TO:	Board of Directors, Massachusetts School Building Authority
FROM:	James A. MacDonald, First Deputy Treasurer, Chief Executive Officer
	John K. McCarthy, Executive Director, Deputy Chief Executive Officer
SUBJECT:	MSBA's Post Occupancy Pilot Program Update
Date:	February13, 2020

Staff Update

This memorandum updates the Board of Directors ("Board") regarding the Massachusetts School Building Authority's ("MSBA") efforts associated with the Post-Occupancy Review Program ("Pilot Program"). As presented at the May 12, 2017 Board meeting, staff recommended, and the Board approved a Pilot Program to assess the benefits of implementing an on-going comprehensive review of the use and effectiveness of schools funded by the MSBA. (Refer to Attachment "A" for associated memorandum.) Subsequently, as presented at the May 22, 2018 Board meeting, staff recommended, and the Board approved an extension to the Pilot Program through FY19. (Refer to Attachment "B" for associated memorandum.) Based on the efforts associated with the Pilot Program to date, staff anticipates preparing a formal recommendation at the April Board meeting for the following:

- Implementation of a Post-Occupancy Evaluation ("POE") process for MSBA-funded Core Program projects;
- Approval of additional MSBA staff beginning in FY21 to administer the POE process; and
- The continued services of professional consultants to support the management of the POE process.

Introduction

The MSBA continues to provide grants that annually support $750 million to $1 billion in school construction projects. With that comes an imperative responsibility to ensure that the Commonwealth's investment is protected. Throughout the Pilot Program, the focus has been on how the MSBA can best understand that projects that have received a grant from the MSBA are operating and performing as they were designed. Efforts have also focused on how the MSBA can add value to its current process.

Pilot Program Efforts and Addition of Module 9

Since the Pilot Program commenced in May 2017, staff have worked to establish a system unique to the MSBA's process, including a thorough review of Capital Planning's Core Program modules. This has enabled staff to identify opportunities that will inform future projects and includes the addition of "Module 9" which will become the guideline for the MSBA's post-occupancy evaluation process. Module 9 will be incorporated as the final Module in the lifecycle of an MSBA Core Program project and will serve as an appropriate conclusion to a multiyear, multiphase process. Although Module 9 will appear last in a sequence of existing modules, the work that will inform post-occupancy begins at the outset of a Core Program project and will continue in parallel throughout the process.

It is important to note that a post-occupancy building visit is only one component of the overall post occupancy process. The POE will commence three years following the date of substantial completion. It will include many essential pre-occupancy components that defined the basis of design and will eventually inform the elements of a post-occupancy evaluation after a building has been occupied. Figure 1 illustrates the lifecycle of an MSBA Core Program project and indicates some of the beneficial information that will be captured within Modules 1 through 8.

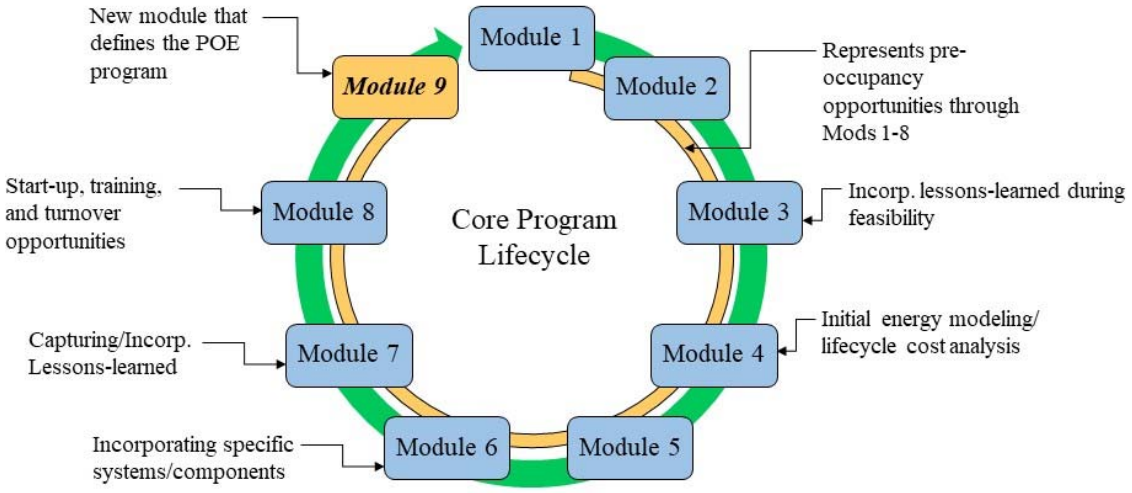

Figure 1

In addition to reviewing and evaluating the MSBA's current Core Program process, staff conducted initial post-occupancy pilots with several districts. Fourteen MSBA-funded schools were visited in FY19 with staff focused on further understanding the performance and operation of the building systems. Based on the information collected and evaluated as a result of these visits, as well as the inclusion of end-user feedback and programmatic utilization, staff anticipates that a wealth of valuable information will be collected, evaluated, and reported as part of an MSBA post-occupancy evaluation program going forward. Please refer to Attachment "C" for a complete list of participating districts and schools visited in FY19, and Attachment "D" for a sample of an individual report prepared by the MSBA's consultant.

Required Staffing and Estimated Cost

Based on the efforts of the Pilot Program to date, additional MSBA staff and external consultants will be required to implement a Post-Occupancy Evaluation program going forward. Staff estimates an approximate increase of (6%) six percent to the MSBA's annual salary budget would be required. In addition, an estimated annual consultant budget of $420,000 would be required, for a combined annual total of approximately $925,280. Figure 2 illustrates how these estimates compare to MSBA's FY20 employee salary, and Figure 3 illustrates how the combined estimated budget compares to the projected annual construction cost. Discussion regarding the development of a POE database that will provide user interface cost is underway. This cost is not included in the annual estimated total above.

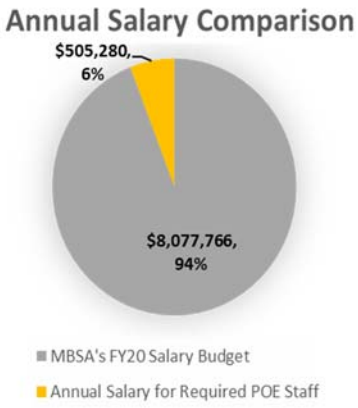

Figure 2

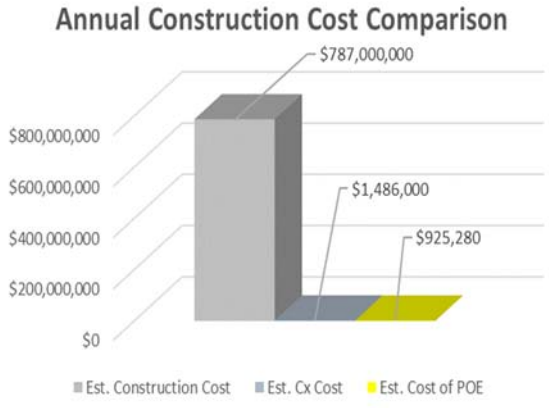

Figure 3

Pilot Conclusion/ POE Program Implementation and Roll-out

Beginning in FY21, and over the course of the next five fiscal years, staff projects that post-occupancy evaluations could be performed for 50-60 MSBA-funded school buildings. Figure 4 illustrates the anticipated number of projects that would be eligible for post-occupancy evaluations in FY21-FY25.

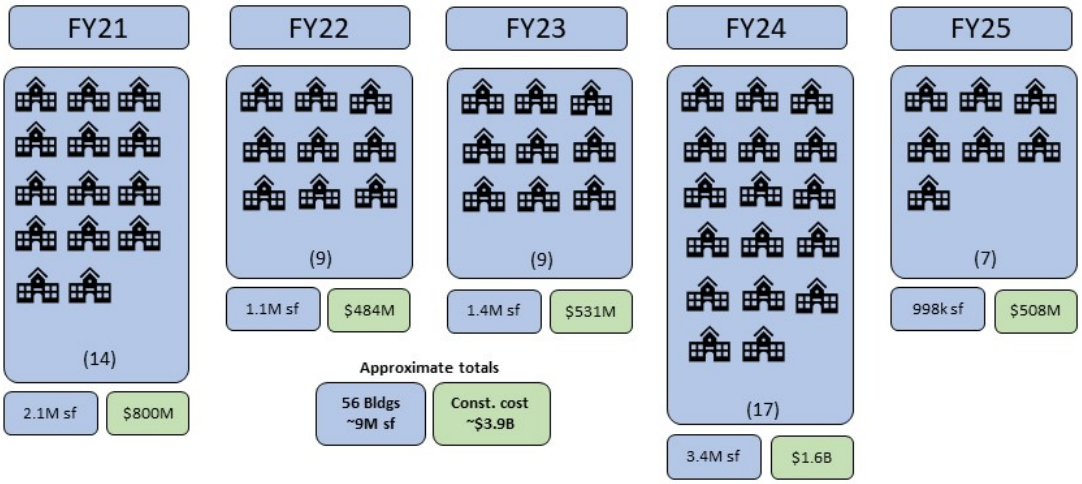

Figure 4

In order for MSBA's proposed Post-Occupancy Evaluation Program to commence, the following must be realized over the course of the next several months:

- **Feb-Apr 2020:** Recommend and obtain Board approval of an MSBA Post-Occupancy Program;
- **Mar-Apr 2020:** Finalize and conclude the Pilot Program, including individual report distribution;
- **May 2020:** Establish Budget at May Business meeting;
- **May-Dec 2020:** Develop Module 9, advertise/hire POE staff, perform IT development, establish POE onboarding/start-up; and
- **Spring 2021:** Perform first POE visit. (Please refer to Attachment "E" which illustrates the anticipated post-occupancy roll-out.)

Deliverables

In conjunction with any Pre-Occupancy data, it is anticipated that MSBA staff will create individual Post-Occupancy Evaluation Reports for subject buildings resulting from the collection and analysis of Post-Occupancy survey data, District interviews and feedback, and MSBA staff and consultant field observations. Specific content, format, and reporting examples associated with the proposed Post-Occupancy Evaluation program can be found in Attachment "F". These reports would be further reviewed as part of the IT development process.

It is anticipated that these individual reports will provide information that school districts can use to take corrective measures, when necessary, to ensure the long-term success in protecting their investment. Through the evaluation of more schools, it is anticipated that a post-occupancy evaluation program will enable the MSBA to harvest collected information that will inform the design, construction, operation, and maintenance practices for current and future MSBA-funded projects in an effort to understand that buildings continue to operate and perform as designed and to protect the Commonwealth's investment.

Anticipated Staff Recommendation

Based on the efforts associated with the Post-Occupancy Pilot Program conducted May 2017 through December 2019, staff anticipates recommending the implementation of an MSBA Post-Occupancy Evaluation program at the April 2020 Board meeting.

Attachments:
“A”- Board of Directors Recommendation for Pilot Program, dated May 3, 2017
“B”- Board of Directors Recommendation for Pilot Program Extension, dated May 15, 2018
“C”- List of Participating Districts and Schools Visited in FY19
“D”- Individual School Building Post-Occupancy Systems Report Sample
“E”- Anticipated Post-Occupancy Roll-out Schedule
“F”- Post-Occupancy Reporting Content/Format Sample

Attachment "A"

TO:	Board of Directors, Massachusetts School Building Authority
FROM:	James A. MacDonald, First Deputy Treasurer, Interim Chief Executive Officer
	John K. McCarthy, Executive Director, Deputy Chief Executive Officer
SUBJECT:	Post Occupancy Review Pilot Program Recommendation
Date:	May 3, 2017

Introduction:

The Massachusetts School Building Authority (the "MSBA") continues to assess its policies and practices in support of its mission to advance the design and construction of educationally appropriate, flexible, sustainable, and cost-effective public school facilities. In an effort to further this mission, staff is recommending a Post Occupancy Review Pilot Program (the "Pilot Program") to assess the benefits of implementing an on-going comprehensive review of the use and effectiveness of schools funded by the MSBA. Similar to the MSBA's Model School Visits and the 2016 School Survey, the proposed Pilot Program will assess and document facility operation through the observations of staff and/or consultants.

Scope of Memorandum

This memorandum includes a review and evaluation of the timing of the post occupancy visits, the information that will be collected, staffing, consultant resources and the method for collecting the information, and how the information will be used.

Timing of the Post Occupancy Visits

A new facility should be in use for a reasonable period of time to allow the occupants to become accustomed to the spaces and adapt to the new facility. In addition, building systems should have been in operation for at least several seasons so facilities personnel have had a reasonable opportunity to understand the operation and performance of new systems under various conditions and to perform necessary adjustments to optimize those systems. As a consequence, MSBA staff recommends that post occupancy visits for the Pilot Program be limited to Core Program projects that have been in operation for a period of no less than three years from the date of substantial completion.

Information to be Collected

Staff recommends that the following four major categories be evaluated through the Pilot Program: Enrollment, Program, Building Interior/Exterior, and Facility Operation and Performance. Information will be collected from multiple sources including, pre-existing data that is available to the MSBA, district answers to MSBA's interview questions, and observations gathered during the site/building walkthroughs. Similar to the previous Model School visits, it is anticipated that each post occupancy visit will begin with a brief interview with district representatives, including facilities personnel, followed by a walk-through where information will be gathered through staff observation of the facilities. The interview will supplement information that has been gathered previously and will be structured to encourage an open discussion regarding the utilization, function, and performance of the facility.

Staffing

It is anticipated that two or three MSBA staff members will be required to conduct the Pilot Program visits. The MSBA also plans to have MSBA Commissioning Consultants provide technical support for the Pilot Program and $350,000 has been set aside in the fiscal year 2018 budget to fund that support. If, upon completion of the Pilot Program, a continuing Post Occupancy Review Program is established, it is anticipated that a larger group of MSBA staff will be required to conduct the visits and the MSBA will also use consultant-based technical support.

Similar to the 2016 School Survey, staff propose to evaluate the collection of information and photographs electronically through the use of a tablet, which will have the capability of syncing to a report database. Distribution, format, and storage of the gathered information will be developed, refined, and evaluated as part of the Pilot Program.

How Collected Information will be Utilized

It is anticipated that the MSBA will be able to collect a broad range of information with each post occupancy review including, data related to enrollment, space utilization, layout configuration, systems design/operation, and routine maintenance practices. In addition, the MSBA will be able to share that information with the education and design communities to help improve the outcomes of future projects supported by the MSBA. It remains important to note that early choices made during design to facilitate the delivery of a District's educational program can result in positive applications for the end-user which are consistent with the approved design.

Schedule

During the first half of fiscal year 2018, staff will: prepare to conduct the Pilot Program; visit five to ten schools; compile the information collected from the visits; evaluate the process; and report the findings of the Pilot Program. Based on the findings of the Pilot Program, staff will provide recommendations for schedule, budget, and any necessary consultant support for implementation of a broader Post Occupancy Review Process to be initiated during fiscal year 2019.

Staff Recommendation

As presented and discussed at the April 12, 2017 Facilities Assessment Subcommittee meeting, MSBA staff recommends instituting a Post Occupancy Review Pilot Program, which will include visits to five to ten schools and will be conducted as set forth above.

