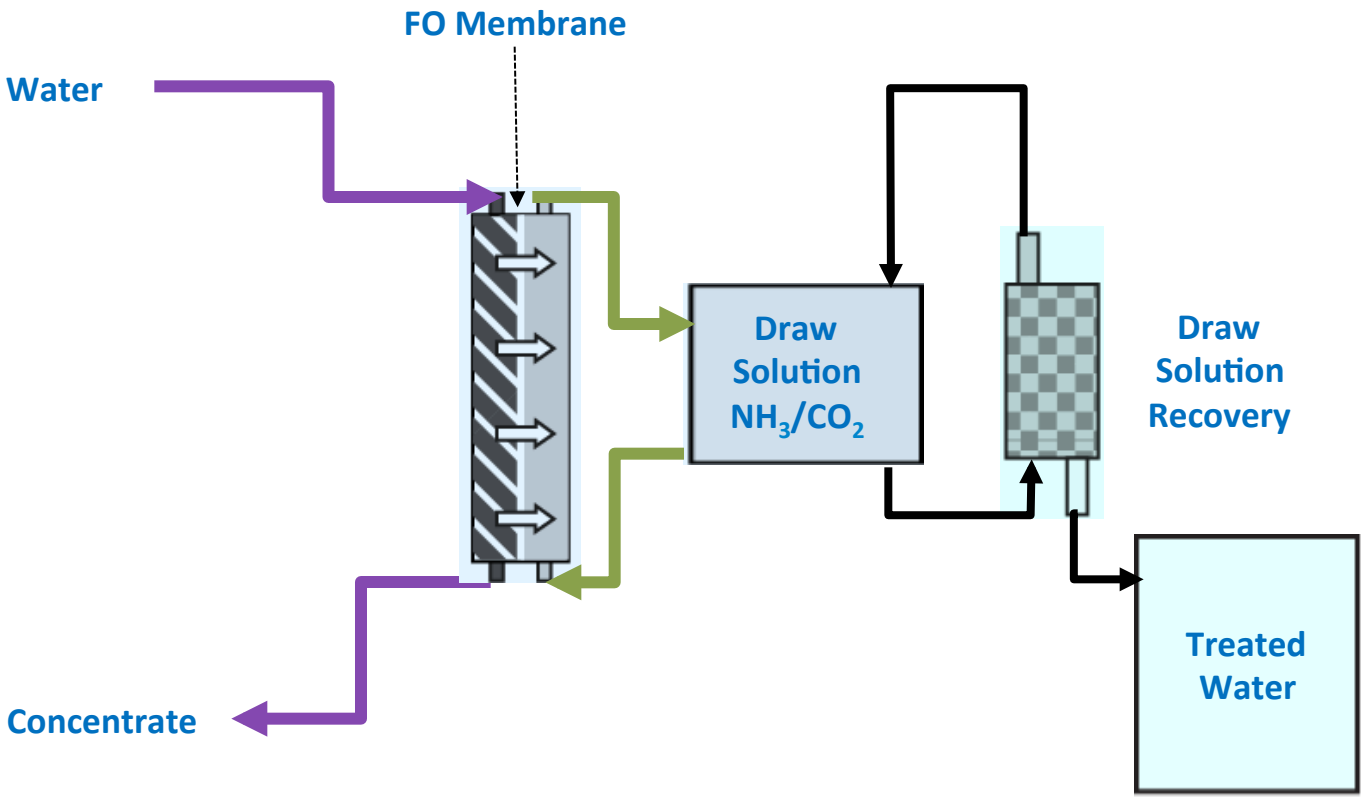
Diluted Solution

100 mg/l TDS = 1 psi

