Solar Thermal Assisted Air Conditioning System

Measuring and Verification Evaluation Report

2019

Assessment Period: SEPT 3 – OCT 14, 2019

Prepared for:

Pioneer Insurance and Surety Corporation
Pioneer House Makati
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I. DATA MEASUREMENT

Kilowatts per Hour (kWh)	-	HOBO Data Recorder
External Temperature	-	www.wunderground.com
External Humidity	-	www.wunderground.com
Precipitation	-	www.wunderground.com

II. PROJECT OVERVIEW

The facility was installed 7 years ago with a Mitsubishi "FDC 400KXE6"VRF system. This project includes 5 - 2.0 tons 4-way cassettes and two 1-ton cassettes. One of the 2.0 tons cassettes was turned off by the client during this Beta data gathering. We also asked the client to have the main door going to the room closed for the Beta testing since we noticed that it was being left open most of the time during regular operation hours.

This Beta room generates heat load due to personnel and their computers. The room is adequately insulated since it is sandwiched by two offices. The FCU temperature settings were 22 degrees Celsius for 2 – 2.0 tons cassettes, 24 degrees Celsius for 2 - 2.0-ton cassette and the 2 – 1-ton cassettes are in two separate small rooms (1 each) and turned on when needed only. This room for the Beta project was selected by the client.

Benny Energy Philippines partnered their Solar Collector (thermodynamic) system with this existing VRF system.

The sequence of tasks was:

1. Project installation started May 20, 2019 – This installation required two solar collectors to match the VRF's compressor. Pioneer and Benny Energy Philippines (BEP) have agreed to:
    a. BEP will install the Solar collector system on top of the VRF system cage and have the refrigerant piping of the collector system end beside the existing VRF outdoor unit.
    b. Prior to cutting of the VRF refrigerant line, removal of the existing refrigerant was done by MIT-AIR. This process was not measured, the refrigerant was only recovered and taken away.
    c. BEP did a pressure test for the Solar system prior to the connection while MIT-AIR and Pioneer personnel were in observance. MIT-AIR and Pioneer agreed on the test.
    d. MIT-AIR (Pioneer's Service Company) was to connect the Solar system to the existing VRF unit's refrigerant piping before the condenser of the existing VRF. BEP pointed out the connection point. – During this connection process MIT-AIR decided for BEP to do the connection instead.
    e. The vacuuming procedure was supposed to be performed by MIT-AIR but MIT-AIR asked BEP to do this task.
    f. The recharging of the VRF system with refrigerant was done by MIT-AIR. The charging process was done using a pressure gauge and MIT-AIR's laptop to see that the outdoor unit was running normal. BEP was asked to bring their weighing scale by MIT-AIR but the scale was not used in the process. Mitsubishi VRF process of filling the refrigerant requires that the refrigerant be measure and calculated as per the pipe refrigerant length and area (volume). This method is

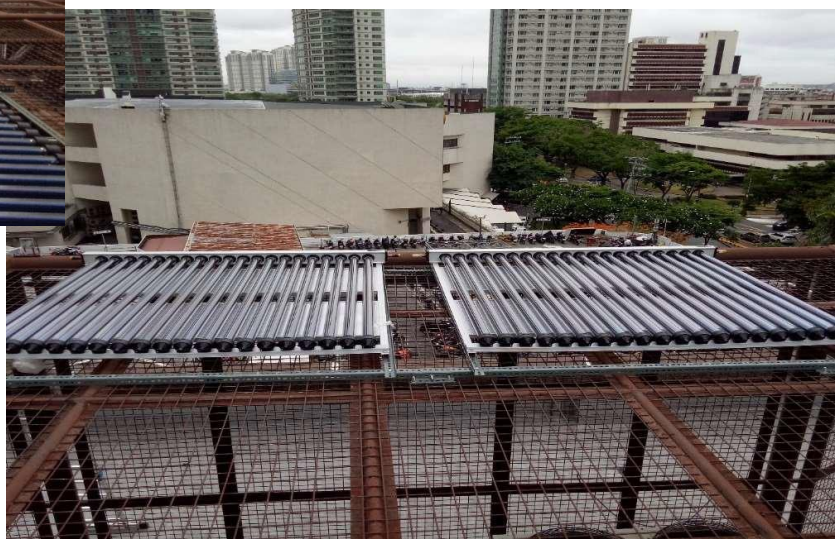
done on the test run mode if the charging cannot be completed while on idle. This method is also called the test run mode.

g. A test run was done by MIT-AIR for a few hours and monitored with their laptop.
h. The commissioning of the system was done the next day by Pioneer personnel with BEP.

