Digi-RTU Saved 2,100,000 kWh/yr

Large Distribution Center Applications

Executive Summary

The facility located in Texas has 108 rooftop units (RTU) with a total cooling capacity of 1,955 tons. BES-Tech proposed to install Digi- RTU optimizers for the compressor and indoor fans with the objective of improving the indoor humidity control and reducing building energy consumption.

The facility started operations in October 2021. Digi-RTU optimizers were installed to these units between October 2022 and May 2023. Measured energy savings provided in this report only account for the warehouse RTUs. As operations ramped up an increase in internal building load is observed. The quality of annual energy savings estimate is affected by limited availability of baseline energy consumption data and uneven load dynamics of the facility.

Baseline energy consumption is about 15,439,370 kWh. The measured annual energy savings is 2,131,110 kWh. The proposed annual energy savings for these units (1663 tons) is 3,463,237 kWh. The energy savings accounts for an increase in internal heat gain of 192kW. The annual cost savings at a utility rate of $0.0786/kWh can be $167,505.

The major observations are provided below.

1. Annual energy savings can be as high as 3,940,000 kWh based on the energy savings at high ambient temperatures. Replacing the flow-proving switches with the correct sizes will enable the fan speed to be reduced and improve overall energy savings.
2. During Digi-operation, the space temperature is higher than the baseline operation. However, the space relative humidity is lower indicating better dehumidification.
3. Digi-RTU controls the space temperature and humidity of the warehouse in a smaller range in comparison to the baseline operation.
4. HVAC energy data seems to have a scale factor issue and is corrected accordingly.

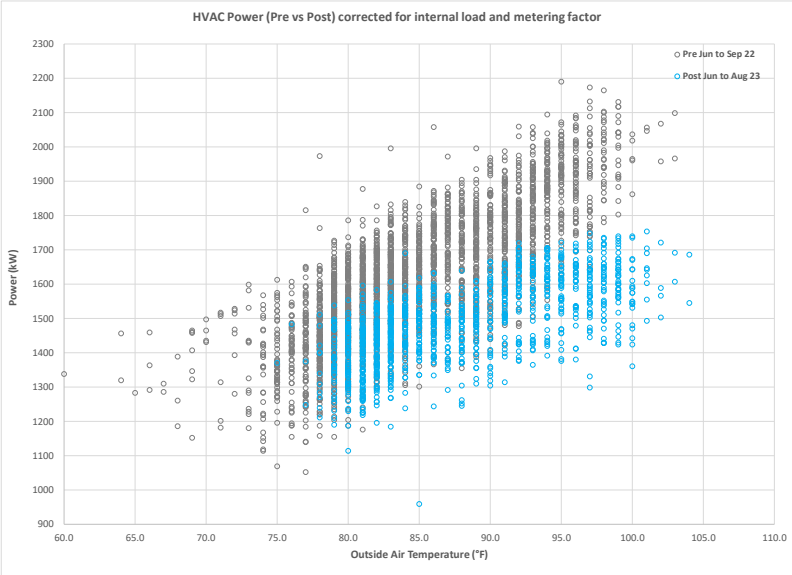

Figure 1 HVAC power vs OAT corrected for internal heat gain and metering factor

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RTU Information

The facility located in Texas has a total of 108 rooftop units (RTU). The capacity varies from 3 tons to 25 tons serving office and warehouse. Digi-RTU has been installed on sixty-seven (67) 25-ton packaged rooftop units.

Digi-RTU Installation Information

The first batch of Digi-RTUs were installed between October 2022 and November 2022 on thirty-nine packaged rooftop units serving the office, stairwell, and loading dock areas with unit size ranging from 3-ton to 10-ton with total cooling capacity of 242.5 tons. The second batch of Digi-RTUs were installed between January 2023 and May 2023 on sixty-seven 25-ton packaged rooftop units serving the warehouse area and three 12.5-ton packaged rooftop units serving the loading dock area with total cooling capacity of 1700 tons.

Analysis of Energy Savings

Customer provided hourly HVAC energy consumption data from January 1st, 2022 to August 17, 2023. The data were analyzed and reviewed carefully. Energy savings were calculated using BIN hour method. Baseline and Digi-operation data timeline are determined based on the following considerations.

1. The facility energy consumption increases singificantly from January 2022 to June 2022 due to non weather related reason. Since this is a new facility, it is concluded that the data from January to May 2022 is not representative of the baseline operation and the data for that period is excluded for the energy analysis. Baseline data in this report is from June 2022 to September 2022.
2. The post Digi-RTU data is taken from June 30th 2023 to August 17th 2023. The data during Digi-RTU installation period (January 2023 to May 2023) was not included in the post retrofit data.

The following are the observations from the measured data.