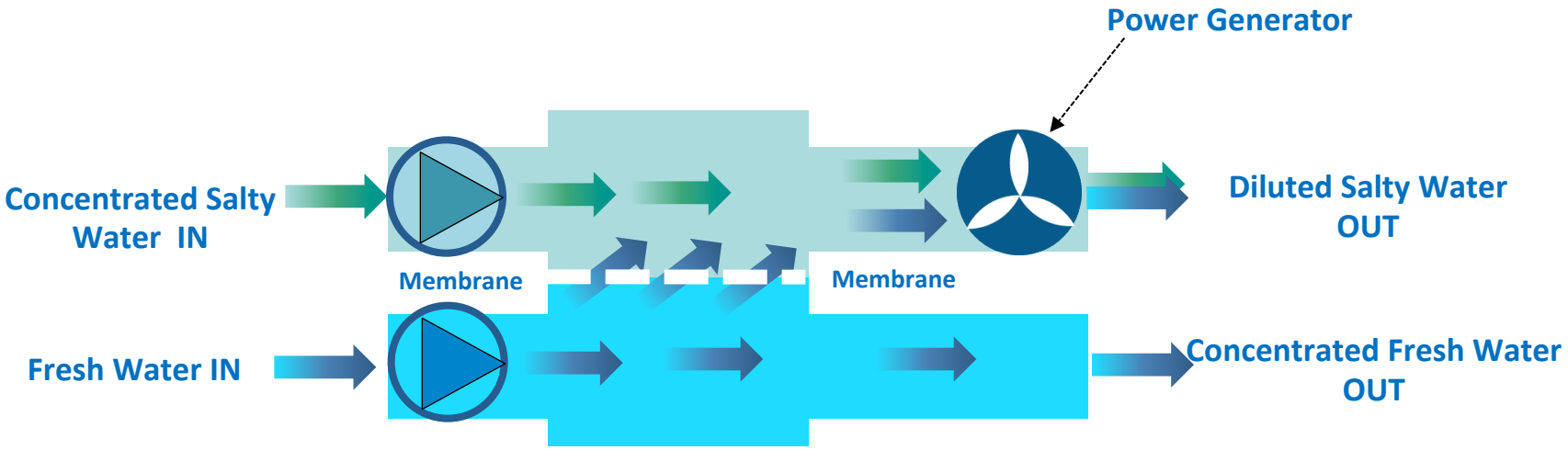
RO Desalination Technology Growth Trends

