TEST REPORT: No.157

Date: 28 July 2021

TEST REPORT - TELECOM ADIABATIC PRE-COOLING **SMART COOLING™** DEVICE PERFORMANCE AND CLIMAVENETA NECS0452T CHILLER ELECTRICITY CONSUMPTION REDUCTION.

Participated in the test:

Customer: C/O IMMOBILE TELECOM

Contractor: TIM (TELECOM ITALIA MOBILE)

Installer: ITAF SRL

Swiss Integrated Energy Technologies AG: Luca Gallarate

Project name: TIM MILANO LIMBIATE

Object address: Limbiate, Italy

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Introduction:

Type of building: TIM Site, Italy.

Cooling units: air-cooled water chiller Climaveneta NECS 0452T.

Nominal cooling capacity by manufacturer's data performance sheet: 107 kW

Energy consumption by manufacturer's data performance sheet: 112 kW

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

3-unit chiller retrofits were made to reduce the energy consumption of chillers and to increase chiller COP efficiency. Chillers were equipped with an intelligent adiabatic pre-cooling system **Smart Cooling™** PRO 10. Chiller booster PRO 10 is based on pre-cooling of air before it enters condensers by using water evaporation technology - spraying and vaporizing a very fine water mist before entering the condenser (hot air comes into contact with the fine water mist, the temperature of the incoming air in the condenser is reduced).

Chiller booster components ensure 100% condenser protection from direct contact with water. The water must not reach the condenser.

Main components:

The protective membranes: the membranes are installed outside before the condenser, covering 100% of the condenser surface, thus preventing the water mist from coming into direct contact with the condenser. Water filtration, water purification, water sterilisation: the system provides water purification from minerals and water sterilization to avoid the risk of bacterial occurrence.

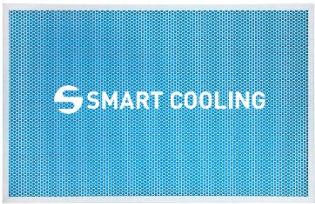
High-pressure pump capable of providing water pressure up to 70 bar.

A water recirculation system that drains non-evaporated water into a water purification and pump system.

The control unit, which provides complete system control according to ambient air temperature and humidity, provides the complete operation of the system, analyses the parameters of the chiller, ambient air temperature, and humidity, and provides the required amount of water in the adiabatic system according to data gathered.

A high-pressure nozzle panels provide 5-40-micron droplet water spraying.

A set of fasteners and fixings ensuring the compatibility of the chiller booster system with the chiller.



Equipment tested: **Air-cooled water chillers, Climaveneta NECS 0452T.**

Chiller with **Smart Cooling™** system

In Picture No.2 it can be seen that the chiller condensers are fitted with protective membranes that prevent the water from entering the chiller condenser. To the right, there is the chiller booster pump station, which includes 70 bar water preparation, water sterilization, and purification. The equipment is equipped with a programmable Siemens controller. The right side of the chiller shows the water drain line connected to the pump station. The water that enters the drain is re-filtered and reused.

Testing procedures test Nr.1:

Picture 2; Chiller with **Smart Cooling™** system

Measuring instruments:

The test was carried on through a RIELS RIF 600 W ultrasonic flow meter. The RIF 600 W works by sending and receiving an ultrasound signal through a fluid between two transductors, placed on a pipe in a location determined by the instrument itself by the application. The time difference between sending and receiving the signal through the fluid is directly proportional to its velocity and thus to the volumetric flow. The equipment was connected to the pipes of the chiller to verify the efficiency with both the **Smart Cooling™** system on and off. Energy consumption data were retrieved from the equipment in the electrical substation. The formula for calculating the COP. EI/kW ÷ cooling / kW = cop

Step 1

A data logger was installed on the subject HVAC equipment to collect all applicable real-time energy consumption and unit performance information. Data was collected with Eniscope analytics and energy measurement.

Step 2

Switch ON the **Smart Cooling™** system.

Step 3

The next 5 days (83 hours of use) of the test measured the energy used by the chiller with an Intelligent adiabatic system **Smart Cooling™**. The average temperature during the period was 20° C. After data analysis monitoring numbers Difference/energy savings that provide **Smart Cooling™** system per 5 working days was 1376,73 KW/h (Kilowatt hours) of electricity.
Tables below show all numbers, used energy consumption kw/h, before and after use adiabatic system, air temperature, and working hours.
Compare total KWh consumed by rack «B» chiller system for 5 consecutive days with adiabatic pre-cooling system OFF – to 5 consecutive days with adiabatic system ON (with comparative temp. data).

The below TABLE 1 reports the following data for each month:

- total number of hours;
- for how many hours the **Smart Cooling™** system would have worked;
- average increase in cooling capacity, both calculating only the hours when the system would have been working (“SC ON”) and the whole month (“All month)
- average decrease in energy consumption, again for both the scenarios.

From the data reported in the chiller manufacturer’s HANDBOOK** (in this case CLIMAVENETA) shown in TABLE 2 it is then possible to obtain the variation in performance, both in terms of increase in cooling capacity and of decrease in energy consumption, according to the temperature of the air reaching the coil, at the same output water temperature.

TABLE 3 reported the data for a typical day (based on the weather data of the closest airport) with the **Smart Cooling™** system at work

For a typical day, the following data are reported:

- Time
- Temperature and relative humidity
- Temperature of the air reaching the coil with Smart Cooling at work
- Increase in cooling capacity
- Decrease in energy consumption
- Saving
- Water consumption

There are two types of saving to be kept into account, i.e. DIRECT SAVING, which can be immediately measured, and INDIRECT SAVING, resulting from a lesser use of the chiller with the same cooling demand.

