Resilient water supply and demand

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Symposium on the Water-Energy Nexus: Holistic Solutions for Climate Change and Resiliency

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BERKELEY LAB
Lawrence Berkeley National Laboratory

Outline

- Global and national water risks
- Water resiliency planning
  - Supply side
  - Demand side
- Future ideas for water supporting energy resiliency

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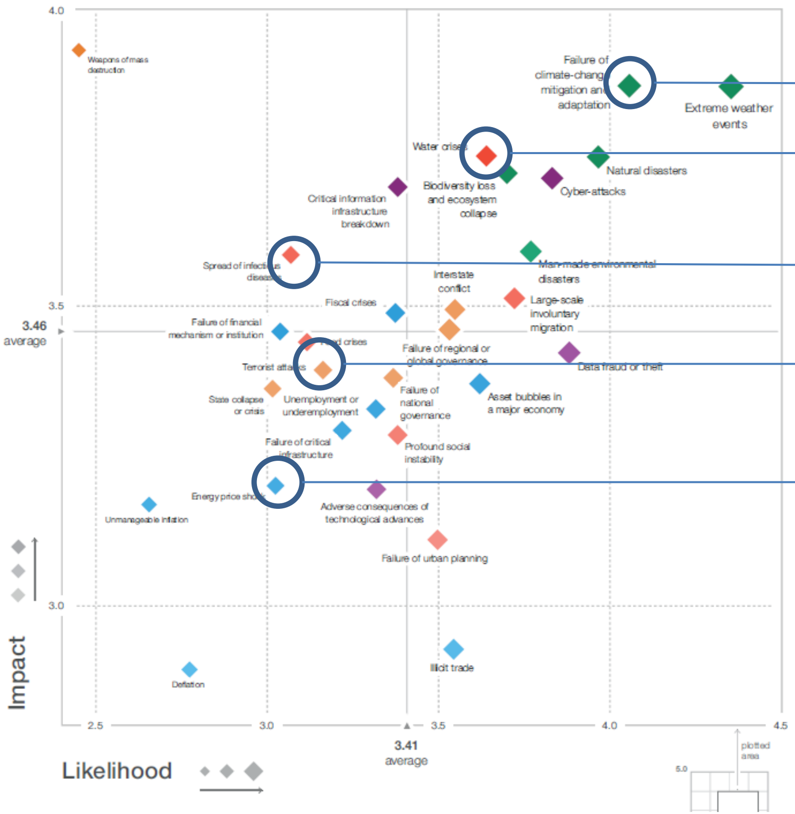
Water Crisis Globally



Climate change

Water crisis

Spread of infectious diseases

Terrorist attacks

Energy price shocks

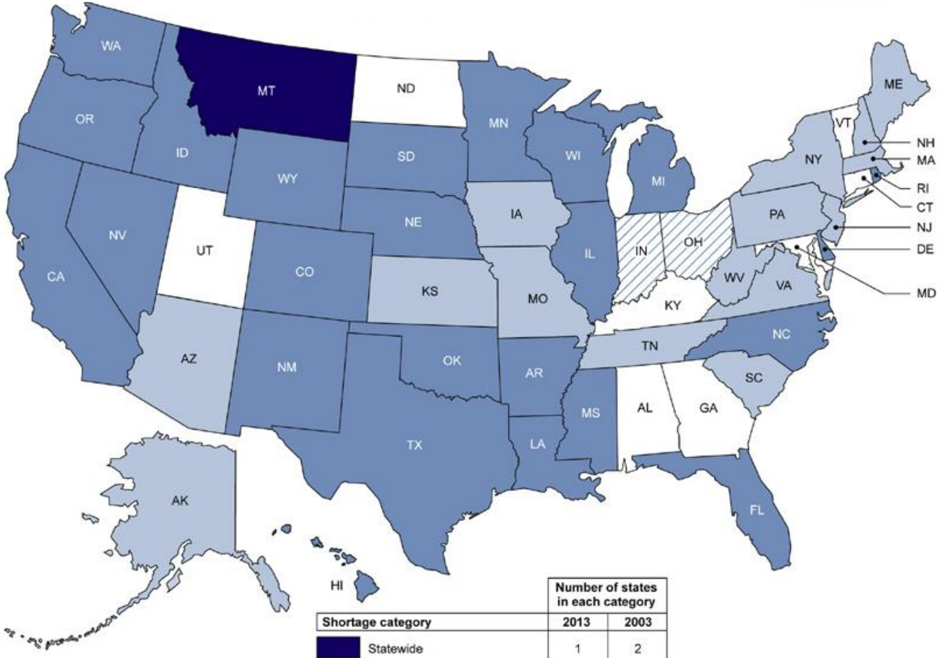
Source: World Economic Forum. 2019. The Global Risks Report. 14th Edition.

