12 September 2016

MEASUREMENT AND VERIFICATION SAVINGS REPORT IPMVP PROTOCOL

AENA MADRID AIRPORT

ABEL BASCUÑANA AVILA
CERTIFIED
MEASUREMENT AND VERIFICATION PROFESSIONAL

Test Result

This test reflects how the energy consumption of cooling equipment and air conditioners decreases if they are supplied with new generation "Smart cooling™" equipment including the BY 70 pre-cooling adiabatic condenser together with the Trane RTAC 185 cooling device.

Main office
Avda. Emilio Lemos 2, 607.1
41020 Seville
Tel: +34 954045108

iON smart energy

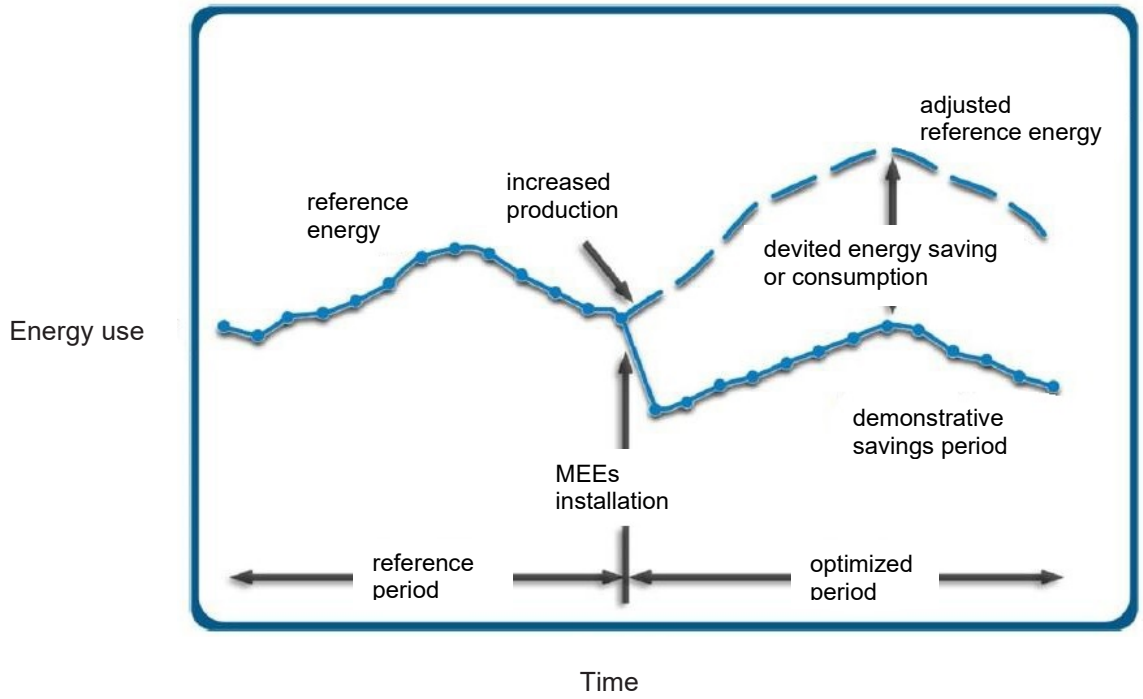
Regional officeC/ l'Acer 30, pl 2, B39
08038 Barcelona

Index

Objective

Measurement and Verification (M&V) is the process of using measurement to reliably establish the actual savings created at an installation within an energy management program or action. Savings cannot be measured directly, as it represents the absence of energy consumption. For this reason, savings have to be determined by comparing the consumption before and after the implementation of an energy efficiency project, while making the appropriate adjustments in accordance with the variation in the initial conditions.

The diagram below shows an outline of the process for determining savings after the implementation of an energy efficiency improvement measure (EEIM)



Graph 1 - Energy saving according to EVO's Measurement & Verification protocol

As energy savings cannot be directly measured (the absence of energy consumption cannot be measured), they are determined by comparing consumption, or demand, before and after the implementation of an energy efficiency project, while making the necessary adjustments according to the variation in initial conditions.

The following Measurement & Verification report for savings according to the EVO (Efficiency Valuation Organization) International Performance Measurement and Verification Protocol (IPMVP) has been made to determine the savings achieved from 24 July to 3 September in a chiller, as a result of the installation of the "Smart Cooling™" adiabatic pre-cooling system on a TRANE. RTAC 185 chiller unit at Madrid Barajas Airport T3.

