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PHOENIX'S URBAN HEAT ISLAND EFFECT COULD MEAN WE'RE HEADING FOR 100-DEGREE NIGHTTIME LOWS. WILL SCIENTISTS STEP UP TO HELP COOL US DOWN?

It was a time when parents encouraged their children to wet the bed. In fact, they often did it themselves. In front of their neighbors.

It was Phoenix in the early 1900s, B.A.C. (before air conditioning), when homes sweltered and residents spilled into their comparatively cooler yards every summer evening for some semi-communal grilling. Afterward, Dad put cots on the lawn, setting the legs in cans of kerosene so scorpions wouldn't crawl up to cuddle, then hosed down the cots and sheets. Mom sprayed the kids with citronella, tucked them into the wet beds, and they'd all sleep under the stars, damp and cool in the 75-degree air.

For this was also a time when summer nights in Phoenix averaged 75 degrees. When longtime Phoenicians wax rhapsodic about how it used to be cooler here, it's no "I walked five miles uphill to school both ways" story. But those days are gone.

"It's been getting significantly hotter," says Harvey Bryan, senior sustainability scientist at ASU's School of Architecture and Landscape Architecture. "It's a magnitude now of about 12 degrees above our historical nighttime lows. It was very typical to have summer evenings of 78 degrees back in the 1950s. Today we rarely go below 90. I think we're headed to conditions where we have 100 degrees as our maximum nighttime low."

Climate change plays a part – 21st-century Arizona is about 2 degrees hotter than 20th-century Arizona – but that's nothing compared with the urban heat island effect. The concrete jungle of metro Phoenix is about 10 to 15 degrees hotter than the surrounding rural areas – and it's getting hotter earlier in the day and staying hot longer. In the 1950s, Phoenix averaged seven days a year over 110 degrees. In the 2000s, it's 22.

That not only means more mercury-induced misery for residents. It means we're coughing up tens of millions of dollars more in energy costs, breathing 30 to 45 percent more smog, pumping out more greenhouse gases, risking more heat-related deaths, and suffering untold losses for the many businesses that effectively go into a heat-induced coma during summer.

Thankfully, scientists and city planners offer several savvy solutions, from the futuristic (heat-seeking-missile-proof paint) to the ancient (architecture under which Aristotle ambled). Added together, they could prevent us from surging to three-digit nighttime lows and make Phoenix a more pleasant – and profitable – place to live.

Island in the Sun

In the early 1900s, Phoenicians escaped scorching summer days by putting the top down on the Ford and cruising north. As the wind blew through their hair, many swore they sensed the temperature drop the second they left the sun-baked city, crossed the bridge on North Central and entered the countryside, around Indian School Road.

Imagine that the city of Phoenix is a potato. Put that spud in the oven, and it will absorb the heat. Take it out, and it will cool off by radiating its heat outward, warming the air around it (see that steamy spot on the plate?). Shoestring fries would cool quickly, but a baked potato has so much mass that it retains and radiates its heat much longer.

That is the urban heat island (UHI) effect. On scorching days, Phoenix's asphalt, concrete and buildings absorb the oven-like heat. At night, when the atmosphere cools, the pavement and buildings radiate their stored heat, warming the surrounding air. Rural areas with only a few, shoestring fry-like roads cool relatively quickly. But the city's core, with its huge, dense mass of pavement and buildings that trap escaping heat, is like a baked potato that never cools down before it's thrown in the oven again the next day.

Metropolises around the world experience UHIs, but Phoenix's differs in two ways, Bryan says. First, ours is more of a nighttime phenomenon. Cities ringed by a forest or water are significantly steamier than their surroundings during the day. But under the unrelenting sun, our unshaded desert often broils at a higher temperature than the building-shaded city. At night, however, the desert cools off very quickly because heat easily escapes the air- and moisture-permeable dirt, whereas the city's asphalt is like a heat Alcatraz.

Second, Bryan says, the Valley's heat island is one of the most extreme and most rapidly increasing in the world. And if you thought a college degree was expensive, it's peanuts compared with one degree of heat.

Temperature's Toll

Cooling early 1900s Phoenix didn't take much energy, unless you were one of the street urchins paid to constantly crank the giant fans hanging from restaurant ceilings. The first local "air conditioning" was dreamed up by staff at the Adams Hotel in Downtown Phoenix, who set fans over 300-pound blocks of ice in the lobby. Later, folks who couldn't afford the new evaporative coolers (made from a fan blowing past water dripping through burlap fastened with chicken wire) fashioned their own with a fan blowing through apple crates, wet sheets, charcoal and wood chips.