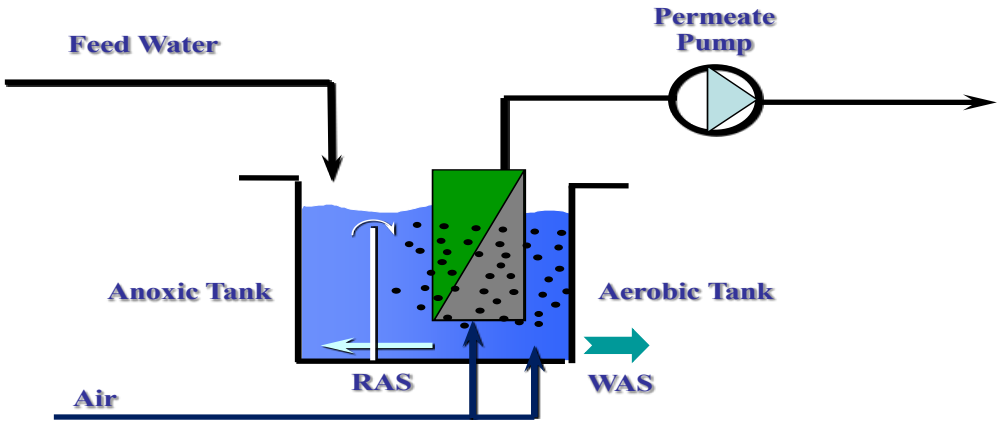


Forward Osmosis - FO

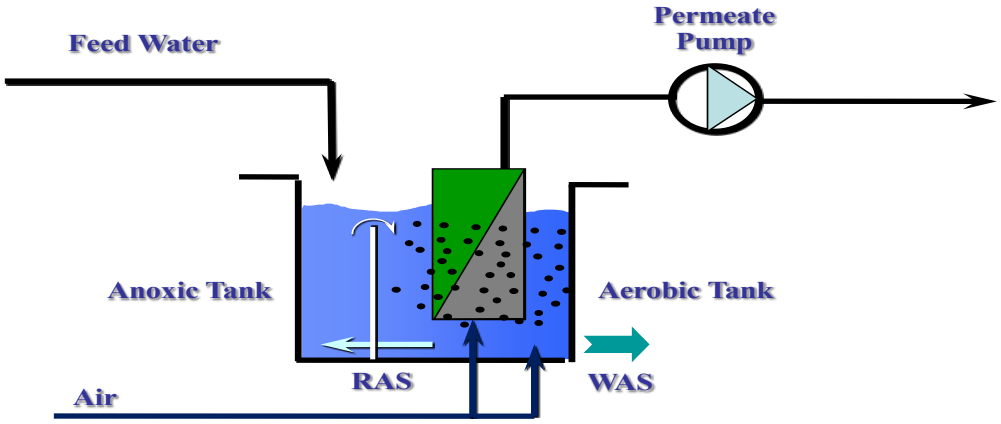


Pressure Retarded Osmosis - PRO





MBR Driven by Permeate Pump



