OUR EXPERIENCE WITH RCX SOFTWARE: TRIUMPHS AND CHALLENGES

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ABSTRACT

With the ever increasing complexity in commercial building HVAC and building automation systems, there are often gaps between a building's potential level of energy efficiency and the actual operation. A vast amount of data is now available to analyze equipment operation and identify these gaps. Fortunately, analytical software tools can turn the flood of building data into actionable information. These software tools add great benefit to building operation with the ability to visualize data and automatically detect operational issues. Utilizing these tools also brings challenges that should be considered from making the initial data connection to addressing the increased quantity of issues uncovered.

ANALYTICS SOFTWARE OVERVIEW

The building analytics software tool market, often referred to as Energy Management and Information Systems (EMIS), has rapidly expanded in recent years. EMIS tools utilize either meter data, typically from whole building energy meters, or system data, typically from building automation systems, and can be grouped into six categories as shown in FIGURE 1 (Guild, Koeppel, and Hilger 2012) [1]:

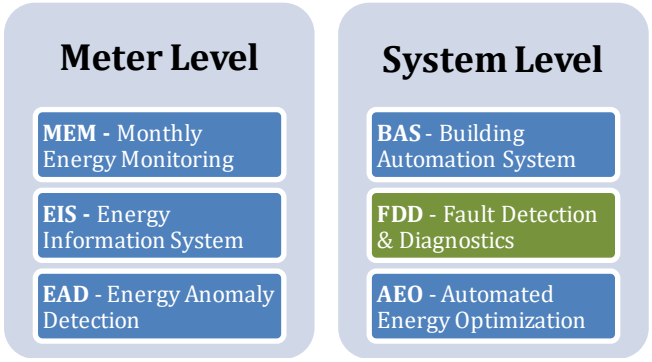

FIGURE 1. EMIS SOFTWARE TOOL CATEGORIES

Marketing claims of various EMIS software tools can be misleading with references to ongoing commissioning. To truly be considered commissioning analytics software, system level monitoring and analytics are required. The category of software most commonly applicable is Fault Detection and Diagnostics or FDD. This software can be referred to in different ways such as Retro-commissioning (RCx) or Monitoring Based Commissioning (MBCx) software and can be used for existing building or new building commissioning. *FIGURE 2* displays data from a study indicating that FDD tools represented less than 15% of the EMIS tools available in 2012 (Guild, Koeppel, and Hilger 2012) [1]. With this in mind, selection of an MBCx software tool should be made carefully with the features and benefits fully understood.

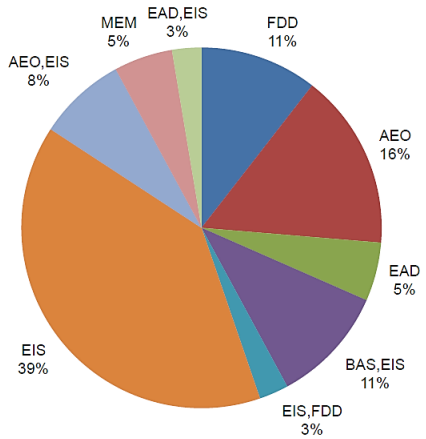

FIGURE 2. EMIS TOOL CLASSIFICATION SUMMARY (GUILD, KOEPPEL, AND HILGER 2012)

FDD or MBCx software pulls data from a variety of sources such as the Building Automation System (BAS), energy meters, and weather data. Rules are then programmed to automatically detect operating issues across similar types of equipment. Most MBCx software tools reside in the cloud and can be accessed from any web browser. Once rules are programmed, these tools will automatically find operating

issues and present them in the user interface. These tools only provide information and still require human action to evaluate the data and make a plan for change.

Ideally, MBCx tools are integrated and utilized in conjunction with a comprehensive commissioning process then left in place to continuously monitor and optimize building operation. FIGURE 3 displays an optimal cycle that begins with finding and correcting issues and continues to ongoing proactive maintenance, which is repeated continuously. MBCx software makes a thorough version of this process viable for complex buildings and equipment.