The system is activated (operation set point) when the outside temperature is equal to or above 24ºC, based on 3 algorithms: one for temperatures from 24ºC to 27ºC; the second from 27ºC to 32ºC; and the third for temperatures higher than 32ºC.

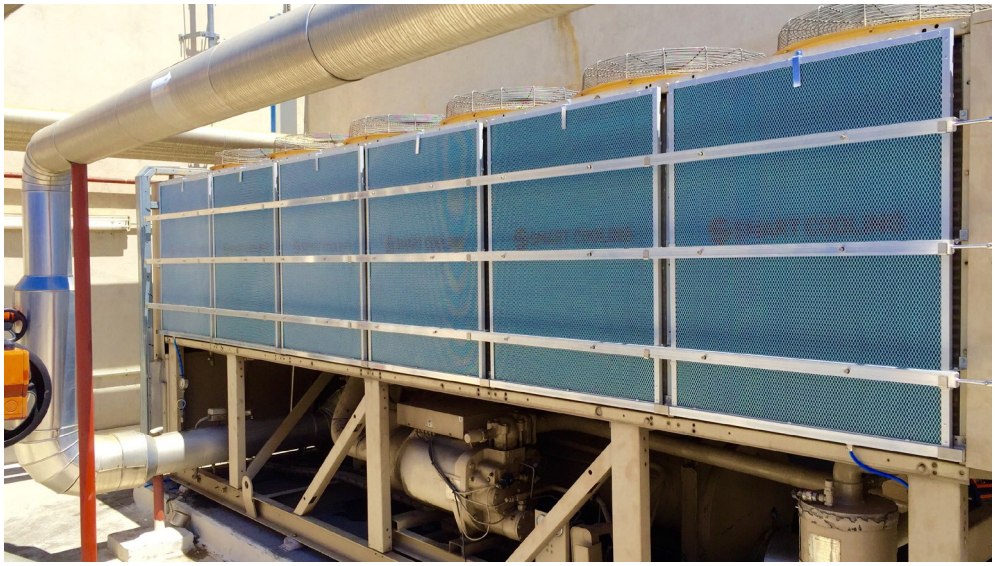
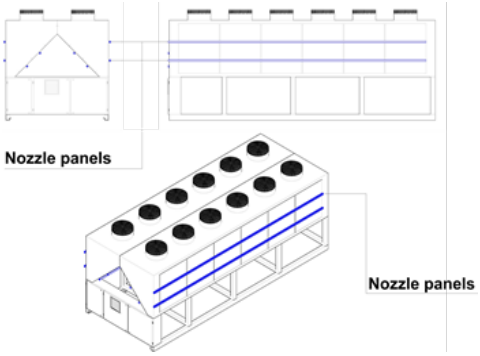
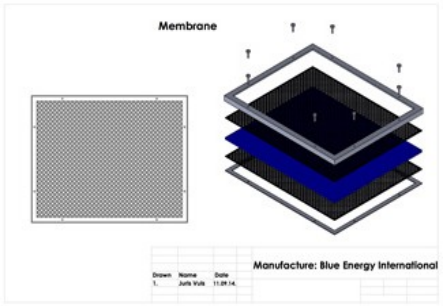
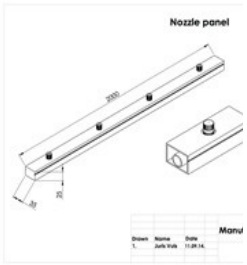
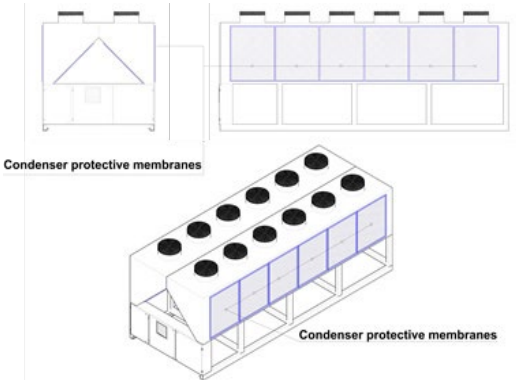


