Monitoring Based Commissioning Program

2014 Higher Education/IOU Partnership

Final Baseline Assessment Report

Humboldt State University

Gist Hall

Laurel Drive `

Arcata, CA 95521

Report by

kW ENGINEERING

ourevolution energy & engineering

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1 Introduction

Humboldt State University hired kW Engineering and Our Evolution, together the kW Team, to perform this study as part of the Higher Education / Investor Owned Utility MBCx Partnership Program. The goals of the MBCx program are the following:

- Establish the baseline energy use through whole building monitoring
- Enhance the control and operation of existing equipment
- Document operational and capital modifications to reduce energy use
- Implement low and no cost modifications
- Implement capital modifications through future funding
- Perform ongoing monitoring to ensure the persistence of savings in future years

This Baseline Assessment (BA) Report provides a description of the monitoring based commissioning (MBCx) investigation's initial findings for Gist Hall located at Humboldt State University in Arcata, CA. The document includes all deliverables associated with Phase 1of the MBCx process. The BA Report includes the following sections:

- General Facility Description
- Scope of the MBCx Project
- Description of the Systems Evaluated, Controls and Initial Findings
- Historical Energy Use Analyses and Benchmarking

The appendices include:

- Meeting Minutes from the MBCx Project Kickoff Meeting
- The initial Findings Log - 4/29/2014
- Calibration check results from spot measurements performed April 8, 2014.
- Trends and loggers that have been set up to capture the baseline building operation.

In the next phase of the MBCx process we will download the collected trend data (Appendix 5.3 and 5.4) and analyze the data to determine energy savings and economics of the measures presented in the initial findings log (Appendix 5.2).

1.1 Project Contacts

The project team for this building is shown in the table below:

Table 1.1: Primary Facility and Project Contacts

Name/Title	Role	Organization	Contact Information
Silas Biggin, PE, CEM	Chief Engineer / Project Manager	Humboldt State University	(707) 826-5899 Silas.Biggin@humboldt.edu
Mike Fisher	University Planner	Humboldt State University	(707) 826-4111 Michael.Fisher@humboldt.edu
Craig West & Brad Paz	Facility Operators	Humboldt State University	wcw7001@humboldt.edu brad.paz@humboldt.edu
Arik Cohen, PE Eric Martin	MBCx Agents	kW Engineering	(510) 834-6420 cohen@kw-engineering.com emartin@kw-engineering.com
Andy Sorter, PE, LEED AP Scott Willits	MBCx Agents	OurEvolution	(707) 633-4210 andy@ourevolution.com scott@ourevolution.com

2 Facility Description

2.1 Facility Description

Gist Hall is a two-story, 48,562 square foot concrete building originally constructed in 1932. The building houses offices, classrooms, studios, a computer lab, a small theater, a student-run radio station, and audiovisual production studios. Although there are only two main floors, the building also contains an occupied basement and a mezzanine over the second floor.

Figure 2.1: Building Arial View (source: google.com)

Building Occupancy

According to Facility staff, the building is typically occupied from 8 AM to 6 PM Monday through Friday. However, scheduling is sometimes extended due to specific class and event schedules. According to obtained control sequences, the ventilation systems serving Gist Hall are enabled from 5 AM to 6 PM. The heating hot water system at Gist Hall also serves Jenkins Hall and Science A, which requires the boilers and hot water pumps to operate from 5 AM to 12 PM. The All system are off on weekends and on from 8 am to 10 am on holidays.

Building Documentation

All plan sets and drawings, including original construction and renovations, are available online via HSU FacilitiesLink. Initial review of the information provided for Gist Hall indicates that a complete set of mechanical and electrical drawings are available.

As part of the initial site investigation, the kW Team evaluated all points lists and logic control documentation provided for the building automation system (BAS). These diagrams and points lists were compared to the actual control sequences contained in the existing BAS software. Discrepancies between the BAS documentation and existing control logic found within the BAS were noted for further investigation and optimization as part of the larger MBCx process.

3 Scope of Services

3.1 MBCx Scope

The objective of this MBCx project is to:

- Pinpoint deficiencies in existing energy-consuming systems and related controls
- Identify potential optimization strategies for these systems
- Assist the owner in implementing corrective actions, operational and maintenance (O&M) improvements, and energy conservation measures (ECMs, or measures) that optimize existing equipment and produce sustainable reductions in energy consumption and demand.
- Verify the implementation of measures and perform ongoing monitoring to ensure the persistence of savings in future years

To achieve these objectives, the kW Team conducts comprehensive on-site investigations and analysis to identify and document cost-effective energy savings opportunities.