Global water crisis by the numbers

- Global water demand is expected to increase by 55% in 2050 over 2000 levels
  - 1.6B → 3.9B living in water stressed areas
- Climate change could lead to a 40% increase in people living in water stressed areas

Organisation for Economic Co-operation and Development (OECD). 2012. *OECD Environmental Outlook to 2050: The Consequences of Inaction.* Paris: OECD.
Schewe J., Heinke, J., Gerten, D., Haddeland I., Arnell NW., et al. 2014. Multimodel assessment of water scarcity under climate change. *PNAS* 111(9): 3245 – 50.

Water Shortages in the US

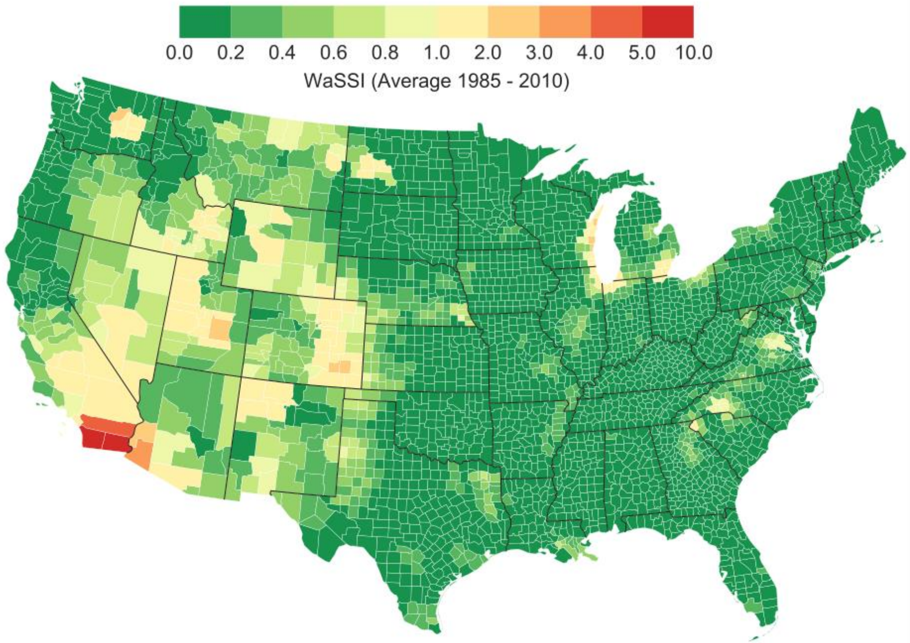


Shortage category	Number of states in each category 2013	2003
Statewide	1	2
Regional	24	16
Local	15	18
None	8	9
No response or uncertain	2	5

- 40 of 48 responding state water planners anticipate water shortages in their state next ten years
- 42 anticipate water shortages in the next 10 to 20 years

U.S. GAO (2014) *Freshwater Supply Concerns Continue, and Uncertainties Complicate Planning.*

Long term water stress in the US



$$WaSSI = \frac{Water\ Use + Water\ System\ Loss}{Surface\ Water\ Supply + Groundwater\ Supply + Return\ Flows}$$

