

# A cooling tower's best friend:

new technology reduces water use by up to 80 percent



Have you ever noticed puffs or cloud plumes coming from cooling towers on cityscapes?

They've been around for decades, a silent reminder of the millions of gallons of water wasted each year as we seek to provide cooling for offices, factories, data centers and even power plants.

By Thomas P. Carter, P.E.,  
Senior Program Manager,  
Heat Rejection Technology  
Johnson Controls

Johnson  
Controls 

 BLUE  
STREAM

A new hybrid cooling technology has shown results that could turn the reduction in plumes into a positive signal that we're actually saving an astonishing 25 to 80 percent of water usage in comparison to all-evaporative heat rejection systems. Working in conjunction with the National Renewable Energy Laboratory and the Electric Power Research Institute, Johnson Controls is testing this new technology in actual field applications.

### BlueStream™ Hybrid Cooling Technology

Like fanning away sweat on a hot day, open cooling towers reduce the temperature of water heated in chillers, industrial processes, data centers and other high-heat practices. Through a "wet" process, the warm water is sprayed over the fill in a cooling tower to increase the contact area, and the heat is removed through evaporation.

A constant supply of water is needed to replace the water evaporated from the cooling tower, but in many regions, continuing droughts and increasing competition for this vital resource limit water availability. Additionally, some water is continuously bled from the system to reduce the buildup of undissolved solids as water is evaporated. This generates a large wastewater stream, often containing many additional water treatment chemicals.

We are testing a new approach with very promising results: the BlueStream™ hybrid cooling system. Used in conjunction with a traditional cooling tower, a hybrid cooling system offers a way to not only reduce environmental impact, but also lower operating costs and increase the resiliency of critical operations.

The system offers "dry" cooling, using a thermosyphon process, in which refrigerant circulates naturally, with no need for a pump or compressor. Intelligent, web-connected controls coordinate the operation of both the wet and dry system components and adjust in all weather and thermal load conditions for optimum efficiency, utilizing "wet" cooling when it's hot and "dry" cooling when it's not.

Best of all, because of the connection to building automation systems, building owners can maximize efficiency and have detailed operating information, which allows for better understanding of trends and helps forecast costs.

Certainly there are some limitations. If it's too hot outside or if the process temperatures aren't warm enough, it's inefficient to use dry cooling during these times.

Intelligent buildings make decisions automatically. In addition to responding to changing weather and system load conditions, the controller adjusts the fan speeds for the wet and dry units based on the Water-to-Energy Cost Equivalence Ratio (WECER) – the ratio of water costs to electricity costs for optimum system economic savings.



## Tremendous Market Potential

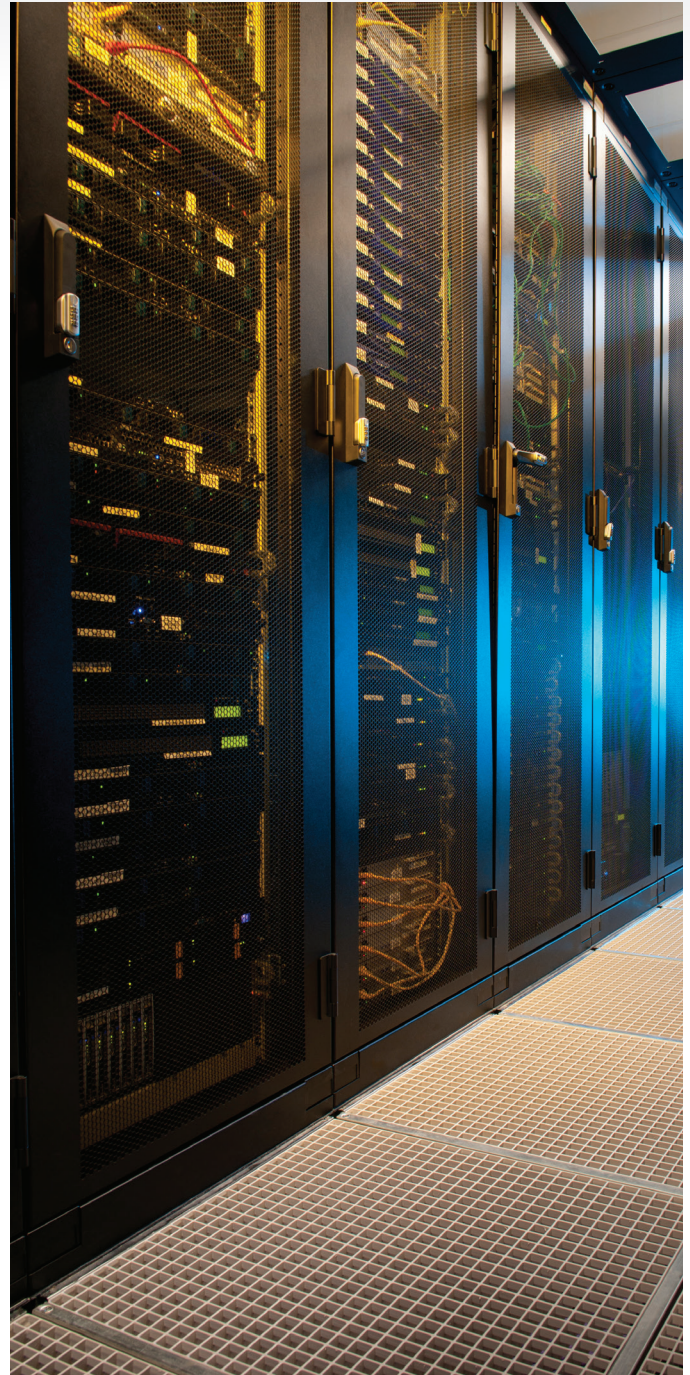
The current outlook is good in cities with high water prices, such as Atlanta and Seattle, or those with water shortages, such as Phoenix and Dallas. Whether as an add-on to an existing system or designed for new construction, thermosyphon hybrid cooling offers options for significantly reduced water usage while maintaining peak energy performance on the hottest summer days.

