RESPONSE
TO RFP

RETRO-COMMISSIONING SERVICES

State of Iowa
Dept. of Administrative Services

RFP1821005278

Proposal for Retro-Commissioning Services

SystemWorks LLC
Commissioning Sustainable Buildings

SystemWorks LLC | 409 Fifth Street, West Des Moines, IA 50265 | **phone:** 515.975.0575 | **fax:** 515.255.1155

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May 21, 2021

Bobbi Pulley
Iowa Department of Administrative Services
Hoover State Building – Level 3
1305 East Walnut
Des Moines, IA 50319-0105

RE: RFP1821005278 Retro-Commissioning Services

Dear Ms. Pulley and the DAS Team,

Thank you for the opportunity to present our qualifications for this project. We are a large, local firm, with experience working for the State of Iowa on new construction projects as well as existing buildings. We have staff based in Des Moines and the Quad Cities, and we are well suited to serve multiple State Agencies.

Our team has read the RFP and associated addendums, asked clarifying questions, and prepared this Technical Proposal to give the evaluation committee detailed information about our ability to provide the best value to the State.

SystemWorks is an independent third party firm, so you can trust that our analysis and recommendations are not influenced by a desire to sell products or design services. Our recent work at the Oran Pape building is an example of our data-centric approach to a challenging building. When the window replacement project started in 2019, we were selected to provide building enclosure testing and commissioning. We recognized that some of the symptoms the building displayed were likely caused by the mechanical system, and through an investigation determined that was indeed the case. The building was operating under a negative pressure and not always providing ventilation air due to a design issue with the ventilation air ductwork. A temporary programming change was implemented immediately to bring in ventilation air, and new ductwork was installed to permanently resolve the issue.

Our team has a track record of delivering results. At the Iowa Events Center, the implementation of our recommended improvements saves more than $150,000 annually – savings which have been validated through measurement and verification. While energy savings and operational efficiency are key deliverables, our team is also keenly aware that occupant comfort drives productivity, and can be a significant intangible benefit from Retro-Commissioning.

I am confident we will continue to provide the level of quality the State has come to expect from SystemWorks. I will be the State's primary contact, and will have support from the team members identified in this response and others within our organization. Thank you again for the opportunity; please contact us if you have questions.

Sincerely,

Andrew Bennett

Andrew Bennett, PE, CCP
Principal
515-975-0575
Fax: 515-255-1155
Andrew.Bennett@SystemWorksLLC.com

SystemWorks, LLC
409 Fifth Street
West Des Moines, IA 50265

Exhibit 2 – Executive Summary

This proposal is submitted in response to RFP1821005278 Retro-Commissioning Services. Based on our industry experience, SystemWorks is uniquely qualified to provide valuable Retro-Commissioning Services to the State. SystemWorks will comply with RFP Specifications stated in Section 4, Contract Provisions in Section 6, and all Addendums. SystemWorks understands the expected scope of work and will maintain a quarterly review schedule of RFP requirements to ensure compliance.

Exhibit 3 – Firm Proposal Terms

SystemWorks guarantees that the services offered in this proposal are currently available with sufficient resources, and that all Proposal terms listed in the Technical Proposal and Cost Proposal will remain firm for 120 days as indicated in the RFP. Per Section 6.3.5, a sample Service Ticket is included below:

Summary Description of Service

Customer P.O. Number: 25692 **4/15/2021**

Customer Name: ____

Job Name: Metasys /Building Set up /Troubleshooting and Repairs

Job Location: ____

Description of Work Performed:

4/15/21 Met onsite to assist in training of setting up building schedules. Occupied AHU-2 that serves the 1st floor. Ran summary of VAV's and discussed air flows that properly to building personnel. Discussed building pressure sensor reading issues. Recommended verification of building pressure control. Resent contact info to contractor.
4/21/21 Working on quote for repairs on 2 VAV's, AHU-2 building pressure control and AHU equipment labeling.
4/22/21 Repairs quote sent. Also discussed chiller loading requirements.
4/28/21 Corresponded about scheduling.
5/3/21 Worked on AHU-1 and 2 Labeling issues. Corrected labeling discrepancies. Reviewed chiller reguirements and SystemWorks retro Cx report. Also worked on reviewing how to split the 1st and 2nd Flr scheduling.

Summary of Work Performed (Note): Metasys Training_Scheduling_List of issues_

Job Complete: YES ☑ NO ☐ **Percent Complete:** ____

Material Summary

Qty		Cost

Labor Summary

Date	Travel	Reg	OT	Initials	Miles
4/15/21		4.5			
4/21/21		0.5			
4/22/21		1			
4/28/21		0.5			
5/3/21		3			

Prepared By:

5/3/21
SystemWorks, Name and Date

Reviewed By:

Customer, Name and Date

Exhibit 4 – Respondent Background Information

SystemWorks LLC is a limited liability company registered with the Office of the Iowa Secretary of State. SystemWorks was incorporated in 2003 in the state of Iowa and is a registered contractor with the Iowa Division of Labor (C101400).

SystemWorks is based in West Des Moines, with two remote employees in eastern Iowa. Our firm has the resources and tools necessary to perform this retro-commissioning work in-house and will not utilize any subcontractors.

The contractual and technical contact for this work will be: Andrew Bennett, PE, CCP, Principal, 409 5th St, West Des Moines, IA 50265, 515-975-8251, andrew.bennett@systemworksllc.com

SystemWorks has maintained a business banking relationship with Bank of the West since its inception and utilizes the accounting firm Welgaard CPAs.

For a financial reference, please contact: Lance Dieleman, CPA, Welgaard CPA, 8550 New York Avenue, Urbandale, IA. (515) 253-0099, LDieleman@welgaardcpa.com

Exhibit 5 – Letters of Reference

Three clients provided Letters of Reference in support of SystemWorks technical skills, communication, and results. Cara Kennedy, the VP of Sustainability for JLL based in Chicago, worked with Andrew Bennett and Zack Valigosky on several LEED for Existing Buildings projects on the Principal Campus in downtown Des Moines.

Harold Peterson, the Operations Manager of the Iowa Events Center worked with Jordon Crouse and Zack Valigosky when SystemWorks retro-commissioned the Wells Fargo Arena, HyVee Hall, and Community Choice Credit Union.

Adam Springer, a Senior Project Manager with JLL, leads build-out projects for Principal Financial Group in properties across the country. SystemWorks has partnered with JLL to provide existing building commissioning for offices in Minneapolis, Indianapolis, Lansing, Charlotte, and several other cities. The HVAC systems in these properties have ranged from pneumatic controlled VAVs to water-sourced heat pumps, and the end result has been a consistent comfort and controllability across Principal's entire portfolio.

These letters are included on the following pages.

OFFICE LOCATION

SystemWorks LLC
409 Fifth Street
West Des Moines, IA 50265

PRINCIPALS

Rick Boozell, CCP, LEED AP
Certified Commissioning Professional
TABB Certified Supervisor

Andrew Bennett, PE, CCP
Certified Commissioning Professional

HISTORY

Founded in 2003

18 Professional and Technical Staff
Professional Engineers
Mechanical Engineers
Controls Engineers and Technicians
Master State Licensees
  HVAC, Refrigeration, Hydronics,
  Electrical and Plumbing
TAB Certified Supervisors and Technicians

SERVICES

Commissioning
Mechanical/Electrical Systems Commissioning
Building Enclosure Commissioning
Retro-Commissioning
Continuous Commissioning

Facility Analysis
Energy Audits
Energy Modeling
Utility Bill Analysis and Benchmarking
Trend Data Analysis
Thermal Imaging
Indoor Air Quality Testing

Testing, Adjusting and Balancing
Air and Hydronics
Flow Meter Calibrations
Duct & AHU Leakage Testing

ABOUT SYSTEMWORKS

SystemWorks LLC is an independent, third-party commissioning firm. Over the past 18 years in business, SystemWorks has engaged in over 300 sustainable/retro-commissioning projects in Central Iowa. SystemWorks employs 18 professional and technical staff members with an average of 16 years of experience in the industry.

We deliver buildings that work.

SystemWorks offers certified testing, adjusting and balancing services, building envelope commissioning, facility analysis, energy modeling, utility bill and trend data analysis, thermal imaging, and indoor air quality testing.

RETRO-COMMISSIONING HISTORY

Since our inception, troubleshooting problem buildings and making them work correctly has been a core competency. Our team has provided RCx for private corporations, private colleges, State of Iowa properties like the Oran Pape Public Safety Building, 8th Judicial, and the Iowa Lottery Headquarters, and more.

FIRM ACCREDITATIONS

Three of our Commissioning Agents hold a Certified Commissioning Professional (CCP) credential. SystemWorks is a Certified Commissioning Firm (CCF), accredited by the Building Commissioning Association (BCA). The BCA offers nationally recognized certification through the independent Building Commissioning Certification Board. SystemWorks is also a certified testing, adjusting and balancing firm by the Testing, Adjusting, and Balancing Bureau (TABB). TABB is endorsed by SMACNA and their certification process is ANSI-accredited (ISO Standard 17024).

AFFILIATIONS

Our company is a member of the U.S. Green Building Council, Building Commissioning Association, Association of Energy Engineers, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Allied Gold Member of the AIA Iowa Chapter, Air Barrier Association of America, Sheet Metal and Air Conditioning Contractor's National Association, and Testing, Adjusting and Balancing Bureau.

Form **W-9** (Rev. October 2018) Department of the Treasury Internal Revenue Service

Request for Taxpayer Identification Number and Certification

▶ Go to *www.irs.gov/FormW9* for instructions and the latest information.

Give Form to the requester. Do not send to the IRS.

Print or type. See **Specific Instructions** on page 3.

1 Name (as shown on your income tax return). Name is required on this line; do not leave this line blank.

SystemWorks LLC

2 Business name/disregarded entity name, if different from above

3 Check appropriate box for federal tax classification of the person whose name is entered on line 1. Check only **one** of the following seven boxes.

☐ Individual/sole proprietor or single-member LLC ☐ C Corporation ☐ S Corporation ☐ Partnership ☐ Trust/estate

☑ Limited liability company. Enter the tax classification (C=C corporation, S=S corporation, P=Partnership) ▶ S

Note: Check the appropriate box in the line above for the tax classification of the single-member owner. Do not check LLC if the LLC is classified as a single-member LLC that is disregarded from the owner unless the owner of the LLC is another LLC that is **not** disregarded from the owner for U.S. federal tax purposes. Otherwise, a single-member LLC that is disregarded from the owner should check the appropriate box for the tax classification of its owner.

☐ Other (see instructions) ▶

4 Exemptions (codes apply only to certain entities, not individuals; see instructions on page 3):

Exempt payee code (if any)

Exemption from FATCA reporting code (if any)

(Applies to accounts maintained outside the U.S.)

5 Address (number, street, and apt. or suite no.) See instructions.

P. O. Box 65722

Requester's name and address (optional)

6 City, state, and ZIP code

West Des Moines, IA. 50265

7 List account number(s) here (optional)

Part I Taxpayer Identification Number (TIN)

Enter your TIN in the appropriate box. The TIN provided must match the name given on line 1 to avoid backup withholding. For individuals, this is generally your social security number (SSN). However, for a resident alien, sole proprietor, or disregarded entity, see the instructions for Part I, later. For other entities, it is your employer identification number (EIN). If you do not have a number, see *How to get a TIN,* later.

Note: If the account is in more than one name, see the instructions for line 1. Also see *What Name and Number To Give the Requester* for guidelines on whose number to enter.

Social security number

– –

or

Employer identification number

86 – 1070223

Part II Certification

Under penalties of perjury, I certify that:

1. The number shown on this form is my correct taxpayer identification number (or I am waiting for a number to be issued to me); and
2. I am not subject to backup withholding because: (a) I am exempt from backup withholding, or (b) I have not been notified by the Internal Revenue Service (IRS) that I am subject to backup withholding as a result of a failure to report all interest or dividends, or (c) the IRS has notified me that I am no longer subject to backup withholding; and
3. I am a U.S. citizen or other U.S. person (defined below); and
4. The FATCA code(s) entered on this form (if any) indicating that I am exempt from FATCA reporting is correct.

Certification instructions. You must cross out item 2 above if you have been notified by the IRS that you are currently subject to backup withholding because you have failed to report all interest and dividends on your tax return. For real estate transactions, item 2 does not apply. For mortgage interest paid, acquisition or abandonment of secured property, cancellation of debt, contributions to an individual retirement arrangement (IRA), and generally, payments other than interest and dividends, you are not required to sign the certification, but you must provide your correct TIN. See the instructions for Part II, later.

Sign Here Signature of U.S. person ▶ Andrew Bennett Date ▶ May 21,2021

General Instructions

Section references are to the Internal Revenue Code unless otherwise noted.

Future developments. For the latest information about developments related to Form W-9 and its instructions, such as legislation enacted after they were published, go to *www.irs.gov/FormW9.*

Purpose of Form

An individual or entity (Form W-9 requester) who is required to file an information return with the IRS must obtain your correct taxpayer identification number (TIN) which may be your social security number (SSN), individual taxpayer identification number (ITIN), adoption taxpayer identification number (ATIN), or employer identification number (EIN), to report on an information return the amount paid to you, or other amount reportable on an information return. Examples of information returns include, but are not limited to, the following.

- Form 1099-INT (interest earned or paid)
- Form 1099-DIV (dividends, including those from stocks or mutual funds)
- Form 1099-MISC (various types of income, prizes, awards, or gross proceeds)
- Form 1099-B (stock or mutual fund sales and certain other transactions by brokers)
- Form 1099-S (proceeds from real estate transactions)
- Form 1099-K (merchant card and third party network transactions)
- Form 1098 (home mortgage interest), 1098-E (student loan interest), 1098-T (tuition)
- Form 1099-C (canceled debt)
- Form 1099-A (acquisition or abandonment of secured property)

Use Form W-9 only if you are a U.S. person (including a resident alien), to provide your correct TIN.

If you do not return Form W-9 to the requester with a TIN, you might be subject to backup withholding. See What is backup withholding, *later.*

Cat. No. 10231X Form **W-9** (Rev. 10-2018)

May 17th, 2021

Recommendation of SystemWorks, LLC.

To Whom it May Concern,

SystemWorks is an excellent candidate for Retro-Commissioning Services for the State of Iowa. I am writing this recommendation to show my enthusiastic support of their proposal to be a qualified service provider.

JLL has worked with SystemWorks in many capacities, I have personally worked with them for the past five years. In our most recent project, SystemWorks led and managed the ASHRAE Level II Audit, Retro-Commissioning Program, Refrigerant Calculations, ASHRAE 62.1 compliance and more for a 500,000 square foot Class-A office building in downtown Des Moines. They kicked off the project less than one week from being awarded in order to support the client's preferred timeline. They maintained communication and status updates with the greater team throughout the 7-month project duration. SystemWorks managed all elements within their scope without any oversight needed, making my job easier. SystemWorks' deliverables were thorough and thoughtful, considering the history and current conditions of the building along with the budget and goals of the engineering and property management teams. The final reports and analyses provided by SystemWorks were extremely valuable to the building owner and their capital planning process, allowing them to make informed decisions based on data, ROI, and decades of industry knowledge and best practices.

Besides being incredibly competent, SystemWorks is always enjoyable to work alongside. They are team players.

I am very happy to recommend SystemWorks in their proposal. Please feel free to call me with any questions.

Sincerely,

Cara Kennedy
VP, Sustainability

Jones Lang LaSalle
Project and Development
200 East Randolph Drive
Chicago, Illinois 60601

T +1 312 228 3131
C +1 412 877 5414
Cara.Kennedy@am.jll.com
jll.com

IOWA EVENTS CENTER
Community Choice Credit Union Convention Center
Hy-Vee Hall | Wells Fargo Arena

730 3rd Street | Des Moines, IA 50309
T: 515.564.8000 F: 515.564.8001

5/17/2021

To Whom It May Concern,

This letter outlines the work SystemWorks provided the Iowa Events Center over the course of several years while providing continued support of our needs.

The Iowa Events Center has roughly 1,000,000 square feet spread over an arena and two convention centers located in the heart of Des Moines. Knowing that our facilities had not gone through a commissioning during construction for HyVee Hall and Wells Fargo Arena in 2004/2005 we knew we wanted this done to ensure our building systems and equipment were functioning to specs, prolong system life and run optimally to reduce utility costs.

SystemWorks took the lead and helped us take advantage of rebates offered through our utility provider for the retro commissioning study as well as implementation rebates. There communication along the way was tremendous and they took care of all the details and paperwork needed to maximize our rebates.

Being a large complex with multiple buildings there were certainly challenges along the way including the approval of the initial cost even considering the large initial projected savings. We were able to work with SystemWorks to creatively break the project down over the course of two to three years to fit this project in our operating budget, so our capital budget needs were not affected. Another challenge with spreading out this study over time was accounting for systems in one building that provided services for other buildings as well. SystemWorks was able to work through these and other challenges easily throughout the retro commissioning process.

The onsite engineers were also great to work with. They took the time to understand our industry that requires complex calculations to accurately track our savings. This was certainly no easy task as we are an event-based business where we could be using full capacity at any given time for several weeks or months and then have short periods where only limited space was being used. The engineers took the time to understand this and work through tricky events where we might use our systems out of the norm for air quality concerns or reaching extreme temps for event needs. Communication was on point throughout. They did a great job asking questions when they saw something out of the norm to ensure everyone was on the same page.

When comparing quotes for our retro commissioning we found SystemWorks to be the best price for the services they provided. Looking at all they offered and their commitment to us through the entire process made choosing them the obvious choice. Their customer service has been fantastic from day one. We have saved in utility costs over the last few years to cover more than the cost of the study and implementation costs combined. We will continue working with SystemWorks for our commissioning needs.

Best Regards,

HAROLD PETERSON
Operations Manager
Iowa Events Center
Spectra Venue Management
O:515.564.8042 M: 515.418.2605
Harold.Peterson@spectraxp.com
www.iowaeventscenter.com

May 18th, 2021

To Whom it may concern:

I am writing in regards to my experiences in working with SystemWorks, LLC over the past 3 years. My team works on Tenant Improvement projects across the country, typically with different HVAC systems from site to site as they are leased space we are building out.