Data from NC State, USDA, USFS. *WaSSI Ecosystems Services Model.*

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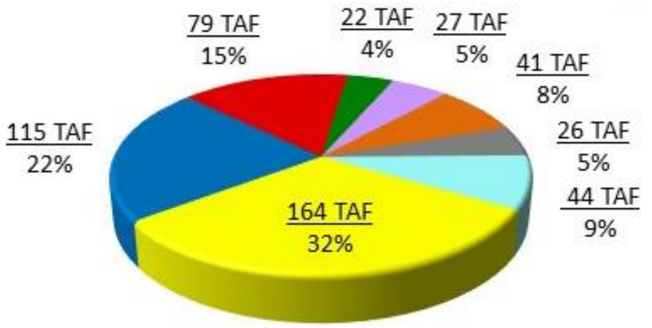
Seawater desalination can provide supply stability

San Diego then (1991, 578 TAF)

San Diego now (2018, 518 TAF)

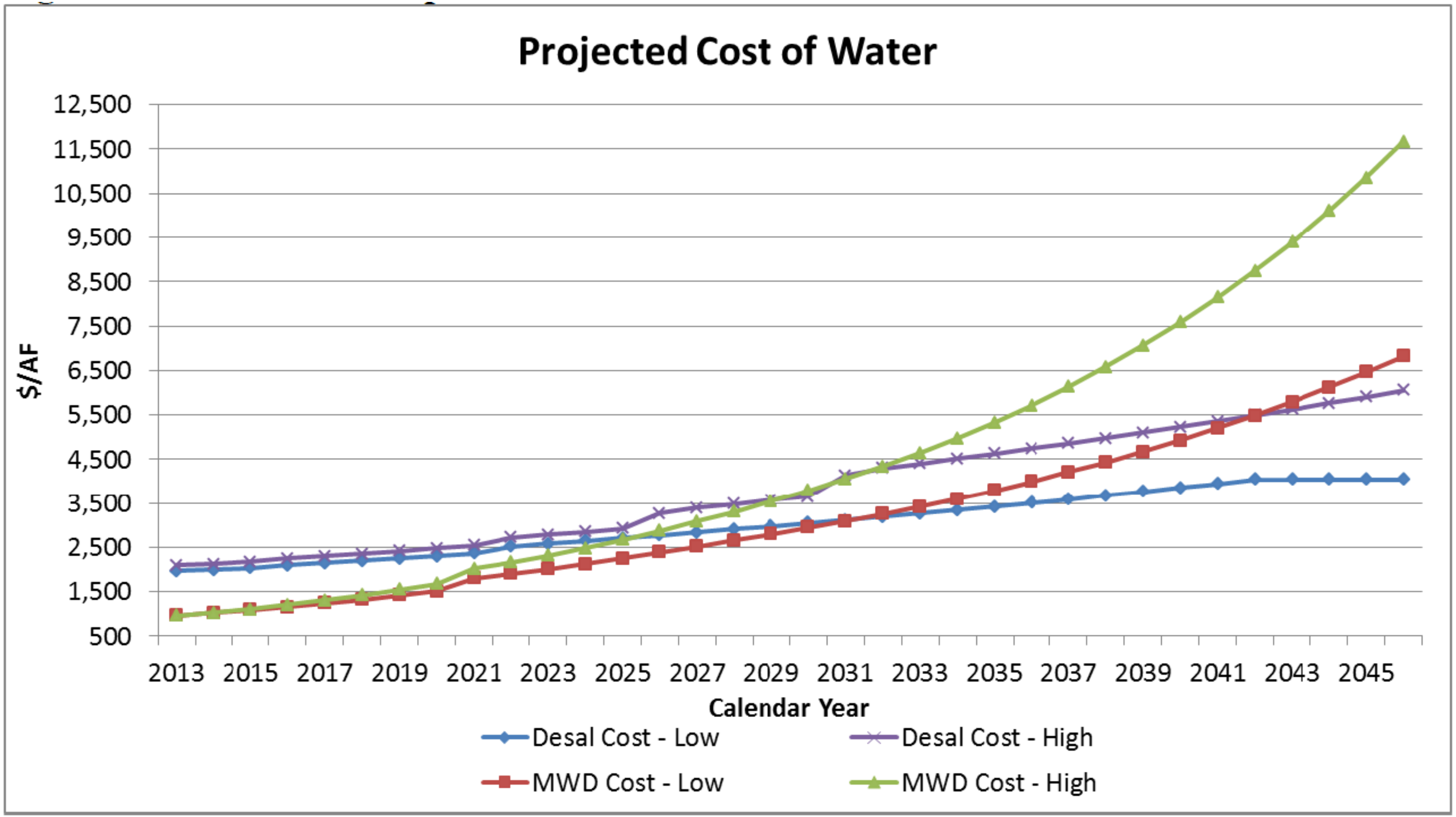


Drought forced MWD to cut supply by 30%

>25% from own sources, including ~10% from SWRO

http://www.sdcwa.org/water-supplies

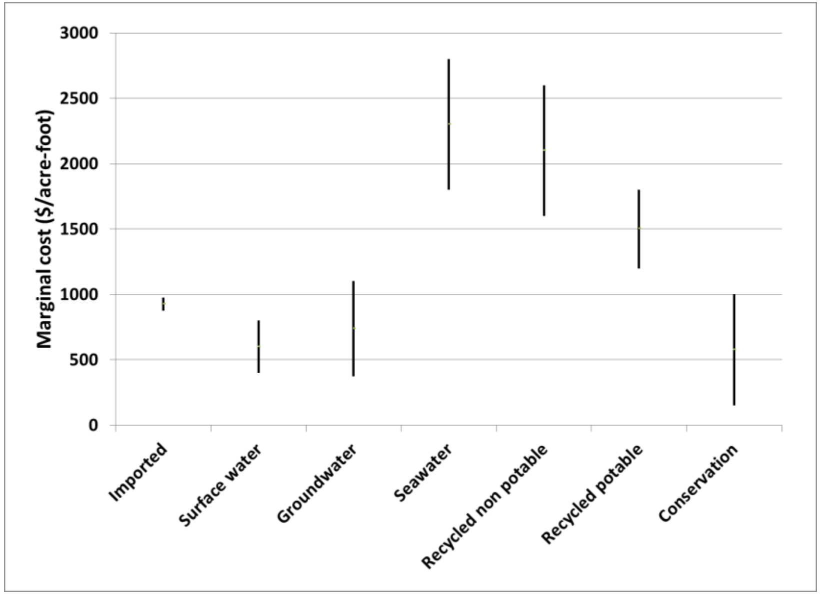
