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Creating Water Resources Through On-Site Reverse Osmosis

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WATER STANDARD

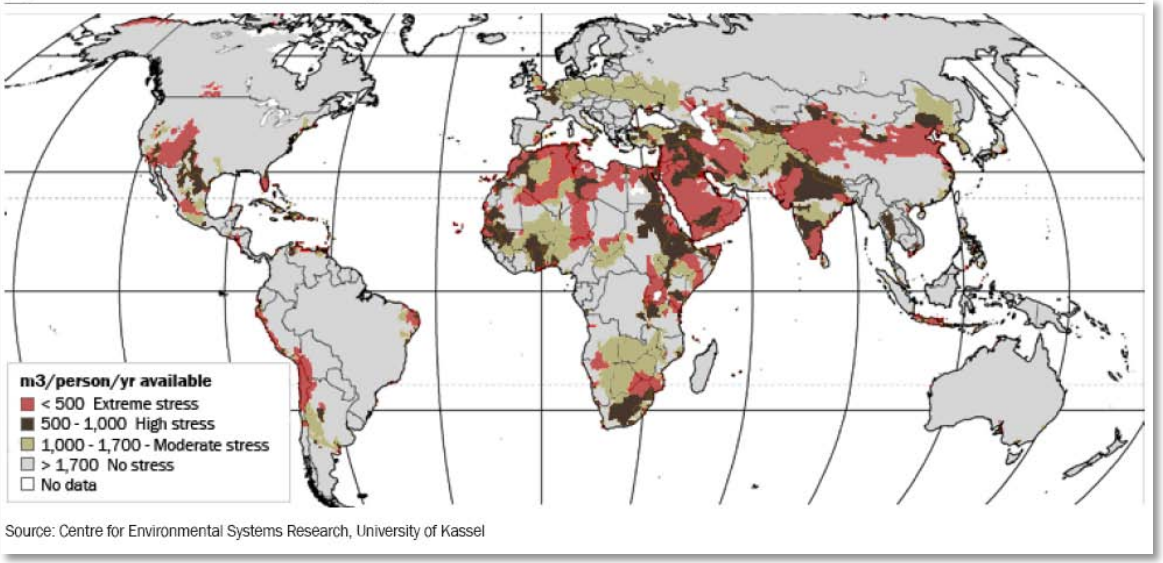
Outline

- Water: The Essential Commodity of This Century
- Changing Demand Patterns
- Options for New Water Supply
  - Why Desalination, Why Reverse Osmosis
    - Process, Trends, Limitations
- Modes of Delivery and Transport: Towards Smarter Point of Use Options and a Sustainable Water Footprint

Water: The Essential Commodity of This Century

Water Scarcity is a Growing Problem and is Exacerbated By Growing Macro-Economic Drivers.

World Water Availability



Source: Centre for Environmental Systems Research, University of Kassel

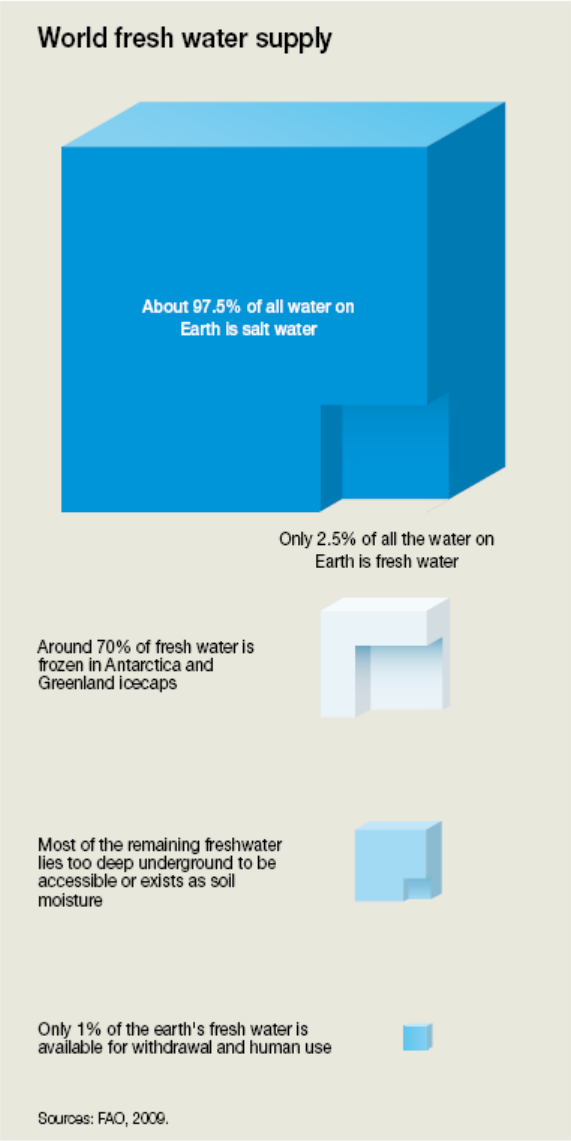
- **Population Growth:**
  - 2 billion more people over next 20 years.
  - 4 billion people will experience chronic water shortages by 2050 – eight times as many as today.
  - Populations living in scarce water conditions globally are expected to double in 20 years.
- **Population Density at Coast Lines:**
  - Today 50% of the global population lives in coastal areas with this number increasing annually through migration toward the coast.
- **Rising Standards of Living is resulting in increased water consumption.**
- **Climate Change:**
  - Droughts are extending in duration due to changes in hydrological cycle.
- **Overuse and Pollution:**
  - Annually, an estimated 300-500 million tons of industrial toxic waste accumulates in fresh water sources. In developing countries, 70% of this industrial waste is dumped untreated into the water supply chain.

