

TEST REPORT No.45

Date: 31 July 2019

CHILLER EFFICIENCY PERFORMANCE WITH INTELLIGENT ADIABATIC CHILLER-BOOSTING **SMART COOLING™** PRO 10 SYSTEM

Test Participants

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Project Title: Double Tree by Hilton Dubai Al Barsha Hotel - UAE

Structure Location: Al Sabbat Street 49, Dubai, United Arab Emirates

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Introduction

Type of Structure: Multistory hotel building.

Cooling equipment: Carrier 30XA 1002 air-cooled water chiller (2 units).

Cooling capacity as per manufacturer's data performance sheet: 1000 kw

Electricity consumption as per manufacturer's data performance sheet: 344 kw

Chiller booster: Smart Cooling™ PRO 10 – adiabatic technology with condenser protection.

Chillers were retrofitted with the intelligent adiabatic **Smart Cooling™** system to reduce their electricity consumption and increase COP (Coefficient of Performance) efficiency.

The intelligent adiabatic **Smart Cooling™** system combines an adiabatic evaporative pre-cooling process and condenser protection with mechanical air filtration. The intelligent adiabatic **Smart Cooling™** system is mounted externally in front of the condensers of the cooling equipment. **Smart Cooling™** initiates the adiabatic process even before the mechanical cooling kicks in and the equipment receives a temperature-reducing fine mist of processed water that reduces the temperature of condensation within the cooling circuit.

Main components

Smart Cooling™ comprises the following key components: protective membranes, water treatment and recirculation systems, high-pressure water pump, control unit, high-pressure nozzle panels, fasteners and fixings.

Protective membranes are installed outside the condenser and cover its entire surface, preventing water mist from coming into direct contact with the condenser.

Water filtration, purification and sterilization: the system purifies water from minerals and sterilizes water to prevent bacterial occurrence.

A high-pressure pump provides water pressure of up to 70 bar while a water recirculation system reintroduces non-evaporated water into the water purification and pump system.

The control unit regulates the system according to real-time data sets such as chiller parameters, ambient air temperature and humidity to supply the adiabatic system with the appropriate amount of water.

A high-pressure nozzle provides water spray with 5- to 40-micron droplets.

A set of fasteners and fixings ensure the compatibility of the equipment with the chiller.



Equipment tested: Carrier 30XA1002 air-cooled water chillers.



Chiller without **Smart Cooling™**



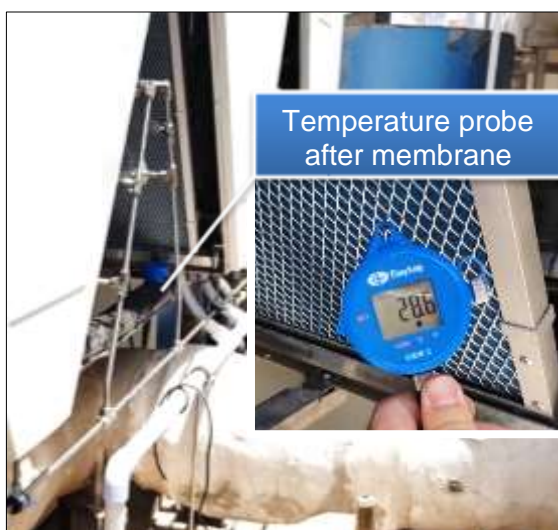
Chiller with **Smart Cooling™**

Shown in picture No.2 are the chiller's condensers fully enveloped by **Smart Cooling's™** protective membranes, which prevent water damage infiltration and damage. To the right of the image is the **Smart Cooling's™** pump station, pumping meticulously treated water at a 70-bar pressure. The system is equipped with an automated Siemens controller. The system also includes a water drain line to re-filter and safely reuse water, seen on the top right-hand side.



Picture No.2 - chiller equipped with **Smart Cooling™**

Temperature probe Nr.1



Probe showing inflowing air temperature past the protective membrane: +28.6° Celsius.

Temperature probe Nr.2



Probe showing inflowing air temperature before reaching the protective membrane: +43.0° Celsius.