NOTE: all the saving percentages are calculated assuming the chiller working at 100% capacity and calculated according to the data for temperature and humidity.

The data in the attached report have been compared in terms of saving with other systems running in NORTHERN ITALY and have been proven CONGRUENT and CONSERVATIVE.

Please note that slight variations in the savings are natural and mainly due to the type of compressor, the type of gas, the shape of the coils (indicatively, a TURBO CORE compressor or a SCREW compressor with inverter allow for higher savings than a SCROLL compressor; as well, a MICROCHANNEL COIL is more influenced by the change in temperature than a normal coil).

It is necessary however to point out that a detailed calculation of the saving that can be achieved is not possible, since it is impossible to know in advance the precise weather conditions in any given location. A calculation based on the last five years allows in any case for a correct approximation.

** **Handbooks generally report the data at 25 – 30 – 35 – 40°C. Thanks to our agreement, we have access to reserved data about the algorithms for calculations.**

TABLE 1

JANUARY		
	Total Hours	744
	Working Hours	0
Average increase in cooling output	When SC ON	
	All month	0,00%
Average decrease in energy consumption	When SC ON	
	All month	0,00%

FEBRUARY		
	Total Hours	672
	Working Hours	0
Average increase in cooling output	When SC ON	
	All month	0,00%
Average decrease in energy consumption	When SC ON	
	All month	0,00%

MARCH		
	Total Hours	744
	Working Hours	0
Average increase in cooling output	When SC ON	
	All month	0,00%
Average decrease in energy consumption	When SC ON	
	All month	0,00%

APRIL		
	Total Hours	720
	Working Hours	147
Average increase in cooling output	When SC ON	6,21%
	All month	1,27%
Average decrease in energy consumption	When SC ON	-7,99%
	All month	-1,63%

MAY		
	Total Hours	744
	Working Hours	281
Average increase in cooling output	When SC ON	4,96%
	All month	1,87%
Average decrease in energy consumption	When SC ON	-6,33%
	All month	-2,39%

JUNE		
	Total Hours	720
	Working Hours	563
Average increase in cooling output	When SC ON	6,26%
	All month	4,90%
Average decrease in energy consumption	When SC ON	-7,72%
	All month	-6,03%

JULY		
	Total Hours	744
	Working Hours	676
Average increase in cooling output	When SC ON	5,97%
	All month	5,42%
Average decrease in energy consumption	When SC ON	-7,17%
	All month	-6,51%

AUGUST		
	Total Hours	744
	Working Hours	635
Average increase in cooling output	When SC ON	6,42%
	All month	5,48%
Average decrease in energy consumption	When SC ON	-7,63%
	All month	-6,51%

SEPTEMBER		
	Total Hours	720
	Working Hours	394
Average increase in cooling output	When SC ON	5,22%
	All month	2,85%
Average decrease in energy consumption	When SC ON	-6,55%
	All month	-3,58%

OCTOBER		
	Total Hours	744
	Working Hours	121
Average increase in cooling output	When SC ON	4,87%
	All month	0,79%
Average decrease in energy consumption	When SC ON	-6,36%
	All month	-1,03%

NOVEMBER		
	Total Hours	720
	Working Hours	0
Average increase in cooling output	When SC ON	
	All month	0,00%
Average decrease in energy consumption	When SC ON	
	All month	0,00%

DECEMBER		
	Total Hours	744
	Working Hours	0
Average increase in cooling output	When SC ON	
	All month	0,00%
Average decrease in energy consumption	When SC ON	
	All month	0,00%

SOURCE: Climaveneta Technical Bulletin

TABLE 2

COOLING CAPACITY PERFORMANCEE / NECS B

0452T																		
Ta	**25**	**30**	**32**	**35**	**40**	**42**	**25**	**30**	**32**	**35**	**40**	**42**	**25**	**30**	**32**	**35**	**40**	**42**
Tev	**6**						**7**						**8**					
Pf	**123**	**116**	**114**	**109**	**101**	**98,0**	**127**	**120**	**117**	**112**	**104**	**101**	**131**	**123**	**120**	**116**	**107**	**104**
Pat	32,5	35,7	37,1	39,3	43,2	44,9	32,9	36,1	37,5	39,7	43,6	45,3	33,3	36,5	37,9	40,1	44,0	45,7
Qev	21,2	20,0	19,5	18,8	17,4	16,9	21,9	20,6	20,1	19,3	18,0	17,4	22,5	21,2	20,7	19,9	18,5	17,9
Dpev	20,8	18,5	17,6	16,3	14,0	13,1	22,0	19,6	18,7	17,2	14,9	13,9	23,3	20,8	19,8	18,2	15,8	14,8
Tev	**9**						**10**						**11**					
Pf	**134**	**127**	**124**	**119**	**110**	**107**	**138**	**130**	**127**	**122**	**113**	**-**	**141**	**133**	**130**	**125**	**116**	**-**
Pat	33,6	36,9	38,3	40,5	44,4	46,1	34,0	37,2	38,6	40,8	44,8	-	34,3	37,6	39,0	41,2	45,2	-
Qev	23,1	21,8	21,3	20,5	19,0	18,4	23,7	22,4	21,9	21,0	19,5	-	24,3	23,0	22,4	21,6	20,1	-
Dpev	24,6	21,9	20,9	19,3	16,7	15,6	25,9	23,1	22,0	20,4	17,6	-	27,3	24,4	23,2	21,4	18,6	-

