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Special Report

The End of Wasted Water

A Revolution in Reuse Is Underway

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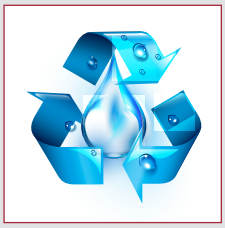
INTRODUCTION



The End of Wasted Water: A Revolution in Reuse Is Underway

Freshwater has been so plentiful for so long that we have taken it for granted. Today, we use more water than ever before — to quench our thirst, grow our food, power our industries and dispose of our waste. Until recently, in geologic terms, we have been able to wait for nature to recycle our wastewater back into usable freshwater. No more. As a species, we'll have to learn to use our technology and political will to put an end to wasted water.

This special report picks up where the February 27, 2019 conference, "Resource Revolution of Water Reuse," left off, exploring the scope of the global water crisis and the possible ways forward.

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Global Water Stress and What Can Be Done About It

BY 2050, AN ESTIMATED 9.7 BILLION PEOPLE WILL INHABIT THE EARTH. According to a 2014 report from MIT, "The Future of Global Water Stress," more than half (52%) of them will be living in regions experiencing water scarcity. (Watersheds are considered stressed when the demand from power plants, municipalities and agriculture exceeds 40% of available supply, reports the U.S. Global Change Research Program.)

The situation is already dire. More than 40% of the world's population is affected by water scarcity now. The World Resources Institute (WRI) said in a 2019 report that 17 countries are currently under "extremely high" water stress, using almost all of their resources. Among global cities with populations above three million, WRI said in the report that 33 (with a combined population of more than 255 million) have severe water problems.

According to United Nations figures, "Over 1.7 billion people are currently living in river basins where water use exceeds recharge." And growing population and economic growth are driving an additional 1.8 billion people into mainly urban water-stressed areas — 80% of them in developing countries.

By 2025, 3.5 billion people could face water scarcity. And by 2040, WRI reports, the crisis will have accelerated to such a degree that 33 countries will be facing extremely high water stress. Many of these countries are in the Middle East, but seven countries are tied for the most water stressed: Bahrain, Singapore (which recycles drinking water from waste), Kuwait, Qatar, San Marino and United Arab Emirates. Turkey, Greece, Chile, Armenia and Macedonia are also on the list.

The United Nations recognized access to water as a basic human right in 2010, but 2.1 billion people live without clean drinking water now, and 4.5 billion lack adequate sanitation, according to the U.N. World Health Organization (WHO) and UNICEF Joint Monitoring Programme in 2017. Some 2.3 billion lack even basic sanitation services.

> "As many as 1.6 million people, 350,000 of them children, die annually of avoidable water-borne diseases."
>
> — Steven N. Schonberger, director, water global practice, World Bank

"As many as 1.6 million people, 350,000 of them children, die annually of avoidable water-borne diseases," said Steven N. Schonberger, director of the World Bank's water global practice, speaking at "The Resource Revolution of Water Reuse" conference hosted by Wharton's Initiative for Global Environmental Leadership (IGEL) and Suez — a global water resource management firm — in February, in San Francisco. And water scarcity could cost some regions up to 6% of their GDP. Just learning to manage water better can have a huge effect on the overall welfare of a country's people." The UN confirms Schonberger's figures, estimating that preventable water and sanitation-related diarrheal diseases kills 1,000 children a day.

Global agriculture and the ability to feed the world's people are also threatened. The *Guardian* reported in 2015 that some 600 million people live in the vast area from eastern Pakistan to Bangladesh, which is among the most intensely irrigated land in the world. "Up to 75% of farmers rely on pumped groundwater to water their crops and water use is intensifying—at the same time that satellite images show supplies are shrinking alarmingly."

According to Jon Freedman, senior vice president of global government affairs for Suez's water technologies and solutions business, we are only scratching the surface of treating wastewater to address water scarcity: "Even though we are seeing increasing scarcity in many parts of the world, collectively we're only reusing 3% to 4% of the world's wastewater. And if you look here in a wealthy country like the United States, the number is only 8% to 10%. So, in effect, we have a huge reservoir of untreated wastewater that we can tap into and treat so that it can be used to do things like grow crops, run power plants, and fill drinking water reservoirs."