Testing procedures on Test Nr.1

Measuring instruments

An RIF600 ultrasonic waterflow meter was used to assess the effectiveness of the chiller.

An Eniscope Analytics energy monitoring equipment was used to measure electricity consumption.

The formula for COP calculation was: $El/kw \div cooling/kw = cop$.

Testing Procedure

A data logger was installed on the subject HVAC equipment to collect all applicable real-time electricity consumption and unit performance statistics. Data was collected by the Eniscope Analytics device.

During the first 5 days (120 hours of use) of testing measured electricity consumption by the condenser without **Smart Cooling™**. During this period the chillers consumed 70,112 KW/h (Kilowatt hours).

Water consumption was 0 m³ and the average temperature and relative humidity during the period were 36°C and 34% RH.

During the following 5 days (120 hours of use), with **Smart Cooling™** switched on and fully operational, data gathered shows the chiller consumed 53,386 KW/h. Water consumption was 88 m³ and the average temperature and relative humidity during the period were 36°C and 45% RH.

After analyzing the monitoring, results show that energy savings gain delivered by **Smart Cooling™** during 5 operating days was 16,726 KW/h.

In the following pages, tables discriminate electricity consumption, air temperature and operating periods, before and after **Smart Cooling™**.

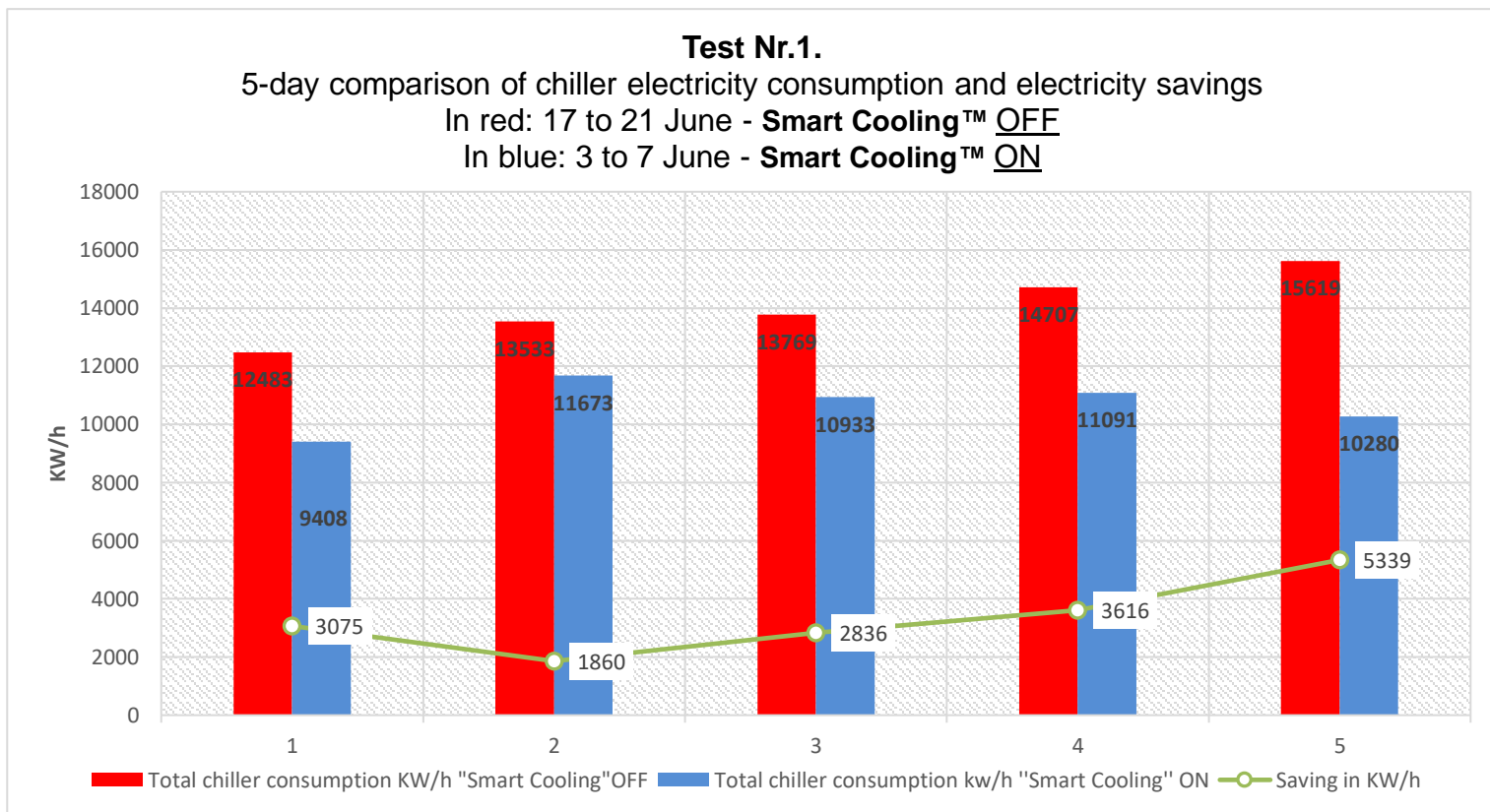
In all tables below, chiller operation without **Smart Cooling™** are shown in red and chiller operation with **Smart Cooling™** fully operational are shown in blue.

