Pro Commercial Desalination

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Argument Outline

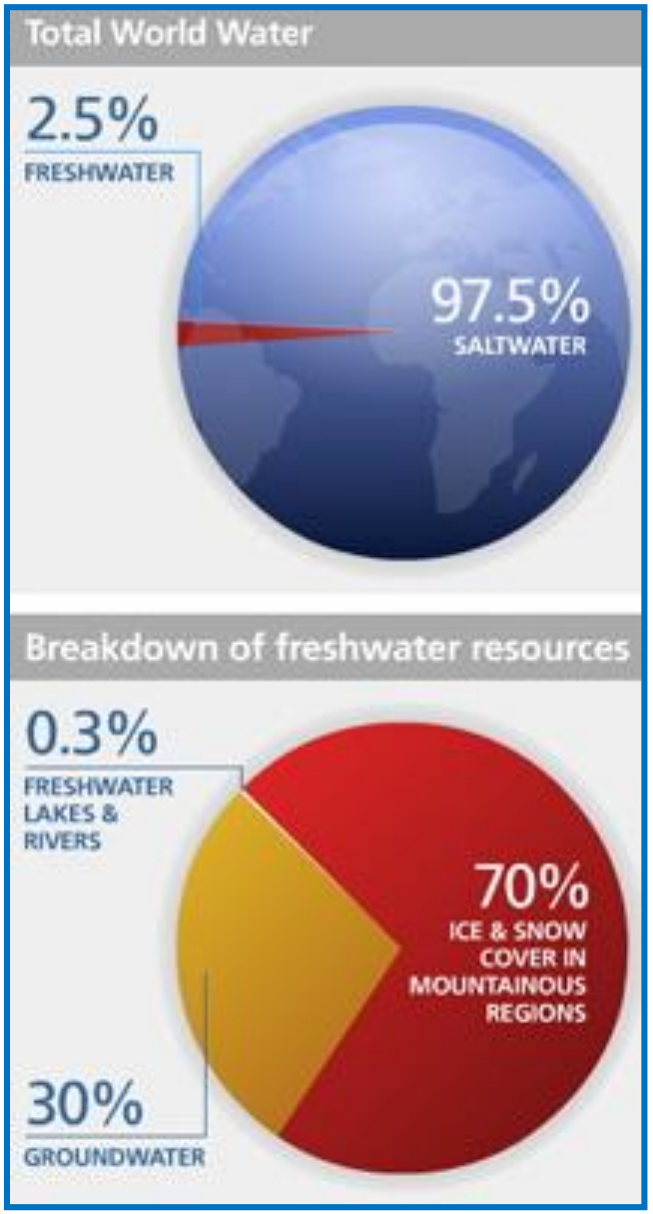
1. Global Water Crisis (Heidi)
2. Success so far (Emily)
3. Economics (Anna)
4. Marketable byproduct (Will)

Global Water Crisis:
Demand for Desalination

http://www.toonpool.com/cartoons/World%20fresh%20water%20supply_31345

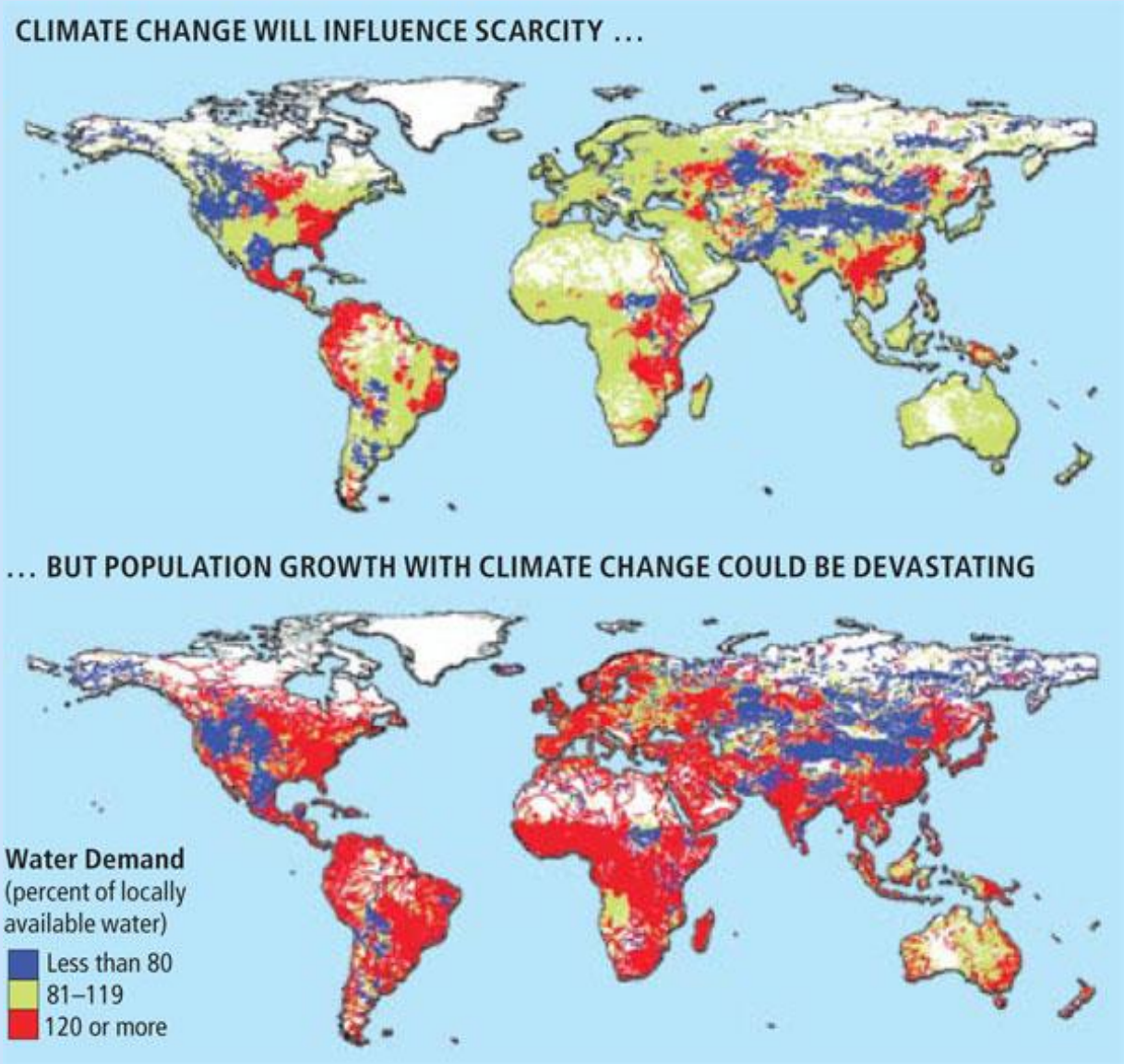
Availability of Freshwater

- 97.5% of the water on earth is in the ocean.
- Only 2.5% freshwater
  - 70% is permanently frozen in glaciers
  - 30% is groundwater
  - 0.3% is in rivers and lakes