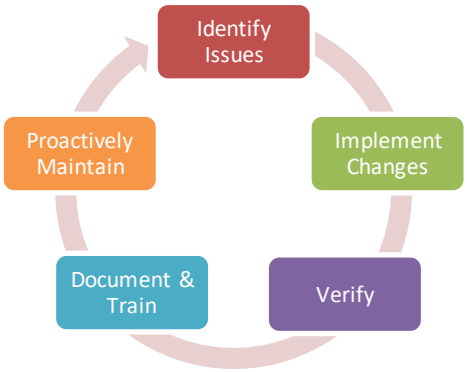

FIGURE 3. ONGOING OPTIMIZATION CYCLE

After using MBCx software for dozens of projects, the power of the software has become clear to our teams with more thorough evaluation of equipment operation and more issues identified. However, using and implementing these tools also comes with challenges. The following sections summarize the top triumphs and challenges we have experienced with MBCx software.

TRIUMPHS

#1 – Evaluate More Equipment Faster

Large buildings, campuses, and portfolios can have large quantities of equipment that are difficult to track. Monitoring the operation of each detailed component is often not feasible. Using software makes it possible to look at **100% of equipment**, including zone devices. At the zone level, rules can be used to detect common issues across hundreds of devices. FIGURE 4 displays the status of air handling units (AHUs) in a building that has (32) AHUs. As can be seen by the colored bars in the figure, software was able to detect (2) units operating 24/7 and (1) unit not operating leaving occupants without ventilation. Even basic on/off status can be difficult to detect for dozens of devices without assistance from software.

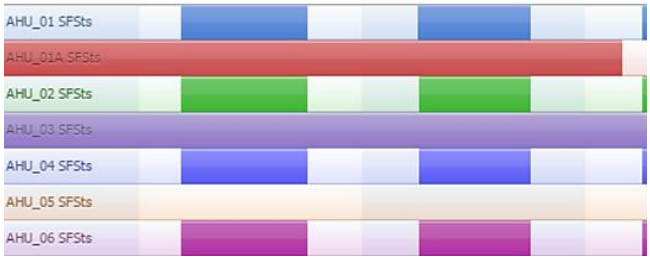

FIGURE 4. VISUALIZATION OF EQUIPMENT STATUS

Zone devices are often overlooked or sampled in a retro-commissioning process since each device has a small impact on energy use. However, each device is important for comfort and can be evaluated with software using programmed rules.

#2 – Monitor Equipment Long Term

Traditional retro-commissioning looks at equipment operation for a snapshot in time. Trend data is often gathered for 2-3 weeks. Testing can mimic other seasons but it does not provide a true representation of operation throughout changing weather conditions. Using MBCx software is like opening up tunnel vision to see the whole picture as the seasons change. It also provides visualization of equipment interacting as a system, such as zone valves responding to different system temperatures and pressures. This enhances the team's ability to optimize equipment operation without negatively impacting other components.

#3 – Fix Comfort Issues at the Zone Level

As stated previously, zones are often overlooked or sampled since testing hundreds of devices does not fit within typical project budgets. Teams do not have time to test equipment for hundreds of hours or make spreadsheets of all the data associated with these devices. While each device does not have a big impact on energy, each device is important for the people in the space served by the device. Using MBCx software has allowed our teams to look at every device in the building and correct comfort issues in all spaces.