3.2 Description of Systems Evaluated

Lighting Systems

The lighting systems at Gist Hall are generally comprised of a combination of T-8 linear fluorescent lamps in recessed troffer style fixtures. The lighting in many of the classrooms and office spaces has been upgraded to direct/indirect T8 linear fluorescent light fixtures.

Several of the private offices and classrooms have occupancy sensors, but most of the building's lights are operated manually and are not programmed to perform nightly sweeps.

At night, the custodians manually turn off hallway fixtures. In order to better understand the daily pattern of lighting use, the kW Team installed data loggers on the main lighting panel controlling common area lighting. According to building operators, exterior lighting is controlled by both photosensors and timers.

Ventilation

Six built-up air handlers provide heating and ventilation to the building.

The two main air handlers (AH-1 and AH-2), located in the first floor mechanical room, are constant volume, dual duct systems equipped with VFDs on the supply and return fans. Supply fan VFD speed is programmed to increase from 90% to 95% as outside air temperature increases in order to provide more ventilation. The hot and cold decks are supplied a mixture of outdoor air (OA) and return air (RA) by a single supply fan. AH-1 and AH-2 share a common mixing box, with OA and EA dampers on either side. We noted that OA and EA dampers open and close together. AH-1's return fan was noted as operating at 100% speed. This may be caused by improper damper operation. This control issue will be further investigated in upcoming phases of the MBCx process and documented in the Phase 6 Deliverable; MBCx Improvement Options Report.

We observed a relatively high pressure drop across the supply air filters (roughly 0.4 IWG) for both AH-1 and -2.

AH-3 and AH-4 are smaller, single-duct, constant volume, built up air handlers, located in the first floor mechanical room. AH-4 draws “outside air” from AH-1 and AH-2 mixing box. We observed the pneumatic signal was forcing the actuators on the exhaust and return dampers to close at the same time. This control malfunction causes severe flow restriction after the return fan, a condition known as “dead head”. This control issue will be further investigated in upcoming phases of the MBCx process and documented in the Phase 6 Deliverable; MBCx Improvement Options Report.

AH-3 is located in the same mechanical room as AH-1, -2, and -4 but has its own, separate OA intake. AH-3 has EA and RA dampers, but no OA dampers (i.e., no control over incoming outside air). During the site visit, the EA and RA dampers were both fully open. Further investigation revealed a broken actuator on the RA damper. Considering the size and flow of OA relative to RA, we suspect that installing an OA damper may help reduce gas consumption, especially during building warm-up.

AH-5 is a small, single duct, constant volume built up air handler that is located in the basement ceiling and serves the basement rooms. The units OA, RA, and EA dampers are controlled pneumatically. AH-5 is difficult to access, which prevented a detailed investigation of this unit during the site visit.

AH-6 is a smaller, single-duct, constant volume, built up air handler, located in the second floor mechanical room. We observed the supply filters were not securely fitted, and had a pressure drop of about 0.25 IWG. We also observed the RA and EA dampers fully open at the same time that the hot water valve was fully open. This condition indicates a control malfunction.

Damper controls on AH-3 through -6 are served by a single 2 hp air compressor. In addition to the above-mentioned issues with the damper controls on AH-2, -3 and -6, we found several leaks in the pneumatic lines. For these reasons, the kW team installed a data logger to monitor compressor operation for a better understanding of the pneumatic control system.

Table 3.1: Air Handler Inventory

Air Handler	Area Served	Air Volume [CFM]	Supply Fan Size [hp]	Configuration
AH-1	East Side 1st and 2nd Floors	14,140	15	Dual Duct, CV
AH-2	West Side 1st and 2nd Floors	18,260	20	Dual Duct, CV
AH-3	Theater (217, 219 A-D)	6,600	5	Single Duct, CV reheat
AH-4	A/V and Radio Studios	2,530	2	Single Duct, CV reheat
AH-5	Basement Rooms 1A/B & 2	4,450	5	Single Duct, CV reheat
AH-6	Rooms 102, 104, 202, 203, 205	6,860	5	Single Duct, CV reheat
		52,840	160	240

Cooling

The majority of Gist Hall does not have mechanical cooling. A 4 ton DX AC unit provides cooling to the computer lab. An additional three 4 ton AC units are installed and operational, but are currently not used.

Heating

Heating hot water is provided by two 3,000 MBtuh Unilux gas-fired hot water boilers. The hot water is circulated by three 7.5 hp Taco pumps (220 GPM, 75 feet TDH) that are equipped with VFDs. Boilers and pumps are locked out when outside air temperature is measured over 68 °F.

The hot water pumps are staged to maintain a 5 psi differential pressure in the Science A loop. It appears that the VFDs speeds are controlled in unison, also to maintain 5 psi.