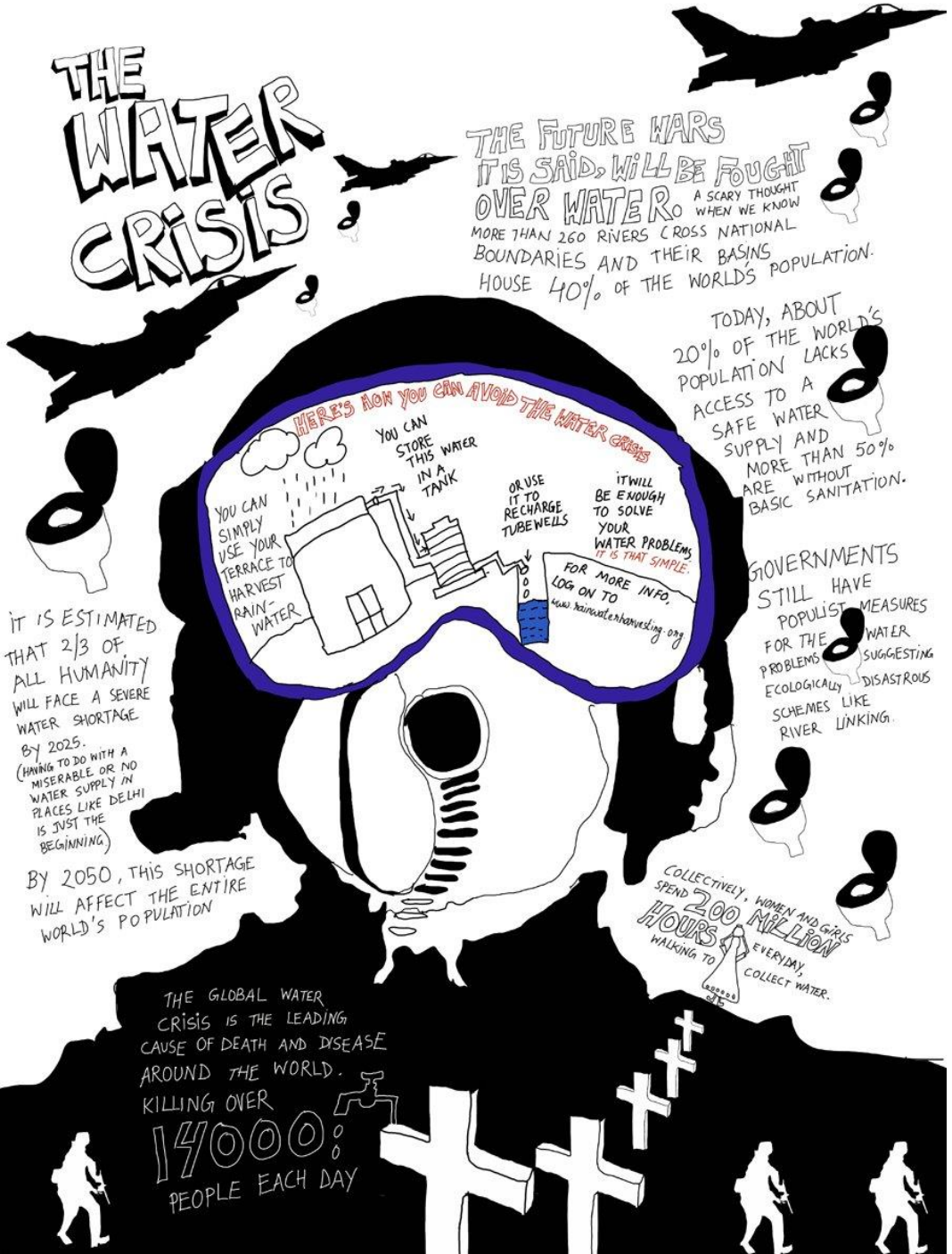


UN Water, 2011
http://www.unwater.org/statistics.html

Freshwater Demand by 2025



Scientific American, August 2008



By 2025…

Freshwater demand will rise by 2/3

1.8 billion people will be living in countries or regions with absolute water scarcity, and **2/3 of the world population** could be under stress conditions.

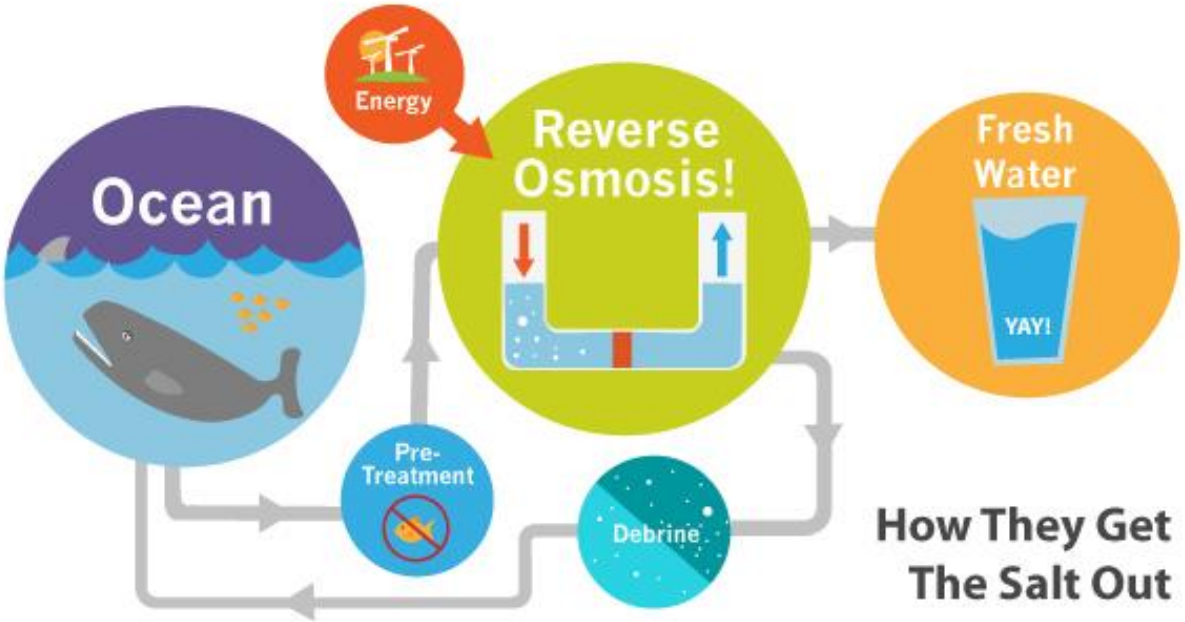
Water withdrawals are predicted to increase by **50%** in developing countries, and **18%** in developed countries.

Science, Aug. 2011

United Nations Water Statistics, 2011

http://www.munnaontherun.com/2008/06/water-crisis.html

Desalination



- Unlimited, steady supply of high-quality water, without impairing natural freshwater ecosystems.