We began partnering with SystemWorks to provide a consultative approach to the design of our HVAC at these sites acting on behalf of Principal as well as testing and balancing the sites at the end of a project. Their expertise on understanding the requirements to make an office comfortable and ability to communicate that to local Engineers and Contractors has been a great value to my projects.

It's nice to have a partner that I can count on to act on my clients behalf but also ensuring that the end users have a comfortable environment to work in. As part of their services they typically travel to sites during construction and have been able to catch issues early on and talk through how to address them.

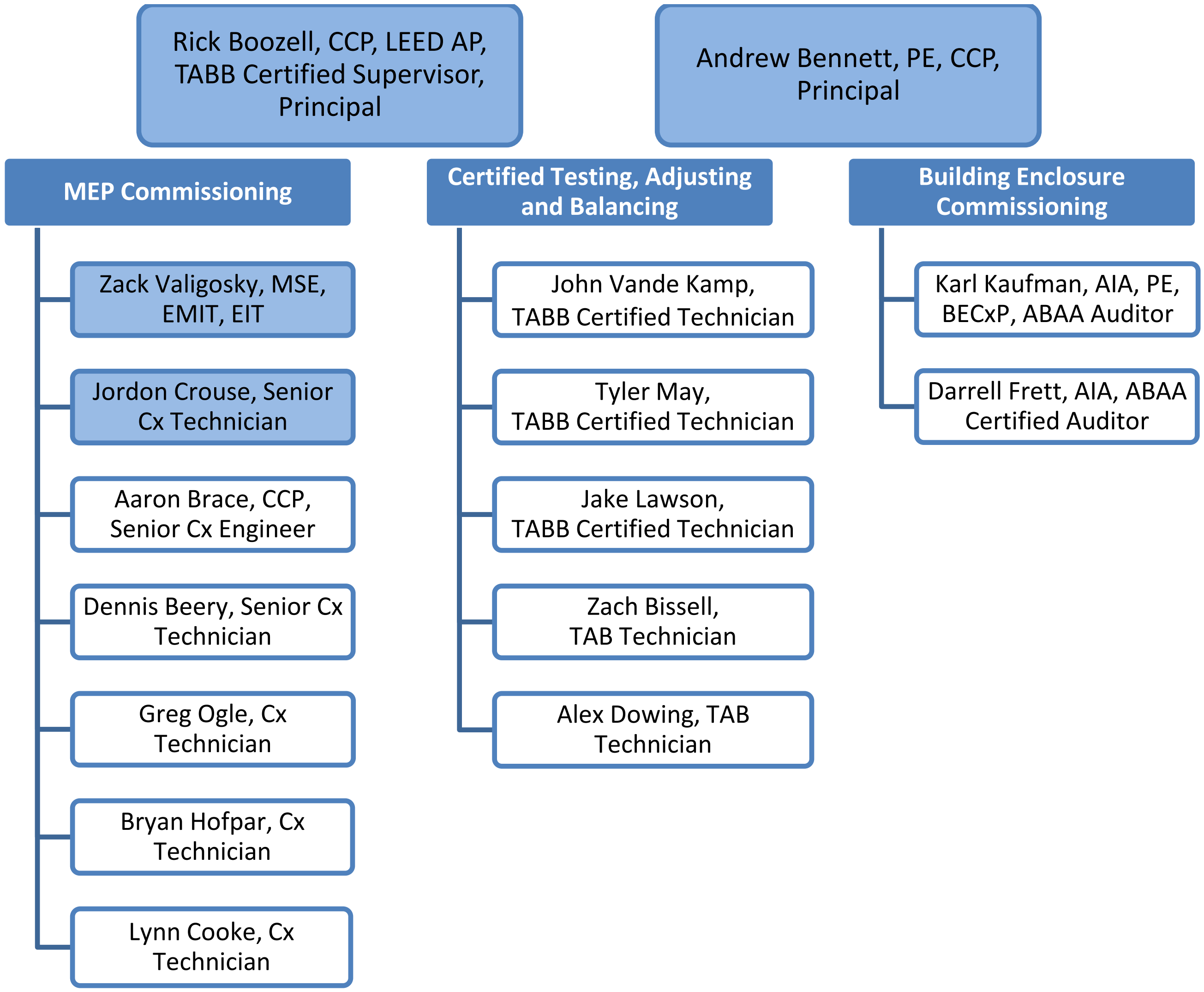
I would highly recommend partnering with System Works as I know they have been a valuable and trusted partner on my projects.

Sincerely,

Adam Springer
Sr. Project Manager
711 High St.
Des Moines, IA 50392
515-350-6695

Exhibit 5 – The SystemWorks Team

SYSTEMWORKS' ORGANIZATIONAL CHART



TEAM DESCRIPTION

We believe it takes a team to fully commission a building, not a single individual. Included in this RFP are resumes of multiple commissioning agents from our firm who may be engaged at various points in the Retro-Commissioning Process, based on their background and specialization. This will be coordinated internally by the Retro-Commissioning Project Managers. Andrew Bennett will serve as the primary point of contact for the State.

Resumes for the team members allocated for this project have been included under the Project Staffing and Organization section of this RFP response.

SystemWorks is a large local commissioning firm, which allows the team to take a "boots on the ground" approach to commissioning. This enables our commissioning team to quickly react to requests from State Agencies, perform site visits on short notice, and ensure that SystemWorks maintains a strong presence throughout the project.

Exhibit 5 – Project Staffing and Organization

Rick Boozell, CCP, LEED AP, TABB Certified Supervisor

Rick Boozell has 21 years of experience in test and balance and mechanical/control integration. Rick is a Certified Commissioning Professional (CCP) and a LEED AP. Rick is also a TABB Certified Supervisor and TABB Certified Commissioning Supervisor through the Testing, Adjusting and Balancing Bureau (TABB). He brings a wealth of knowledge in retro-commissioning, commissioning, and MEP systems for universities, laboratories, and health care facilities. Rick's clients include the State of Iowa, Grinnell College and the Ames and West Des Moines school districts. Rick will provide guidance on intended and ideal system operation and the best system updates to provide improved comfort and ventilation based on his many years of experience. Rick will be supported directly by Andrew Bennett, Jordon Crouse, and Zack Valigosky.

Andrew Bennett, PE, CCP

Andrew Bennett graduated from the University of Iowa with his BS degree in Mechanical Engineering with an emphasis in Energy Systems and the Environment. Andrew earned his Professional Engineer's license in 2017, and his Certified Commissioning Professional accreditation shortly after. Andrew has commissioned LEED and non-LEED projects, and has also led LEED certification of Existing Buildings. Some of Andrew's recent projects include several projects for the Iowa City Community School District, Iowa State University Research Park Hub and Prairie Ridge Integrated Behavioral Health Unit. Andrew will assist the retro-commissioning team by providing engineering assistance on applicable codes, initial design intent, and indoor environmental quality.

Zack Valigosky, BSME, EIT, EMIT

Zack graduated from the University of Dayton as a Master of Science of Renewable and Clean Energy and as a Bachelor of Mechanical Engineering with an emphasis in Energy Systems. Zack is currently an Engineer-in-Training and Energy Manager-in-Training. Zack joined SystemWorks in 2019 and collaborates with building owners and managers to perform retro-commissioning projects, energy analysis, and energy audits. Zack's experience to date includes over 100 ASHRAE Level II energy assessments at commercial and industrial facilities. Zack has provided energy assessments for the State's Hoover Office Building and Iowa Utilities Board/OCA building. Zack will provide engineering assistance, energy calculations,

Jordon Crouse, Senior Commissioning Technician

Jordon's primary focus at SystemWorks is existing building commissioning. He supports Knapp Properties and other commercial real estate clients, and also works closely with the Johnston Community School District to support their existing equipment and controls system, troubleshoot issues as they arise, update programming logic, and functionally test systems through seasonal changes. Jordon was part of the retro-commissioning team for the Iowa Events Center complex, which assessed over 1 million square feet of special purpose spaces.

Andrew Bennett, PE, CCP, Principal

Andrew Bennett, PE, CCP
Firm Principal

CONTACT INFORMATION

Andrew.Bennett@systemworksllc.com
515.975.8251 cell

CURRENT ASSIGNMENTS

US Federal Courthouse Des Moines
Pre-Commissioning & TAB

Iowa City Community School District
City High HVAC Renovation

University of Iowa Hospitals and Clinics
Inpatient Psychiatry Renovation
AHU Replacement Projects
Pathology Renovation

Marion Fire Station
Building Commissioning

University of Iowa
Campus Recreation & Wellness Center
Pool Pak AHU Replacement Project

Waukee Community School District
Sugar Creek Elementary New Construction
Vince Meyer Learning Center Addition

PROFILE

Andrew graduated from the University of Iowa with his BS degree in Mechanical Engineering with an emphasis in Energy Systems and the Environment. Andrew earned his Professional Engineer's license in 2017, and his Certified Commissioning Professional accreditation shortly after. Since joining SystemWorks 2013, Andrew has commissioned LEED and non-LEED projects, and has also been involved with retro-commissioning studies and led LEED certification of Existing Buildings. He has attended manufacturer courses in HVAC systems design, products and building envelope air barrier design.

EDUCATION

The University of Iowa
Bachelor of Science: Mechanical Engineering with Honors

CERTIFICATIONS

Professional Engineer
State of Iowa, License # P2442532

Certified Commissioning Professional (CCP)
Building Commissioning Association (BCxA)

Certified Indoor Environmentalist
Indoor Air Quality Association

ExoAir AVB
Applicator Training

Xylem Bell & Gossett Little Red Schoolhouse
Design and Application of Water-Based HVAC Systems

PROJECT REFERENCES

Iowa City Community School District – Commissioning for Liberty High School, Penn Elementary, Alexander Elementary, Twain Elementary, Southeast Junior High, and other additions/renovations

SingleSpeed Brewery – LEED Fundamental & Enhanced Commissioning

Iowa State University Research Park - Economic Core Development Facility

Indian Creek Nature Center - Living Building Challenge

Delta Dental of Iowa - LEED Silver Office Expansion

Market One Historic Renovation - LEED Platinum Targeted

Van Meter, Inc. Carroll - LEED Silver New Construction

Principal Child Development Center - LEED for Existing Buildings, Gold

Zack Valigosky, EMIT, EIT

Zack Valigosky, EMIT, EIT
Commissioning Engineer

CONTACT INFORMATION

Zack.Valigosky@systemworksllc.com
515.975.7181 cell

CURRENT ASSIGNMENTS

Principal Financial Group
LEED Existing Building Operations and Maintenance
Field Office Commissioning

Iowa City Community School District
Grant Wood Renovation and Addition
Kirkwood Renovation and Addition
Lemme Renovation and Addition
Shimek Renovation and Addition

Holland Farms Assisted Living
New Construction Commissioning

Wells Fargo
Campus-wide Building Automation System Upgrades

Midland Power Cooperative
New Construction Commissioning

PROFILE

Zack graduated from the University of Dayton as a Master of Science of Renewable and Clean Energy and as a Bachelor of Mechanical Engineering with an emphasis in Energy Systems. Zack is currently an Engineer-in-Training and Energy Manager-in-Training. Zack joined SystemWorks in 2019 and collaborates with building owners and managers to perform retro-commissioning projects, energy analysis, and energy audits. Zack's experience to date includes over 100 ASHRAE Level II energy assessments at commercial and industrial facilities.

EDUCATION

University of Dayton – Dayton, OH
Master of Science of Renewable and Clean Energy (2016)
Bachelor of Mechanical Engineering (2014)

CERTIFICATIONS

Engineer in Training
National Council of Examiner for Engineering & Surveying (NCEES)

Energy Manager in Training
Association of Energy Engineers

Improving Variable Speed Pumping Control to Maximize Savings
2016 ASHRAE Conference, Technical Paper Award

PROJECT REFERENCES

Waldorf University Boman Fine Arts – On-going Commissioning

Wells Fargo Home Mortgage – Fire/Life Safety Commissioning

Kum & Go – New Construction Commissioning

Polk County Criminal Courts – Measurement & Verification

Figge Art Museum – Energy Assessment

Prairie Meadows Casino – Energy Assessment

Shenandoah Medical Center – Energy Assessment

Des Moines Buccaneers' Hockey Arena – Energy Assessment

State of Iowa, Hoover Office Building – Energy Assessment

State of Iowa, Iowa Utilities Board/OAC – Energy Assessment

Jordon Crouse, Senior Commissioning Technician

CONTACT INFORMATION

Jordon.Crouse@systemworksllc.com
515.975.1657 cell

CURRENT ASSIGNMENTS

Johnston Community School District
On-going Commissioning

Carroll Community School District
HVAC Investigation & Troubleshooting

Peterbilt of Ankeny
New Construction Commissioning

Ames Community School District
On-going Commissioning

Kum & Go Stores
New Construction Commissioning

Central Decatur School District
On-going Commissioning

PROFILE

Jordon has been with SystemWorks LLC as Commissioning Authority since 2010. His background in Johnson Controls makes him an excellent commissioning agent for On-going and Retro-Commissioning projects, as well as existing building investigations. He has commissioned BAS upgrade projects for existing systems, as well as new construction projects.

Jordon commissions with a service mindset, and is very talented at troubleshooting and determining the root cause of a problem. He generates detailed documentation and is competent working on both hardware and software systems.

EDUCATION

Avionics / Electronics School – Millington, TN (1989)

Organizational Level Avionics School – Jacksonville, TN (1990)

HVAC Basics, Troubleshooting, and Repair School – Milwaukee, WI

CERTIFICATIONS

Johnson Controls
HVAC Mechanical Systems Mechanical Systems
Metasys GPL Engineering
Metasys DX9100 Programming
Metasys PMI Operation

Bell & Gossett
System Design and Pump Setup/Performance

PROJECT REFERENCES

Drake University – Fine Arts Chiller Retro-commissioning

Iowa Events Center: Wells Fargo Arena, HyVee Hall, Community Choice Credit Union – Retro-Commissioning

John Deere Chapman Warehouse – New Construction Commissioning

Northwest Bank Ankeny – New Construction Commissioning

Centerville Community Schools – HVAC Investigation

Kum & Go West Lakes Headquarters – Ongoing Commissioning

Johnston Community School District – Ongoing Commissioning, BAS Upgrades Commissioning

Rick Boozell, CCP, LEED AP, TAB Supervisor, Principal

CONTACT INFORMATION

Rick.Boozell@systemworksllc.com
515.975.9938 cell

CURRENT ASSIGNMENTS

University of Iowa Hospitals and Clinics
Building Commissioning, Infectious Control, Duct and AHU Leakage Testing, and TAB

Facebook Data Centers – New Construction
Altoona, Iowa

Principal Financial Group – Multiple Locations
Building Commissioning and TAB

Grinnell College – HSSC
Building Commissioning and TAB

Wells Fargo – Multiple Projects
Building Commissioning and TAB

Ames Community School District
New High School

PROFILE

Rick is a Testing, Adjusting and Balancing Bureau (TABB) Certified TAB Supervisor Certified Commissioning Professional with 25 years of experience in the mechanical and HVAC industry. Rick is also a LEED Accredited Professional receiving his LEED AP BD+C credential through the U.S. Green Building Council. Rick's work experience also includes function testing and commissioning with certification through the Building Commissioning Associated as a Certified Commissioning Professional. For the past thirteen years, Rick's focus has been on systems commissioning and mechanical/control integration.

EDUCATION

International Training Institute
4-year Sheet Metal Apprenticeship Program

CERTIFICATIONS

Testing, Adjusting and Balancing Bureau (TABB)
Certified Testing, Adjusting & Balancing Supervisor
Commissioning Supervisor
Certified Sound and Vibration Analysis Engineer

United States Green Building Council (USGBC)
sLEED Accredited Professional

Building Commissioning Association (BCxA)
Certified Commissioning Professional

Phoenix Controls - Lab Controls

State of Iowa Journeyman HVAC License

PROJECT REFERENCES

West Des Moines Community Schools – Commissioning and TAB for eight school buildings

Southeast Polk Junior High School – Building Commissioning

Noyce Science Center, Grinnell College – LEED Silver

Upper Iowa University Liberal Arts Building – LEED Silver

Principal Financial Group – Building Commissioning and TAB

Iowa City Community Schools – Building Commissioning and TAB for eleven school buildings

Delta Dental of Iowa – Building Commissioning and TAB

New Johnston High School – Building Commissioning and TAB

Exhibit 6 – Termination, Litigation, and Debarment

SystemWorks has never been involved in litigation or arbitration, and performs work with a high level of professional integrity. SystemWorks has not had a contract terminated. Our payroll is regularly audited by the local unions we are signatory to, as well as their national organizations, and we have not had any issues.

SystemWorks is sufficiently insured through Holmes Murphy of Waukee and will maintain compliance with the insurance requirements of the State of Iowa. Our firm carries Commercial General Liability and Automobile Liability with a $5M Umbrella Liability policy as well as Workman's Comp, Professional Liability Insurance, Errors & Omissions.

Exhibit 7 – Criminal History and Background Investigation

SystemWorks explicitly authorizes the Agency to conduct criminal history and/or background investigations of all parties involved with this work. Our team has submitted background checks to access the North Central Correctional Facility, New Ft. Madison Penitentiary, Eldora State Training School, and Oran Pape Public Safety. We also perform our own periodic background checks, and do not have any concerns with respect to our team's compliance.

Exhibit 8 – Acceptance of Terms and Conditions

SystemWorks hereby accepts the terms and conditions laid out in the RFP as well as the General Terms and Conditions, without change.

SystemWorks is set up to receive EFT/ACH payment transactions for multiple State of Iowa Projects.

Exhibit 9 & 10 – Attachments 1 & 2

Exhibit 9, the Certification Letter, and Exhibit 10, the Authorization to Release Information, are included on the following pages.

