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3rd April 2019

FMCore Ltd
Valley Mansions Level 1
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B'Kara

For the attention of Ing. Edward Cauchi

Dear Sir,

BUILDING SERVICES REPORT ON SOLAR THERMAL SYSTEM AIDING RHOSS CHILLER AT MDH

With reference to the above subject, kindly find attached our report for your perusal.

We trust the above is in line with your requirements. Should you need any further assistance please do not hesitate to contact the undersigned.

Yours faithfully,
MTS CONSULTING LIMITED

Ing. Sebastiano Genovese
Consulting Engineer

Encl.
sg/vg

MTS QUALITY ASSURANCE SYSTEM

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BUILDING SERVICES REPORT

1.0 SCOPE

We have recently been approached by Modern Refrigeration to provide them with a performance report on a Solar Thermal installation they have carried out on a Rhoss chiller feeding the pharmacy store at Mater Dei.

The scope of this report is to evaluate the overall energy savings by having a Solar Thermal system connected to the refrigerant circuit on one of the existing chillers serving the Pharmacy Block at MHD.

Conditioning of the pharmacy store is provided by means of chilled water which is produced by 2No. Rhoss air cooled chillers with heat recovery. Chilled water flow is circulated between the chillers and the terminal units by means of fixed speed circulating pumps. Heat recovery is not currently being used.

Several Solar Thermal Solar panels were installed on both two refrigeration circuits of the Rhoss chiller. The Solar Thermal panels have been connected in between the compressor and the condenser. A set of valves have been installed to enable the chiller to operate with the Solar Thermal panels or without.

During the test the systems will be monitored to make sure that the pharmacy store IAQ is not affected.

2.0 SURVEY PROCEDURES

The survey procedures consisted on monitoring the power and energy used by the chiller retrofitted with the Solar Thermal system.

The procedures observed in order to execute this study were as follows:

Switch off all refrigeration circuits apart the ones under test. This will provide the refrigeration circuits in question with adequate load for testing purposes since at this time of the year the load is relatively small, and a single chiller can cope with the cooling demands. Data recording were carried out throughout the day including night time.

Two temperature data loggers were installed on the flow and return chilled water lines of the chiller.

An energy meter was installed on the chiller's entering main cable.

External temperature and RH were also monitored.

Solar radiation was also retrieved from published data in order to evaluate any detrimental factors attributed to the external conditions.

Tests were carried out on similar consecutive days; the first test was done with Solar Thermal system off (diverted) and the day after with the Solar Thermal system feeding into the chiller.

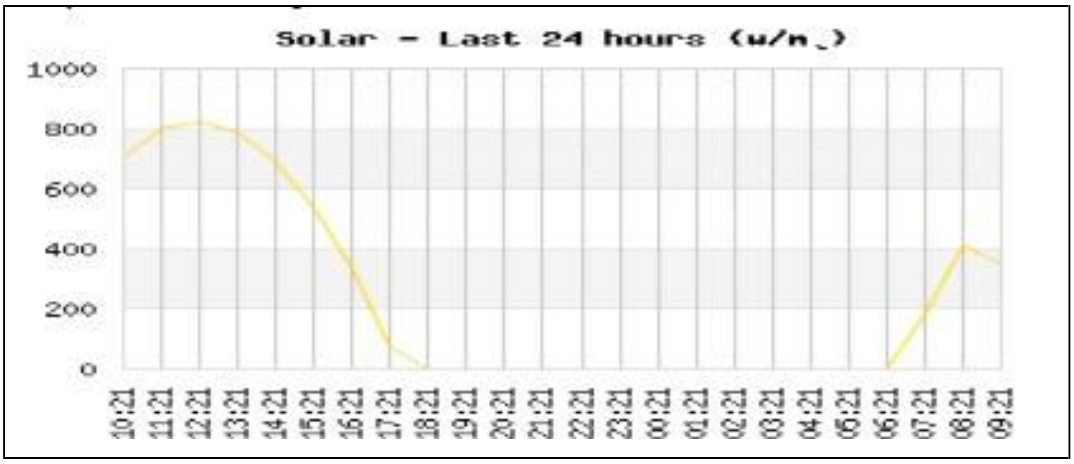
For logistic reasons the test with the Solar Thermal system non-operational started at 13:00 on the 5th March, whilst the test with the Solar Thermal system fully operational started at 13:00 on the 6th March and concluded at 13:00 the day after (7th March 2019).