Ta [°C] - Air temperature

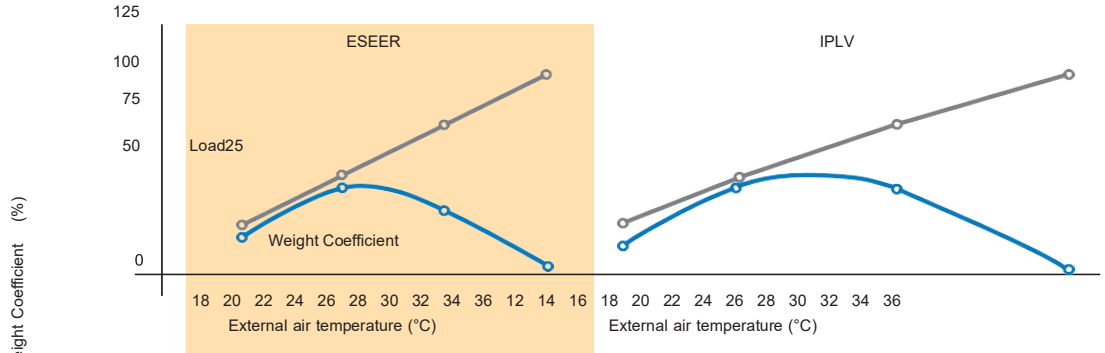
Tev [°C] - Plant (side) cooling exchanger output water temperaturePf [kW] - Cooling capacity

Pat [kW] - Total power input

Qev [m³/h] - Plant (side) heat exchanger water flow

Dpev [kPa] - Plant (side) cooling exchanger pressure drop'-' Conditions outside the operating range

Waterflow and pressure drop on heat exchangers calculated with 5°C of delta TNOTE: Data on grey background: unit switched to non-silenced operation



Load	Air Temp.	Weight Coefficient	Air Temp.	Weight Coefficient
100%	35°C	3%	35°C	1%
75%	30°C	33%	26,7°C	42%
50%	25°C	41%	18,3°C	45%
25%	20°C	23%	12,8°C	12%

Weight= quantity of energy produced in the respective load conditions

SIZE	VERSION	ESEER
0425	B	3,59
	HT	3,36
	LN	3,76
	SL	3,14

GENERAL TECHNICAL DATA / NECS B

Evaporator temp. leaving	**6,7 °C constant**			
Evaporator dirtying factor	**0,018 m2 °C/kW**			
Delta T full load	**5 °C**			
Load	**100%**	**75%**	**50%**	**25%**
Cond. Water temp.	**35 °C**	**26,7 °C**	**18.3 °C**	**12,8 °C**

	0452T
NECS COOLING	
Cooling capacity **kW**	**112**
Total power input (unit) **kW**	39,7
EER	2,83
ESEER	3,59
Heat exchanger water flow **m³/h**	19,3
Heat exchanger pressure drop **kPa**	17,2

TABLE 3

CHILLER DATA		DAIKIN EWAD 980		UTILITY COST CITY:		LIMBIATE			24 HRS PERFORMANCE					
Compressor type		Screw		Electricity		0,17	Value/kWh		INCREASING OF COOLING CAPACITY			REDUCTION ELECTRIC CONSUMPTION		
Cooling capacity		973	kWf											
Electric consumption		313,87	kWh	Water		1,28	Value/m³		Average	Min	Max	Average	Min	Max
Air Flow		300000	m³/h						10,15%	3,53%	19,20%	-11,67%	-4,78%	-20,10%
	Date:	July												