Attachment #1
Certification Letter

(Date) 05/21/2021

Bobbi Pulley, Issuing Officer
Iowa Department of Administrative Services
Hoover State Office Building, Level 3
1305 East Walnut Street
Des Moines, IA 50319-0105

Re: RFP1821005278 Retro-Commissioning Services- PROPOSAL CERTIFICATIONS

Dear Bobbi Pulley:

I certify that the contents of the Proposal submitted on behalf of **(Name of Respondent)** in response to **Iowa Department of Administrative Services** for RFP1821005278 Retro-Commissioning Services are true and accurate. I also certify that Respondent has not knowingly made any false statements in its Proposal.

Certification of Independence
I certify that I am a representative of Respondent expressly authorized to make the following certifications on behalf of Respondent. By submitting a Proposal in response to the RFP, I certify on behalf of the Respondent the following:

1. The Proposal has been developed independently, without consultation, communication or agreement with any employee or consultant to the Agency or with any person serving as a member of the evaluation committee.

2. The Proposal has been developed independently, without consultation, communication or agreement with any other Respondent or parties for the purpose of restricting competition.

3. Unless otherwise required by law, the information found in the Proposal has not been and will not be knowingly disclosed, directly or indirectly prior to Agency's issuance of the Notice of Intent to Award the contract.

4. No attempt has been made or will be made by Respondent to induce any other Respondent to submit or not to submit a Proposal for the purpose of restricting competition.

5. No relationship exists or will exist during the contract period between Respondent and the Agency or any other State agency that interferes with fair competition or constitutes a conflict of interest.

Certification Regarding Debarment
I certify that, to the best of my knowledge, neither Respondent nor any of its principals: (a) are presently or have been debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by a Federal Agency or State Agency; (b) have within a five year period preceding this Proposal been convicted of, or had a civil judgment rendered against them for commission of fraud, a criminal offense in connection with obtaining, attempting to obtain, or performing a public (federal, state, or local) transaction or contract under a public transaction, violation of antitrust statutes; commission of embezzlement, theft, forgery, falsification or destruction of records, making false statements, or receiving stolen property; (c) are presently indicted for or criminally or civilly charged by a government entity (federal, state, or local) with the commission of any of the offenses enumerated in (b) of this certification; and (d) have not within a three year period preceding this Proposal had one or more public transactions (federal, state, or local) terminated for cause.

This certification is a material representation of fact upon which the Agency has relied upon when this transaction was entered into. If it is later determined that Respondent knowingly rendered an erroneous certification, in addition to other remedies available, the Agency may pursue available remedies including suspension, debarment, or termination of the contract.

Certification Regarding Registration, Collection, and Remission of Sales and Use Tax
Pursuant to *Iowa Code sections 423.2(10) and 423.5(8) (2016)* a retailer in Iowa or a retailer maintaining a business in Iowa that enters into a contract with a state agency must register, collect, and remit Iowa sales tax and Iowa use tax levied under *Iowa Code chapter 423* on all sales of tangible personal property and enumerated services. The Act also requires Respondents to certify their compliance with sales tax registration, collection, and remission requirements and provides potential consequences if the certification is false or fraudulent.

By submitting a Proposal in response to the (RFP), the Respondent certifies the following: (check the applicable box)

- ☑ Respondent is registered with the Iowa Department of Revenue, collects, and remits Iowa sales and use taxes as required by *Iowa Code chapter 423*; or
- ☑ Respondent is not a "retailer" or a "retailer maintaining a place of business in this state" as those terms are defined in *Iowa Code subsections 423.1(47) and (48)(2016)*.

Respondent also acknowledges that the Agency may declare the Respondent's Proposal or resulting contract void if the above certification is false. The Respondent also understands that fraudulent certification may result in the Agency or its representative filing for damages for breach of contract in additional to other remedies available to Agency.

Sincerely,

Andrew Bennett

Signature

Andrew Bennett, Principal
Name and Title of Authorized Representative

05/21/2021
Date

Attachment #2
Authorization to Release Information Letter

(Date) 05/21/2021

Bobbi Pulley, Issuing Officer
Iowa Department of Administrative Services
Hoover State Office Building, Level 3
1305 East Walnut Street
Des Moines, IA 50319-0105

Re: RFP1821005278 Retro-Commissioning Services - AUTHORIZATION TO RELEASE INFORMATION

Dear Bobbi Pulley:

(Name of Respondent) hereby authorizes the **Iowa Department of Administrative Services** ("Agency") or a member of the Evaluation Committee to obtain information regarding its performance on other contracts, agreements or other business arrangements, its business reputation, and any other matter pertinent to evaluation and the selection of a successful Respondent in response to RFP1821005278 Retro-Commissioning Services.

The Respondent acknowledges that it may not agree with the information and opinions given by such person or entity in response to a reference request. The Respondent acknowledges that the information and opinions given by such person or entity may hurt its chances to receive contract awards from the State or may otherwise hurt its reputation or operations. The Respondent is willing to take that risk.

The Respondent hereby releases, acquits and forever discharges the State of Iowa, the Agency, their officers, directors, employees and agents from any and all liability whatsoever, including all claims, demands and causes of action of every nature and kind affecting the undersigned that it may have or ever claim to have relating to information, data, opinions, and references obtained by the Agency or the Evaluation Committee in the evaluation and selection of a successful Respondent in response to the RFP.

The Respondent authorizes representatives of the Agency or the Evaluation Committee to contact any and all of the persons, entities, and references which are, directly or indirectly, listed, submitted, or referenced in the Respondent's Proposal submitted in response to RFP.

The Respondent further authorizes any and all persons, and entities to provide information, data, and opinions with regard to its performance under any contract, agreement, or other business arrangement, its ability to perform, business reputation, and any other matter pertinent to the evaluation of the Respondent's Proposal. The Respondent hereby releases, acquits and forever discharges any such person or entity and their officers, directors, employees and agents from any and all liability whatsoever, including all claims, demands and causes of action of every nature and kind affecting the Respondent that it may have or ever claim to have relating to information, data, opinions, and references supplied to the Agency or the Evaluation Committee in the evaluation and selection of a successful Respondent in response to RFP.

A photocopy or facsimile of this signed Authorization is as valid as an original.

Sincerely,

Andrew Bennett

Signature

Andrew Bennett, Principal — 05/21/2021

Name and Title of Authorized Representative — **Date**

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Exhibit 11 – Mandatory Specification

4.1. Tasks

4.1.1. Yes, SystemWorks has provided Commissioning Services since 2003 and engaged in over 300 sustainable/retro-commissioning projects in Central Iowa.

4.1.2. Yes, SystemWorks has staff experienced in building systems design, installation, and operation.

4.1.3. Yes, SystemWorks has staff experienced in verifying measure performance in both theory and application through energy calculations and field measurements and observations.

4.2. Competence

4.2.1. Yes, SystemWorks has three Building Commissioning Association Certified Commissioning Professionals (CCPs) on staff.

4.2.2. Yes, SystemWorks has conducted Retro-Commissioning for the Iowa Events Center, Principal Financial Group, Wells Fargo Card Services, and ACT, Inc., among many others.

4.2.3. Yes, SystemWorks employees three staff who have an average of 30 years of experience in the installation of Energy Management Controls Systems, in addition to the numerous Commissioning Providers and TAB technicians.

4.2.4. Yes, SystemWorks' employees have a significant amount of field experience, whether that is in HVAC system design, installation, operation, and maintenance. Our team also includes two registered Architects who have field experience with building enclosure systems.

4.2.5. Yes, SystemWorks has a couple of employees with many years of experience in building operation and maintenance.

4.3. Compliance – Yes, SystemWorks conducts all work with safety front of mind and is experienced with all relevant codes for conducting Retro-Commissioning Services.

Exhibit 12 – Retro-Commissioning Approach & Methods

Retro-Commissioning (RCx) Services fall under the larger umbrella of Existing Building Commissioning (EBCx). EBCx is a more comprehensive approach to buildings as compared to typical Commissioning Firms' approach to RCx. When possible, SystemWorks incorporates best practices from Existing Building Commissioning into our Retro-Commissioning projects. These additional aspects will be discussed underneath the phase to which it is applicable in the sections that follow, which carries into Exhibit 13 – Existing Systems Investigation & Plan.

MANAGING THE RCX PROCESS WITH FACILITY GRID

Facility Grid is an online commissioning tool we utilize to organize issues and observations. The entire commissioning process will be documented in Facility Grid, an online commissioning platform. This software will allow the State Agency to view project progress on the project's dashboard, as shown in Figure 1 below. The dashboard includes issue, task, and testing progress. Additionally, each identified improvement or issue can be tracked and commented on by those involved with the project, as shown in Figure 2 below. Every comment will be associated to a specific system or piece of equipment, which results in a full commissioning history for every system component.

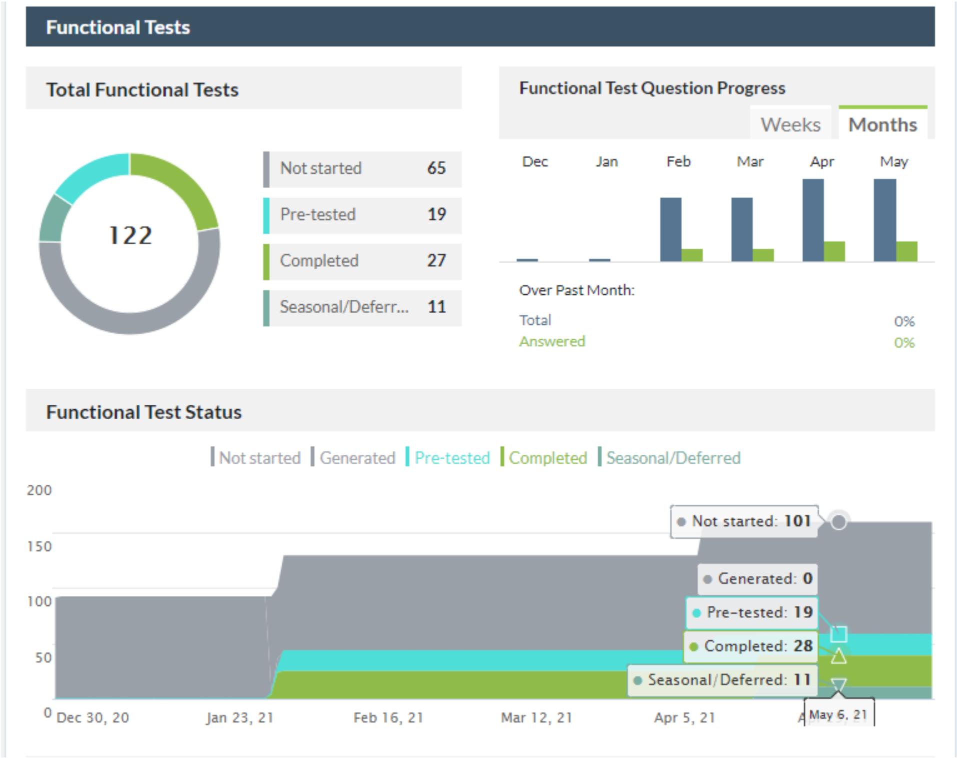


Figure 1: Example of Facility Grid Dashboard. This particular chart is one of many available charts, and shows the progression of opening/closing items.

#	Code	Internal Ref	Status	Priority	Asset	Description	Location	Responsibility	Reported On	Responses	Last Response On	
			1 set	Any				Any				
1	SO-1-001		Closed	Low	UH-1	Are there any issues or concerns among the design team and others with the location of the unit heater in the basement mechanical room? Sprinkler pi...	Floor: Basement	General Contractor	03/05/2019	2	04/16/2019 09:47 AM CDT	Actions
2	SO-1-002		Closed	Medium	FR-07	There are access constraints at Flow Regulator #7. Current installation will make it difficult to install and service Trane controls. 30" of cleara...	Floor: First Semi-Restricted Hall 125	Sheet Metal Contractor	03/05/2019	2	05/10/2019 10:34 AM CDT	Actions
3	SO-1-008		Closed	Medium		It was observed that adjacent TDC joints on the same duct run did not consistently have the same number of cleat connections. This was noted in seve...		Sheet Metal Contractor	03/05/2019	2	05/10/2019 10:32 AM CDT	Actions

Figure 2: Screenshot of the Facility Grid Issues Log. Similar format to the traditional Excel log, but with easier sort/prioritize/respond features.

PLANNING PHASE

At a minimum, the planning phase includes a brief site visit and a kickoff meeting. Ideally, SystemWorks believes that Current Facility Requirements should be documented, if only for SystemWorks' internal reference. As seen on any project with infrequent interaction, an expectation and goal setting conversation is key to understanding the target at which the RCx team is collectively aiming. These expectations provide context for the Commissioning Provider to reference and update throughout the course of the project.

- Cursory Site Walk-through
    - To gain an understanding of the types of spaces and equipment
    - Briefly interview building occupants
- Draft Retro-Commissioning Plan
- Kickoff Meeting for Existing Building Commissioning Process
    - Interview building operators regarding building HVAC functionality
    - Review Retro-Commissioning Plan
    - Document meeting minutes
- Current Facility Requirements (CFR)
    - Define current operational needs – energy goals, temperature, humidity, ventilation, or filtration
    - Determine optimal operational parameters based on current building use

Exhibit 13 – Existing Systems Investigation & Plan

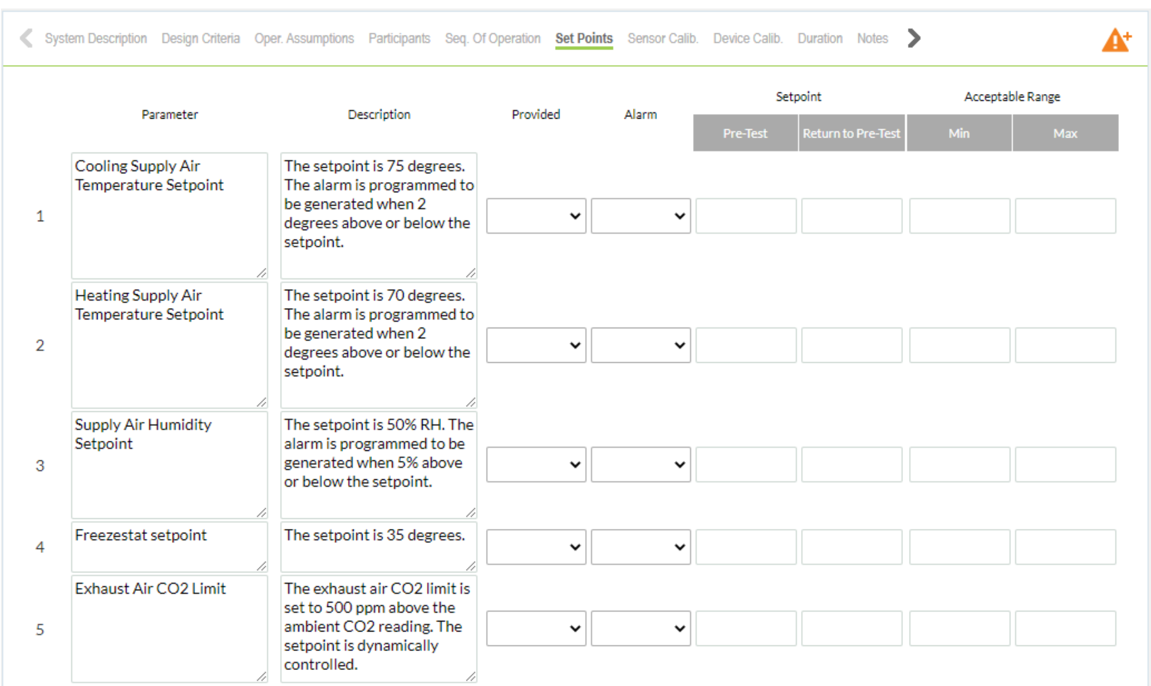
During the investigation phase, the Commissioning Provider develops a deeper understanding of the building systems through an energy use analysis, a Diagnostic Monitoring and Test (DM&T) Plan, and a more comprehensive site visit.

Ideally, with the Cursory Site Walk-through included in the Scope of Work, the Commissioning Provider has more context with which to review energy use against expected values and trends. During this analysis, any anomalies are recorded for further review within the diagnostic monitoring plan. The DM&T plan would include expected values for operational parameters and the equipment with which that parameter will be measured. SystemWorks owns all equipment necessary to conduct the DM&T plan and to perform functional testing on building systems.

As described in the attached Cost Proposal, equipment rental costs are not applicable on the basis that SystemWorks has a sufficient amount of equipment necessary for measurement of equipment performance and verification of identified system updates. For larger facilities, it is assumed that a Building Automation System (BAS) is present and has historical trend data capabilities. SystemWorks' personnel will adjust their approach as needed depending on BAS server storage capacity in order to ensure that accurate information is provided to the State Agency for which services are being provided. All equipment is kept calibrated and NIST-Traceable. Our team members are trained to use all of our equipment, which includes:

- Air and Water Flow and Pressure Meters
- Temperature and Humidity Meters and Loggers
- Carbon Dioxide Meter and Logger
- Ultrasonic Flow Meter

The comprehensive site visit is used as an opportunity to dial in the Functional Performance Test (FPT) Procedures, confirm that the DM&T Plan will perform as intended, and to initiate the DM&T Plan. The implementation of the DM&T plan would involve employing the equipment mentioned earlier and recording values in the commissioning software called Facility Grid. The screenshot below displays the Set Points section of Equipment in Facility Grid. Expected parameters will be added in the Acceptable Range. Any data recorded over a periods of time will be handled in Microsoft Excel.



System Description | Design Criteria | Oper. Assumptions | Participants | Seq. Of Operation | Set Points | Sensor Calib. | Device Calib. | Duration | Notes

	Parameter	Description	Provided	Alarm	Setpoint		Acceptable Range	
					Pre-Test	Return to Pre-Test	Min	Max
1	Cooling Supply Air Temperature Setpoint	The setpoint is 75 degrees. The alarm is programmed to be generated when 2 degrees above or below the setpoint.						
2	Heating Supply Air Temperature Setpoint	The setpoint is 70 degrees. The alarm is programmed to be generated when 2 degrees above or below the setpoint.						
3	Supply Air Humidity Setpoint	The setpoint is 50% RH. The alarm is programmed to be generated when 5% above or below the setpoint.						
4	Freezestat setpoint	The setpoint is 35 degrees.						
5	Exhaust Air CO2 Limit	The exhaust air CO2 limit is set to 500 ppm above the ambient CO2 reading. The setpoint is dynamically controlled.						