Seawater desalination can provide cost stability



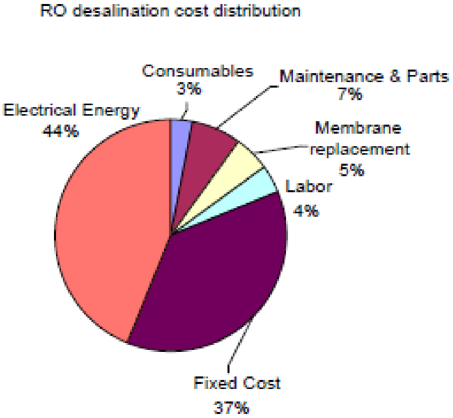
From San Diego Water County Authority Water Purchase Agreement for Claude “Bud” Lewis Carlsbad Desalination Plant, available at: https://www.sdcwa.org/seawater-desalination

Can seawater desalination play a larger role in providing potable water?

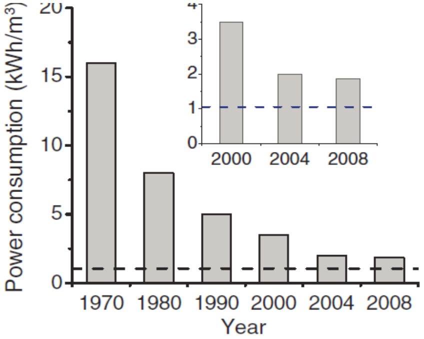
1) Cost of potable water from seawater is relatively high (in the U.S.)