Attachment "B"

TO: Board of Directors, Massachusetts School Building Authority
FROM: James A. MacDonald, First Deputy Treasurer, Chief Executive Officer
John K. McCarthy, Executive Director, Deputy Chief Executive Officer
SUBJECT: Post Occupancy Review Pilot Program - Recommendation for Extension
Date: May 15, 2018

Introduction:

As presented at the May 12, 2017 Board of Directors ("Board") meetings, staff recommended and the Board approved a Post Occupancy Review Pilot Program ("Pilot Program") to assess the benefits of implementing an on-going comprehensive review of the use and effectiveness of schools funded by the MSBA. This memorandum summarizes the FY18 efforts associated with the Pilot Program and recommends an extension to the Pilot Program through FY19.

Post-Occupancy Review Process

Building on the parameters outlined in the Post Occupancy Review Pilot Program Recommendation memorandum dated May 3, 2017, provided for reference as Attachment 'A', staff developed communications and meeting protocol, and generated survey questions regarding general conditions, interior and exterior building components, building system performance, and programmatic aspects intended to capture general consensus and end-user satisfaction.

While drafting and adjusting potential survey material, staff collaborated with MSBA Information Technology ("IT") staff to develop a web-based post occupancy information collection application. Working closely with IT, the post-occupancy team's four members updated survey questions and customized several aspects of this application to align, compliment, and potentially share information with existing MSBA project management applications.

In selecting which schools would be visited, staff reviewed recently completed Core Program projects that have been in continuous operation for a minimum of three years and selected schools with a cross section of grade structure and project types. The following is a list of schools visited by staff beginning in December 2017 and continuing through February 2018:

School	District	Project Type	Grades	Completed
Norton High School	Norton	Add/Reno	9 to 12	2014
Sherwood Middle School	Shrewsbury	New Construction	5 to 6	2012
Rockland Middle/High School	Rockland	Add/Reno	6 to 12	2012
Morton Middle School	Fall River	New Construction	6 to 8	2013
Goodyear Elementary School	Woburn	New Construction	K to 5	2011
Southeastern Reg. Voc. Tech. High School	Easton	Renovation	9 to 12	2013
Central Middle School	Quincy	New Construction	6 to 8	2013

Information Collected

Using the IT developed web-based post-occupancy collection tool, staff collected a broad range of information associated with general conditions, site circulation, interior and exterior building components, building system performance, and programmatic aspects. This information was collected from multiple sources including, pre-existing data, District answers to MSBA's survey questions, and staff observations during the site/building walkthroughs. MSBA's post-occupancy survey included approximately 170 questions subdivided into nine categories/subcategories. Pilot Program survey questions are provided for reference as Attachment 'C'.

Enrollment Review

MSBA reviewed the original forecasted enrollment for both the District and the subject school and compared this information to current enrollment figures and updated forecasts for each of the schools visited as part of the Pilot Program. The MSBA does not base its design enrollments on peaks or troughs in the projected years. Instead, the MSBA uses the 10-year average of projected enrollments which in combination with the MSBA space summary guidelines positions Districts to efficiently meet space capacity needs throughout future enrollment variations.

This comparison revealed that six of the seven schools visited as part of the Pilot Program continue to provide sufficient classroom space for the realized enrollment and updated forecasts. Please note that one of the schools visited was Southeastern Regional Vocational Technical High School, which is an application school, with a long-standing wait-list of applicants. This school is generally fully-enrolled to Chapter 74 program capacity, which is program specific. Please refer to Table 1 in Attachment 'B' for additional information for each of the schools visited as part of the Pilot Program. Please note that an independent effort is underway to review and analyze the MSBA's enrollment methodology, which will be reported separately.

Observations

Staff experience with the schools visited as part of the Pilot Program was positive and appeared to be well-received by District personnel. Staff sensed a general appreciation from District representatives for MSBA's efforts to return to previously completed schools and engage with District personnel to share their experience during the initial use of their updated or new facilities. Based on the seven schools visited during the Pilot Program, staff offer the following observations and potential benefits of returning to a building following 2-3 years of use:

- Serves as an appropriate enhancement to complete the life cycle of a project in the grant program that helps the MSBA in understanding the use and effectiveness of facilities funded by the MSBA;
- Provides an opportunity to review the effectiveness of the high-performance components and systems incorporated into school designs; and
- Obtains end-user feedback that could inform local design-decisions and highlights features that could be included in future MSBA-funded projects by sharing thematic experiences and outcomes with the education and design communities.

Continuing the pilot with the assistance of building commissioning professionals could result in additional benefits. Enhanced review that identifies changes in building equipment, changes in occupant needs, and other components that may be affecting the efficiency and energy use of a building are examples. Review of this nature provides an opportunity to evaluate building system performance by analyzing energy and water consumption and cost as well as common occupant challenges that could inform a process to potentially return equipment and systems back to optimal operation.

Staff Recommendation

Staff recommend extending the Post Occupancy Review Pilot Program through Fiscal Year 2019 to achieve the following objectives:

- Utilize the current Master Services Agreement for Commissioning Consultants to develop post-occupancy facility performance evaluation procedures and implement them at up to twenty Core Program projects that have been in operation for three or more years, including the seven schools visited as part of the FY18 Pilot Program; The Work Order will commence on July 1, 2018, for a

term of 12 months, with the MSBA holding an option to extend the term of the Work Order for such period of time as may be necessary to complete the services required by the Work Order, at the MSBA's sole discretion.

- Engage professional services for guiding and assisting MSBA staff in creating Pre- and Post-Occupancy review guidelines, including review of FY18 Pilot Program survey questions and MSBA feasibility study and design-related project submittal documentation. Staff will determine if this scope of work could best be met by an MSBA Commissioning Consultant or if a separate procurement will be required (If a separate procurement is determined to be the most advantageous, staff will commence and report back to the Board prior to awarding any contract).

Staff recommend that the Board of Directors authorize the MSBA to continue the Post Occupancy Review Pilot Program in FY 19, as outlined above.

Attachments:
'A'- Board of Directors Recommendation for Pilot Program, dated May 3, 2017
'B'- Original Enrollment Forecast Comparison
'C'- FY18 Pilot Program Survey Questions

Attachment "C"

MSBA Post - Occupancy Pilot Program - Schools Visited in FY19

District	School Name	Address	Year Completed
Stoneham	Stoneham Middle School	149 Franklin Street, Stoneham, MA 02180	2014
Wilmington	Wilmington High School	159 Church Street, Wilmington, MA 01887	2015
Auburn	Auburn Middle School	9 West Street, Auburn, MA 01501	2015
Webster	Park Avenue Elementary School	58 Park Avenue, Webster, MA 01570	2015
Norton	Norton High School	66 W Main Street, Norton, MA 02766	2014
Southeastern Regional	Southeastern RVTHS	250 Foundry, Rt. 106, South Easton, MA 02375	2014
Ayer-Shirley	Ayer-Shirley Regional High School	141 Washington Street, Ayer, MA 01432	2015
Berlin-Boylston	Tahanto Regional High School	1001 Main Street, Boylston, MA 01505	2013
Fall River	Morton Middle School	1135 North Main Street, Fall River, MA 02720	2013
Woburn	Goodyear Elementary School	41 Central Street, Woburn, MA 01801	2011
Quincy	Central Middle School	875 Hancock Street, Quincy, MA 02170	2013
Shrewsbury	Sherwood Middle School	28 Sherwood Avenue, Shrewsbury, MA 01545	2012
Wakefield	Galvin Middle School	525 Main Street, Wakefield, MA 01880	2015
West Bridgewater	West Bridgewater Middle-Senior High School	155 West Center Street, West Bridgewater, MA 02379	2015

Attachment "D"

CADMUS

Auburn Middle School

MASSACHUSETTS SCHOOL BUILDING AUTHORITY

POST-OCCUPANCY PILOT PROGRAM

January 21, 2020

Prepared for:

Massachusetts School Building Authority

Attachment "D"

Prepared by:
David Korn, Ridgeline Energy Analytics
Brad Jones, Cadmus

CADMUS

CADMUS

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Glossary

Acronym or Abbreviation	Definition
AHU	Air handling unit. Consists of a fan encased in duct work and a motor that may be internal or external. Usually contains a system of dampers and controls that serves to deliver heating, cooling and/or ventilating air to a space.
BMS	Building Management System. Synonymous with Building Automation System and Energy Management System.
BTU	British thermal unit, which is the quantity of heat required to raise the temperature of 1 pound (0.454 kg) of water 1°F.
DX	Direct expansion. DX refers to refrigerant systems that use refrigerant to directly cool air streams in air handling and roof top units. They are in contrast with chilled water systems where cooling is provided by chilled water or water glycol mixtures in cooling coils.
ERW	Energy recovery wheel. A rotating wheel pervious to air flow that recovers heat from exhausted air.
FCU	Fan coil unit is a terminal device in the HVAC system containing a fan and coil(s). Typically providing heating and/or cooling to one zone.
GPM	Gallons per minute. A flow rate used for heating hot water, chiller water, condenser water, and service hot water.

Acronym or Abbreviation	Definition
kBTU	1,000 BTUs. Often used as a metric for energy use per building area, as in kBTU/ square foot.
kW	1,000 Watts of power. This measurement is usually used to show the peak power that a facility draws.
MMBTU	Used in heating system nomenclature to refer to 1 million BTUs
OA	Outside or outdoor air. Usually refers to air drawn into an AHU or RTU to ventilate a building. Can refer to temperature (OAT) or to a damper (OAD)
RA	Return air. Usually refers to air drawn into an AHU or RTU from the heated or cooled space—it is "returned" to the unit then back to the space. Can refer to temperature (RAT) or to a damper (RAD)
RTU	Roof top unit. A packaged rooftop unit is a type of HVAC system that contains all the components needed to provide conditioned air in one integrated unit that is designed to be installed outdoors.
RWT	Return water temperature. This refers to the temperature of heating hot water as it returns to the boiler and enters the heat exchanger.
SHW	Service hot water refers to hot water that is not used for space heating.
SWT	Supply water temperature. This refers to the temperature of heating hot water supplied to the heating system. It is sometimes called the header water temperature because condensing boilers often serve a single header.

CADMUS

Introduction

On behalf of the Massachusetts School Building Authority (MSBA), Cadmus conducted an extension of the MSBA's Post-Occupancy Pilot Program to review how buildings delivered through the MSBA process operate and how the project documentation and training provided at project turnover has impacted building performance. The specific intent of this evaluation is to review the energy performance of the buildings and systems for a sample of recently completed and occupied MSBA Core Program projects to assist MSBA in the development of post-occupancy evaluation procedures. This evaluation also included the collection of feedback regarding the project turnover process as it relates to documentation and training. These elements of the turnover process are key in providing the operations staff with the resources that are needed for long-term operation and maintenance of a building.

This report presents the results of Cadmus' commissioning-focused review at the Auburn Middle School, located at 9 West Street in Auburn, Massachusetts shown in Figure 1 in construction phase. This report summarizes Cadmus' activities, observations, and school-specific recommendations. Text in bold highlights recommendations for the school district about this particular school and for the MSBA where a point is broadly applicable.

About the School

The Auburn Middle School was built in 2015 for a cost of roughly $32.6M to house 560 students. **Error! Reference source not found.** shows the firms involved in the school's construction.

Table 1. Auburn Middle School Construction Firms and Roles

Role	Firm
Construction Manager/ OPM	Skanska USA
Architect	Lamoureux Pagano & Associates, Inc.
General Contractor	Fontaine Bros, Inc.[1]
Electrical	ART Engineering Corp.
Mechanical	Seaman Engineering Corp.
Commissioning Consultant	WSP

[1] https://fontainebros.com/auburn-middle-school.html

Figure 1. Auburn Middle School

Kickoff and Site Visit Activities

Cadmus conducted a kickoff phone call and initial survey with the school on January 18, 2019, followed by a one-day site visit on January 23, 2019. During the site visit, Cadmus met with the district and MSBA staff listed in Table 2 to discuss the school and the hand off process, then walked through the school with the MSBA to examine systems including HVAC, lighting, building envelope, and the building

management system (BMS). We also installed electrical meters on the two lighting panels and on a panel powering heat tracing tape on the service hot water (SHW) system.

Table 2. Commissioning-Focused Review Attendees

Attendee Name	Attendee Company, Role
David Korn	Ridgeline Energy Analytics, Cadmus subcontractor
Chris Alles	Massachusetts School Building Authority
Kevin Sullivan	Massachusetts School Building Authority
Mary Ellen Brunelle	Auburn School District, Superintendent
Gregg Desto	Auburn School District, Principal
Joe Fahey	Auburn School District, Director of Facilities and Maintenance
Cecilia Wirzbicki	Auburn School District, Business Manager

Energy Usage

The following sections outline electricity and propane usage for the school.

Electricity Consumption

In 2017 and 2018, the school consumed an average of 660,000 kWh per year with almost no year to year variation and minimal monthly variation (see Table 3). The energy use was equivalent to 6.6 kWh per square foot and 22.5 kBTU per square foot.

Table 3. Electricity Bills (kWh), 2017 and 2018

	Jan	Feb	Mar	Apr	May	Jun	Jul
2018	50,800	49,000	56,200	55,200	55,600	62,600	47,400
2017	63,600	42,200	46,800	55,600	48,600	56,800	53,400
	Aug	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	**Average**
2018	53,000	72,400	60,800	49,000		**612,000**	**55,636**
2017	49,200	61,600	67,200	56,800	54,000	**655,800**	**54,650**

When examining energy use in kilowatt-hours per day, although there are seasonal trends with relative maximums each fall, there appears to be a slight increase in electricity use over time (Figure 2) with the average monthly electricity use rising slightly through 2018. The annual total appears to be a decrease but only because December was missing for 2018. **Cadmus recommends continually assessing the building electricity consumption (including for several types of equipment as recommended in this report) to bring this trend back down.**