Hour	Temp (°C)	RH (%)	Temp (°C) with SC	Cooling output			Electric consumption			Saving		Water consumption		Saving / hr
				Nominal	With SC	D%	Nominal	With SC	D%	kWh	value/h	m³/h	value/h	Value
00:00	26,80	65,00	22,7	1076,81	1123,26	4,31%	276,48	260,75	-5,69%	15,74	2,68	0,39	0,50	2,18
01:00	27,70	64,00	22,4	1070,49	1123,26	4,93%	278,57	260,75	-6,40%	17,82	3,03	0,41	0,53	2,50
02:00	26,80	65,00	22,7	1076,81	1123,26	4,31%	276,48	260,75	-5,69%	15,74	2,68	0,39	0,50	2,18
03:00	26,50	67,00	22,1	1082,51	1126,63	4,08%	274,66	259,79	-5,41%	14,87	2,53	0,36	0,46	2,07
04:00	26,50	67,00	22,1	1082,51	1126,63	4,08%	274,66	259,79	-5,41%	14,87	2,53	0,36	0,46	2,07
05:00	25,90	68,00	22,1	1088,22	1126,63	3,53%	272,83	259,79	-4,78%	13,04	2,22	0,34	0,44	1,78
06:00	26,50	67,00	22,1	1082,51	1126,63	4,08%	274,66	259,79	-5,41%	14,87	2,53	0,36	0,46	2,07
07:00	28,40	59,00	22,6	1057,69	1123,26	6,20%	282,83	260,75	-7,81%	22,08	3,75	0,49	0,62	3,13
08:00	29,90	50,00	22,5	1038,57	1123,26	8,15%	289,53	260,75	-9,94%	28,78	4,89	0,65	0,83	4,06
09:00	31,10	43,00	22,1	1025,59	1126,63	9,85%	294,05	259,79	-11,65%	34,26	5,82	0,79	1,01	4,81
10:00	32,10	43,00	22,9	1012,45	1119,88	10,61%	298,74	261,70	-12,40%	37,04	6,30	0,81	1,04	5,26
11:00	32,90	42,00	23,3	999,47	1113,66	11,42%	303,61	263,62	-13,17%	39,99	6,80	0,83	1,06	5,74
12:00	33,90	39,00	23,6	986,32	1113,66	12,91%	308,65	263,62	-14,59%	45,04	7,66	0,91	1,16	6,49
13:00	36,40	35,00	24,2	952,93	1107,43	16,21%	321,96	265,53	-17,53%	56,43	9,59	1,06	1,36	8,23
14:00	36,70	32,00	23,2	952,93	1119,88	17,52%	321,96	261,70	-18,71%	60,25	10,24	1,12	1,43	8,81
15:00	37,30	28,00	22,8	939,52	1119,88	19,20%	327,52	261,70	-20,10%	65,82	11,19	1,24	1,59	9,60
16:00	36,70	30,00	22,7	952,93	1123,26	17,87%	321,96	260,75	-19,01%	61,21	10,41	1,15	1,47	8,93
17:00	34,90	32,00	22,5	973,00	1123,26	15,44%	313,87	260,75	-16,93%	53,12	9,03	1,08	1,38	7,65
18:00	33,20	34,00	21,5	999,47	1129,31	12,99%	303,61	258,83	-14,75%	44,78	7,61	1,01	1,29	6,32
19:00	33,40	33,00	21,5	992,90	1129,31	13,74%	306,13	258,83	-15,45%	47,30	8,04	1,03	1,31	6,73
20:00	33,70	35,00	21,9	992,90	1126,63	13,47%	306,13	259,79	-15,14%	46,34	7,88	0,99	1,27	6,61
21:00	32,80	40,00	22,9	999,47	1119,88	12,05%	303,61	261,70	-13,80%	41,91	7,12	0,86	1,11	6,02
22:00	30,69	43,00	21,3	1032,08	1129,31	9,42%	291,79	258,83	-11,29%	32,95	5,60	0,77	0,99	4,61
23:00	29,43	56,00	22,8	1044,89	1119,88	7,18%	287,27	261,70	-8,90%	25,56	4,35	0,54	0,69	3,65

All data are at 100% of nominal Chiller power				DIRECT SAVING (Local currency)	121,51
Total Kwe saving (day)	849,80			SAVING (due to increased chiller power) (local currency)	122,69
Reduction emission (Kg) Co^2	558,83			*Daily saving* *20,20%*	*244,20*
Daily water consumption	17,94				

The results are reported in the following tables:

TABLE 4

DATE	NOW	TEMPERA-TURE	HUMIDITY	TEMP.SM	TEMP.SM	CAPA-CITY	T. IN	T. OUT	REFRIGERATING POWER PRODUCED	CORRENTE ASSORBITA FASE 1	ABSORBED ELECTRICITY	EER
				ON THE SURFACE	OUTSIDE							
06.07.2021		°C	%	°C	°C	m³/h	°C	°C	kWf	A	kWe	N
	10.30	30,40	36,00	28,40	39,40	10	12,00	7,30	54,90	26,40	15,53	3,54
Smart Cooling OFF	10.45	30,00	36,00	28,90	39,60	10	12,00	7,40	53,30	26,60	15,65	3,41
	11.00	31,00	34,00	28,80	40,30	10	12,00	7,30	56,00	26,80	15,76	3,55
	11.15	31,00	34,00	28,90	41,20	10	12,10	7,10	58,00	27,00	15,88	3,65
	11.30	33,00	31,00	30,00	41,50	10	12,00	8,40	52,00	26,50	15,59	3,34
	11.45	34,00	31,00	30,80	41,30	10	13,60	8,90	58,50	27,80	16,35	3,58
Smart Cooling ON	12.00	34,00	40,00	19,50	36,50	10	13,60	8,50	65,00	23,20	13,65	4,76
	12.15	34,00	38,00	18,70	34,30	10	13,00	8,30	63,00	22,40	13,18	4,78
	12.30	35,00	39,00	19,30	35,80	10	12,80	7,50	67,00	23,30	13,71	4,89
	12.45	34,00	36,00	18,90	34,70	10	13,00	8,20	65,00	23,40	13,76	4,72
Smart Cooling OFF	13.15	33,00	33,00	28,90	41,90	10	12,80	7,80	55,00	27,50	16,18	3,40
	13.30	31,00	36,00	27,40	40,10	10	12,50	8,00	52,00	26,70	15,70	3,31
	13.45	31,00	40,00	29,50	40,80	10	12,30	7,80	50,00	26,80	15,76	3,17
Smart Cooling ON	14.00	31,00	54,00	19,90	34,60	10	12,00	7,30	59,00	23,00	13,53	4,36
	14.15	31,00	48,00	18,90	34,80	10	12,40	7,30	61,00	23,40	13,76	4,43
	14.30	32,00	43,00	18,00	33,70	10	13,20	7,50	63,00	23,90	14,06	4,48

Conclusion	° C on the surface	Output power	Absorption	EER
Smart Cooling OFF	29,07	54,41	15,82	3,44
Smart Cooling ON	19,03	63,29	13,66	4,63
INCREASE Refrigeration power		14,02%		
DECREASE electrical absorption		13,65%		
EER increase				1,19
SAVING OBTAINED during the test	25,79%			

This table reports the data acquired on the same day, both with the **Smart Cooling™** system on and with the system off.

From such data it is possible to affirm that the increase in EER (energy efficiency) was on an average of 1,19, which corresponds to a **25,79% increase**.