The boilers are currently operated to supply 170°F heating hot water to Gist Hall, Jenkins Hall, and the east side and fifth floor west side of Science A. Although Gist hall closes at 6 PM, the boilers operate until 11 PM to provide heating for Science A labs. Only one class at Jenkins Hall is currently occupied. The kW team installed data loggers to monitor the boiler fans, hot water circulation pumps, and hot water supply/return temperature on the Jenkings/Science A loop to better understand the heating hot water system.

Figure 3.1: Two Unilux Heating Hot Water Boilers

We noted one boiler in operation and flow through both boilers during our site visit. Supply water temperature to the building was measured at 140 °F.

Domestic hot water is provided by an natural gas Rheem 100-gallon commercial hot water heater operated at 140°F.

3.3 Description of Site Controls and Trending Capability

The control system at Gist hall features a ConrolPAK® Building Automation and Control System with direct digital controls (DDC). All boilers, VFDs, heating hot water valves, and circulation pumps are equipped with DDC and controlled by the BAS. The building's thermostats, mixing boxes, and valve actuators are controlled pneumatically.

The control system has trending capabilities for all monitored points. Prior to our initial site visit, the whole building energy use was being monitored in hourly and daily intervals for approximately three years.

3.4 Description of New Monitoring Capabilities

As part of the MBCx process, the kW Team has initiated 15 minute trends of most of the I/O information provided via the BAS. This volume of trending is not anticipated to be a permanent feature of the BMS due to the burden it places on the control system CPU and RAM. Permanent monitoring and trending of key parameters will be developed as part of the larger MBCx process. In addition to the new trendlogs, the Team has installed temporary data loggers on the main corridor lighting, boiler fans, supply and return hot water lines to Jenkins/Science A, the air compressor, and boiler pump VFDs. Results from this logging effort will inform the larger trending and control strategies to be developed during the MBCx process.

4 Historic Energy Use

4.1 Annual Energy Use

This section provides a review of historical electricity consumption (kWh), and natural gas consumption (therms).

Electricity Consumption

The following figure shows the average 12-month electricity consumption history at this site based on whole building energy data provided via the BMS trends.

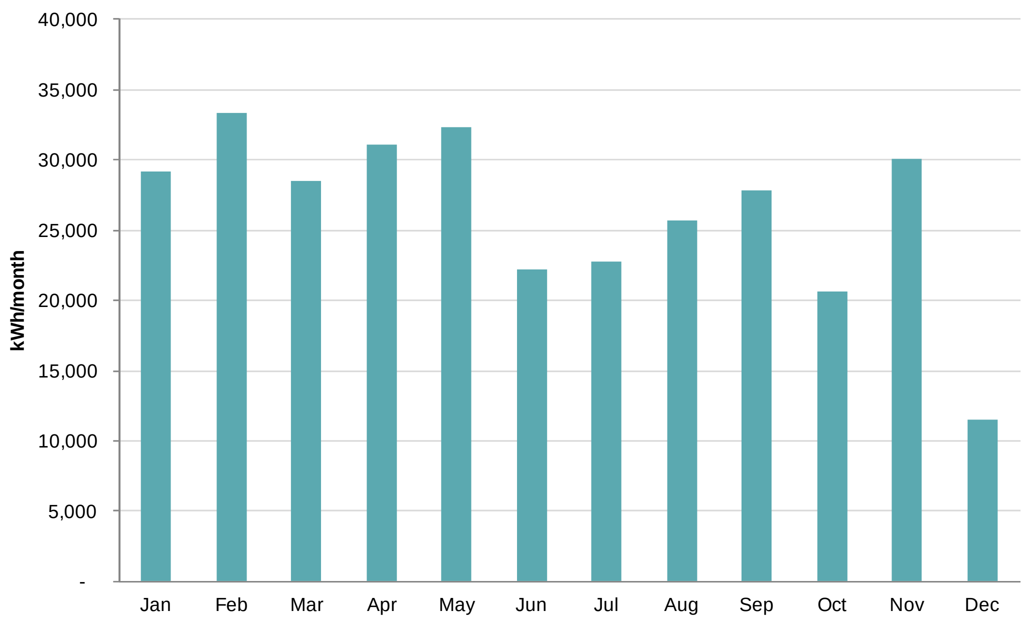

Figure 4.1: Monthly Electricity Consumption

This figure shows that this site has fairly consistent electricity use throughout the school year, with lower usage between semesters (December) and during the summer months. The steady monthly usage is due to relatively moderate weather conditions and the absence of mechanical cooling in most of the building.

Natural Gas Consumption

The following figure shows the 12-month gas consumption history at this site based on whole building energy data provided via the BMS trends.