Figure 2. Kilowatt-Hours per Day, 2016–2018

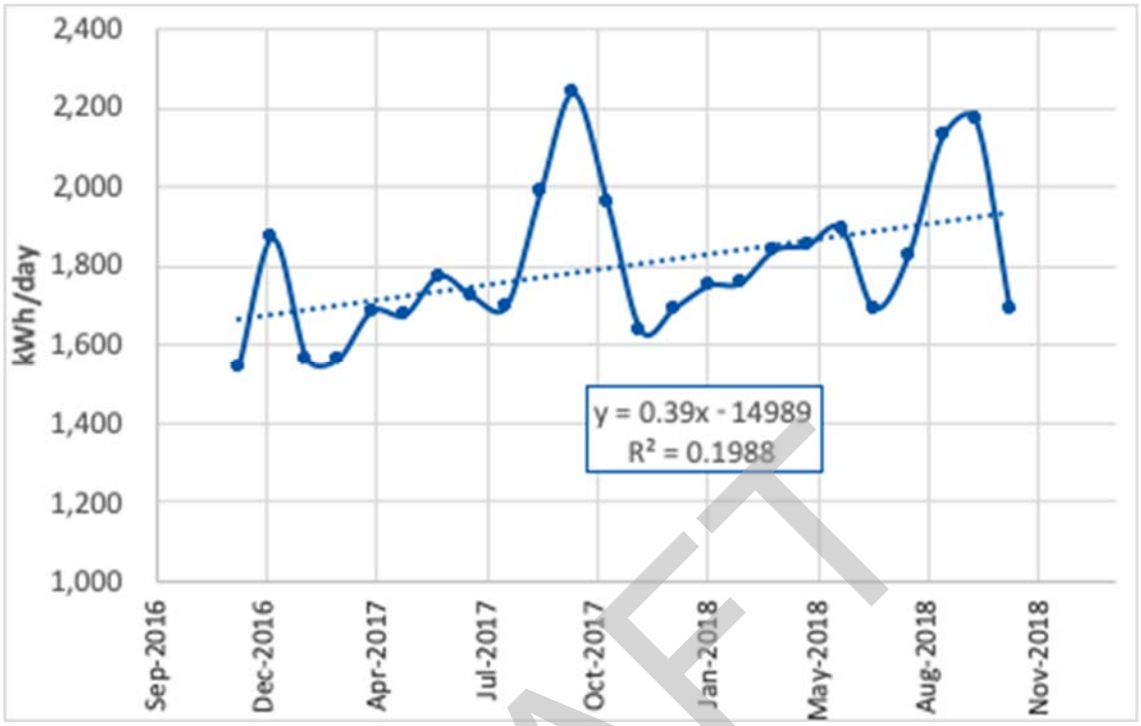
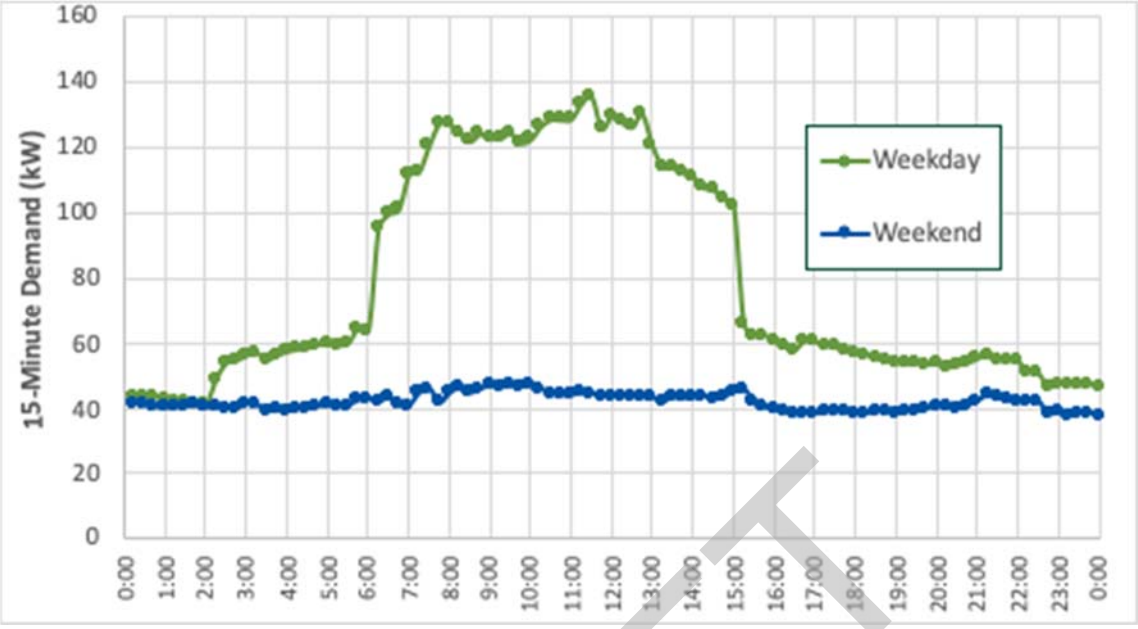


Figure 3 shows daily kilowatt curves for the average of two weeks in November 2018, separated between weekdays and weekend days. The curves show that the building is well-controlled with lower use during weekday nights and weekend days; but even with the control shown in the curves, there appear to be more opportunities for savings. Energy use appears to rise at about 2 a.m., possibly unnecessarily since the building does not appear to ramp up until 6 a.m. each weekday. **Cadmus recommends using optimal start algorithms to heat the building so it meets the needs by the occupied time. By using temperature patterns, carbon dioxide sensors (where installed) can help to optimize the use of ventilation.**

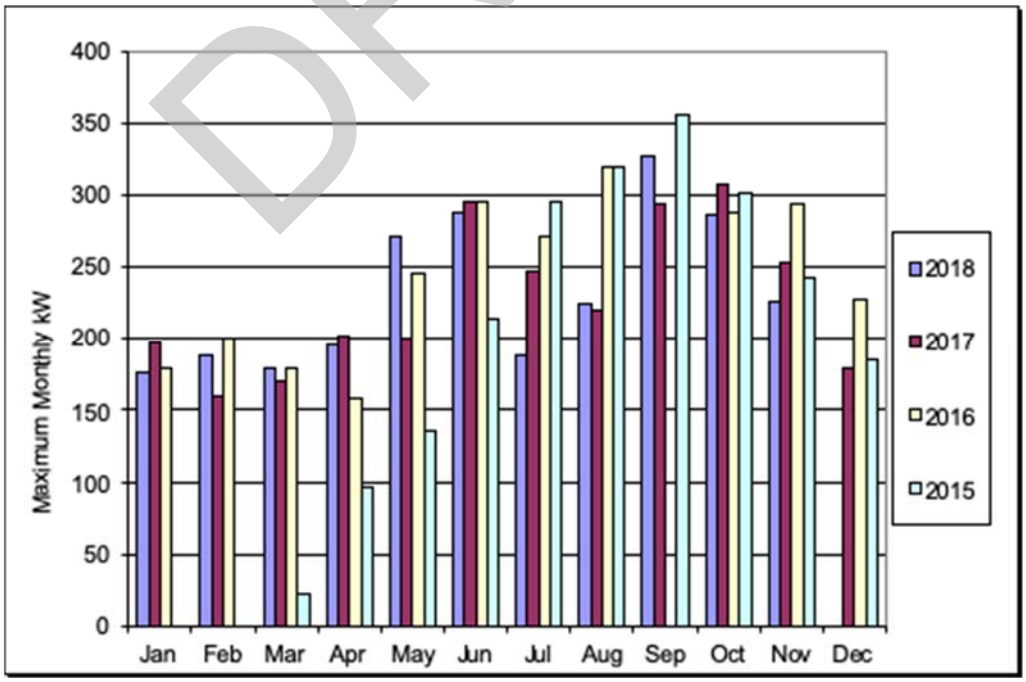
Figure 3. Kilowatt Demand Curves for Two Weeks, November 2018



Electricity Demand

The maximum electricity demand from 2015 through 2018 is shown in Figure 4. During winter months, the demand is approximately 200 kW, with some decrease in 2018. Summer months can peak at over 300 kW of demand, presumably due to cooling and dehumidification.

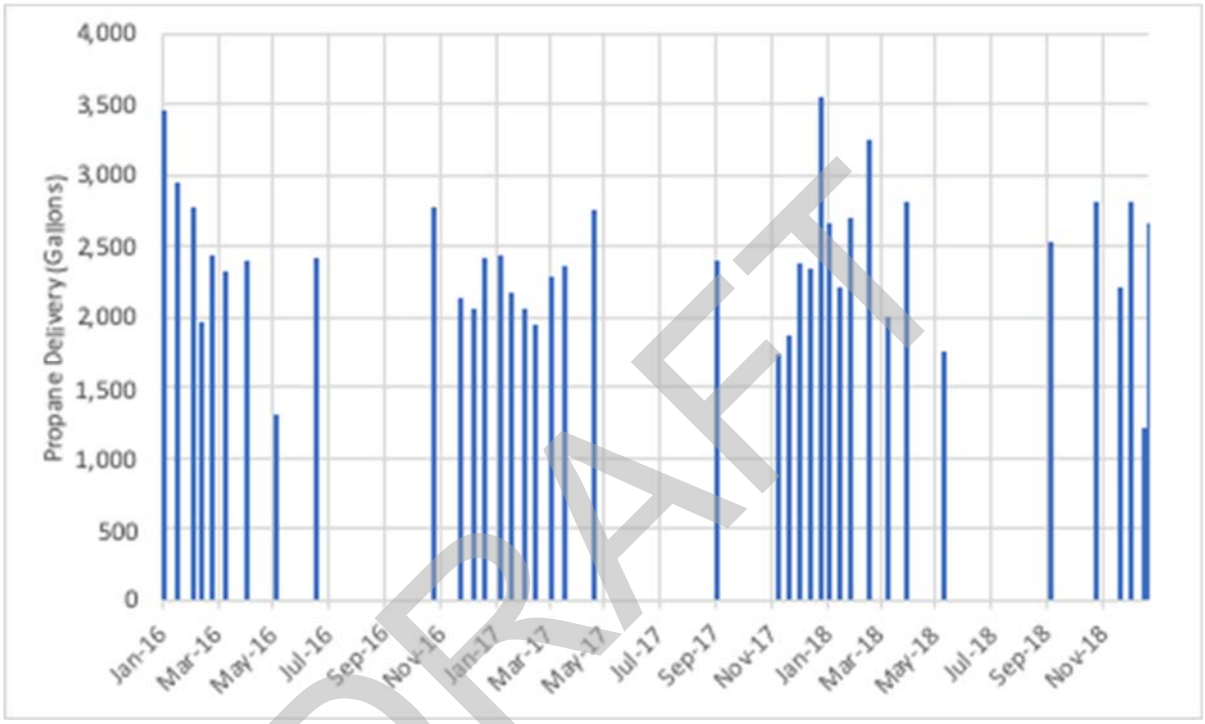
Figure 4. Maximum Monthly Kilowatt Demand, 2015–2018



Propane

Propane at the school is provided by Osterman Propane. There are five 1,000-gallon storage tanks on site. Propane use is recorded in the BMS by two meters, one for the boilers and one for SHW heater. As shown in Figure 5, based on the deliveries from fall through spring (there are no summer deliveries), the annual use is about 30,000 to 31,000 gallons. During the 2017 to 2018 heating season, total propane use was somewhat lower at 27,000 gallons, or 0.27 gallons per square foot, which is about 24.3 kBTU per square foot per year.

Figure 5. Propane Usage



Energy Benchmarking

Benchmarking a facility refers to the best practice of comparing a building to similar buildings in order to establish the building's performance relative to a population. For the purpose of this study, the building metric being used for comparison is the overall energy use of the facility. Benchmarking facility energy use is considered a facility management best practice.

Energy Use Intensity

The energy use intensity (EUI) is a basic measure of a facility's energy performance. It is expressed in amount of energy (kBTU) used annually per square foot of space. This metric is important because it is the standard by which buildings are typically measured for energy consumption comparisons. The building energy use totals 22.5 kBTU per square foot per year for electricity and 24.3 for fuel, and 46.8 kBTU per square foot. A 2009 study of Green Schools built in Massachusetts to CHPS standards found that the median green school used 26 kBTU/SF/year for electricity and 34.9 kBTU/SF/year for fuel, and 60.9 kBTU/SF/year in total (Table 4). Auburn Middle School is well below these values for the Green Schools built to Collaborative for High Performance Schools standards, where electricity is about 13%

lower and fuel use is 30% lower. Compared with the current study, Auburn Middle School fuel use is about 9% lower than the average middle school for both fuel and electricity.

Table 4. Comparative Massachusetts School Energy Use

	Fuel	Electricity	Total
Auburn Middle School	24.3	22.5	46.8
Average 2019 Study (this study)	33.1	25.5	58.5
High Schools	40.8	26.2	67.0
Middle Schools	26.7	24.7	51.4
Elementary Schools	29.1	25.5	54.6
Median Green School (2009)*	34.9	26.0	60.9
Median "Standard" School (2009)*	41.8	25.2	67.0
**Massachusetts Technology Collaborative study (2009)*[2]			

ENERGY STAR Portfolio Manager

ENERGY STAR Portfolio Manager[3] is a free U.S. Environmental Protection Agency (EPA) online tool that building owners can use to measure and track energy and water consumption, as well as greenhouse gas emissions. One of the key benefits of Portfolio Manager is that building owners can benchmark the energy performance of their facility to other, similar facilities nationwide, accounting for weather and climate.

As part of this post-occupancy evaluation study, Cadmus has created an ENERGY STAR Portfolio Manager user account for participating districts that did not have one established and created a building profile for the school participating in the study. Cadmus entered preliminary information about the building and worked with district staff to establish a connection with utility accounts (where an automated date update link is offered by the utility). With basic building parameters and at least one year of energy data, a building can receive an ENERGY STAR score. The score, which ranges from 1 (lowest score) to 100 (highest score), indicates the percentile of performance for the building relative to similar buildings across the country. A score of 50 is the median. So if your building scores below 50, it means it's performing worse than 50 percent of similar buildings nationwide, while a score above 50 means it's performing better than 50 percent of its peers. A score of 75 or higher means it's a top performer and may be eligible for ENERGY STAR certification.

Auburn does not currently use ENERGY STAR Portfolio Manager to track energy performance, however, our review of the ENERGY STAR database indicated that an account profile had been created for Auburn

[2] https://chps.net/sites/default/files/MA_POStudy_FINAL_110509.pdf

[3] https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/learn-how-portfolio-manager

and a building profile was set up for the Middle School. Both existed, but data had not been entered for the building. To benchmark energy use in ENERGY STAR for this study, Cadmus utilized a preliminary ENERGY STAR screening tool with basic information about the building to get a general idea of how the facility scored. The preliminary result for this school indicated an ENERGY STAR score of 74, above the median value of schools nationwide and also above the average score of 59 for schools in the MSBA study. **Cadmus recommends updating the ENERGY STAR profile to receive score and also sharing the score and ongoing energy performance data with the facility staff at the school.** Once the building data is finalized and the score is trued up, if the building scores above 75 it is eligible for recognition through the ENERGY STAR program. **If the score is above 75, Cadmus recommends applying for the ENERGY STAR designation.**

Boilers and Heating Hot Water Distribution

Two Lochinvar Crest 2.5 MMBtu boilers, shown in Figure 6, provide all heat to the school, with the possible exception of the heat pump capability of the roof top units (RTUs).

Lochinvar Crest Condensing Boilers

On the day of the site visit, one boiler was on standby and the other was operating at 67% of capacity for a total output of roughly 1.67 MMBtu. The daily temperature at the closest airport, Worcester, was a minimum of 13°F and a maximum of 30°F. At the time of the site walkthrough the temperature was 22°F. Assuming a linear response and a balance point of 65°F, the boilers would reach capacity at –64°F, indicating a large reserve capacity. At 0°F, the coldest temperature expected at the site, only about 50% of the boilers' capacity is needed, indicating that the system was designed to meet expected temperatures with a single boiler.

