Data center cooling system energy efficiency Test report

Chiller retrofit with intelligent chiller booster, adiabatic pre-cooling system "SMART COOLING™"

Vodafone Group Plc

2017

About

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Project location:	Portugal, Alfragide, Vodafone data center
Test time	Sept 8, 2017 - Sept 21, 2017

This test report shows data of efficiency, energy savings on the cooling equipment provided by intelligent adiabatic pre-cooling system BY 70 from 'Smart Cooling™'.
In order to reduce the energy consumption of the data center cooling system, air-cooled chiller TRANE Model 39CA538.01 was equipped with adiabatic pre-cooling system 'Smart Cooling™' BY 70.
8 Day Study to Measure the Ability of a TRANE air cooled water chiller System to Lower KWh consumption of an Air-Cooled Condenser, Model 39CA538.01

Contents

The Test

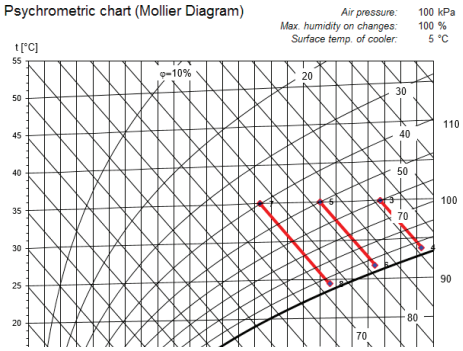
The test was designed & conducted to measure specific KWh and weather conditions during a 4 consecutive day period with the pre-cooling system off versus a 4 consecutive day period with the pre-cooling system on. The total KWhs used during each period was compared to each other along with weather conditions during each period in order to determine the efficacy of the pre-cooling system to save energy.

A 4-day period was chosen so that other factors would be equal. The 4-day periods where run consecutively in order to provide as similar test conditions for each period as possible

The "Smart Cooling™" equipment was installed and the study was conducted by Vodafone data analytics. It was overseen & verified by personnel from Vodafone Italia Claudio Romaneto.

The equipment used consisted of adiabatic system "Smart Cooling™" BY 70.

Before installation



The diagram shows the drop in the intake air temperature into the condenser by using (SM).
Dry bulb (SM) OFF Wet bulb (SM) ON

