WHITE PAPER

The Positive Impact of Humid Environments on the Payback of IPC 11550 for Retrofit Projects

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The IPC 11550 is a chilled water plant automation solution that employs a digital era control algorithm, namely Hartman LOOP™ technology, for ultra-efficient operation of an all-variable-speed chilled water plant. Interestingly, in the case of chiller plant retrofits, the economics, including payback period, are more favorable in humid environments than in drier more arid environments.

This counter-intuitive statement is often difficult to accept for individuals who are familiar with the impact of condenser water relief on variable-speed chillers. The most commonly heard argument against this idea is “there is no opportunity for condenser relief in humid environments”. This is generally agreed, for the most part, and fortunately, the IPC 11550 with Hartman LOOP™ technology is not dependent on condenser water relief. For those not familiar with the concept of condenser water relief, quite simply during periods of low load and lower ambient wet bulb temperatures, the cooling tower fans can be run to deliver condenser water to the chiller at a temperature that is lower than design day. By reducing the water temperature the variable speed compressor on the chiller can be slowed down to save energy.

To demonstrate this concept we will compare two identically-sized chiller plants in two different cities. The cities are Miami, Florida and San Diego, California. Miami is notorious for high humidity, whereas San Diego is in general an arid pleasantly dry atmosphere.

For each city we will consider an IPC retrofit for 3 starting scenarios;

1. an existing fixed-speed chiller plant with constant primary and variable speed secondary pumping
2. an existing variable speed chiller plant with constant primary and variable speed secondary pumping
3. an existing variable speed chiller plant with variable primary and variable secondary pumping.

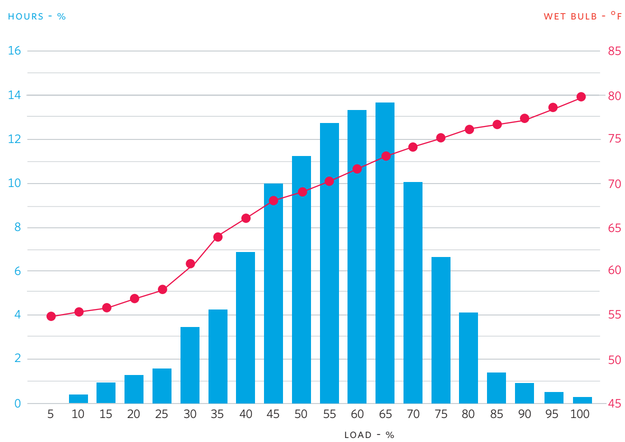
The final plant retrofitted condition will be the all-variable-speed chiller plant with variable primary pumps, and variable speed condenser water pumps, automated using Hartman LOOP™ Technology.

The chart below informs us of some critical differences between these two applications for a similar design day load. First, the tower fan motor draw for 100% fan speed in Miami is over twice that required in San Diego. Also, the annual ton-hours in Miami are almost twice that of San Diego. This results from the two different load profiles that are largely humidity induced.

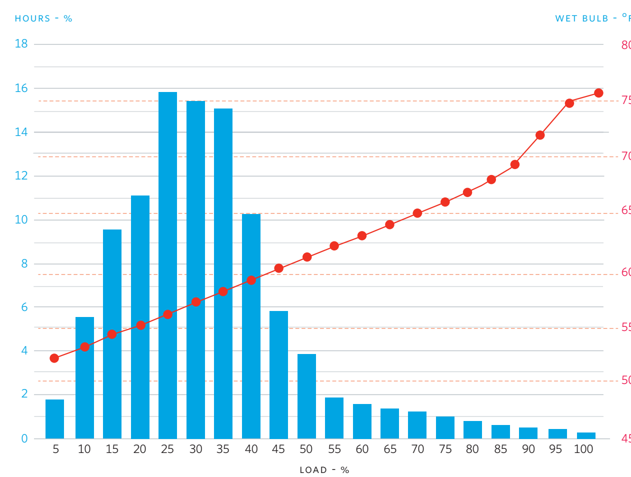
	Miami, FL	San Diego, CA
Design day WBT	80°F	76°F
Annual hours of operation	8400	8182
Design day load	2400	2400
Annual ton-hrs(000)	11,235	6,115
Electrical energy cost	$0.0786	$0.0786
Base cast CW reset	NO	YES
Tower fan kW load	147 kWe	70 kWe

The charts below allow us to compare the annual average load profile and weather profile (by wet bulb temperature), for the two cities. We can see that the majority of operating hours in Miami are above 45% design day load of the plant, with a wet bulb above 68F. Whereas, in San Diego, the majority of operating hours are below 40% design day load with a wet-bulb temperature below 60°F.

