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## Water Desalination: The Answer to the World's Thirst?

By [Jeff Hull](#)

**Randy Truby's wardrobe** -- broad, rectangular glasses; a long-sleeve navy blue corduroy shirt; navy slacks; and oxblood cowboy boots on an 80-degree day in Southern California -- does little to minimize his distinct physical presence. But an almost elfin energy animates Truby's big-fella frame when he starts talking about water. "If you consider rainfalls, and you look at rivers and lakes -- all that water is pretty well known," he says. "If you look at the Colorado River, that water is all adjudicated and consumed. In a place like Southern California, people have to look at the sea."

Truby is the CEO of Toray Membrane U.S.A., one of the world's largest makers of the membranes used in a process called "reverse osmosis" (RO), which, among other things, separates salt from seawater. In a world of dwindling freshwater, RO desalination is now the fastest growing new source.

A quick spin through recent headlines reveals just how badly -- and how soon -- we're going to need new supplies of freshwater: Over the past 18 months in the United States alone, the governor of Georgia declared a state of emergency due to water shortages; salmonella contaminated municipal water in Colorado; and eight states ratified the Great Lakes Basin Compact, an agreement designed to ensure that Great Lakes water, nearly 20% of the world's freshwater, won't be shipped beyond those basins -- not even to nearby Minneapolis or Pittsburgh.

Worldwide, the picture is far bleaker. Global water consumption has roughly doubled since World War II, and yet, according to the United Nations, 1.1 billion people still have no access to a clean, reliable supply. Eighty percent of disease and deaths in developing countries -- more than 2.2 million people a year, including 3,900 children each day -- are caused by diseases associated with unsanitary water. The cost of waterborne diseases and associated lost productivity drains 2% of developing countries' GDP each year.

China, meanwhile, is designing massive aqueducts to siphon Himalayan meltwater across thousands of miles of landscape to support its emerging megacities. The mass movement of rural people to urban centers in sub-Saharan Africa, the Indian subcontinent, and much of South America is placing enormous strain on already-tapped-out water supplies. And those shortages irritate already destabilized regions. The Darfur tragedy was aggravated by water shortages. Both the Tigris and Euphrates are dwindling in Iraq, as Turkey builds upstream water storage projects. North and South Korea squabble over the Han River. The Ganges is a source of tension between India and Bangladesh. Water wars have exacerbated the conflicts between Israelis and Palestinians for decades.

Global warming won't help. Scientists think much of the Arctic's freshwater ice will melt into saline seas by 2050. On land, snowpack, which feeds reservoirs and critical river systems such as the Colorado, is predicted to decline: California's Department of Water Resources forecasts a 25% reduction by 2050. A recent report from the U.S. Department of Agriculture predicts that stream volumes across the American West will fall 20% by midcentury, leaving population centers such as

Phoenix, Las Vegas, and Southern California parched -- and crippling U.S. agricultural production. (Worldwide, agriculture accounts for roughly 70% of freshwater consumption.)

And yet global warming will *raise* sea levels. The Pacific Ocean at the Golden Gate Bridge has climbed 8 inches in the past century. Saltwater already comprises 97.5% of the water resources on the planet, and 60% of the world's population lives within 65 miles of a seacoast. Why not desalinate seawater and slake the thirst of nations?

**Randy Truby** wasn't the first person to embrace the idea. Forty-eight years ago, John F. Kennedy believed desalination would change the world. In April of 1961, when Truby was a high-school freshman, the president told the Washington press corps that "if we could ever competitively, at a cheap rate, get freshwater from saltwater, that ... would really dwarf any other scientific accomplishments." Three years later, the first modern American desalination plant, built at Point Loma, California, was shipped to Guantánamo Bay after the Cuban government cut off water flow to the U.S. naval base there.

In energy-rich, water-desperate countries in the Middle East and Asia, desalination already fills a vital role. Saudi Arabia currently produces about 18% of the world's desal output, and the Middle East is expected to invest \$30 billion in the technology by 2015. Places such as Algeria, Dubai, Libya, and Singapore all depend on desal for drinking water. China's desal investments are expected to increase by an order of magnitude, from about \$60 million to more than \$600 million in the next 10 years. The worldwide market, now about \$11 billion, is expected to explode to \$126 billion by 2015.