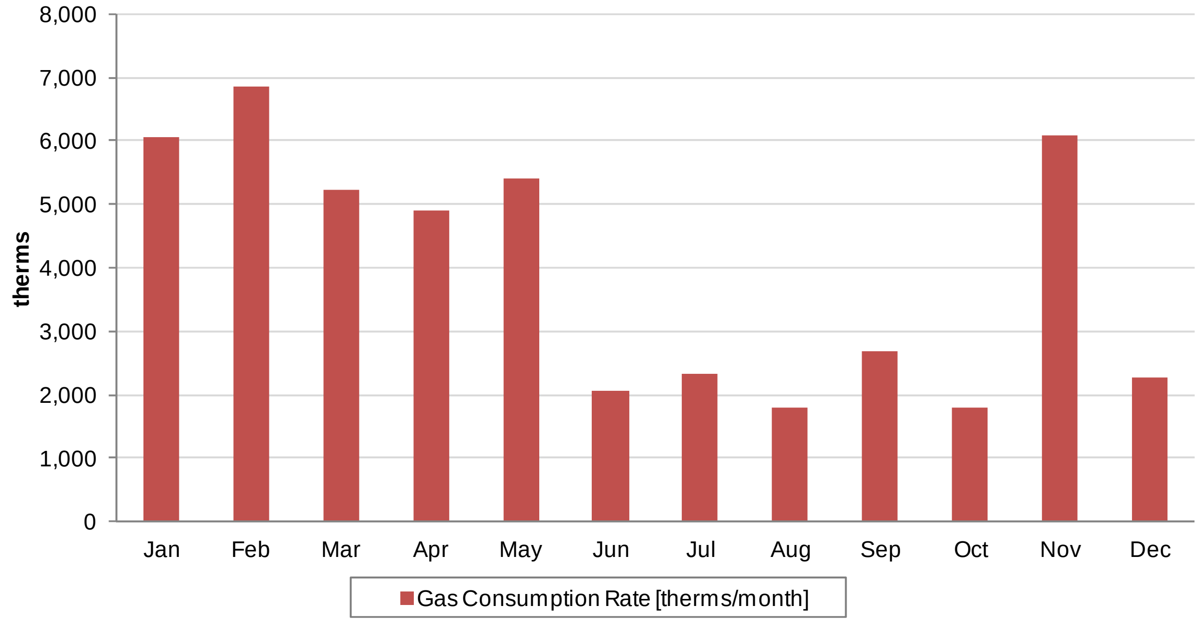

Figure 4.2: Monthly Natural Gas Consumption

Gas at Gist Hall is used primarily for heating hot water boilers that serve the two large dual duct air handlers (AH-1 and AH-2) and the single-zone terminal box reheat coils. The boilers also provide heating hot water for Jenkins Hall and the west side of Science A. This figure shows that this site has fairly consistent gas use throughout the school year, with lower usage between semesters (December) and during the summer months.

4.2 Annual Energy Cost

The total annual cost of energy at Gist Hall is $91,684 assuming $1.00/therm and $0.14/kWh. The annual cost is based on university commodity costs received May 6, 2014.

Table 4.1: Annual Energy Cost and Usage Summary

Utility	Annual Consumption	Annual Cost	Average Cost	Rate Schedule
Electricity	315,461 kWh	$44,164	$0.14/kWh	SE20P
Natural Gas	47,520 Therms	$47,520	$1.00 Therms	NRG1

4.3 Benchmarking

Benchmarking compares the energy use of a facility to those of similar size and purpose. The energy use is compared on a "per square foot" basis to enable comparisons of different sized buildings.

The Commercial End Use Survey (CEUS) benchmark uses average annual energy use intensity from the 2006 Commercial Building Survey Report[1] in different climate zones of California. The figure below shows how recent annual energy use at Gist Hall compares with CEUS data for educational buildings. In the figure, a lower percentile indicates lower energy use relative to other University buildings.

