Achieving Energy Reductions With Evaporative Roof Cooling

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The headlines are everywhere, and the news that follows them paints a troubling picture. Energy prices are up, and no one has been spared the pain of their endless meteoric rise. As a result, entire industries have been created to develop and market the latest energy saving technologies to businesses around the globe. We've all seen their ads. They use catchy buzzwords like "green," "sustainable," and "clean." But more often than not, their solutions are only moderately effective, yet expensive enough to make even the most ardent of spendthrifts blush.

It's this backdrop that has set the stage for possibly the greatest challenge for facility maintenance managers: the desire to save energy, but the need to do so economically. Is this even possible? The answer is a definitive yes. But the technology wasn't developed in a laboratory on the outskirts of Silicon Valley. The idea is nearly as old as time itself, and employs concepts no more complicated than basic physics.

Evaporative Cooling's Industrial Applications

The process of evaporation is by far the simplest and most effective method for carrying heat away from a given structure. But the question becomes how can we harness the cooling effects of evaporation in a large industrial setting, and on a continuous basis? The answer is no surprise: to cool the interior of a structure, you must first cool its roof. The roof is the only surface of any building that is constantly exposed to the sun's radiant heat, and therefore generates the greatest heat load—nearly 50 percent of the total for the entire structure. It stands to reason, then, if we eliminate the roof as a source of radiant heat, there can be an overall temperature reduction inside the building. This is where an evaporative roof cooling system comes in.

The cooling associated with evaporation, while effective, is only temporary. In order to achieve continuous cooling, there must be a system in place to automatically deliver a thin film of water to the roof in predetermined intervals. Notice the use of the phrase "thin film of water." Ponding water on a roof is not only ineffective, but actually counterproductive. Any puddle will act as an insulator, trapping heat on the roof instead of carrying it away.

Generally, most evaporative cooling systems divide the roof into zones, each consisting of numerous spray heads. A control scheme (either software or programmable control box) activates each zone for a period of 15-20 seconds, spraying the aforementioned thin film of water. Once all zones have been adequately sprayed, a "dwell time" of 2-3 minutes is allowed for evaporation to take place. The cycle then begins anew. This entire sequence is usually monitored by a thermostat wired into the control scheme, which only permits the system to activate if conditions exist to facilitate complete evaporation.

How Can Roof Cooling Save Energy?

We’ve discussed exactly what evaporative cooling is and how it can be applied to a roof in an industrial setting. I’m sure by now you’re thinking, “That’s great, but how is this going to help my facility reduce its energy costs?” For the answer, let’s start by looking at a few basic facts:

The evaporation of 1 gallon of water will absorb 8,652 BTUs of heat energy.

One ton of air conditioning is the equivalent of 12,000 BTUs of energy.

Given the above statements, and applying some simple math, we see that it takes the evaporation of less than 1.5 gallons of water to provide the equivalent cooling effect of one ton of air conditioning. Since the cost of 1.5 gallons of water is considerably less than the cost to run 1 ton of air conditioning, can you begin to see the savings? Here’s the takeaway: every one ton of heat load removed by an evaporative roof cooling system means one less ton of cooling load placed on your facility’s HVAC system.

What can this reduction in cooling load mean for your facility? First and foremost, it translates into direct energy savings that go straight to your bottom line. A reduced heat load results in an immediate reduction in A/C cycle time frequency and duration, and thus electrical consumption. For large industrial facilities that consume mass quantities of electrical power, the addition of an evaporative roof cooling system can also soften the blow of costly demand charges and ratchets imposed by many power companies.

Some of you may be thinking, “I’ll just add more insulation under the roof. That will reduce the overall heat load.” Sadly, doing so only delays the inevitable. Insulation merely slows the process of heat transfer, and does not stop it completely. The fact remains that the heat radiating from your roof will eventually find its way into the interior of your building, regardless of your insulation’s R-value. However, by systematically cooling the roof directly above the insulation, you radically decrease the rate of heat transfer, and actually improve its insulating effect.

What’s This Going To Cost Me?

This is without a doubt the million dollar question. When weighed against the cost and effectiveness of alternatives, as well as the continued costs of doing nothing, the response is “not as much as you’d think.” Why? A professionally installed, properly programmed evaporative roof cooling system lasts for many years, requires little continuous maintenance, and its operating costs are minimal compared to a large HVAC system. Also, there is no decrease in system effectiveness over time. This is not the case with such alternatives as reflective roof coatings. Over time, the coating deteriorates, along with its reflective capabilities. It must then be removed and reapplied, incurring additional cost for your facility.

Let’s look at an example to demonstrate cost savings and return on investment: 100,000 square foot facility with tar and gravel roof, 1 inch of fiberglass insulation with a U-factor of 0.26, 400 tons of A/C capacity, electric rate of $0.07/kWh, and a cost of $5 for 1000 gallons of water.

On any given summer day, an untreated tar and gravel roof can reach 155 degrees F. With an evaporative cooling system, that temperature could easily be brought down to 90 degrees F. Therefore, the heat load removed from the HVAC system is:

[100,000 x (155-90) x 0.26]/12,000 = 140 tons of heat load removed.

It takes approximately 1.3 kW per hour to operate 1 ton of air conditioning, and on average it runs 2,500 hours per year. With that in mind, our projected yearly energy savings is as follows:

140 x 1.3 x 0.07 x 2,500 = $32,039.58 in energy savings

The evaporative cooling system uses about 0.1 gallon per square foot per day, meaning our system would cost $50 per day or $10,000 per year to run. This translates into a net annual savings of $22,039.58, and a payback of just over 2 years on a $50,000 system. A payback period of this length is well below the 3-3.5 year industry standard for an energy conservation system.

Putting It All Together

The tide of high energy prices shows no sign of ebbing anytime soon—global unrest, waning supply, high demand, and investor speculation will see to it. Businesses large and small, whether local or multinational, continue to face challenging head winds in dealing with this trend. However, we have seen that the solution need not be complicated or expensive. All it takes is rudimentary physics, some water, and a little help from Mother Nature!