5-day Periods On-Off Testing Measurement Outcomes

With **Smart Cooling™**, in a period of 5 days, the customer economized 16,726 kw/h of electricity.

Electricity supply charges were, at the time, 0.46 Emirati Dirham (AED) per kw/h. Thus, total savings in electricity charges were of 7,693 AED.

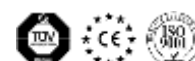
Water usage during the period was 88 m³ and water supply charges at the time were 10.5 AED per m³. In total, water supply expenses were of 924 AED.



Test Nr.1 Summary

Smart Cooling™ granted total savings post running costs of 6,769 AED in 5 days or 1,353 AED per day. On average, Smart Cooling™ reduced electricity consumption by 3,345 kw/h per day.

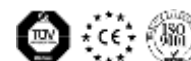
Smart Cooling™ engineers forecasted 17% savings for a 14-hour period within a 24-hour operational period – initially evaluated as 755 kw/h savings based on a 10°C temperature drop. However, the results measured during the system’s operation show that **Smart Cooling’s™** performance went well beyond predictions, delivering on average a 14°C decrease and further boosting chiller efficiency.



Test Nr.1

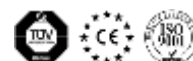
Five-day electricity consumption comparison – 17 to 21 June with Smart Cooling™ OFF and 3 to 7 June with Smart Cooling™ ON

Date	Total chiller consumption in KW/h with Smart Cooling™ OFF	Total chiller consumption in kw/h with Smart Cooling™ ON	Savings in kw/h	Savings in %	Chiller load with Smart Cooling™ OFF	Chiller load with Smart Cooling™ ON	Temperature with Smart Cooling™ OFF	Temperature with Smart Cooling™ ON
	17 June	3 June					17 June	3 June
17/06/2019 00:00	528	292	236	45%	84%	57%	33.49	31.00
17/06/2019 01:00	504	347	157	31%			33.24	30.44
17/06/2019 02:00	496	302	193	39%			32.79	30.01
17/06/2019 03:00	480	304	176	37%			32.59	29.87
17/06/2019 04:00	480	368	112	23%			32.51	30.02
17/06/2019 05:00	468	302	166	35%			32.26	29.87
17/06/2019 06:00	443	304	139	31%			31.21	29.79
17/06/2019 07:00	412	336	76	18%			32.13	30.99
17/06/2019 08:00	469	365	104	22%			34.63	34.04
17/06/2019 09:00	497	391	105	21%			36.81	34.78
17/06/2019 10:00	499	394	104	21%			38.01	35.96
17/06/2019 11:00	519	397	122	24%			41.79	38.24
17/06/2019 12:00	572	379	193	34%			42.82	38.82
17/06/2019 13:00	581	400	182	31%			39.74	36.75
17/06/2019 14:00	569	427	142	25%			38.05	36.26
17/06/2019 15:00	564	506	59	10%			37.39	35.12
17/06/2019 16:00	565	470	95	17%			36.11	34.56
17/06/2019 17:00	595	493	102	17%			35.42	34.00
17/06/2019 18:00	606	483	123	20%			34.10	33.02
17/06/2019 19:00	565	454	111	20%			33.54	32.48
17/06/2019 20:00	543	440	103	19%			33.17	32.38
17/06/2019 21:00	566	413	153	27%			32.79	32.29
17/06/2019 22:00	495	451	45	9%			32.25	32.17
17/06/2019 23:00	467	391	76	16%			32.05	32.36
Day Total	12483	9408	3075	25%				