3.0 OBSERVATIONS AND ASSUMPTIONS

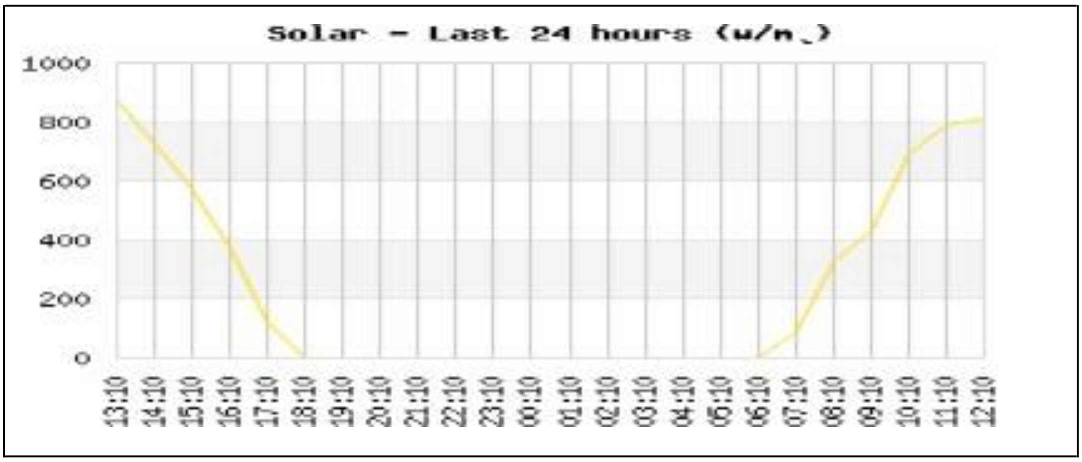
In order to get a realistic comparison, all data recorded during the absence of solar radiations were discarded.

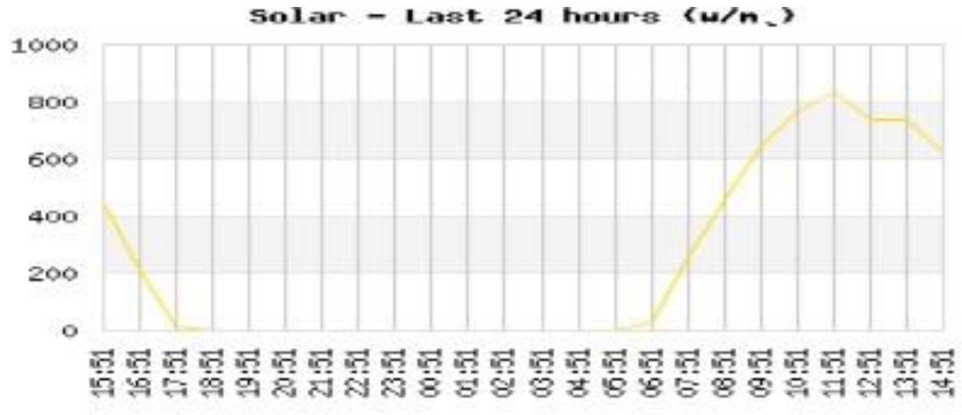
However, also a night time analysis was also conducted to evaluate if the Solar Thermal system would compromise the system efficiency when such system is not directly exposed to the solar radiation or check for any standing losses.