During FPTs, issues and potential improvements are recorded for review with the Owner. At the end of this phase, a status meeting is conducted with meeting minutes to narrow down the list of measures to feasible items and to update the RCx team on Commissioning Process progress. Additionally, now that the Commissioning Provider is more familiar with the system, an update to the Current Facility Requirements or Retro-Commissioning may be warranted.

- Preliminary Energy Use Report
  - Analyze utility metering data and energy bills
  - Collect historical system data using building automation systems wherever possible
  - Benchmark buildings against similar facilities to quantify overall building performance
- Diagnostic Monitoring and Test Plan
- Comprehensive Site Walk-through
  - Thorough and detailed walk through with facility staff to evaluate issues and opportunities
  - Perform system inspections using the building automation system
  - Document findings in Site Observation Report
- Functional Performance Test Procedures – written with a focus on confirming equipment performance meets Current Facility Requirements
- Perform Functional Performance Testing
  - Verify component and equipment performance under a full range of loads and responses to inputs
  - Coordinate testing with facility staff
  - Calibrate sensors that are critical to effective building systems' operation
  - Document identified issues and findings
- Master List of Findings
  - Perform calculations on identified issues that will improve equipment operation or expected life, reduce energy costs, improve student learning, or improve occupant comfort
- Status Meeting for Existing Building Commissioning Process
  - Review Master List of Findings
  - Work with facility staff to prioritize improvements
  - Work with preferred contractors to determine any implementation costs for a simple payback

IMPLEMENTATION PHASE

At this stage in the process, involvement from Operations and Maintenance (O&M) staff becomes even more critical. As no- and low-cost measures are implemented, changes in building operation may need to occur. Additionally, for more expensive measures, an implementation plan is developed so that the Owner understands what steps are necessary. Ideally, a Re-Commissioning (Re-Cx) Plan is developed and reviewed with O&M staff. At it's basest level, the Re-Cx Plan provides the test procedures to the staff that will operate the building. The test procedures in the Re-Cx plan would also be updated include steps to verify persistence of measures identified during the project.

- Facility Improvement List
  - Narrowed down from Master List of Findings
  - All identified and approved no-cost and low-cost improvements will be implemented
- Implementation Plan
  - Plan to guide implementation process to meet Current Facility Requirements
  - Provides details on steps to be followed to complete implementation
  - Indicates which measures will be implemented within EBCx process or deferred to a later date
- Re-Commissioning Plan – documents elements of Commissioning process to be repeated at regular intervals to ensure Current Facility Requirements are met

HAND-OFF PHASE

Many commissioning firms like to call this phase Turn Over. However, SystemWorks believes the nomenclature of Hand-Off implies a collaborative process with O&M staff to assist with implemented measure persistence. Buildings can be quite complicated and taking time to review unique characteristics that the Commissioning Provider discovered during the study will go a long way toward simplifying the building. Ideally, a Systems Manual is created or updated to document these complexities.

- Final Report of Existing Building Commissioning Process – Record of findings and implementation for reference by current and future facility staff
- Lessons Learned Meeting
  - Provides a platform to debrief on unique aspects of project for current facility staff
  - Also, a platform to provide feedback on what went right and what went wrong during EBCx process
  - Document meeting minutes
- Compile or Update Systems Manual
  - A compilation of documents to ensure future facility staff are equipped to effectively manage the facility
  - Includes an Index, Current Facility Requirements, Construction Records, operations and maintenance manuals, ongoing optimization guidance, training materials, and EBCx report

EXAMPLE RETRO-COMMISSIONING PLAN

The following pages contain a sample Retro-Commissioning Plan for a previous project.

RETRO-COMMISSIONING PLAN

655 9th is a 500,984 square-foot office building located in downtown Des Moines built in 1986 and is shown in Figure 1 below. In 2019, a significant renovation was completed as a part of Campus Blueprint. At that time, the building's HVAC equipment was modified or replaced as needed and outfitted with DDC controls where needed. The building provides office and meeting spaces for approximately 1,783 occupants and features a kitchen and dining area. 655 9th is connected to the rest of the Principal Financial Group campus via three skywalks located on the second floor.

Figure 1: 655 9th Aerial View from south looking north (Google Maps image, post-2019 renovation)

RETRO-COMMISSIONING GOALS

The goal of this retro-commissioning process is to ensure that the energy efficiency upgrades from the renovation are indeed saving energy, and to identify any additional opportunities to save energy or improve comfort. This is a proactive approach, driven by JLL and Principal Financial Group's desire to provide an optimal work environment.

All major HVAC systems will be reviewed during functional testing by the retro-commissioning team, with emphasis placed on the air handling units and hot water reheat, as they are two of the largest energy consumers. The team will also focus on tuning zone set points to maintain comfortable temperatures throughout the space and preventing the exterior and interior zones from operating in conflicting modes. Additionally, sequences of operation will be reviewed to ensure they operate as intended.

RETRO-COMMISSIONING SCHEDULE

2019: Investigation and analysis phase by SystemWorks. Substantial Completion of Renovation phases. Phases will be tested as they are completed.

July – October 2019 Baker Group implements measures identified by SystemWorks and JLL.

November 2019 SystemWorks provides Commissioning Report after issues log is closed out, fire life safety systems are completed, and TAB is completed.

RETRO-COMMISSIONING SCOPE OF WORK

The following scope of work is the scope of work to be completed by the retro-commissioning team. Some verifications are performed with on-site functional performance tests, while others are performed remotely by reviewing trend data collected by the BAS. SystemWorks will perform a sampling of the initial functional test procedures verify the following systems are operating as designed.

Floor Air Handling Units and Dedicated Outside Air Handling Units

- Verify occupancy schedule is correct. Verify control in both occupied and unoccupied mode.
- Confirm unit will cycle in unoccupied times.
- Maintaining correct discharge air temperature.
- Maintaining adequate duct static pressure to satisfy the VAV boxes, supply fan modulating appropriately.
- Maintaining correct outside, return, and supply airflow rates.
- Verify damper positions and accuracy of airflow measuring stations.

Zone Level Terminal Units

- Confirm space temperature set points are met, with appropriate deadbands and unoccupied setbacks.
- VAV box fans and hot water reheat is cycling correctly. Random sample of VAVs.
- Perimeter heat is staging and controlling appropriately.
- Verify unoccupied setbacks are appropriate and maintained.

Boilers and Heat Exchanger System

- Confirm status of each pair of loop pumps
- Confirm entering/leaving water temperatures of each heat exchanger are consistent with the current reset strategies
- Confirm modulation of the 1/3 and 2/3 steam valves meets the original sequence of operation
- Review staging history of the Steam Boiler Plant
- Review the operation of AHU-B208N, the Boiler Room Make-up Air Handling Unit
- Verify select safeties and alarms. Review alarm log for frequent alarms and investigate.

General BAS Features

- Confirm global control points are accurate (outside air temperature, humidity, etc.)
- Review any active alarms.
- Review any overridden points.
- Discuss operation with JLL building engineer.

Snow Melt System

- Compare actual weather data to the weather data used in the programming logic to enable/disable the snowmelt system
- Confirm status of each zone pump
- Review loop temperatures and confirm the heat exchanger and valves are maintaining the correct slap temperature and entering/leaving water temperatures
- Verify select safeties and alarms. Review alarm log for frequent alarms and investigate.

Fire/Smoke Evacuation Testing, Stairwell Pressurization

- Verify all modes of operation
- Confirm floor-by-floor unit operation
- Verify LEDs at the Fire Alarm Control Panel match the actual statuses of dampers and fans throughout the smoke evacuation system
- Measure differential pressure between the stairwell and each floor to confirm the stairwells are sufficiently positive and still allow for safe entry

Specialty AHUs (Café & Yoga)

- Review unit overall physical appearance (drain pan, filters, belts, sound level, etc.)
- Review occupied and unoccupied runtime data
- Discharge Air Temperature Control verification, using trend data
- Confirm interlocks
- Verify select safeties and alarms. Review alarm log for frequent alarms and investigate.

Blower Coil Units

- Verify occupancy schedules
- Verify zone temperature control
- Supply fans enabled based on heating/cooling demand
- Verify select safeties and alarms. Review alarm log for frequent alarms and investigate.

Lighting Systems

- Verify occupancy schedules
- Verify exterior lights illuminate before dusk, and turn off after sunrise
- Verify occupancy sensors and vacancy sensors by entering darkened rooms to trigger the switch, and timing delay before the system turns off.

Miscellaneous Systems

- Review functionality – domestic hot water system, exhaust fans, transfer fans, elevator equipment room pressure control, parking garage ventilation system, Global Security CRAC unit, unit heaters

PROJECT MANAGEMENT TOOLS

Baker Group maintains as-built drawings and sequences of operation for 655 9th, as well as historical revisions. JLL utilizes Energy Star Portfolio Manager to log and analyze data, as well as establish reasonable targets for the building. Excel will be used to log issues and potential energy conservation measures along with responses and input from the team. Excel will also be used to calculate the energy and cost savings for individual measures.

RETRO-COMMISSIONING TEAM

Representatives from JLL, SystemWorks, and Baker Group Controls participated in the retro-commissioning efforts. Randy Brown is the Operations Manager for the Principal Financial Group properties in Des Moines. His team of Engineers and Support staff monitor the building operations and coordinate with other JLL staff as needed.

Matt Minnick is the lead Commissioning Agent for the building renovation. As part of the enhanced commissioning process, Matt will also re-commission the building 10 months after substantial completion as a warranty period review.

Russ Zimmerman is the Controls Project Manager for this renovation. He will provide input regarding adjustments which could be made to improve the building's operation, as well as coordinate the implementation of measures identified by JLL and SystemWorks.

Name	Position	Phone	Email
Randy Brown	Operations Manager, JLL	*515-235-1007*	Brown.Randy@principal.com
Garth Swisher	Assistant Chief Engineer, JLL	*515-802-2705*	Swisher.Garth@principal.com
Lee Bridgeford	Associate, Systems Support, JLL	*515-494-4814*	bridgeford.lee@principal.com
Matt Minnick	Commissioning Agent, SystemWorks	*515-975-0575*	matt.minnick@systemworksllc.com
Andrew Bennett	Mechanical Engineer, SystemWorks	*515-975-8251*	andrew.bennett@systemworksllc.com
Joe Howard	Controls Technician, Baker Group	*515-421-6760*	howardj@thebakergroup.com
Joel Bartlett	Professional Engineer, Baker Group	*515-299-4212*	bartlettj@thebakergroup.com
Russ Zimmerman	Controls Project Manager, Baker Group	*515-612-2213*	zimmermanr@thebakergroup.com
Tom O'Brien	Electrical Project Manager, Baker Group	*515-262-4000*	obrient@thebakergroup.com
Alex Wolf	Mechanical Project Manager, Baker Group	*515-262-4000*	wolfa@thebakergroup.com

Exhibit 14 – Retro-Commissioning Report

The Retro-Commissioning (RCx) Report documents the activities conducted during the RCx process. In our experience, the most valuable reports include information that O&M staff or other building professionals can reference in the future. This includes items such as the Functional Performance Test Procedures and Results, Re-Commissioning Plan, and an Updated Systems Manual, if these items were included in the Scope of Work. At a minimum, a report for State Agency would include:

- Building Systems' Descriptions
- Energy Use Analysis
  - Fuel Use Breakdown
  - End-Use Breakdown
  - Weather-Dependent Energy Use
- High-Level Description of Building Performance Issues
- Feasible Facility Improvement Measures
  - Measure Description
  - Current Condition
  - Proposed Improvement
  - Operation and Maintenance Impact
  - Approach to Persistence
- Master List of Findings

EXAMPLE RETRO-COMMISSIONING REPORT

The following pages contain a sample Retro-Commissioning Report for a previous project.

Exhibit 14 – Example RCx Report

Exhibit 15 – Customer Service

LOCAL & RESPONSIVE

SystemWorks is a large, Iowa-based, commissioning firm. With staff based in Des Moines and the Quad Cities, we can quickly react to requests for Retro-Commissioning Services or site visit requests, regardless of the location in Iowa. Des Moines will be the location from which primary consulting services are provided.

CUSTOMER SUPPORT AND COMMUNICATION PLAN

Since SystemWorks is familiar with Iowa and a number of State-owned facilities, we have an improved ability to respond quickly with good background information when State Agencies request RCx Services. With our experienced staff, if our main point of contact is not available to answer a question about an improvement made at a facility, another staff member will easily be able to respond within 24 hours to phone calls from State Agencies. This is made easier through the use of Facility Grid, where SystemWorks' employees can log in and quickly view relevant information about a building's systems.

When a request for Retro-Commissioning Services is received, our main point of contact will inquire with the State Agency's contact regarding their preferred method of communication. Our commissioning staff are great communicators that shift their communication methods depending on the staff they are in contact with. If the staffperson is dedicated to facility operation, they most likely do not spend much time at their desk and our staff is aware that a phone call is the best way to reach them. If the staffperson is in more of a management role, our staff is aware that an email may be the best way to communicate. However, if a phone is used to communicate with any Agency staff, an email documenting that conversation is best practice to ensure that resolution is achieved.

CUSTOMER SERVICE EVALUATION AND IMPROVEMENT PLAN

If a customer is dissatisfied by the services provided, the manager of the staffperson with whom the Agency is dissatisfied would contact the relevant Agency. During this conversation, the reason for dissatisfaction will be reviewed and the manager will determine a plan for reviewing this information with the staffperson with whom the Agency is dissatisfied. If the Retro-Commissioning Services are still in process, the manager will discuss with the relevant State Agency to determine a frequency for regular check-ins to ensure ongoing improvement in satisfaction.

Exhibit 16 – Performance-Based Criteria

SystemWorks proposes a performance-based incentive and disincentive that is based on a maximum number of Retro-Commissioning projects that can be maintained at any point in time, alongside quarterly customer satisfaction surveys. The incentive for SystemWorks in this scenario is to complete projects satisfactorily and in a timely manner such that we are able to bid on a future project. If we are at our maximum and not completing any projects in the near future, it provides a value to the State from the perspective of not over-loading our staff. This way staff will be able to commit the proper amount of time to the project. This number would be negotiated with the State after the Notice of Intent to Award is delivered. SystemWorks believes this to be the best approach because of the manner in which Retro-Commissioning projects often proceed. Building systems are complex and the issues associated with them can require varying lengths of time to identify, implement, and verify correct operation. As such, setting a schedule and providing a disincentive if the project extends past that would lead to many scenarios where building complexities are not given the time that they are due.

Quarterly customer satisfaction surveys and their format would be negotiated with the State after the Notice of Intent to Award is delivered. These could include scales from 1 to 5 on categories such as: Perceived Value to the State, Technical Competency, Responsiveness to Requests, Clarity of Communication, and Respect for Confidentiality and Security (where applicable). These surveys would be completed by the Agency for which Services are being provided and sent to the Department of Administrative Services where they would anonymize results and review those with SystemWorks. If results are unsatisfactory, SystemWorks would then provide a plan for resolution to the Department of Administrative Services.

REPORT

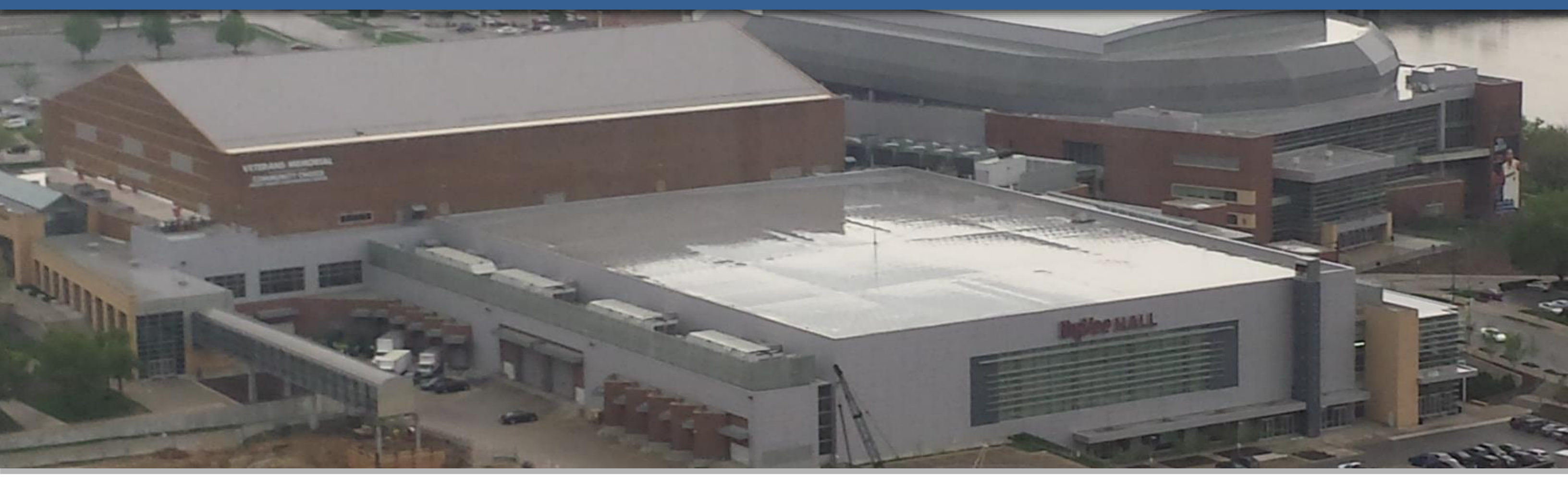
RETRO-COMMISSIONING STUDY

IOWA EVENTS CENTER

COMMUNITY CHOICE CREDIT UNION

CONVENTION CENTER

DES MOINES, IOWA



SystemWorks LLC
Commissioning Sustainable Buildings

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Abbreviations

°F	degrees Fahrenheit
AHU	air handling unit
BTU	British thermal unit
CFM	cubic feet per minute
CO	carbon monoxide
CO2	carbon dioxide
DCV	demand control ventilation
DX	direct expansion
ft^2	square foot
GPM	gallons per minute
hp	horsepower
kW	kilowatt
kWh	kilowatt hour
lbs	pounds
MBH	one thousand BTUs
OA	outside air
ppm	parts per million
RCx	retro-commissioning
RTU	roof-top unit
VAV	variable air volume
VFD	variable frequency drive
W	Watt
w.c.	water column

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Executive Summary

SystemWorks began a retro-commissioning study on March 21, 2018 at Community Choice Credit Union Convention Center (CCCUCC) for the Iowa Events Center. The facility is approximately 377,000 square feet of open exhibit halls, meeting rooms, and office space. The overall Iowa Events Center campus is 1,067,000 square feet.