Water is a non-substitutable commodity. Supply/Demand imbalances dictate the opportunities and challenges.

Water: The Essential Commodity of This Century

"Water is needed to generate energy. Energy is needed to deliver water. Both resources are limiting the other – and both may be running short. Is there a way out?"

Scientific American

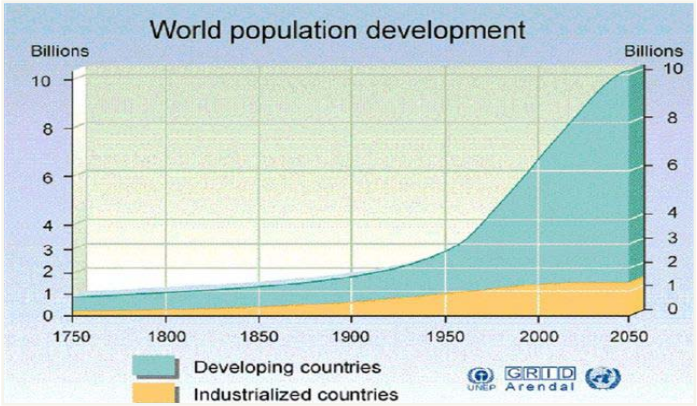


Global Increases in Demand for Water:

Rethinking How Water is Delivered

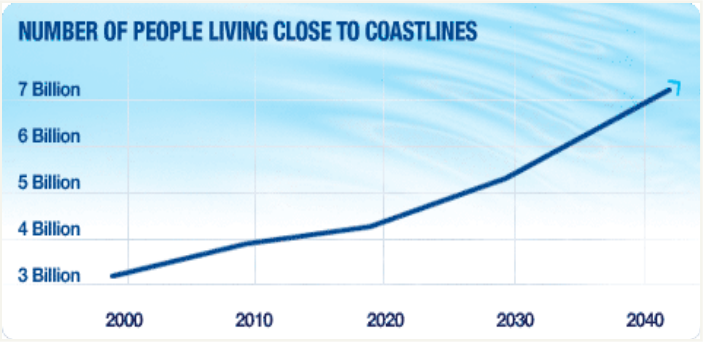
POPULATION GROWTH

- Today's population of 6.7 billion is already placing unsustainable demands on water resources; global water demand is currently 2.1 trillion cubic meters of water per year—the equivalent of two times the volume of Lake Superior (the largest lake in the world).
- The addition of 2.5 billion people by 2050—*the equivalent of two more China's*—will primarily be in less developed regions where infrastructure and water resources are insufficient and have not been able to adequately provide for the existing population base.
- It is expected that at current consumption patterns, this increase in population will require 20% more water than is currently available. This takes into account water that is "lost" in water systems.



POPULATION PATTERNS

- Populations worldwide are increasingly concentrated along or near coastlines occupying only 10% of the world's land. Today 50% of the global population lives in coastal areas and by 2050, 70% of the world's population will be living within 60 to 250 miles of the coast. California is already at 87%
- Half of the world's available water resources are located in only six countries.
- The correlation between poverty and disease and lack of access to a safe and reliable source of water is undeniable.



Source(s): Research and Markets Report 2007-Desalination Markets 2007: A Global Industry Forecast; Energy and Water in Kuwait: A sustainability viewpoint, Part II, M.A. Darwisha and A.M. Darwish 2008; Evaluating the Economic and Environmental Impacts of Water Subsidies in Kuwait, Mohammad Alshawaf 2005; Water-Day Gulf: Forced to Look Beyond Desalination Plants Meena Janardhan DUBAI, Mar 21, 2007; UNESCO; Coastal Waters of the World: Washington D.C Island Press Updated 2007.

Climate Change

- The continuing effect of climate change has an immediate impact on the availability and delivery patterns of fresh water.
  - Record droughts.
  - Changes in water patterns.