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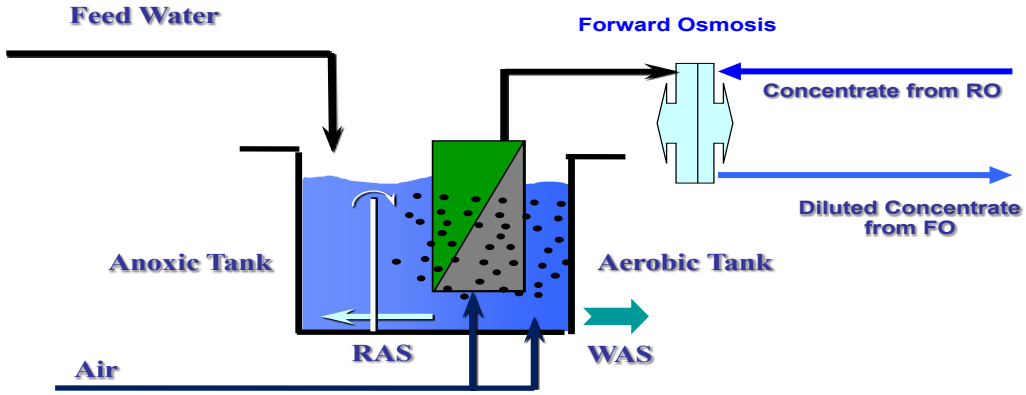
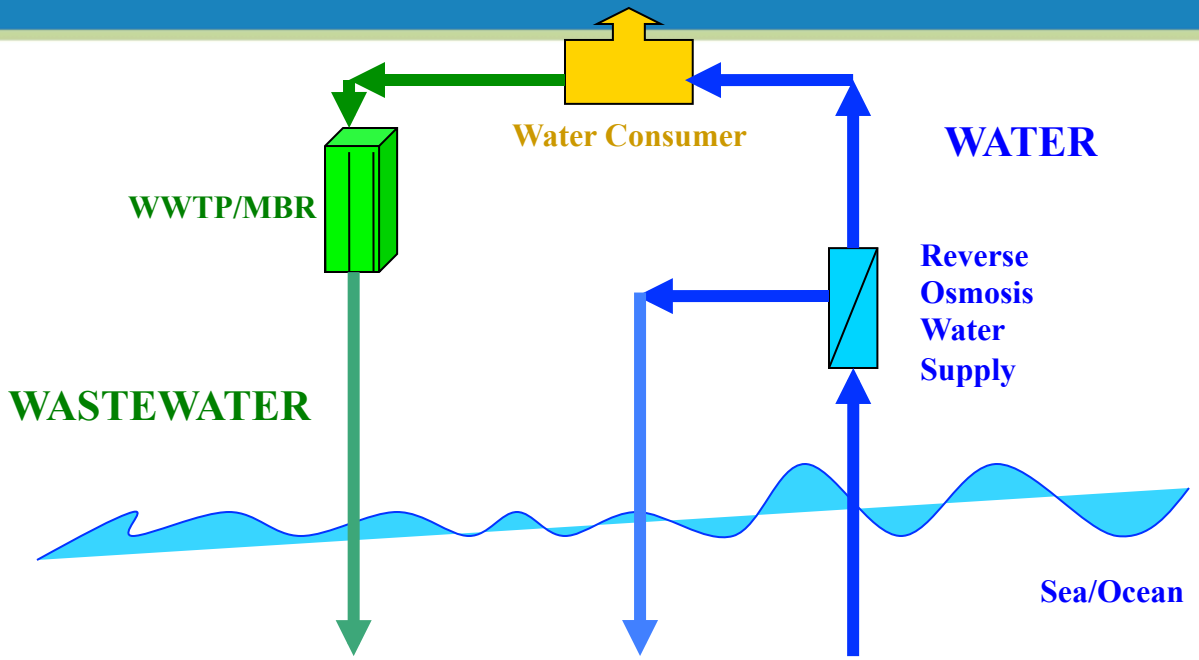
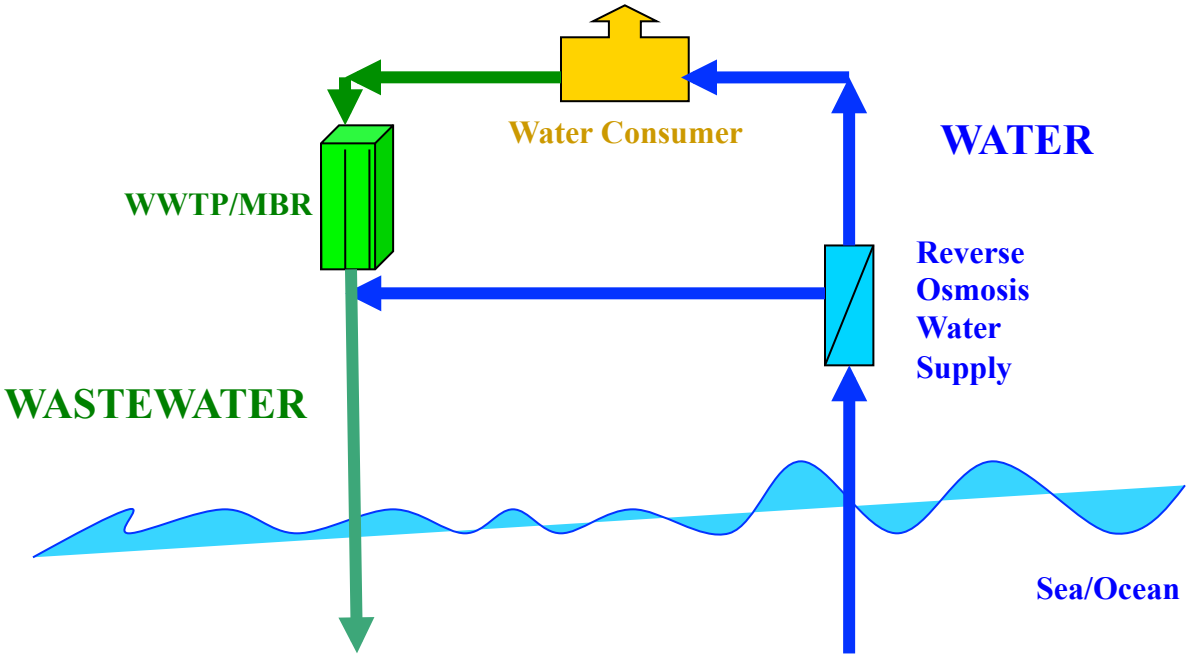