Historical trend data gathered between March 1, 2017 and February 28, 2018 provided the basis for determining how much energy the HVAC used. Calculating the amount of energy consumed (fan energy, cooling energy, and heating energy), by each device, outliers can be identified and targeted for improvement. Eleven air handlers were baselined for energy consumption. These air handlers account for almost 50% of all the heating and cooling energy consumed at CCCUCC. Out of this energy usage, four air handling units (AHU-1CC, 2CC, 7CC and 8CC) account for more than 62.4% of the air handler total energy usage. As for the rest of the HVAC equipment, the five Kitchen Make-up Air Units consumed 20.1% of the heating & cooling energy, while the sixty-nine Variable Air Volume (VAV) Boxes consumed 13.9%, and the twenty-six Fan Coil Units consumed 12.2%.

Over the course of the study, SystemWorks was able to identify and refine a list of potential energy conservation opportunities as well as a list of non-energy related maintenance items that, if repaired, would improve occupant comfort and air quality.

Project Evaluation:

- All 15 energy saving opportunities are recommended to implement
- Study cost was $49,100 and the estimated implementation cost is $56,880
- Rebate for the study is $24,550 and the estimated implementation rebate is $21,125
- Simple Payback after rebate for study and implementation is 1.6 years
- Electrical Energy Savings: 299,996 kWh (1.9% of Campus Electrical Energy Consumption)
- Natural Gas Energy Savings: 30,624 therms (8.2% of Campus Natural Gas Consumption)
- Utility Cost Savings: $37,023 (3.0% of Campus Utility Costs)

If all the identified projects found in this report are implemented, the simple payback will be 2.9 years before any rebates are applied. This includes the study cost and cost to implement the projects. After the rebates are applied, this payback will drop to 1.6 years. The estimated utility cost savings is 3% of total annual energy costs which equates to over $37,000 per year.

Table 1 on the next page shows the breakdown for each of the fifteen energy conservation opportunities (ECOs). Many of the identified ECOs have an immediate payback after rebate.

Section 3 shows the list of identified non-energy related items.

Table 1: Recommended Energy Saving Opportunities

Energy Conservation Opportunity		Estimated Savings						
		Electric (kWh)	Natural Gas (therms)	Utility Cost ($)	Potential Rebate ($)	Cost to Implement ($)	Simple Payback (Years)	Simple Payback (Years)
	Overall Project Evaluation	299,996	30,624	$ 37,023	$ 45,675	$ 105,980	2.9	1.6
	Retro-Commissioning Study			$ -	$ 24,550	$ 49,100		
	Calculated Savings	1.9%	8.2%	3.0%				
	Calculated Savings	299,996	30,624	$ 37,023	$ 21,125	$ 56,880	1.5	1.0
1	Improved Schedules	127,819	10,725	$ 14,422	$ 8,536	$ 1,510	0.1	-0.5
2	Improved Humidity Control	13,402	-	$ 858	$ 670	$ 6,410	7.5	6.7
3	Seal AHU-10CC Outside Air Damper	3,122	4,756	$ 2,968	$ 1,107	$ 2,980	1.0	0.6
4	Add Economizer Controls to AHU-1V	4,377	-	$ 280	$ 219	$ 3,380	12.1	11.3
5	Repair AHU-1V Chilled Water Control Valve	6,609	-	$ 423	$ 330	$ 4,480	10.6	9.8
6	Repair AHU-1V Steam Control Valve	13,294	1,159	$ 1,526	$ 897	$ 3,780	2.5	1.9
7	Limit Control Valve Maximum Positions	6,933	-	$ 444	$ 347	$ 4,980	11.2	10.4
8	Make-Up Air Discharge Air Temp Reset	-	7,260	$ 4,225	$ 1,452	$ 9,080	2.1	1.8
9	Limit VAV Discharge Air Temperature	-	1,554	$ 905	$ 311	$ 6,380	7.1	6.7
10	Improved Ventilation Reset Controls	20,247	398	$ 1,527	$ 1,092	$ 4,710	3.1	2.4
11	Repair AHU-6CC Chilled Water Control Valve	70,906	1,018	$ 5,131	$ 3,749	$ 3,780	0.7	0.0
12	Calibrate AHU-1CC AFMS	17,730	-	$ 1,135	$ 887	$ 1,500	1.3	0.5
13	Implement Supply Duct Static Pressure Reset	10,173	-	$ 651	$ 509	$ 3,520	5.4	4.6
14	Allow Exhibit Hall Units to Economize	(8,205)	3,755	$ 1,660	$ 341	$ 260	0.2	0.0
15	Reset Fan Coil Units Space Temp Setpoints	13,587	-	$ 870	$ 679	$ 130	0.1	-0.6

1 Introduction

Trends were set up December 2014 which greatly enhanced the effectiveness of the study to show actual equipment operation. Due to the complexity of the scheduling and building operator override frequency, it was important to have a full year of data to see how the system functions to maintain comfort and meet the scheduling requirements. Trend data from 3/1/2017 to 3/26/2018 was used for the analysis. This timeframe allowed SystemWorks to capture all seasonal operations from heating to cooling to economizing.

The trend data captured was used to estimate what typical annual energy consumption would be for a baseline. In conjunction with the trend evaluation, SystemWorks had technicians and engineers onsite for an extended period. They function tested the equipment to identify damper operation, heating and cooling operation and verified airflow measuring station calibrations.

Section 2 is the Observation and Recommendation section which contains each energy saving opportunity that was identified along with a recommendation to address the issue, a project cost evaluation, and the calculation method used.

Observation Sections: All units were reviewed separately. A detailed breakdown of the energy evaluation can be found in Appendix A. Similar units and issues were combined to reduce the number of projects to price out and track.

The observation sections include supporting documentation to justify the estimated savings. Several identified opportunities were put through function testing to see how the systems would react to changes.

Recommendation Sections: This section is typically kept very brief to communicate to the implementing contractor what is expected with the change.

Project Evaluation Sections: The individual project energy savings, utility cost savings, rebate, implementation cost and simple payback are found in these sections. The energy savings provided for most of the recommendations show interactive savings assuming everything will be implemented. If everything is not implemented, these numbers could be re-evaluated.

Calculations: The energy calculation method is shown here. Identified opportunities were analyzed using TMY3 BIN data. The detailed calculation is typically completed in a BIN format either to outside air temperature, flow or another critical measurement that shows a correlation to the issue identified.

2 Observations and Recommendations

2.1 IMPROVED SCHEDULE

2.1.1 Observation #1

Several units are operating more than necessary:

1. AHU-7CC: This unit serves the West Lobby area. There is no active schedule for this unit. Since this space does not have substantial human traffic outside of normal scheduling hours, the unit should be allowed to setback space temperature setpoints and close outside air dampers during nighttime operation. This unit should be scheduled to match the existing schedule of air handlers AHU-5CC and 6CC: occupied from 6am to 6pm, seven days a week.
2. AHU-8CC: This unit serves the area nearby the West Skywalk connection. There is no active schedule for this unit. Since this space does not have substantial human traffic outside of normal scheduling hours, the unit should be allowed to setback space temperature setpoints and close outside air dampers during nighttime operation. This unit should be scheduled to match the existing schedule of air handlers AHU-5CC and 6CC: occupied from 6am to 6pm, seven days a week.

2.1.2 Recommendation #1

Implement the following schedules:

1. AHU-7CC: 6am to 6pm, Sunday through Saturday
2. AHU-8CC: 6am to 6pm, Sunday through Saturday

2.1.3 Project Evaluation #1

- Annual Electrical Energy Savings: 127,819 kWh
- Annual Natural Gas Energy Savings: 10,725 therms
- Annual Utility Cost Savings: $ 14,422
- Potential Rebate: $8,536
- Implementation Cost: $1,510
- After Rebate Simple Payback: Immediate

2.1.4 Calculations #1

2.1.4.1 Fan Energy Savings

$$kWh = (VFD\ Speed)^{2.4} \times Max\ Fan\ Power \times hours$$

Note: The exponent of 2.4 is used instead of the exponent of 3 to better match actual fan operation using a VFD and to help be conservative on the energy saving estimation.

$$Max\ Fan\ Power = \frac{HP \times Conversion\ Constant \times Load\ Factor}{Motor\ Efficiency}$$

$$Conversion\ Constant = 0.746\ kW/HP$$

2.1.4.2 Cooling Energy Savings

$$kWh = \frac{1.08 \times CFM \times \Delta T \times hours \times Cooling\ Efficiency}{Conversion\ Constant}$$

$$\Delta T = Average\ Cooling\ Value$$

$$Hours = Total\ hours\ at\ BIN \times Cycle\ Factor$$

$$Cool\ Cycle = how\ frequent\ cooling\ is\ enabled\ based\ on\ OAT$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

2.1.4.3 Heating Energy Savings

$$therms = \frac{1.08 \times CFM \times \Delta T \times hours}{heating\ efficiency \times Conversion\ Constant}$$

$$\Delta T = Average\ Reheat\ Value$$

$$Hours = Total\ hours\ at\ BIN \times Cycle\ Factor$$

$$Heat\ Cycle = how\ frequenct\ heating\ is\ enabled\ based\ on\ OAT$$

$$Heating\ Efficiency = 0.8\ (Based\ on\ boiler\ nameplate)$$

$$Conversion\ Constant = 100{,}000\ BTUs/therm$$

2.2 RETURN AIR HUMIDITY CONTROLS

2.2.1 Observation #2

Air Handlers AHU-1CC, 4CC, 5CC, and 6CC have automation logic to maintain return air humidity levels by reducing supply air temperature. As the return air humidity levels rise above 50%, the controls will reset the unit supply air temperature below the current setpoint. Many times throughout the measurement period, the unit would provide supply air as much as 3 degrees lower than the current setpoint (typically 55°F). This control sequence is effective at controlling space humidity levels, but is unnecessary in a variable-air-volume system. VAV systems are inherently effective at controlling space humidity due to the fact that moisture is removed by maintaining a cooling coil discharge air temperature at 55°F. Supply air temperatures below 55F only provides marginal extra dehumidification, but requires a substantially larger amount of energy.

The return air humidity control programming should be modified to control high-limit space humidity during UNOCCUPIED periods only. During unoccupied operation, when space humidity levels rise above 60% relative humidity, the unit should engage, and provide 55°F air until space humidity levels drop below 50% RH. During this mode of operation, there should be no outside air introduced unless economizing.

2.2.2 Recommendation #2

Implement programming so that the unit will NOT control supply air temperature to maintain return air humidity setpoint while in the occupied mode. Install a space humidity sensor for unoccupied control in one of the areas controlled by the associated AHU. Program the unit to maintain space humidity in these spaces during unoccupied periods as described above.

2.2.3 Project Evaluation #2

- Annual Electrical Energy Savings:13,402 kWh
- Annual Natural Gas Energy Savings: 0 therms
- Annual Utility Cost Savings: $858
- Potential Rebate: $670
- Implementation Cost: $6,410
- After Rebate Simple Payback: 6.7 Years

2.2.4 Calculations #2

2.2.4.1 Cooling Energy Savings

$$kWh = \frac{1.08 \times CFM \times \Delta T \times hours \times Cooling\ Efficiency}{Conversion\ Constant}$$

$$\Delta T = Average\ Cooling\ Temp\ Drop$$

$$Hours = Total\ hours\ at\ BIN$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

2.3 SEAL AHU-10CC OUTSIDE AIR DAMPER

2.3.1 Observation #3

The outside air damper serving AHU-10CC does not fully seal when damper is at 0% open. Visually, daylight can be seen coming through the damper seals. To quantify the amount of leakage, air velocity was measured at the outside air damper while the supply fan was off. With an average measured velocity of 138 FPM, this indicates a substantial amount of unconditioned outside air is being drawn in through the outside air damper during unoccupied periods.

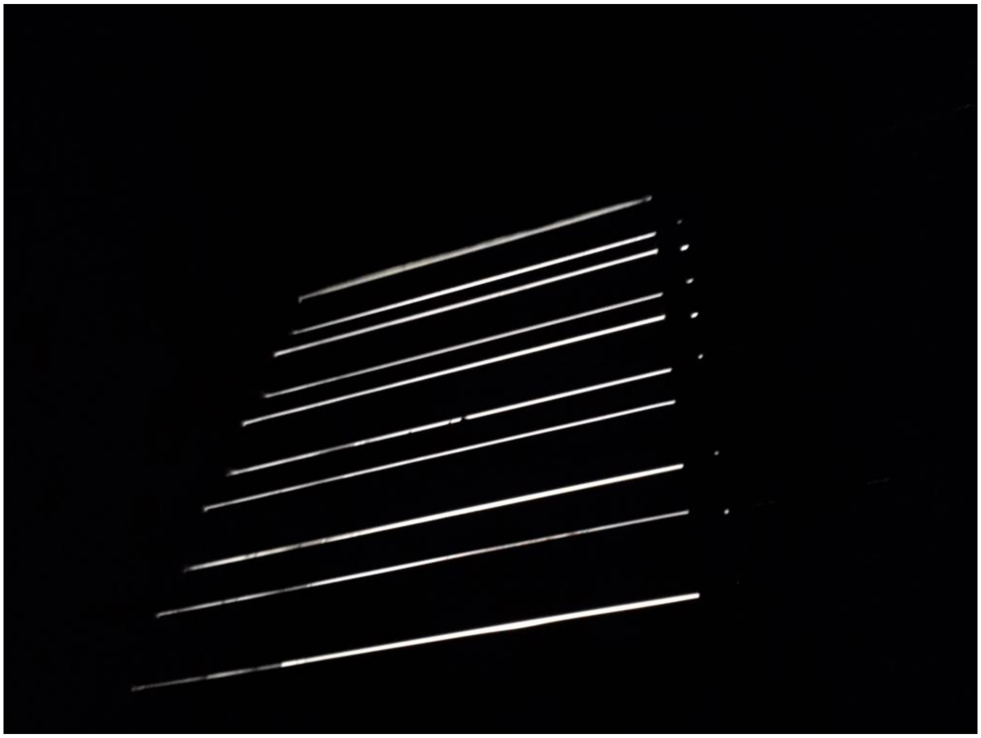


Figure 1: AHU-10CC outside air damper at 0% open

2.3.2 Recommendation #3

Repair outside air damper mechanism and seals to reduce the amount of outdoor air infiltrating into the building while the damper is closed.

2.3.3 Project Evaluation #3

- Annual Electrical Energy Savings: 3,122 kWh
- Annual Natural Gas Energy Savings: 4,756 therms
- Annual Utility Cost Savings: $2,968
- Potential Rebate: $1,107
- Implementation Cost: $2,980
- After Rebate Simple Payback: 0.6 Years

2.3.4 Calculation #3

2.3.4.1 Cooling Energy Savings

$$kWh = \frac{1.08 \times CFM \times \Delta T \times hours \times Cooling\ Efficiency}{Conversion\ Constant}$$

$$\Delta T = Average\ Cooling\ Value$$

$$Hours = Total\ UNOCCUPIED\ hours\ at\ BIN$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

2.3.4.2 Heating Energy Savings

$$therms = \frac{1.08 \times CFM \times \Delta T \times hours}{heating\ efficiency \times Conversion\ Constant}$$

$$\Delta T = Average\ Reheat\ Value$$

$$Hours = Total\ UNOCCUPIED\ hours\ at\ BIN$$

$$Heating\ Efficiency = 0.8\ (Based\ on\ boiler\ nameplate)$$

$$Conversion\ Constant = 100{,}000\ BTUs/therm$$

2.4 ADD ECONOMIZER CONTROLS TO AHU-1V

2.4.1 Observation #4

Unit AHU-1V currently operates as a 100% recirculating air unit. This unit does have outside air control dampers and economizing capabilities. The unit programming currently prohibits the unit from introducing any outside air into the building.

2.4.2 Recommendation #4

Implement economizer controls into the unit, utilizing existing control devices and sensors. Unit should enter economizer mode when outside air dry-bulb temperature falls below 73°F. While in economizer mode, the unit should modulate the outside and return air dampers to maintain the units mixed air temperature setpoint (MAT-SP). During economizing, MAT-SP should track the unit effective discharge air temperature setpoint (EFFDAT-SP), minus 2 degrees. A mixed air temperature low limit of 45°F should also be utilized to avoid coil freezing.

2.4.3 Project Evaluation #4

- Annual Electrical Energy Savings: 4,377 kWh
- Annual Natural Gas Energy Savings: 0 therms
- Annual Utility Cost Savings: $280
- Potential Rebate: $219
- Implementation Cost: $3,380
- After Rebate Simple Payback: 11.3 Years

2.4.4 Calculations #4

2.4.4.1 Cooling Energy Savings

$$kWh = \frac{1.08 \times CFM \times \Delta T \times Hours \times Cooling\ Efficiency}{Conversion\ Constant}$$

$$\Delta T = Mixed\ Air\ Temp - Leaving\ Coil\ Temp$$

$$Hours = Total\ OCCUPIED\ hours\ in\ BIN$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

2.4.4.2 Heating Energy Savings

$$therms = \frac{1.08 \times CFM \times \Delta T \times Hours}{heating\ efficiency \times Conversion\ Constant}$$

$$\Delta T = Leaving\ Coil\ Temp - Mixed\ Air\ Temp$$

$$Hours = Total\ OCCUPIED\ hours\ in\ BIN$$

$$Heating\ Efficiency = 0.8\ (Based\ on\ boiler\ nameplate)$$

$$Conversion\ Constant = 100{,}000\ BTUs/therm$$

2.5 REPAIR AHU-1V CHILLED WATER VALVE

2.5.1 Observation #5

The Chilled Water control valve tied to AHU-1V does not close off 100%. As a result, there is a substantial amount of uncontrolled cooling energy being introduced into the unit airflow.