Image: http://www.good.is/post/seawater-our-only-hope-for-a-drink/

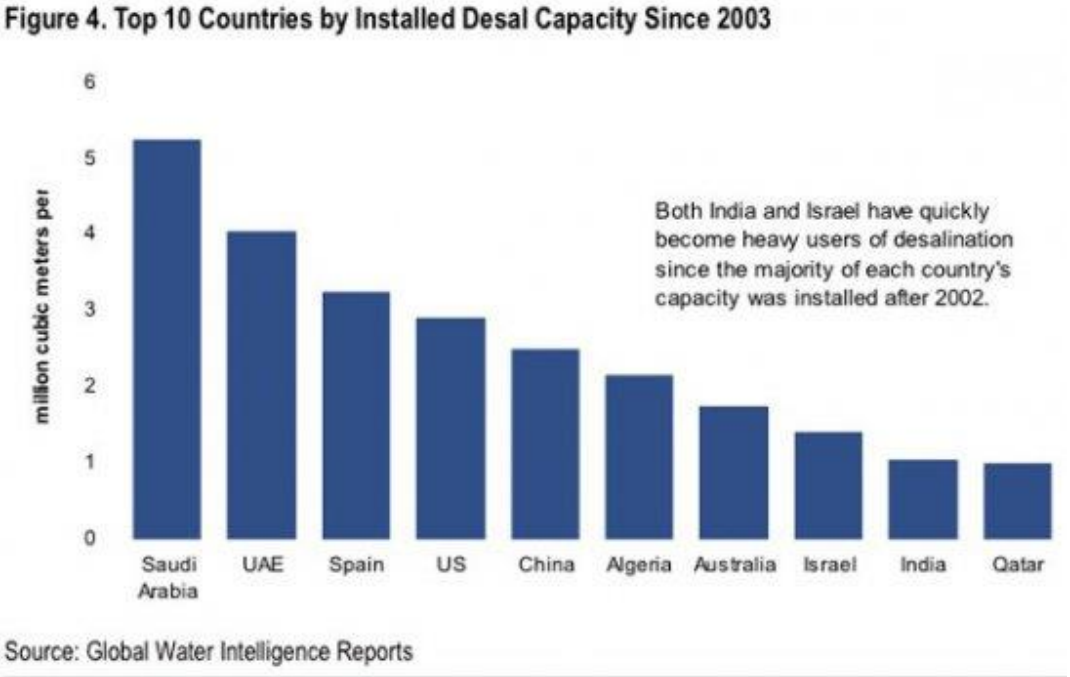
Desalination Today

- Nearly 15,000 desalination plants today
  - Provide some 300 million people with water
  - Still less that 2% of total planetary water consumption

Explosion of demand in the Middle East and North Africa region

Also widely employed in Spain, the Caribbean, and Australia

New markets are growing in China, India, Singapore, Chile, and the USA



Case Studies

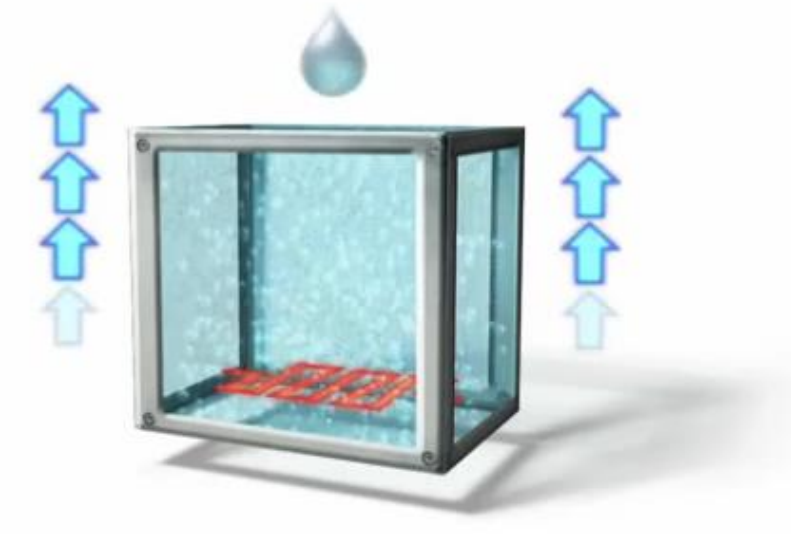
- There are already 14,451 desalination plants in use world wide
- These plants produce 59.9 million cubic meters of water per day (15.8 billion gallons of water)
- Information: the International Desalination Association as of 2009

Co-generation

- Co-generation uses “duel purpose facilities to produce both electricity and water”
- Also called CHP for Combined Heat and Power
- Excess heat from power production is incorporated into the process of thermal water desalination
- Fossil fuels or nuclear power are often used with desalination plants in the Middle East and North Africa
- Information: New World Encyclopedia

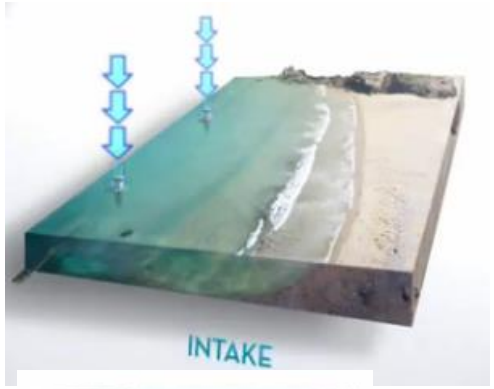
Thermal/Multi Stage Flash

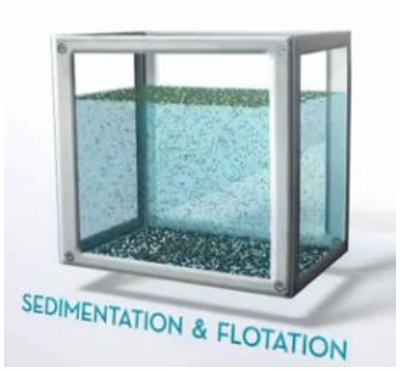
- Thermal: heated water to boiling point, condensation (pure water) is collected at the top and impurities left behind

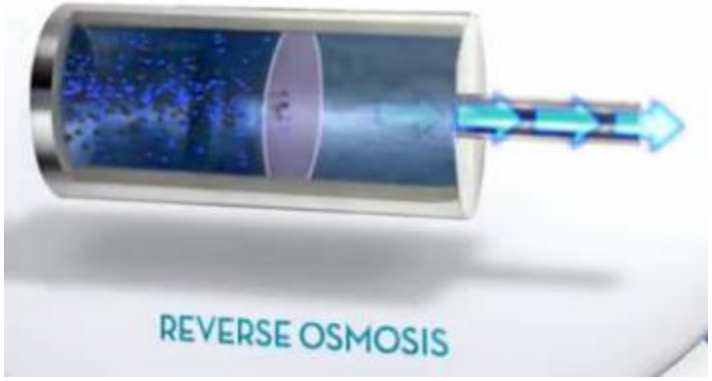


Reverse Osmosis/Membrane

- Intake system → Membrane Process → Pre-treat water → Reverse Osmosis membrane → Post Treatment