The potential is enormous, especially in these areas:

### DATA CENTERS:

The compound annual growth rate of the global data center construction market is expected to grow 12.5 percent from 2016-2020, according to a 2016 Research and Markets report.<sup>1</sup> Servers and other electronic components within these centers are operating at increased temperatures, which require increased cooling capacity and 24/7 reliability. Early projects have shown success:

- **U.S. Department of Energy National Renewable Energy Laboratory** – Johnson Controls thermosyphon technology was installed at NREL’s Golden, Colorado 1 MW data center in 2016, where it is projected to save a million gallons of water each year. According to David Sickinger, the NREL project lead for this project, “This data center is the single largest source of water and power demand on campus, so dramatically reducing water use while continuing efficient data center operations is of significant interest.”
- **U.S. Department of Energy Sandia National Laboratories** – Based on NREL’s success, the Albuquerque location is planning a system at its 12-14 MW data center that is expected to annually save 4-5 million gallons of water. “We see a payback of just a few years,” says Sandia engineer Dave Martinez. “We’re also looking at ways to use that heat in labs, absorption machines or making chilled water.”
- **Dallas, Texas Data Center** – Johnson Controls modeled a 16 MW data center and found the hybrid cooling system not only saves over 25 percent of the annual water use, but also reduces energy. The combined HVAC energy and water operating cost savings exceeded \$470,000/year compared to the base water-cooled chiller system and was more than \$610,000 compared to the air-cooled chiller system.<sup>2</sup>





### POWER PLANTS:

Hydropower stations and thermoelectric plants, which depend on water to generate energy, together contribute about 98 percent of the world's electricity production, according to the U.S. Energy Information Agency.<sup>3</sup> Water temperature shifts and lack of fresh water due to climate change could lead to reductions in electricity production capacity in more than two-thirds of the world's power plants between 2040 and 2069, according to the International Institute for Applied Systems Analysis in *Nature Climate Change*.<sup>4</sup> More efficient cooling could drastically impact power availability and reliability.

- **Georgia Power** – Working with the Electric Power Research Institute, Johnson Controls installed a pilot project consisting of a thermosyphon and a small conventional mechanical draft cooling tower at the Water Research Center in Cartersville, Georgia. The data collected over the year-long test program revealed significant reductions, with monthly average water savings of 34 to 78 percent, even during average monthly ambient temperatures above 70°F.<sup>5</sup>

### COMPLEX INDUSTRIAL / MANUFACTURING PLANTS:

Although water use in U.S. manufacturing is declining, it still totals almost 16 billion gallons per day.<sup>6</sup>

- **Houston, Texas Chemical Plant** – The Texas Industries of the Future along with Phelps Engineering conducted a detailed annual economic analysis for a chemical plant in the Houston, Texas area to determine the impact of water constraints on overall plant profitability. Simply installing various numbers of thermosyphon coolers can cost-effectively provide additional operational resiliency and ensure plant profitability even with water constraints. For this particular chemical plant, even a minor 15 percent reduction in the water allocation over a four-month period would erode net operating profits by approximately \$20 million per year. Installing the units would allow the plant to maintain its full production and operating profitability with a 15 percent reduction in the four-month summer water allocation.<sup>7</sup>

### CENTRAL CHILLER PLANTS:

Large universities, hospitals and office building complexes that commonly handle smaller year-round base loads are ideally suited for thermosyphon cooler applications. For example, a base load of just 500 tons can require between six and nine million gallons of cooling tower make-up water annually. While there always has been a focus on reducing energy associated with these plants, rapidly escalating water, wastewater and chemical treatment costs now represent 20 to 40 percent of the plants' total utility spend. A 2014 study

presented at the International District Energy Association's 27th Annual Campus Energy Conference showed that installing thermosyphon cooler systems to a 500-ton, base-loaded central plant allowed the facility to reduce its annual water consumption by one to six million gallons while simultaneously reducing its total annual utility spend by \$5,000 to \$50,000. Thermosyphon systems' modular design offers the ability to add multiple units in parallel to handle a wide range of water conservation requirements.<sup>8</sup>

## The urgency to act is growing stronger

Businesses are concerned about their vulnerability to water restrictions, along with the accompanying operational, productivity and economic risks. And recently introduced federal legislation would direct the U.S. Department of Energy to integrate water considerations into its energy research, development, and demonstration programs and projects by, among other things, improving the understanding of the water required to provide reliable energy supplies.