Solar radiation graph for the 05-06 March 2019



Solar radiation graph for the 06-07 March 2019

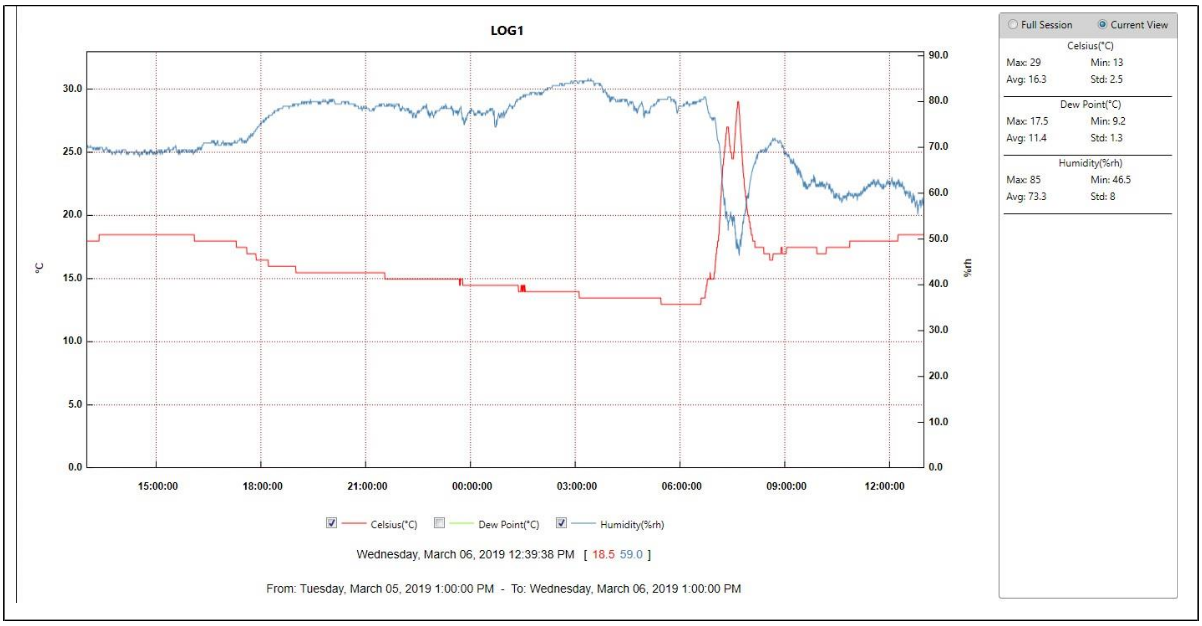


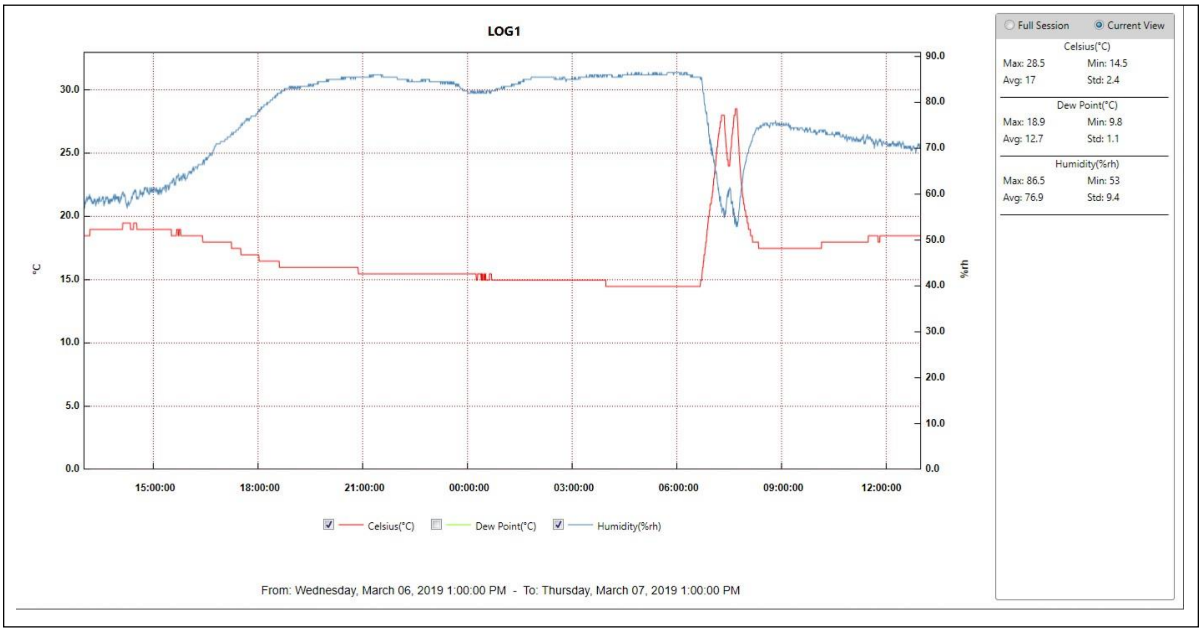


Thus, from the graph above, the representative period that can be considered would be between 13:00 and 18:00 and from 07:00 and 13:00.

It was observed that the external temperature and conditions during the period of the testing were quite similar.

The graph below depicts the recorded external temperature and humidity for the two consecutive days.





The peak temperature recorded early morning is attributed to the fact that the sensor of the data logger was directly radiated by the sun when its altitude was almost horizontal.

4.0 ANALYSES OF FINDINGS

The energy consumption recorded by the energy meter was mainly taken into consideration for the scope of this analysis.