After installation

Test results

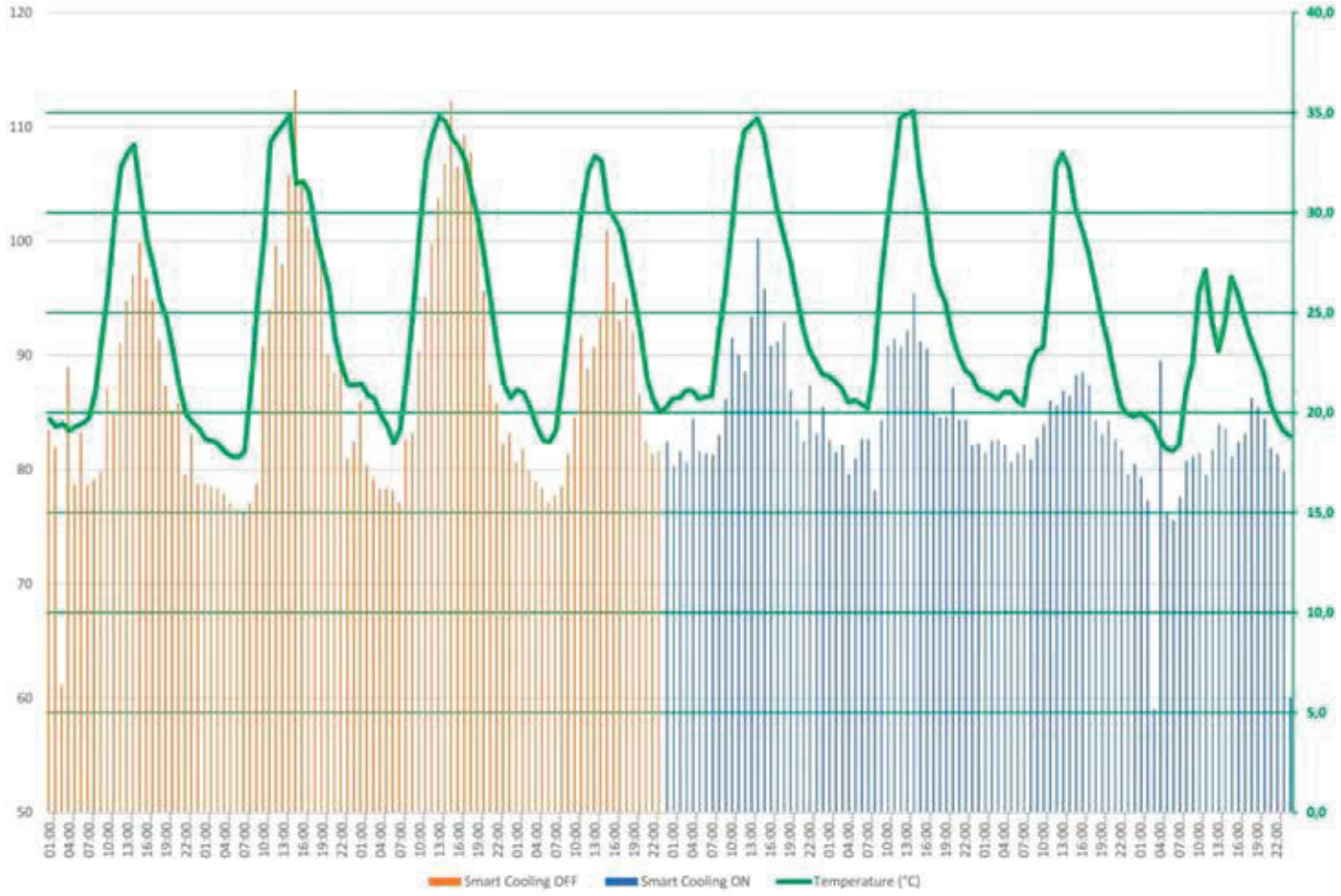
Methodology

Comparison has been carried on by recording data on air temperature, relative humidity and energy absorption of the chillers for two 4-day periods:

- From July 24th to 27th, 2017, with the "Smart Cooling™" system OFF;
- From July 28th to 31st, 2017, with the "Smart Cooling™" system ON.

Similar thermo-hygrometric conditions over the two periods make the comparison reliable.

The graph shows that, with comparable thermo-hygrometric conditions, Smart Cooling™ allows for a remarkable decrease in energy absorption of the chiller.



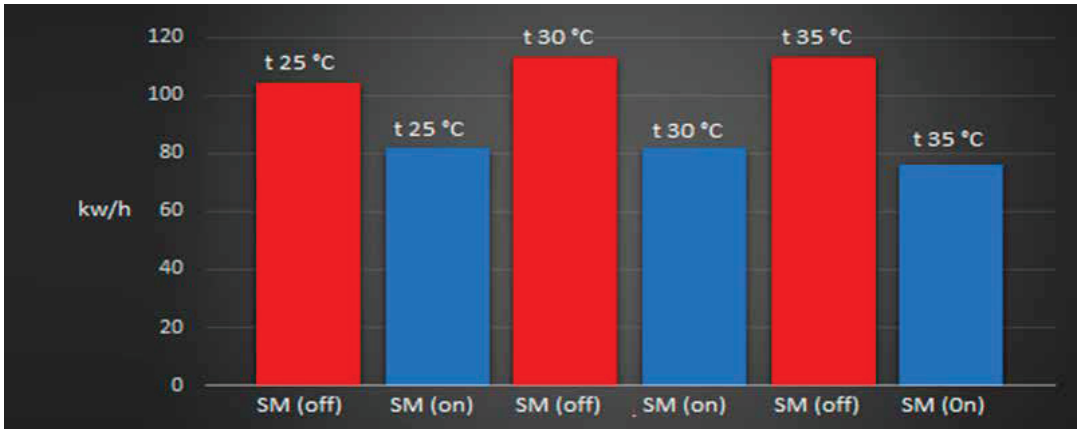
Point-on-point comparison

In the two examined periods, points having the same thermo-hygrometric conditions were selected.
As expected, the higher the temperature the better the system performs, with a peak of more than 30% saving at 35°C (highest temperature recorded).