By comparing our data with the ones reported on the TECHNICAL BULLETIN CLIMAVENETA we calculated the following:

CATALOGUE DATA		SMART COOLING ON	INCREASE IN NUMBER	INCREASE IN PERCENTAGE
EER**	2,83	4,89	2,06	72%
ESEER***	3,59	5,48	1,89	52%

** EER calculated at 35°C with water 12-7
*** ESEER calculated according to the above-reported formula

We have furthermore compared the data, keeping into account the energy absorption and temperatures as recorded by the TIM monitoring system.

The results are shown in the blow tables, divided between when the **Smart Cooling™** system was on and when it was off.

Raw data – Smart Cooling system ON

Devices Label	GF2	AIR TEMPERATURE ON COILS	COOLING CAPACITY	GF2	THL EXT	EER	EER
Devices Location	FLOW RATE		KWF	PT BT cabin	PT External North Side	WITH Smart Cooling	NOMINAL
Value Types Label				Three-phase Active Power	Temperatur e		
Unit	MC/H	°C		W	°C		
5/7/21 11.00	10	16,23	99,38	18648,10705	24,23	5,33	
5/7/21 12.00	10	16,93	158,32	30383,81395	24,93	5,21	
5/7/21 13.00	10	18,13	112,03	21900,47198	26,13	5,12	
5/7/21 14.00	10	19,82	142,57	33327,17017	27,82	4,28	
5/7/21 15.00	10	20,72	32,36	7367,745232	28,72	4,39	
5/7/21 16.00	10	20,99	77,31	17507,78336	29,99	4,42	
5/7/21 17.00	10	21,85	76,89	18618,71498	30,85	4,13	
5/7/21 18.00	10	23,41	74,32	18610,94168	31,41	3,99	
5/7/21 19.00	10	27,18	75,48	18696,10311	37,18	4,04	
5/7/21 20.00	10	26,70	72,34	18299,44173	36,70	3,95	
5/7/21 21.00	10	21,12	70,47	17437,45091	29,12	4,04	
5/7/21 22.00	10	18,38	79,32	17035,95365	26,38	4,66	
5/7/21 23.00	10	16,76	84,75	16845,99883	24,76	5,03	
6/7/21 0.00	10	15,78	88,33	16727,55773	23,78	5,28	
6/7/21 8.00	10	16,18	79,03	14519,85078	24,18	5,44	
6/7/21 9.00	10	18,95	77,52	17400,08234	26,95	4,46	
6/7/21 10.00	10	20,78	75,40	18307,76691	28,78	4,12	
6/7/21 12.00	10	19,50	65,23	18729,26073	29,49	3,48	
6/7/21 13.00	10	21,09	74,67	18772,24663	30,09	3,98	
6/7/21 14.00	10	19,90	59,02	13750,25577	31,00	4,29	
6/7/21 15.00	10	22,12	74,05	17245,39675	32,88	4,29	
6/7/21 16.00	10	26,11	52,48	11808,33503	34,11	4,44	
6/7/21 17.00	10	23,95	72,13	17397,60422	33,95	4,15	
6/7/21 18.00	10	23,67	53,21	13632,40421	33,67	3,90	
6/7/21 19.00	10	22,39	69,05	17238,38325	32,39	4,01	
6/7/21 20.00	10	22,67	56,93	13845,11109	30,67	4,11	
6/7/21 21.00	10	20,05	69,31	17297,17904	29,05	4,01	
6/7/21 22.00	10	19,66	72,12	17859,97827	27,66	4,04	
6/7/21 23.00	10	18,40	76,32	17449,4893	26,40	4,37	
7/7/21 0.00	10	17,22	64,51	13523,94731	25,22	4,77	
7/7/21 1.00	10	16,45	67,85	13240,94409	24,45	5,12	
7/7/21 2.00	10	15,79	82,35	16621,10835	23,79	4,95	
7/7/21 3.00	10	15,52	65,32	13441,71057	23,52	4,86	
7/7/21 6.00	10	15,52	78,51	15790,77575	23,52	4,97	
7/7/21 7.00	10	17,44	60,81	13191,1422	25,44	4,61	
7/7/21 8.00	10	18,96	73,46	16748,02088	26,96	4,39	

