Practical Energy Solutions
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HVAC Controls Analysis

Springfield Township
Administration/Police Building
Free Library
Wyndmoor, PA

October 7, 2022

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Executive Summary

In 2020, Practical Energy Solutions (PES) conducted a building automation system (BAS)-based analysis of HVAC operations at the Springfield Township Administration/Police and Free Library buildings during the 2019/2020 heating season. More recently, the Township contracted with PES to perform a second BAS-based analysis during the cooling/shoulder seasons, with the aim of improving energy efficiency year-round and further reducing energy consumption. We based our analyses on information gained from the Township's *enteliWEB* BAS dashboard.

As part of our current assessment, we performed a second benchmark of whole-building energy performance of both facilities and compared annual results from 2019-2022. There has been a clear trend to reduced energy use resulting from the HVAC control changes recommended by PES and implemented by the Township in early 2020 – namely, better control of airflow, the PD AHU static pressure setpoint adjustment, and more aggressive temperature setbacks during unoccupied times. Since 2019, energy use in the Administration/Police and Library buildings has declined 25% and 17%, respectively, after normalizing for variations in weather.

Our original recommendations were not fully implemented, in part due to pandemic-related ventilation concerns, and the Police/Administration building and Free Library continue to operate less efficiently than comparable buildings across the country. In the Police/Administration and Free Library buildings, energy consumption is 25% and 3.5% higher than the median for similar buildings in the U.S., suggesting opportunities for further energy reductions.

We recommend reconsidering the recommendations in our original report that have not yet been instituted, with the exception of the airflow management recommendation, which we have modified due to COVID-19 concerns, as noted below. Many of these refinements will improve efficiency year-round during all seasons.

The recommendations resulting from our current assessment include:

- Further reduce minimum airflow requirement to 15% across the board, in both buildings, during all seasons. This will reduce simultaneous heating and cooling during the summer season and excessive heat load during winter months, while allowing for increased ventilation as we continue to experience COVID-19 transmissions.
- Reduce outside air (OA) intake into the building by setting all AHU OA intake minimum damper positions to 10%.
- Calibrate and potentially relocate OA temperature sensors to ensure accurate readings.
- Further refine hot water supply temperature algorithms to reduce unnecessary water heating.
- Address BAS display and sensor malfunctions as noted in this report to ensure proper system monitoring and function.

These measures will further improve the energy efficiency of Springfield Township's Administration/PD and Free Library buildings, and help the Township move closer to achieving the energy efficiency reductions as originally quantified in our 2019/2020 report.

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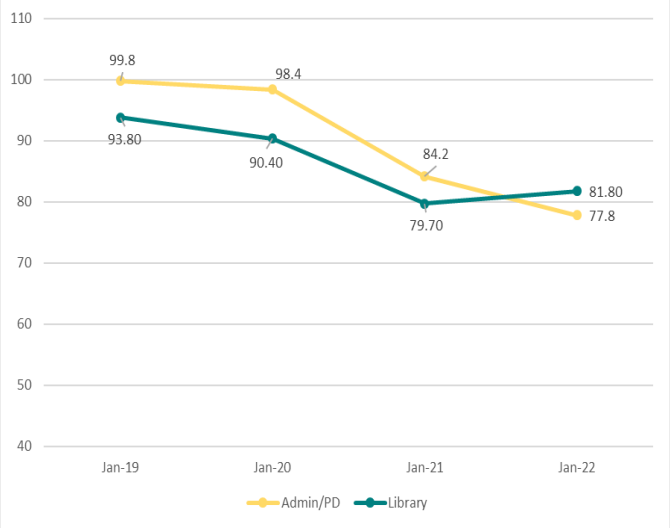
Project Rationale/Background

In July 2022, Practical Energy Solutions (PES) benchmarked the whole-building energy performance of the Springfield Township Police/Administration and Free Library buildings and compared the results with prior years. The analysis shows a clear and positive benefit resulting from the Township's partial implementation of PES's December 2019 recommendations. Since 2019, whole-building energy use dropped 25% and 17% in the Administration/PD facility and Library, respectively, after normalizing for weather and climate variations (Fig. 1).