"Our membrane business has grown for the last three years about 20% to 25% per year," Truby says, seated in his office, 20 miles inland from San Diego in the town of Poway. Outside, dry scrub-brush hills rise from a sea of glass and concrete office buildings. "We're over \$100 million in global sales. In the last three months of 2007, we landed three major seawater desalination projects. We're looking at projects in India, in China, Saudi Arabia, Trinidad, and Peru."

In the United States, the desal industry had been stuck in a quaint, seaside-cottage phase, constrained by high costs. But a series of incremental advances in RO membrane technology and systems engineering, plus one huge breakthrough in energy conservation, has recently brought it to a competitive brink -- a situation that has attracted multinationals on the scale of General Electric, which have jumped into desal with both feet.

When Truby emerged from San Diego State University in 1968 with a biology degree, he'd never heard of desalination. After an honorable discharge from the Navy, while dropping off résumés in the neighborhood, he popped into the offices of a company called General Atomic. The company's reverse-osmosis division had just invented a cartridge or "element" to house semipermeable membranes, which seawater could be forced through to remove salt. Truby was signed on as a sort of test engineer, trying to improve the membranes' efficiency and durability.

He received a crash course in RO desalination: Under intense pressure -- about 800 pounds per square inch (a fire hose gushes 100 to 300 psi) -- seawater is forced through a spiral of membrane sheets. About 50% of incoming water is collected as freshwater on the other side of the membranes and runneled away to its intended use. The other 50%, now twice as salty, exits the system separately as concentrated brine wastewater to be dumped back into the sea.

Truby set about finding new uses for RO membranes. He tried using them to filter chromium from wastewater at a Coors bottling plant in Colorado (too costly). He tried using them to treat acidic runoff from abandoned coal mines in Appalachia (they worked). He sold RO systems to companies that wanted to concentrate apple juice and maple syrup; to cheese producers, which use membranes

to capture whey and proteins (and still represent almost 10% of the membrane market); and to semiconductor manufacturers constantly in need of ultrapure water (this, too, remains a healthy market).

Then there were the membranes sold to the desal market, especially in the Middle East, where energy and money were plentiful -- and water wasn't. Truby helped develop the first major seawater desalination plant, a 3.2-million-gallon-per-day facility in Jeddah, Saudi Arabia, in 1977.

"Everything was going so fast," Truby says while systematically working through a lunch platter of oysters Rockefeller at a fish house near his office. "You could be in a semiconductor manufacturing plant in the morning, and then be having dinner with a municipality that has a sewage-treatment plant that evening. I ended up in the desert of Oman installing RO systems. I went to Libya. Those were places I had no idea where they even were until someone said, 'You're going there.' "

Then, suddenly, desal sort of stalled. "In the mid-'80s or so, things were not growing as fast as we'd hoped. That was a difficult period," Truby remembers. "There were times we sat around and said, 'Maybe we have a great technology but there's just no need for it.'

"A lot of guys got out, got into other industries," Truby adds, recalling the dry years. "But I'm a water guy."

**Sandy Schexnaider** (pronounced *SHECKS-ny-der*) is a water guy, too, and he is fascinated by the way people view water in this country. "I call it the 'hydro-illogical cycle,'" he says. Schexnaider, who once worked for a company called Ionics is now, by virtue of its acquisition, with GE's Water and Process Technology division.

Schexnaider is standing amid an orderly maze of tubes, pipes, tanks, and high-pressure pumps arrayed on a cement pad a few feet above the Pacific -- a small desal plant that provides water for PG&E's Diablo Canyon nuclear reactor, a few hundred yards away. Just offshore, hundreds of seals and sea lions bob on the edges of kelp beds.

The desal system is a "BOO," Schexnaider explains in a soft country-gentleman's voice that still carries a trace of his native Louisiana, a "build, own, operate" facility. "We used to call them 'build, own, operate, maintain,'" he adds, "but 'boom' is not a good thing to say around a nuke plant."

Schexnaider oversees GE's water supply business at 45 nuclear plants in North America (Diablo Canyon is the only one cooled by desalinated seawater). He has been in the business since 1992, long enough to see the circular thinking that has tied desal to rainfall.