Today, for every degree the mercury rises, air conditioners use 2 to 3 percent more electricity, according to Arizona Public Service Co. Officials for the Salt River Project calculated that for every one-degree temperature increase, the utility company's 610,000 Valley residential customers alone pay $3.2 to $3.8 million more every month in cooling bills.

Scientists at the U.S. Department of Energy's Lawrence Berkeley National Laboratory (LBNL) estimate that Los Angeles' UHI is responsible for an extra 1 to 1.5 gigawatts of power – about $100,000 per hour, or $100 million per year. (How that corresponds to Phoenix is difficult to pin down: L.A.'s population is higher, but our UHI is worse.)

The same study on L.A. found that for every degree the temperature soars above 70 degrees, smog increases 3 percent. That means that in Phoenix, with a UHI of 10 to 15 degrees, we could be choking on 30 to 45 percent more smog, risking health problems and losing federal money if the city fails to meet EPA pollution level targets.

"For every degree of heat, we use so much more electricity for cooling, which is more carbon-based energy produced, and then the emissions go out in the Valley," says Phoenix Mayor Phil Gordon. "The reduction of electricity is important for the environment, and it's important for health."

The UHI also could lead to more deaths from heat, which is the No. 1 weather-related killer in the country, according to the Centers for Disease Control and Prevention. In this regard, the heat island is not an equal opportunity effect: It hits the poor hardest.

A 2009 study led by ASU geographer Darren Ruddell found that for every $20,000 an area's average income rises, the temperature drops 1 degree. That's because poorer 'hoods – generally set in the sparsely landscaped inner city, packed with buildings, houses and pavement – are the hottest pockets in Phoenix. To make matters worse, many residents in these areas cannot afford to crank up the A/C, or even turn it on, making them the most vulnerable to heat-related health problems, such as dehydration and heat stroke.

The UHI also acts as a firewall deterring tourists (and their dollars) from visiting the city. And it means most residents "summer hibernate," chilling out with the A/C and a pint of Cherry Garcia till the weather cools off around Halloween. Meanwhile, not only do our social lives suffer, but areas of the city turn into temporary ghost towns. One Downtown bar owner says he could have closed between last July and September.

That's not all attributable to the UHI, but the community's (understandable) unwillingness to go outside puts a considerable damper on the city's attempts to create the vibrant cultural, social, retail and entertainment networks that define urban life.

"People want to be outside," Gordon says. "People feed off each other's energy, and you can't see that if you're inside in dark windows. People outside attract people. The more people outside, the more business."

The trouble is, we'll never become a really cool city unless we can become a cooler city.

A Whiter Shade of Pale

A 1972 PHOENIX magazine article recalls the early 1900s, when Phoenicians understood the cooling benefits of light colors in summer. Men were dapper in white linen ensembles, while women entertained in semi-transparent white sundresses: "An accepted summer diversion at the drug store fountain was appraising female silhouettes as the ladies entered through the doorway with bright sunlight behind them. Some of the bolder gentry gathered around the Adams Hotel in the late afternoon to watch the girls cross Central walking east."

Fashion designers and the savvy citizens who whitewashed Mediterranean villages know that light colors cool. But, buoyed by air conditioning, city designers have drifted away from this truth on a tide of trends. And just as science was slow to realize the effects of burning coal and petroleum on global climate, it's been slow to discover the collective effects of color on temperature.

Dressing roofs and pavements in light colors might not titillate Phoenix's bolder gentry, but it can reduce surface temperatures up to 100 degrees and decrease a city's UHI by 5 degrees. That's according to the LBNL, which found that if Phoenix whitewashed its roofs alone, we could save a net $37 million every year in cooling costs.

Less energy also means fewer greenhouse gases. Two years ago, U.S. Energy Secretary Steven Chu, citing LBNL research, announced that if the world's 100 largest cities lightened all their roofs and pavements, it would offset 44 billion tons of carbon dioxide emissions. That's the equivalent of taking every car in the world off the road for 18 years, the LBNL's Art Rosenfeld later told the Wall Street Journal.

Phoenix has already made some progress in the reflective-roof arena, Gordon says, but he does not favor initiatives requiring residents to break out the whitewash. "It has to be organic in terms of people wanting to do it, or it has to be subsidized. It has to work on its own economically."

In addition to roofs, other structures could be lightened to mitigate the UHI and provide immediate relief to people. For example, Gordon says the city found that many bus stop structures are dark metal, making them hotter inside than outside. They could be repainted to mimic our light rail stations, which are models of cooling through color.