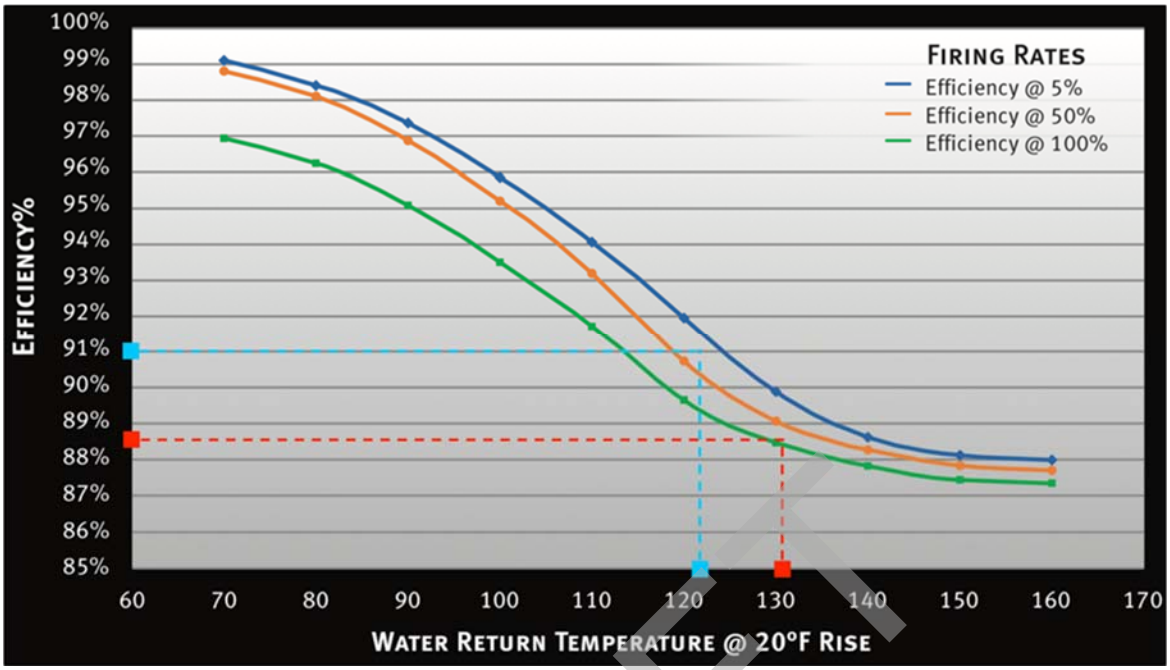
Because the boilers reach high efficiencies at partial load, **Cadmus recommends turning on the second boiler when the first boiler reaches 40% capacity**. During the site visit, higher efficiency could have been achieved if both boilers were operating at 33% of capacity. In fact, Lochinvar's product literature refers to the Crest Cascade being set for "efficiency optimization," with each boiler firing at the same low Btu per hour input rate to receive the benefits of the highest thermal efficiency. **Cadmus recommends sequencing the condensing boilers to bring the second boiler online when the first operating boiler reaches 40% load.**

Figure 6. Two 2.5 MMBtu per Hour Lochinvar Condensing Boilers

Rated Efficiency

Our recommendation is illustrated in Figure 7, which shows the efficiency curve for the Crest boilers, as provided by Lochinvar. Efficiency increases as the return water temperature (RWT) and the firing rate decrease. At the observed conditions, the boilers were operating at a 131°F RWT with a 67% firing rate, yielding an efficiency of roughly 88.5% (shown as red dotted line and red squares). Had the boilers both been operating, splitting the load more evenly, and had the supply water temperature decreased to yield an RWT of about 122°F, an efficiency of 91% could have been achieved (shown as blue dotted line and blue squares). This would have increased efficiency by about 2.5% and would have cut losses from 11.5% to 9%.

Figure 7. Efficiency Curve for Lochinvar Crest Boilers



Return Water Temperature

The screen capture from the second boiler, shown in Figure 8 , had a supply water temperature of 150°F and a return water temperature (RWT) of 131°F (when the first boiler was in standby at 4%). These setpoints do not appear optimal for efficiency and are high for the moderate winter temperatures of that day. Trimming the supply water temperature by 8°F or 9°F should allow the boilers to operate more efficiently. The design documents note a supply water temperature of 136°F. Checking the BMS on January 30, we noted an outside air temperature of 22°F, Boiler 1 operating at 53% and Boiler 2 operating at 4%. The system return water temperature was 132°F, outside of the condensing range (Figure 9). A better sequence would have been both boilers operating at 28%, and the return water in the 120°F range. This would increase operating efficiency by about 2%. During this period the lead HW pump is operating at 57% and most RTU HW valves are nearly closed in the 10-20% range, and the AHU valves vary from 18% to 60%. A lower supply water temperature would still meet the heating needs of the school. **Cadmus recommends that Auburn work with their controls company or mechanical contractor to alter the outdoor air and supply water temperature curve to allow for lower RWTs.**

Figure 8. Control Screen for Second Boiler

Figure 9. BMS Screens for Boiler 1 accessed January 30, 2019

Boiler Natural Gas Usage

The Director of Facilities and Maintenance (from the Auburn School District Facilities) indicated that the propane usage for the boiler and for SHW heater is tracked separately. **Cadmus recommends tracking the boiler propane usage with heating degree days. We also recommend checking the tracked propane amounts against propane delivery records to ensure that the tracking meters are reading correctly.** The BMS appears to show that nearly all gas use is used for heating during the winter months with only a few percent going to SHW generation.

Heating Hot Water Pumps

The system consists of two variable frequency drive (VFD)-controlled hot water circulating pumps that operate in a lead/lag fashion (Figure 10 and Figure 11), hot water coils in the rooftop units (RTUs), and perimeter fin and tube heaters. During the site visit, a single pump was operating at 42.3 Hz, or 70% of full speed. The VFD provides savings over a constant speed motor, as constant speed motors use about 70% of full power and the VFD uses roughly 35% of full power.

Figure 10. Heating Hot Water Pumps

Figure 11. Motor Nameplate from Heating Hot Water Pumps

The motors specified for the 20 HP pumps have National Electrical Manufacturers Association (NEMA) ratings of 93%, equivalent to the Energy Independence and Security Act required efficiency for a two-pole (1,800 RPM) open motor.

Heating Distribution System

The following section describes the heating distribution systems in the Auburn Middle School.

Heating Hot Water

Heating distribution was originally conducted through a water system that had freezing problems, presumably in the coils and RTUs. The system was retrofitted by the District to operate with a glycol

solution after a winter season. It is curious that the RTU hot water coil system was not designed with glycol from the beginning.

Rooftop Units

The school staff reported numerous issues with the Addison RTUs. The school is unhappy and has had numerous problems with the brand. The District noted that to fix the units, specialists had to be flown in from Florida. Addison units were not originally specified but were bid and installed. Because of this, the school staff recommended taking steps to avoid inferior equipment installation. Due to procurement regulations specific brands are typically not sole sourced. If there are particular features that cause issues, the procurement may be able to be written is such a way that most brands are still eligible but problematic features are excluded.

One difficulty with the Addison units was their lack of ability to interact with the BMS. As discussed further in the *Building Management System* section of this report, the original KMC BMS was replaced by an Automated Logics BMS. Even though the control boards in the Addison units were manufactured by ALC Manufacturing, they were incompatible with the ALC head end and had to be replaced by the district.

Heat Pump Capability of Rooftop Units

The hot water coils in the RTUs operate with additional heat provided by the perimeter fan and tube heat (Figure 12). The Director of Facilities and Maintenance indicated that many of the RTUs have built-in heat pump capability that has not been used to date. During a second site visit to the school we discovered that the heat pumps were set to turn off at outdoor air temperatures below 38°F. Because the RTUs contain heat recovery wheels, the mixed air temperature is rarely low enough to need heat when the outdoor air temperature is much above 38°F. When the heat pumps are operated at moderate mixed air temperatures they trip out on high head pressure. It is also possible the low temperature lock out is set too high. The combination of the energy recovery wheels and the heat pump means that the heat pumps rarely, if ever operate. This means that potential savings are lost and the cost of the heat pumps was wasted.

Figure 12. Classroom Perimeter Heat

Table 5 shows the approximate cost to heat with propane and electricity at moderate temperatures, above 30°F, revealing that the cost of the two heating methods are fairly similar. The coefficient of performance of the heat pumps is much higher, but so is the cost for electricity. At colder temperatures the efficiency of the heat pump declines and the cost rises. Any savings at moderate temperatures are modest.

Table 5. Comparison of Heating Costs: Propane Hot Water versus Heat Pumps

Parameter	Value	Notes
Cost of propane	$1.45/gallon	Estimated
Propane heat content	90,000 Btu/gallon	-
Efficiency as operated	86.5%	Includes 2% losses in pipes and pump
Cost: 1,000 Btu heat	$0.0186	-
Cost of electricity	$0.15/kWh	-
Electricity heat content	3,412 Btu/kWh	-
Efficiency/ (coefficient of performance) as operated	260%/ (2.6)	Estimated
Cost: 1,000 Btu heat	$0.0169	-
Savings	7%	-

Service Hot Water

This section describes the service hot water system (SHW) that serves sinks and the kitchen.

AO Smith Service Hot Water Heaters

Two AO Smith, 400,000 Btu, propane-fired SHW heaters operate in a lead/lag fashion (

Figure 13). They are both rated at 95% thermal efficiency. During the site visit, one SHW heater was operating and set to 140°F tank temperature and the other heater was off. One of the heaters had failed under warranty and recently been replaced.

Figure 13. AO Smith Service Hot Water Heaters

Service Hot Water Mixing Circuits

The school has two mixing valves (MV-1 and MV-2) with two associated circulation pumps (shown in Figure 14). During the site visit, MV-1 was sending out 132°F water and MV-2 was sending out 125°F water (based on approximate readings from dial gauges). **Cadmus recommends shutting off the circulation pumps during unoccupied hours to both save electrical energy and to reduce system heat loss. The system will need to be turned on 1 hour prior to occupancy to warm up at the beginning of each day.**

Figure 14. Service Hot Water 1/8 HP and 1/35 HP Circulator Pumps

In addition, the Director of Facilities and Maintenance indicated that, although inside the building, the circuit's pipes have a heat trace circuit (which is essentially electrical resistance heat tape) between the pipe's exterior and the pipe insulation. The purpose of this interior heat trace was unclear but was possibly set to ensure that the hot water stayed hot, which is an unusual design since that is also the point of the circulating design.

As shown in Table 6, the cost of heating hot water using the tape was 2.5 times the cost of generating the heat using the propane-fired heaters. **Cadmus recommends checking whether the heat tape provides an anti-freezing function. If it does not, we recommend checking the heat tape schedule and experimenting with shutting the tape off for most periods, or alternately setting the tape's thermostat to only turn on when freezing is a concern.**

Table 6. Comparison of Cost of Propane-Fired Solar Hot Water and Electric Tape Heating

Parameter	Value	Notes
Cost of propane	$1.45/gallon	Estimated
Propane heat content	90,000 Btu/gallon	-
Efficiency as operated	95.0%	Nominal from nameplate; pipe losses are assumed equal for propane and heat tape
Cost: 1,000 Btu heat	**$0.017**	-
Cost of electricity	$0.15/kWh	-
Electricity heat content	3,412 Btu/kWh	-
Efficiency (coefficient of performance) as operated	100%	Estimated
Cost: 1,000 Btu heat	**$0.044**	-
Savings	61%	-

Lighting

The following section describes the school's lighting system and lighting control systems.

Eaton Controlled LED Lighting System

The school was built with LED fixtures for both interior and exterior lighting. The Eaton lighting control system, shown in Figure 15, currently gives the school staff the most concern. The school staff indicated that infrequently, but as often as five times per year, banks of lights go out for no discernible reason. Because the system does not have override switches or contactors, it must be rebooted and reset. So far, the issues and failed drivers have been covered under warranty or extended service plans, but future issues may not be covered. There have also been some issues with lights coming back on or flickering. Cadmus talked with one teacher who spoke of issues with certain fixtures.

Figure 15. Eaton Lighting Control System

The lights are linked in with the BMS. Corridor lights are on from 6 a.m. to 10 p.m. and stairwell lights are on 24/7. The lights will also come on after hours based on occupancy sensors.

Occupancy Sensors

Occupancy sensors are present throughout the school and work well. Cadmus turned off the lights in the electrical closet while metering to attest to their function.

Building Management System

The school's BMS had been a major source of concern for the school staff. A controls firm, Zenergy Building Technologies (https://zenergybt.com), originally installed a BMS made by KMC. The system did not work and many issues were reported. Information at the unit did not match information at the BMS head end. One of the band rooms was continually heated to 86°F. A consultant was hired to assess the issues and found incorrect wiring where two-wire conductors had been substituted for the required three-wire conductors and found other control points that were not hooked up.

After 18 months of continuing issues, the primary controller was replaced with an Automated Logic system (Figure 16), using $300,000 from contingency funds, although many of the original KMC control modules were retained (Figure 17). The school staff report that now the system works "flawlessly;" The director of facilities operates the BMS and identified no current problems with keeping it operational.

The school staff relayed a story about their ability to tightly control the school. They have one student diagnosed with cystic fibrosis, who requires that relative humidity be kept below 50%. The school HVAC system allows for this setting, giving this student greater freedom of movement than he would otherwise have.

Figure 16. ALC Primary Controller

Figure 17. Retained KMC Controllers

Electrical Components

Transformers

Many schools specify K-rated transformers. These transformers are designed to handle uneven current waves also referred to as either non-linear loads or harmonic generating loads. The transformers have larger neutral wires, and some have flat coil wires. Some highly specialized K-rated transformers have zig-zag windings that are meant to deal with high harmonic loads. These transformers are significantly more expensive than standard transformers adding up to several thousand dollars per transformer, and in some cases are less efficient that standard transformers. The use of these transformers arose in the 80s and 90s when concern over harmonics grew. One cause of the concern was computer power supplies that at the time injected harmonics into building wiring. Computer power supplies have since advanced reducing harmonics. In Cadmus' opinion K-rated transformers are generally not necessary in schools except in computer laboratories where there is a high density of computers, yet they continue to be specified adding cost to school's electrical systems. Auburn's construction included some K-rated transformers (Figure 18).

Figure 18. K-rated Transformer TC1A

Building Envelope

During the pre-visit phone interview and site visit, Cadmus discussed the building envelope with school staff, focusing on roofs, windows, and doors. School staff noted no issues with windows, walls, and doors, but noted two issues with the roofs:

1. The white roof ices quickly even when there is only mist in the air and is slow to melt and clear in comparison to the black roof. This is a slipping hazard during periods with temperatures below freezing. Several schools Cadmus has visited have brought up this complaint about white

roofs. **Cadmus recommends Auburn work with their roofing contractor to install roof compatible walking pads around frequently visited HVAC equipment to reduce slipping hazards and wear and tear on the roof. There is some sort of pathways around Auburn's HVAC equipment, but this did not appear to provide the traction that the District was looking for. The pads also go to the units and in some cases around the unit, however the pads are still several feet from the equipment. Maintenance staff need to step off the pad on and onto the white roof surface to access the equipment for maintenance.**

2. There were two leaking seams soon after the school was constructed that were repaired under warranty.

Maintenance

The school staff perform preventive maintenance—replacing filters four times per year, servicing the boiler annually, and cleaning the boiler condensate traps twice per year—all tracked on a spreadsheet.

Custodial work is performed in house and simple electrical work is provided by a part-time staff electrician. Mechanical and plumbing issues are handled by Apex and William Lynch plumbing. The custodial staff maintains a dry erase version of the school's plan view (Figure 19) to track activities.

Figure 19. Dry Erase View of School Plan

Overall, the school appeared well-maintained and the school staff noted that they perceive the school to be in excellent condition and are very happy with its operation. In our initial view of the BMS, sensors appeared to be working properly with no broken or malfunctioning sensors. Views of interval data and metering data confirmed that the school is operating well with equipment turning on and off at times the school staff noted, and in a manner consistent with school occupancy.

Facility Operations Benchmarks

One of the key goals of this study is to identify ways that the MSBA project process may be enhanced to assist beneficial long term operations and maintenance (O&M) of facilities. In order to accomplish this, Cadmus developed a list of criteria to assess how each school in the study implements key elements of O&M best practices. By understanding current typical maintenance practices, MSBA can make adjustments to their process to help facilitate the implementation of maintenance best practices at schools.