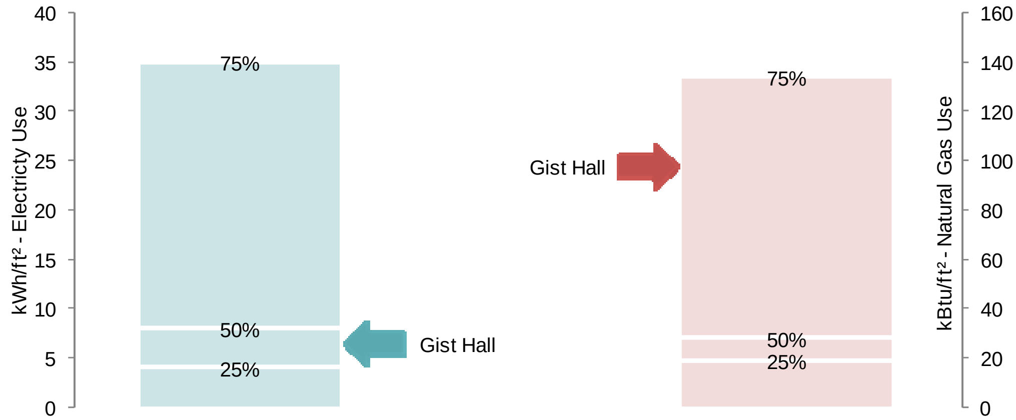

Figure 4.3: Benchmark compared to CEUS data

The electric consumption is a bit lower than average. This is not surprising considering that site is being compared to other sites that have active electric cooling.

[1] California Commercial End-Use Survey, Itron, Inc., March 2006, CEC-400-2006-005, http://www.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF

5 Appendices

5.1 MBCx Kickoff Meeting Minutes

Investigation Phase Kick off Meeting Minutes

2014 Higher Education / Investor Owned Utility Partnership Programs

Gist and Founders Hall, Humboldt State University

Present:

Name/Title	Role	Organization	Contact Information
Silas Biggin, PE, CEM	Chief Engineer / Project Manager	Humboldt State University	(707) 826-5899 Silas.Biggin@humboldt.edu
Mike Fisher	University Planner	Humboldt State University	(707) 826-4111 Michael.Fisher@humboldt.edu
Brad Paz & Jeff Robison	Facility Operators	Humboldt State University	
TallChief Comet	Director of Sustainability	Humboldt State University	TallChief.Comet@humboldt.edu
Arik Cohen, PE Eric Martin	MBCx Agents	kW Engineering	(510) 834-6420 cohen@kw-engineering.com emartin@kw-engineering.com
Andy Sorter, PE, LEED AP	MBCx Agents	OurEvolution	(707) 633-4210 andy@ourevolution.com

cc: Traci Ferdolage (HSU), Mike Anderson (Newcomb Anderson McCormick), Scott Willits (OurEvolution),

By: Eric Martin

Date: April 8, 2014

Discussion

Meeting participants were introduced.

Arik Cohen summarized MBCx program structure and background information. Explained that the MBCx process is similar to retro-commissioning, and requires understanding design intent and how current operations relate to original design.

Arik Cohen presented the kick-off meeting PowerPoint presentation. The presentation also included discussion on topics from the meeting agenda developed by Silas. The presentation and following discussion covered the following topics:

1. Project Goals (in order of importance according to HSU personnel)
    a. On time and on budget
    b. HSU-specific deliverables
        i. Building Assessment Report

            Silas confirmed that this report could be taken directly from the first sections of the Baseline Report required by the MBCx program (aka the Phase 6 Deliverable; MBCx Improvement Options Report).

            1. . Sections will include benchmarking, facility description and historic energy usage.
    c. HSU Plant Ops staff to have complete understanding of building assessments, ECMs and improvements via the report and training.
    d. 20% savings, while maintaining or increasing indoor comfort with a focus on controls, operations and maintenance improvements rather than retrofits where possible.
    e. Project payback: 4.2 years
    f. Student involvement and curriculum development
        i. For student enrichment only, not required by contract. Opportunities and ideas for student involvement should be communicated with TC and/or Silas before going to professors/students.
        ii. Silas Biggin indicated that with the end of semester approaching, student involvement may be limited. Further, he stated that Plant Operations has no time or budget to manage students.
        iii. Mr. Fisher stated that the University understands and supports the potential enrichment opportunities of student involvement, however, he advised that this involvement should be tempered such that the project schedule and budget are not impacted.
        iv. TallChief Comet indicated that original budget for the HEIF interns that are currently doing VAV assessments is funded through the end of the semester and that funding for summer work for the existing interns would be discussed at HEIF's 4/11/14 meeting.
    g. Project Schedule

i. One year duration total

ii. 3 months of initial whole building trend data (15 minute electric, and hourly or 15 minute gas)

iii. After retrofit, monitor whole building for another 3 months

iv. Silas Biggin asked what the biggest schedule concern was.

1. Arik Cohen indicated that getting three months of accurate baseline data and acquiring the required three months of M&V data will tend to constrain the project.

2. Phase VII (Construction) is also a concern as HSU's procurement policy may cause delays. Cohen further stated that the kW team will be conscious of construction/procurement delays and to the extent possible try to specify upgrades that can be completed "in house" by HSU personnel.