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— Jon Freedman, senior vice president, Suez

NOT JUST SCARCITY

According to CNBC, just 2.5% of the world's water is fresh, and only 1% is accessible to the global population. Of the 3,359 cubic miles of freshwater that is accessible, only a third is actually being used. That means there's enough water on the planet, but geographic and social distribution is very unequal — some people have more water than they need, and others have far less.

According to the World Water Council's 2000 Vision Report, "The crisis is not about having too little water to satisfy our needs. It is a crisis of managing water so badly that billions of people —and the environment — suffer badly."

With inequality and scarcity will come conflict — and considerable population movement and human suffering. Water theft — sometimes by secretly and illegally tapping into reservoirs and pipelines — has occurred on a large scale in India, Brazil and Mexico, CNBC said. According to Richard Damania, the World Bank water global practice lead economist and author of the "Uncharted Waters" bank report, "If we don't take deepening water deficits and the bigger and more frequent storms that climate change will bring seriously, we will find water scarcity spreading to new regions of the world, potentially exacerbating issues of violence, suffering and migration. Current methods for managing water are not up to the challenge."

The coming era of water scarcity sits beside climate change as a major global problem. At the conference, Charles Iceland, director of global and national water initiatives at WRI, showed maps with areas of acute stress — such as Australia, Mexico and Central America, the Middle East, northern Africa — in bright red.

"Some places have seasonal stress, and some have the opposite problem — too much water, which can lead to severe flooding as in Pakistan," Iceland said. "We're seeing increased flooding risk, more coastal storm surge risk indicators and drought, because climate change is already taking a bite out of rainfall. Australia just had its worst drought in 1,000 years, and after it ended there were catastrophic floods, then bouts of drought and flood. China is losing groundwater, and much of its water is contaminated. Four million people in Cape Town, South Africa have experienced severe drought, and they are contemplating Day Zero when they have to turn off the taps. Sao Paulo, Brazil also experienced its worst drought on record."

In the U.S., much of the Southwest, the western Great Plains and parts of the Northwest experience widespread chronic water stress, and regions as diverse as South Florida and New York City have experienced sea-level rise, flooding and contamination of freshwater sources.

Climate change is a growing part of the problem. In an interview after the conference, Rich Henning, senior vice president of Suez North America, said, "Most people don't realize that four billion people will experience severe water stress, and the situation will worsen with climate change."

His point was dramatically highlighted in a recent *New York Times* article. "Countries that are home to one-fourth of Earth's population face an increasingly urgent risk: The prospect of running out of water," reported the *Times*. "Climate change heightens the risk. As rainfall becomes more erratic, the water supply becomes less reliable. At the same time, as the days grow hotter, more water evaporates from reservoirs just as demand for water increases."

The 2017 UN report "Uncharted Waters: The New Economics of Water Scarcity and Variability," sees a vicious circle of geographic feedback loops. "With population growth, water scarcity will proliferate to new areas across the globe," the report said. "And with climate change, rainfall will become more fickle, with longer and deeper periods of droughts and deluges."

INDUSTRY IS PAYING ATTENTION

"At Suez, we have more than 50,000 industrial customers around the world. I can tell you that many of them are increasingly concerned about how water scarcity will impact their operations," said Freedman.

Human consumption represents only 12% of total water use, according to Barclays Investment Bank. But as business and industry expand, the human need for water is increasing dramatically. "In the past 100 years, world population tripled, but water use for human purposes multiplied six-fold! Today perhaps half of all available freshwater is being used for human ends — twice what it was only 35 years ago," reports the World Water Council's Vision Report. Industry and agriculture account for a large share of global water use. The sector that uses the most water is thermoelectric power generation (42% of commercial use), followed by irrigation (32%).