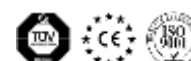
Test Nr.1

Date	Total chiller consumption in KW/h with Smart Cooling™ OFF	Total chiller consumption in kw/h with Smart Cooling™ ON	Savings in kw/h	Savings in %	Chiller load with Smart Cooling™ OFF	Chiller load with Smart Cooling™ ON	Temperature with Smart Cooling™ OFF	Temperature with Smart Cooling™ ON
	18 June	4 June					18 June	4 June
18/06/2019								
00:00	526	429	97	18%			32.28	32.62
18/06/2019								
01:00	512	447	65	13%			32.13	31.53
18/06/2019								
02:00	508	394	113	22%			31.88	30.42
18/06/2019								
03:00	500	418	82	16%			31.40	30.72
18/06/2019								
04:00	491	456	35	7%			30.63	31.32
18/06/2019								
05:00	481	447	35	7%			30.00	31.04
18/06/2019								
06:00	486	450	36	7%			29.70	31.46
18/06/2019								
07:00	512	462	50	10%			30.87	32.40
18/06/2019								
08:00	516	470	46	9%			31.97	34.87
18/06/2019								
09:00	540	477	62	12%			33.81	37.52
18/06/2019								
10:00	587	466	121	21%			36.98	41.48
18/06/2019								
11:00	596	492	103	17%			39.52	46.57
18/06/2019					86%	77%		
12:00	584	473	111	19%			42.07	45.03
18/06/2019								
13:00	590	470	120	20%			39.12	40.57
18/06/2019								
14:00	610	475	135	22%			37.86	37.73
18/06/2019								
15:00	654	614	40	6%			36.57	37.77
18/06/2019								
16:00	655	614	41	6%			35.74	37.29
18/06/2019								
17:00	653	568	85	13%			35.22	36.56
18/06/2019								
18:00	636	539	97	15%			34.18	36.03
18/06/2019								
19:00	624	523	101	16%			33.73	36.63
18/06/2019								
20:00	632	524	108	17%			34.29	36.89
18/06/2019								
21:00	610	511	99	16%			34.25	37.63
18/06/2019								
22:00	521	479	42	8%			33.83	37.69
18/06/2019								
23:00	509	475	34	7%			33.60	37.61
Day Total	13533	11673	1860	14%				



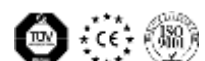
Test Nr.1

Date	Total chiller consumption in KW/h with Smart Cooling™ OFF	Total chiller consumption in kw/h with Smart Cooling™ ON	Savings in kw/h	Savings in %	Chiller load with Smart Cooling™ OFF	Chiller load with Smart Cooling™ ON	Temperature with Smart Cooling™ OFF	Temperature with Smart Cooling™ ON
	19 June	5 June					19 June	5 June
19/06/2019 00:00	561	428	133	24%	85%	85%	33.86	37.42
19/06/2019 01:00	586	425	161	27%			34.43	36.78
19/06/2019 02:00	558	427	131	24%			34.69	36.12
19/06/2019 03:00	528	434	95	18%			34.52	35.29
19/06/2019 04:00	510	468	42	8%			34.24	34.85
19/06/2019 05:00	500	446	54	11%			33.93	34.53
19/06/2019 06:00	500	448	52	10%			33.65	34.61
19/06/2019 07:00	519	457	62	12%			33.84	35.68
19/06/2019 08:00	575	472	104	18%			34.27	36.73
19/06/2019 09:00	558	474	83	15%			35.35	38.78
19/06/2019 10:00	577	467	110	19%			37.23	41.86
19/06/2019 11:00	597	482	115	19%			41.03	46.33
19/06/2019 12:00	635	388	247	39%			42.99	45.59
19/06/2019 13:00	644	414	230	36%			40.22	40.39
19/06/2019 14:00	621	429	193	31%			37.99	39.16
19/06/2019 15:00	634	560	74	12%			36.52	37.80
19/06/2019 16:00	635	528	107	17%			35.46	36.60
19/06/2019 17:00	637	525	112	18%			34.55	36.05
19/06/2019 18:00	636	531	106	17%			33.70	35.35
19/06/2019 19:00	589	517	72	12%			32.99	34.74
19/06/2019 20:00	578	451	128	22%			32.92	34.95
19/06/2019 21:00	571	383	189	33%			32.89	35.40
19/06/2019 22:00	524	377	148	28%			32.51	35.69
19/06/2019 23:00	493	405	89	18%			32.25	35.43
Total of day	13769	10933	2836	21%				