Amazon River Brazil

September 2006

Lake Mead Nevada

April 2007

Kouris Reservoir Cyprus

March 2008

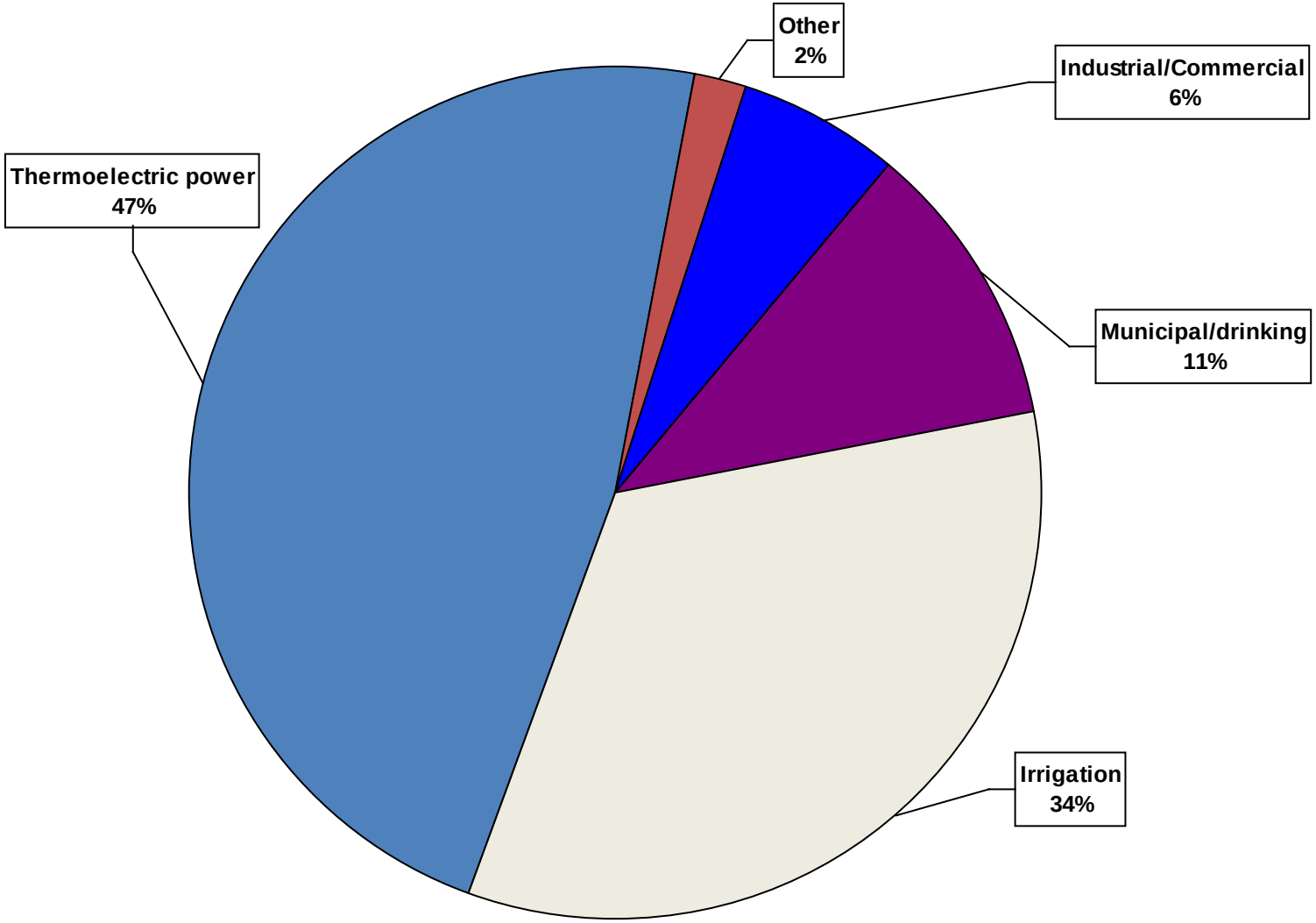
CLIMATE CHANGE IMPACTS:

- Rising costs
- Calculation of "Water Footprint" for all users
- Regulatory caps for water use
- Regulatory restrictions for specific industrial activities
- Conflicts with local communities and regional/political implications
- Impact on site locations and permitting for industry
- Operational disruptions and associated financial loss

Water and its availability and quality will be the main pressures on societies and the environment under climate change.* Systems have to become more efficient.