- Pictures from International Desalination Association video

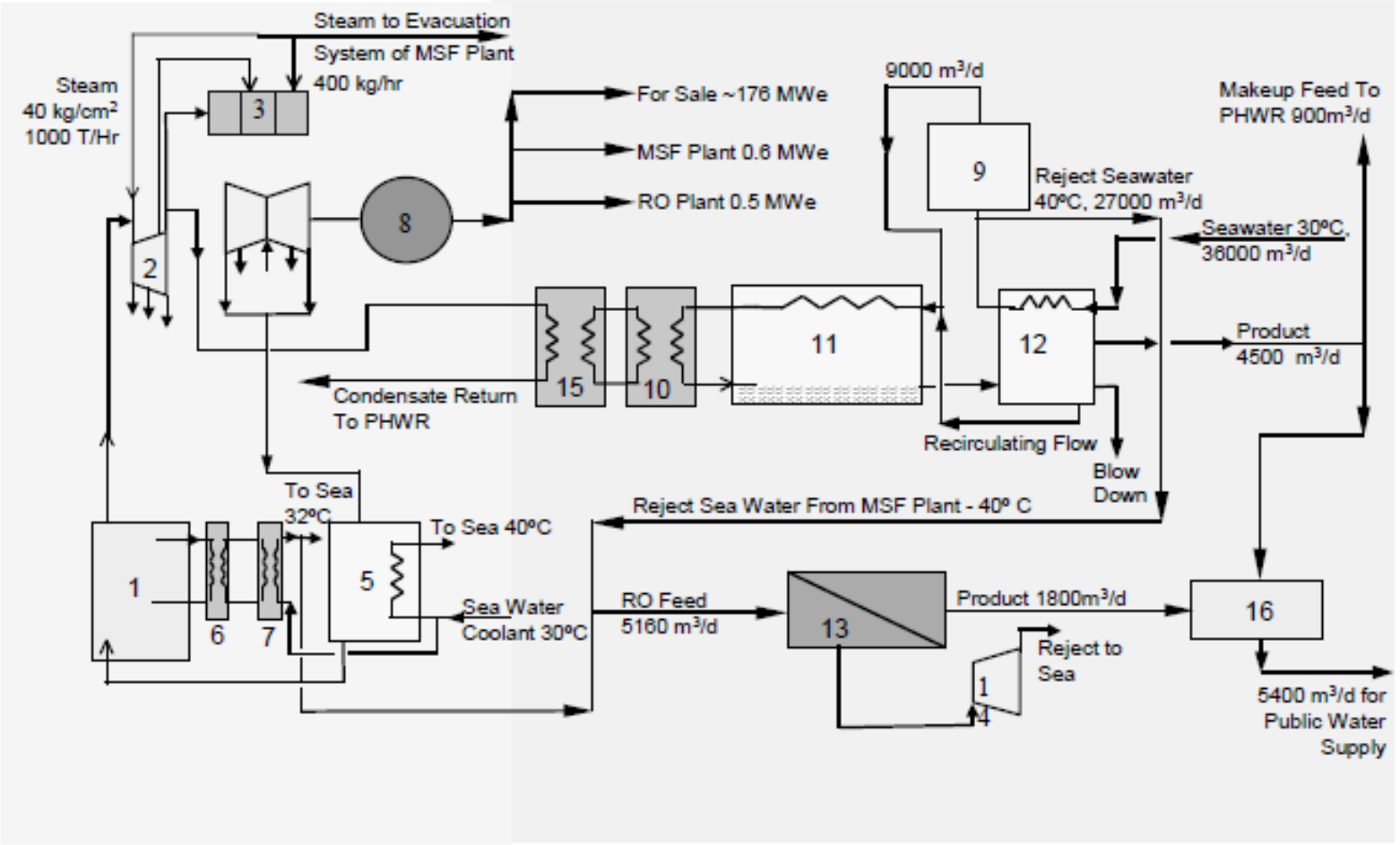
Nuclear Desalination

- There have been over 15 years of experience with nuclear desalination, mainly in India, Japan, and Kazakhstan
- In Japan, 8 nuclear reactors are linked to 10 desalination plants
- India: hybrid Nuclear Desalination Demonstration Project (NDDP)
- Information: World Nuclear Association

India's Nuclear Desalination Demonstration Project (NDDP)

- Incorporates thermal (MSF) and reverse osmosis (RO) desalination plants as well as a nuclear power plant
- "The preheat RO system part of the hybrid plant uses reject cooling seawater from the MSF plant. This allows a lower pressure operation, resulting in energy saving."
  - Membrane life extended in the RO plant because operated at a lower pressure

Figure 1 6,300 m^3/d MSF–RO desalination plant coupled to 170 MWe PHWR

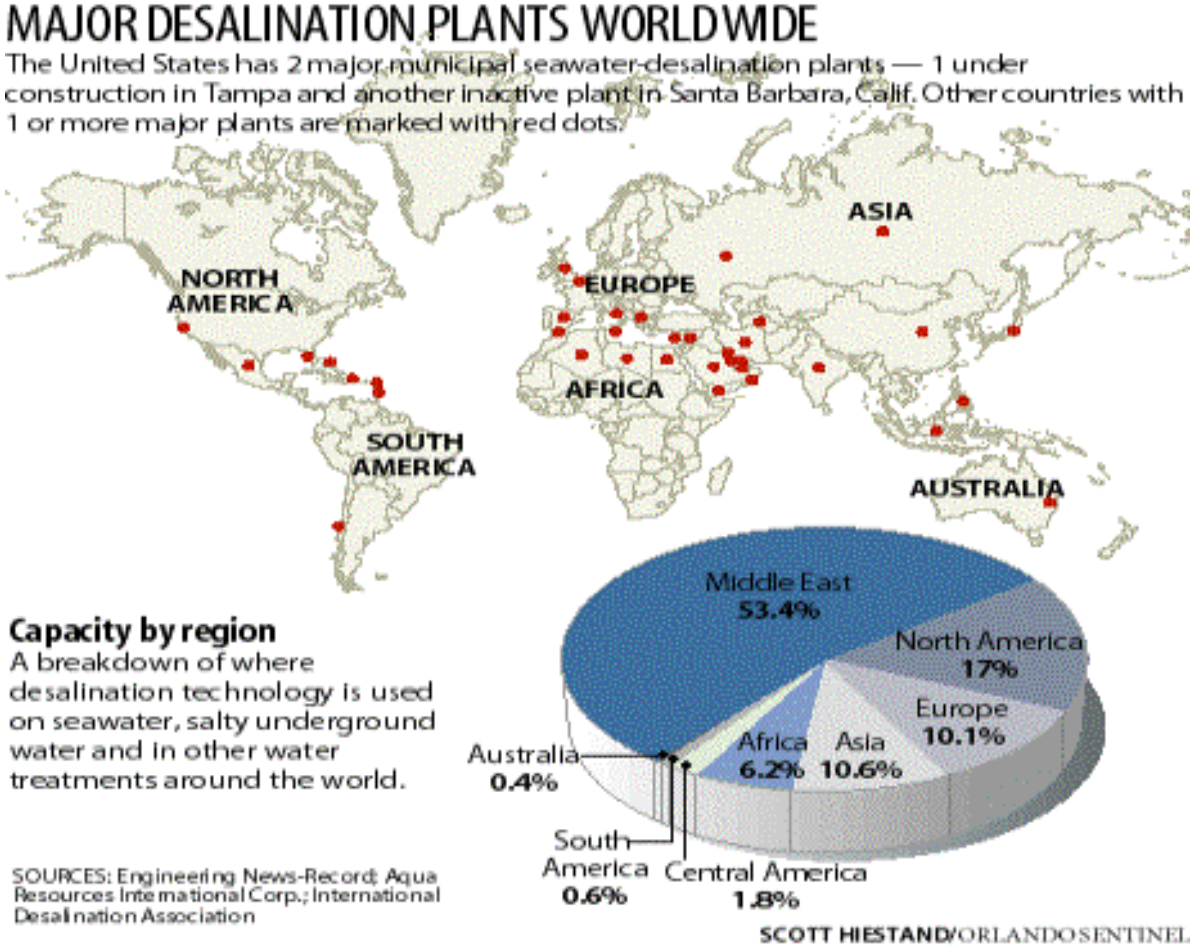


1. PHWR 170 MWe
2. HP Turbine
3. Moisture Separator / Reheater
4. LP Turbine
5. Power Plant Condenser
6. Moderator - DM Water Cooling Loop
7. DM Water - Sea Water Cooling Loop
8. Generator
9. MSF Plant Chemical Pretreatment Section
10. MSF Plant Brine Heater
11. MSF Plant Heat Recovery Section
12. MSF Plant Heat Reject Section
13. RO Plant
14. RO Plant Energy Recovery Turbine
15. Intermediate Heat Exchanger
16. Product Storage Tank