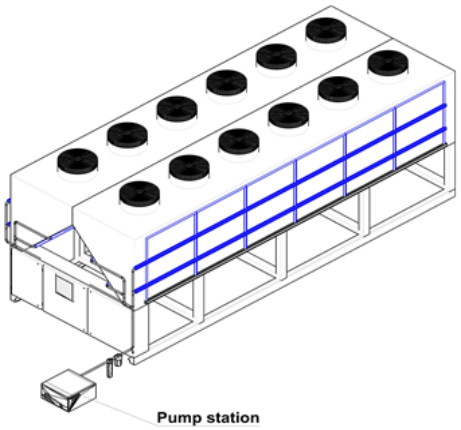
Illustration 1- Smart Cooling adiabatic cooling system installed in a chiller.











Measuring System and Equipment

The blauLabs Energy Management platform was used to capture, register and monitor data.

- blauLabs energy management platform

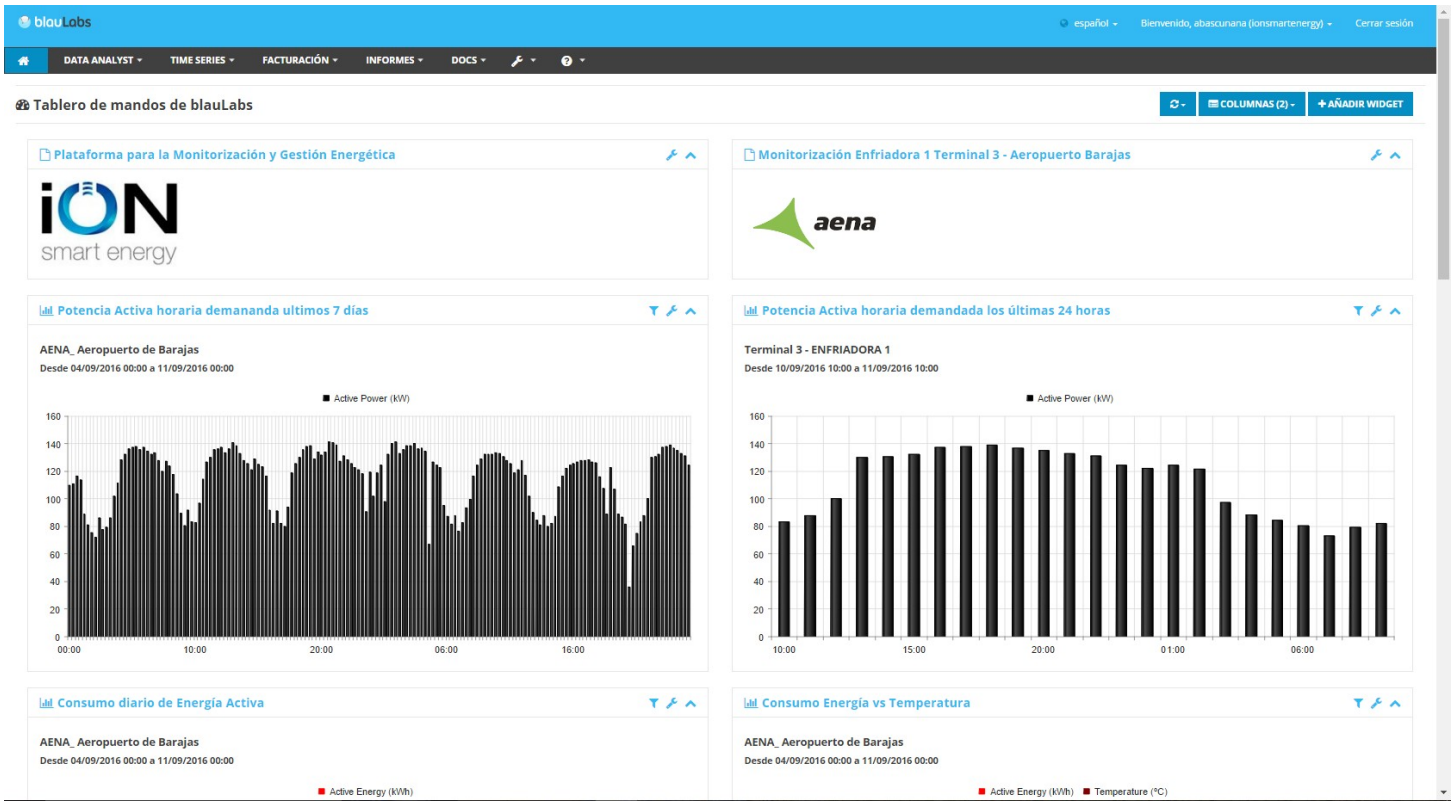


Illustration3 - blauLabs platform for energy measuring and management.

