CHALLENGING CONVENTIONAL WISDOM

Making the case for high energy efficiency air-cooled chillers in 300- to 1,000-ton systems

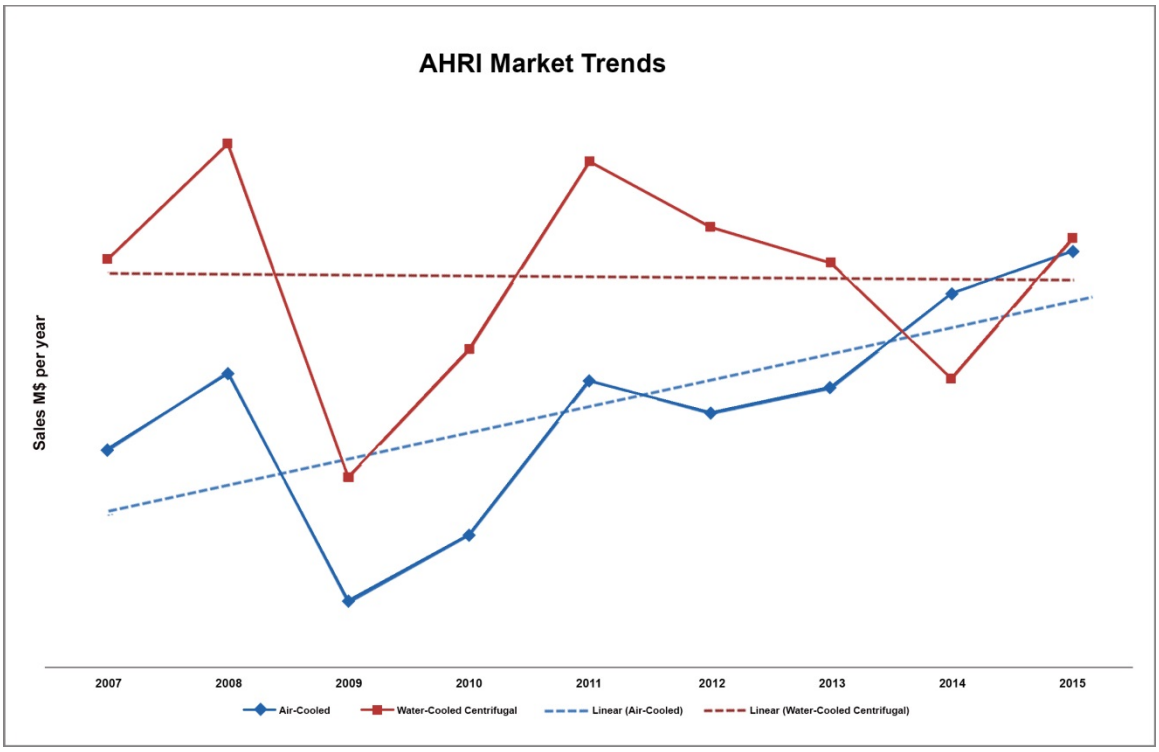
By Robert Landes

While water-cooled centrifugal chiller systems were once the undisputed champions of efficiency, the latest advancements in air-cooled chillers have changed the script. If you're not already comparing air-cooled chillers alongside water-cooled in 300 to 1,000 ton systems, it's time to take a step back and reevaluate today's options.

As engineers, we're inclined to think about air-cooled chillers as a low first-cost investment that sacrifices performance. Recent efficiency improvements in air-cooled technology are debunking this notion, making them a cost-effective alternative not only from a first cost perspective, but also a total cost of ownership perspective. Once you've done the comparisons, you may even be surprised to find that air-cooled chillers are likely to become your preferred solution in systems less than 1000 tons.

To get a holistic view of the air-cooled vs. water-cooled comparison, let's break this down — comparing the systems' total operating costs.

You don't need to take my word on the movement toward air-cooled chillers. According to the Air-Conditioning, Heating and Refrigeration Institute (AHRI), while water-cooled centrifugal chillers have historically occupied the lion's share of the chiller market segment, times are changing. Air-cooled chiller bookings have risen as these systems have become more competitive with large water-cooled chillers.[1]



The reasons behind this shift likely vary from economic to water scarcity to reduced health risks. At an economic level, recent studies[2,3] show air-cooled chillers offer a lower total cost of ownership and ease of maintenance. Global water scarcity in many regions may also be driving this trend. In fact, with drastic water shortages is some regions of the United States, this year alone has seen a 14 percent increase5 in the air-cooled chiller market. We also cannot overlook recent news stories about the rise of legionella disease as a result of cooling towers associated with water-cooled systems.

Advancements in energy efficiency and system specification

Further fueling the trend toward air-cooled chillers are notable technology upgrades. These include high energy efficiency air-cooled chillers that are equipped with variable speed technology and variable volume ratio technology, allowing compressors to be tailored to any operating condition and boosting energy efficiency and performance. With these features building managers and owners achieve more accurate control, better real world performance, and lower sound levels.

The level of configuration new air-cooled chillers offer gives engineers the freedom to define their project and have equipment built to their precise requirements by mixing and matching compressor or evaporator sizes and other features. By investing only in the performance and features needed, engineers specifying air-cooled chillers can help their customers improve the bottom line and increase efficiency.