Cadmus developed a rating scale of 1 to 4, with a score of 1 indicating there are opportunities for improvement, 2 indicating that some activities are performed on a limited basis, 3 indicating that activities are generally performed, and a score of 4 indicating that best practices are being implemented in key areas of facility maintenance. The intent of this scale is to give the schools a general sense of how their O&M structure compares to industry best practices and to the other schools in the study. Through staff interviews, documentation reviews and data collected during the site visit, Cadmus assigned rating values to each criteria. These assessment values should not be viewed as an indication of performance for specific individuals at the districts or facilities, but are intended to provide system level feedback. The assessment was performed with an eye toward the district level approach to the operations and maintenance criteria. A summary of the information by general category is provided in Table 7 and details for the specific criteria are provided in Appendix A. This information is also being used to inform and enhance the MSBA process, particularly as it relates to project turnover and training.

The assessment criteria are focused on:

- Specific building systems: HVAC, building management system (HVAC controls), and lighting controls
- Preventive maintenance planning and tracking
- Energy management practices
- District reported satisfaction with building and systems

The last category about satisfaction is primarily being used to provide feedback to MSBA. District reported satisfaction levels range from 1= Dissatisfied to 4=Very satisfied.

Table 7. Summary of Assessment Ratings

Category	Auburn Middle School	All Schools in the 2019 MSBA Study	Notes
	Rating (1 to 4)	Average Rating (1 to 4)	
HVAC - O&M Staff Assessment (5 Criteria)			
Average of Category Criteria	3.8	3.0	Ratings are above other participants.
Maximum within Category	4	3.9	
Minimum within Category	3	2.1	

Category	Auburn Middle School	All Schools in the 2019 MSBA Study	Notes
	Rating (1 to 4)	Average Rating (1 to 4)	
BMS - O&M Staff Assessment (6 Criteria)			
Average of Category Criteria	3.8	2.8	Ratings are above other participants.
Maximum within Category	4	3.1	
Minimum within Category	3	1.8	
Lighting Controls - O&M Staff Assessment (5 Criteria)			
Average of Category Criteria	3	2.9	Ratings are comparable to other participants.
Maximum within Category	3	3.2	
Minimum within Category	3	2.6	
Preventive Maintenance Assessment (2 Criteria)			
Average of Category Criteria	4	3.2	Ratings are above other participants.
Maximum within Category	4	3.2	
Minimum within Category	4	3.1	
Energy Management Assessment (2 Criteria)			
Average of Category Criteria	3	1.5	Ratings are above other participants.
Maximum within Category	3	1.6	
Minimum within Category	3	1.4	
Satisfaction with New Building and Systems			
Overall	4	3.9	
HVAC	3	3.4	
HVAC Controls	2	3.0	
Lighting Controls	2	2.7	
Building Envelope	4	3.4	
Project Turnover Training	2	2.4	
Roof Access	3	3.1	
Roof Access Method	Ships Ladder	Varies	

Commissioning, Training and Building Hand Off

Training was widely viewed by school staff as being short and poor. The combined training for the boilers, electrical system, and hot water system was only two hours and contained virtually no hands-on

component. This training was not recorded. Manufacturers' materials were left in binder format, viewed as high quality and consulted infrequently (but as needed).

The Director of Facilities noted that he had hoped to learn from the commissioning consultant but found that they were generally not knowledgeable. The major issue was that they accepted the school as complete during the commissioning process, yet the building controls remained non-functional for 18 months after the school was occupied.

It is interesting to note the recommendation from the commissioning report regarding future recommissioning. These intervals are probably more frequent than necessary but none of the schools that we visited had ongoing commissioning. Most of the schools did not trend data from their BMS and many did not know how to fully operate those systems. The excerpt from the Auburn commissioning report is as follows:

> *It is recommended that every 12 to 24 months all systems mentioned below should be re-commissioned. This will ultimately provide for a greater control of your entire system and will limit the damage, if any, to any moving and/or working parts.*

Commissioning Report Table 2

System	***Frequency***
Air Handling Units	*Every 12 months*
Hot Water Plant	*Every 12 months*
Terminal Boxes	*Every 24 months*
Cabinet & Unit Heaters	*Every 24 months*
Convectors & Finned Tube Elements	*Every 24 months*
Exhaust Fans	*Every 24 months*
Lighting Controls	*Every 12 months*
Domestic Water Heaters & Mixing Valves	*Every 24 months*
Generators & ATS Switches	*Every 12 months*
Public Address & Master Clock System	*Every 24 months*
Acid Neutralization System	*Every 12 months*

Cadmus reviewed the Commissioning Consultant's *User Guide* and found it lacking in useful content. The school staff could not recall ever having seen the document. Of 17 pages of content, 10 pages had essentially duplicate details with varying titles, leaving seven pages of non-duplicated content that largely showed pictures of the light switches and sensors. There were no actual directions for how to operate or program the equipment.

Additional Considerations

School district staff indicated that they are negotiating a power purchase agreement with Apex solar for a 302 kW solar photovoltaic system, which would produce roughly 330,000 kWh, or just over half the

school's annual needs. During a sunny day the system should be able to provide all the school's power, nearly eliminating peak daytime summer kilowatt usage. The proposed system would cover much of the gym and would extend above classroom areas.

Metering

During the site visit elected to meter lighting. Other loads like the HVAC system could be monitored via the BMS. We also decided to meter the panel with SHW heat tape to verify that load. Table 8 shows details from the second floor electrical room, while Table 9 shows details from the first floor electrical room and Table 10 shows the metering of the SHW heat tape.

Table 8. Second Floor Electrical Room

Metered Location	Panel L2A - Lighting
Voltage	480/277 V, mislabeled as 108/277 V on panel front
Watt Node	480/277V
Current Transformers	(3) 50A Blue
Pulse	Serial #10283927
RX3000	Serial #10780949
Notes	Panel had three CTs on the three panel legs; The director of facilities was unsure where those CTs fed

Table 9. First Floor Electrical Room-Lighting

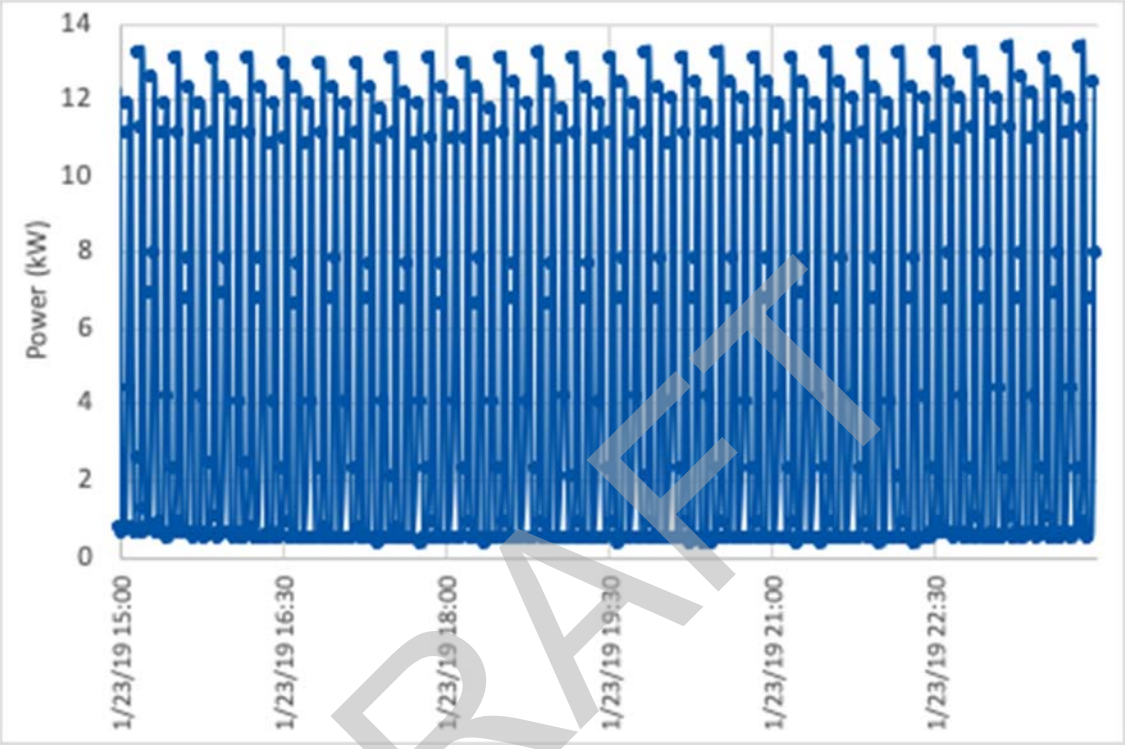
Metered Location	Panel L1A - Lighting
Voltage	480/277 V, mislabeled as 108/277 V on panel front
Watt Node	Serial #115311
Current Transformers	(3) 100A Black
Pulse	Serial #10283884
RX3000	Serial #10780957
Notes	Tied in with Panel H1A2 (shown in Table 10)

Table 10. First Floor Electrical Room-Mechanical

Metered Location	Panel H1A2 - Heat Tape and Lighting
Voltage	480/277 V, mislabeled as 108/277 V on panel front
Watt Node	Serial #31677
Current Transformers	(3) 100A Black
Pulse	Serial #10226283
RX3000	Serial #10780957
Notes	Tied in with Panel L1A (shown in Table 9); spot readings showed roughly 5 Amps per leg (two legs) for first heat tape and < 0.5 Amps for the second heat tape. Only one other load showed power draw, of about 1.5 Amps

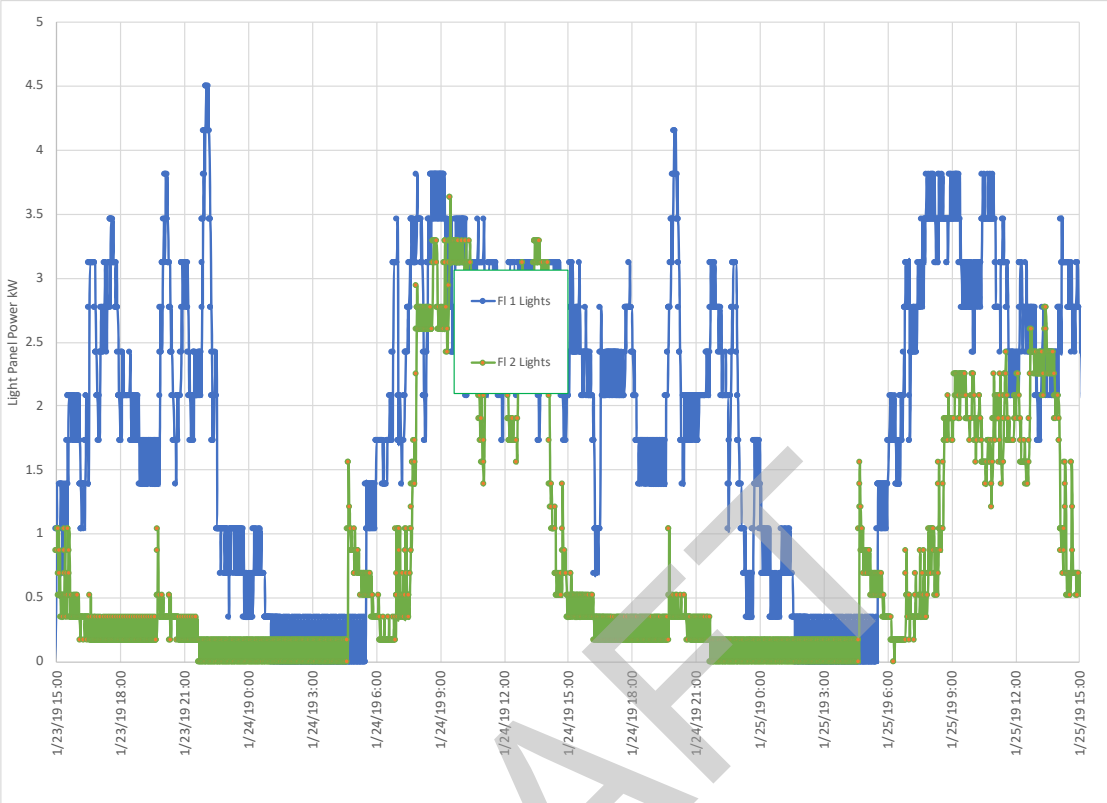
Panel H1A2 contains several heat trace circuits attached to SHW piping and another very small miscellaneous load of about 1 kW. The panel's load continually cycles every seven minutes from about 450 watts to over 12 kW. The cycling is very regular and continues 24/7 regardless of whether the building is occupied. The average load on this panel during January was 4.3 kW (Figure 20).

Figure 20. Power Draw of Panel H1A2 Containing Several Heat Trace Circuits



The two metered lighting panels are shown in Figure 21. The first-floor light circuits peak at 3 kW to 4 kW and decrease between 9 p.m. and 10 p.m., then are nearly off from 10:30 p.m. until about 5:30 a.m. The second-floor lighting panel appears to turn on earlier, at about 4:30 a.m., and to shut off much earlier, at about 2:30 p.m. These circuits draw little power, totaling roughly 6 kW during the day. The lighting schedules appear to match reported schedules. **To save more energy, it is possible to turn on the lights slightly later and to turn off the first floor circuits slightly earlier. These savings would be modest, however, on the order of 500 kWh per year.**

Figure 21. Power Draw of Lighting Panels LA1 and LA2



Summary of Observations and Recommendations

The purpose of this study is to review how buildings delivered through the MSBA process are operated and maintained, including energy performance. The information collected in the study of this building will be combined with the findings from other schools to identify recommendations which can be made for enhancement of the MSBA process.

Based on Cadmus' review of the school, we offer the following observations and recommendations for Auburn Middle School:

1. Recommendation: Because the boilers reach high efficiencies at partial load, we recommend turning on the second boiler when the first boiler reaches 40% capacity. During the site visit it was observed that higher efficiency could have been achieved if both boilers were operating at 33% of capacity. In fact, Lochinvar's product literature refers to the Crest Cascade being set for "efficiency optimization," with each boiler firing at the same low Btu per hour input rate to receive the benefits of the highest thermal efficiency. We recommend sequencing the condensing boilers to bring the second boiler online when the first operating boiler reaches 40% load.

2. Recommendation: We recommend working with the school controls company or mechanical contractor to manage the outdoor air and supply water temperature curve to allow for heating hot water RWTs below 128°F. A lower return water temperature will allow the condensing boilers to operate more efficiently.
3. Observation: The school was originally constructed with water used for heating coils in RTUs. Due to freezing issues this was changed to a glycol solution. Glycol should probably have been originally specified for RTU hot water coil systems.
4. Recommendation: For circulating SHW systems, we recommend that schools shut circulating pumps off during unoccupied periods to save electrical energy and to reduce heat loss from the system. The system will need to be turned on to warm up at the beginning of each day. We also recommend checking with the latest legionella disease guidance to make sure that they are followed.
5. Recommendation: Auburn's service hot water pipes have a heat trace circuit (which is essentially electrical resistance heat tape) between the pipe's exterior and the pipe insulation. The purpose of this interior heat trace was unclear but was possibly set to ensure that the hot water stayed hot, which is an unusual design since that is also the point of the circulating design. As shown in the report, the cost of heating hot water using the tape was 2.5 times the cost of generating the heat using the propane-fired heaters. We recommend checking with the Designer whether the heat tape provides an anti-freezing function. If it does not, we recommend checking the heat tape schedule and experimenting with shutting the tape off for most periods, or alternately setting the tape's thermostat to only turn on when freezing is a concern.