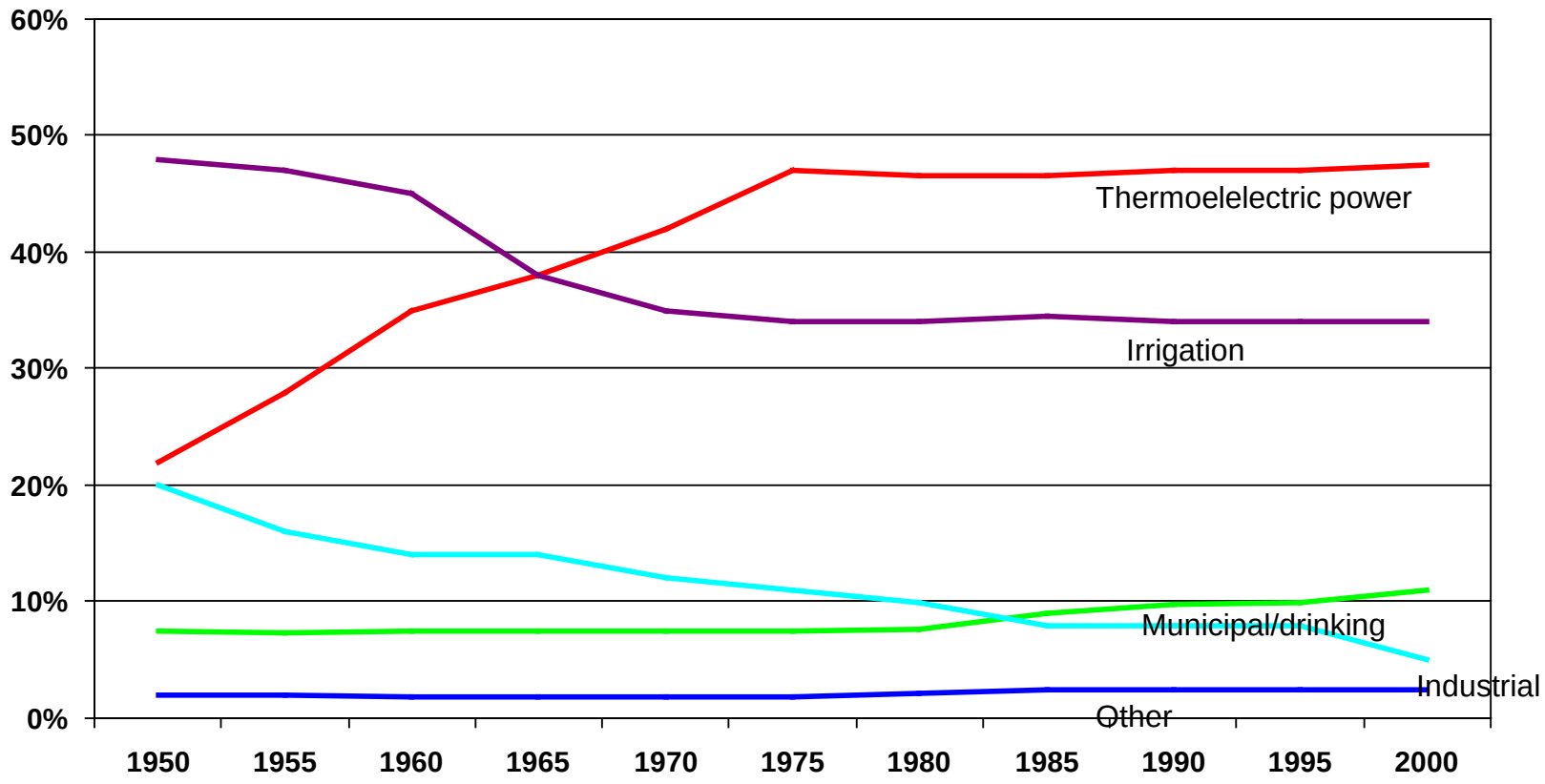
Source(s): *IPCC Technical Paper, "*Climate Change and Water*", June 2008; Ceres Water Scarcity and Climate Change; "*Growing Risks for Businesses and Investors*", April 2009; *Research and Markets Report 2007-Desalination Markets 2007: A Global Industry Forecast*

Sources of Water Demand in U.S.