The Columbia Water Center reports, "Industrial supply chains may have more water risk due to climate variability. Reliance on imported river water or mined groundwater hides the true risk to supply chains through the communities which share water supplies. It is important to expose the underlying water stress in the face of spatial competition for existing water resources."

According to WRI's Iceland, "Fortune 500 companies — including Coca-Cola, Mars, Walt Disney and Ikea — have realized that water risks and scarcity are serious. They're conducting water-risk assessments of direct operations, studying their supply chains — including their agricultural suppliers' water and fertilizer use — and developing water stewardship strategies."

WRI developed Aqueduct, a global water risk-mapping tool for companies, investors and governments, and it's used regularly by Bloomberg on its terminals, by the International Energy Agency, by global corporations, NGOs and universities.

Only 20% of the companies disclosing data to CDP Water, a nonprofit group that tracks corporate water use, say they fully understand their water risk. WRI outlines five recommended water-related actions that corporations can take: invest in data, but don't leave it in a silo — analyze and disclose it; set priorities (as Mars did with its Water Stewardship Position Statement and Nestlé with its Siting Framework) for internal and external action; incorporate water planning into the corporate growth strategy (as PG&E, Coca-Cola and Unilever do); embrace innovation; and integrate water stewardship into company culture (as General Motors does).

Michael Ferrari, founder of Atlas Research Innovation, said at the conference, "If we do water-risk management the right way, we will recognize and understand the full amount of water exposure for the world's companies. There is not one area of commercial activity that is not affected by water."

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TOWARDS A SOLUTION

Traditional approaches play an important role in resolving the world's water crisis, including elimination of polluted discharge into water bodies; water conservation (eliminating leaks, using water-saving appliances) and drought mitigation (efficient irrigation is one tool); and capturing and storing rainwater before it can evaporate. All these solutions are being applied, but the scale needs to increase exponentially, and it is becoming increasingly clear that recovering wastewater will be key.

The World Bank, Schonberger said, has $29.12 billion in its water global practice portfolio, which it's using to "help the developing world get up to speed" on water and water reuse. Africa alone, with severe water problems, is allocated more than $7 billion of the total. Other forms of financing are also needed, according to the World Water Reserve (WWR), such as water credit investments, via government and public-sector organizations, plus micro-credit and private funding.

"We need to go beyond conventional thinking," Henning said at the conference. "We take water from rivers, lakes and aquifers, and treat it to be safe for drinking, and after it's used, it flows down the drain or toilet and is lost as a source of drinking or non-potable water. We've had the technology to use treated wastewater for drinking, irrigation or industrial uses for three decades, and it's our best solution to help cities meet their water demand."

Technology exists today to enable water reuse for various applications. Depending on the water source, the desired outcome and how much water is needed for

reuse, technology can be combined to create specific water reuse goals.