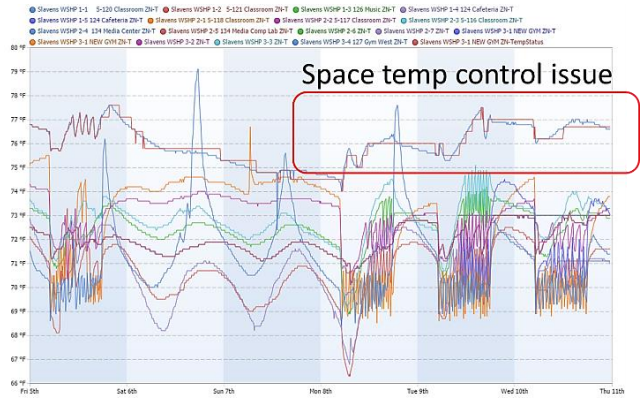

FIGURE 5 displays temperature data from (18) heat pump zones, highlighting (2) zones that were not maintaining

comfort. It was discovered that the heat pump compressors in these units were not responding properly to a call from the thermostat.

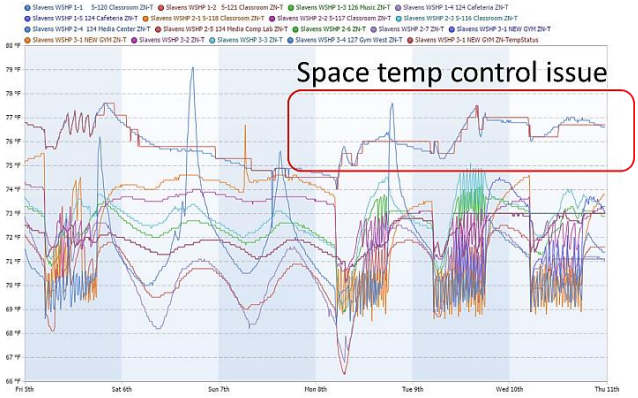

FIGURE 5 SPACE TEMPERATURE CONTROL ISSUE

When there are hundreds of zone devices, programmed rules are beneficial to automatically detect operating issues across similar devices, such as variable air volume (VAV) boxes not meeting airflow setpoints or VAV valves not responding properly to commands. Problem zones can then be evaluated in further detail instead of testing a random sample.

#4 – Enable True Verification

A retro-commissioning investigation can identify hundreds of issues that need to be corrected in a facility. Ideally, a complete RCx process would also include verification of the corrections made for each item. Many of the problems identified are hidden and can be difficult to confirm when repaired. Due to the manual testing and spreadsheet analysis required when MBCx software is not used, verification is often limited or non-existent leaving the building team and owner having to trust the people making repairs. With software, verification can be done with a click of a button and the same issue can be checked over and over until it is corrected. FIGURE 6 displays the before and after data of large pumps that were not modulating speed properly. Software provided visual confirmation that programming modifications were complete.

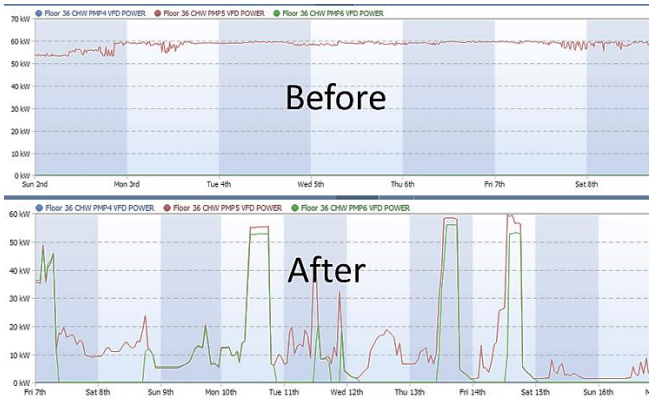

FIGURE 6 PUMP CONTROL VERIFICATION

With the use of MBCx software, verification of changes can be effectively and economically conducted ensuring the promised savings are achieved.

#5 – Find More Issues, Save More Money

All of these triumphs contribute to the primary motivators for using software to aid in the retro-commissioning process – find more issues, save more energy, and save more money. These tools allow consultants and building teams to watch all equipment in the building over long time frames and achieve continuous optimization. From a recent campus project our team conducted, performing an evaluation of building operation with MBCx software identified **$145,000/yr in savings** opportunities and found **60% more issues** than a recent RCx project conducted for the same facilities.