Fig. 1. Weather-normalized site EUIs: Administration/PD and Library



Site EUI=Energy use intensity: the total amount of energy used per square foot in the building.

However, both buildings continue to consume more energy than the average (median) comparable facility in the U.S. Table 1 shows the percent increase in energy use above the median in both facilities for 2019 and 2022. This suggests continued opportunities to improve energy efficiency in both buildings.

Table 1. Weather-normalized site EUIs compared with similar buildings in the U.S.

	Year Ending	% Higher Than Median*
Admin/PD	June 2019	57.4%
	June 2022	24.3%
Free Library	June 2019	12.3%
	June 2022	3.5%

**Weather-normalized site vs median site EUIs for comparable buildings across the country.*
Source: ENERGY STAR Portfolio Manager national database

Methods

PES's Dianne Herrin, CEM, and Ben Pressman, P.E., performed a site visit of the two buildings on August 8, 2022. We evaluated actual space conditions so we could make general presumptions about how the HVAC systems are performing and verify actual findings against BAS observations. We gained on-line guest access to the Township's *enteliWEB* BAS dashboard and assessed the control system algorithm during working and unoccupied hours (except the PD, which operates 24/7). We also assessed HVAC function in the Administration/PD conference room during a Township meeting and in the library during a public function to further ascertain system performance during full occupancy. From these assessments, we developed recommendations for improving energy efficiency during the cooling/shoulder season. Our results follow.

Administration/Police Building

Recommendations

Recommendation #1: Assess outside air (OA) sensor location and calibrate.

OA sensor. The OA sensor was reading ~7°F higher than the local weather station was reporting at the time of our assessment (88.4°F / 66.2% relative humidity vs 82°F). Review OA sensor location to be sure it does not receive direct sunlight at any time during the day. If so, relocate the sensor to the shade and away from windows, doors, vents and dampers, preferably on the north side of the building. In any case, calibrate the sensor to ensure proper working order.

Rationale: An OA sensor that is in direct sunlight or producing higher than actual OA temperatures will cause the HVAC system to overcool and reheat air or run unnecessarily, resulting in excess energy use and potential discomfort.

Recommendation #2: Set minimum airflow (cfm) to 15% of maximum for all VAVs.

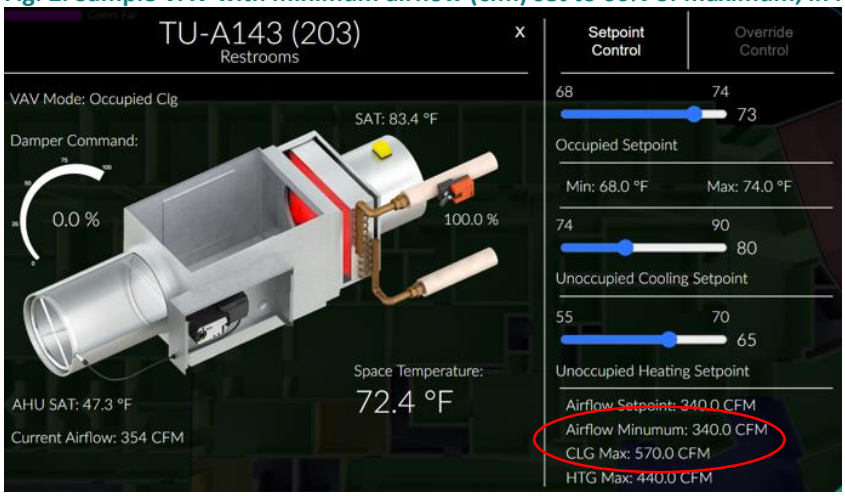
VAV minimum airflow control. Set minimum airflow to 15% of maximum airflow for all VAVs. Allow space temperature and demand-controlled ventilation (DCV) sequence (CO_2 ppm) to influence airflow based on occupancy and space temperature setpoints.