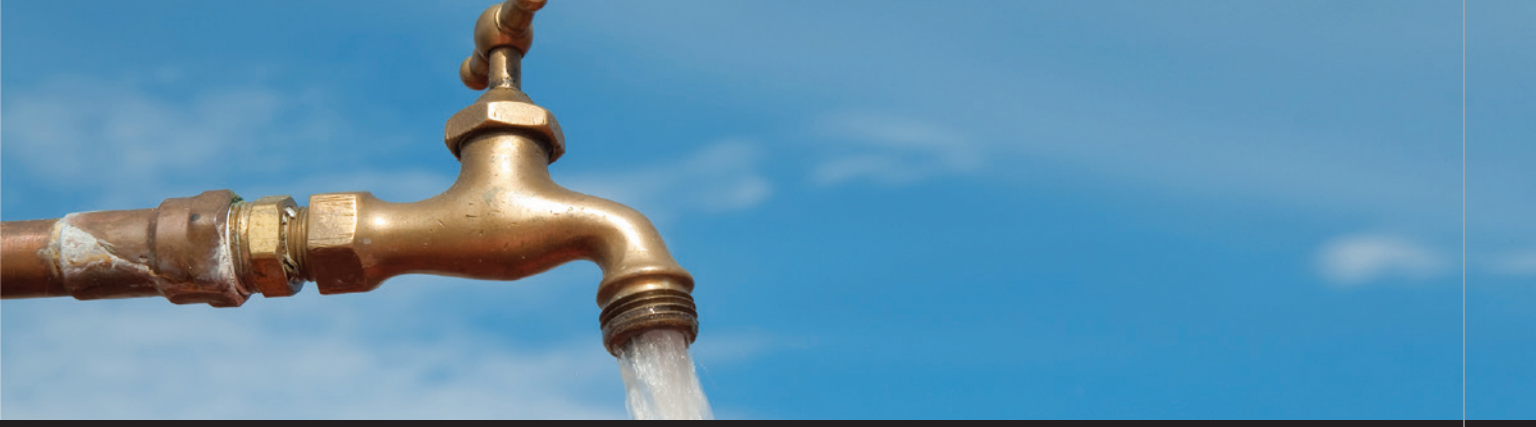
Membrane bioreactor technology continues to be a primary building block for water reuse applications. It is great for plants that don't have a large footprint, because it allows for upgrades in existing tanks. Reverse osmosis is often part of the treatment train for high-quality reuse water due to its efficiency in removing salinity and many inorganic and organic contaminants. It also provides a barrier for pathogens. Electrodialysis removal is gaining momentum for streams with brine challenges. This technology is a great option for any wastewater stream that needs total dissolved solids (TDS) removal prior to reuse. It has a high recovery and low fouling tendency.

As potable water reuse becomes more of a possibility globally, we are seeing an increase in the level of monitoring. Ozone and UV are both used in the advanced treatment process for potable reuse applications.

For even tougher-to-treat waters, like produced water, zero-liquid discharge technology can achieve around 98% water reuse.

Howard Neukrug, executive director of the Water Center at the University of Pennsylvania, said in an interview that wastewater recovery operations have proceeded, with various degrees of public acceptance, from "sewage treatment" and "water pollution control plants" to the currently popular "resource recovery" operations. Today, he said, we need to see these facilities as "the utilities of the future."

Henning cautions that "investing in any water project is a complex decision, with benefits that extend many years into the future." That's undoubtedly true, so it is important for governments, NGOs and the private sector to unite around such complex decisions, if we are to avoid the worst effects of the global water crisis.



Water Reclamation from Waste — How Does It Work? How Can It Grow?

"WE HAVE TO BE SURE WE'RE OPTIMIZING ALL OF OUR WATER ASSETS," said Tracy Mehan, the American Water Works Association (AWWA) executive director for government affairs. "I think it is doable. There's no such thing as wastewater, just water that is wasted. And direct reuse is the Holy Grail."

He made his comments at the "Resource Revolution of Water Reuse" conference organized by Wharton's Initiative for Global Environmental Leadership (IGEL) and sponsored by Suez — a global water resource management firm — in February, in San Francisco

Howard Neukrug, executive director of the Water Center at the University of Pennsylvania, said that climate change and the water crisis are "intertwined" but the solutions are vastly different, and equitably distributing freshwater supplies and reclaiming our wasted supplies are not insurmountable problems. "From my perspective as a water engineer we are on the cusp of solving our water problems. We have the technology, and it has become more efficient over time. World water stress is brought on by a crisis in governance and funding, rather than technology. And you can't say that about climate change."

The technology is mostly idle. Globally, 80% of all wastewater is discharged without treatment back into rivers, lakes and oceans. In developing countries, only 8% of water is treated at all. And even when it does receive treatment, most of it goes unused.

"Recovering water, energy, nutrients and other precious materials embedded in wastewater is an opportunity for cities to transition to the circular economy and contribute to improved water security," according to the 2017 report, "Wastewater: The Reuse Opportunity," published by the International Water Association (IWA) and the OPEC Fund for International Development.

Water reuse "is the way of the future for cities that want to continue to grow said Pat Sinicropi, executive director of the WateReuse Association, at the conference. "In the age of climate change, there is no alternative."