But the city can do even better than plain pastel or white paint, says Bryan, who was recently asked by Valley Metro to make design recommendations for light rail expansion. He advises building stations with ceramics instead of metal and spraying on specialized paint such as highly reflective or low-infrared, military-grade varieties. "We paint tanks to run cool because they have to have a low thermal signature to eliminate heat-seeking missiles," he says. "We have all of these stealth-like qualities that we've developed for paints for military applications that are now slowing being brought into civilian applications."

But in a city that's 40 percent pavement, even more crucial than lightening roofs and structures is getting our asphalt in gear.

The figures aren't available for Phoenix, but the LBNL estimated that if all roads, parking lots and other pavements in L.A. were replaced with lighter colored material during routine maintenance, in less than 20 years that city would save $90 million a year in energy and smog costs. Cooler pavements cost more initially, but because they don't get as stressed by heat as regular asphalt, they don't need to be replaced as often.

Even so, most cities would feel lukewarm at best about repaving all their streets. But what if there were an easier solution?

Enter Emerald Cities, a Scottsdale-based eco-company that recently resurfaced the world's first solar reflective green asphalt parking lot at the Robert L. Duffy Charter School in Phoenix.

Inspired by Chu's pale-pavement manifesto two years ago, CEO Sheri Roese went in search of planet-saving pastel pavers with the durability and non-blinding color scheme necessary for roads. But she came up against an inconvenient truth: "We couldn't find anything," Roese says.

So with her experience in physics and color chemistry, Roese worked with LBNL scientists to invent a pastel-hued combination of polymers, nano-cement and nano-silicas, plus photocatalytic chemicals that help clean the air. The product, which currently costs $1 per square foot plus labor, can be sprayed in a 1/16th-inch-thick layer over asphalt and last five to eight years.

"The road industry has not thought about what the color black is doing to the environment," Roese says. "I'm a colorist. I came up with beautiful teals, blue-grays, green-grays. Instead of a gray road, why can't it be green-gray, or a beautiful purple gray – it looks like an Impressionist shadow."

And it isn't just aesthetic. The company measured the temperatures of various paving materials on a 110-degree summer day. Fresh, black asphalt: 214 degrees. Older, worn asphalt: 160 degrees. Cement: 150 degrees. Emerald Cities' teal-tinted paver: 135 degrees. That's up to 80 degrees difference.

So what's next, a baby-blue Loop 202? Not so fast, Roese says. "We're not going to approach the highways. It's just too big of an undertaking." Plus, she says, highway pavers must be much more durable and skid-proof than parking lot pavers, and Emerald Cities' product has not been tested enough to be deemed safe for the fast lanes. Yet.

For now, Roese says, "At least we can change the color of the heat sinks in the city, which are parking lots, airports, roadways, pedestrian areas, schoolyards, crosswalks, bike lanes, parks."

As of press time, two new Emerald Cities solar reflective crosswalks are anticipated to be completed by May: at Ash and Fifth streets in Tempe and outside Scottsdale's

City Hall. Also in May, a Downtown Phoenix location will be the launch site for Emerald Cities' 100 Cities Cool Pavement Initiative.

Another prime candidate for a parking lot makeover, Roese says, is the Phoenix Zoo, with its vast plain of panther-black bitumen. And instead of its hot asphalt pathways, wouldn't cool lavender lanes perfectly set off the flamingos' feathers?

Emerald Cities also wants to green-pave underprivileged inner-city schools, where, she says, "People suffer the most. How can you expect your 3-foot, 4-foot child to go out at recess and exercise in a smoggy city, in the hottest zone on the asphalt play yard?"

In addition, Roese is working on a reflective coating that can be sprayed on pervious pavement – a relatively new product made of concrete or crumb rubber that resembles gray Rice Krispies treats. Unlike asphalt, pervious pavement allows water to flow straight down to the ground below, preventing flooding during storms and tempering the UHI by cooling more quickly at night.

Phoenix's Civic Space Park has pervious sidewalks, and Glendale's University of Phoenix Stadium has a pervious pavement parking lot. Bryan says it's more sensible than asphalt. "It's crazy. We have impervious paving and then we have to have these big swells at the end of the parking lot to keep all the water that comes off."

Pervious pavements have the added benefit of helping aerate and hydrate nearby trees, which themselves curtail the UHI but which often die because asphalt chokes off the oxygen to the roots, Bryan says.