Source(s): US Department of the Interior 2005

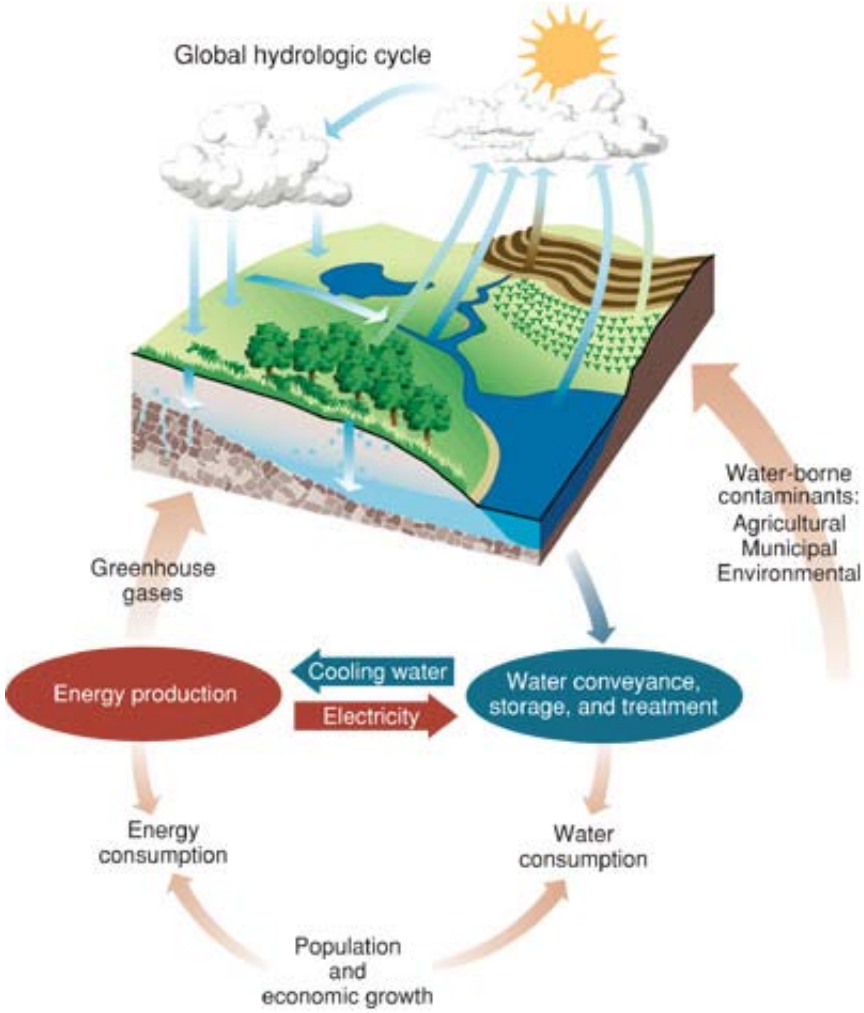
Changes in US Water Demand Since the 1950s



US industrial demand has reduced as a result of outsourcing production to developing nations. In developing nations, industrial and commercial use is increasing.

Source(s): US Department of the Interior

The Water-Energy Nexus



- Water and energy are fundamental elements of economic growth and national security. 5% of the total power production in U.S. is used in supply, treatment and distribution of fresh water.
- These two critical resources are inextricably linked:
  - Water treatment, storage and distribution are dependent on available energy. (20% of California's total energy consumption is for moving water)
  - Energy production is dependent on reliable water supplies.
  - Energy today uses 8% of all fresh water withdrawn annually.[1]

"We cannot build more power plants without realizing that they impinge on our fresh water supplies. And we cannot build more water delivery and cleaning facilities without driving up energy demand. Solving the dilemma requires new national policies that integrate energy and water solutions and innovative technologies that help to boost one resource without draining the other."[2]

Source(s): 1. *Science & Technology Review*; 2. *Scientific America*, 2008; Energy Vision Update 2009; Thirsty Energy, Water and Energy in the 21st Century

Natural Tension Between Energy Production and Water

- Overall, Americans consume massive quantities of water to generate energy, and consume massive quantities of energy to deliver clean water.
- The tension between the two is rising:
  - Water restrictions are hampering solutions for generating more energy, and
  - Energy problems, particularly rising prices, are curtailing efforts to supply more clean water.
- The California Aqueduct, which transports snowmelt across two mountain ranges to the thirsty coastal cities, is the biggest electricity consumer in the state.
  - Such projects are set to increase, as countries that have large populations but limited water resources are considering megaprojects which consume vast energy supplies.
- In addition, local municipalities have to clean incoming water and treat outgoing water, which together consume about 3% of the nation's electricity. Health standards typically get stricter with time, so the degree of energy that needs to be spent per gallon will only increase.
- THEN there are losses that have to be considered including: broken pipes, evaporation, wasteful irrigation methods and no accountability.

Source(s): Scientific American, Aug 2008.

The Value of Water

- The challenge of water scarcity is that water is either available in the wrong place, available at the wrong time, or it is of a quality which is not suitable for drinking or using on crops. It means that communities facing water scarcity have four options:
  - Increase the efficiency of water usage (i.e. promote water conservation and introduce water saving technologies).
  - Access more distant freshwater resources (i.e. build canals or pipelines to access distant catchments).
  - Build more water storage capacity (i.e. build new dams and reservoirs).
  - Draw on lower quality but available water resources (i.e. introduce wastewater reuse or seawater desalination).
  - Or rethink how water is sourced.

- At the root of the problem is the way in which we value and deliver water. The result is that water has been historically very cheap in comparison to other basic necessities.