2) Energy is a significant portion of costs..



3) ..in spite of the energy efficiency of RO systems improving over the past 40 years

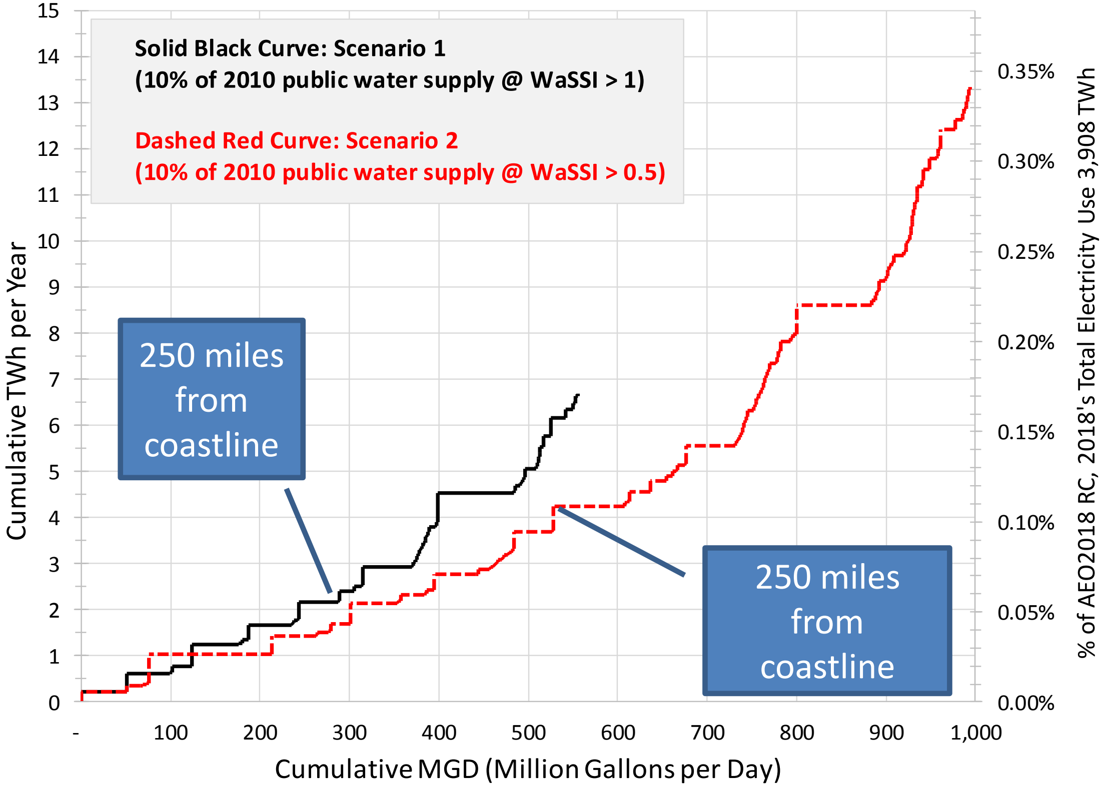


Fermanian Business & Economic Institute. 2010. San Diego's Water Sources: Assessing the Options. Equinox Center.
Public Interest Energy Research (PIER). (2011). *Desalination Facility Design and Operation for Maximum Efficiency.* Water Research Foundation.
Elimelech M, Phillip WA. 2011. The future of seawater desalination: energy, technology, and the environment. *Science* 333(6043):712--17

Potential energy impact under greater adoption of seawater desalination

- Potential impact of greater uptake: Supply 10% of water demand for stressed regions of the continental US with desalinated seawater from U.S. coastal areas
- Evaluated using open ocean intake RO system operating at state-of-the-art conditions (e.g., Carlsbad Desalination Facility) with water demand equivalent to 2010 public water demand (from USGS)