6. Recommendation: LED lighting systems and their controls appear to be an issue at this school. We recommend examining the prevalence of issues with flicker and system failures, and work with the provider of the system to explore what can be accomplished under warranty or a service contract.
7. Recommendation: We recommend Auburn work with the controls contractor to use optimal algorithms to start the building to meet the needs just by the occupied time. Using temperature patterns and, where installed, carbon dioxide sensors can help to optimize the use of ventilation.
8. Recommendation: Consider reviewing the benefits and disadvantages of white roofs. Staff at several of the schools in the study complained of hazards where cold mist froze on the roof, causing slip and fall hazards. In their opinion, black roofs would melt this thin layer of ice that white roofs do not melt. Schools are lightly used during summers and the high levels of insulation may render the energy benefit of the white roof to be very small.
    a. District Recommendation: If the existing walking pad layouts do not provide adequate cover for required access to roof top equipment, we recommend working with the roofing contractor to add additional walking pads.
9. Recommendation: We recommend Auburn implement a process to track facility energy usage over time and benchmark performance.
    a. Tracking energy performance over time allows facility staff to identify potential anomalies in performance and address them. Benchmarking allows the facility staff to see how the school performs relative to other schools in the district and other schools across the county. It appears that there is an ENERGY STAR Portfolio Manager account for the school, however it is not up to date. We recommend Auburn assign a designated resource to keep it up to date.
    b. The ENERGY STAR screening used for this study resulted in a score of 74 which indicates the building is close to qualifying to earn an ENERGY STAR designation. If the score goes above 75 once data is trued up, Cadmus recommends applying for the ENERGY STAR designation to receive recognition for its performance.

Appendix A – District O&M Assessment Results

The full results of the assessment are provided in the table below. Data is presented for this site and the average of all schools that participated in the MSBA Post Occupancy Evaluation Study. The study included fourteen schools, including two elementary schools, six middle schools and six high schools (or high school/middle school). Each general category has a summary including the average and the range of the individual ratings. Overviews of the categories are discussed in the main report. This detailed data is presented so the district can review and identify specific areas it may want to address. Items with scores of 1 or 2 represent areas of opportunity for staff training or procedure updates. The assessment was performed with an eye toward the district level approach to these items. As such, these assessment values should not be viewed as an indication of performance for specific individuals at the districts or facilities, but are intended to provide system level feedback. District reported satisfaction scores are ranked from 1= Dissatisfied to 4=Very Satisfied.

Table 11. Detailed Assessment Results

Category	Auburn Middle School	All Schools in 2019 MSBA Study
	Rating (1 to 4) / Data Point	Average Rating (1 to 4) / Data Point
HVAC - O&M Staff Assessment (5 Criteria)		
Average	3.8	3.0
Max	4	3.9
Min	3	2.1
Demonstrate understanding of whole building systems layout within the building.	4	3.3
Demonstrate understanding of whole building systems operating sequences and settings and how components interact with each other, with the building, its occupants, and the environment.	4	3.1
Organize and maintain library of documentation and O&M manuals including as built drawings, device specifications and sequence of operation, vendor service manuals, instrumentation calibration sheets, in-house service and maintenance schedules.	4	3.0
Use in-house documentation and manuals to troubleshoot including manufacturer's specifications, instrument calibration sheets, service and maintenance schedules, sequence of operation, and equipment reports.	3	2.2

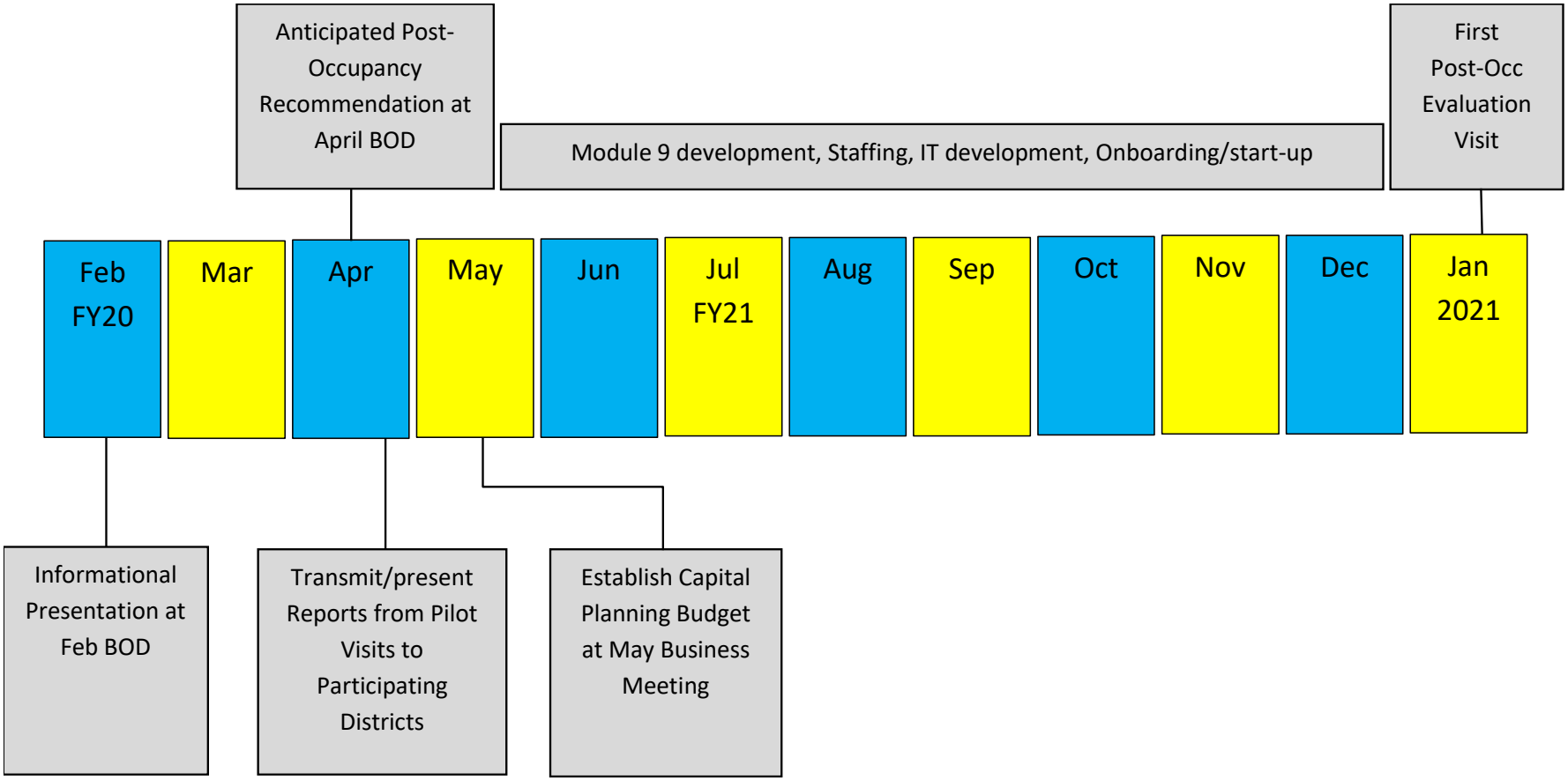
Category	Auburn Middle School Rating (1 to 4) / Data Point	All Schools in 2019 MSBA Study Average Rating (1 to 4) / Data Point
Use in-house as-built documentation as an aid to troubleshoot issues and monitor system operation.	4	3.5
Specialized Maintenance	Outsourced	Outsourced = 14
Routine Maintenance (filters, belts, etc.)	In house	Outsourced = 1 In house = 13
BMS - O&M Staff Assessment (6 Criteria)		
Average	3.8	2.8
Max	4	3.1
Min	3	1.8
Ability to access BMS and navigate system to monitor building system performance.	4	3.1
Adjust HVAC time schedules to optimize facility operation.	4	3.1
Operate HVAC system and adjust setpoints for energy savings and occupant comfort.	4	3.2
Use building management system to set alarms for out of parameter conditions, manage alarms, and collect and analyze building performance data.	4	3.2
Use building management system to set trends and collect and analyze building performance data.	4	2.0
Address issues openly and keep a log of important communications.	3	2.5
Specialized Maintenance	Outsourced	Outsourced = 14
Routine Maintenance (schedule changes, setpoints, etc.)	In house	Outsourced = 2 In house = 12
Lighting Controls - O&M Staff Assessment (5 Criteria)		
Average	3	2.9
Max	3	3.2
Min	3	2.6
Demonstrate understanding of lighting systems layout within the building.	3	3.3
Demonstrate understanding of lighting systems operating sequences and settings and how components interact with each other, with the building, its occupants, and the environment.	3	2.8
Ability to access lighting controls and navigate system to monitor building system performance.	3	3.1

Category	Auburn Middle School Rating (1 to 4) / Data Point	All Schools in 2019 MSBA Study Average Rating (1 to 4) / Data Point
Adjust lighting time schedules to optimize facility operation.	3	3.1
Operate lighting system and adjust setpoints for energy savings and occupant comfort.	3	2.9
Specialized Maintenance	Outsourced	Outsourced = 10 In house = 4
Routine Maintenance (schedule changes, setpoints, etc.)	In house	Outsourced = 4 In house = 10
Lighting Controls System Type	Centralized	Centralized = 14
Lighting Controls Daylighting Controls?	Yes	Yes = 13 No = 1
Lighting Controls integrated to BAS?	Yes	Yes = 2 No = 12
Preventive Maintenance Assessment (2 Criteria)		
Average	4	3.2
Max	4	3.2
Min	4	3.1
Read and interpret maintenance schedules, manufacturer and as-built building system specifications and follow recommendations for preventative maintenance requirements. Establish a preventive maintenance program.	4	3.2
Implement preventive maintenance program, schedule and plan activities, and track completion.	4	3.3
Ongoing training provided to O&M staff?	No	Yes = 4 No = 10
Ongoing training on building systems provided to occupants?	No	Yes = 2 No = 12
Energy Management Assessment (2 Criteria)		
Average	3	1.5
Max	3	1.6
Min	3	1.4
Energy Manager assigned?	District	Yes = 4 None = 10

Category	Auburn Middle School Rating (1 to 4) / Data Point	All Schools in 2019 MSBA Study Average Rating (1 to 4) / Data Point
Collect and track energy use data using utility bills, rate structures, utility meter data, submeters, digital controls, and other operating data. Provide this data to staff at the building.	3	1.5
Benchmark building performance and compare the performance to other buildings and national benchmarks. Provide this data to staff at the building.	3	1.4
Energy management- submetering installed	No	Yes = 6 No = 8
Energy management- submetering used now	No	No = 14
Energy management- ENERGY STAR Portfolio Manager benchmarking tool set up?	No	Yes = 1 No = 13
Energy management- ENERGY STAR Portfolio Manager benchmarking tool used regularly?	No	Yes = 1 No = 13
Commissioning Documentation		
MSBA Commissioning Documentation available at the site.	Yes	Yes = 6 No = 8
MSBA Commissioning Documentation used on regular basis?	No	Yes = 1 No = 13
Project Turnover Training		
Project Turnover Training Satisfaction	2	2.4
Staff trained at project turnover are still with district	Partial	Partial = 6 Yes = 4 No = 4
Training handouts were provided at project turnover training.	Yes	Yes = 7 No = 3 Unknown = 4
Training handouts provided at turnover are still used.	No	Yes = 5 No = 9 (assume Unknown = No)
Project Turnover Training video provided.	No	Yes = 7 No = 5 Unknown = 2
Project Turnover Training video used now.	No	No = 14 (assume Unknown = No)
Satisfaction with New Building and Systems		
Overall	4	3.9
HVAC	3	3.4
HVAC Controls	2	3.0
Lighting Controls	2	2.7
Building Envelope	4	3.4

Category	Auburn Middle School	All Schools in 2019 MSBA Study
	Rating (1 to 4) / Data Point	Average Rating (1 to 4) / Data Point
Project Turnover Training	2	2.4
Roof Access	3	3.1
Roof Access Method	Ships Ladder	Varies

Anticipated Post-Occupancy Roll-out



Attachment "F"

October 2019

Massachusetts School Building Authority Post-Occupancy Evaluation Study Phase 2 Report

DRAFT

Perkins&Will

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Contents

→

Massachusetts School Building Authority Mission

Partner with Massachusetts communities to support the design and construction of educationally-appropriate, flexible, sustainable, and cost-effective public school facilities.

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Phase 2 Summary

MSBA POE Study Objectives:

1. Establish a POE process, specific to MSBA-funded K-12 schools
2. Understand if the schools funded by the Authority are operating and performing as designed.
3. Measure the impact of design on site systems, building performance, and human experience metrics.

Process: This study was broken into two phases, Phase 1: Process Review and Phase 2: Pilot Review. Phase 1 consisted of a deep dive into existing grant program submission requirements and evaluation of the potential for submittals to inform a POE (See appendix for Phase 1 Report). Phase 2 evaluated MSBA's FY18 Post-Occupancy Survey Pilot and identified opportunities to further develop the program.

2.1 Pilot Review

1. Evaluate building survey questions from FY18 Post-Occupancy Pilot
2. Interview MSBA staff who conducted the FY18 Post-Occupancy Pilot and document lessons learned
3. Conduct a gap analysis to compare the current survey with desired outcomes

2.2 Template & Report

1. Prepare a modified version of survey questions and criteria that would apply to a one-day, non-invasive School District meeting and building walk-through
2. Develop a methodology for data management
3. Create a standard summary report

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Phase 2 Summary

FY18 Post-Occupancy Pilot Evaluation:

- A wide range of topics at multiple scales were addressed
- The one-day timeline with two MSBA staff members seemed to be enough time to conduct a site visit
- Majority of the questions are for the district and school leadership to answer, while some were MSBA observations
- The survey form was filled out by the MSBA while on site or after the site visit concluded
- Several of the questions were open-ended making it difficult to fill out the information while on site
- It was sometimes difficult to get the appropriate people to attend the site visit (e.g. facilities, principal)

FY18 Post-Occupancy Gap Analysis:

Based on the study objectives the following opportunities have been identified for the updated POE survey:

Create a baseline: Collect data that documents design intent to establish a point of comparison for post-occupancy and gain understanding of whether schools funded by the Authority are performing as designed.

Length: Reduce total number of questions for increased response rates and reduced measurement error.

Multiple perspectives: Administer the survey to multiple audiences (leadership, staff, students, parents) to gain a comprehensive understanding of how the design is functioning.

Anonymous Survey: Structure the survey for anonymity to increase response rate, improve accuracy of feedback, provide unbiased data and create more actionable outcomes.

Rating scales: Implement rating scales on majority of questions to collect more nuanced data that does not force an either-or response.

Mixed Method: Divide the existing survey into multiple data collection tactics to collect both quantitative and qualitative data points and assure consistent data collection.

POE Process Recommendations

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POE Process Recommendations

01
Create Module 9 to include a Post Occupancy Evaluation as part of the standard grant funding process for all projects

02
Expand on the 2018 POE Pilot process with multiple data collection tactics, including a site visit, pre-visit form, and an online survey

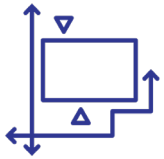
03
Capture data submitted during Modules 1-8 as part of the POE process to compare actual outcomes vs original intent

04
Co-locate POE data for all completed schools in a central database with an online dashboard for comparison and analysis of trends

05
Summarize POE findings in a standard report template that will be used for each school

Revised process

Modules 1-8



Online Survey

Pre-Visit Questionnaire

Site Visit

Post Occupancy Evaluation Central Database

- Web-based Reporting Dashboard
- Standard Building POE Report

Actionable items and lessons learned to improve future MSBA projects

Data Collection Tactics

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Data Collection Tactics

Note: Number of questions and list of topics to be updated following the final review of survey questions.