Rationale: During our first (2019/2020) assessment, minimum airflow was set to ~60% of maximum cfm at all VAVs. During heating season, this continuous, high flow of heated air into the building results in unnecessary heating. We therefore recommended setting minimum airflow in all VAV boxes to zero and setting the CO_2 threshold at standard recommended levels (1,000-2,000 ppm) to allow the system to function as it is designed to perform; that is, allow space temperatures and occupancy levels to control ventilation. Our current assessment shows that, as a result of our recommendation, the Township reset minimum airflows to ~30% of maximum in the PD only [13 of

the 24 (54%) total VAV boxes in the building], and kept airflow at 60% in the Administration section, while maintaining a low CO_2 threshold (800 ppm) throughout the building. This reduction of air flow in the PD is a significant reason for the overall energy reductions noted since 2019.

However, significant energy is still being wasted during both heating and cooling seasons as a result of the high minimum airflow settings. In the summer, constant influx of conditioned air into the building leads to overcooling, which forces the boiler to run so the VAV boxes can reheat the air to bring indoor air temperatures back up to setpoint. This simultaneous cooling and heating wastes boiler, hot water pump, and AHU fan energy. During our current analysis, six VAV boxes were in active reheat mode despite the warm outdoor temperature. Figure 2 shows active heating on a warm summer day due to the continuous influx of 47°F conditioned air from the AHU.

Fig. 2. Sample VAV with minimum airflow (cfm) set to 60% of maximum, in reheat mode



We realize the Township wanted to retain high ventilation rates due to the pandemic. Therefore, rather than setting minimum cfm to zero, we suggest taking another step to improve efficiency while still retaining higher-than-normal ventilation rates by resetting airflow to *15% of maximum* in all VAV boxes throughout the facility (Admin and PD) and keeping CO_2 concentrations at the current, low threshold. This will help retain airflow even during relatively low occupancy levels, while further reducing simultaneous heating and cooling.

Recommendation #3: Hot water reset.

Hot water setpoint overshoot. During the current assessment, the actual supply hot water temperature was 134.5°F even though the setpoint was 120°F. Address this overshoot by reducing the low limit temperature during cooling season (e.g., 110°F).

Rationale: During our first (2019/2020) assessment, we recommended establishing a more efficient hot water temperature sequence that sets supply water temperature based on *return* water temperature to better ensure the boiler responds to the actual needs of the building and maximizes energy efficiency. Alternately, we recommended implementing a more aggressive supply hot water reset sequence than is currently in place (Table 2).

Table 2. Recommended supply hot water reset sequence

Recommended		Design	
Outdoor Air Temperature (°F)	**Hot Water Setpoint Temperature (°F)**	**Outdoor Air Temperature (°F)**	**Hot Water Setpoint Temperature (°F)**
15	150	15	180
40	130	40	160
60	110	60	140