10% of public water supply for water stressed counties



Rao et al. 2018. Energy considerations associated with increased adoption of seawater desalination in the United States. *Desalination.*

For entire US		
	WaSSI > 1	WaSSI > 0.5
Water demand (MGD)	555	994
Total energy requirement (TWh/yr)	6.7	13.3
% of 2018 US electricity consumption	0.2%	0.3%

Context: Water supply is currently ~1% of U.S. electricity consumption; food processing uses 73 TWh; primary metals uses 134 TWh

Further considerations

Whole System Economic and Operational Characteristics							
Fixed cost ($)	Construction	Siting	Permitting	Land Use	Equipment	Construction time	
Variable cost ($)	Labor	Chemicals	Maintenance	Parts	Disposal		
Energy cost ($)	Electricity	Natural gas	Steam				
Operational characteristics	Water quality	Flow rates (m^3/day)	Temperature (°C)	Pressure (kPa)	Energy (kWh)	Chemicals	Brine (m^3/day)
	System lifetime	Modulation capability	Operation when under loaded	Capacity Factor	Availability (hours/year)	Operability with other components	Water recovery (%)

Water In

Salinity/TDS (ppm)
TOC (ppm)
TSS (ppm)
pH
Marine life
Required flow rate (m^3/day)
Temperature (°C)
Pressure (kPa)
Distance to plant (km)

Non-potable water for dilution

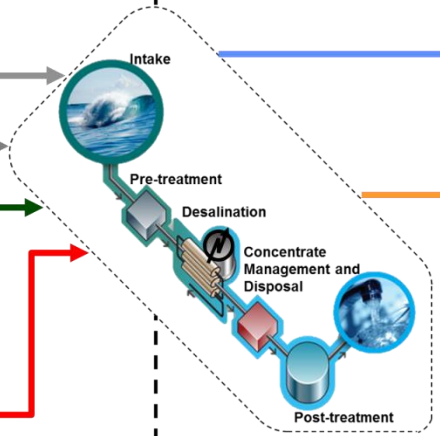
Chemicals Used/Added

- Pretreatment chemicals (ppm)
- Disinfection (ppm)
- Re-mineralization (ppm)
- Adjustment for taste
- Cleaning chemicals (ppm)

Energy Intensity

(Energy/Volume of water produced ($kWh_{T,equiv}/m^3$))

- Electricity (kWh_e/m^3)
- Equivalent electrical energy for:
  - Direct heat ($kWh_{e,equiv}/m^3$)
  - External waste heat ($kWh_{e,equiv}/m^3$)
- Temperature of the direct or external waste heat (°C)



Source: Circlepoint (http://www.scwd2desal.org/Page-Desal_Tech.php)

Water Out

EPA drinking water requirements
Flow rate (m^3/day)

To Water Storage

To Discharge

Contaminant concentration (ppm)
Chemicals (ppm)
Contaminant type
Discharge location

- Seawater: surface, subsurface ocean discharge.
- Inland brackish water: rivers, evaporation ponds, land use, injection, Zero Liquid Discharge

Fresh water
Feed water
Chemicals
Energy
Concentrate/Waste
Energy/Pressure Recovery Opportunity

Whole System Environmental Considerations	
Emission intensity (tCO_2/m^3)	• CO_2 emissions (tCO_2/m^3 of freshwater produced)
Other	• Marine life • Concentrate disposal • Consumables disposal and chemical use/disposal • Electric grid impact • Water system integration • Co-location with power generators