We recommend the following four data collection tactics. Each is explained in greater detail in the following pages. A full list of questions and documentation can be found in the appendix.

Modules 1-8

Data from 2 modules
15 total questions

Topics covered:
- Building performance
- Square footage
- Design enrollment
- Budget
- Program

Online Survey

5 respondent groups
35 total questions

9 survey sections:
- Demographics
- Site & Circulation
- Safety & Security
- Materials & Systems
- Maintenance
- Spaces
- User – Teacher/Staff
- User – Student
- User – Parent

Pre-Visit Questionnaire

4 respondent groups
84 total questions

Topics covered:
- Grant information
- Project team
- Enrollment
- Configuration
- Programs
- Parking
- Maintenance
- Building systems
- Space utilization
- Community uses
- Operating costs
- Commissioning

Site Visit

1 day visit
2 MSBA employees

Topics covered:
- Site & circulation
- Site systems
- Maintenance
- Safety & security
- Building performance
- Space Utilization
- Metering

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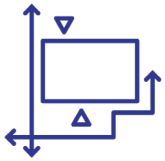
Modules 1-8



Recommendation — Capture data points already collected during Modules 1-8 and utilize them in the POE process to measure the performance of the new building compared to the design intent.

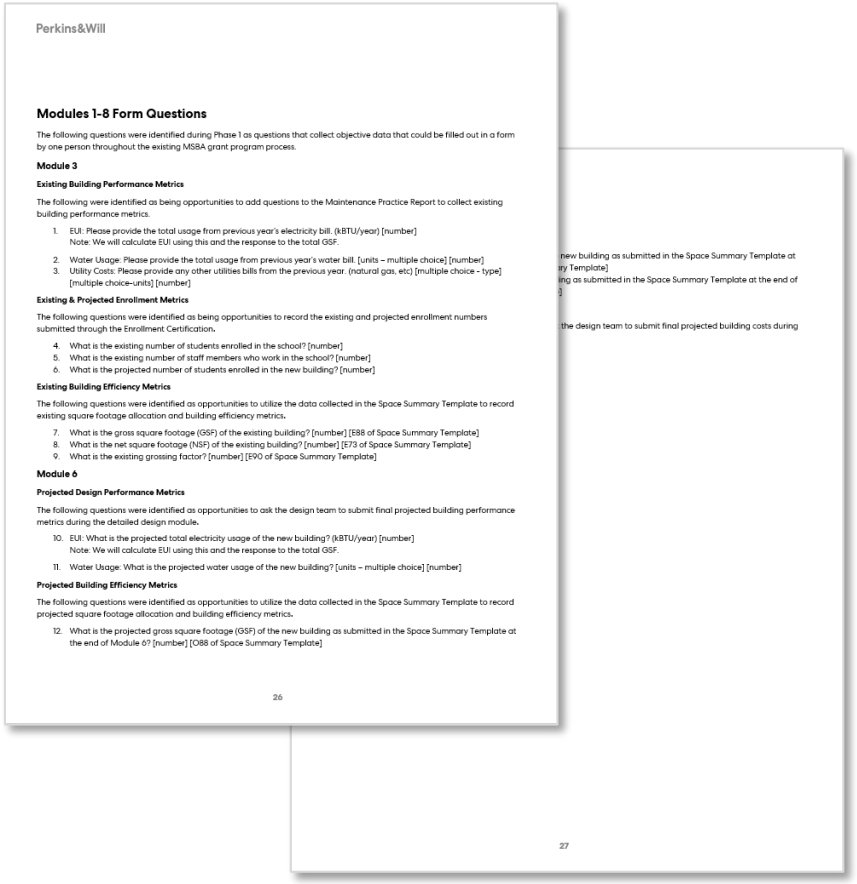
Tool — Develop a form that collects specific data points already submitted in Modules 1-8 and feeds into the central POE database like the form used in the FY18 POE Pilot.

Respondents — MSBA and Design Team.

Timeline — To be completed during Modules 3 & 6.

Implementation — MSBA to provide the appropriate forms to the design teams and log data as it is submitted during Modules 3 & 6. Design team to record data points about projected building performance during Module 6.

Analysis — MSBA to log data in central POE database and summarize findings in the POE summary report.



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Modules 1-8 Form Questions

The following questions were identified during Phase 1 as questions that collect objective data that could be filled out in a form by one person throughout the existing MSBA grant program process.

Module 3

Existing Building Performance Metrics

The following were identified as being opportunities to add questions to the Maintenance Practice Report to collect existing building performance metrics.

1. EUI: Please provide the total usage from previous year's electricity bill. (kBTU/year) [number]
   Note: We will calculate EUI using this and the response to the total GSF.
2. Water Usage: Please provide the total usage from previous year's water bill. [units – multiple choice] [number]
3. Utility Costs: Please provide any other utilities bills from the previous year. (natural gas, etc) [multiple choice - type] [multiple choice-units] [number]

Existing & Projected Enrollment Metrics

The following questions were identified as being opportunities to record the existing and projected enrollment numbers submitted through the Enrollment Certification.

4. What is the existing number of students enrolled in the school? [number]
5. What is the existing number of staff members who work in the school? [number]
6. What is the projected number of students enrolled in the new building? [number]

Existing Building Efficiency Metrics

The following questions were identified as opportunities to utilize the data collected in the Space Summary Template to record existing square footage allocation and building efficiency metrics.

7. What is the gross square footage (GSF) of the existing building? [number] [E88 of Space Summary Template]
8. What is the net square footage (NSF) of the existing building? [number] [E73 of Space Summary Template]
9. What is the existing grossing factor? [number] [E90 of Space Summary Template]

Module 6

Projected Design Performance Metrics

The following questions were identified as opportunities to ask the design team to submit final projected building performance metrics during the detailed design module.

10. EUI: What is the projected total electricity usage of the new building? (kBTU/year) [number]
    Note: We will calculate EUI using this and the response to the total GSF.
11. Water Usage: What is the projected water usage of the new building? [units – multiple choice] [number]

Projected Building Efficiency Metrics

The following questions were identified as opportunities to utilize the data collected in the Space Summary Template to record projected square footage allocation and building efficiency metrics.

12. What is the projected gross square footage (GSF) of the new building as submitted in the Space Summary Template at the end of Module 6? [number] [O88 of Space Summary Template]

26

new building as submitted in the Space Summary Template at
ry Template]
ing as submitted in the Space Summary Template at the end of
]

the design team to submit final projected building costs during

27

Image: Example screen shot of Module 1-8 Form

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Online Survey

Recommendation — Collect subjective data from multiple perspectives through an online survey to develop a comprehensive understanding of how the facility is functioning and measure effectiveness of the new building.

Tool — Utilize a third-party survey tool to streamline survey administration and analysis.

Respondents — Multiple respondents have been identified including: School and District leadership, facilities personnel, teachers and staff, students, and parents. Each audience will respond to a set of questions that is appropriate for them.

Timeline — The survey should remain open for a 2-week period to assure participants have ample time to respond.

Implementation — MSBA to schedule online survey deployment with district, provide district with survey communications, deploy online survey, monitor responses, and troubleshoot any problems.

Analysis — MSBA to download raw survey data, summarize overall findings and input those into the central POE database and POE summary report.

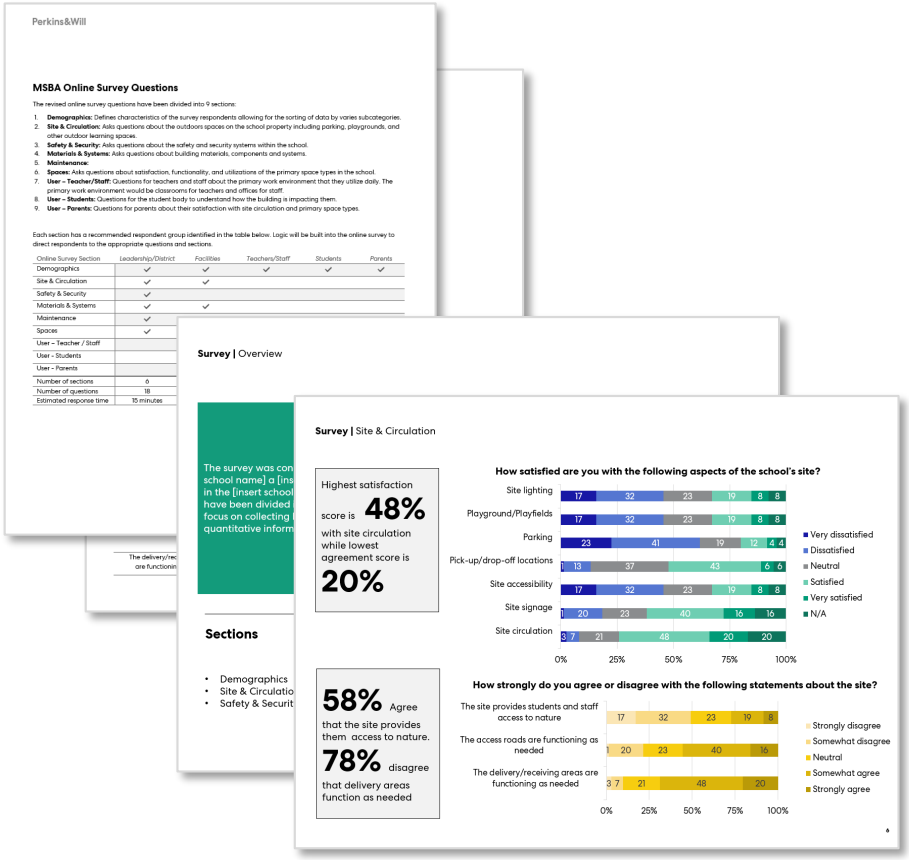

Image: Example screen shot of Online Survey questions and Survey Summary Template

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Pre-Visit Questionnaire

Recommendation — Create a form that collects information from select individuals prior to the MSBA site visit.

Tool — Develop a form that collects data and feeds into the central POE database like the form used in the FY18 POE Pilot.

Respondents — MSBA and School and District leadership.

Timeline — To be completed before the site visit to provide the MSBA with insight to how the building is performing prior to being on site.

Implementation — MSBA to send form to School. District leadership and fill out the MSBA section of the form.

Analysis — MSBA to review content submitted, note anything important to follow-up on during site visit, input data into central database and the POE summary report.

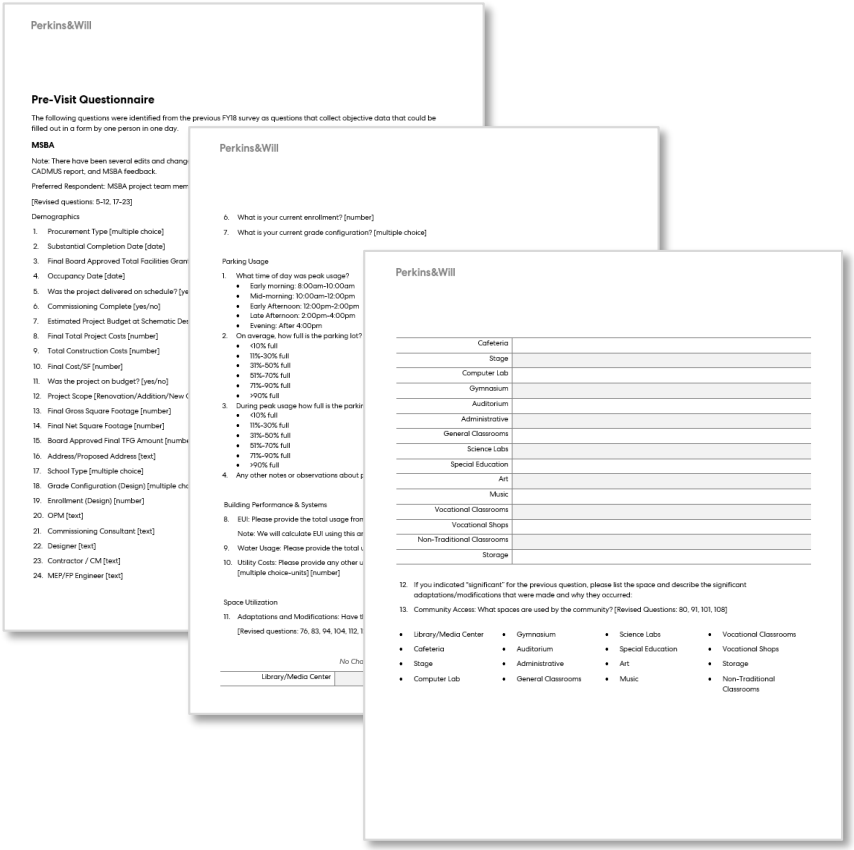

Image: Example screen shot of Pre-Visit Questionnaire

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Site Visit

Recommendation — Continue to conduct one day non-invasive site visit with two MSBA employees. One to ask the district questions and take necessary photos and the other to log information in the site visit form on a tablet.

Tool — Edit the existing FY18 POE Pilot application with the revised site visit questions.

Respondents — MSBA

Timeline — To be conducted after the online survey is administered and the pre-visit questionnaire is received. Any spaces or topics that might have had low scores from the survey can be followed up on during the site visit.

Implementation — MSBA to schedule site visit with district, fill out form and document findings while on site.

Analysis — MSBA to save form and any supporting photographs from the visit, input data into central database and summarize findings in the POE summary report.

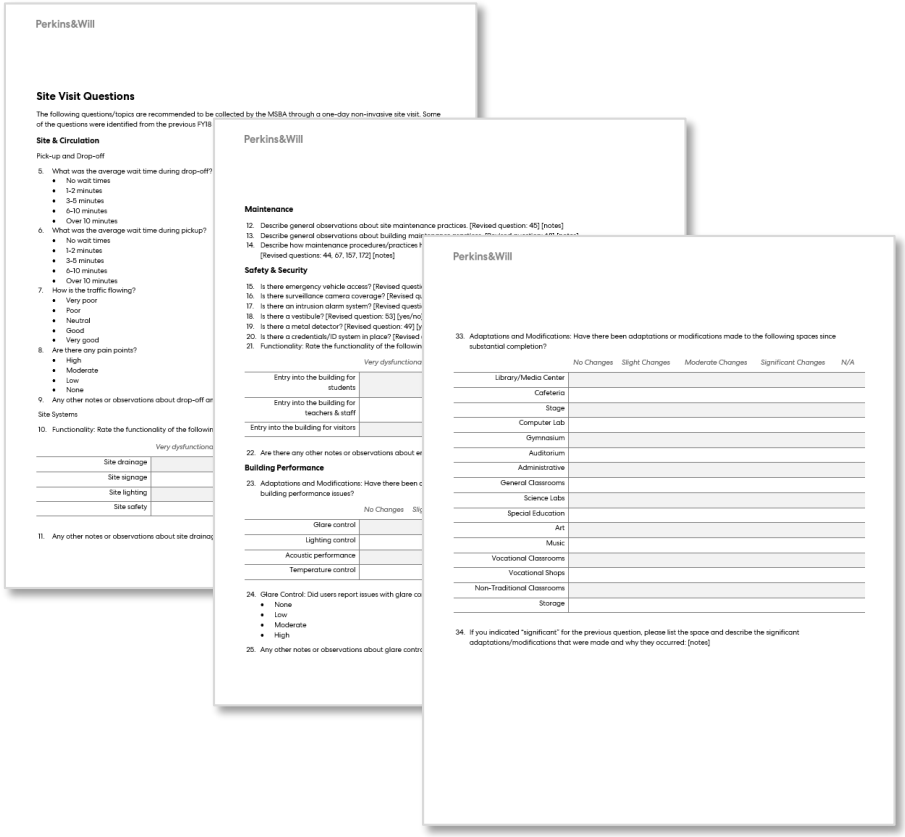

Image: Example screen shot of Site Visit questions

Database Format

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Data Tables and Fields

Module 1-8

- **Building ID**

- SF
- Design enrollment
- Budget
- Program

+/- 30 fields

Online Survey

- **Building ID**

- Demographics
- Site & Circulation
- Safety & Security
- Materials & Systems
- Maintenance
- Spaces
- User – Teacher/Staff
- User – Student
- User – Parent

+/- 30 fields

Pre-Visit Questionnaire

- **Building ID**

- Grant information
- Enrollment
- Project team
- Enrollment
- Configuration
- Programs
- Parking
- Building performance
- Space modifications
- Community uses
- Operating costs

+/- 30 fields

Site Visit

- **Building ID**

- Site & Circulation
- Site Systems
- Maintenance
- Safety & Security
- Building Performance
- Space Utilization
- Metering

+/- 30 fields

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Example Data Table

Building ID	Square Footage	Year Completed	Budget	Design Enrollment	Grade Levels	Other Fields...
Building 1						
Building 2						
Building 3						
Building 4						
Building 5						

Example Form

Building ID: _____
Square Footage: _____
Year Completed: _____
Budget: _____
Design Enrollment: _____
Additional Fields (see appendix)

Forms populate each row of the table

Each building is a row in the table

The online survey will be summarized before loading into the central database

Raw data:

100's of responses x 30 questions

Raw data archived separately

Processing functions to calculate averages and totals – e.g. overall teacher satisfaction

Averages and totals loaded into central database.