1. Effect of Space Temperature & Humidity on Energy Savings.
    a. The average space temperature setpoints are found to be similar during the baseline and Digi operation modes. However, the average space temperature during Digi operation is higher than baseline operation.
    b. The average space humidity was found to be lower during Digi operation than baseline operation indicating better dehumidification control. This could be the cause of lower energy savings at lower ambient temperatures. Detailed plots are provided in Appendix A. With similar space conditions energy savings are higher at lower ambient conditions as seen from data for RTU-C5 presented in Appendix C.
2. Increase in internal heat gain.
    a. An increase in the internal heat gain of about 192 kW is observed from the measured main electricity data. The impact of the internal heat gain is corrected properly to both the baseline and Digi-operation data. Detailed information is presented in Appendix B.
3. Scaling factor for HVAC energy meter

a. The measured peak hourly HVAC energy consumption is about 1500 kW. The actual peak demand is estimated to be 2,000 kW. The measured whole HVAC electrical consumption may miss some of the units or may need be corrected. The correcting factor can be as high as 1.43. The savings calculation is also corrected for this. Detailed information can be found in Appendix B.

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Appendix A: Space Temperature and Humidity Comparison

Space temperature and humidity data were provided by the client from January 1st, 2022, to September 12th, 2023. This analysis focuses on the average temperature and humidity for the warehouse.

The average space temperature is found to be about 3°F higher during Digi-operation than during baseline operation as indicated in Figure-2. When the ambient temperature is in the range of 90 to 75°F, the average space temperature during Digi operation is closer to the baseline operation.

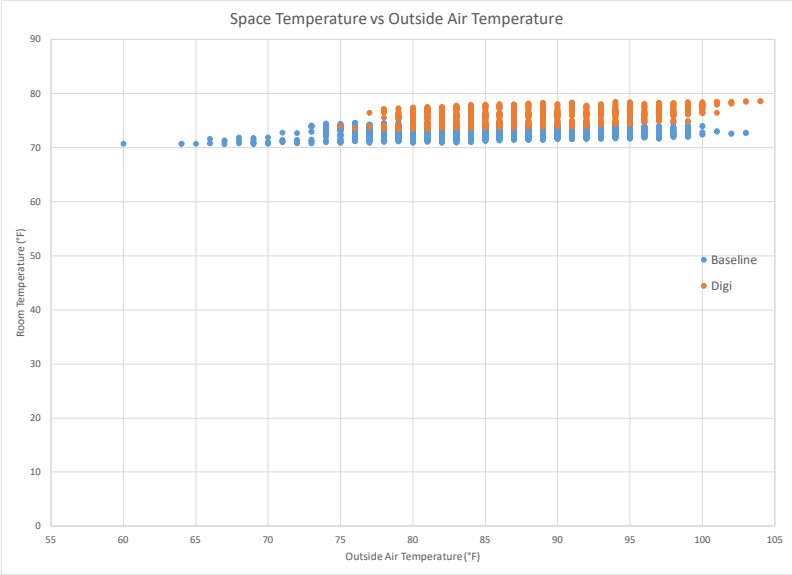

Figure 2 Warehouse average space temperature vs OAT during Baseline and Digi operation

As seen in figure 3 the average space relative humidity during Digi operation is found to be lower than baseline operation by about 3% to 5%. The range of average space humidity is also smaller than baseline operation indicating better dehumidification and control.

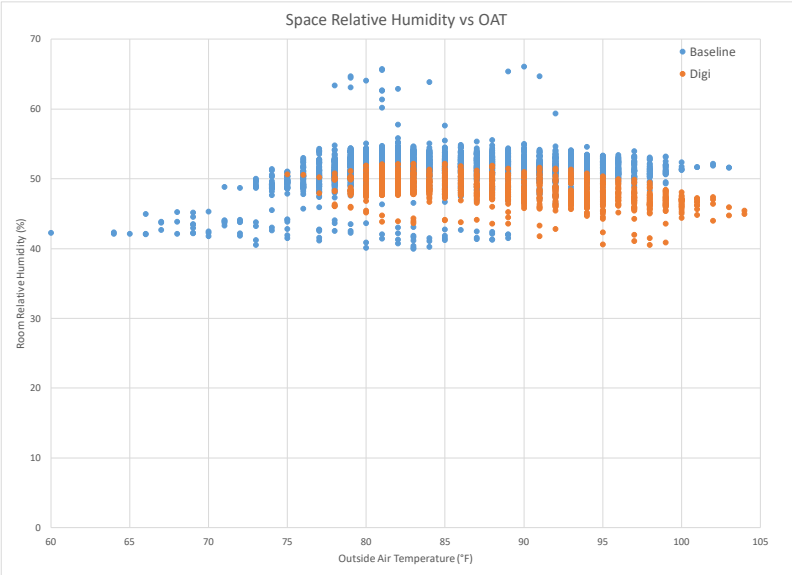

Figure 3 Warehouse average relative humidity vs OAT during Baseline and Digi operation

Appendix B: Measured Internal Heat Gain from Electricity

The baseline data is between June 1st – September 30, 2022. The data between January and May of 2022 is excluded to eliminate the impact of growing internal load during this period. The Digi-RTU data is between June 30 and Aug 22, 2023 (note: the installation was completed on May 4th, 2023). Data from May 4th to June 29th is excluded as the Digi-RTU operation was being optimized.