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Water management

Benefits

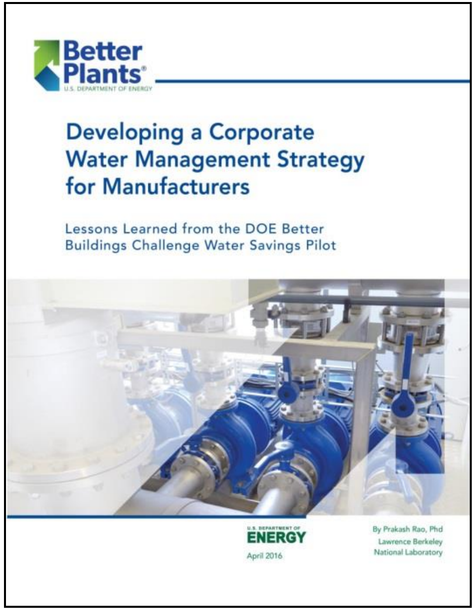
- Operational resiliency
  - 2015 CDP Water Report: Respondents from the Industrial and Consumer Staples sectors ranked the US as a top country for facilities at risk of water related issues
- Allows for growth and planning
- Cost savings
  - Not just water, but energy, chemicals, regulatory costs too
- Improved public image
- Helps EE program

Challenges

- Resources and technical assistance not widely available
- Water efficiency and management principles are less developed and promoted than energy efficiency and management principles
  - Less financial incentive to invest and/or reduce
  - But plenty of other drivers: regulation, business risk, community access,
- Lack of data

Observed Corporate Water Management Strategies

- 7 companies shared their water management strategies with DOE
- Topics addressed include:
  - Making the business case for water saving projects
  - Facilities and water sources on which to focus initial efforts
  - Establishing baselines and targets
  - Water efficiency measures implemented



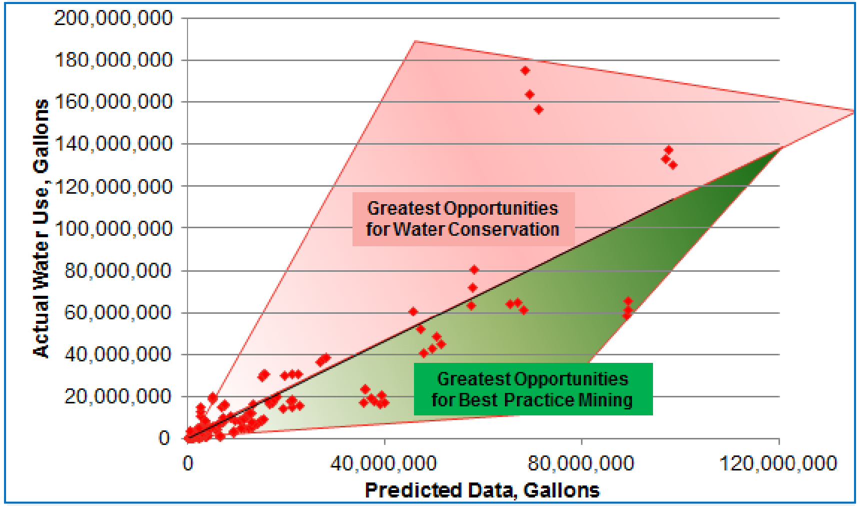
Available at: https://betterbuildingssolutioncenter.energy.gov/resources/corporate-water-management-strategy-manufacturers

Making the business case

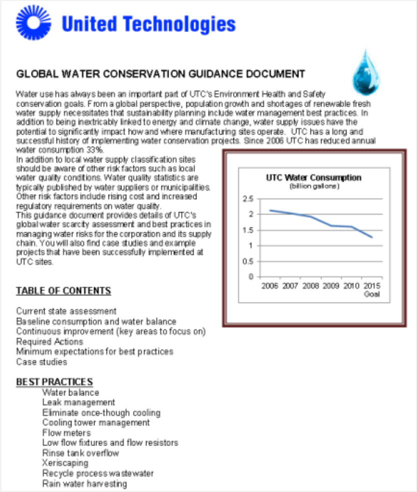
- Implement low or no cost actions (e.g. leak repair)
- Realize water savings as an ancillary benefit
- Connect water and sustainability programs
- Consider avoided risk, water availability concerns, local regulations when considering projects
- Use the "True Cost" of water: water volume, energy, chemicals, business risk, maintenance of equipment
  - Cummins calculated true cost to be 3-5x billed water costs
  - 10-12x for high energy/water intensive operations