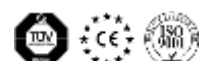
Test Nr.1

Date	Total chiller consumption in KW/h with Smart Cooling™ OFF	Total chiller consumption in kw/h with Smart Cooling™ ON	Savings in kw/h	Savings in %	Chiller load with Smart Cooling™ OFF	Chiller load with Smart Cooling™ ON	Temperature with Smart Cooling™ OFF	Temperature with Smart Cooling™ ON
	20 June	6 June					20 June	6 June
20/06/2019 00:00	537	377	160	30%	88%	79%	32.44	35.13
20/06/2019 01:00	527	353	173	33%			32.29	34.91
20/06/2019 02:00	516	347	169	33%			32.04	34.61
20/06/2019 03:00	504	337	167	33%			31.63	33.84
20/06/2019 04:00	490	424	67	14%			30.97	33.77
20/06/2019 05:00	495	400	95	19%			30.49	33.79
20/06/2019 06:00	497	399	98	20%			30.58	32.43
20/06/2019 07:00	486	411	74	15%			31.85	33.89
20/06/2019 08:00	530	451	79	15%			33.56	35.83
20/06/2019 09:00	613	516	97	16%			35.50	38.44
20/06/2019 10:00	613	508	105	17%			38.41	41.69
20/06/2019 11:00	647	507	141	22%			43.42	47.04
20/06/2019 12:00	712	509	203	29%			45.52	45.52
20/06/2019 13:00	731	512	219	30%			43.53	39.53
20/06/2019 14:00	709	501	209	29%			38.16	38.01
20/06/2019 15:00	693	556	137	20%			36.75	36.37
20/06/2019 16:00	690	568	122	18%			35.89	35.29
20/06/2019 17:00	686	554	132	19%			35.57	34.63
20/06/2019 18:00	674	527	148	22%			34.91	33.86
20/06/2019 19:00	691	510	181	26%			34.15	33.71
20/06/2019 20:00	733	517	216	30%			33.65	33.71
20/06/2019 21:00	728	475	253	35%			33.71	33.97
20/06/2019 22:00	625	423	202	32%			33.65	34.26
20/06/2019 23:00	580	410	170	29%			33.21	34.15
Day Total	14707	11091	3616	25%				