NDDP

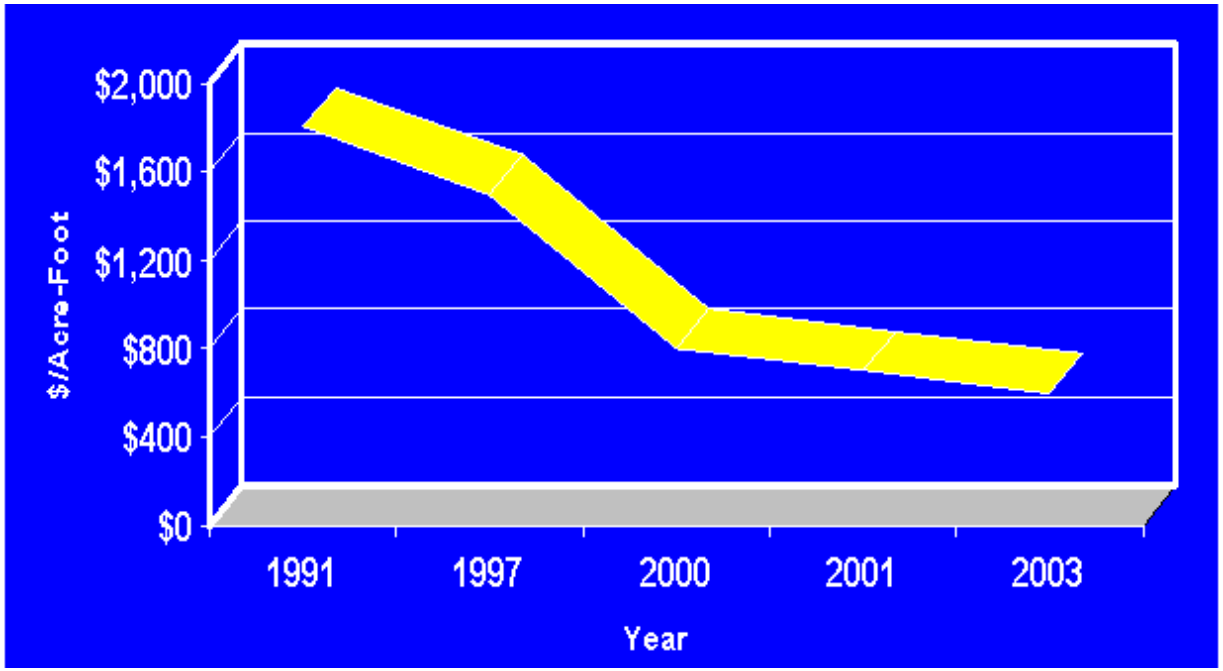
- "…qualities of water produced are usable for the power station as well as for drinking purposes with appropriate blending."
- "The post-treatment is also simplified due to blending of the products from MSF and RO plants."
- Information: Journal – *Advances in Nuclear Desalination* by Dr. Misra PhD from India, Research Associate at Harvard & UCLA

World Desalination Plants



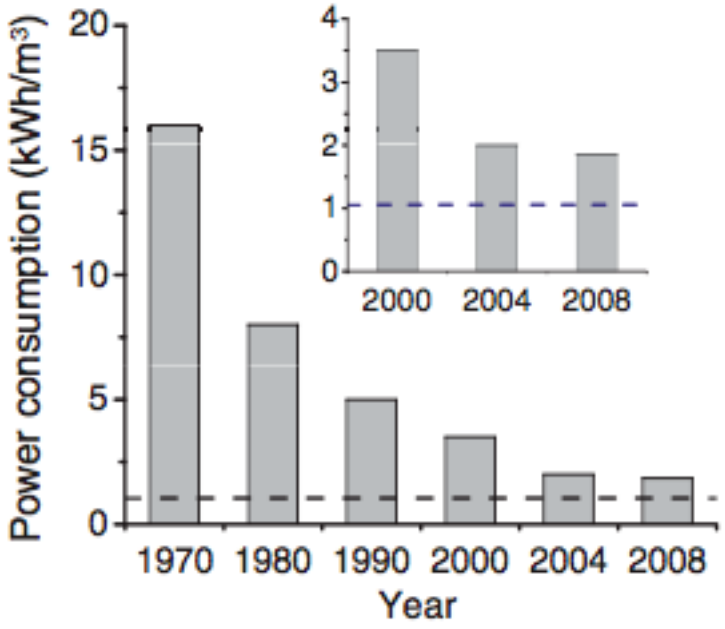
Economics

- Increase in technology such as improvements in the use of membranes are increasing efficiency and reducing cost



http://hbfreshwater.com/desalination-101/desalination-worldwide

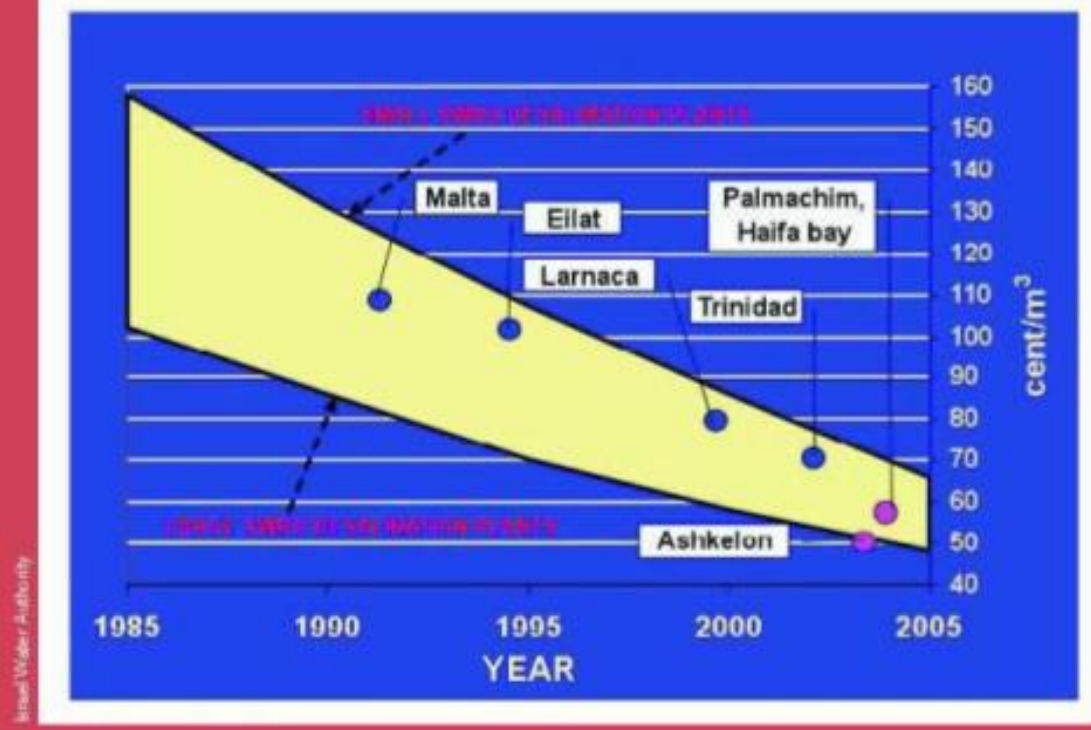
- Decreasing the use of energy consumption over time is reducing the cost of operation



http://hbfreshwater.com/desalination-101/desalination-worldwide

- Decrease in cost leads to a decrease in price making freshwater more affordable

Figure 2: The price of desalinated water, 1985–2005.