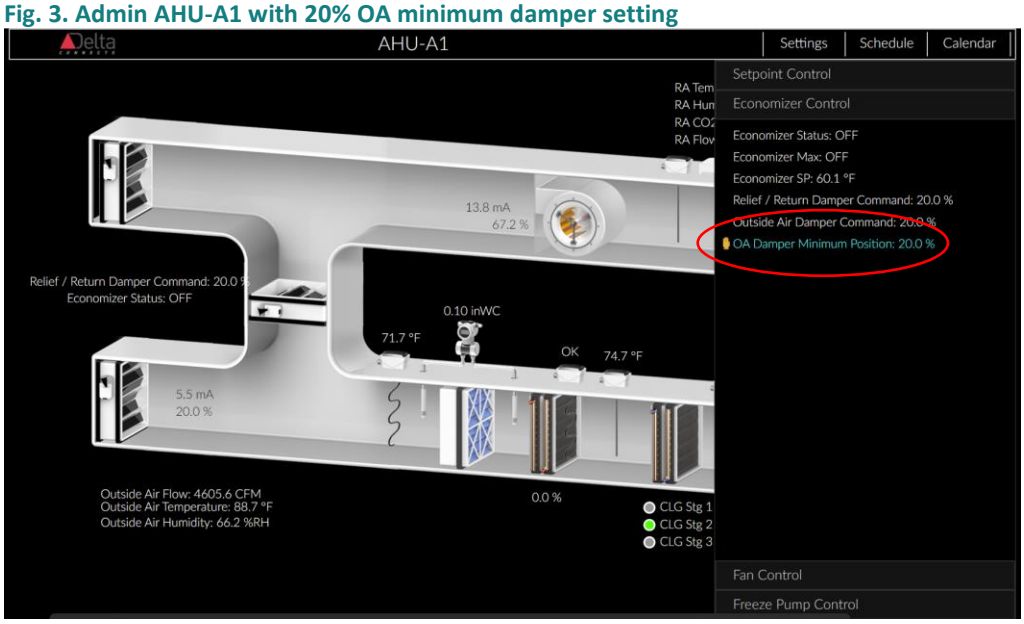
Currently, supply hot water temperature is set at 120°F and is overshooting by ~10-15°F. A *load reset sequence* as described, or a sequence like that shown in Table 2, will better ensure the boiler responds to the actual needs of the building and will maximize energy efficiency year round.

Recommendation #4: Reset minimum OA control and discharge air temperature for AHU-A1 (Administration).

OA control. Reset AHU-A1 (Administration) minimum OA damper position from its current 20% open position to 10% open position. Reset cooling discharge air temperature from 50°F to 55°F for consistency with other AHUs and current standards.

Rationale: The Administration AHU-A1, Meeting Room AHU-A2, and PD AHU-P1 have minimum OA damper positions set to 20%, 10%, and 10%, respectively. Setting the Administration AHU-A1 to a minimum open OA damper position consistent with the others (10%) will reduce OA intake on hot days and reduce cooling demands while better achieving temperature setpoints and controlling humidity. The low CO_2 threshold will ensure that the damper opens up and additional OA is ventilated into the building during occupied hours. (See Figure 3, next page.)

Fig. 3. Admin AHU-A1 with 20% OA minimum damper setting



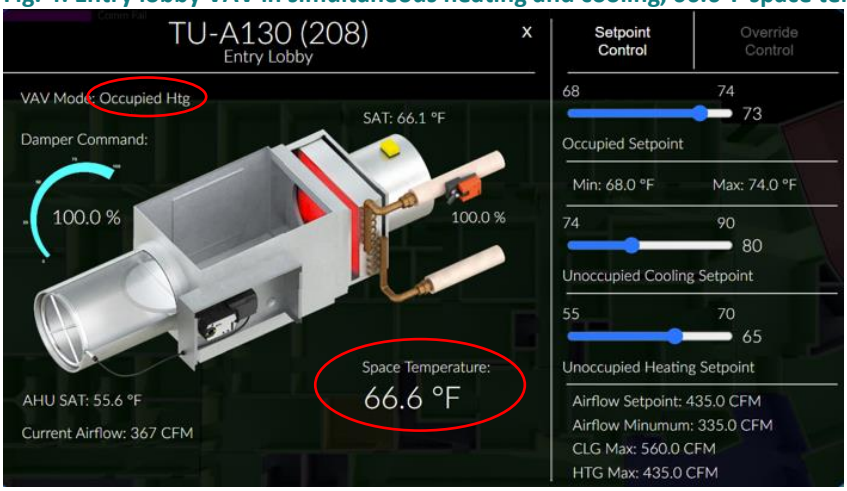
Additionally, the discharge cooling air temperature is 50°F; increasing this to 55°F will help address overcooling and improve energy efficiency, while ensuring consistency with other AHUs in this building.

Recommendation #5: Address entry lobby VAV malfunction.

VAV TU-A130(208) malfunction. Investigate reasons why this space reports unusually low temperatures (66.6°F on an 88.4°F day) and remains in occupied heating mode in an attempt to restore temperature to the 74°F setpoint.