CHALLENGES

#1 – Integrating an Active Connection

Many MBCx software tools have a software-as-a-service (SaaS) model where the analytics software is hosted in the cloud as shown in FIGURE 7. This requires active connections for the data to travel from the building automation system(BAS) to the cloud hosted tool. Even for MBCx software tools that can be purchased as a license and installed locally, it is beneficial to have the software accessible outside of the building for remote configuration and troubleshooting. Integrating live data can be a tedious and challenging process with cooperation from IT and the BAS contractor often required. This process can delay a project for months as the IT access is granted, a database is established, trend data is setup, etc. In some cases, the MBCx software project is killed all together due to these hurdles.

FIGURE 7. GETTING TO THE CLOUD

Solutions:

1) Plan far in advance and start the conversations early with all of the right stakeholders.

2) Look into hardware and software options to make the data transfer easier. There is promising new hardware recently available that will push data out from a BACnet network with almost no involvement from the BAS contractor and little impact on IT. This hardware is a likely path forward along with integration of BAS types that have fewer hurdles.

#2 – Software Does Not Replace Onsite Testing

When considering MBCx software for a project, it is tempting to eliminate testing all together to reduce costs. However, software will only get you so far. It may identify that an AHU outside air damper is not bringing in the right amount of outside air, but it can be difficult to tell if the actuator stopped working properly or programming was overridden. It is important to have some level of boots on the ground observation and testing. It may be possible to build the onsite testing component into the operations team's responsibilities, but this can be a challenge for building operators already stretched thin.

Solutions:

1) Continue to include onsite testing of major devices and sensors in retro-commissioning investigations, such as testing of large AHU outside air dampers and calibration checks for temperature and pressure sensors associated with large equipment.

2) Work with the operations team to build sensor calibration and major device testing into their ongoing Preventative Maintenance (PM) program so these checks get completed on a schedule with limited cost from outside consultants moving forward.

#3 – Data and Issue Overload

One of the major triumphs stated earlier was the use of software to find more issues. This same characteristic is also a challenge. When every device in a building is monitored, the quantity of faults can be in the hundreds, even after corrections and repairs are made. FIGURE 8 displays almost 200 faults identified for one floor of a large high rise building over the span of one month. This is for a building that has an EnergyStar score of 88 and has a high performance operations team.

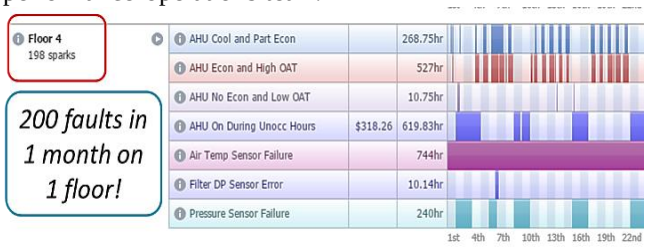

FIGURE 8. EXAMPLE OF HIGH QUANTITY OF FAULTS

Some faults have a short duration, such as a zone that didn't meet temperature on a hot day, and some last long durations. Some faults can have a minor impact on energy but a major impact on the person in the space being served. Others can have a major impact on energy but no impact on comfort, such as simultaneous heating and cooling at an AHU. It can be daunting to sort through the issues, prioritize, and find the time to take corrective actions.

Solutions:

1) Plan and implement high quality rules from the start of monitoring to reduce false faults. Tracking down an issue that doesn't exist is frustrating and can cause users to lose trust in the software.

2) If the tool is to be used by internal staff, designate a single person with the responsibility to look at the software tool and create work orders or request service for resolution. This person needs to have proper training and time carved out in their schedule for this activity; operators are already stretched thin and won't have "extra free time" if not specifically planned.

3) Compile and update good documentation of building equipment and control sequences so this knowledge can be transferred with staff changes.

