# Out of Thin Air
## Pros and Cons in the Search for Water

Harold D. Hunt
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Although working from home is not a new concept, the recent pandemic has accelerated its appeal for many Texans. Past limitations are being addressed through improved efficiencies and new technology. Online shopping for almost anything is now just a click away. FedEx and UPS deliver anywhere. High-speed satellite Internet is already in beta testing in parts of the United States.

When the decision is made to work from home, the next question may be where to live. Texas has a great deal of land outside urban areas. When choosing to reside in a more rural location, limitations such as available electricity and potable water may come into play. Not every part of the state is considered habitable for a residence.

Unavailability of electricity in remote areas can be addressed through existing wind and solar photovoltaic technology. Back-up generators and battery systems are becoming more commonplace, providing the security of uninterrupted power. The bigger hurdle in many areas of the state could be water availability.

**The Takeaway**

While Texas' rural areas could appeal to many urban residents looking to move, the shortage of potable water in those regions presents a problem. Several methods of obtaining water might offer solutions.

Other factors may be considered when deciding to relocate to a rural area. Families with children might consider the quality of local school districts, for example. However, removing the constraint of insufficient potable water from the decision of where to live could be a potential game-changer for migration patterns and rural real estate markets across Texas.

Can sufficient potable water be secured for whole-house needs in areas of Texas where there is no water, very little water, or water not fit to drink? Methods such as rainwater harvesting, reverse osmosis, and atmospheric water generators may offer solutions.

## Rainwater Harvesting

One way to acquire water for residential use is through rainwater harvesting. However, annual rainfall varies greatly across the state. The Texas State Historical Association's Handbook of Texas reports that El Paso receives the lowest average annual rainfall of any Texas city at just under eight inches. Much of West Texas receives only 12 to 16 inches of rainfall annually. Meanwhile, the City of Orange in East Texas averages just over 59 inches per year.

In addition to showing precipitation levels, a report by the Texas Water Development Board (TWDB) reveals the typical longest span of continuous days without rainfall in most of East Texas is less than 60 days. That number increases to 125 days in much of West Texas. As a result, harvesting sufficient rainwater for a residence in the driest parts of the state could be challenging.

Several sources, including the U.S. Geological Survey, state the average American uses somewhere between 80 and 100 gallons of water per day. This number includes water for drinking, showering, washing clothes, and flushing toilets.

Assume a family of four using 100 gallons of potable water per day per person wanted to live in an area of Texas receiving ten inches of annual rainfall and the possibility of no rain for 125 days. The amount of necessary water storage and surface capture area can be estimated using TWDB calculations. In this example, a family of four would require 50,000 gallons of water storage (400 gallons used per day x 125 possible days without rainfall). It would be prudent to have the storage tanks initially full before usage, which could mean hauling water to the site before drawing on the system.

When estimating the possible amount of rainwater harvesting, the rule of thumb is 600 gallons of water collected per inch of rainfall from a 1,000-square-foot surface area. However, a 15 percent loss can be expected due to leakage and system overflows during heavy rain events. Approximately 510 gallons would more likely be captured in a one-inch rain event, or 5,100 gallons over a year, assuming ten inches of annual rainfall.

A surface area ten times larger, or 10,000 square feet, would be required to capture 50,000 gallons with a 1,000 gallon additional buffer. Although roof surface areas vary, an average estimate is 1.5 times the square footage of the home. Based on that, a 2,000-square-foot house provides about 3,000 square feet of surface area for rainwater harvesting. To obtain the required 10,000 square feet of surface area in the West Texas example, other outbuildings such as barns would have to be used to catch sufficient rainfall.

The surface area required in East Texas would be considerably less. Assume the same family of four lives where rainfall is 50 inches per year and there are only 60 days between expected rain events. The amount of required storage would be 24,000 gallons (400 gallons per day used x 60 possible days without rainfall).

At 510 gallons of water captured in a one-inch rain event per 1,000 square feet of surface area, 50 inches of rainfall provides 25,500 gallons of captured water. Again, if storage tanks were prudently filled before drawing any water, a mere 1,000 square feet of surface area should be sufficient to provide enough water to span the typically longest dry period of 60 days.

Before drinking, rainwater will have to be filtered and disinfected. Furthermore, storing any water in ponds, pools, or storage containers for extended periods will require whole-house filtration systems to make the water safe for drinking.

## Reverse Osmosis

Reverse osmosis (RO) is a water purification process that has been in use for several decades. Units are sold today that have the capability to provide whole-house potable water needs.

RO systems could be used in areas where sufficient water is available but not fit to drink. A partially permeable membrane is used to separate water from unwanted chemicals and bacteria. Normal household water pressure forces water through the membrane. Specialized RO systems are often used in the purification of seawater or brackish water, where sea salt is removed from the water.

RO has its downsides. It must be used in combination with other filtration techniques. The systems must be backflushed, requiring disposal of the nonpotable sludge generated during the process. Anywhere from two to 20 gallons of discharge may be produced for every gallon of potable water generated, depending on water quality. The accumulated sludge cannot be used for any other purpose.