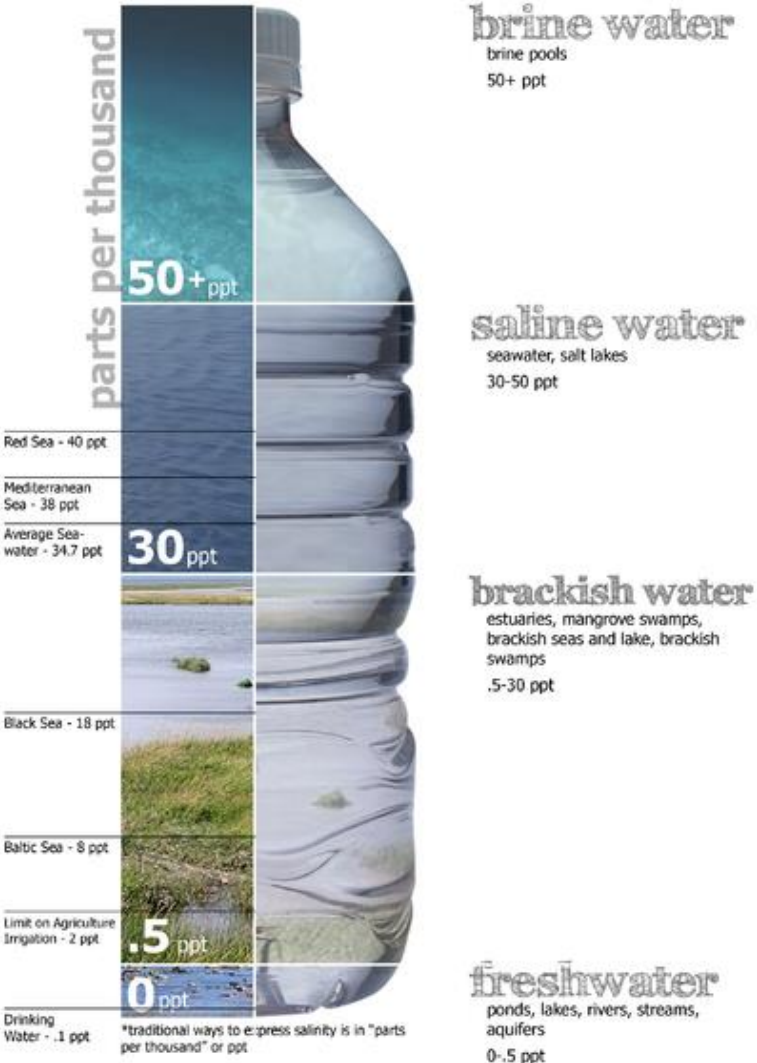
www.tandfonline.com/loi/venv20

- Outstanding career opportunities for professionals engaged in water industry, science or engineering.
  - IDA's Young Leaders Program
  - Provide a forum for communication, networking and exchange of ideas among these emerging leaders and the industry at large.

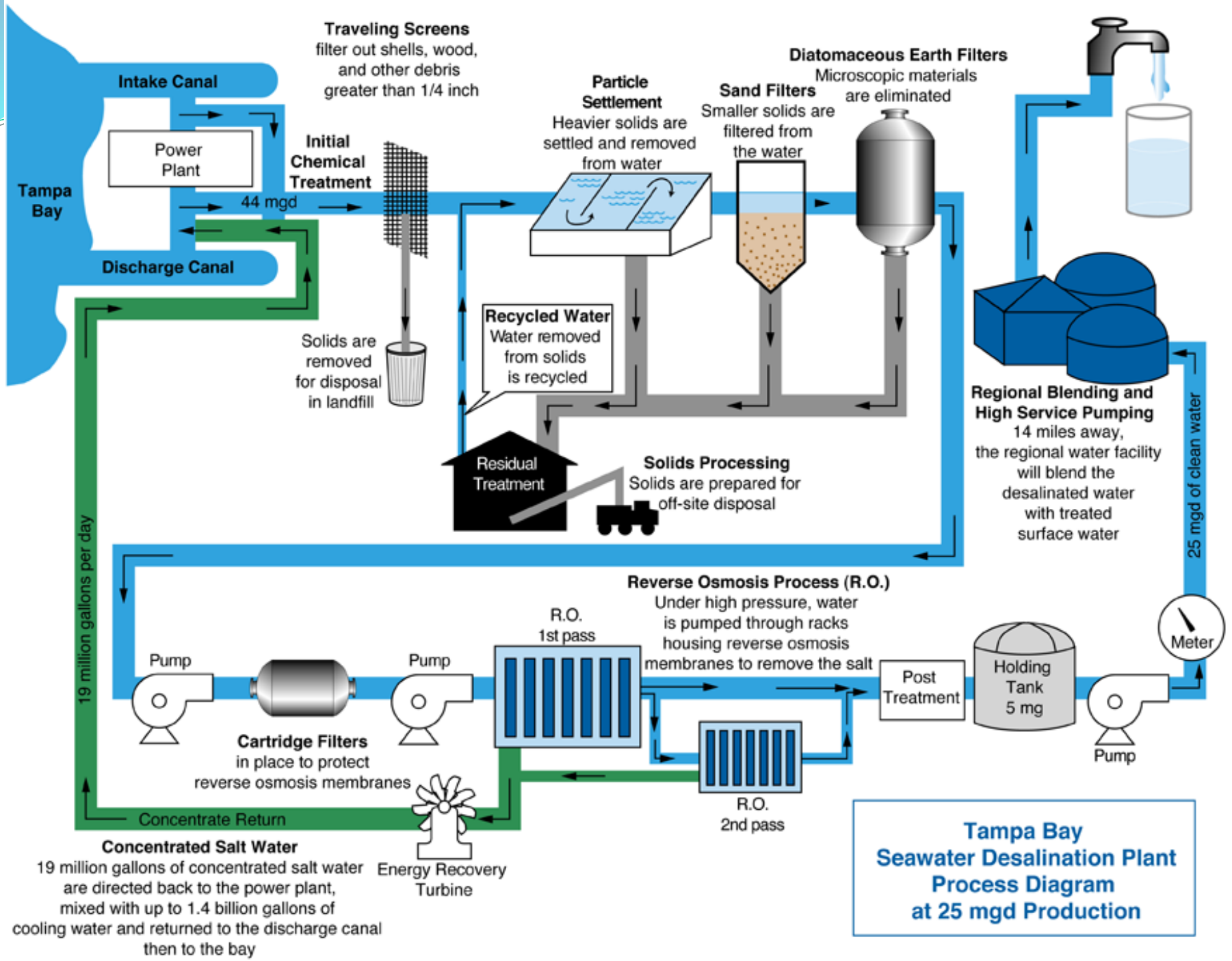
Example: Australia

- Desalination will provide a secure and predictable supply of freshwater to places such as Australia, who's other source of freshwater is capturing rain water which is highly variable and infrastructure intensive
- Australia has already implemented this technology successfully, utilizing 3 in-use plants, 3 in progress plants and 1 planned plant

By-Product


parts per thousand
50+ ppt
30 ppt
0 ppt
Red Sea - 40 ppt
Mediterranean Sea - 38 ppt
Average Sea-water - 34.7 ppt
Black Sea - 18 ppt
Baltic Sea - 8 ppt
Limit on Agriculture Irrigation - 2 ppt
.5 ppt
Drinking Water - .1 ppt
*traditional ways to express salinity is in "parts per thousand" or ppt
brine water
brine pools
50+ ppt
saline water
seawater, salt lakes
30-50 ppt
brackish water
estuaries, mangrove swamps, brackish seas and lake, brackish swamps
.5-30 ppt
freshwater
ponds, lakes, rivers, streams, aquifers
0-.5 ppt