2.5.2 Recommendation #5

Repair seals on the control valve body and reset control actuator travel range to ensure proper valve sealing.

2.5.3 Project Evaluation #5

- Annual Electrical Energy Savings: 6,609 kWh
- Annual Natural Gas Energy Savings: 0 therms
- Annual Utility Cost Savings: $423
- Potential Rebate: $330
- Implementation Cost: $4,840
- After Rebate Simple Payback: 9.8 Years

2.5.4 Calculation #5

2.5.4.1 Cooling Energy Savings

$$kWh = \frac{1.08 \times CFM \times \Delta T \times hours \times Cooling\ Efficiency}{Conversion\ Constant}$$

$$\Delta T = Measured\ air\ temperature\ drop\ with\ fan\ on\ and\ CWV\ at\ 0\%\ open$$

$$Hours = Trend\ hours\ where\ unit\ is\ occupied\ and\ CWV\ poistion\ is\ 10\%\ or\ less$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

2.6 REPAIR AHU-1V STEAM CONTROL VALVE

2.6.1 Observation #6

The one-third steam control valve tied to AHU-1V does not close off 100%. As a result, there is uncontrolled steam heating energy being introduced into the unit airflow.

2.6.2 Recommendation #6

Repair seals on the control valve body and reset control actuator travel range to ensure prosper valve sealing.

2.6.3 Project Evaluation #6

- Annual Electrical Energy Savings: 13,294 kWh
- Annual Natural Gas Energy Savings: 1,159 therms
- Annual Utility Cost Savings: $1,526
- Potential Rebate: $897
- Implementation Cost: $3,780
- After Rebate Simple Payback: 1.9 Years

2.6.4 Calculations #6

2.6.4.1 Cooling Energy Savings

$$kWh = \frac{1.08 \times CFM \times \Delta T \times hours \times Cooling\ Efficiency}{Conversion\ Constant}$$

$$\Delta T = Measured\ air\ temperature\ rise\ with\ fan\ on\ and\ HWV\ at\ 0\%\ open$$

$$Hours = Trend\ hours\ where\ unit\ is\ occupied\ and\ HWV\ poistion\ is\ 0\%$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

2.6.4.2 Heating Energy Savings

$$therms = \frac{1.08 \times CFM \times \Delta T \times hours}{heating\ efficiency \times Conversion\ Constant}$$

$$\Delta T = Measured\ air\ temperature\ rise\ with\ fan\ on\ and\ HWV\ at\ 0\%\ open$$

$$Hours = Trend\ hours\ where\ unit\ is\ occupied\ and\ HWV\ poistion\ is\ 0\%$$

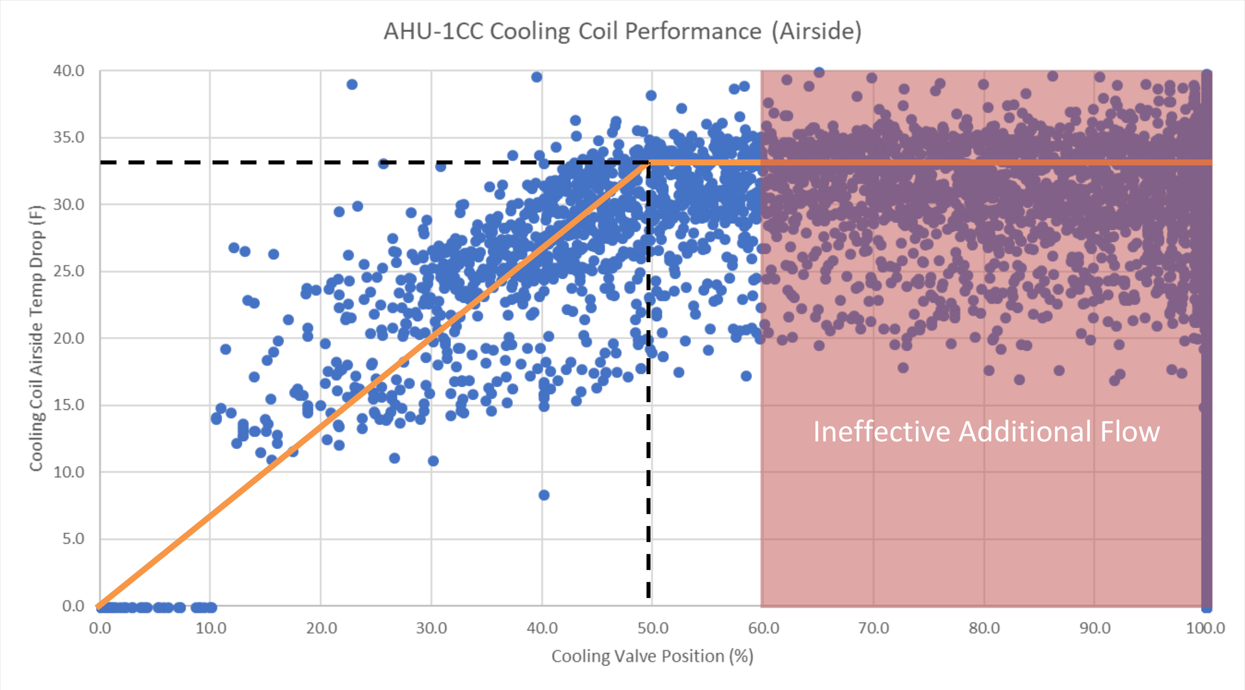
$$Heating\ Efficiency = 0.8\ (Based\ on\ boiler\ nameplate)$$

$$Conversion\ Constant = 100{,}000\ BTUs/therm$$

2.7 LIMIT CONTROL VALVE MAXIMUM POSITIONS

2.7.1 Observation #7

Based on gathered trend data, a performance analysis of each cooling and heating coil provided some useful information about how well each coil performs. Comparing discharge air temperatures with valve positions throughout the year gives a visual representation of each coil's valve operation. Industry studies have shown that pumping energy savings can be easily realized by identifying the point at which coils do not provide meaningful increases in capacity above a certain water flow.



In the above example, the cooling coil for AHU-1CC can achieve design air temperature drop with the cooling control valve only open 50%. When the valve is opened up further than 50%, it becomes apparent that the additional flow of chilled water through the coil does not produce any additional cooling effect – the coil is effectively "tapped out".

2.7.2 Recommendation #7

Re-configure the control parameters on all air handling units listed below, limiting the valves' maximum position. The maximum position should be set up as a user-adjustable parameter on each AHU graphic. This is to give maintenance staff maximum flexibility in the event of a future failure. Alternatively, programming logic could be set up to automatically remove the limit if the supply water temperature rises above 39F (based on the original design).

UNIT	Cooling Coil Max Position
AHU-1CC	60%
AHU-2CC	50%
AHU-3CC	50%
AHU4-CC	60%
AHU5-CC	80%
AHU-6CC	60%
AHU-7CC	80%
AHU-8CC	70%

2.7.3 Project Evaluation #7

- Annual Electrical Energy Savings: 6,933 kWh
- Annual Natural Gas Energy Savings: 0 therms
- Annual Utility Cost Savings: $444
- Potential Rebate: $347
- Implementation Cost: $4,980
- After Rebate Simple Payback: 10.4 Years

2.7.4 Calculations #7

2.7.4.1 Pumping Energy Savings

$$kWh = \frac{(Pump\ Motor\ Horsepower)\left(0.746\frac{kW}{hp}\right)(Pump\ Speed\ \%)^{2.4}(Hours)(Load\ Factor)}{Pump\ Motor\ Efficiency}$$

Pump Speed % = Reduced Pump Speed resulting from limiting AHU CWV position.

Hours = Trend Data Increment (0.25 Hours)

Load Factor = 0.75 throughout

Pump Motor Efficiency = 0.9 throughout

2.8 MAKE-UP AIR DISCHARGE AIR TEMPERATURE RESET

2.8.1 Observation #8

There are currently five (5) direct fired natural gas make up air units that serve the kitchen area on the lower (exhibition) level of CCCUCC. These units are currently controlled through direct wire interlock with their associated kitchen exhaust fan. When one of the exhaust fans is switched on manually by kitchen staff, the associated make-up unit is enabled. The make-up air units then control a modulating burner to maintain a discharge air temperature setpoint. The discharge air setpoint is set by a manual slider mounted on the unit controller. Johnson controls has installed discharge air temperature sensors and exhaust fan status switches to provide some operational info about the units, but all temperature controls are resident at the make-up air units.

Since the units have the capability to accept a remote signal from an automation system to control the discharge air setpoint, Iowa Events Center could realize some savings in resetting the discharge air temp setpoints to eliminate over heating the makeup air. Current DAT setpoints are set between 75°F and 85°F. The units will continue to produce heating until the DAT setpoint is met. This indicates that the units are producing heated air when outside air temperatures are above 65°F.

Automatic controls should be installed to provide proper discharge air temps throughout the year in an effective and efficient manner. Anytime the outside air temperature rises above 65°F, the units should not provide any heating whatsoever. Since this is a kitchen application, the discharge air temperature does not need to be provided any warmer than 75°F to maintain space comfort levels.

2.8.2 Recommendation #8

Add discharge air temperature inputs and general alarm or fan status outputs to each of the five make-up air units. Reset discharge air temp signal to limit all unit discharge air temps to the following schedule:

Outside Air Dry-Bulb Temp	Discharge Air Temp Setpoint
Above 65°F	65°F
65°F to 20°F	Linear reset between 65°F and 75°F
Below 20°F	75°F

2.8.3 Project Evaluation #8

- Annual Electrical Energy Savings: 0 kWh
- Annual Natural Gas Energy Savings: 7,260 therms
- Annual Utility Cost Savings: $4,225
- Potential Rebate: $1,452
- Implementation Cost: $9,080
- After Rebate Simple Payback: 1.8 Years

2.8.4 Calculations #8

2.8.4.1 Heating Energy Savings

$$therms = \frac{1.08 \times CFM \times \Delta T \times hours}{heating\ efficiency \times Conversion\ Constant}$$

$$\Delta T = Discharge\ Air\ Temp - Outside\ Air\ Temp$$

$$Hours = (TMY3\ Hours)(Average\ Unit\ Runtime)$$

$$Heating\ Efficiency = 0.8\ (Based\ on\ boiler\ nameplate)$$

$$Conversion\ Constant = 100{,}000\ BTUs/therm$$

2.9 LIMIT VAV DISCHARGE AIR TEMPERATURE

2.9.1 Observation #9

The variable air volume (VAV) boxes are designed to provide both cooling and heating for many spaces throughout CCCUCC. In most cases, air is discharged into spaces via air diffusers located in the ceiling. Air is returned to the air handler through an open, above-ceiling plenum via return air diffusers located in the ceiling. During heating mode, the VAV boxes, will open hot water heating valves to allow hot water to flow through a reheat coil. The programming in each of the heating VAV boxes will open the control valve much further than necessary, raising the supply air temp to over 120°F. With the supply and return diffusers being located in the ceiling, overly-heated air will tend to stratify near the ceiling. Occupants below will not receive the full effect, and the system will need to work harder to compensate.

ASHRAE recommends limiting the discharge air temperature to 20°F above the current space temperature setpoint (ASHRAE Standard 90.1-2013). This will reduce the buoyancy of the air and provide more effective air distribution and ventilation. ASHRAE gives a ceiling-ceiling arrangement a Zone Air Distribution Effectiveness rating (Ez) of 0.8 with a warm supply air temp 15°F ***higher than*** space temp. This is 20% lower than the Ez rating of 1.0 for the same arrangement with supply air temps ***less than*** 15°F higher than space temp.

2.9.2 Recommendation #9

Implement programming at each of the (68) heating VAV boxes so that the controller will still vary the airflow in response to space temp, but also maintain a constant heating discharge air temperature by modulating the hot water control valve. The discharge air setpoint should be set to 15°F above the active space temperature setpoint.

2.9.3 Project Evaluation #9

- Annual Electrical Energy Savings: 0 kWh
- Annual Natural Gas Energy Savings: 1,554 therms
- Annual Utility Cost Savings: $905
- Potential Rebate: $311
- Implementation Cost: $6,380
- After Rebate Simple Payback: 6.7 Years

2.9.4 Calculations #9

2.9.4.1 Heating Energy Savings

$$therms = \sum_{All\,VAVs} \left[\frac{1.08 \times CFM \times \Delta T \times hours}{heating\ efficiency \times Conversion\ Constant} \right] (Overheat\ \%)$$

$$CFM = (Design\ VAV\ Box\ Airflow)(Average\ Damper\ Position)$$

$$\Delta T = Discharge\ Air\ Temp - Supply\ Air\ Temp$$

$$Heating\ Efficiency = 0.8\ (Based\ on\ boiler\ nameplate)$$

$$Conversion\ Constant = 100{,}000\ BTUs/therm$$

$$Overheat\ \% = \%\ of\ time\ when\ DAT\ is > 92°F$$

2.10 IMPROVED VENTILATION CONTROLS

2.10.1 Observation #10

Air Handling Units AHU-5CC and AHU-6CC each utilize a space CO2 sensor to optimize the ventilation rate for served areas. Currently, each air handler has its own CO2 sensor. The controls reset the outside air damper position in response to the space CO2 reading. As CO2 levels increase, the outside air damper position is opened further. Based on functional testing, it appears that the existing sequence is over-ventilating by opening the outside air damper when CO2 levels have not yet reached a typically actionable level.

The programming also appears to reset the damper position directly as opposed to resetting the minimum damper position. This overrides potential economizer free-cooling savings, by limiting the outside air damper position when the unit could be in full economizer mode.

2.10.2 Recommendation #10

Re-program the unit sequences for AHU-5CC and AHU-6CC so that the controllers will reset the minimum damper position in response to space CO2 readings. The minimum position should be reset linearly (as per ASHRAE Standard 62.1) as shown below:

CO2 Reading (parts-per-million)	MINIMUM Outside Air Damper Position
Below 800	Min Position
800 to 1,000	Linear reset from Min Pos to 100% Open
1,000 and higher	100%

2.10.3 Project Evaluation #10

- Annual Electrical Energy Savings: 20,247 kWh
- Annual Natural Gas Energy Savings: 398 therms
- Annual Utility Cost Savings: $1,527
- Potential Rebate: $1,092
- Implementation Cost: $4,710
- After Rebate Simple Payback: 2.4 Years

2.10.4 Calculations #10

2.10.4.1 Cooling Energy Savings

$$kWh = \frac{1.08 \times CFM \times \Delta T \times hours \times Cooling\ Efficiency}{Conversion\ Constant}$$

$$\Delta T = Leaving\ Coil\ Temp - Mixed\ Air\ Temp$$

$$Hours = Total\ OCCUPIED\ hours\ in\ BIN$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

2.11 REPAIR AHU-6CC CHILLED WATER CONTROL VALVE

2.11.1 Observation #11

It appears that the chilled water control valve for AHU-6CC is allowing a substantial amount of chilled water to flow through the cooling coil while the valve is commanded to 0% open position. During functional testing, the coil was cooling air by as much as 28°F while indicating a 0% open position command and 0% open position feedback. This indicates a mechanical problem with the valve or valve actuator. When the valve was overridden to 100% open, the coil was only able to cool the air by an additional 1 degree.

2.11.2 Recommendation #11

Repair the chilled water control valve so that there is no flow through the cooling coil while the valve is commanded to a 0% open position.

2.11.3 Project Evaluation #11

- Annual Electrical Energy Savings: 70,906 kWh
- Annual Natural Gas Energy Savings: 1,018 therms
- Annual Utility Cost Savings: $5,131
- Potential Rebate: $3,749
- Implementation Cost: $3,780
- After Rebate Simple Payback: Immediate

2.11.4 Calculations #11

2.11.4.1 Cooling Energy Savings

$$kWh = \frac{1.08 \times CFM \times \Delta T \times hours \times Cooling\ Efficiency}{Conversion\ Constant}$$

$$\Delta T = Mixed\ Air\ Temp - Leaving\ Coil\ Temp$$

$$Hours = Total\ OCCUPIED\ hours\ in\ BIN$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

2.11.4.2 Heating Energy Savings

$$therms = \frac{1.08 \times CFM \times \Delta T \times hours}{heating\ efficiency \times Conversion\ Constant}$$

$$\Delta T = Leaving\ Coil\ Temp - Mixed\ Air\ Temp$$

$$Hours = Total\ OCCUPIED\ hours\ in\ BIN$$

$$Heating\ Efficiency = 0.8\ (Based\ on\ boiler\ nameplate)$$

$$Conversion\ Constant = 100{,}000\ BTUs/therm$$

2.12 CALIBRATE AHU-1CC AIRFLOW MEASURING STATION

2.12.1 Observation #12

SystemWorks performed airflow reading accuracy checks on each of the 20 airflow measurement stations (AFMS) to determine if any of them were out of calibration or experiencing any sensing problems. It was determined that the AFMS on the supply fan of AHU-1CC was reading around 1,246 CFM higher than the actual airflow. Since the speed of the return fan is dependent and offset by the airflow of the supply fan, calibrating the supply fan AFMS will reduce the airflow and speed of the return fan.

2.12.2 Recommendation #12

Calibrate the airflow measurement station on the supply fan for AHU-1CC so that it accurately measures airflow.