Water is a precious resource. BlueStream™ hybrid cooling technology has the potential to make a huge difference by reducing our impact on the environment and freeing up water for more critical uses.



[www.JohnsonControls.com/BlueStream](http://www.JohnsonControls.com/BlueStream)

### Notes:

1. Global Data Center Construction Market 2016–2020. Rep. no. ID: 3846178. Research and Markets, Sept. 2016. Web. 14 Oct. 2016. <[http://www.researchandmarkets.com/research/452zhn/global\\_data](http://www.researchandmarkets.com/research/452zhn/global_data)>.
2. Johnson Controls Internal Study – Detailed annual system simulation wperformed by Johnson Controls. Thomas P. Carter, P.E. July, 2015
3. “U.S. Energy Information Administration – EIA – Independent Statistics and Analysis.” What Is U.S. Electricity Generation by Energy Source? U.S. Energy Information Administration, 1 Apr. 2016. Web. 14 Oct. 2016. <<https://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3>>.
4. Van Vliet, Michelle T. H., David Wiberg, Sylvain Leduc, and Keywan Riahi. “Power-generation System Vulnerability and Adaptation to Changes in Climate and Water Resources.” *Nature Climate Change*. Nature Climate Change, 27 Nov. 2015. Web. 14 Oct. 2016. <<http://www.nature.com/nclimate/journal/v6/n4/full/nclimate2903.html>>.
5. “Performance Evaluation of a Thermosyphon Cooler Hybrid System at the Water Research Center at Plant Bowen.” EPRI. Electric Power Research Institute, 13 Dec. 2013. Web. 14 Oct. 2016.<http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=00000003002001594>
6. Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2014, Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405, 56 p., <http://dx.doi.org/10.3133/cir1405>.
7. Ferland, Kathey, and Peter Phelps. Evaluation of Water Curtailment on Energy Use and Plant Net Profitability. Proc. of Industrial Energy Technology Conference, New Orleans, LA. Texas Industries of the Future, 4 June 2015. Web. 14 Oct. 2016. <<http://texasiof.ceer.utexas.edu/PDF/Reports/2014/IETC%202015%20Water%20Energy%20Process%20Cooling%20Eval%20for%20web.pdf>>.
8. Carter, Thomas P., 2014, Water Savings Using the Thermosyphon Cooler Hybrid Heat Rejection System: Case Studies from Atlanta, Phoenix, Seattle and Boston, Districtenergy.org. <http://districtenergy.org/assets/pdfs/2014-Campus-Atlanta/Track-B/2B.1Carter.pdf>
9. Global Risks 2016. Rep. no. REF: OREF: 08011680116. World Economic Forum, 14 Jan. 2016. Web. [http://www3.weforum.org/docs/GRR/WEF\\_GRR16.pdf](http://www3.weforum.org/docs/GRR/WEF_GRR16.pdf)
10. H.R.5979 – 114th Congress (2015–2016) Introduced in House (09/09/2016) Energy and Water Research Integration Act of 2016 <https://www.congress.gov/bill/114th-congress/house-bill/5979>

### About Johnson Controls

Johnson Controls is a global diversified technology and multi industrial leader serving a wide range of customers in more than 150 countries. Our 130,000 employees create intelligent buildings, efficient energy solutions, integrated infrastructure and next generation transportation systems that work seamlessly together to deliver on the promise of smart cities and communities. Our commitment to sustainability dates back to our roots in 1885, with the invention of the first electric room thermostat. We are committed to helping our customers win and creating greater value for all of our stakeholders through strategic focus on our buildings and energy growth platforms. For additional information, please visit <http://www.johnsoncontrols.com> or follow us @johnsoncontrols on Twitter.

### About Johnson Controls' Building Technologies & Solutions

Johnson Controls' Building Technologies & Solutions has an unmatched portfolio of HVACR products and solutions, security and fire safety products and solutions to create safer, smarter and more efficient buildings. Operating in more than 150 countries through a strong network of distribution channels, Buildings' smart building integration capabilities and energy financing solutions help building owners, operators, engineers and contractors impact the full lifecycle of a building for a safe, connected and sustainable environment. Its market leadership is established through a full array of trusted brands, including fire and safety brands Simplex and Grinnell, and HVACR brands YORK®, Sabroe® and Metasys®. For more information, visit [www.johnsoncontrols.com](http://www.johnsoncontrols.com) or follow @JCI\_BEnews.