3. Mr. Fisher indicated that the schedule was important, but that the schedule should not dictate the types of measures that were considered.

h. Team Roles and Responsibilities

i. Arik Cohen – Lead MBCx Agent, primary contact, manage day-to-day ops

ii. Andy Sorter – Oversee energy metering, lead diagnostics and functional performance testing

iii. Eric Martin and Scott Willits – Data collection/analysis, assist with deliverables

i. Communication Channels

i. Silas will be primary HSU contact with Traci Ferdolage as backup. Arik will be primary MBCx team contact with Andy as backup.

1. Arik will serve as the primary contact with NAM.

ii. TC will act as the main contact for student involvement.

iii. All building access should be scheduled through Silas.

j. Obstacles/Concerns

i. Baseline data: initiate trend or develop steps to obtain

ii. Be cognizant of timeline, ensure measures can be implemented within the allowable timeframe

iii. Any projects costing over $5,000 must go out to bid

1. HSU has a Job Order Contract in place

iv. Gist hall boilers provide heating hot water for one room in Jenkins hall as well as the entire east side and 5th floor west side of Science A

1. Gist hall closes at 6 PM but boilers provide heating for All of Jenkins Hall (only one room currently in use) and Science A which has labs running until 11 PM.

2. Silas would like kW Team to investigate energy savings opportunities involving the Science A heating loop.

Phase Deliverables Turnaround

Silas agreed to turnaround the required MBCx deliverables (with comments/feedback) for each phase as listed below.

- Phase 1: Initial Assessment (Building Assessment Report) – 2-3 days
- Phase 2: Draft MBCx plan – 10 days
- Phase 3: Updated MBCx plan and findings log – 5 days
- Phase 4: Diagnostic and Functional Testing – 5 days
- Phase 5: Analysis of Monitoring and Testing Results (Baseline Report) – 5 days
- Phase 6: Final MBCx Improvement Options Report – 10 days, potentially longer
    - This may be a phased approach, with no-brainer measures approved immediately and on-the-fence measures considered by a committee
- Phase 7: Implementation of MBCx Improvement (no deliverables by kW Team)
- Phase 8: Post-install Measurement, Verification and Documentation – 5 days
- Phase 9: Final MBCx Report – 10 days

Housekeeping

Access: Silas will issue key(s) for each visit (24-hour notice preferable).

Parking: Permits are available for each site visit. Request from Silas (72-hour notice preferable).

Hours of Operation: Buildings are occupied 8 AM to 5 PM. Engineers typically work 7 AM to 4 PM

Payment Procedure: Payment upon completion of phase deliverables (be sure to include contract #)

Scope Adjustments: Extra service proposals must be submitted and approved by Silas.

Existing Documentation and Data: Silas to provide web access to drawings via HSU FacilitiesLink

5.2 Initial Project Deficiency and Resolution (PDR) Log

We have attached the Initial PDR Log below and also as a separate Excel spreadsheet for easy review and comment.

Measure Tag	Measure Name	System Affected	Description of Deficiencies	Date of Finding	Recommended Improvement/Possible Issues	Status
RCx-1	Re-calibrate key BAS temperature sensors	Various	We performed spot measurements with stand alone loggers and compared values to those recorded by the BAS. We found that several BAS sensors are out of calibration.	4/8/2014	We have provided the university with a list of sensors that require calibration.	
RCx-2	New control sequence to control supply fan VFD speed	AH-1 and AH-2	Review of the existing control sequences indicate that the VFDs are reset based on measured outside air temperature between 90% and 95% speed .	4/8/2014	Recommend a control sequence that lowers the minimum speed while maintain occupant comfort and ventilation requirements. Control sequence will use outside air temperature, CO2 readings, and space temperature to reduce fan speed.	
RCx-3	Revise control of outside air and exahaust air dampers	AH-1 and AH-2	We observed that that OA and EA dampers open and close together. We also observed that the VFD on R/E1 was running at 100% speed.	4/8/2014	Revise controls so that when the OA damper opens that OE damper closes and visa-a-versa. This will reduce pressure drop and allow the return fan to operate at lower speeds.	
RCx-4	Optimized start on air handlers	All air handlers	All fans start operation at 5AM.	4/8/2014	Recommend an optimized start routine that determines fan start time based on space temperature. During warm-up mode, before occupants are in the building, shut outside air dampers and open return air dampers.	
RCx-5	Fix economizer damper control on AH-4.	AH-4	We observed the pneumatic signal was forcing the actuators on the exhaust and return dampers to close at the same time. This control malfunction causes severe flow restriction after the return fan, a condition known as "dead head".	4/8/2014	Revise controls so that when the OA damper opens that OE damper closes and visa-a-versa.	
RCx-6	Fix economizer damper control on AH-3	AH-3	We found the RA damper disconnected from it's actuator and no outside air damper.	4/8/2014	Reconnect RA damper. We will review air handler temperature trends to determine if installing an outside air damper makes financial sense.	
RCx-7	Fix economizer damper control on AH-6	AH-6	We found the RA and EA dampers fully open and no OA damper.	4/8/2014	Revise controls so that when the OA damper opens that OE damper closes and visa-a-versa. We will review air handler temperature trends to determine if installing an outside air damper makes financial sense.	
RCx-8	Install VFDs on AH-3,5, and 6 supply and return fans.	AH-3, 5, 6.	AH-3, 5, and 6 are constant volume single zone system.	4/8/2014	We will determine the cost effectiveness of installing VFDs on these systems and revising control to reduce fan speed when possible.	