The RO process removes minerals such as iron, magnesium, calcium, and sodium, which are essential to human health. This makes the water essentially tasteless. Systems are available to add minerals back to the water.

RO membranes are subject to decay and clogging, lowering the quality of the treated water without proper maintenance. Most importantly, RO systems require a sufficient water source to produce the desired amount of potable water, making it impractical in areas where little or no water is available.

## Atmospheric Water Generation

Atmospheric water generators (AWGs) require no water source other than what's held in surrounding air. Unlike RO systems, no discharge is generated by the process. AWGs are being looked at as one possible solution for areas with no potable water.

Dr. Anjali Mulchandani, an assistant professor at the University of New Mexico, has been researching the water scarcity problem at the university's Center for Water and the Environment.

"In the U.S. Southwest, population is booming, and the water supply is diminishing," says Mulchandani. "But there is this other reservoir we don't even think about, and that's the atmosphere. It actually has more water than all the rivers."

According to the Environmental Protection Agency, the most commonly used AWG systems employ condenser and cooling coil technology to pull moisture from the air in the same way a household dehumidifier does.

AWGs use a blower system to draw the air from the atmosphere into the unit where filters first remove dust, dirt, and other particles. Air is then directed into a heat exchange and cooling process that causes the water to condense. The water is captured and filtered to remove any remaining impurities or contaminants before being transferred to storage.

Water production rates are highly dependent on the air temperature and the amount of water vapor (humidity) in the air. Altitude can be a factor as well, as humidity generally decreases with increases in altitude. AWG operational minimums are about 45 degrees Fahrenheit and 40 percent relative humidity. The higher the temperature and humidity, the more water produced. The volume of air passing over the cooling coil and the AWG's capacity to cool the coil are also factors.

AWGs large enough to produce sufficient water for whole-house use are relatively new and relatively rare. An Internet search of companies offering systems large enough to provide whole-house water needs revealed few viable candidates.

"There are several patents on AWGs, but it is difficult to track them to commercial devices available for sale today," says Mulchandani.

One AWG machine available for purchase by homeowners is the Maxim, manufactured by RussKap, the largest supplier of AWGs to the U.S. government. The company has more than 100 units of different sizes in use by the U.S. Marine Corps alone.

"One Maxim unit can produce up to 200 gallons of potable water per day," says Ed Russo, CEO of RussKap Holdings LLC. One or more AWG machines should supply adequate potable water for residential use in Texas, depending on environmental conditions and the volume of water required.

RussKap's AWGs use the same basic components as a home air conditioner, so unit longevity should be similar.

"Homeowners could expect a useful life of about 15 years," says Russo. "Making water from air is only one part of the AWG system. Another important piece is keeping it safe to drink and tasting good."

AWGs are heavy energy users compared with water harvesting and RO systems.

"You have to convert water from a vapor phase to a liquid phase," says Mulchandani. "That phase change is what's so energy-intensive. How can we sustainably supply that energy off the electrical energy grid?"

James McCanney, physicist and owner of JMCC WING LLC, has spent years researching ways to reduce the energy cost to make potable water. McCanney was the winner of the Technology Innovation Achievement Award in the 2018 Water Abundance XPRIZE competition. The XPRIZE goal was to collect a minimum of 2,000 liters (about 525 gallons) of water per day from the atmosphere using 100 percent renewable energy at a cost of no more than two cents per liter, or about eight cents per gallon.

"All 98 teams in the XPRIZE competition had a water-making machine of some type," said McCanney. "Where they stumbled was attaining that low energy cost." McCanney married his patented JMCC WING Generator, an efficient high torque wind-energy system, to his commercial AWGs to keep the energy cost down.

## Alternate AWG System Under Development

Scientists at GE Research are working with three U.S. universities to develop a refrigerator-size AWG unit meant to produce about 500 liters (130 gallons) of drinking water per day. Although primarily focused on providing water for military troops in the field, it could also become a source of potable water for folks living in arid or water-stressed areas.

The unit contains a dense proprietary "metal sponge" and heat exchanger that work together to soak up water from very thin air. The metal sponge sucks in the air while the heat exchanger creates condensed drops of water vapor. The water is then captured. When power is added to speed up the process, the unit can go through several water-producing cycles per day.

The system is being designed to produce water in some of the driest deserts in the world. Early tests conducted in Arizona and the Mojave Desert have shown water can be harvested in regions with relative humidity in the single digits.

## Once Unthinkable Now Maybe Possible

All three of these systems have their advantages and disadvantages, depending on the environment they will be operating in. However, the technical feasibility of providing sufficient potable water for whole-house residential needs in most regions of Texas looks favorable.

Comparisons involving the cost, energy consumption, and efficiency of these three systems have not been discussed. A more in-depth follow-up article will provide additional insight into the systems, especially AWGs, as more research and data become available.

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*Dr. Hunt (hhunt@tamu.edu) is a research economist with the Texas Real Estate Research Center at Texas A&M University.*