Sea of
Galilee
Dead
Sea


Intake Canal
Power Plant
Tampa Bay
44 mgd
Discharge Canal
Traveling Screens
filter out shells, wood, and other debris greater than 1/4 inch
Initial Chemical Treatment
Particle Settlement
Heavier solids are settled and removed from water
Sand Filters
Smaller solids are filtered from the water
Diatomaceous Earth Filters
Microscopic materials are eliminated
Solids are removed for disposal in landfill
Recycled Water
Water removed from solids is recycled
Residual Treatment
Solids Processing
Solids are prepared for off-site disposal
Regional Blending and High Service Pumping
14 miles away, the regional water facility will blend the desalinated water with treated surface water
25 mgd of clean water
Meter
19 million gallons per day
Reverse Osmosis Process (R.O.)
Under high pressure, water is pumped through racks housing reverse osmosis membranes to remove the salt
R.O. 1st pass
Pump
Pump
Cartridge Filters
in place to protect reverse osmosis membranes
Post Treatment
Holding Tank 5 mg
Pump
R.O. 2nd pass
Concentrate Return
Concentrated Salt Water
19 million gallons of concentrated salt water are directed back to the power plant, mixed with up to 1.4 billion gallons of cooling water and returned to the discharge canal then to the bay
Energy Recovery Turbine
Tampa Bay
Seawater Desalination Plant
Process Diagram
at 25 mgd Production

A Marketable By-Product

Byproduct references

- http://www.water-technology.net/projects/tampa/
- http://www.desalination.biz/
- http://www.desware.net/

Rebuttal

Re-mineralization of end product

- 4 processes to re-mineralize desalinated water:

Remin. Process	Description	Minerals
1	Blend with 1% clarified seawater + pH neutralization	15 mg/L Mg + 5 mg/L Ca + 125 mg/L Na + 220 mg/L Cl + 25mg/L SO4 pH 7-7.5
2	CO_2 addition + Calcite Limestone ($CaCO_3$, MgO) percolation + Na_2CO_3	80 mg/L CaCO3 pH 7-7.5
3	CO_2 addition + Dolomite Limestone ($CaCO_3$, $MgCO_3$) percolation + Na_2CO_3	80 mg/L CaCO3 + MgCO3 pH 7-7.5
4	Addition of $CaCl_2$ + $NaHCO_3$	100 mg/L CaCO3 100 mg/L Na + 50 mg/L Cl pH 7-7.5

Re-mineralization of end product

- Water quality for drinking/irrigation

Remin. Process	TDS after 2-pass SWRO (Boron Removal Process for Drinking Water)	EC after SWRO +IX (Boron Removal Process for Irrigation water)	SAR after SWRO +IX (Boron removal Process for Irrigation water)
1	350-400 mg/L	0.8-0.9	8
2	50-100 mg/L	0.3-0.4	2.5
3	50-100 mg/L	0.3-0.4	2.5
4	250-300 mg/L	0.6-0.8	6.5

- Process Comparisons:

Process	Investment	Operation	Water quality	Ease of operation
1	Very Low	Low	Medium water quality - high sodium chloride content	Easy
2	High	High	Good water quality (very small sodium increase)	Easy
3	High	High	Very Good water quality (very small sodium increase, more magnesium)	Easy
4	Very Low	Low	Medium water quality - high sodium chloride content	Time consuming (chemical dissolution)

Re-mineralization of end product

- Can re-mineralize the water to avoid dietary deficiencies
- Information: Lenntech (org. created by alumni of Netherlands' Technical University of Delft; references include US Army, DSM Pharmaceuticals, Universities etc.)

Seawater Intake Precautions

- The impact on a population level is not clear given the naturally high mortality of larval organisms in marine systems.
- Appropriate screens and low intake velocity on open surface intakes can minimize impingement.
- Locating intakes away from biologically productive areas can substantially reduce or eliminate entrainment of small planktonic organisms.
  - Underground beach wells

Menachem Elimelech, et al. *Science* Aug. 2011

Brine Impact

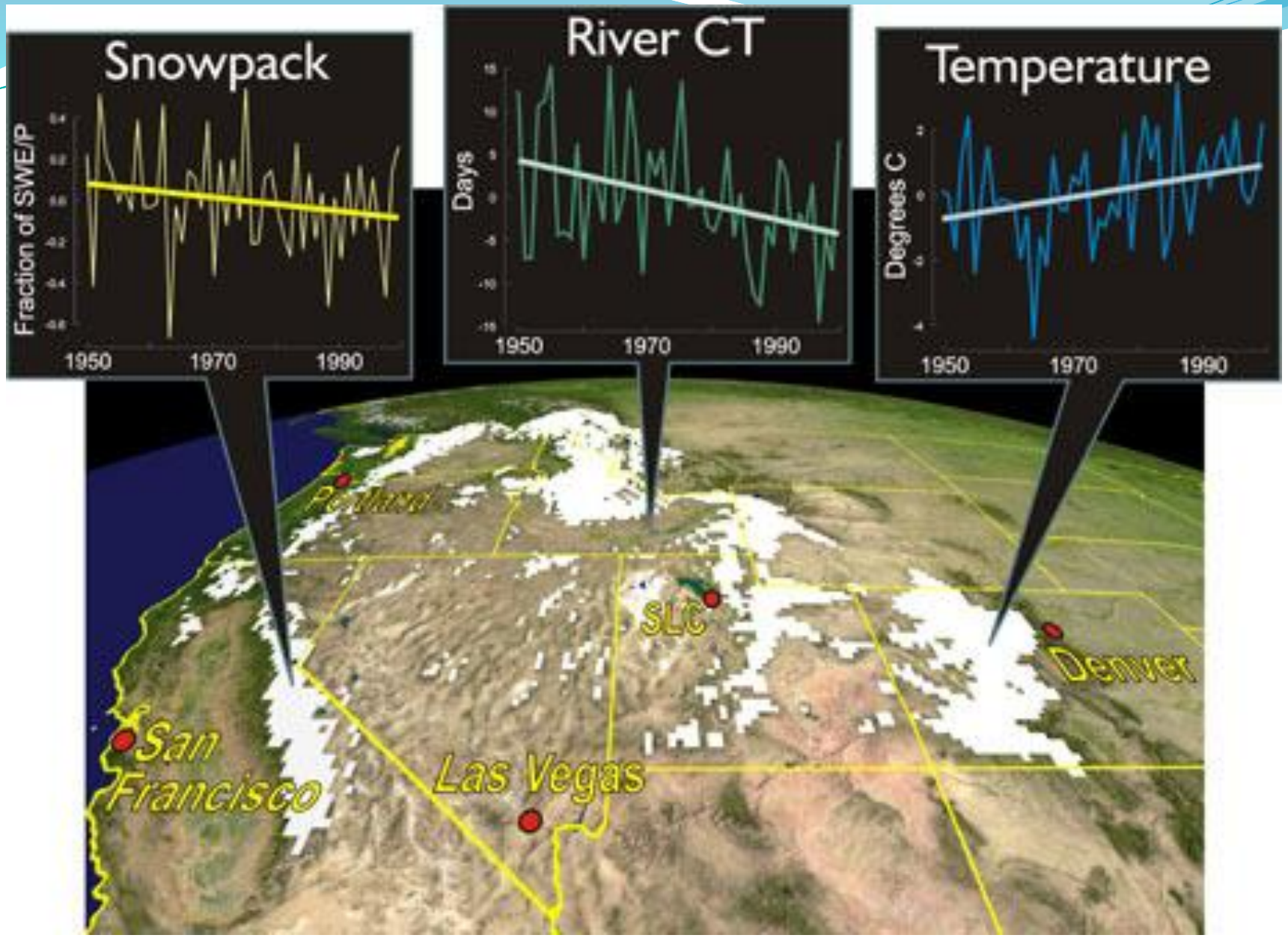
- In the planning phase for Israel's Ashkelon desalination facility there were concerns about the impact of the brine that the desalination process produces
  - Discharged 1km into the sea
  - Residual dilution
  - Diffuser above seabed
- Effects:
  - Minimal salinity change
  - Creation of a positive "mini-fishery" microenvironment

Tal, Alon. *Environmet: Science and Policy for Sustainable Development*

Sludge

- Yuma, Arizona
- Cooperative research and development agreement with Envirock Inc
- Sludge → “Green” concrete mix formulation
- Reduce operating costs by up to US$ 245,000/year

Announcement of the US Bureau of Reclamation on September 21, 2011



- National Geographic, January 2008

97.5%
of the water on Earth is salty. Around one per cent of that is brackish groundwater.