Bryan also advises restaurants with patio misting systems to adopt pervious pavements that wick water, along with shade trees and fountains, to create a cool oasis.

"We can possibly extend our outdoor eating in restaurants to other periods of the day or year," he says. "I think that's a big profit maker for restaurants, if you can have people feel comfortable and extend your hours."

The downside to pervious pavement (in addition to being pricey) is that it can actually blaze hotter than asphalt during the day because sunlight seeps into its crevasses and bakes the inside, Roese says. She hopes that by developing a light-reflective coating for pervious pavement, it could run cooler day and night, plus control storm water.

Still, the biggest problem with asphalt, Bryan says, is that there's too much of it: "Our parking requirements per square foot of building are much more generous than almost any other city. Our road widths are very generous given our traffic in our residential streets." He prescribes narrowing streets and paving some parking lots with cooler, permeable materials such as gravel or plastic mats. "We don't have to put asphalt on everything. The desert soils cool off at night. I think we can mimic that."

Unfortunately, instead of mimicking desert soils, the city is paving them to reduce dust particulates to EPA-approved levels. (Maricopa County has consistently violated EPA air-quality standards for more than a decade.) Since 2000, the City of Phoenix has paved more than 85 miles of dirt roads, 300 miles of alleys and 58 miles of road shoulders. This is a shortsighted fix, because asphalt comes with its own air-quality quandaries, expelling black particulates and jacking up the temperature, which stimulates more smog. And with so few trees to help clean the air, the Valley can't afford to choke on more smog.

Shady Deals

A visitor to Phoenix in 1905, quoted in the City of Phoenix Tree and Shade Master Plan, observed, "Everywhere there is shade and plenty of it. The entire valley, from Mesa into Phoenix, is one solid mass of green, and every road is a perfect avenue. Chinaberry trees, palm, and cottonwoods line the lanes… and the entire distance from Mesa to Phoenix can be driven under an almost unbroken arch of shade."

Today Phoenix is covered with less than 13 percent vegetation (including non-shading shrubs and grass), according to an ASU study. But that could change soon. The City of Phoenix Tree and Shade Master Plan's goal is to create "a connected oasis that radiates out from Downtown," shading the city with 25 percent tree canopy. Gordon says the city is working on a grant to encourage tree planting along the Camelback Road-to-Sky Harbor International Airport light rail corridor.

Trees have a thermostat-like knack for regulating temperature through shade and evapotranspiration (releasing vapor that cools the air), which in turn reduces the urban heat island.

A U.S. Forest Service study found that planting trees in a parking lot decreased vehicle interior temps by 47 degrees. According to Bryan's light rail study, planting a row of trees along station platforms could block the 120-degree heat radiating from buildings, cooling the platform surface temperature to 90 degrees. (This recommendation was nixed for security reasons, since police need a clear view through the platform.)

Again, lower temps mean lower energy costs: Strategically planted trees can trim heating and cooling consumption an average of 25 percent every year, according to the U.S. Department of Energy. And a 2003 study by the U.S. Forest Service found that strategically planting 50 million trees around California would eliminate the need for seven new 100-megawatt power plants.

Plus, the benefit of investing in trees is that money actually does grow on them: Every $1 invested in the urban forest yields $2.23 in benefits, mostly from property value increases and energy savings, according to the Tree and Shade Master Plan. But even the plan acknowledges we cannot return to the water-sucking shade-scape of yore (plus, the county does not even allow water-intensive trees). On the other hand, desert trees, while less thirsty, yield skimpy shade and evapotranspiration.

Bryan advocates a compromise: “We should have a condition or requirement where you can put [shade] trees in pedestrian areas, where cooling and comfort is important. [They do] require a little more water, but that water is effectively used as cooling. Other areas where there aren’t pedestrians and it’s more ornamental, then we can go with desert trees.”

Another solution is a canopy that requires no water: architecture. Porticos, for example, were all the rage in ancient Greece and remain an effective and attractive shading staple in Latin America and the Mediterranean. In the early 1900s, Phoenix had something similar: Look at old photos and you’ll see that the second floors of buildings often extended over a wooden-walled walkway, where citizens strolled, shielded from the sun and dirt streets.

As Phoenix developed and became totally reliant on air conditioning, we became less creative about temperature-reducing urban planning. But to reduce the heat island – and its many costs – we will have to start designing smarter, employing both low- and high-tech solutions. Fortunately, all of these solutions – from pastel pavers to porticos to palo verde trees – would have the added benefit of beautifying Phoenix, creating jobs and making the city a little cooler, in both senses of the word.