MBR Driven by Forward Osmosis



Combination of Reverse Osmosis with Forward Osmosis



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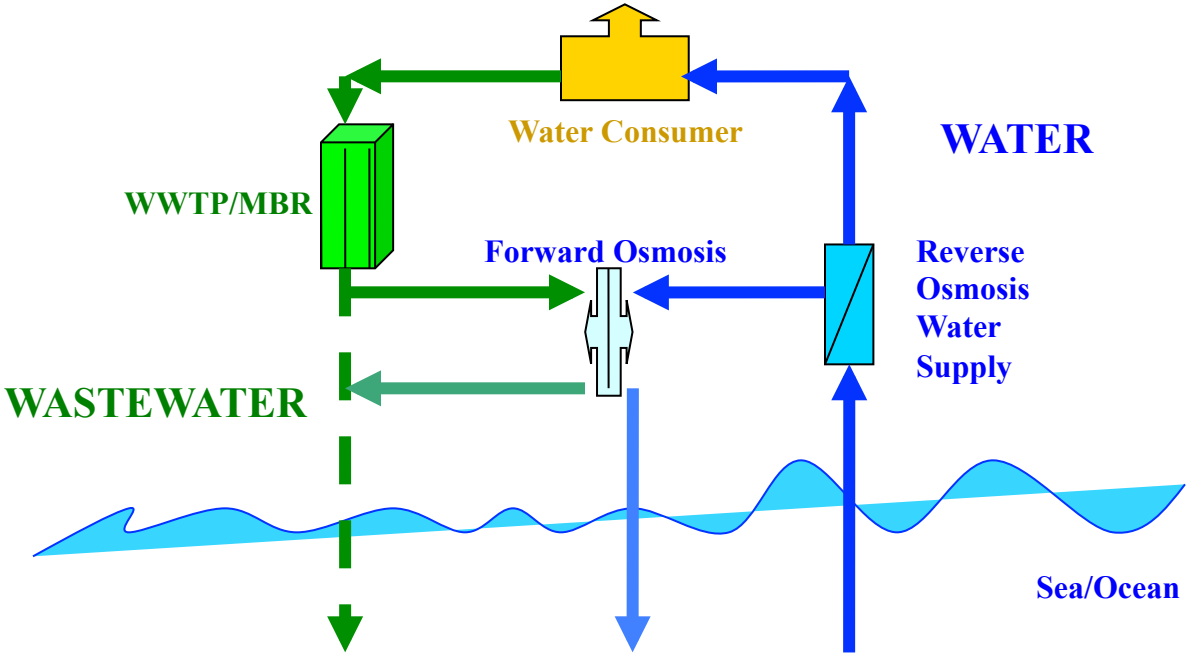

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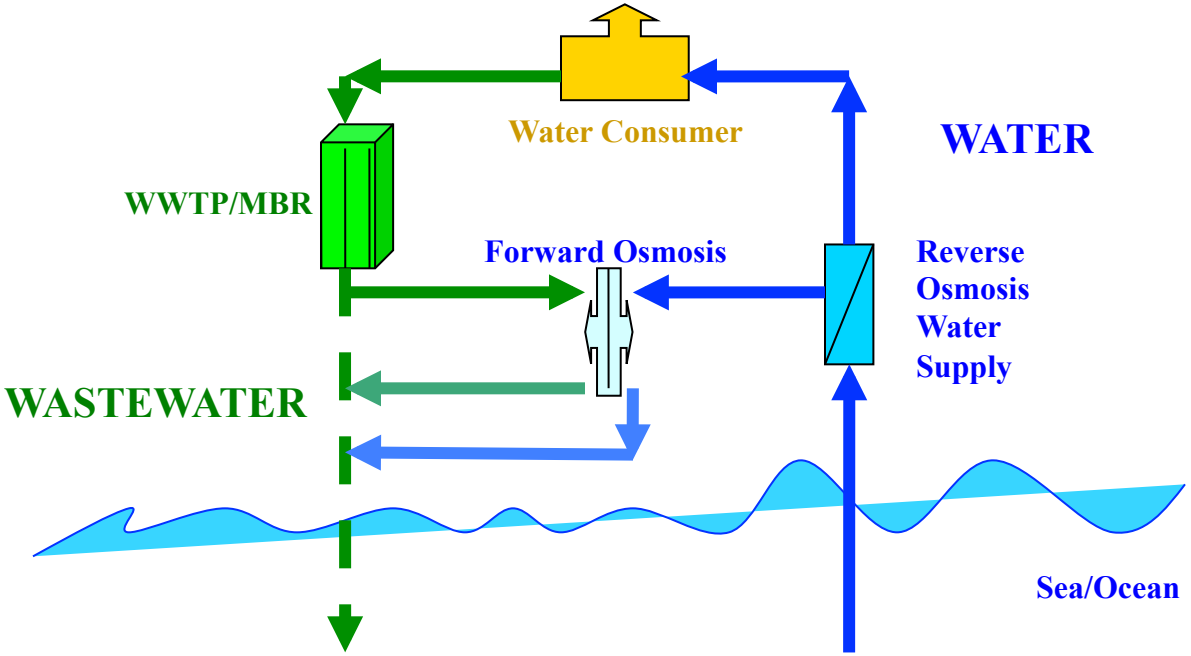