The following consumption values were recorded on the platform on a quarter-hourly basis:

- Active Energy (kWh)
- Power (kW)
- Water volume (m3)
- Temperature (ºC)
- Relative humidity (RH)

The following devices were used to measure consumption data and temperature and relative humidity parameters:

- Network Analyzer with M-Bus protocol M-Bus.

- Temperature and RH sensor with M-Bus protocol.

- M-Mus GPRS Gateway Cme2100

- COMBI water meter with M-Bus protocol

Main office
Avda. Emilio Lemos 2, 607.1
41020 Seville
Tel: +34 954045108

Regional office
C/ l'Acer 30, pl 2, B39
08038 Barcelona
Tel. 934 60 67 22

Scope

The IPMVP protocol option was used to verify savings: Option B. Isolated measurement of all the parameters for the electricity consumption of the chiller where the energy efficiency improvement system was installed.
This option involves the use of the data measured by the network analyser installed in the relevant chiller and the temperature data measured by the sensor installed in the same roof where the chiller is located.
These are the values of the different parameters and variables in the measurement made:

- Measurement Period:	24 July to 3 September 2016
- Independent variable:	Temperature (ºC)
- Check option used:	Option B - Isolated measurement of all system parameters (chiller).
- Energy measurement:	Network analyser installed in the chiller.
- Temperature measurement:	Temperature sensor installed on the roof.
- Water Measurement:	Cold water meter installed in the water supply pipe to the system.

Measurement Period

The measurements taken from 24 July to 3 September were used, during which time the system was activated and deactivated in order to be able to compare the consumption of the machine in each state. During this period the chiller did not always work at full capacity (the two compressors) because from 10 August the machine was working at 50% owing to a failure in a control panel card in one of the cooling circuits.
There are also days where the system was working intermittently (hours during which it was on and off in the same day), which makes it difficult to measure and verify savings under the same operating conditions. In this sense, in order to standardize as much as possible, despite this variance in the operation of the system and chiller, only whole days on which the same system operating conditions were present (or with the system on or off for most of the day) were taken into account. The ON-OFF system analysis was separated into the days on which two compressors were operating and the days on which a single compressor was operating.

For the system running with two compressors operating the following days were used:

- ON: from 1-8 August.
- OFF: from 24-31 July and 9 August. For the system with a working compressor:
- ON: 13-14 August and 29 August-3 September
- OFF: 16-23 August.

Average savings during the test period

Below is the measurement data for the period under analysis, the status of the system and the average hourly rate of kWh consumed per ºC of temperature.

Measurement Data for System operated with 2 compressors

Day	System	Average temperature	Total kWh	Average kWh	kWh/ºC average OFF
24 Jul	OFF	31.746	3999.7	215.100	6.776
25 Jul	OFF	30.618	4898.1	203.179	6.636
26 Jul	OFF	32.126	4958.6	206.604	6.431
28 Jul	OFF	35.628	4227.4	209.992	5.894
29 Jul	OFF	33.354	4643.2	196.209	5.883
30 Jul	OFF	31.532	4842.3	202.117	6.410
31 Jul	OFF	29.889	4891.9	204.859	6.854
9 Aug	OFF	29.635	4566.1	187.850	6.339
8		31.816	37027.3	203.239	6.403
Total days		Average	Total	Average	Average

Table 1- Measurement data system OFF with two operating compressors.

Day	System	Average temperatur e	Total kWh	Total m3	Average kWh	Average kWh/ºC ON
1 Aug	ON	33.350	4317.3	2.512	186.125	5.581
2 Aug	ON	31.833	4124.9	5.372	172.038	5.404
3 Aug	ON	30.581	2444.3	3.87	158.362	5.178
4 Aug	ON	33.353	2791.2	3.546	200.350	6.007
5 Aug	ON	31.006	3514.1	4.915	145.996	4.709
6 Aug	ON	33.084	3512.7	2.087	188.079	5.685
7 Aug	ON	31.103	4293.6	2.456	191.148	6.146
8 Aug	ON	27.621	4601.3	1.128	158.136	5.725
8		31.491	29599.4	25.886	175.029	5.554
Total days		Average		Total	Average	Average

Table 2-Measurement data system ON with two operating compressors.