Rationale: This VAV is continually in heating mode despite warm outdoor temperatures and proximity to the front door. Reducing the airflow setpoint from 60% of maximum cfm to 15% will help reduce the need for reheating, although we suspect the temperature sensor may be malfunctioning, or some other issue is causing the simultaneous cooling and heating. Several spot checks at different times of day showed the BAS consistently reporting space temperatures far below setpoint relative to other spaces in the building. (See Figure 4, next page.)

Fig. 4. Entry lobby VAV in simultaneous heating and cooling, 66.6˚F space temperature



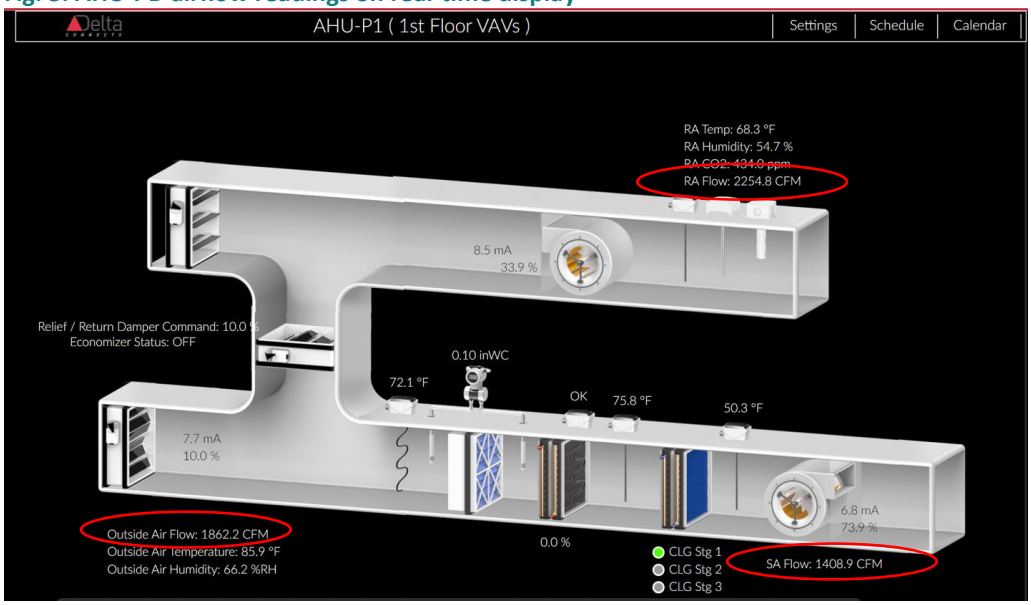
Recommendation #6: Address incorrect AHU airflow readings.

Address AHU airflow readings. Airflow readings are incorrect on the actual AHU displays. During our assessment, the BAS system reported the following:

- AHU-A1: OA=SA and RA>SA
- AHU-PD: OA>SA, RA>SA

Rationale: The incorrect airflow readings on the AHU real-time display screens should be fixed to ensure proper monitoring and maintenance of the system setpoints and building pressurization.

Fig. 5. AHU-PD airflow readings on real-time display



Free Library

Recommendations

The recommendations for the Free Library mirror those of the Administration/Police Building. We have provided screen shots from the control system to demonstration the rationale.

Recommendation #1: Assess outside air (OA) sensor location and calibrate.

OA sensor. The OA sensor was reading ~6°F higher than the local weather station was reporting at the time of our assessment (87.5°F / 66.1% relative humidity vs 82°F). Review OA sensor location to be sure it does not receive direct sunlight at any time during the day. If so, relocate the sensor to the shade and away from windows, doors, vents and dampers, preferably on the north side of the building. In any case, calibrate the sensor to ensure proper working order.

Rationale: An OA sensor that is in direct sunlight or producing higher than actual OA temperatures will cause the HVAC system to overcool and reheat the indoor air or run unnecessarily, resulting in excess energy use and potential discomfort.