Devices Label	GF2	AIR TEMPERATURE ON COILS	COOLING CAPACITY	GF2	THL EXT	EER	EER
7/7/21 9.00	10	20,16	72,81	17043,17355	28,16	4,27	
7/7/21 10.00	10	20,10	72,33	16978,3555	29,10	4,26	
7/7/21 11.00	10	21,87	75,31	17250,45965	29,87	4,37	
7/7/21 12.00	10	22,96	70,43	17483,21249	30,96	4,03	
7/7/21 13.00	10	25,41	68,49	17317,01593	33,41	3,96	
7/7/21 14.00	10	23,73	57,42	14118,32217	33,73	4,07	
7/7/21 15.00	10	26,00	64,95	17963,86588	34,00	3,62	
7/7/21 16.00	10	22,59	68,98	17528,23749	32,59	3,94	
7/7/21 17.00	10	23,94	58,03	14044,7314	31,94	4,13	
7/7/21 18.00	10	21,16	70,41	17339,58567	30,16	4,06	
7/7/21 19.00	10	16,81	75,34	16721,97303	24,81	4,51	
7/7/21 20.00	10	15,79	75,38	16410,8935	23,79	4,59	
8/7/21 8.00	10	15,76	71,38	13380,07855	23,76	5,33	
8/7/21 9.00	10	17,56	59,56	13198,92647	25,56	4,51	
8/7/21 10.00	10	19,13	72,93	16813,13333	27,13	4,34	
8/7/21 11.00	10	20,20	57,56	13456,29851	29,20	4,28	
8/7/21 12.00	10	21,91	71,35	17306,76281	29,91	4,12	
8/7/21 13.00	10	22,48	68,76	17319,36592	31,48	3,97	
8/7/21 14.00	10	21,89	54,10	13503,075	30,89	4,01	
8/7/21 15.00	10	20,06	70,21	17070,289	28,06	4,11	
9/7/21 11.00	10	16,28	71,23	13466,11574	24,28	5,29	
9/7/21 12.00	10	17,60	70,54	14295,05335	25,60	4,93	
9/7/21 13.00	10	18,90	75,60	16239,02299	26,90	4,66	
9/7/21 14.00	10	19,99	63,14	13871,90859	27,99	4,55	
9/7/21 15.00	10	20,83	60,54	13529,64024	28,83	4,47	
9/7/21 16.00	10	21,15	72,32	17100,00993	29,15	4,23	
9/7/21 17.00	10	21,45	58,56	13676,22658	29,45	4,28	
9/7/21 18.00	10	22,08	59,89	14771,76252	30,08	4,05	
9/7/21 19.00	10	24,84	68,73	17488,35041	34,84	3,93	
9/7/21 20.00	10	24,81	55,56	14254,7329	34,81	3,90	
9/7/21 21.00	10	19,20	70,99	14678,00142	27,20	4,84	
9/7/21 22.00	10	16,07	78,32	15726,02272	24,07	4,98	
10/7/21 9.00	10	15,71	73,85	14821,48876	23,71	4,98	
10/7/21 10.00	10	17,25	79,85	16998,22774	25,25	4,70	
10/7/21 11.00	10	18,54	79,13	18217,55213	26,54	4,34	
10/7/21 12.00	10	19,71	66,87	14828,19595	27,71	4,51	
10/7/21 13.00	10	20,66	78,97	18776,04728	28,66	4,21	
10/7/21 14.00	10	20,57	75,87	18717,70202	29,57	4,05	
10/7/21 15.00	10	21,40	61,15	15079,30294	30,40	4,06	
10/7/21 16.00	10	22,03	74,35	18963,32624	31,03	3,92	
10/7/21 17.00	10	21,71	72,71	18928,57984	31,71	3,84	
10/7/21 18.00	10	21,56	70,04	18659,5653	31,56	3,75	
10/7/21 19.00	10	25,83	55,45	14941,2326	35,83	**3,71**	
10/7/21 20.00	10	24,24	68,02	18489,2255	34,24	3,68	

Devices Label	GF2	AIR TEMPERATURE ON COILS	COOLING CAPACITY	GF2	THL EXT	EER	EER
10/7/21 21.00	10	19,32	66,32	14022,5668	28,32	4,73	
10/7/21 22.00	10	18,52	70,02	17486,77976	26,52	4,00	
10/7/21 23.00	10	17,26	74,32	17233,90603	25,26	4,31	
AVERAGE	**10,00**	**20,28**	**72,18**	**16587,07**	**28,85**	**4,36**	
WORKING HOURS							
83				1376726,55			

RAW DATA – SMART COOLING™ OFF

Devices Label	GF2	AIR TEMPERATURE	COOLING	GF2	THL EXT	EER
Devices_Location	FLOW	ON COILS	CAPACITY	PT BT cabin	PT External North Side	
ValueTypeId	RATE			1057	3	
ValueTypes_Label	MC/H	°C	KWF	Three-phase Active Power	Temperature	
Unit				W	°C	
5/7/21 0.00	10	19,06	65,32	20450,54241	19,06	3,19
5/7/21 1.00	10	18,38	58,32	17825,78661	18,38	3,27
5/7/21 2.00	10	17,91	78,67	25514,8794	17,91	3,08
5/7/21 3.00	10	17,53	57,2	18274,31145	17,53	3,13
5/7/21 4.00	10	17,14	63,42	20487,767	17,14	3,10
5/7/21 5.00	10	17,00	82,34	26657,03204	17,00	3,09
5/7/21 7.00	10	18,50	65,48	20826,49252	18,50	3,14
5/7/21 8.00	10	19,83	64,39	20661,02321	19,83	3,12
5/7/21 9.00	10	21,40	70,42	23469,21512	21,40	3,00
6/7/21 1.00	10	22,94	64,32	16701,47881	22,94	3,85
6/7/21 2.00	10	22,40	59,30	16534,33816	22,40	3,59
6/7/21 3.00	10	22,03	60,03	16538,31558	22,03	3,63
6/7/21 4.00	10	21,54	65,34	16425,92925	21,54	3,98
6/7/21 5.00	10	21,06	63,21	16303,97029	21,06	3,88
6/7/21 6.00	10	21,24	65,11	16363,07981	21,24	3,98
6/7/21 7.00	10	22,47	48,32	13250,19644	22,47	3,65
6/7/21 11.00	10	28,97	63,20	18720,32393	28,97	3,38
7/7/21 4.00	10	23,34	43,46	13179,29547	23,34	3,30
7/7/21 5.00	10	23,03	42,12	13974,67626	23,03	3,01
7/7/21 21.00	10	22,48	48,12	13228,48905	22,48	3,64
7/7/21 22.00	10	22,23	47,35	13259,35234	22,23	3,57
7/7/21 23.00	10	22,04	55,02	16926,69556	22,04	3,25
8/7/21 0.00	10	21,98	56,02	16512,63316	21,98	3,39
8/7/21 1.00	10	21,48	41,03	12958,06801	21,48	3,17
8/7/21 2.00	10	21,40	44,04	13771,96086	21,40	3,20
8/7/21 3.00	10	21,13	51,05	15354,06442	21,13	3,32
8/7/21 4.00	10	20,94	41,15	13081,22522	20,94	3,15

