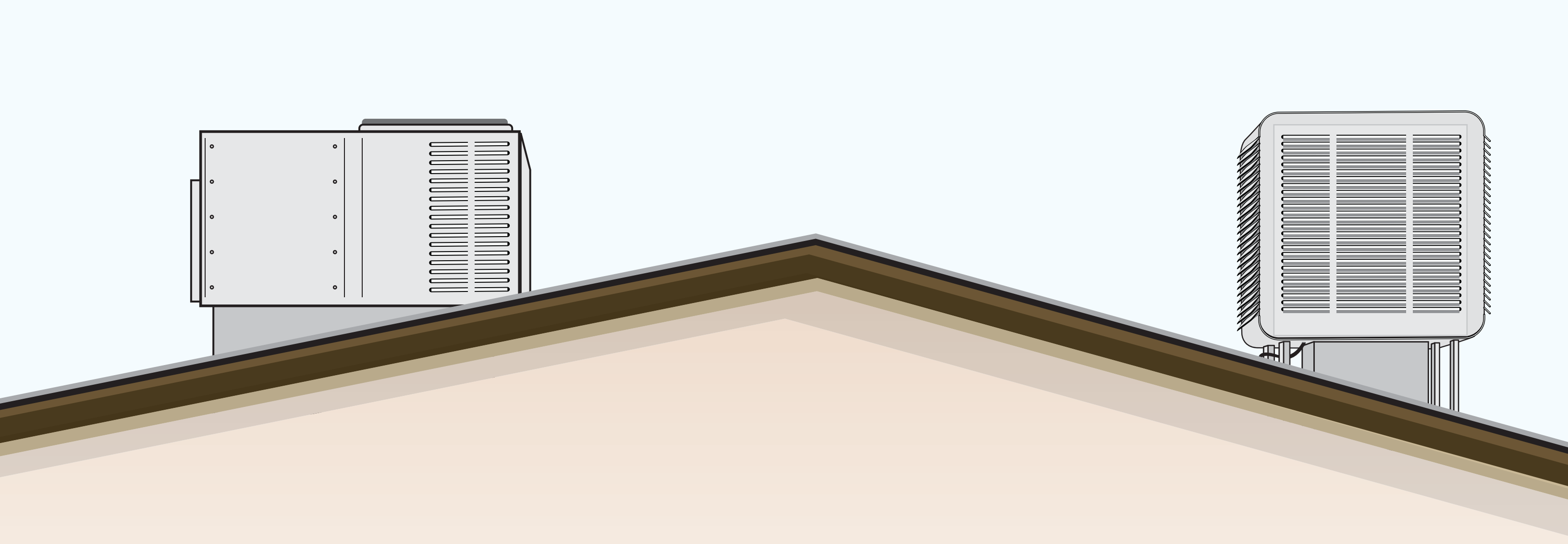

Water-Energy Trade-Offs Between Swamp Coolers and Air Conditioners

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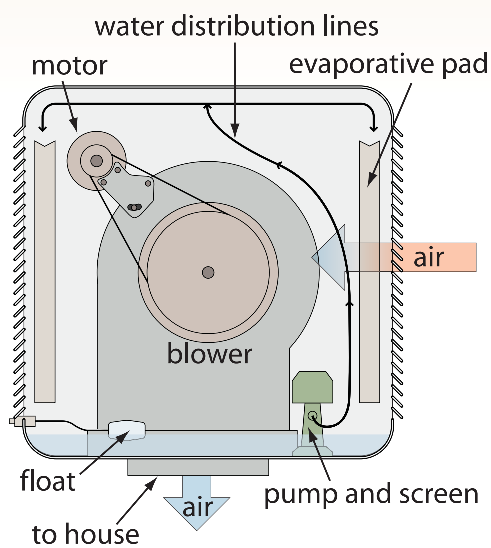
Residential cooling and heating account for about 56 percent of the total energy consumed in the typical U.S. home, according to the U.S. Dept. of Energy (DOE, 2005). In the Southwest, this energy is increasingly going toward air-conditioning rather than the traditional evaporative coolers, known as swamp coolers. The shift has implications for energy use, water use, and climate.