Test Nr.1

Date	Total chiller consumption in KW/h with Smart Cooling™ OFF	Total chiller consumption in kw/h with Smart Cooling™ ON	Savings in kw/h	Savings in %	Chiller load with Smart Cooling™ OFF	Chiller load with Smart Cooling™ ON	Temperature with Smart Cooling™ OFF	Temperature with Smart Cooling™ ON
	21 June	7 June					21 June	7 June
21/06/2019								
00:00	658	433	224	34%			33.22	33.76
21/06/2019								
01:00	609	400	209	34%			33.27	33.29
21/06/2019								
02:00	607	405	201	33%			33.36	32.99
21/06/2019								
03:00	602	351	251	42%			32.96	32.49
21/06/2019								
04:00	670	424	245	37%			33.03	32.77
21/06/2019								
05:00	599	380	218	36%			33.61	32.12
21/06/2019								
06:00	568	391	178	31%			33.76	31.66
21/06/2019								
07:00	578	378	200	35%			34.51	33.10
21/06/2019								
08:00	601	449	152	25%			35.73	35.08
21/06/2019								
09:00	628	492	135	22%			37.63	38.14
21/06/2019								
10:00	729	423	307	42%			40.30	39.04
21/06/2019								
11:00	722	464	258	36%	74%	66%	41.61	41.30
21/06/2019								
12:00	783	467	316	40%			41.64	41.52
21/06/2019								
13:00	780	459	321	41%			38.43	38.99
21/06/2019								
14:00	768	494	275	36%			36.87	38.35
21/06/2019								
15:00	716	482	233	33%			35.55	36.88
21/06/2019								
16:00	758	475	283	37%			34.98	35.90
21/06/2019								
17:00	626	490	136	22%			34.57	35.29
21/06/2019								
18:00	632	444	188	30%			34.27	34.26
21/06/2019								
19:00	635	432	203	32%			34.02	34.30
21/06/2019								
20:00	730	426	304	42%			34.05	35.04
21/06/2019								
21:00	620	419	201	32%			33.98	35.29
21/06/2019								
22:00	502	347	155	31%			33.81	35.01
21/06/2019								
23:00	499	354	145	29%			33.69	34.89
Day Total	15619	10280	5339	34%				
PERIOD TOTAL	70112	53386	16726	24%				



Test Nr.2 – 30-day summary

Test No.2 was carried out for the period of 30 days, between 31 May and 30 June 2019. During this period, the chillers' electricity consumption was calculated with **Smart Cooling™** turned ON.

The Carrier 30XA 1002 chillers operated with the **Smart Cooling™** unit ON for consecutive 20 days, during when the total energy consumption of the chillers' MW/h was measured.

Measured consumption with “Smart Cooling™” ON

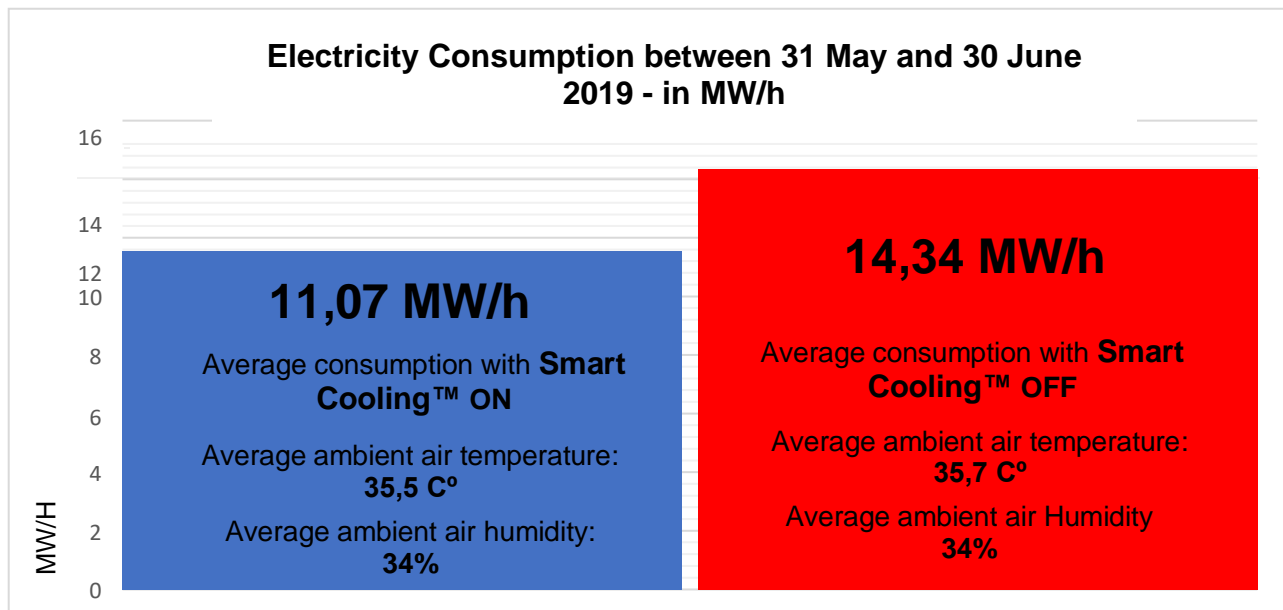
Smart Cooling™ equipment was ON for 20 days with an average hotel occupancy of 72%. In 20 days, total chiller consumption was of 221.41 MW/h, an average of 11.07 MW/h per day. Formula: $(221.41 \text{ MW/h} \div 20 \text{ days}) = 11.07 \text{ MW/h}$ on a 24-hour average.