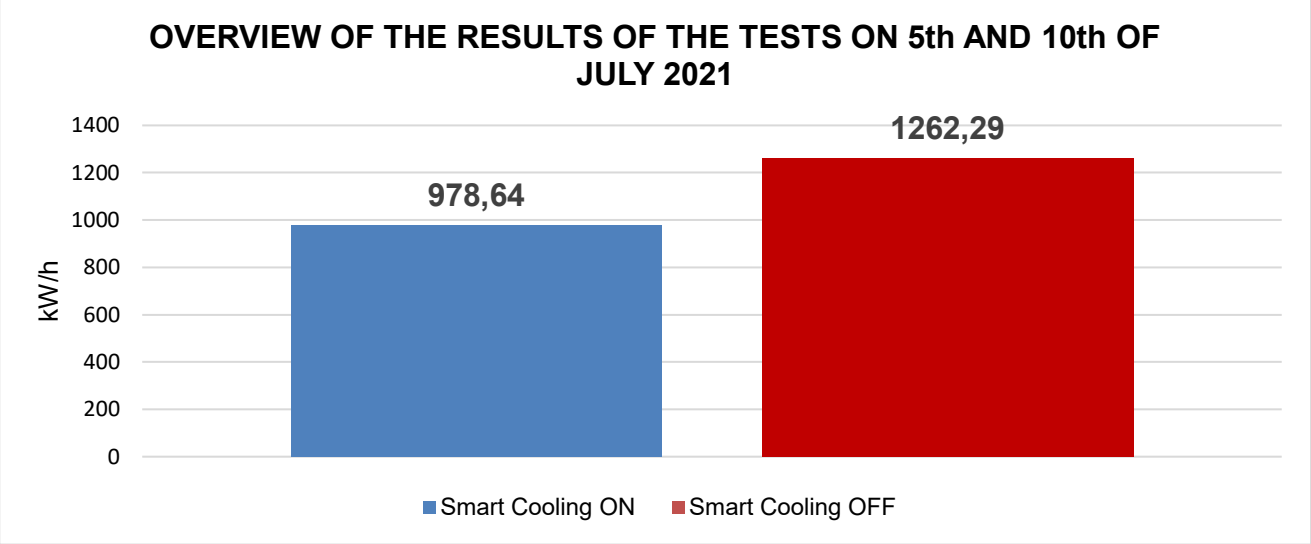
Devices Label	GF2	AIR TEMPERATURE	COOLING	GF2	THL EXT	EER
8/7/21 5.00	10	21,19	41,01	12950,37296	21,19	3,17
8/7/21 6.00	10	21,73	41,15	12961,03178	21,73	3,17
8/7/21 7.00	10	22,59	55,12	16374,29761	22,59	3,37
8/7/21 16.00	10	20,00	52,03	15748,6645	20,00	3,30
8/7/21 17.00	10	18,64	41,04	12508,83713	18,64	3,28
8/7/21 18.00	10	17,93	43,15	12578,82119	17,93	3,43
8/7/21 19.00	10	17,94	61,02	15854,94875	17,94	3,85
8/7/21 20.00	10	17,53	45,02	12474,56061	17,53	3,61
8/7/21 21.00	10	17,26	61,02	15760,42884	17,26	3,87
8/7/21 22.00	10	17,38	41,04	12627,34266	17,38	3,25
8/7/21 23.00	10	17,56	62,58	16046,2	17,56	3,90
9/7/21 0.00	10	17,25	44,31	12404,40985	17,25	3,57
9/7/21 1.00	10	16,76	49,12	12301,62563	16,76	3,99
9/7/21 2.00	10	16,27	49,77	12180,34563	16,27	4,09
9/7/21 3.00	10	15,88	44,31	10718,09467	15,88	4,13
9/7/21 4.00	10	15,69	52,03	12004,00895	15,69	4,33
9/7/21 5.00	10	15,48	54,01	12132,56625	15,48	4,45
9/7/21 6.00	10	15,89	44,03	9877,084143	15,89	4,46
9/7/21 7.00	10	17,46	41,12	12350,89987	17,46	3,33
9/7/21 8.00	10	19,32	40,58	12657,78652	19,32	3,21
9/7/21 9.00	10	21,16	47,35	15325,76051	21,16	3,09
9/7/21 10.00	10	22,89	48,50	13400,21596	22,89	3,62
9/7/21 23.00	10	22,10	42,30	13056,53365	22,10	3,24
10/7/21 0.00	10	20,80	41,01	13066,07183	20,80	3,14
10/7/21 1.00	10	19,97	51,33	16200,90704	19,97	3,17
10/7/21 2.00	10	19,27	41,54	12719,18297	19,27	3,27
10/7/21 3.00	10	18,56	50,31	15861,754	18,56	3,17
10/7/21 4.00	10	17,98	42,58	12586,40117	17,98	3,38
10/7/21 5.00	10	17,61	43,21	12666,89154	17,61	3,41
10/7/21 6.00	10	17,86	55,01	15912,92874	17,86	3,46
10/7/21 7.00	10	19,53	43,01	13250,90722	19,53	3,25
10/7/21 8.00	10	21,64	42,5	13476,27492	21,64	3,15
Average	**10**	**19,81**	**52,13**	**15208,26**	**19,81**	**3,46**
WORKING HOURS				897287,2994		
59						