The next step was for BEP to start the data gathering of the kilowatt consumption of the VRF system. Due to a stormy weather this process was delayed for almost 2 weeks. Around June BEP's OWL data recorded was installed. The reading was coming in higher than was expected. Then BEP installed a HOBO data recorder to see if the results came out the same. After a month of recording with the HOBO equipment the results were the same. The results were sent to Falkonair for analysis. Falkonair said that the system was lacking refrigerant. This information was relayed to Pioneer.

By close to the end of August BEP was called by Pioneer due to the BETA room not getting cold. BEP mentioned to Pioneer that this is also the result of lack of refrigerant. Pioneer scheduled the adding of refrigerant for August 31. MIT-AIR and BEP went for this task with BEP bringing the refrigerant. During this process, the VRF outdoor unit was opened, it was observed that the refrigerant pipeline going to the compressor (low side) was freezing. This was an indication that the system was low or lacking refrigerant. The adding of refrigerant was then done the same way as before without the calculated measurement. BEP reminded Pioneer that Falkonair asked that a measured process was to be done to make sure that the needed refrigerant was added. MIT-AIR added the refrigerant the same way as before without the measurement.

BEP then started a new data recording for the VRF system. Data was gathered starting September to October. The rainy days recorder was not used for this Beta.



Installation Overview:

- The average sun hours of the Solar system we installed is around 7 hours per day average per year.
- The outdoor VRF unit is installed on the roof deck of this 7-story building.
- There were 7 indoor FCUs (5 - 2.0 tons cassettes and 2 -1-ton cassettes). One of the 2.3 tons cassettes was turned off.

III. INSTALLED SYSTEM

The Solar systems was partnered with the existing 7 years old Mitsubishi Heavy Industries, 12 tons VRF system. This was Pioneer's unit #25. This system supplies cool air to the admin office with personnel and computers.

IV. BASELINE DATA

The baseline data for this project was the consumption of the existing Mitsubishi VRF outdoor system. We have recorded a two weeks data with Solar collector system and one week without Solar system. We have excluded data from rainy days for this Beta project.

V. POST DATA

The power consumption data collected is shown below.

The post-implementation power and energy measurements was compared to that of the baseline and the savings and ROI calculated from the same, as such representing what the consumption was before and after Solar.

VI. LIKE-FOR-LIKE COMPARISON

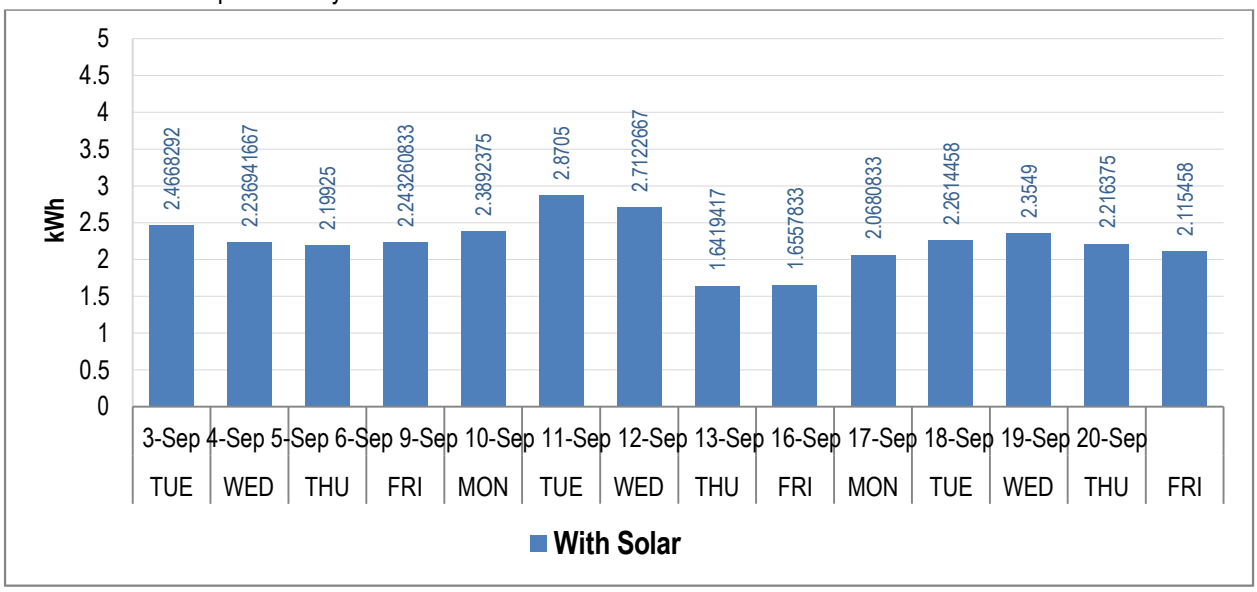
To ensure a credible data comparison of Baseline vs. Post data, the following principles have been used:

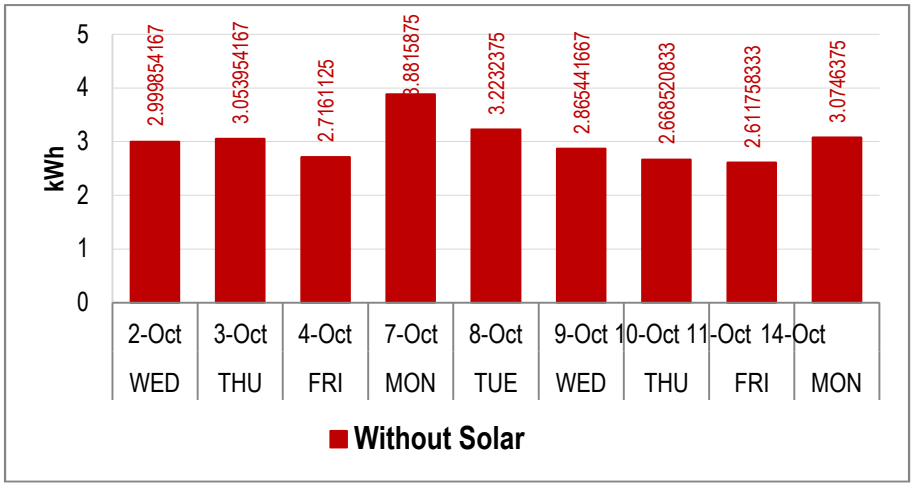
i. Exact like for like system run times

ii. As near as possible external ambient temperature
iii. As close as possible comparable external humidity
iv. As near as possible comparable precipitation levels
v. Same day of the week comparison assuming the number of users is as close as possible

VII. SAVINGS

The data logging provides the recorded data over the period of evaluation to date. The graphs below plot the kWh of the three direct comparable days of 'like-for-like' data.