- What we will see over the next decade is governments realizing that they can no longer finance the growing gap between the cost and the price of water.

WHY DESALINATION NOW?

OPTIONS FOR NEW WATER SUPPLY

Additional water supply for increasing demand can only be obtained through four (4) basic sources:

Finding Additional Traditional Sources of Supply: Rainwater Catchment, Aquifers, Rivers and Lakes/Dams

Environmental drivers and regulations are moving markets away from dams and traditional sources of supply, which have also been significantly impacted by climate change.

Conservation

Consumption elasticity limits the supply potential that can be realized from this option.

Reuse (Wastewater Retreatment)

Political price and infrastructure cost related to adding reuse as an option beyond direct point of use is prohibitive.

Consumer reluctance to consume treated wastewater also hinders this option.

Desalination

Desalination is the only viable, cost-effective source of new water that:

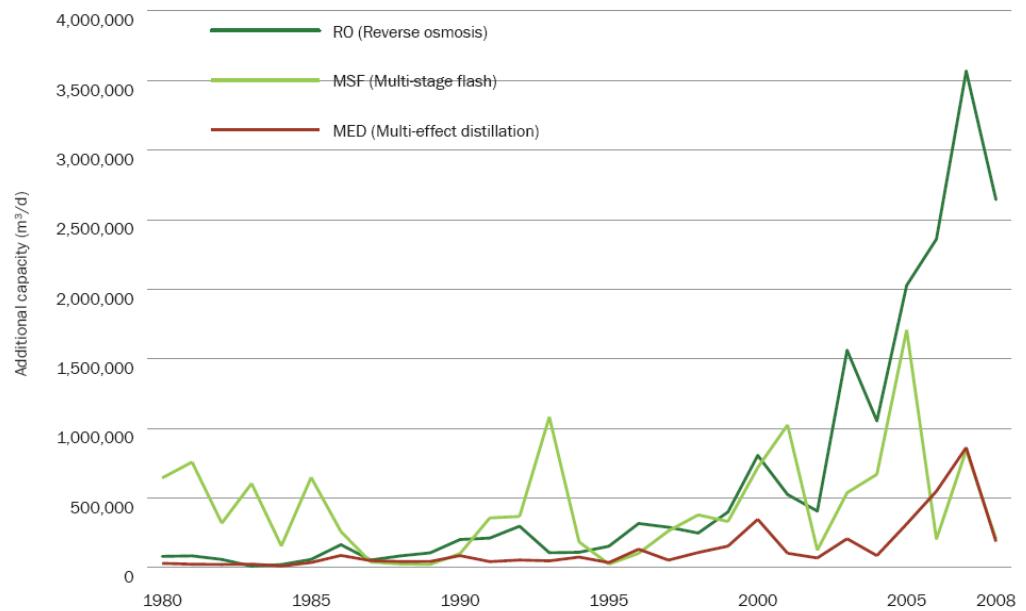
- is drought proof
- is a predictable and scalable source that can be quickly increased to meet demand
- has not been previously allocated to a prior use; no conflicts with agriculture
- is sourced from an inexhaustible supply

Desalination and water treatment is not the only alternative but is now expected to be one of the primary, long-term solutions needed to meet increasing global water needs.

Desalination Process Trends

- Desalination is the process of removing salt and other minerals from water. The process is most commonly used to make seawater or brackish water drinkable, but it can also be applied to obtain ultrapure water that far exceeds drinking water requirements, for certain industrial processes.
- The two primary approaches to desalination:
  - Thermal (raw water is boiled and the vapour condensed as pure water)
    - Techniques include multistage flash (MSF) and multi-effect distillation (MED).
  - Membrane desalination (a semi-permeable membrane is used to filter out the dissolved solids).
    - The dominant membrane desalination technique is reverse osmosis (RO), although nanofiltration (NF), electrodialysis (ED, EDR) and electrodeionisation (EDI) each have niche applications.