Overview of the results of the tests conducted on 5th and 10th of July 2021

HR	ABSORPTION	DAY		CAPACITY	TEMPERATURE	POWER	ABSORPTION	TEMPERATURE	EER
CHECK	TOTAL	FROM 5 TO 10 JULY 2021		WATER	ON SURFACE	COOLING		EXTERNAL	
				MC/H	°C	KWF/HR	Watt/HR	°C	N
83,00	1376,73	SMART COOLING ON	Average	10	20,28	70,76	16587,07	28,85	4,36
59,00	897,29	SMART COOLING OFF	Average	10	19,81	52,13	15208,26	19,81	3,46
24	479,44	DIFFERENCES		0	0,47	18,63	1378,81	9,04	0,90
28,92%	34,82%	IN PERCENTAGE		0%	2,34%	26,33%	8,31%	31,34%	20,64%

	AT EQUAL HOURS (59 HR)	
SMART COOLING ON	978,64	KW
SMART COOLING OFF	1242,40	KW
	WITH EQUAL POWER DELIVERED	
SAVING IN KW	263,76	
SAVING IN %	21,23%	
INCREASE OF COOLING POWER IN%	26,33%	
INCREASE EER	20,64%	

TABLE 5



Conclusion 5 days off and 5 days on of Smart Cooling™ equipment:

Starting from the data reported in Table 1 (if the **Smart Cooling™** System will work for a total of 2817 hours) and from the data in Table 1A, which reports an average increase in the temperature of 6°C, compared to those recorded at the airport (the only available data history), it is possible to deduct that the system will work for 3124 hours per year.
The above data, based on the 59-hours comparison, show that the saving that can be achieved is more than 14.000 kW/year. Such data is not related to temperature but keeps into account only the working hours.

Keeping into account the results shown in Table 4, we obtain that at the same temperature above 24°C the saving is 19.744 kW/year against an average cooling power of the chiller of 65 kWf.

During the test, the chiller was working at 50% capacity:
should the chiller work at 100% capacity, it can be assumed, considering the nominal cooling capacity of 122 kW (reported in the Climaveneta catalog) that
saving would be up to 39 MW per year

Final observations

The test validated the theoretical data (on which the first analysis was based), proving they were **conservative** and can hence be used for a preliminary evaluation.
Data collected during the test show that remarkable savings can be achieved (ref. Table 5) considering the operating hours, considering and calculating the consumption at the same temperature and humidity conditions.
The saving would be 25% or higher in the 2817 hours (as shown in Table 1) when the air temperature in the Milan area crosses 24°C, the threshold for the **Smart Cooling™** system to operate. Even if the temperatures are going to increase in the forthcoming years due to climate change, keeping into account only the data for the previous years it is possible to affirm that in the whole year an 9% saving could be achieved using the **Smart Cooling™** system.
Coming to the various locations of the TIM sites, the operational hours range from the 2817 in Milan to 3560 in Reggio Calabria, where savings in the whole year go beyond 12% also as a consequence of the higher air temperature.
Another indirect advantage of the **Smart Cooling™** system (as shown in Column 5 of Table 4) is the capability of operating the chiller even if the air temperature near the chiller crosses 50°C (**something that can easily happen in case of critical installations**), thanks to the ability of the **Smart Cooling™** system to decrease the air temperature by around 15°C. Maintenance people would therefore not have

to intervene anymore to reactivate the chillers, blocked due to high temperature, or to keep them operating by, for example, spraying water directly on the coils.
We got in touch with the maintenance at the Limbiate site, who confirmed that since the **Smart Cooling**™ system was installed, it was not necessary to intervene on the chiller like the previous years, even if the outdoor temperature was higher.

Average energy saving: **11,67 %**
The average increase in cooling capacity: **10,15%**
Assuming the actual value for energy **(0,17€ per Kw/h)**
And water (1,28 € per cubic meter)
The following savings can be achieved :
615 kW chiller = 156,61€ per day x 120 operating days = 18.793,00€ per year
973 kW chiller = 244,20€ per day x 120 operating days = 29.304,00€ pr year

The return on investment would be the following
615 kWf chiller = 45.000,00 / (18.793,00 -2.500,00) = 2,7 equal to 3 years
973 kWf chiller = 45.000,00 / (29.304,00 -2.500,00) = 1,6 equal to 2 years

Luca Gallarate

July 28th, 2021

Annex

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RIF600 | Clamp-on Ultrasonic Meter Calibration Report

Pipe diameter	DN80	Date	15/12/2018
Ambient temperature	29°C		
Standard Device before test	Normal	Model:	RIF600W
Standard Devide 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	0,759	-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	
	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 JJG 1030-2007 < Ultrasonic flowmeter verification procedures >
Scale Factor=1

Riels instruments srl | test Report

Pag. 1 di 2

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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		
Dispositivo standard prima del test	Normale	Model:	RIF600W
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	101,47	25,0	0,300	102,27	102,10	0,739	0,759	-0,147	0,147
	101,47		25,0	0,300	102,07		0,591			
	101,42		25,0	0,300	101,97		0,542			
Punto 2	71,27	71,27	25,0	0,300	71,75	71,75	0,673		-0,146	
	71,19		25,0	0,300	71,65		0,646			
	71,34		25,0	0,300	71,86		0,729			
Punto 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 JJG 1030-2007 < Ultrasonic flowmeter verification procedures >
Scale Factor=1