Measure Tag	Measure Name	System Affected	Description of Deficiencies	Date of Finding	Recommended Improvement/Possible Issues
RCx-9	Isolate flow to lag boiler when off.	B-1 and B-2	We noted one boiler in operation with constant temperature setpoint of 170 °F and flow through both boilers during our site visit. Supply water temperature to the building after mixing was measured at 140 °F.	4/8/2014	When lag boiler is not in operation
RCx-10	Reset pressure differential setpoint controlling hot water pumps.	P-1,2,3	During the site visit we noted that 3 HW pumps were in operation, The VFDs on the hot water pumps are controlled to maintain a 5 psi differential setpoint as measured in Science A.	4/8/2014	Investigate a control sequence that resets the differential pressure to maintain the worst case hot water valve at 95% open.
RCx-11	Optimized control of comman area lighting		According to staff, common area lighting is turned off by facility staff at midnight.	4/8/2014	.We have installed current transducers on the lighting panels to determine if the lights are indeed turned off at night. Based on the data we may make a recommendation to automate the lighting control.
RCx-12	Daylighitng controls		We noted several classrooms with manual lighting controls only.	4/8/2014	Install day lighting controls in class rooms with abundant daylight.

5.3 Results of Calibration Check

We have attached the results of the calibration check preformed April 8, 2014 as a separate Excel spreadsheet.

Gist Hall Initial Building Assessment Data - BAS Calibration
Completed by Andy Sorter, P.E.
Field Dates: April 8-10, 2014
Data Entry: April 16, 2014

Overall BAS Accuracy (O)	4.03	Calculated
Assumed ETE Sensor Accuracy (S)	0.5	User defined
Overall Accuracy of the Calibrating Instrument (I)	4	User defined
Maximum Calibration Tolerance [C]	0.1	User defined

System	I/O Point	Point Description	BAS Value	Measured Value	Unit	Error	Pass/Fail	Comments
Bldg	AI13	OAT	45.1	56	F	-10.9	FAIL	Thermistor located in main OSA intake; corroded and covered in debris.
AHU-1	AI2	RAT	76.9	72	F	4.9	FAIL	
AHU-1	AI3	MAT	59.8	64	F	-4.2	FAIL	
AHU-1	AI4	SAT-HOT DECK	113.1	112	F	1.1	PASS	
AHU-1	NONE	SAT - COLD DECK		66	F	n/a	n/a	
AHU-2	AI5	RAT	72.4	72	F	0.4	PASS	
AHU-2	AI6	MAT	58.5	64	F	-5.5	FAIL	
AHU-2	AI7	SAT-HOT DECK	89		F	n/a	n/a	EM has data
AHU-3	AI24	RAT	70.2	70	F	0.2	PASS	
AHU-3	AI21	MAT	55.7	56	F	-0.3	PASS	
AHU-3		SAT			F	n/a	n/a	
AHU-3	AI33	219 ROOM TEMP	70.7	69	F	1.7	PASS	Thermostat labeled AI-1
AHU-3	AO4	219 HWV Position	3.4		V	n/a	n/a	0-10V
AHU-4	NONE	RAT		70	F	n/a	n/a	
AHU-4	AI22	MAT	58.6	66	F	-7.4	FAIL	
AHU-4	NONE	SAT		71	F	n/a	n/a	EM has data
AHU-4	AI38	109B ROOM TEMP	70.1	72	F	-1.9	PASS	Thermostat labeled AI-7, located next to exterior loading door with poor seals in theater
AHU-4	AO8	109B HWV Position	4.2		V	n/a	n/a	0-10V
AHU-5	AI-10	MAT	71.5	68	F	3.5	PASS	
AHU-5	AI9	2 ROOM TEMP	65.7	69	F	-3.3	PASS	
AHU-5	AO5	MAD	6		V	n/a	n/a	0-10V
AHU-5	AO6	HWV Position	5.7		V	n/a	n/a	0-10V
AHU-6	AI15	MAT	78.8	75	F	3.8	PASS	
AHU-6	AI11	205 ROOM TEMP	71.5	75	F	-3.5	PASS	Thermostat located in room with audio/video equipment and servers
AHU-6	AO12	HWV Position	8		V	n/a	n/a	0-10V
AHU-6	AI12	203 ROOM TEMP	66.1	74	F	-7.9	FAIL	Check AI12 vs. points list
AHU-6	AO11	HWV Position	10V		V	n/a	n/a	0-10V
AHU-6	AI14	104 ROOM TEMP	71.7	70	F	1.7	PASS	
AHU-6	AO9	HWV Position	10		V	n/a	n/a	0-10V
AHU-6		FAN FLOW		6035.4	CFM		PASS	Estimate based on average velocity of 335.3 ft/min and 18 SF flow area