From the data recorded the energy used by the chiller for the period when the Solar Thermal system was disconnected was 123.208kWh, whilst the energy used by the chiller with the Solar Thermal system connected was 107.860kWh. Hence, the use of energy was reduced by 12.5%.

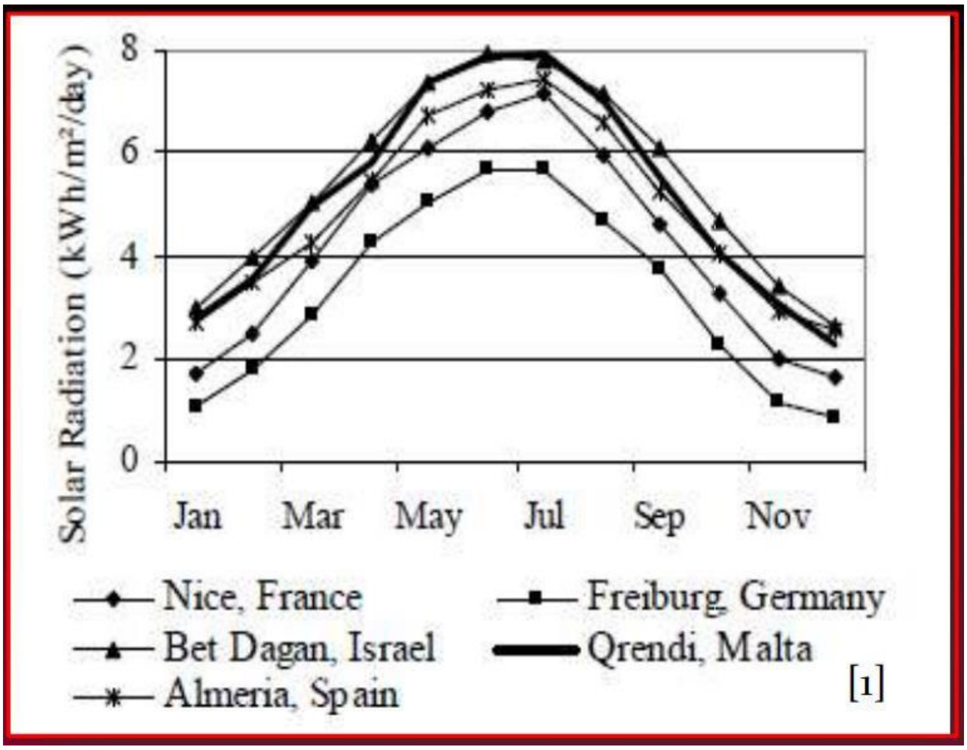
It is also to be said, that the cooling demand was 7% higher during the testing with the Solar Thermal system connected, this could be directly attributed to the slightly warmer day. Hence, considering that the system had to generate more cooling due to the higher demand, the reduced percentage of energy use increases from 12.5% to 22.3% (considering a linear and directly proportional relation of the Chiller EER).

$$EER= (1.07/0.875) = 1.223 \rightarrow 22.3\%$$

Sunlight hours in Malta range between 5:19hrs/day in December and 12:23hrs/day in July.