Energy Use

Strictly in terms of energy use, the ongoing shift from swamp coolers to air conditioners could be considered unfortunate. Air conditioners generally use two to four times more electricity than swamp coolers. For a typical 2,000-square-foot Tucson residence, the electricity used by a swamp cooler can be as low as 250 kilowatt-hours in an average month, while an air conditioner consumes about 850 kilowatt-hours. In Tucson, this translates to a monthly electrical cost of $25 versus $85.

But a scarcity of water in the Southwest makes the comparison more complex, posing a challenge in determining the conservation strategy that can yield optimum savings for both energy and water. T. Lewis Thompson of the Environmental Research Laboratory (ERL) at the University of Arizona found that during summer conditions in Tucson (May-September), a swamp cooler working at 75 percent efficiency uses an average of 150 gallons of water per day, while air-conditioning units do not directly use water. However, the generation of electricity requires water, a behind-the-scenes use that is easily overlooked.

Torcellini and others (2003) estimate that hydropower, which supplies about 12 percent of Arizona's electricity, consumes about 65 gallons of water per kilowatt-hour generated because of high regional evaporation rates from reservoirs where it is generated (this value considers the total water evaporated from reservoirs serving Hoover and Glen Canyon dams versus the amount of electricity generated.) However, the coal-fired plants that supply most of Tucson's electricity consume about half



Swamp coolers typically consist of a box with vented sides. A fan draws ambient air through vents and through pads that are kept moist by a water supply, pump, and distribution lines. The cooled, moist air is then delivered to the building via a vent in the roof or wall.

	Coal-powered electricity		Hydropower	
	Swamp cooler	Air conditioner	Swamp cooler	Air conditioner
Electricity used (kWh/month)	250	850	250	850
Water used directly by cooler (gals/month)	4,495	0	4,495	0
Off-site water used to generate electricity (gals/month)	125	425	16,250	55,250
Total water used (gals/month)	4,620	425	20,745	55,250
Electricity cost (monthly, assuming $0.10/kWh)	25	85	25	85

Monthly energy and water consumption with resulting cost analysis for cooling a 2,000-square-foot Tucson residence using coal-powered energy and a rated 4,500-cubic-foot per minute evaporative cooler operating on low for May through September. For comparison, hydropower-based energy calculations are also shown, and indicate greater water use by an air conditioner than a swamp cooler. Thus, the source (or mix of sources) of energy is critical to this analysis.

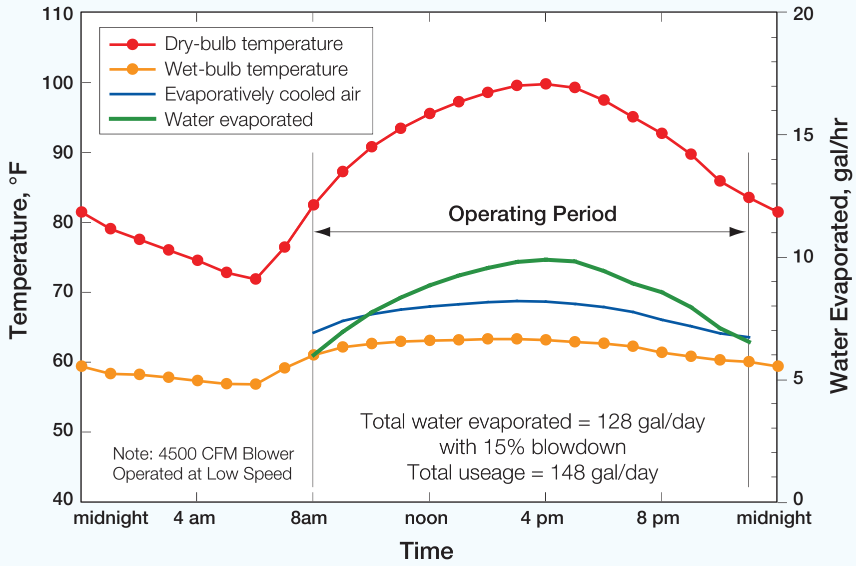
a gallon of water for each kilowatt-hour of electricity produced. Applying this standard to the cooling of a 2,000 square-foot home, an ERL analysis found that monthly water consumption for an air-conditioning system is about 425 gallons, while an evaporative cooler requires about 4,620 gallons, including direct and indirect usage for both (see table below left). The source of energy is critical to this analysis, however. If the same calculations are made using hydropower, an air conditioner uses 55,250 gallons of water per month compared to an evaporative cooler's use of 20,745 gallons per month.