Recommendation #2: Set minimum airflow (cfm) to 15% of maximum for all VAVs.

VAV minimum airflow control. Set minimum airflow to 15% of maximum airflow for all VAVs. Allow space temperature and demand-controlled ventilation (DCV) sequence (CO_2 ppm) to influence airflow based on occupancy and space temperature setpoints.

Rationale: During our first (2019/2020) assessment, minimum airflow was set to ~60% of maximum cfm at all VAVs. Our current assessment shows that, as a result of our recommendation, the Township reset minimum airflows to ~30% of maximum in all but one library VAV (22/23 VAVs). This reduction of airflow is a significant reason for the overall energy reductions noted since 2019.

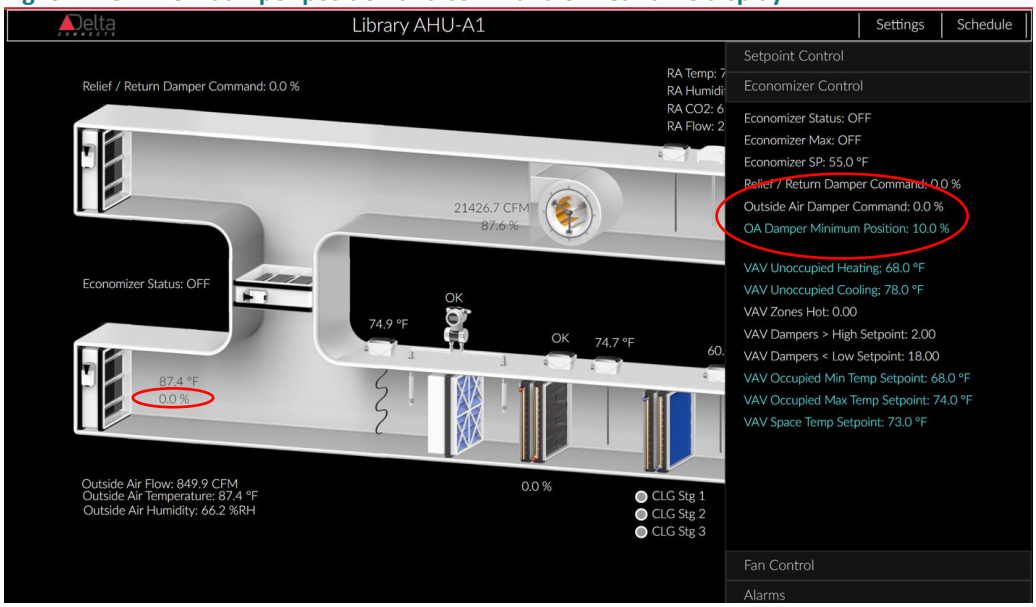
During our current analysis, nine VAV boxes were in active reheat mode despite the warm outdoor temperature. We recommend taking the same action as the Administration/PD building; that is, reset airflow to *15% of maximum* in all VAV boxes and keep CO_2 concentrations at the current, low threshold (800 ppm). This will help retain airflow even during relatively low occupancy levels, while further reducing simultaneous heating and cooling.

Recommendation #3: Address OA damper position readings/commands in AHU-A1.

OA damper readings. OA damper commands consistently read 0% despite an OA damper minimum position setpoint of 10%. Evaluate and correct.

Rationale: Fixing the incorrect readings/commands will ensure proper monitoring and maintenance of system setpoints, OA intake, and building pressurization.

Fig. 6. AHU-A1 OA damper position and command on real-time display



Recommendation #4: Fix malfunctioning space temperature readings/sensors

Space temperature readings. Space temperature readings in the café (TU-L102) and IT office/work area (TU-L119) are reading "NULL" (Fig. 7). Assess and correct.

Rationale: Proper space temperature readings/functioning sensors are necessary to maintain control of temperatures and system functionality.

Fig. 7. Space temperature reading "NULL" in café