THE BARRIERS

Reliable data is one obstacle to the further growth of water reuse. A 2013 study from Japan's Tottori University and the United Nations University's Canada-based Institute for Water, Environment and Health examined 181 countries around the world, and found that only 55 had information on three key components of wastewater — generation, treatment and reuse. Only 69 countries had data on one or two of those areas, and 57 had no information at all. And even when data does exist, it's outdated — 63% was five or more years old.

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>
> — Howard Neukrug, executive director, Water Center, University of Pennsylvania

Other barriers to greater water reuse include a lack of clear standards and concern about safety, said Jon Freedman, senior vice president of global government affairs for Suez's water technologies and solutions business. "But economics is the greatest barrier. It's easier for business and municipalities to continue taking water from the ground or from rivers, where it might be free, or from a potable source, where it's almost always

underpriced," Freedman said. He added that the status quo simply puts no pressure on major water users. "There's no price signal of stress," he said.

The challenge of water pricing is as daunting as it is long-standing. Dave Ross, assistant administrator for the office of water at the Environmental Protection Agency, said at the conference, "When the drivers go away, we regress to the mean. We talk about integrated planning, but we don't do it. We just don't think we should have to pay for water."

> **"When the drivers go away, we regress to the mean. We talk about integrated planning, but we don't do it. We just don't think we should have to pay for water."**
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> — Dave Ross, assistant administrator, EPA

Consumer pressure is absent, because water is currently so inexpensive. Robert Glennon, a water expert at The University of Arizona told *The Atlantic*, "We Americans are spoiled. We wake up in the morning and turn on the tap and out comes as much water as we want for less than we pay for cellphone service or for cable television. So we take water for granted."

According to Heather Cooley, director of research at the Pacific Institute, also at the conference, "We need to move toward full pricing for water. But we also need to take care of the people who couldn't afford full pricing. We see water reuse as one of the solutions, along with efficiency and storm water recapture."

Full-cost pricing "is an aspirational goal," said Mehan, who pointed out that increasing the price of water is painful to elected officials. "It's like root canal for them," he said.

"Right now, we have more than 50,000 drinking water systems in the U.S., and for the most part the rates are set at the city council level," Freedman said. "It's hard to simply throw a switch and have instant water reform. To achieve full-cost pricing for water, we need leadership from the federal government. In some countries outside the U.S., water tariffs are set at the federal level, and it is an easier fix."

MOVING AHEAD GLOBALLY — BUT SLOWLY

Despite all this, water reuse is on the rise, however incrementally. According to IWA, the world market for wastewater recycling and reuse neared $12.2 billion in 2016, and could reach $22.3 billion by 2021.

"The adoption of membranes for water filtration started small," said Steve Katz, market development manager of Suez water technologies and solutions, at the conference. "It was decentralized and small scale, for flushing toilets and irrigation. But the costs have come down and the benefits are enabling larger and larger facilities. We're seeing large projects in Kuwait and other countries. We're not making any new water, so reuse has grown in importance."

Ferrari said at the conference that engineers can be bad communicators, and that water reclamation needs to be properly "framed" and explained to consumers, especially if it involves converting waste to augment drinking water. That case was successfully made in water-scarce Singapore, where bottled Newater reclaimed from waste is widely accepted for drinking.

According to Singapore's water utility, "Today, there are five Newater plants supplying up to 40% of Singapore's current water needs. By 2060, Newater is expected to meet up to 55% of Singapore's water demand." Among other things, the government opened the Newater Visitor Centre, a water museum "to showcase our journey towards water sustainability."

Israel (70% desert) is also a showcase, recycling nearly 90% of its wastewater for irrigation.

Australia, plagued by droughts, has adopted guidelines for adding to its drinking water supplies from reclaimed sources. According to those guidelines, "Treated reclaimed water is now widely regarded as a resource available for use, rather than a waste requiring disposal. With the protection of public health as an overarching principle, beneficial uses of reclaimed water should be encouraged where it is safe, practicable and economic to do so."