Temperature (°C)	Date	Time	RH (%)	Actual data	
				Energy absorption (kWh)	SAVING
25	24/07/2017 (SM OFF)	18:00	53,3	104,15	**21,11%**
	29/07/2017 (SM ON)	19:00	61,2	82,16	
30	25/07/2017 (SM OFF)	14:45	40,1	113,50	**27,10%**
	30/07/2017 (SM ON)	15:00	40,6	82,74	
35	25/07/2017 (SM OFF)	13:15	41,3	111,95	**31,99%**
	29/07/2017 (SM ON)	12:15	37,8	76,14	

Period-on-period comparison for the 4 days (June 24th to 27th, 2017 vs June 28th to 31st, 2017)
For the period-on-period comparison, the following data have been excluded:

- All absorption figures of the OFF chiller
- All absorption figures when T<24°C (minimum threshold for the adiabatic system to start working)



- Total consumption from July 24th to 27th, 2017 when SMART COOLING OFF **4.494.664 Wh**
- Total consumption from July 28th to 31st, 2017 when SMART COOLING ON **3.504.837 Wh**

July 24th to 27th, 2017 SMART COOLING OFF **4.494.664 Wh**	July 28th to 31st, 2017 SMART COOLING ON **3.504.837 Wh**

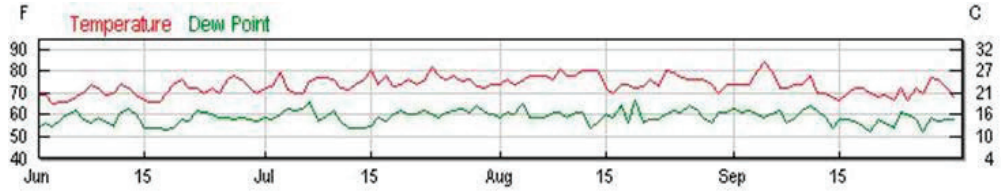
Difference in energy consumption when system is ON (T≥24°C)
989.827 Wh

Period-on-period comparison for the 4 months (June '16 – Sept -16 vs June '17 – Sept -17)

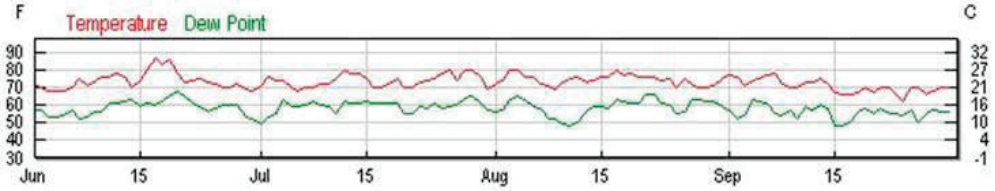
The below table reports the data on absorption from June 1st to September 30th, 2016, when SM system was not operating

The following table reports the absorption from June 1st to September 30th, 2017, with SM system at work.

To complete the analysis, below are reported the average temperatures in Lisbon
Year 2016



Year 2017



By comparing the data about the two June-September periods, it results that the saving achieved was 20,72 MWh (8%), despite the average temperature in the period June - September 2017 being 10% higher.

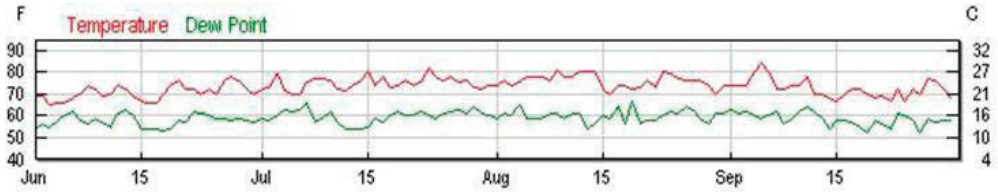
Another important finding is that with the "Smart Cooling™" system energy absorption never crossed 2,41 MWh between June and September 2017, while in the same period in 2016 - without "Smart Cooling™" - such value had been often crossed, with peaks of 2,76 MWh.

Year	Consumption MWh	Average MAX temperature	Hours with T >24°
2016 SM OFF	267,60	29	484
2017 SM ON	246,88	31	403
Saving	**20,72**		

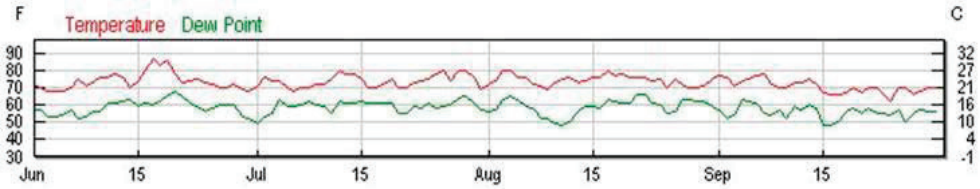
And the data about temperature and actual energy consumption used for the general report.