Each school gets a single average or total value for each question

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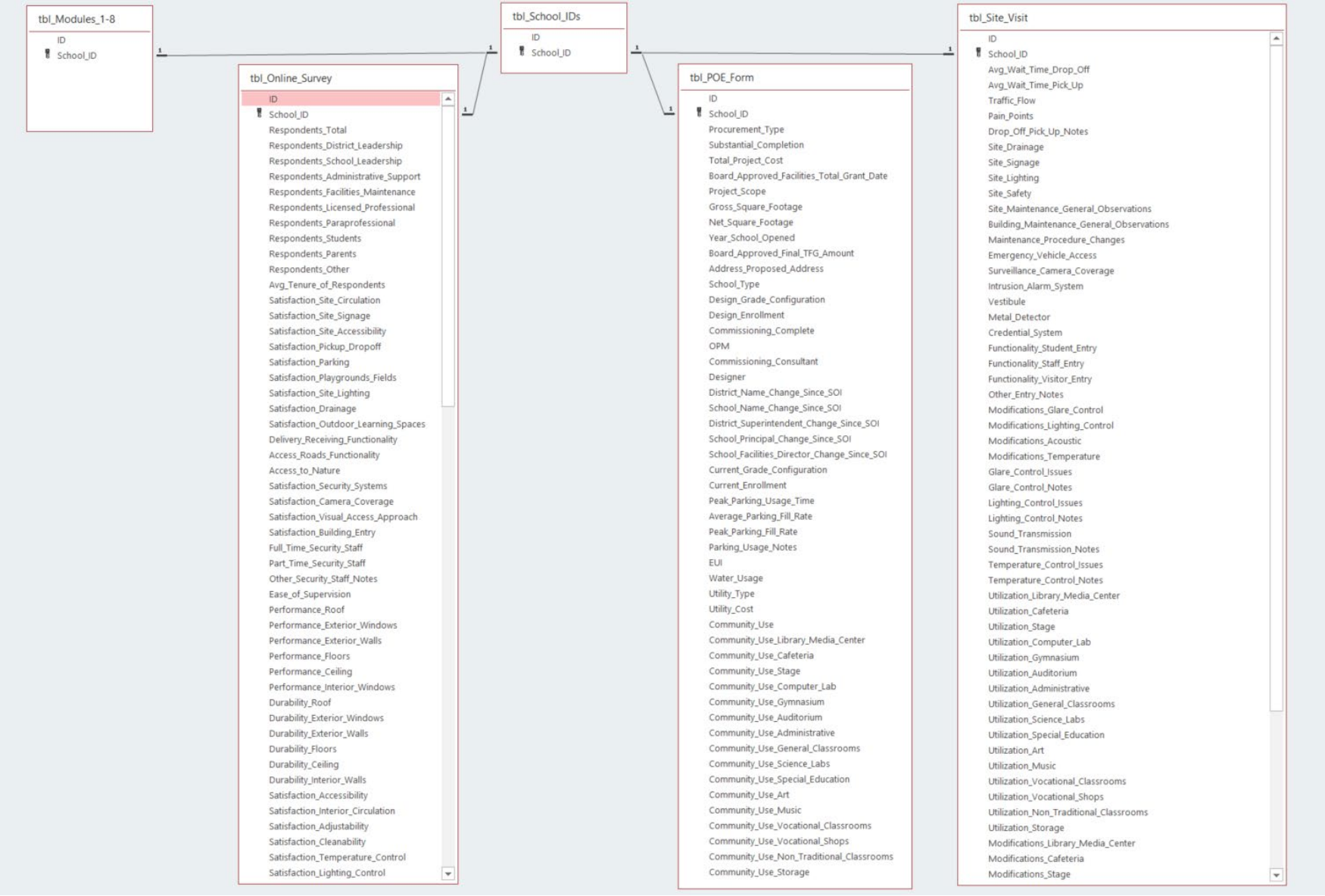
Database Relationship Diagram

Note: The image below shows a mockup of the relational structure of the database. Live files are provided separately for reference.



Dashboard Mockup

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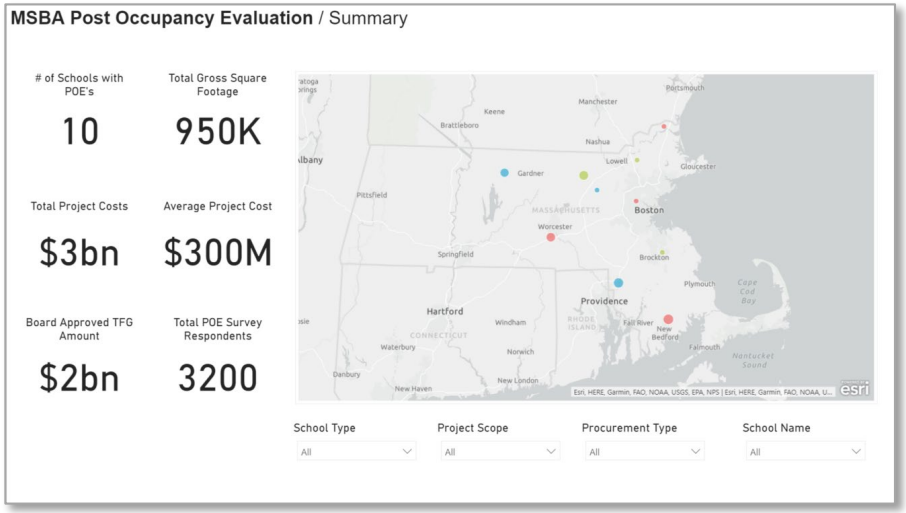
Dashboard Mockup

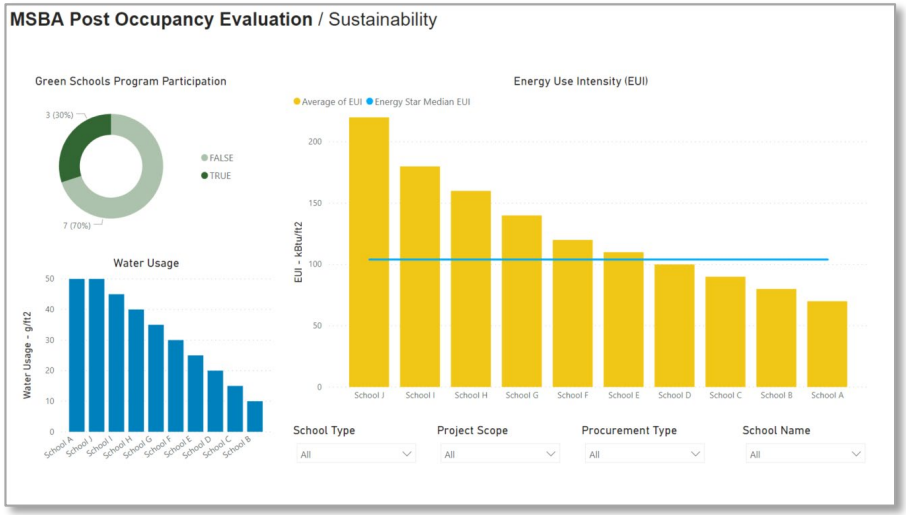
We recommend an interactive web-based dashboard to view summarized data from the POE database.

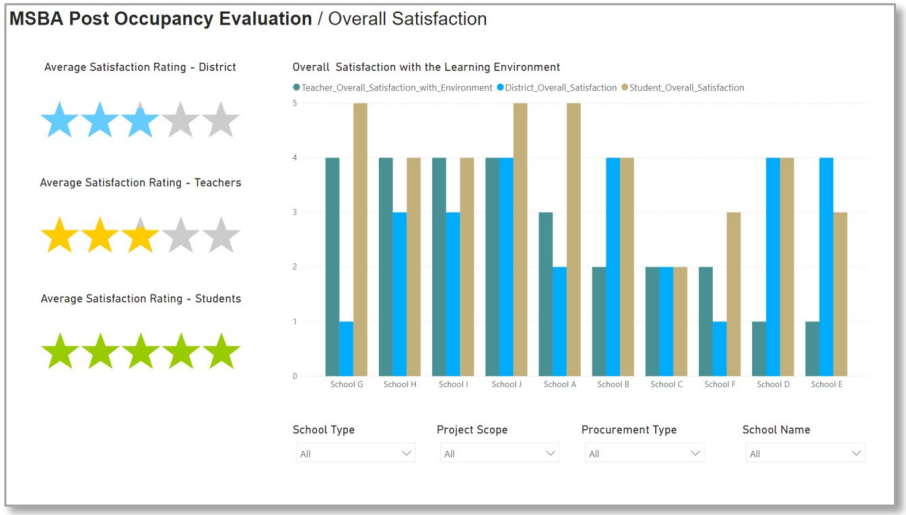
The example mockups shown here are created in Power BI and can be implemented using Excel as the underlying database, with a real-time live link between the database and the dashboard.

Each page can be filtered to include results from all schools, or specific schools.

Create a page for each major category of the POE: e.g. maintenance, square footage, etc.







Images: Example screen shot of dashboard mockup

Standard Building POE Report Template

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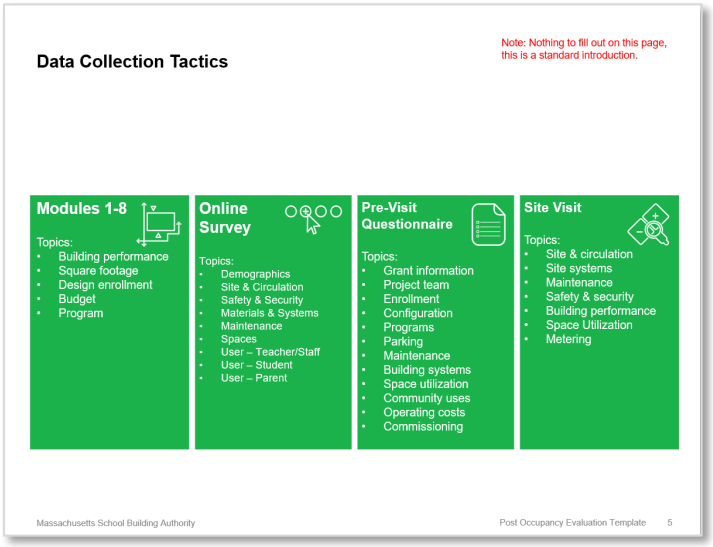
Standard Building POE Report Template

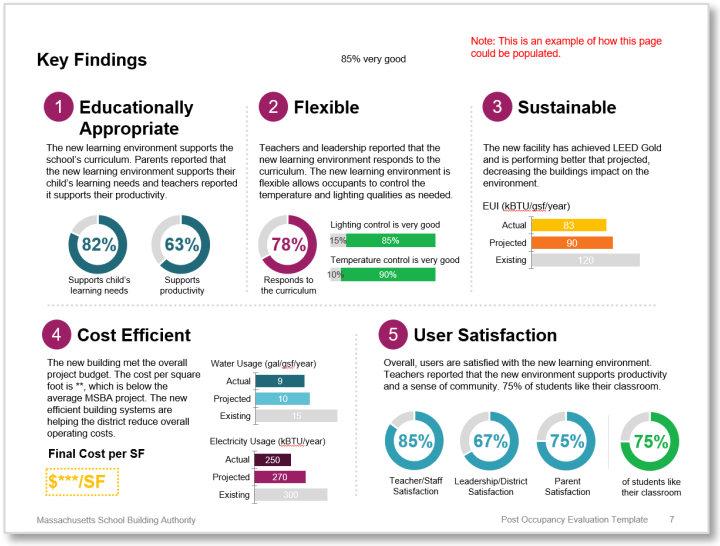
A standard building POE report template has been developed in PowerPoint for the MSBA can utilize for all POEs moving forward.

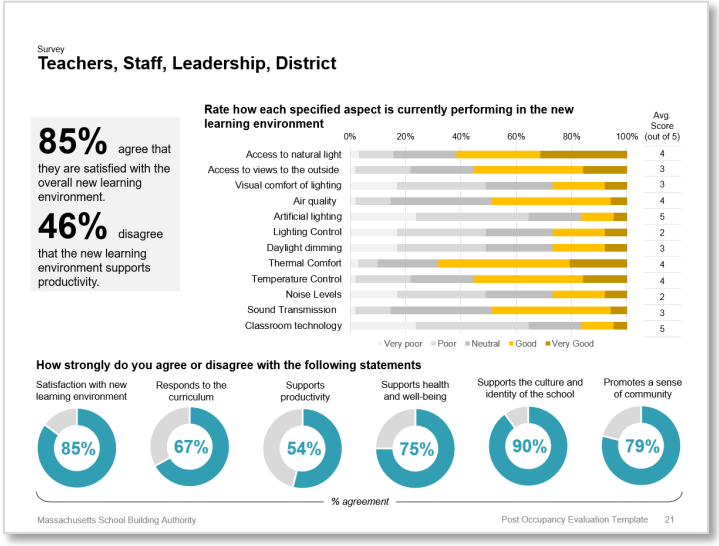
The template will allow the MSBA to report back to the districts after POE efforts are completed.

The report incorporates the findings from the four data collection tactics and summarizes findings in the beginning of the report.

See appendix for the complete template.







Images: Example screen shot of Standard Building POE Report Template

Conclusion & Next Steps

Post Occupancy Evaluations provide critical feedback to inform educationally appropriate, flexible, sustainable, and cost-effective buildings.

For the MSBA to accomplish this the following steps must be taken:

01
Approve and implement Module 9

02
Develop tools to implement the four data collection tactics

03
Capture data submitted during Modules 1-8 as part of the POE process

04
Create a central database with online dashboard for trend comparison

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Next Steps

1. Determine IT integration
2. Approval of the process
3. Refine the procurement strategy
4. Approval of Module 9
5. Select a survey platform
6. Develop online survey from the questions provided
7. Develop the summary calculations to summarize the raw survey data

Appendix