"The first stage of the hydro-illogical cycle is drought," Schexnaider says. "Then comes awareness. People start to note that water is, number one, not free, and, number two, not inexhaustible. Next comes concern. People start looking for new water sources, and this is when they start thinking about desal. Then comes panic as the drought worsens, and it starts to affect their lives significantly. And then it rains, and everybody forgets there was a problem and forgets about desal until the next drought."

Schexnaider's point, of course, is that one day, the drought won't end. The rain won't come, or at least not enough of it. And we're going to need another solution.

Schexnaider's boss, Earl Jones, general manager of global commercial development for GE Water, points out that people tend to think water should be free -- as it has been for the bulk of human history. "We're not quite at the knee in the curve," Jones says, "but when people are out of water, or when people don't have clean or safe water, that psychology changes."

GE is in the water business specifically because its executives believe the supply curve is about to be kneed. Jones, a former submarine officer in the Navy, tends to talk about water with a

Kennedyesque sense of mission; recently he and other GE Water execs decided to launch their own moon shot: "We were reflecting on Kennedy's speech about sending a man to the moon," Jones says, "and we said, 'Look, water is very important.' We feel like we have a moral responsibility to the globe to go help solve some of the critical water problems we're facing -- scarcity being one of them.

"We have a responsibility," says GE's Jones, "to help solve these critical water problems."

"What the world really needs is a very low cost to desalinate water. We said 10 cents per meter cubed [an 80% reduction from today's average]. But you can't think incremental innovation will get us there. You have to think breakthrough. It will take new science, new engineering, breakthrough innovation."

It was one such breakthrough that brought GE into the desal industry in the first place. In the 1980s, an inventor named Leif J. Hauge developed a simple device to help his brother, a farmer on Norway's coast, efficiently pump cold fjord water uphill to refrigerate his warehouse. Hauge eventually made his way to the United States and designed the PX Pressure Exchanger, which has become a crucial tool in reducing the energy requirements of desal. (Hauge ended up being ousted by his own investors, who walked off with all the original patents for the PX.) In a desal plant, the stream of concentrated brine water -- the 50% of the water that does not pass through the RO membrane but instead carries away the rejected salt -- traditionally poured out of the RO cartridges at high pressure and was wasted. Hauge's device pipes that pressure into a series of open cylinders in a spinning column, much like the magazine of a .38 revolver, given a whirl. The PX captures 98% of the energy contained in the wastewater stream. It has reduced energy consumption in desal plants by more than 50%.

"The introduction of energy recovery, that was a step-change that went *bam*," Jones says. "You could find a lot more markets where desal started making sense."

By the time Jones arrived at GE Water, in 2005, the company had acquired Ionics and three other market-leading water-services companies. They would add a fifth as part of a seven-year shopping spree that now positions GE Water to supply everything from pretreatment filters to membranes, from self-contained desal units for tropical resort hotels to megaplant infrastructure for Middle Eastern cities. GE Water is a \$2.5 billion business, employing 7,800 people in 43 countries. And the company has said it's aiming for \$5 billion in water revenue in the next five years. Not all of those figures apply to desal, and the company doesn't publicize breakdowns by market sector, but GE has positioned itself to play a major role in addressing the world's water woes.

**All of this talk** about manufacturing freshwater has, unsurprisingly, stirred up some antagonism in certain circles.

"I consider the ocean to be a public-trust resource," says Susan Jordan, director of the California Coastal Protection Network, "and once you start using a public-trust resource for private gain without appropriate controls, I think you have the makings of a disaster for consumers." Jordan and others see desal as an example of corporate opportunism at the expense of the average citizen.

"When you have a company funded and owned by an investment firm out of New York, a global player, you start to get very far removed from the consumer."

Jordan is referring to a proposed 50-million-gallon-per-day desal facility on Agua Hedionda Lagoon, in Carlsbad, California -- a venture in which GE is a partner and which received some of its early funding from Warburg Pincus. The plant's planners, Poseidon Resources, claim they can make water while emitting no more greenhouse gas than the State Water Project, the antiquated system of canals and pumps that hauls water from the Sacramento -- San Joaquin Delta southward, and which single-handedly drains 2% to 3% of the state's annual energy budget. Poseidon says the Carlsbad

plant will become North America's largest desal facility, providing drinking water to 300,000 customers at a daily cost comparable to other municipal sources.