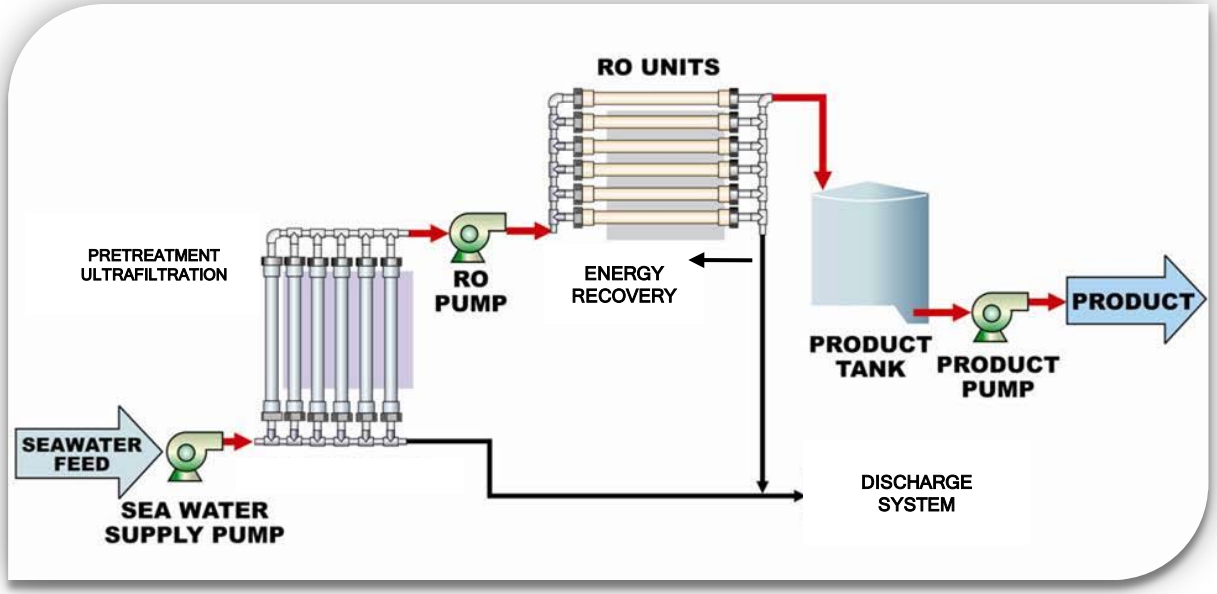
Figure 3.23 Trends in desalination process technology contracted since 1980



Source: GWI DesalData

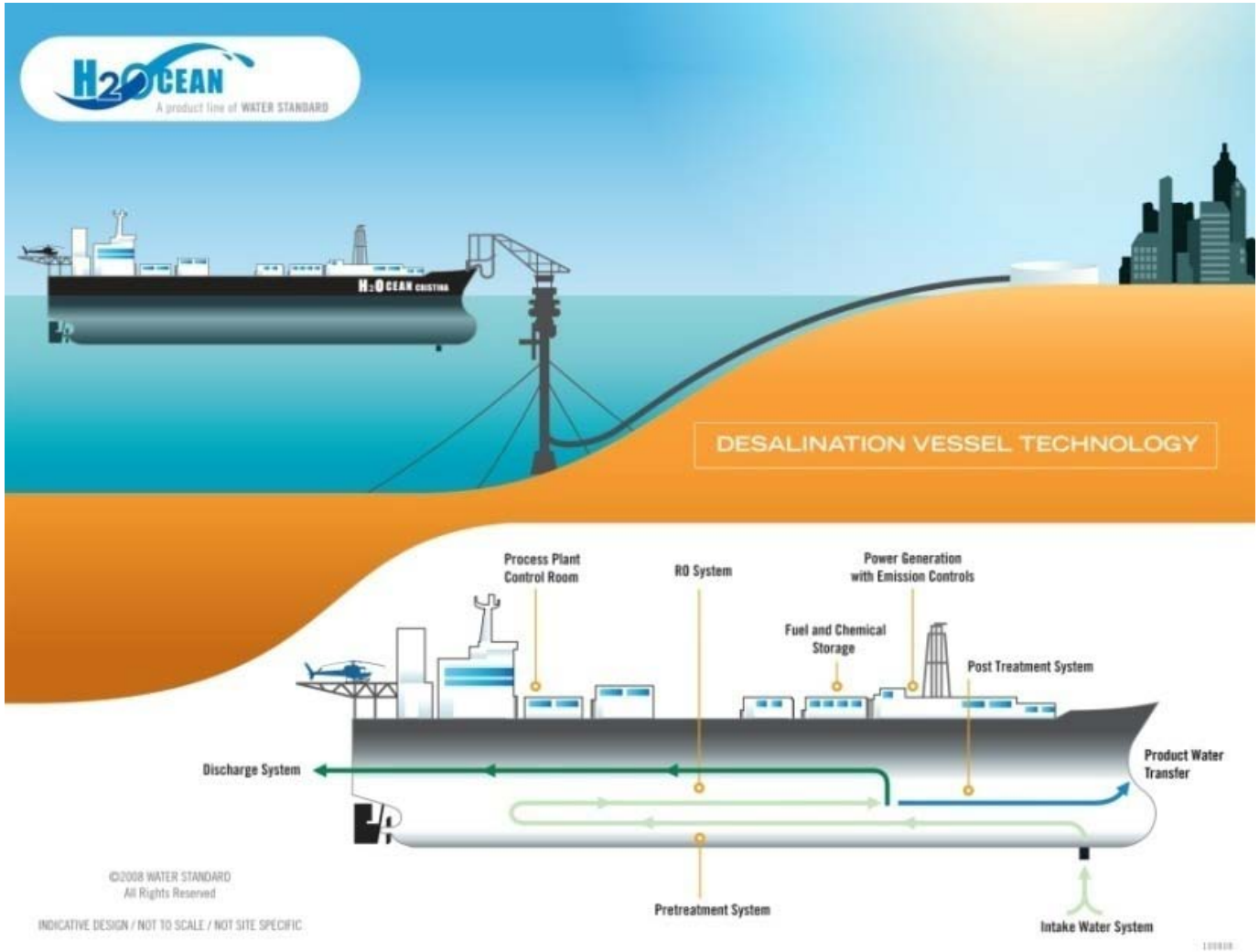
Reverse Osmosis (RO)