In the water-scarce region of Brazil, the predominant use of recycled water is for agricultural irrigation, with 10% being used in environmental projects such as increasing river flows.

U.S. PROGRESS SLOWER

The National Research Council (NRC)'s 2012 report "Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater" concludes, "Approximately 12 billion gallons of municipal wastewater effluent is discharged each day to an ocean or estuary out of the 32 billion gallons per day discharged nationwide. Reusing these coastal discharges would directly augment available water resources (equivalent to 6% of the estimated total U.S. water use or 27% of public supply)."

Reusing wastewater for non-potable use is not a new idea, but it was slow to spread. Sewage effluent was used for cooling at water-intensive power plants in the 1970s. Today, treated supplies (with the advantage of very consistent quality and temperature) are used at 70 U.S. generating sites. But there are 8,652 power plants of one megawatt or more in the U.S. A University of Pittsburgh study discovered that an incredible 97% of new power plants could meet their water needs with treated sources located within 25 miles of the facility.

The cost of treating wastewater for agriculture through the installation of simple disc filtration (often used in irrigation, it forces water through narrow gaps that capture small particles) ranges from $500,000 to $1 million, reports *Power* magazine. Ultrafiltration for industrial use has proven very effective. The cost is sometimes an obstacle, but the benefits can outweigh that, especially in water-stressed regions. The magazine concluded, "Decreasing discharges of secondary effluent and reducing pressure on water resources to the benefit of local communities could be a positive example of corporate social responsibility for power companies."

Though the use of wastewater for industry and agriculture is now standard practice, the reclaiming of such water to replenish potable supplies has yet to become widely established. But that is changing. Michael Price, vice president at Stantec Consulting Services, said at the conference, "We're not far from being able to treat wastewater and blend it into the drinking water supply. The cost of treatment is relatively small, and we can use the same pipes to deliver it to costumers." Price said he thinks we will see significant movement in reclaiming wastewater before 2035.

Ferrari noted that the pace of public acceptance for reclaimed water is hard to predict. First, water companies have to get on board.

"Utilities are on a journey," said Paula Kehoe, director of water resources with the San Francisco Public Utilities Commission, at the conference. "There are cultural changes happening within the utilities themselves that are in response to needs expressed by the private sector. It's a win-win."

According to Freedman, state and federal governments could help facilitate water reuse by making grants to municipalities and providing tax relief and other incentives to business. He also said that governments could incentivize the merging of small water systems with larger ones, creating entities sizable enough for water technology investment.

The EPA's Ross said at the conference that he is "a bit disappointed" that we haven't gotten further in reclaiming wastewater, but now there's some progress being made. "We should double the amount of water we reuse in the U.S. by 2030," he said. "We've tended to see wastewater as something to get rid of, but now we're realizing it's an important resource."

The need to move from that realization to concrete action on reuse is urgent. Melissa Meeker, who heads the Water Innovation Center in Georgia, told *The New York Times*, "The amount of water intentionally reused in America is still quite low and it will stay that way as long as the public regards reuse as an emergency measure… Conservation cannot meet future water demands alone and other measures that create new sources of water, like desalination, are still more expensive. Water reuse is the easiest and most economical fix. It should be included in the water supply portfolio of every community."

Reusing wastewater will be a very useful tool — even in regions that are *not* water-stressed. According to Sinicropi, "Water reuse will be the way of the future, whether in a dry climate or a wet one. More and more businesses and communities will be integrating water recycling into their overall water management programs."

> **"In 20 or 30 years, half of the drinking water supply will likely be some form of recycled effluent."**
>
> — Pat Sinicropi, executive director, WateReuse Association

So far, industry and agriculture have been the primary beneficiaries of recycled water, but Sinicropi and others see a bright future for recycled drinking water, as well. Direct use is already catching on in arid areas with persistent drought. "We will continue that trend, and we will also see more treated wastewater in municipal drinking water supplies," said Sinicropi, adding, "In 20 or 30 years, half of the drinking water supply will likely be some form of recycled effluent."