Temperatures

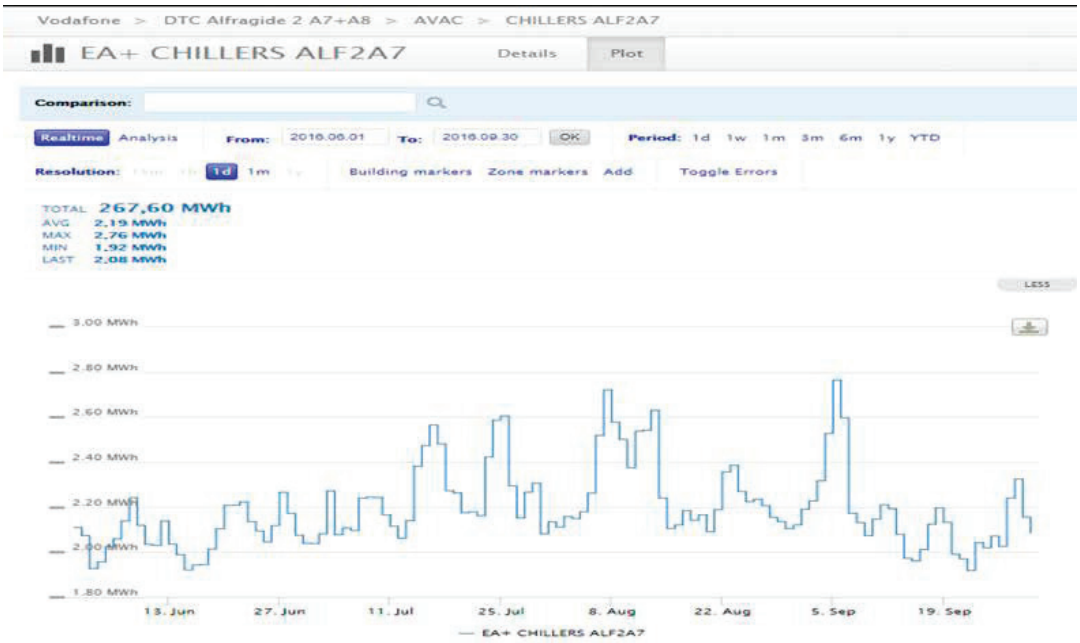
Year 2016



Year 2017



Energy consumption



Actual data on energy consumption from June 1st to September 30th show an overall saving of 20,72 MW. This data refers to a four-month period instead of the five months set as working period; it can be therefore assumed that the saving would have been 25,90 MW over the five months (this value has been obtained by dividing the 20,72 MW saving value by 4 and then by multiplying it by 5).

Water consumption was 411,26 over four months and, using the same calculation used for electricity cost, has

Additional considerations

Three factors contribute to this high Return on Investment time.

1. Each of the two chillers has been equipped with an independent system, despite the chillers not working at the same time.

In view of the past experiences, SM have developed a system, suitable for configurations with chillers below 400 Kw cooling capacity, capable of managing both the chillers, as long as they don't work at the same time. Implementing such system would have costed around 25% less.

2. The condensation control of the chiller, whose priority is to reduce the noise by reducing the speed of the fans, tends to keep the pressure constant even with lower temperatures.

3. The configuration of the chillers is oversized, compared to the actual requirements of the site.

4. Data provided by Vodafone on the energy consumption of the chillers in 2016 show that they work at 100% capacity only for 56 hours over a 2.880-hous period. The same data show that on an average the chillers work at 65% of the maximum capacity.

5. Data for 2017 show that chillers have worked at 100% capacity only for 4 hours over 2.880, as well as an average utilization of the chillers at 43% of their capacity.

Final considerations
Our analysis brings us to suggest undertaking the following in order to increase the overall efficiency of the cooling system:

1. To modify the configuration of the fans, so that they will start working at 100% when the temperature crosses 26°C, instead of 35°C (this change, that can be done through the chiller's microprocessor, will not hamper in any way the functioning of the chiller);
2. To decrease the amount of water, sprayed by the Smart Cooling system, by 28% (it is sufficient to set the adiabatic system's microprocessor).

These implementations would increase the overall efficiency of the chiller + Smart Cooling system, increasing the achievable saving by 40%.

We further suggest to modify the frequency of switching between the two chillers, bringing it to six months. Since the chillers are equipped with multiple compressors and they are used at less than 50% capacity, this would allow for an actually-uniform wearing of the compressors, which at present may actually not beinghappening.

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