#4 – Added Cost

While using MBCx software can reduce some effort in the retro-commissioning process such as less manual analysis of trend data and reduced onsite testing, there is often some level of added cost. If the software is integrated as a standalone project, the up-front cost can be higher than a building owner's budget allows. There are also ongoing costs to consider. Depending on the software model, the costs can be $0.05 - $0.09/sq.ft./yr for the software alone, not including consulting time or costs for contractors to correct issues. Ongoing consulting can be beneficial to help the operations team sort through the issues identified, look for root causes, track repairs, and verify corrections. The costs of MBCx software can be well worth the expense providing a great return on investment. However, the software itself does not save energy, people making changes saves energy. If people do not have the time or the training to digest the results, no payback on the investment will be realized.

Solution:

1) Integrate the software as part of a retro-commissioning or commissioning process. This will provide economies since the commissioning team will already collect information and learn the equipment operation. It will also provide immediate value to find savings opportunities, implement, and verify.

2) Consider all ongoing costs involved before embarking on the MBCx software path. This may lead to a different choice in software or a different approach to ongoing troubleshooting. If there is not an in-house person available to evaluate the data and make a plan for action, external consulting costs should be included in this analysis.

SUMMARY – THE PATH FORWARD

Building analytics software, specifically FDD software that enables monitoring-based commissioning, provides great insight into building operation. While periodic commissioning activities provide great value, complex buildings with high quantities of equipment can greatly benefit from continued monitoring with automated detection of issues.

There are important questions to consider to determine if integrating MBCx software is a good fit for your facility. This includes the following:

a) Do you have complex systems, large quantities of equipment and/or high energy costs?
b) Do you have plans to replace major equipment or controls?
c) Do you have an up-to-date modern BAS? How will integration be addressed and are there limitations?
d) Are there IT limitations that will pose a problem? Are there other data integration alternatives available that will bypass the IT hurdles?
e) Who will be responsible to take information from the tool and create a plan for action long-term?

If major equipment is going to be replaced or the control system is slated for an upgrade, full integration of an MBCx software tool may be better planned for the future. For all applications, there must be a plan in place to take action in order to see true results.

As long as these key questions are addressed, MBCx software and processes can provide great benefit for the long term. FIGURE 9 displays the increase in energy buildings experience without ongoing attention (Mills and Mathew, 2012) [2].

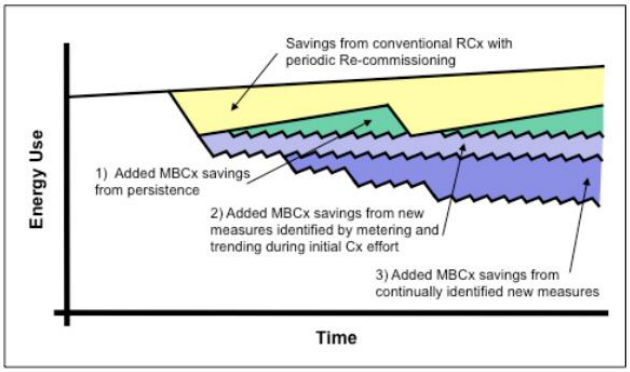

Figure 1. MBCx provides three streams of additional energy savings relative to RCx – conceptual illustration

FIGURE 9. PERIODIC RETRO-COMMISSIONING ENERGY IMPACT, LAWRENCE BERKELEY NATIONAL LABORATORY, JUNE 2009 REPORT

This study found that projects that included detailed MBCx and ongoing evaluation had a median simple payback of 2.5 years and median source energy savings of 11%. Even with the additional cost of metering and monitoring equipment, this approach can still provide excellent savings with strong economics (Mills and Mathew, 2012) [2].

In addition to the cost savings, building occupants can see improvements in comfort and indoor air quality as systems are evaluated comprehensively down to the zone level. While the improvements in health and productivity are difficult to quantify, they should still be considered as important driving factors.

MBCx software can have challenges, but these are offset by great benefits, both from the perspective of lowering operating costs and improving the quality of the indoor environment. It is an exciting time as we have the tools available to take building operation to the next level. Now it is time to WDNIT action.

REFERENCES

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