Los Angeles, which is planning to reuse 100% of its wastewater by 2035, is certainly moving in that direction. By the time it reaches its goal, the city expects 35% of its recycled water to be used for drinking.

"Water recycling technology is good and rapidly getting better, said Sinicropi. "We are arriving at a point where we can treat any kind of water from any source, to any water quality standard that is needed for any purpose."

The Future of Recycled Water Is Closer Than You Think

EXHIBIT #1: LOS ANGELES — California has endured severe droughts before, but the four-year period of 2011-2015 was the driest on record. Before it was over, then-governor Jerry Brown had declared a statewide drought emergency and issued a Water Action Plan that, among other goals, aimed to increase regional self-reliance.

Cities and agencies throughout the state responded with aggressive plans of their own. Many included an expanding role for water recycling, but none went as far in that direction as the plan Los Angeles mayor Eric Garcetti announced to the press in February 2019 when he declared that the city would be recycling 100% of its wastewater by 2035. "Maximizing L.A.'s recycling capacity will increase the amount of water we source locally, and help to ensure that Angelenos can count on access to clean water for generations to come."

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> — Eric Garcetti, mayor, Los Angeles

Three of the area's smaller water treatment plants are already at 100%, he noted, but the huge Hyperion Water Reclamation Plant, which handles 81% of the city's wastewater, currently recycles just 27%. The rest of the wastewater it processes, hundreds of millions of gallons a day (mgd), is treated and discharged into the ocean.

L.A. can no longer tolerate such waste. When the city began importing water in 1913, its population was under half a million. Today it is the second-most populous city in the country, with nearly four million residents. (And Greater Los Angeles, the full metropolitan area, has 18.79 million.) Yet L.A. still gets as much as 80% of its water supply from distant sources, according to Liz Crosson, director of infrastructure in the mayor's office.

Rather than continue the region's reliance on imported water, Garcetti wants to "flip the paradigm," said Crosson. "By 2035, we're looking at being 70% locally sourced," she explained. The goal is to use 35% of the city's recycled water for drinking, with the rest going to meet industrial and agricultural needs.

ORIGINS IN THE 1990S

The West Basin Municipal Water District was created in 1946 to distribute imported drinking water to 17 cities in the western part of Los Angeles County. In 1994, after a devastating six-year drought, West Basin partnered with Suez to design and construct the Edward C. Little Water Recycling Facility in the City of El Segundo.

"Our first customer in 1995 was El Segundo Lakes golf course," said Rich Henning, senior vice president of Suez North America. But the facility grew quickly after that. "As of last year," Henning told conference attendees, "Suez has processed 200 billion gallons of wastewater through its partnership with West Basin."

At first, the plant supplied recycled water for just two purposes: irrigating municipal property and recharging aquifers. "But before long, local refineries came knocking at the door and West Basin added additional water qualities," explained Antonine Vuillermet, project director for Suez. Today, the company operates and maintains the original recycling facility as well as three satellite

facilities and produces five types of water, each for a specific purpose.

Three of the five "designer waters" are piped to refineries, where they are used as feed water for low-pressure boilers, high-pressure boilers and cooling towers. The fourth type of water is used for irrigation and the fifth is destined for local aquifers. In the past, drinking quality water was used for all five purposes, so while none of the five recycled waters is consumed directly by area residents, together they free up 45 mgd of potable water for drinking.

The recycled water that goes to the aquifers also plays a key role in preserving this valuable local resource. According to the California Water Science Center, as long as the water level in the underground basins is higher than sea level, water pressure keeps the nearby ocean at bay. But when water is pumped out of the ground faster than it is naturally replenished, the level of the aquifer drops, the water pressure falls and saltwater begins intruding into the freshwater supply.

Because California has never regulated groundwater removal, such over-pumping has been a serious problem. "In the troubled Westlands Water District, for instance, aggressive pumping during the recent drought depleted the aquifer at a rate of 660,000 acre-feet per year—about as much water as a city of 6.6 million people would use annually," according to *The New York Times*.