Average Daily kWh Consumption - Weekly reading

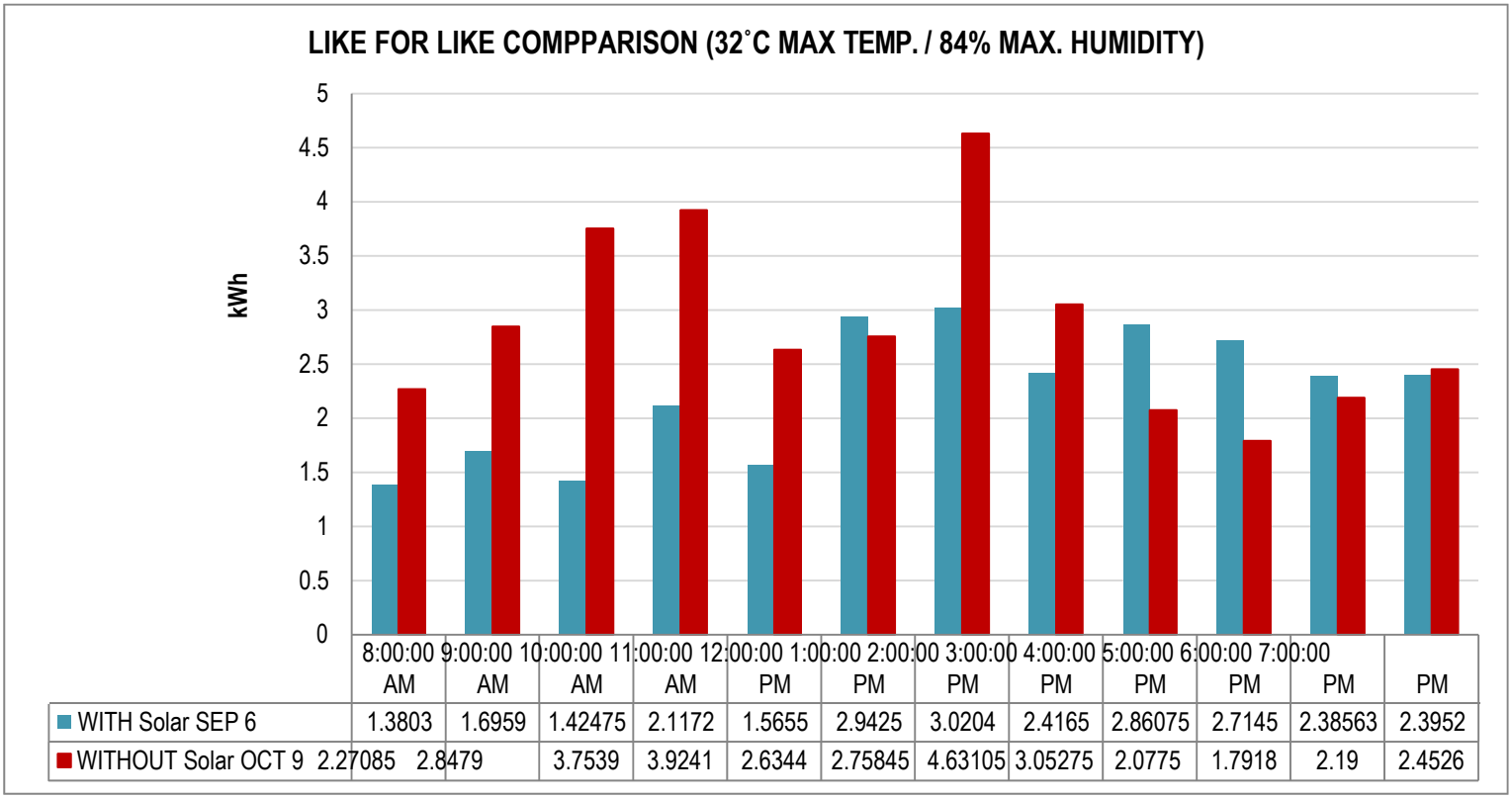
With Solar - SEP 03 -20, 2019

AVERAGE DAILY kWh = 2.2

Savings : 27%

Without Solar - OCT 02 - 14, 2019

AVERAGE DAILY kWh = 3.0



WITH Solar - SEP 6, 2019

AVERAGE DAILY kWh = 2.2

Savings: 24%

WITHOUT Solar – OCT 9, 2019

AVERAGE DAILY kWh = 2.9

VII. CONCLUSION

WITHOUT SOLAR = 3.0 kWh average daily

WITH SOLAR = 2.2 kWh average daily

SAVINGS = 27% average daily

This shows that a 7 years old Mitsubishi VRF System can achieve ample savings when partnered with Solar thermodynamic system. Even though we only have an average of seven hours of sun rays per day during the period of this Beta project due to the adjacent high rise building next door's shadow.

The normal kWh consumption graph for systems with Solar generally shows a lower power consumption. We also know and believe that we can achieve a higher savings percentage if we have the correct amount of refrigerant using the recommended refrigerant loading method by Mitsubishi VRF. This method of measuring the required refrigerant for the system is also what Falkonair recommends achieving the best result in savings.
We have also noted that this VRF system is being used on Saturdays and with longer weekdays which will give a better ROI.

IX. APPENDIX

WITH SOLAR READING DATES

WEEK	DATE	TEMPERATURE (* C)		HUMIDITY (%)		PRECIPITATION (in)
		Max	Min	Max	Min	Avg
1	Tuesday, September 03, 2019	31	25	94	66	0.00
	Wednesday, September 04, 2019	32	26	89	66	0.00
	Thursday, September 05, 2019	32	26	89	66	0.00
	Friday, September 06, 2019	32	28	84	62	0.00
2	Monday, September 09, 2019	31	25	94	74	0.00
	Tuesday, September 10, 2019	28	24	94	74	0.00
	Wednesday, September 11, 2019	29	-	89	-	0.00
	Thursday, September 12, 2019	27	26	94	74	0.00
	Friday, September 13, 2019	31	25	94	62	0.00
3	Monday, September 16, 2019	27	25	100	89	0.00
	Tuesday, September 17, 2019	30	25	94	74	0.00
	Wednesday, September 18, 2019	31	-	94	-	0.00
	Thursday, September 19, 2019	30	25	94	74	0.00
	Friday, September 20, 2019	30	25	94	74	0.00

WITHOUT SOLAR READING DATES

WEEK	DATE	TEMPERATURE (* C)		HUMIDITY (%)		PRECIPITATION (in)
		Max	Min	Max	Min	Avg
1	Wednesday, October 02, 2019	31	24	94	66	0.00
	Thursday, October 03, 2019	31	24	89	55	0.00
	Friday, October 04, 2019	32	26	89	66	0.00
2	Monday, October 07, 2019	35	26	83	46	0.00
	Tuesday, October 08, 2019	33	-	79	-	0.00
	Wednesday, October 09, 2019	32	-	84	-	0.00
	Thursday, October 10, 2019	32	26	89	62	0.00
	Friday, October 11, 2019	31	26	89	66	0.00
	Monday, October 14, 2019	33	25	89	46	0.00