Measured consumption with “Smart Cooling™” OFF

Smart Cooling™ equipment was OFF for 9 days with an average hotel occupancy of 82%. In 9 days, total chiller consumption was of 129.06 MW/h, an average of 14.34 MW/h per day. Formula: $(129.06 \text{ MW/h} \div 9 \text{ days}) = 14.34 \text{ MW/h}$ on a 24-hour average.

Test Nr. 2 summary:

After a 30-day, 24-hour comparison test of average electricity consumption of a Carrier 30XA1002, we ascertained that average savings were of 2 to 3 MM/h, contingent on the hotel's occupancy rate. Total 30-day water consumption, including **Smart Cooling™** maintenance was 375 m3.



Test Nr.2

30-day overview with Smart Cooling™ turned ON and OFF

Smart Cooling™ Water and Electricity Consumption Readings								
Date	Previous water consumption in m ³	Current water consumption in m ³	Total Consumed	Total Mw/h consumed	OCCP %	Smart Cooling™ operational notes	Average ambient air temperature	Highest ambient air temperature
31/05/2019	0	36	7918.56	8.77	47.08	On - final adjustments performed	34	43
01/06/2019	36	50	3079.44	8.25	47.08	on	34	40
02/06/2019	50	60	2199.6	8.43	47.08	on	34	43
03/06/2019	60	78	3959.28	9.41	54.04	on	33	39
04/06/2019	78	95	3739.32	11.67	57.94	on	36	46
05/06/2019	95	112	3739.32	10.93	76.32	on	37	46
06/06/2019	112	130	3959.28	11.09	83.29	on	37	47
07/06/2019	130	148	3959.28	10.28	77.44	on	35	41
08/06/2019	148	162	3079.44	9.92	66.02	on	35	45
09/06/2019	162	175	2859.48	10.43	77.16	on	35	43
10/06/2019	175	184	1979.64	11.36	81.62	on - after 14:00, one Smart Cooling™ circuit not operating	33	41
11/06/2019	184	197	2859.48	12.2	82.73	on - after 14:00, one Smart Cooling™ circuit not operating	35	42
12/06/2019	197	212	3299.4	12.27	86.07	on	37	44
13/06/2019	212	228	3519.36	12.13	93.31	on	37	44
14/06/2019	228	241	2859.48	12.45	88.86	on	36	44
15/06/2019	241	254	2859.48	12.54	77.16	on	35	43
16/06/2019	254	265	2419.56	12.54	86.35	on	35	42
17/06/2019	265	274	1979.64	12.48	84.96	At 17:00, Smart Cooling™ turned off	34	43
18/06/2019	274	274	0	13.53	86.35	off	34	43
19/06/2019	274	274	0	13.77	85.24	off	35	43
20/06/2019	274	274	0	14.71	88.02	off	35	45
21/06/2019	274	274	0	15.62	74.37	off	35	42
22/06/2019	274	285	2419.56	16.01	74.09	Off (cleaning process)	37	44
23/06/2019	285	294	1979.64	15.36	78.55	Off (cleaning process)	37	43
24/06/2019	294	294	0	13.58	83.84	off	36	44
25/06/2019	294	294	0	12.96	83.29	off	35	43
26/06/2019	294	294	0	13.52	86.91	off	37	42
27/06/2019	294	309	3299.4	12.82	85.79	On, after 15:00	37	44
28/06/2019	309	332	5059.08	12.88	79.67	on	37	44
29/06/2019	332	355	5059.08	12.03	71.03	on	38	48
30/06/2019	355	375	4399.2	11.83	76.32	on	37	47

ROI Summary:**Calculated savings**

Daily electricity savings = 2.5 Mw/h X 0.45 AED (energy supply rate) = **AED 1,125.**

Monthly electricity savings = AED 1,125 X 30 days = **AED 33,750.**

Operation costs

Monthly water consumption = 375 m³ X 10 AED (water supply rate) = **AED 3,750.**

Biochemical materials and maintenance costs= **AED 600.**

Total operational costs = **AED 4,350.**

Monthly net savings = AED 33,750 - AED 4,350 = AED 29,400.