2.12.3 Project Evaluation #12

- Annual Electrical Energy Savings: 17,730 kWh
- Annual Natural Gas Energy Savings: 0 therms
- Annual Utility Cost Savings: $1,135
- Potential Rebate: $887
- Implementation Cost: $1,500
- After Rebate Simple Payback: 0.5 Years

2.12.4 Calculations #12

2.12.4.1 Return Fan Energy Savings

$$kWh = (VFD\ Speed)^{2.4} \times Max\ Fan\ Power \times Hours$$

$$Hours = Number\ of\ OCCUPIED\ hours\ in\ BIN$$

$$Max\ Fan\ Power = \frac{HP \times Conversion\ Constant \times Load\ Factor}{Motor\ Efficiency}$$

$$Conversion\ Constant = 0.746\ kW/HP$$

$$Load\ Factor = 0.75\ throughout$$

$$Motor\ Efficiency = 0.9\ throughout$$

2.13 IMPLEMENT SUPPLY DUCT STATIC PRESURE RESET

2.13.1 Observation #13

Over the course of functional testing, SystemWorks uncovered a number of issues with various VAV boxes. Many of these issues are responsible for limiting the air handler controller's ability to reduce the discharge air static pressure setpoint (DSP-SP). AHU-1CC and AHU-4CC already have programming in place that allows the unit to reset DSP-SP downward if all served VAV boxes are at 90% open or less. VAV boxes that were limiting the reset were:

- TAB-225CC is not achieving the SAFLOW-SP 230 cfm. SA-F reading 7.4 cfm. DPR-O 100%
- TAB-231CC is not achieving the SAFLOW-SP 1180 cfm. SA-F reading 163.1 cfm. DPR-O 100%
- TAB-227CC is not achieving the SAFLOW-SP 1400 cfm. SA-F reading 245 cfm. DPR-O 100%
- TAB-303CC is not achieving the SAFLOW-SP 5145 cfm. SA-F reading 4243.7 cfm. DPR-O 100%

AHU-5CC and AHU-6CC also serve VAV boxes and would benefit by adding the ability to reset DSP-SP – they do not currently have this programming. There are currently 4 VAV boxes that would limit the air handlers' ability to reset DSP-SP:

- TAB-102CC is not achieving the SAFLOW-SP 250 cfm. SA-F reading 179 cfm. DPR-O 100%
- TAB-114CC is not achieving the SAFLOW-SP 210 cfm. SA-F reading 11.2 cfm. DPR-O 100%
- TAB-113CC is not working correctly. SAFLOW-SP 0 cfm. SA-F reading 230.3 cfm. DPR-O overridden to 75%
- TAB-111CC is not achieving the SAFLOW-SP 1040 cfm. SA-F reading 29 cfm. DPR-O 100%

2.13.2 Recommendation #13

Diagnose and repair issues on each of the VAV boxes listed above. In order for the duct static pressure reset to operate properly, all the variable air volume boxes must be operating properly. Implement a duct static pressure reset based on zone-box damper command on AHU-5CC and AHU-6CC. Here are the proposed setpoints:

UNIT	DAP-SP (HIGH)	DAP-SP (LOW)
AHU-5CC	1.3	0.9
AHU-6CC	1	0.7

When a box reaches 90% damper position, the static pressure should begin to reset up to the high limit through a slow-ramping PID loop. If the maximum box damper is less than 80% open, the static pressure setpoint should reset downward to the minimum static pressure setpoint. While setting up the reset sequence, all driving boxes (boxes that are consistently above 85%) should be evaluated to see what is causing the consistently high damper position.

2.13.3 Project Evaluation #13

- Annual Electrical Energy Savings:10,173 kWh
- Annual Natural Gas Energy Savings: 0 therms
- Annual Utility Cost Savings: $651
- Potential Rebate: $509
- Implementation Cost: $3,520
- After Rebate Simple Payback: 4.6 Years

2.13.4 Calculations #13

2.13.4.1 Fan Speed/Fan Static Pressure Relationship

$$Change\ in\ Fan\ Speed\ \propto Change\ in\ Fan\ Total\ Static\ Pressure$$

2.13.4.2 Fan Energy Savings

$$kWh = \ (VFD\ Speed)^{2.4}\ \times\ Max\ Fan\ Power\ \times Hours$$

$$Hours = Number\ of\ OCCUPIED\ hours\ in\ BIN$$

$$Max\ Fan\ Power = \frac{HP\ \times Conversion\ Constant\ \times Load\ Factor}{Motor\ Efficiency}$$

$$Conversion\ Constant = 0.746\ kW/HP$$

$$Load\ Factor = 0.75\ throughout$$

$$Motor\ Efficiency = 0.9\ throughout$$

2.14 ALLOW EXHIBIT HALL UNITS TO ECONOMIZE

2.14.1 Observation #14

The two air handling units that serve the lower level exhibit hall (AHU-9CC and AHU-10CC) do not appear to fully utilize cool outdoor air temperatures for reduced cooling energy. This may be due to manual overrides to the outdoor damper position in an attempt to limit introducing humidity into the space. Over the measured period, trend data indicated extended periods where the outside air dampers were locked in a low position during potentially economizing periods.

2.14.2 Recommendation #14

The units both have economizer sequences already programmed in the unit controllers. Operators should consider resetting the units' discharge air temperature setpoints downward if space humidity is a concern as opposed to limiting ventilation.

2.14.3 Project Evaluation #14

- Annual Electrical Energy Savings: -8,205 kWh (OAD Overrides limited cooling energy in 2017)
- Annual Natural Gas Energy Savings: 3,755 therms
- Annual Utility Cost Savings: $1,660
- Potential Rebate: $341
- Implementation Cost: $260
- After Rebate Simple Payback: Immediate

2.14.4 Calculations #14

2.14.4.1 Cooling Energy Savings

$$kWh = \frac{1.08 \times CFM \times \Delta T \times hours \times Cooling\ Efficiency}{Conversion\ Constant}$$

$$\Delta T = Mixed\ Air\ Temp - Leaving\ Coil\ Temp$$

$$Hours = Total\ OCCUPIED\ hours\ in\ BIN$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

2.14.4.2 Heating Energy Savings

$$therms = \frac{1.08 \times CFM \times \Delta T \times hours}{heating\ efficiency \times Conversion\ Constant}$$

$$\Delta T = Leaving\ Coil\ Temp - Mixed\ Air\ Temp$$

$$Hours = Total\ OCCUPIED\ hours\ in\ BIN$$

$$Heating\ Efficiency = 0.8\ (Based\ on\ boiler\ nameplate)$$

$$Conversion\ Constant = 100{,}000\ BTUs/therm$$

2.15 RESET FANCOIL UNITS' SPACE TEMPERATURE SETPOINT

2.15.1 Observation #15

Out the 26 fan coil units that serve various electrical closets and server rooms, 22 of them only provide cooling on a year-round basis. All of these units have space temperature setpoints at or below 70°F. The original design called for the units to maintain spaces at 75°F. The current sequence of operation initiates the supply fan and fully opens the unit's 2-position chilled water control valve. By increasing the space temperature setpoints for these units, both fan and cooling energy saving would be realized.

2.15.2 Recommendation #15

Adjust the space temperature setpoints for all 22 cooling-only units (FCU-1 through 21, 24, and 25), to 72°F. This should still satisfy space comfort cooling and save energy at the same time.

2.15.3 Project Evaluation #15

- Annual Electrical Energy Savings: 13,587 kWh
- Annual Natural Gas Energy Savings: 0 therms
- Annual Utility Cost Savings: $870
- Potential Rebate: $679
- Implementation Cost: $130
- After Rebate Simple Payback: Immediate

2.15.4 Calculations #15

2.15.4.1 Space Temp/Unit Runtime Relationship

$$\%\ Change\ in\ Space\ Temp\ \propto \%\ Change\ in\ Unit\ Runtime$$

2.15.4.2 Fan Energy Savings

$$kWh = \sum_{All\ FCU} (HP)(Conversion\ Constant)(Hours)$$

$$Conversion\ Constant = 0.746\ kW/HP$$

$$Hours = Number\ of\ Unit\ Reduced\ Run\ Hours$$

2.15.4.3 Cooling Energy Savings

$$kWh = \sum_{All\ FCU} \frac{(Unit\ Cooling\ Cap)(Hours)(Coooling\ Efficiency)}{Conversion\ Constant}$$

$$Hours = Number\ of\ Unit\ Reduced\ Run\ Hours$$

$$Cooling\ Efficiency\ \left(\frac{kW}{ton}\right) = \frac{12}{EER} = 1.72\ (Based\ on\ trend\ data)$$

$$Conversion\ Constant = 12{,}000\ BTUs/ton$$

3 Facility Improvement Opportunities

This section includes items that are not included in the energy saving calculations detailed out in the previous section. These items should be addressed and will allow the equipment to operate better and help improve comfort.

UNIT OPERATIONAL IMPROVEMENTS:

1. MAU-2V not running due to Freeze Relay is enabled.
2. MAU-5V not running due to Freeze Relay is enabled.
3. AHU-4CC – The relief fan output is limited to a 35% minimum value. This does not allow the unit to maintain the required offset between the supply and return.
4. AHU-7CC – Reheat Pump is commanded ON. Status is OFF. Pump is actually running. No alarm present in the system.
5. AHU-8CC – ODA Damper and RA Dampers are not interlocked.
6. VAV Box AHU-5CC RM 300 – This unit is not being occupied with the rest of the TAB boxes.
7. VAV Box AHU-5CC TAB-202CC - Heating Enable is overridden to false.

VAV BOX DISCHARGE AIR TEMPERATURE SENSORS INDICATING FALSE VALUES:

1. AHU-5CC – TAB-106 consistently indicates DAT values 400°F and higher.
2. AHU-5CC – TAB-109 consistently indicates DAT values 250°F and higher.
3. AHU-5CC – TAB-202 consistently indicates DAT values 240°F and higher.
4. AHU-6CC – TAB-204 consistently indicates DAT values 400°F and higher.
5. AHU-4CC – TAB-233 consistently indicates DAT values 500°F and higher.
6. AHU-1CC – TAB-236 consistently indicates DAT values 240°F and higher.
7. AHU-1CC – TAB-240 consistently indicates DAT values 600°F and higher.
8. AHU-5CC – TAB-302 consistently indicates DAT values 240°F and higher.

BUILDING AUTOMATION IMPROVEMENTS:

1. Z-T, ZN-SP, OA-T and OA-Humidity value not shown on Fuel Oil Pump Control graphic.
2. Underground leak point shows "Normal???" on Fuel Oil Pump Control graphic.
3. A number of device graphics are not displaying point values properly:
    a. TF-1CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    b. TF-2CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    c. TF-3CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    d. TF-4CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    e. TF-5CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    f. TF-6CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    g. TF-7CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    h. TF-8CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    i. CUH-1CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    j. CUH-2CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    k. CUH-3CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    l. CUH-4CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    m. CUH-5CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
    n. CUH-6CC OCC-SCHEDULE, SF-S and SEQ-OP points value reading "(text not found)"
4. AHU-5CC Graphic - TAB Boxes Tailored Summaries link is not linked to Tailored Summaries.
5. AHU-4CC OA-LAT Temp OA-LAT temp is not reading correctly.

SPACE CARBON DIOXIDE (CO2) SENSORS OUT OF CALIBRATION:

1. AHU-1CC - TAB-217CC ZN-CO2 Reading 698 ppm. Unreliable.
2. AHU-1CC - TAB-218CC ZN-CO2 Reading 55 ppm.
3. AHU-1CC - TAB-220CC ZN-CO2 Reading 303 ppm.
4. AHU-1CC - TAB-221CC ZN-CO2 Reading 129 ppm.
5. AHU-1CC - TAB-222CC ZN-CO2 Reading 55 ppm.
6. AHU-1CC - TAB-223CC ZN-CO2 Reading 275 ppm.
7. AHU-1CC - TAB-224CC ZN-CO2 Reading 1011 ppm. Unreliable.
8. AHU-1CC - TAB-225CC ZN-CO2 Reading 55 ppm.
9. AHU-1CC - TAB-235CC ZN-CO2 Reading 257 ppm.
10. AHU-1CC - TAB-236CC ZN-CO2 Reading 281 ppm.
11. AHU-1CC - TAB-237CC ZN-CO2 Reading 55 ppm.
12. AHU-1CC - TAB-238CC ZN-CO2 Reading 362 ppm.
13. AHU-1CC - TAB-239CC ZN-CO2 Reading 65 ppm.
14. AHU-1CC - TAB-240CC ZN-CO2 Reading 193 ppm.
15. AHU-1CC - TAB-241CC ZN-CO2 Reading 339 ppm.
16. AHU-1CC - TAB-244CC ZN-CO2 Reading 169 ppm.
17. AHU-1CC - TAB-306CC ZN-CO2 Reading 209 ppm.
18. AHU-4CC - TAB-206CC ZN-CO2 Reading 291 ppm.
19. AHU-4CC - TAB-208CC ZN-CO2 Reading 399 ppm.
20. AHU-4CC - TAB-209CC ZN-CO2 Reading 437 ppm. Unreliable
21. AHU-4CC - TAB-210CC ZN-CO2 Reading 84 ppm.
22. AHU-4CC - TAB-212CC ZN-CO2 Reading 399 ppm.
23. AHU-4CC - TAB-213CC ZN-CO2 Reading 269 ppm.
24. AHU-4CC - TAB-215CC ZN-CO2 Reading 315 ppm.
25. AHU-4CC - TAB-216CC ZN-CO2 Reading -231 ppm. Unreliable
26. AHU-4CC - TAB-226CC ZN-CO2 Reading 129 ppm.
27. AHU-4CC - TAB-227CC ZN-CO2 Reading 226 ppm.
28. AHU-4CC - TAB-228CC ZN-CO2 Reading 399 ppm.
29. AHU-4CC - TAB-229CC ZN-CO2 Reading 252 ppm.
30. AHU-4CC - TAB-230CC ZN-CO2 Reading 386 ppm.
31. AHU-4CC - TAB-231CC ZN-CO2 Reading 291 ppm.
32. AHU-4CC - TAB-233CC ZN-CO2 Reading 258 ppm.
33. AHU-4CC - TAB-234CC ZN-CO2 Reading -232 ppm. Unreliable
34. AHU-4CC - TAB-303CC ZN-CO2 Reading 18 ppm.
35. AHU-5CC - TAB-109CC ZN-CO2 Reading 348 ppm.
36. AHU-5CC - TAB-201CC ZN-CO2 Reading 272 ppm.
37. AHU-5CC - TAB-203CC ZN-CO2 Reading -232 ppm. Unreliable
38. AHU-5CC - TAB-309CC ZN-CO2 Reading 236 ppm.
39. AHU-6CC - TAB-204CC ZN-CO2 Reading -231 ppm. Unreliable
40. AHU-6CC - TAB-205CC ZN-CO2 Reading 286 ppm.

EXHAUST AIR VOLUME BOXES UNABLE TO REACH AIRFLOW SETPOINT:

1. TEF-2CC - ETAB-202CC is not achieving the SAFLOW-SP 625 cfm. SA-F reading 248.4 cfm.
2. TEF-2CC - ETAB-103CC is not achieving the SAFLOW-SP 1225 cfm. SA-F reading 499.7 cfm.
3. TEF-1CC - ETAB-402CC is not achieving the SAFLOW-SP 600 cfm. SA-F reading 345.8 cfm.
4. TEF-1CC - ETAB-401CC is not achieving the SAFLOW-SP 975 cfm. SA-F reading 538.7 cfm.
5. TEF-1CC - ETAB-102CC is not achieving the SAFLOW-SP 700 cfm. SA-F reading 546.0 cfm.
6. TEF-1CC - ETAB-101CC is not achieving the SAFLOW-SP 2725 cfm. SA-F reading 1833.8 cfm.
7. TEF-2CC - ETAB-103CC is not achieving the SAFLOW-SP 1225 cfm. SA-F reading 516.7 cfm.
8. TEF-1CC - ETAB-102CC is not achieving the SAFLOW-SP 1225 cfm. SA-F reading 516.7 cfm.
9. TEF-1CC - ETAB-101CC is not achieving the SAFLOW-SP 2725 cfm. SA-F reading 1795.2 cfm.
10. TEF-2CC - ETAB-202CC is not achieving the SAFLOW-SP 625 cfm. SA-F reading 256 cfm.

4 Utility and Equipment Analysis

Historical trend data gathered between March 1, 2017 and February 28, 2018, provided the basis for determining how much energy the HVAC equipment used. Eleven air handlers were baselined for energy consumption. These air handlers account for almost 50% of all the heating and cooling energy consumed at CCCUCC. Of this energy usage, four air handling units (AHU-1CC, 2CC, 7CC and 8CC) account for more than 62.4% of the air handler total energy usage. As for the rest of the HVAC equipment, the five Kitchen Make-up Air Units consumed 20.1% of the heating & cooling energy, while the sixty-nine Variable Air Volume (VAV) Boxes consumed 13.9%, and the twenty-six Fan Coil Units consumed 12.2%.