5.4 BAS Trend List with Start Dates

Trendlog I.D.	Point	Description	Sample Interval	BAS Trendlog Begin	New/Existing Trend
TL 9	AI30	Whole Building Gas Meter	Hourly	12/1/2011	Existing
TL 11	AI30	Whole Building Gas Meter	Daily	11/30/2011	Existing
TL 12	?	Whole Building Electric Meter	Hourly	11/23/2011	Existing
TL 13	?	Whole Building Electric Meter	Daily	11/30/2011	Existing
TL 15, BMCx1	AI02	AH-1 RAT	15-Minute	4/10/2014	New
	AI03	AH-1 MAT			
	AI04	AH-1 HD Temp			
	AI05	AH-2 RAT			
	AI06	AH-2 MAT			
	AI07	AH-2 HD Temp			
	AI08	AH-2 Room Temp (#4)			
	AI09	AH-5 Room Temp (#2)			
TL 16, BMCx2	AI10	AH-5 MAT	15-MInute	4/10/2014	New
	AI11	AH-6 Room Temp (#205)			
	AI13	OAT			
	AI15	AH-6 MAT			
	AI18	Aud Room Temp (#219)			
	AI21	AH-3 MAT			
	AI23	AH-6 Room Temp (#102)			
TL 17, BMCx3	AI24	AH-3 RAT	15-Minute	4/10/2014	New
	AI25	AH-3 SAT			
	AI27	Room Temp (#215)			
	AI28	Boiler HWR			
	AI29	Boiler HWS			
	AI34	Room Temp (#219C)			
	AI37	Room Temp (#109)			
	AI39	CO2			
TL 18, BMCx4	AI 44	Building Static Pressure	15-MInute	4/10/2014	New
	AI 45	AH-1 HD CFM			
	AI 46	AH-2 HD CFM			
TL 19, BMCx5	AO01	AH-1 MA Dampers	15-Minute	4/10/2014	New
	AO05	AH-5 MA Dampers			
	AO13	AH-3 MA Dampers			
	AO14	AH-4 MA Dampers			
	AO21	AH-1 Supply Fan VFD			
	AO22	AH-2 Supply Fan VFD			
	AO23	RF-1 Return Fan VFD			
	AO24	HWP 1,2,3 VFD			
TL 20, BMCx6	DO03	AH-3 S/S - TC-3	15-Minute	4/10/2014	New
	DO04	AH-4 S/S - TC-4			
	DO05	AH-5 S/S - TC-5			
	DO06	AH-6 S/S - TC-6			
	DO19	Boiler #1 S/S - TC-24			
	DO20	Boiler #2 S/S - TC-25			

5.5 Stand Alone Logger Installation with Start Date

Hobo Data Logger I.D.	Location	System Parameter	Sample Interval	Logging Start Date	1st Download
1	Boiler Room	Boiler #1 Blower	1-Minute	4/10/2014	4/21/2014
?	Boiler Room	Boiler #2 Blower	1-Minute	4/10/2014	4/21/2014
49	Boiler Room	HWP-1	1-Minute	4/10/2014	4/21/2014
68	Boiler Room	HWP-2	1-Minute	4/10/2014	4/21/2014
10	Boiler Room	HWP-3	1-Minute	4/10/2014	4/21/2014
32	Main Mechanical Room	Air Compressor	1-Minute	4/10/2014	4/21/2014
77	Boiler Room	Science A Supply HHW	1-Minute	4/21/2014	-
80	Boiler Room	Science A Return HHW	1-Minute	4/21/2014	-
86	Main Floor Corridor, Panel E	Corridor Lighting	1-Minute	4/21/2014	-
84	Main Floor Corridor, Panel E	Corridor Lighting	1-Minute	4/21/2014	-