These upgrades are helping air-cooled systems change the paradigm by making them increasingly likely to be as or more cost effective as compared to water-cooled systems at 300 to 1,000 tons.

To understand the efficiency gains, let's compare an air-cooled chiller's overall performance against a water-cooled system in a full year energy model using the Daikin Applied Energy Analyzer™ II. The analyzer simulated a 930-ton hospital located in Washington, D.C. with either two VFD-driven high efficiency water-cooled chillers ("HVAC A") or three VFD-driven high energy efficiency air-cooled screw

chillers (“HVAC B”).

Performance Details

	Annual Building Use And Charges			Annual Use and Charges per Square Foot	
	HVAC A	HVAC B	% Change	HVAC A	HVAC B
Total Utility Charges	$1,107,420	$1,076,390	2.80%	$3.16	$3.08
Electrical Usage (kWh)	7,051,990	7,219,767	-2.38%	20.15	20.63
Electrical Consumption Charges	$824,005	$843,741	-2.40%	$2.35	$2.41
Electrical Demand Charges	$35,345	$42,576	-20.46%	$0.10	$0.12
Maximum Electrical Demand (kW)	1,509.9	1,965.5	-30.18%	0.004	0.006
Total Electrical Charges	$859,350	$886,317	-3.14%	$2.46	$2.53
Gas Usage (therm)	85,409	85,409	0.00%	0.24	0.24
Gas Charges	$56,567	$56,567	0.00%	$0.16	$0.16
Water Usage (kGal)	11,557	8,057	0.00%	0.03	0.02
Water Charges	$191,504	$133,506	30.29%	$0.55	$0.38

Numbers don’t lie: air-cooled chillers have lower costs

As you can see in the chart above, while the air-cooled chillers have a higher electrical draw, leading to slightly higher electrical usage and demand costs, these expenses are more than offset by the pump energy and water costs of the water-cooled system. Through this simulation, we’re able to see air-cooled system utility costs that are approximately $31,000 less than the water-cooled system to operate each year, and this yearly savings of $31,000 doesn’t even factor in the reduced maintenance cost of an air-cooled system!

Another reason water-cooled systems may not have a cost of ownership advantage because the number of gallons of water required and treated– in the millions annually for standard 1,000 ton cooling towers, which increases operating costs. While municipal water rate structures differ due to various peak, off-peak, service, commodity, and block consumption charges, what we know for certain is that the cost of water is rising. A recent report in USA Today showed users pay 75 percent more for water today than in 2000 and predicts the rates will continue rising five to 15 percent per year, outpaced only by heating oil.

We must also consider the ecological impact of water usage. Changing weather patterns have led to water shortages, especially in the western region of the United States. Farmers are drilling deeper water wells than ever before to find water for irrigation, and with water reservoirs at record low levels, communities will find themselves forced to make hard decisions on allocating water to various usages.

Owners and operators of HVAC systems must consider future water availability as a key decision point in which kind of system to use. Critical facilities, such as data centers are already starting to move toward air-cooled systems in many locations specifically because they cannot guarantee a guaranteed source for cooling tower make-up water.

Simplified controls, affordable maintenance for busy staff

Along with these energy savings, another critical factor that increases the appeal of air-cooled machines is the reduced costs to treat and maintain them. With no cooling tower, condenser pump or condenser water treatment system to service and maintain, and no associated costs required for condenser water treatment chemicals, air-cooled chillers offer simplified maintenance. Simplistic control of the air-cooled chillers also reduces the need for highly-skilled maintenance staff. Most routine maintenance requirements, such as checking electrical connections for tightness, annual oil analysis, and visual checks of oil and refrigerant levels are simple and straight-forward to perform. Condenser coils are located conveniently and are easy to clean. These factors help decrease maintenance staff and budgets for air-cooled chillers, making them more cost-effective and environmentally responsible alternative to water-cooled systems.

Maximizing rentable space, reducing installation fees and freeze protection

Air-cooled chillers installed outdoors require no mechanical room space and provide easy installation, extending the cost advantages of the latest systems. While freezing weather can pose challenges, the view that glycol is a negative aspect to air-cooled systems is not entirely accurate. In fact, either type of chiller (water or air) must consider cold weather issues since both require system maintenance for freeze protection.

Air-cooled chillers: an undeniable alternative This simulation sets the stage for how the latest air-cooled chiller systems lower total cost of ownership with improved efficiency, reduced maintenance, and markedly less water consumption than variable speed water cooled chiller systems. From a comprehensive view, today's generation of air-cooled chillers are presenting an undeniable alternative and strong overall value in the 300 to 1,000-ton range, where larger water-cooled systems once reigned.

About the author:
Robert Landes is a product manager of positive displacement chillers at Daikin Applied. He holds a bachelor's degree in Integrated Science and Technology and has held various positions in HVAC, having held service technician and applications engineering roles.

1 AHRI statistical data to member organization for air-cooled and water-cooled chiller bookings for 2009.

2 Naguib, R. (2009). Total cost of ownership for air-cooled and water-cooled chiller systems. ASHRAE Journal. 51(4). 42-48. American Society of Heating, Refrigerating and Air conditioning Engineers.

3Schurk, D. (2015). Air-cooled: A (surprisingly) cost-effective alternative to water-cooled chiller plants.