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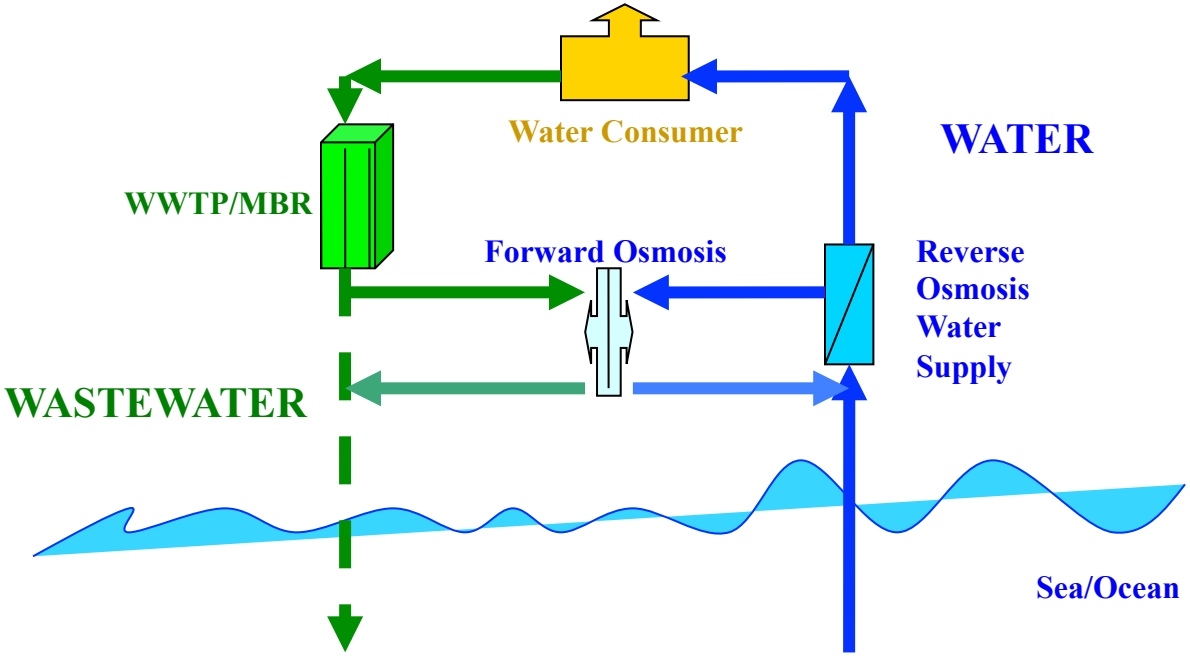

Combination of Reverse Osmosis with Forward Osmosis

Summary

Salt is associated with energy. Removing salt from the water requires energy, the more salt concentration, the more energy is required. Desalination by Reverse Osmosis (RO) has become one of the key technologies for desalinating water. Combination of RO technology with the newer processes may accelerate development of RO and newer processes at the same time providing significant energy savings to desalinate water.

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