Figure 4 shows the non-HVAC electrical power during installation phase of the Digi-RTU from January 2023 to May 2023. The average non-HVAC load during this time is about 3,051 kW.

During the Digi operation phase from June 2023 to August 2023, the average load is higher at 3,243 kW. The increase in the average non-HVAC load is about 192 kW. This translates to an increased cooling power consumption of 96 kW.

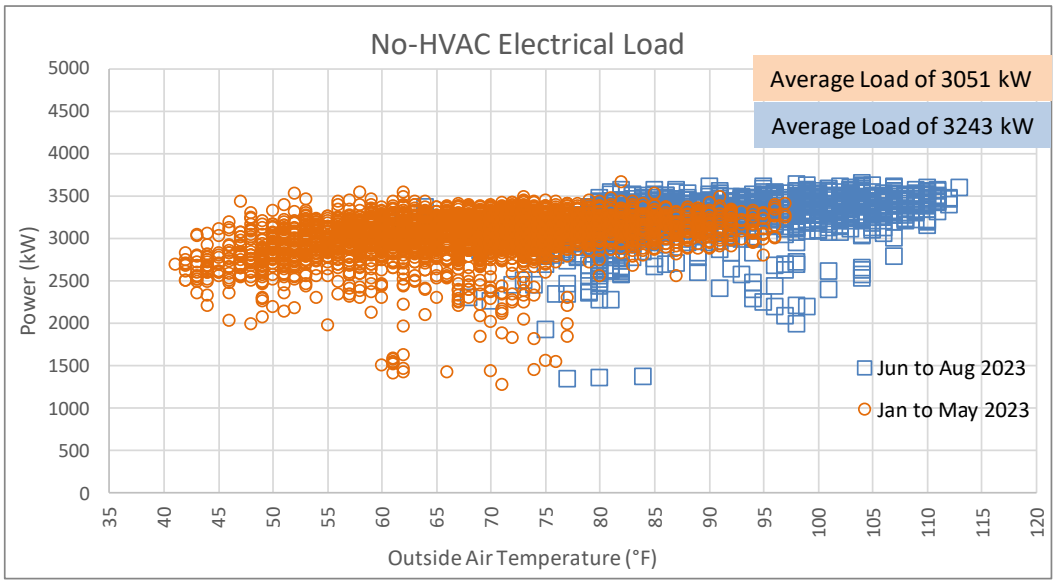

Figure 4 Comparison of Non-HVAC load showing the increase in electrical load.

The HVAC submeter providing the consumption data is not verified or calibrated. Any bias in the submeter data will be cancelled out when calculating the energy savings. However, peak power recorded by the submeter is 1,500 kW. The estimated peak power is 2,000 kW or higher during hot weather. Therefore, energy savings due to meter bias could be underestimated by about 43%.

The measured energy savings presented here should be considered conservative and preliminary due to the following factors:

1. The energy consumption model for Digi-RTU operation is developed based on limited data. Winter and complete hot summer data are not available. See measured savings for C-5 rooftop unit during February 2023.
2. The energy consumption model for baseline operation may be developed using the data when the internal load was not fully developed.

Appendix C: RTU-C-5 Energy Savings

Bes-Tech Digi-SBM was installed on RTU-C-5 for Measurements and Verification (M&V) of energy savings. Table 2 shows the operation mode switch during the M&V period.

Table 1 Schedule of operation mode switch during M&V for spring season

Date	Activity
4/21/2023	9:00am, switched to Base operation
4/14/2023	9:00am, switched to Digi operation
4/7/2023	9:40am, switched to Base operation
3/31/2023	10:00am, switched to Digi operation

System Operation Comparisons

In baseline operation, the system runs one small compressor at low load, two small compressors at medium load, and all three compressors at high load. Digi-RTU converts the fixed speed large compressor to variable speed and keeps the two small compressors as fixed speed. In Digi-RTU operation, the system runs one small compressor at low load, one small compressor and one large compressor at minimum speed at medium load, and all three compressors at high load. Digi-RTU modulates the large compressor based on the load.