Equipment costs

2 **Smart Cooling™** devices = **AED 210,000 (Inc. VAT)**

Return on Investment (ROI)

2 **Smart Cooling™** devices= **210,000 / (29,400 X 8) = 10.7 Months**

ROI Calculation Notes

There are effectively eight operating months comprising heat season and four months with negligible savings, which were not considered for the purposes of this ROI calculation.

As per the readings above, measured savings range from 2 to 3 MW/h per day. For estimation purposes, we have based the ROI calculation on average savings of 2.5 MW/h.

ROI calculation is contingent on a building's cooling requirements and external air temperature).

Ali Soufan



31 July 2019

Annex



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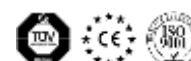


RIF600 | Clamp-on Ultrasonic Meter Calibration Report

Pipe diameter	DN80	Date	15/12/2018
Ambient temperature	29°C	Model	RIF600W
Standard Device before test	Normal		
Standard Device After Test	Normal		
Test result	Qualified		
Measured Medium	Water		
Accuracy	1%		
Signal Strength	UP: 90 DOWN: 90		
Standard device name	Static volumetric method/standard Meter Method Water Flow/Standard Device		
Standard device accuracy	0,20%		

Test	Standard Meter flow		Temperature	Pressure	Tested Meter Flow		Basic Error	Repeatability	
Point	m3/h		°C	Mpa	m3/h		%	%	
Point 1	101,52	101,47	25,0	0,300	102,27	102,10	0,739	-0,147	0,147
	101,47		25,0	0,300	102,07		0,591		
	101,42		25,0	0,300	101,97		0,542		
Point 2	71,27	71,27	25,0	0,300	71,75	71,75	0,673	-0,146	0,147
	71,19		25,0	0,300	71,65		0,646		
	71,34		25,0	0,300	71,86		0,729		
Point 3	26,32	26,36	25,0	0,300	26,51	26,55	0,722	-0,132	
	26,36		25,0	0,300	26,56		0,759		
	26,39		25,0	0,300	26,58		0,720		

Verification Based on JIG 1030-2007 < Ultrasonic flowmeter verification procedures >
 Scale Factor=1





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RIF600 | Test Report misuratore di portata ad ultrasuoni clamp on

Diametro tubazione	DN80	Date	15/12/2018
Temperatura ambiente	29°C	Model:	RIF600W
Dispositivo standard prima del test	Normale		
Dispositivo standard dop il test	Normale		
Risultato del test	Qualified		
Liquido	Acqua		
Accuratezza	1%		
Potenza dei segnali	UP: 90 DOWN: 90		
Tipo di dispositivo standard	Metodo volumetrico statico/Misuratore di portata volumetrico		
Accuratezza del dispositivo standa	0,20%		

Test	Misuratore standard	Temperatura	Pressione	Misuratore testato	errore base	Ripetibilità	
Punti	m3/h	°C	Mpa	m3/h	%	%	
Punto 1	101,52	25,0	0,300	102,27	0,739	-0,147	
	101,47			101,47	102,07		0,591
	101,42			101,97	0,542		
Punto 2	71,27	25,0	0,300	71,75	0,673	-0,146	
	71,19			71,27	71,85		0,646
	71,34			71,86	0,729		
Punto 3	26,32	25,0	0,300	26,51	0,722	-0,132	
	26,36			26,36	26,56		0,750
	26,39			26,58	0,720		

Verification Based on JIG 1030-2007 < Ultrasonic flowmeter verification procedures >
 Scale Factor=1