One way to solve the problem is to reduce the amount of water being pumped out by reducing demand. A number of innovative and highly effective conservation efforts by the Municipal Water District of Southern California have done just that. In fact, despite the addition of five million people to the district's huge service area, Metropolitan actually sold 30% less water in 2018 than it did in 1990, according to general manager Jeffrey Kightlinger, who spoke at the conference.

But while conservation efforts continue, conservation alone cannot slow demand enough to maintain aquifer levels. To make up the difference, water from other sources is used either to replenish the aquifer, raising the overall water level, or to keep the water level near the ocean high enough to prevent seawater from seeping in.

The more recycled water is used for both purposes, the more imported water is available for drinking. After recent improvements in the West Basin plant, the amount of recycled water injected into seawater intrusion barriers has increased dramatically. Today, just 25% of the injected water comes from outside the region.

TOWARDS DIRECT POTABLE REUSE

As effective as West Basin has been at recycling, it will likely need to add a sixth kind of water at some point to play a significant role in L.A.'s vision. To understand why, it's important to differentiate between indirect potable reuse (IPR), recycled water that is added to reservoirs and aquifers before entering the drinking water system, and direct potable reuse (DPR), recycled water that is piped directly into people's homes.

"The standards for direct potable reuse are much higher than for indirect, because there are no buffers between the source and the end-user," explained Felicia Marcus, former chair of the California State Resources Control Board. In addition, "DPR has to be monitored to ensure it is meeting standards 24/7," she said.

The standards for IPR, while stringent, are slightly more relaxed, because all the water in aquifers and reservoirs is treated again when it is withdrawn for use as drinking water. In addition, the time IPR spends in surface or underground storage, so called "residence time," provides yet another safeguard. According to Marcus, "Residence time gives you a chance to respond. If there's a 'burp,' you have time to find out about it and deal with it before the water enters the system." Marcus refers to these multiple levels of safety as "suspenders and belt" protection.

Suez's Vuillermet said that the potential for increasing West Basin's production of IPR is limited.

> "L.A.'s aquifers are pretty near capacity."
>
> — Antonine Vuillermet, project director, Suez

"L.A.'s aquifers are pretty near capacity," he explained, and there is no room to build a reservoir from scratch, as Metropolitan did in rural California between 1992 and 2002. So, to increase West Basin's production of recycled water, the plant will need to go beyond IPR to direct reuse.

"We are going to need some place to put additional water and I think the only place is going to be the drinking water pipes," said Vuillermet. "And that will be possible only if we are able to treat that water to DPR standards."

The likelihood of this happening is increasing rapidly. Not only is the technology becoming more cost-effective, public resistance is also fading, said Amy Dorman, program manager with San Diego's Public Utilities

Department. When San Diego first proposed recycling wastewater for drinking in the 1990s, "It got caught up in the negative 'toilet-to-tap' nomenclature," she explained in an interview for this report.

So, starting in 2002, the city conducted numerous studies and launched a very aggressive outreach program. The results have been impressive. "Public acceptance of recycled water went from about 25% before the outreach to between 70% and 75% afterwards," according to Dorman.

The state's epic four-year drought also played an important role. "Not only was 2015 the driest year on record but we think based on tree rings, it was the driest year in about 1,500 years," said Kightlinger. "The drought was in the news every day, so public awareness was really high. And the severity of the drought seems to be changing people's behavior."

People all over the world are coming to realize that the water supply can no longer be taken for granted. From arid regions plagued by draught to low-lying areas prone to flooding, water scarcity is a looming crisis. The solutions will vary from place to place. As Priyanka Jamwal, a fellow at the Ashoka Trust for Research in Ecology and the Environment in Bangalore, told *The New York Times*, "Water is a local problem and it needs local solutions." The one solution that transcends boundaries is the urgent need to stop wasting water. And as Sinicropi explained, we already know how to treat any kind of water from any source to any water quality standard that is needed for any purpose." All we need now is the will.

Special Report

The End of Wasted Water

A Revolution in Reuse Is Underway

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