Figure 5 shows the time series data of fan speed and supply air, return air and outdoor air temperatures, compressor speed, Y1 status (large compressor), Y2 status (small compressor), Y3 status (small compressor) during the M&V period. The base operation runs the large compressor (Y1) and two small fixed speed compressors (Y2 and Y3) and runs the fan at 60Hz. In Digi-RTU operation, the system runs the large compressor (Y1) at minimum speed and one small fixed speed compressor (Y3) and the other small compressor (Y2) for partial time. The fan speed varies between 35Hz and 60Hz. The supply air temperature is around 52 °F in both modes of operation. The return air temperature stays around 70 °F to 71 °F during the M&V period.

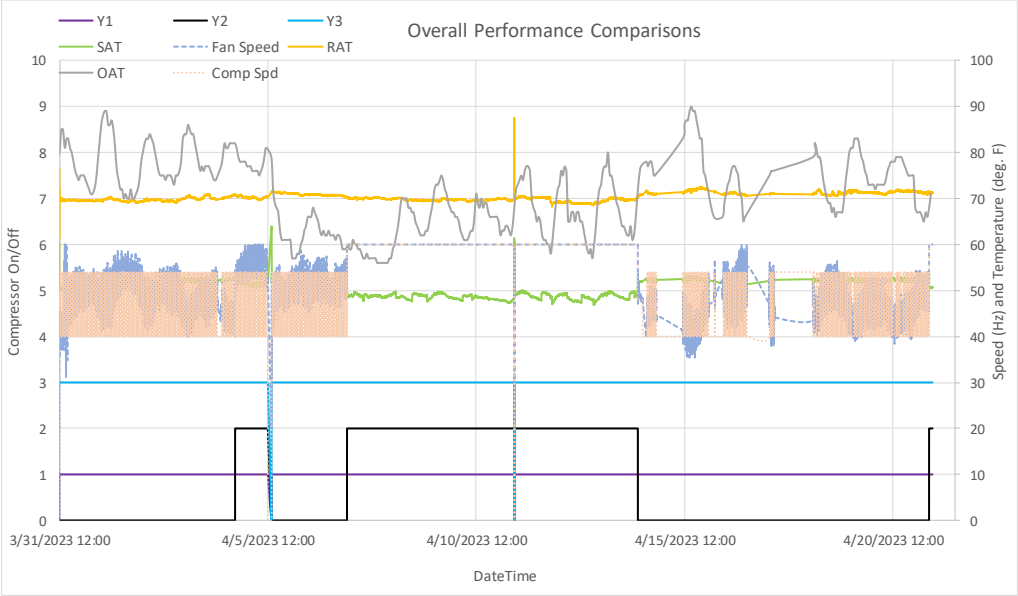

Figure 5 Performance comparison between Baseline and Digi operation - Spring season

Measured Energy Savings

Figure 6 compares the base operation and Digi operation through measured hourly RTU power (kW) consumptions and outdoor air temperature. Based on the measured data, during the spring operation, the Digi-RTU energy savings is about 55%.

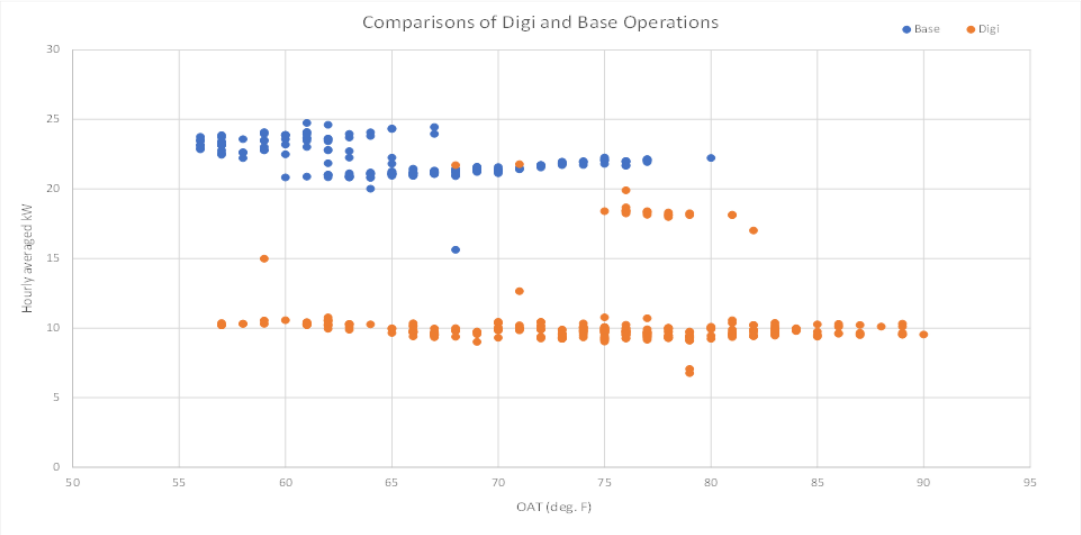

Figure 6 Hourly RTU power vs outdoor air temperature for baseline and Digi operatoins