- Osmosis is when water molecules in a dilute solution are diffused through a semi-permeable membrane to a concentrated solution until an equilibrium between the substances is achieved
  - Pros:
    - Can be used effectively on sea or brackish water
    - Uses less energy than thermal processes
    - Lower capital costs than thermal plants
    - Requires less feedwater than other methods
  - Cons
    - Extremely dependent on effectiveness of pretreatment
    - Lower product water purity than thermal processes
    - More complex to operate than thermal processes



Water Standard

Seawater Desalination Vessel (SDV)
Water Supply for Onshore Applications



How Would On-Site Reverse Osmosis Work

- Large scale desalination facilities
  - Viable at coastlines
  - Frees up more surface water inland
- Rethink water recycling
  - Smaller scale RO units for industrial and municipal wastewater treatment systems, and for treating brackish water aquifers. MBRs can act as decentralized wastewater treatment systems followed by RO for industrial-grade water supply
- Development of cost-effective, energy-efficient small RO systems
  - Consideration of solar and alternative energy sources to eliminate GHG emissions
  - Eliminating pipes and pumping over large distances
  - Managing concentrate discharge is biggest challenge – universities developing solutions

Conclusion

- We cannot build more power plants without realizing that they impinge on our freshwater supplies. And we cannot build more water delivery and cleaning facilities without driving up energy demand.
- We also cannot continue to accept the inefficiency of our water systems.
- Solving the dilemma requires new national policies that integrate energy and water solutions and innovative technologies that help to boost one resource without draining the other.
- We need to value water. We must move away from a long-standing expectation that water should be free or cheap.
- More than anything, however, we need to re-think the way in which water is sourced and delivered, towards smarter point of use options and a sustainable water footprint.

Source(s): Scientific American, Aug 2008.

Market Recognition and Validation

- WATER STANDARD was honored by Nobel Peace Prize winner and former United States Vice President Al Gore with the “Desalination Deal of the Year” award at Global Water Intelligence’s Global Water Awards Ceremony held April 2009 in Zurich, Switzerland. WATER STANDARD was described as “**redefining an industry”**.

- Preliminary environmental impact assessment (PEIA) studies have been completed by CH2M HILL. According to their report, WATER STANDARD’s vessel designs provide significant advantages over land-based plants, with regard to major environmental concerns such as source water intake, concentrate management and disposal, as well as product water conveyance and overall project construction impacts. "**[WATER STANDARD’s vessel design] clearly has some significant environmental advantages over the land-based seawater desalination project approach."** CH2M HILL, Inc.

- The vessel approach has received positive recognition from the Hopkins Marine Station at Stanford University. Dr. George N. Somero, Director of the Hopkins Marine Station said **WATER STANDARD’s vessel designs and approach promise to “help solve a major human problem – providing pure water to communities in great need of this resource – without inflicting damage on the marine environment**.” Dr. Somero has studied the effects of environmental factors on marine organisms for over four decades and, in recognition of his discoveries, has been elected to the United States National Academy of Sciences.

- WATER STANDARD’s processes have also been featured in a special presentation on worldwide water issues by the **Sundance Channel’s Big Ideas for a Small Planet series** which is recognized for its environmental focus and for “celebrating innovators on the front lines of change”.

- In an October 8, 2007 report, Goldman Sachs & Co. reported, "We consider WATER STANDARD to be one of the **most exciting stories in the global water sector**."

- With a technology such as the [SDV], desalination soon may leave the realm of wishful thinking and become one of **the world's primary means to augment clean, environmentally responsible, reliable global water supplies**," according to an article in the Journal of the American Water Works Association.

- Referring to Australia, Global Water Intelligence reported, "A country where the population is concentrated around the coastline is **ideally suited to the benefits offered by WATER STANDARD's Seawater Desalination Vessel**."

- Judges in the 2007 Global Water Awards called the SDV an **"important new direction in the evolution of the desalination industry.**”

WINNER
Global Water Awards
2009

click here to view

Environmental Review of
Seawater Desalination Vessel™
by Dr. George N. Somero, Ph.D, Director, Hopkins Marine Station, Stanford University

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