During the test around 9 hours of sunlight were observed.

The daily historical data for Malta shows that during the period of the data recording (beginning of March) the daily solar radiation is around 4.25kWh/m^2.



During the data recording period the solar radiation intensity was quite reduced when compared to the summer months. From historic data, the peak solar radiation in Malta can reach up to 1311Watts/m^2. Similarly, the length of the solar radiation is reduced when compared to the summer period.

Considering that the average daily solar radiation for Malta can be averaged to 5.25kWh/m^2, and that the test was executed during the period when the estimated average daily solar radiation is around 4.25kWh/m^2, thus the benefit of the Solar Thermal system operating throughout the year could be calculated as follow:

$$y - y_1 = m(x - x_1)$$

$$0 - 22.3 = m(0 - 5.75)$$

$$m = 5.24$$

$$m = \frac{y_2 - y_1}{x_2 - x_1} = 5.24$$

$$5.24 = \frac{y_2 - 22.3}{5.25 - 4.25}$$

$$y_2 = 27.54(\%)$$

Further to the above, it can be evaluated that the yearly energy usage attributed to the Solar Thermal system can reach an overall reduction of 27.54%.

Also, it is to be said that during the switching over of the Solar Thermal system, being done during the peak solar radiation, 11No. of solar tube collectors were irreversibly damaged as a consequence of thermal shock, hence, the Solar Thermal system was operating at 95% of its total installed capacity.

Thus, it can be concluded that the Solar Thermal system can reduce the total yearly energy usage by almost 29% when compared to a standard chiller.

The night time analysis, as mentioned earlier in the report was also conducted to evaluate if the Solar Thermal system would be disadvantageous or still favorable to the overall system efficiency.

The data taken into consideration for the night time analysis is between the 18:00 and 7:00hrs for two consecutive days. The first period would analyze the system with the Solar Thermal system disconnected and the second period with the Solar Thermal system connected.

The energy consumed with the Solar Thermal system disconnected during the night time study was 139.938kWhr against a cooling demand of 1354.700kWhr/m

The energy consumed with the Solar Thermal system connected during the night time study was 124.086kWhr against a cooling demand of 1488.123kWhr/m

From the above data it is evinced that the system would still benefit from the Solar Thermal system even during the night time period, thus providing a 20% increase in terms of overall system efficiency.

5.0 FURTHER COMMENTS AND CONCLUSION

From the monitoring and analysis of the Solar Thermal system, it is evinced that the such system can reduce the chiller energy use by almost 29% averaged throughout the year.

It is to be noted that the Solar Thermal system does not provide any benefit when there is no solar radiation, however, the analysis confirms that the system can further reduce the energy use during the peak months. In most applications the Solar Thermal system would provide a proportional energy input to the actual and proportional cooling demand especially when such demand is dictated mainly by the external conditions.

It is envisaged that the Solar Thermal system can even perform well when connected to a heat pump chiller operating in heat recovery mode, achieving better performance when compare to the system operating on cooling mode.

With regards to the night-time analysis, although such analysis confirms that the Solar Thermal system improves the overall system efficiency (by 20%) even during the night-time period, this might be attributed to the diffused solar radiation still occurring after sunset and before sunrise, and to the air enthalpy being yield by the evacuated tubes even when not directly radiated by the sun.

It is however not known if the Solar Thermal system would be disadvantageous during the winter period due to the energy losses associated with standing losses of the Solar Thermal system. In order to evaluate the above, further monitoring is suggested during such period.

Further to the above, it is recommended that an LCA or PBP analysis would consider the above-mentioned factors.

For and on behalf of,

MTS CONSULTING LIMITED

Ing. Sebastiano Genovese

Consulting Engineer