LOAD PROFILE MIAMI



LOAD PROFILE SAN DIEGO



So, how do these plants perform with a traditional fixed-speed chiller plant design?

ANNUAL EFFICIENCY

	Miami, FL	San Diego, CA
Fixed-speed chiller plant	0.99	1.13

The chart above shows something completely un-expected. The chiller plant in the dry environment is less efficient that the chiller plant in the humid environment. Fundamentally, there are 2 reasons for this,

(1) the fixed speed chiller operates more efficiently near full load, an operating point favoring Miami. In San Diego, the majority of time has 2 chillers operating near or less than 50%,

(2) whenever an additional chiller is added in a fixed-speed chiller plant, the condenser water pumps and primary chilled-water pumps operate at full speed, and as a percent of operating load have a larger impact in San Diego than in Miami.

Let's consider a variable speed chiller with a constant primary and variable secondary pumping arrangement, and apply condenser water relief to the San Diego plant to take advantage of the lower wet bulb (CW at 75F LTWT).

ANNUAL EFFICIENCY

	Miami, FL	San Diego, CA
Fixed-speed chiller plant	0.99	1.13
VS chiller CPVS	0.73	0.72

The chart above now shows that the annual average efficiency favors the plant in San Diego, where we can get the efficiency advantage from compressor turn down through substantial CW relief, as shown in the chart below.

	Fan Speed (%)	ECWT / LTWT
5	29.0	75
10	38.0	74
15	44.0	76
20	54.0	75
25	63.0	74
30	68.0	76
35	56.0	74
40	62.0	74
45	66.0	75
50	71.0	75
55	80.0	75
60	88.0	75
65	90.0	76
70	84.0	75
75	88.0	75
80	100.0	75
85	100.0	77
90	100.0	79
95	100.0	82
100	100.0	85

Below is the plant annual average performance data for a variable primary plant at both locations, and an ultra-efficient all-variable-speed plant automated using IPC 11550 with Hartman LOOP™ technology.

ANNUAL EFFICIENCY

	Miami, FL	San Diego, CA
Fixed-speed chiller plant	0.99	1.13
VS chiller CPVS	0.73	0.72
VS chiller VPF	0.67	0.65
IPC VS Chiller VPF	0.56	0.49

It would seam that on a percentage basis the biggest savings are being realized with IPC in San Diego, and this is the case as shown on the next chart. We have also shown the annual electrical energy cost for the plants.

ANNUAL ENERGY COST

	Miami, FL	San Diego, CA
Fixed-speed chiller plant	$865,225.70	$535,803.56
VS chiller CPVS	$647,979.55	$340,119.08
VS chiller VPF	$593,965.49	$307,232.78
IPC VS Chiller VPF	$491,887.00	$227,632.00

ENERGY SAVING OF IPC

	Miami, FL	San Diego, CA
Fixed-speed chiller plant	43%	58%
VS chiller CPVS	24%	33%
VS chiller VPF	17%	26%
IPC VS Chiller VPF	0.56	0.49

The chart below converts the percent energy savings to actual dollar savings for the efficiency gains described in the 6 scenarios in the previous chart.

ENERGY COST SAVINGS WITH IPC 11550

	Miami, FL	San Diego, CA
Fixed-speed chiller plant	$373,338.70	$308,171.56
VS chiller CPVS	$156,092.55	$112,487.08
VS chiller VPF	$102,078.49	$79,600.78

The cost to implement an all-variable-speed plant will vary dependant on the starting configuration of the existing plant. However, two similar retrofit projects in San Diego and in Miami will have similar costs, those costs are shown in the chart below.

PLANT CONVERT COST

	Miami, FL	San Diego, CA
Fixed-speed chiller plant	$503,196.00	$473,766.00
VS chiller CPVS	$279,304.00	$249,874.00
VS chiller VPF	$247,868.00	$218,438.00

Using the annual energy savings and above costs to convert the plant to an all-variable speed ultra-efficient plant, we arrive at the simple payback periods below given in operating months.

PAYBACK OP MONTHS

	Miami, FL	San Diego, CA
Fixed-speed chiller plant	16.2	18.5
VS chiller CPVS	21.5	26.7
VS chiller VPF	29.2	33.0

The results of the faster payback in Miami are directly related to the greater number of ton-hours that the plant experiences. Even though the percent energy savings maybe smaller for Miami when we look at the annual average, the total dollar energy savings end up being much larger.

In short, the thesis is that a little of a lot can be more than a lot of a little.