But Marco Gonzalez -- an environmental attorney who's helping to sue the California Coastal Commission in an effort to reverse a conditional permit for the Carlsbad plant -- thinks number crunching does not begin to account for costs inflicted upon the sea. Gonzalez, whose shaved head and tiny techno-geek glasses do nothing to distract from his surf-sculpted good looks, thinks that, given Southern California's culture of "desert denial," desal isn't always a bad idea. But sometimes it is, and what's happening in Carlsbad is one of those times.

Gonzalez says that while many environmentalists tend to focus on brine discharge, which they fear will harm marine life, studies show those impacts can be blunted. There are, with desal megaplants, bigger fish to fry. Energy consumption and its associated carbon stomp are two. A third is referred to as the "impingement and entrainment" of marine life -- eggs and larvae of fish, copepods, mollusks, and other animals that get sucked into the intake and killed. You can, Gonzalez says, avoid that destruction -- by digging intakes beneath the seafloor, or sucking water from beach wells, for instance -- but those methods cost more.

"The expense is significant," Gonzalez admits, but so is the cost of not doing it. "Carlsbad is the first big plant [proposed for California]. It sets the stage for every plant coming down the pike. If policy is established that requires sub-seafloor intakes here, you can bet that's going to be the best available tech for every subsequent plant up and down the coast. So it's all about money -- and shortsightedness."

Gonzalez thinks that before officials spend hundreds of millions of dollars on desal plants, they should look at water reuse. "We are discharging more than 200 million gallons a day of secondary treated sewage out into the ocean. The only difference between that and drinking water is reverse osmosis and disinfection," Gonzalez says. "Why in the heck wouldn't we apply the same technology to water recycling?"

Almost everybody in the desal industry concedes that recycling water is a cheap, easy way to augment supplies. But there's one big obstacle: Try telling people they have to drink filtered toilet water. Scooping peanut M&M's from the bowl on his desk, Gonzalez says, "I can, I will, I do constantly."

**When he's not working**, Randy Truby likes to ride his motorcycle around the West -- a big man on a big bike, charging across the arid landscape. Whereas others bailed out during the desal industry's swoon in the 1980s and 1990s, Truby throttled up. "Around the year 2000, I became convinced a new surge was coming," Truby says. In the following two years, megaplants in Yanbu, Saudi Arabia; Fujairah, United Arab Emirates; Singapore; and Tampa, Florida, were planned and built. From 2003 to 2007, the RO market expanded at a compounded growth rate of 55% a year.

Today, Truby is chairman of the Affordable Desal Coalition (ADC), an outfit dedicated to proving the cost-effectiveness of state-of-the-art desal facilities. ADC has been running a pilot study, funded partly by grants from the state of California that in 2006 produced water for roughly the same price per gallon San Diego residents pay -- and using 1 kilowatt-hour less energy per 1,000 gallons than the State Water Project. The ADC project produced an average household's daily water demands using about as much energy as a PC.

"The ADC has shown that, cost-wise, RO seawater desalting is a push compared with aqueducts," Truby says. "And you have the benefit of not transporting water from one region to another."

It has taken both the Joneses and the Trubys of the world to bring desal to the verge of economic viability in the United States. "There are so many very large projects being bid right now," says

Truby, who has just overseen the purchase of two new buildings and the leasing of a third for manufacturing, warehousing, and office space for his 100 employees. "I don't see how anybody can keep up."

Truby knows as well as anyone that the hydro-illogical cycle remains a force to be reckoned with. He's seen big companies come and go. In the 1960s, Gulf Oil ran television ads promoting desal during rocket launches. DuPont dove into the business, then bailed when profitability figures didn't pencil out. Siemens has waded into water and desal behind GE. But something tells him, this time it's going to be different.

Jeff Hull, based near Missoula, Montana, has written for *The Atlantic*, *Outside*, *The New York Times Magazine*, and other publications.

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