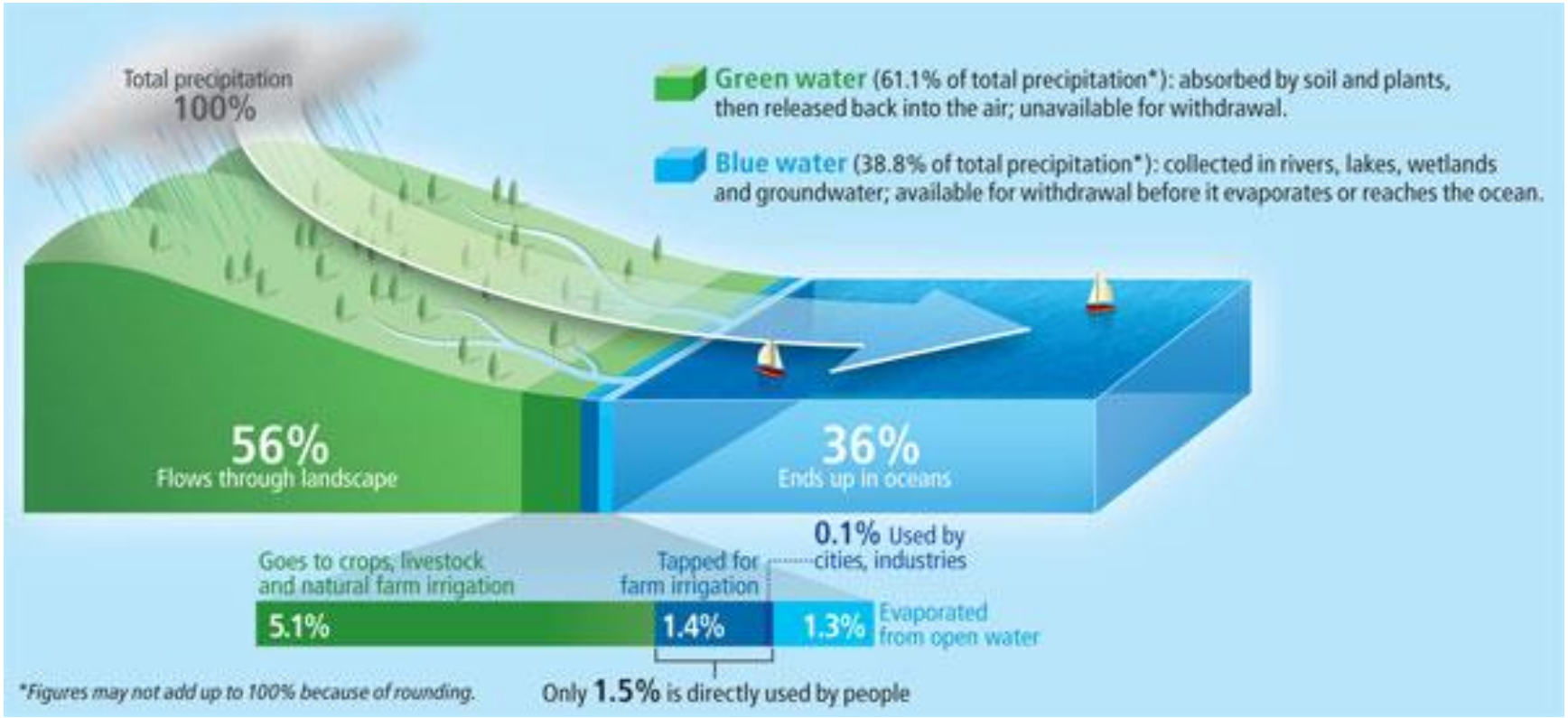
2.5%
of the Earth's water is fresh. About two-thirds of that is frozen; the rest is liquid surface water and groundwater.

Wholesale water cost in southern California (per 1,000 gallons)

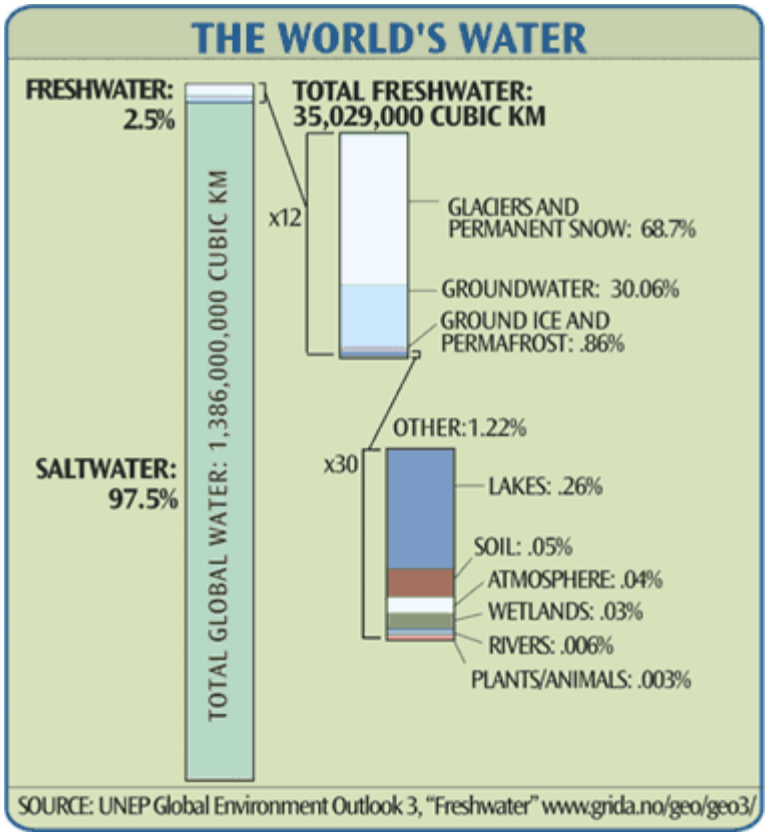
Better technology has driven desalination costs down–closer to the price of fresh water—though lately they've risen again with energy and materials prices.

16 billion
gallons are produced daily by the world's 14,450 desalination plants. Persian Gulf countries rely mostly on seawater.

Precipitation



http://www.scientificamerican.com/article.cfm?id=freshwater-crisis-current-situation



UNEP: United Nations Environment Program
http://www.theglobaleducationproject.org/earth/fresh-water.php?format=print

Cost

- It is true that desalination may be expensive today, but it is a long term solution to the water crisis and as shown, over time the cost will decrease
- It is possible for the desalination plant to run of renewable energy such as solar or wind for example in Perth, Australia, the plant runs on renewable energy from a nearby wind farm. The increased use of renewable energy will reduce the carbon foot print in Australia

Cost

- It is hard to actually predict the cost of a desalination plant because there is little available information
- Cost is determined by a lot of different factors such as the capital and operating costs, type of facility, location, feed water, labor, energy, financing, and concentrate disposal which also makes the cost hard to predict

Cost

- Much of the energy use associated with desalination can ultimately be recovered and recycled further lower the cost