The average system saving with the 2 compressors operating as a function of temperature for the days analysed was 13.2%.

Average saving = 1- ((kWh/ºC average ON) / (kWh/ºC average OFF)) x 100

Average savings = 1- ((5.554) / (6.403)) x 100 = 13.20%

Measurement Data for System operated with 1 compressor

Day	System	Average temperature	Total kWh	Average kWh	Average kWh/ºC OFF
16 Aug	OFF	29.405	2978.8	124.408	4.231
17 Aug	OFF	29.214	2328.7	96.604	3.307
18 Aug	OFF	29.546	2724.5	114.192	3.865
19 Aug	OFF	29.780	2812.8	117.029	3.930
20 Aug	OFF	29.970	3033.1	107.850	3.599
21 Aug	OFF	28.856	2584.6	107.850	3.737
22 Aug	OFF	29.980	2717.5	113.271	3.778
23 Aug	OFF	30.701	2816.5	115.933	3.776
8		29.681	21996.5	112.142	3.778
Total days		Average	Total	Average	Average

Table 3- Measurement data system OFF with 1 operating compressor.

Day	System	Average temperatur e	Total kWh	Total m3	Average kWh	Average kWh/ºC ON
13 Aug	ON	28.662	2387.7	3.139	100.392	3.503
14 Aug	ON	28.093	2685.7	3.218	111.879	3.982
29 Aug	ON	30.833	2866	3.078	118.350	3.838
30 Aug	ON	28.893	2392.7	3.12	99.208	3.434
31 Aug	ON	29.351	2483.2	3.054	103.642	3.531
1 Sep	ON	29.285	2579	3.053	107.254	3.662
2 Sep	ON	29.633	2498.2	3.064	104.446	3.525
3 Sep	ON	30.210	2544.1	3.141	106.013	3.509
8		29.370	20436.6	24.867	106.398	3.623
Total days		Average		Total	Average	Average

Table 4- Measurement data system ON with 1 operating compressor.

The average saving for the system with 1 compressor operating as a function of temperature for the days analysed was 13.2%.
Average saving = 1- ((kWh/ºC average ON) / (kWh/ºC average OFF)) x 100
Average savings = 1- ((3.623) / (3.778)) x 100 = 4.10%

Estimating savings with the chiller

The average saving obtained as a function of temperature for the 100% operational chiller (2 compressors running) was 13.20%. For the days analysed with these conditions for the OFF system for an average temperature of 31.8 ºC, the average consumption per hour was 203.239 kWh; this means that estimating the same conditions for one day gives an average consumption of 4,877.732 kWh per day; extrapolating the same conditions to a month with 30 days, the estimated average monthly consumption of the chiller with the system OFF is 146,332 kWh (146 MWh).

Taking into account the average savings of 13.20% obtained when the system is ON for the fully operational chiller, the estimated active energy consumption avoided for one month is 19,315.82 kWh.

Taking into account an average price of 0.11 euros/kWh, the cost avoided per month for active energy consumption is 2,124.74 euros per month.

Main office
Avda. Emilio Lemos 2, 607.1
41020 Seville
Tel: +34 954045108

Regional office
C/ l'Acer 30, pl 2, B39
08038 Barcelona
Tel. 934 60 67 22

ANNEX I Certified Measurement and Verification Professional

CMVP®

The Efficiency Valuation Organization

EVO EFFICIENCY VALUATION ORGANIZATION

y

The Association of Energy Engineers

aee

Certifican que

Abel Bascuñana Avila

Ha completado con éxito la certificación de profesional en medida y verificación, ha demostrado un alto nivel de competencia y aptitud ética en el dominio de la medida y la verificación y se concede el título de

Profesional certificado en medida y verificación*

Válido hasta: December 31, 2016 2604

Presidente de la junta de EVO

Presidente de la junta del programa CMVP

Director de la certificación internacional

EVO EFFICIENCY VALUATION ORGANIZATION

ASSOCIATION OF ENERGY ENGINEERS CORPORATE SEAL GEORGIA

*CMVP –Certified Measurement and Verification Professional