Evaporative cooling works best in the dry months of summer. During the monsoon when outside air is already moist, the effectiveness of swamp coolers is limited. Air conditioning's appeal is its ability to cool to a thermostatically controlled temperature regardless of the humidity. At some level, though, the cooling of a home usually equates to a warming of the planet, with air conditioners doing more damage than swamp coolers when the source of energy is one that produces greenhouse gases, such as coal.

Climate Considerations

The collective choice of cooling equipment can affect the local climate as well. While air conditioners merely eject heat from the interior of a home or office into the outside air, swamp coolers can actually contribute to cooling the environment, indoor and outdoor. An evaporative cooler pulls air through moist pads, lowering the incoming air by as much as by 30 degrees (see figures, left and above right). Because those cooling their homes with swamp coolers must leave some windows open, some of this cooled air permeates outdoors.

A typical swamp cooler converts about 1 billion joules of energy a day from heat into other types of energy, including kinetic and latent energy. This amount of energy could warm a 6-foot-deep 12 x 12 foot pool by 20°F. Meanwhile, a typical air conditioner ejects about 63 million joules of energy per hour into the outside air, or a billion joules for every 16 hours of operation.



Evaporative coolers work by converting some of the heat energy in air into latent heat and kinetic energy that is trapped in the process of evaporation of water. A modern swamp cooler with an 85 percent efficiency can cool 100°F daytime air down to about 68°F. In the process, it uses about 145 to 150 gallons of water a day, assuming it operates on low during the day and is turned off at night. (Figure and analysis courtesy T. Lewis Thompson of the University of Arizona Environmental Research Laboratory, data for Tucson, Arizona, June 2006.)

Arizona State University researchers were surprised to find daytime temperatures in parts of metropolitan Phoenix were no higher, and in some cases actually lower, than those in the surrounding desert despite the expected urban heat island effect. They surmised that their results reflected the evaporative cooling from pools, urban lakes, landscaped vegetation and perhaps even swamp coolers. ASU researcher Joseph Zender noted that the ongoing shift from swamp cooling to air conditioning may eventually reduce some of that daytime cooling. Once the sun goes down, the desert cools down much quicker than the ciy with its heat-trapping pavement and vegetation. Some Phoenix-area urban temperatures averaged up to 20°F warmer than those in the nearby desert.

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Alternative Cooling

Many factors influence total water consumption in an evaporative cooling system, including residential design, location of the cooler, and the use of air modifiers such as vegetation and water.

The cooling efficiency of a swamp cooler can increase dramatically by "sensible" cooling of the air before it goes through the moist pads of the cooler. Sensible cooling can be achieved by strategic landscaping, rock beds, and water channels.

In a typical summer day in Tucson, air entering an evaporative cooler with 75 percent efficiency at a temperature of 100° F can exit with an air temperature of 75° F. Many newer evaporative cooling systems have an 85 percent efficiency.

For residences at the design stage, cool towers are another way to utilize the principle of downdraft evaporative cooling. Cool towers usually have a wet pad in the top of the tower. The cool air is heavier than warm air and sinks by means of gravity, creating its own airflow and eliminating the need for blowers or fans. The only power required is for a 12-volt pump to circulate water over the cooler pads. Generally, cool towers without fans are 20 to 30 feet tall and between 6 and 10 square feet. These systems require from 100 to 150 watts, and cool 1,000 to 2,500 square feet.

The need to consider energy as well as water demand for cooling options seems likely to increase in the coming years. The Intergovernmental Panel on Climate Change projects that summer temperatures in the Southwest will rise by at least several more degrees on average in decades to come, even more if society fails to stabilize greenhouse gas emissions. As temperatures rise, individuals will continue to seek a cool indoor refuge from outdoor heat. Meanwhile, society must look for ways to provide cooling in the most energy-efficient way possible, given other limitations.

T. Lewis Thompson of the ERL also contributed to the analysis. Contact Arunima Chatterjee at arunima@email.arizona.edu.

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