Focusing initial efforts: Facilities

Cummins water performance index



UTC Global Water Conservation Guidance Document



United Technologies

GLOBAL WATER CONSERVATION GUIDANCE DOCUMENT

Water use has always been an important part of UTC's Environment Health and Safety conservation goals. From a global perspective, population growth and shortages of renewable fresh water supply necessitates that sustainability planning include water management best practices. In addition to being inextricably linked to energy and climate change, water supply issues have the potential to significantly impact how and where manufacturing sites operate. UTC has a long and successful history of implementing water conservation projects. Since 2006 UTC has reduced annual water consumption 33%.

In addition to local water supply classification sites should be aware of other risk factors such as local water quality conditions. Water quality statistics are typically published by water suppliers or municipalities. Other risk factors include rising cost and increased regulatory requirements on water quality.

This guidance document provides details of UTC's global water scarcity assessment and best practices in managing water risks for the corporation and its supply chain. You will also find case studies and example projects that have been successfully implemented at UTC sites.

TABLE OF CONTENTS

BEST PRACTICES

- Water balance
- Leak management
- Eliminate once-though cooling
- Cooling tower management
- Flow meters
- Low flow fixtures and flow resistors
- Rinse tank overflow
- Xeriscaping
- Recycle process wastewater
- Rain water harvesting

Establishing baselines and targets

Driver	# of partners (out of 7)
Regulation of water consumption and use	2
Overall cost of water	3
Energy benefits from water reduction	5
Availability of suitable water supplies	4
Risk associated with lack of access to water	4
Environmental stewardship/corporate sustainability	7
Other	3

“Other” included costs and risks associated with wastewater and business continuity

Data collection methods

- Observed data collection methods
  - Meters for billed sources
  - Combination of estimation techniques and meters for other sources
- Most data collection occurred at the facility level
- Water use at the end-use level generally not tracked

Water use Category	Applicable to company (out of 7)	Able to track or estimate usage volume (out of 7)
Production and in-product use	5	3
Auxiliary processes (e.g., pollution control)	3	0
Cooling and heating (e.g., cooling towers and boilers)	6	2
Indoor domestic use (e.g., restrooms, kitchens, laundry)	6	1
Outdoor (e.g., landscape irrigation)	4	1

Water efficiency measures

Type of Measure	Examples of Type of Measure
Leaks	▸ Leak detection and correction
Monitoring and controls	▸ Adjustment on control valves to improve water efficiency ▸ Automate controls on continuous flow streams ▸ Change faucets to auto type faucets ▸ Install low flow fixtures ▸ Install automatic shutoff valves ▸ Implement procedures to monitor and adjust the flow on water cooled equipment ▸ Monitor water quantity and quality ▸ Monitor cooling tower cycle of concentration
Recycle/reuse	▸ Eliminate once through cooling, including installing closed loop chillers ▸ Recycle non-contact cooling water ▸ Modify existing equipment to eliminate non-contact water cooling ▸ Clean and recirculate treated contact water ▸ Install semi-closed loop water system ▸ Reuse process water, including capturing formerly discharged cooling tower wastewater for use in a recirculating chilled process water loop system.

Water efficiency measures cont.

Type of Measure	Examples of Type of Measure
Substitute water	▸ Replace water with other coolants (i.e. air and antifreeze in a closed loop circuit) ▸ Replace water cooled compressors with air cooled compressors ▸ Replace water cooled chilled water system with air cooled system ▸ Install air cooled systems in place of non-contact cooling water ▸ Replace water cooled vacuum pumps with air cooled units ▸ Install waterless urinals throughout the facility
Training	▸ Increase water usage awareness throughout the facility ▸ Train operators in the most water efficient procedures
Water storage	▸ Design of rinse tank overflow systems ▸ Install rain water harvesting system ▸ Capture and store water during facility shutdowns for future use, instead of discharging to sewers

Thank you!

Collaborators on desalination analysis

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