Table 2: Baseline Energy Consumption Breakdown

HEATING & COOLING UNITS	FAN KWH	COOLING KWH	HEATING THERMS	kBTU	% kBTU
AIR HANDLERS	545,133	711,013	28,030	7,090,255	49.5%
KITCHEN EXHAUST FANS	78,011			266,251	1.9%
KITCHEN MAKEUP AIR UNITS	52,772		26,966	2,876,748	20.1%
TRANSFER FANS	7,757			26,475	0.2%
TOILET EXHAUST FANS	21,815			74,454	0.5%
HOT WATER PUMPS	51,694			176,430	1.2%
CHILLED WATER PUMPS	21,261			72,564	0.5%
VAV BOXES			19,869	1,986,890	13.9%
FANCOILS	29,264	192,931	9,817	1,740,075	12.2%
TOTALS	807,706	903,944	84,683	14,310,143	

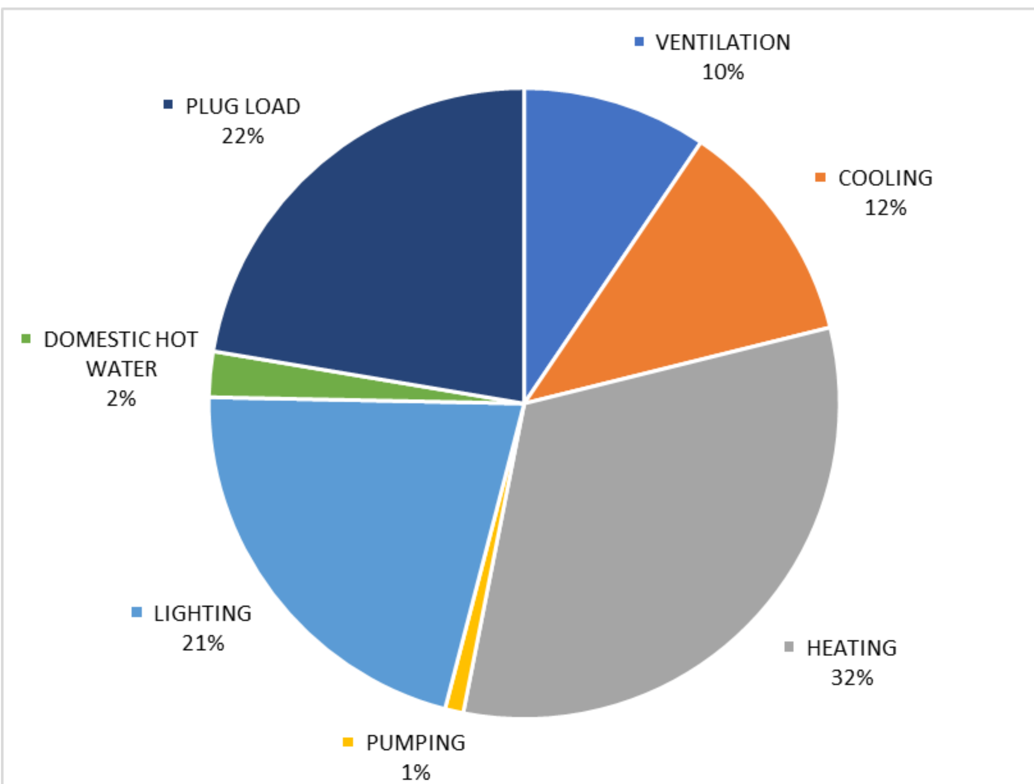
Table 3: Baseline Air Handler Energy Consumption Breakdown

UNIT	SERVES	DESIGN AIRFLOW	OCCUPIED %	FAN KWH	COOL KWH	HEAT THERMS	kBTU	% kBTU
AHU-1CC	SOUTH MEETING ROOMS	25,600	60%	51,395	157,093	99	721,514	10.2%
AHU-2CC	MAIN BALLROOM SOUTH	30,000	32%	16,578	54,766	378	281,331	4.0%
AHU-3CC	MAIN BALLROOM NORTH	30,000	36%	22,093	48,201	713	311,218	4.4%
AHU-4CC	NORTH MEETING ROOMS	27,500	60%	63,359	148,327	125	735,022	10.4%
AHU-5CC	BACK OF HOUSE NORTH	11,000	67%	30,972	54,478	507	342,391	4.8%
AHU-6CC	BACK OF HOUSE SOUTH	10,500	67%	30,389	62,938	1,018	420,334	5.9%
AHU-7CC	WEST LOBBY	10,650	100%	53,214	45,945	11,879	1,526,379	21.5%
AHU-8CC	SKYWALK ENTRY	17,000	100%	128,057	54,048	8,210	1,442,548	20.3%
AHU-9CC	EXHIBIT LEVEL EAST	25,000	26%	21,520	19,536	4,700	610,150	8.6%
AHU-10CC	EXHIBIT LEVEL WEST	30,000	27%	5,023	17,600	399	117,075	1.7%
AHU-1V	KITCHEN AREA	10,700	48%	122,531	48,080	0	582,294	8.2%
TOTALS		227,950		545,133	711,013	28,030	7,090,255	

Table 4: Defined ECOs and Associated Equipment

	Energy Conservaion Opportunity (ECO)	AHU-1CC	AHU-2CC	AHU-3CC	AHU-4CC	AHU-5CC	AHU-6CC	AHU-7CC	AHU-8CC	AHU-9CC	AHU-10CC	AHU-1V	KITCHEN MUAS	VAV BOXES	FAN COIL UNITS
1	Improved Schedules							x	x						
2	Improved Humidity Control	x			x										
3	Seal AHU-10CC Outside Air Damper										x				
4	Add Economizer Controls to AHU-1V											x			
5	Repair AHU-1V Chilled Water Control Valve											x			
6	Repair AHU-1V Steam Control Valve											x			
7	Limit Control Valve Maximum Positions	x	x	x	x	x	x	x	x						
8	Make-Up Air Discharge Air Temp Reset												x		
9	Limit VAV Discharge Air Temperature													x	
10	Improved Ventilation Reset Controls					x	x								
11	Repair AHU-6CC Chilled Water Control Valve						x								
12	Calibrate AHU-1CC AFMS	x													
13	Implement Supply Duct Static Pressure Reset	x			x	x	x								
14	Allow Exhibit Hall Units to Economize									x	x				
15	Reset Fan Coil Units Space Temp Setpoints														x

Table 5: Estimated Energy End Use Breakdown for CCCUCC



4.1 Annual Utility Comparison

Five complete years of utility data has been acquired and analyzed. Below is an annual overview of Iowa Events Center's utilities.

- Between 2014 and 2017, electrical rates per kWh have increased 11%.
- Iowa Events Center's current electric rate of 6.4 cents per kWh is still well below the average Iowa commercial rate of 8.01 cents per kWh and the national commercial average of 10.09 cents per kWh.
- Calendar year 2015 saw a significant drop in gas prices, 40% lower than 2014 at $0.517 per therm. Gas prices stayed right around that mark until the first substantial increase in 2017, where prices increased to $0.582 per therm – a 15% increase in one year.
- 2017 also marked the first partial year energy conservation opportunities were put in place after the first Retro-Commissioning projects, beginning in May 2017. Table 7 indicates year-over-year, the Iowa Events Center realized $35,000 in utility savings (2.8%) even with a 4.2% increase in electrical rates and a 15% increase in natural gas rates. In addition, 2017 was a much colder year than 2016, showing an 8.6% increase in heating-degree-days. Despite the cold temperatures, IEC consumed 6.4% fewer therms.

Table 6: Campus Annual Energy Data

	2014	2015	2016	2017	14-16 AVG
EUI (kBTU/ft2)	95.8	90.3	92.0	85.3	92.7
Total Utility Cost	$ 1,307,839	$ 1,204,062	$ 1,256,847	$ 1,221,848	$ 1,256,249
Total Cost per ft2	$ 1.23	$ 1.13	$ 1.18	$ 1.15	$ 1.18
Electrical Cost	$ 944,305	$ 981,773	$ 1,054,207	$ 1,002,601	$ 993,428
Electrical Rate ($/kWh)	$ 0.058	$ 0.060	$ 0.062	$ 0.064	$ 0.060
Electrical Consumption (kWh)	16,399,709	16,475,974	17,055,976	15,694,939	16,643,886
Peak Electrical Demand (kW)	3,932	3,884	4,840	4,420	4,219
Natural Gas Cost	$ 363,534	$ 222,290	$ 202,639	$ 219,246	$ 262,821
Natural Gas Rate ($/therm)	$ 0.871	$ 0.517	$ 0.506	$ 0.582	$ 0.631
Natural Gas Consumption (therms)	463,134	401,418	400,141	374,491	421,564
Cooling Degree Days (CDD)	1,044	1,176	1,412	1,271	1,210
Heating Degree Days (HDD)	6,373	5,479	5,014	5,444	5,622

Table 7: Comparison between 2017 and 2016

	2016	2017	2017 vs 2016	% Change
EUI (kBTU/ft2)	92.0	85.3	-6.8	-7.3%
Total Utility Cost	$ 1,256,847	$ 1,221,848	$ (34,999)	-2.8%
Total Cost per ft2	$ 1.18	$ 1.15	$ (0.03)	-2.8%
Electrical Cost	$ 1,054,207	$ 1,002,601	$ (51,606)	-4.9%
Electrical Cost ($/kWh)	$ 0.062	$ 0.064	$ 0.003	4.2%
Electrical Consumption (kWh)	17,055,976	15,694,939	(1,361,037)	-8.0%
Peak Electrical Demand (kW)	4,840	4,420	(420)	-8.7%
Natural Gas Cost	$ 202,639	$ 219,246	$ 16,607	8.2%
Natural Gas Cots ($/therm)	$ 0.506	$ 0.582	$ 0.076	15.0%
Natural Gas Consumption (therms)	400,141	374,491	(25,650)	-6.4%
Cooling Degree Days (CDD)	1,412	1,271	(141)	-10.0%
Heating Degree Days (HDD)	5,014	5,444	430	8.6%

4.2 Total Utility Cost Comparison

Table 8

Total Cost							
	2013	2014	2015	2016	2017	2018	Average
1		$ 152,121	$ 132,758	$ 109,412	$ 117,947	$ 119,452	$ 128,059
2		$ 140,762	$ 108,974	$ 100,278	$ 109,091	$ 118,007	$ 114,776
3		$ 136,285	$ 110,205	$ 94,728	$ 101,204	$ 112,349	$ 110,606
4		$ 117,233	$ 77,122	$ 89,180	$ 94,402	$ 91,761	$ 94,484
5		$ 77,352	$ 71,556	$ 75,217	$ 67,626		$ 72,938
6	$ 75,169	$ 83,790	$ 120,094	$ 139,561	$ 124,255		$ 108,574
7	$ 86,342	$ 89,007	$ 113,807	$ 123,402	$ 123,964		$ 107,304
8	$ 91,348	$ 112,107	$ 111,535	$ 116,387	$ 102,772		$ 106,830
9	$ 84,439	$ 122,640	$ 114,012	$ 133,854	$ 124,521		$ 115,893
10	$ 96,689	$ 85,180	$ 83,845	$ 94,591	$ 84,673		$ 88,996
11	$ 102,809	$ 85,067	$ 76,506	$ 84,505	$ 82,849		$ 86,347
12	$ 121,923	$ 106,297	$ 83,649	$ 95,731	$ 88,544		$ 99,229
Total	$ 658,718	$ 1,307,839	$ 1,204,062	$ 1,256,847	$ 1,221,848	$ 441,570	$ 1,234,035

Table 9

Total Cost per Square Foot							
	2013	2014	2015	2016	2017	2018	Average
1		$ 0.143	$ 0.124	$ 0.103	$ 0.111	$ 0.112	$ 0.120
2		$ 0.132	$ 0.102	$ 0.094	$ 0.102	$ 0.111	$ 0.108
3		$ 0.128	$ 0.103	$ 0.089	$ 0.095	$ 0.105	$ 0.104
4		$ 0.110	$ 0.072	$ 0.084	$ 0.088	$ 0.086	$ 0.089
5		$ 0.072	$ 0.067	$ 0.070	$ 0.063		$ 0.068
6	$ 0.070	$ 0.079	$ 0.113	$ 0.131	$ 0.116		$ 0.102
7	$ 0.081	$ 0.083	$ 0.107	$ 0.116	$ 0.116		$ 0.101
8	$ 0.086	$ 0.105	$ 0.105	$ 0.109	$ 0.096		$ 0.100
9	$ 0.079	$ 0.115	$ 0.107	$ 0.125	$ 0.117		$ 0.109
10	$ 0.091	$ 0.080	$ 0.079	$ 0.089	$ 0.079		$ 0.083
11	$ 0.096	$ 0.080	$ 0.072	$ 0.079	$ 0.078		$ 0.081
12	$ 0.114	$ 0.100	$ 0.078	$ 0.090	$ 0.083		$ 0.093
Total	$ 0.617	$ 1.226	$ 1.128	$ 1.178	$ 1.145	$ 0.414	$ 1.157

Table 10

Energy Usage Index (kBtu/ft2)							
	2013	2014	2015	2016	2017	2018	Average
1		14.65	12.55	11.70	12.16	12.10	12.8
2		12.60	10.61	10.26	10.11	11.13	10.9
3		10.91	11.46	8.96	9.38	9.87	10.2
4		8.15	6.68	8.61	8.01	7.91	7.9
5		4.85	5.70	5.86	5.01		5.4
6	4.35	4.72	5.40	5.64	4.86		5.2
7	4.90	4.76	5.07	5.28	4.86		5.0
8	6.14	4.48	4.90	4.79	4.12		4.6
9	5.50	5.57	4.97	6.25	5.23		5.5
10	7.73	7.13	7.31	8.09	6.45		7.2
11	8.95	7.62	6.87	7.34	7.26		7.3
12	11.11	10.39	8.79	9.26	7.82		9.1
Total		95.8	90.3	92.0	85.3		90.9

4.3 Electrical Utilities

Table 11

Electrical Cost ($)							
	2013	2014	2015	2016	2017	2018	Average
1		84,023	76,496	71,729	69,521	73,175	$ 74,989
2		74,050	71,391	67,827	69,480	73,263	$ 71,202
3		74,356	73,223	73,537	70,370	75,004	$ 73,298
4		74,432	63,251	69,194	71,671	69,571	$ 69,624
5		65,700	63,203	66,619	59,089		$ 63,653
6	72,100	77,901	116,055	135,508	118,876		$ 104,088
7	82,906	82,604	110,585	120,378	120,009		$ 103,296
8	83,595	107,691	108,057	113,036	100,947		$ 102,665
9	77,980	112,159	110,992	125,831	118,917		$ 109,176
10	79,500	66,818	68,172	76,786	72,849		$ 72,825
11	76,643	61,630	62,501	66,788	64,483		$ 66,409
12	77,113	62,940	57,848	66,973	66,390		$ 66,253
Total	$ 549,837	$ 944,305	$ 981,773	$ 1,054,207	$ 1,002,601	$ 291,013	$ 977,478

Table 12

Blended Utility Rate ($ per kWh)							
	2013	2014	2015	2016	2017	2018	Average
1		$ 0.053	$ 0.051	$ 0.049	$ 0.049	$ 0.051	$ 0.051
2		$ 0.052	$ 0.050	$ 0.050	$ 0.052	$ 0.052	$ 0.051
3		$ 0.048	$ 0.047	$ 0.049	$ 0.050	$ 0.054	$ 0.050
4		$ 0.055	$ 0.049	$ 0.049	$ 0.052	$ 0.055	$ 0.052
5		$ 0.056	$ 0.050	$ 0.051	$ 0.051		$ 0.052
6	$ 0.059	$ 0.060	$ 0.081	$ 0.090	$ 0.095		$ 0.077
7	$ 0.061	$ 0.063	$ 0.079	$ 0.082	$ 0.090		$ 0.075
8	$ 0.056	$ 0.084	$ 0.082	$ 0.086	$ 0.084		$ 0.078
9	$ 0.057	$ 0.081	$ 0.081	$ 0.083	$ 0.088		$ 0.078
10	$ 0.052	$ 0.049	$ 0.050	$ 0.050	$ 0.054		$ 0.051
11	$ 0.051	$ 0.047	$ 0.048	$ 0.051	$ 0.052		$ 0.050
12	$ 0.053	$ 0.047	$ 0.047	$ 0.049	$ 0.052		$ 0.050
Total	$ 0.055	$ 0.058	$ 0.060	$ 0.062	$ 0.064	$ 0.053	$ 0.059

Table 13

Consumption (kWh)							
	2013	2014	2015	2016	2017	2018	Average
1		1,594,641	1,496,166	1,472,046	1,417,595	1,430,128	1,482,115
2		1,422,263	1,427,653	1,351,855	1,334,870	1,401,775	1,387,683
3		1,535,068	1,562,982	1,509,985	1,412,157	1,385,307	1,481,100
4		1,361,521	1,303,882	1,404,299	1,385,039	1,264,768	1,343,902
5		1,181,855	1,254,291	1,302,498	1,155,428		1,223,518
6	1,226,242	1,308,026	1,437,597	1,508,730	1,251,577		1,346,434
7	1,367,987	1,316,619	1,392,886	1,472,255	1,327,346		1,375,419
8	1,497,253	1,279,079	1,324,383	1,317,401	1,200,756		1,323,774
9	1,370,119	1,380,298	1,375,956	1,516,717	1,347,114		1,398,041
10	1,541,837	1,374,606	1,352,492	1,521,886	1,346,975		1,427,559
11	1,499,783	1,305,894	1,310,679	1,321,833	1,243,516		1,336,341
12	1,444,323	1,339,839	1,237,007	1,356,471	1,272,566		1,330,041
Total	9,947,544	16,399,709	16,475,974	17,055,976	15,694,939	5,481,978	13,509,353

4.4 Gas Utilities

Table 14

Natural Gas Cost ($)							
	2013	2014	2015	2016	2017	2018	Average
1		68,098	56,262	37,683	48,426	46,277	$ 51,349
2		66,711	37,583	32,451	39,611	44,744	$ 44,220
3		61,929	36,982	21,191	30,834	37,345	$ 37,656
4		42,801	13,871	19,986	22,732	22,190	$ 24,316
5		11,652	8,353	8,598	8,536		$ 9,285
6	3,068	5,889	4,039	4,053	5,379		$ 4,485
7	3,436	6,403	3,222	3,024	3,955		$ 4,008
8	7,753	4,415	3,478	3,351	1,824		$ 4,164
9	6,459	10,481	3,020	8,022	5,604		$ 6,718
10	17,189	18,361	15,674	17,805	11,824		$ 16,171
11	26,166	23,437	14,005	17,718	18,367		$ 19,939
12	44,810	43,357	25,801	28,758	22,154		$ 32,976
Total	$ 108,881	$ 363,534	$ 222,290	$ 202,639	$ 219,246	$ 150,557	$ 255,286

Table 15

Blended Utility Rate ($ per therms)							
	2013	2014	2015	2016	2017	2018	Average
1		$ 0.668	$ 0.679	$ 0.505	$ 0.595	$ 0.576	$ 0.605
2		$ 0.776	$ 0.583	$ 0.513	$ 0.635	$ 0.631	$ 0.628
3		$ 0.967	$ 0.536	$ 0.481	$ 0.594	$ 0.643	$ 0.644
4		$ 1.055	$ 0.518	$ 0.454	$ 0.594	$ 0.538	$ 0.632
5		$ 1.017	$ 0.462	$ 0.475	$ 0.608		$ 0.640
6	$ 0.669	$ 1.028	$ 0.472	$ 0.465	$ 0.587		$ 0.644
7	$ 0.608	$ 1.095	$ 0.487	$ 0.495	$ 0.600		$ 0.657
8	$ 0.535	$ 1.070	$ 0.487	$ 0.545	$ 0.604		$ 0.648
9	$ 0.543	$ 0.847	$ 0.500	$ 0.538	$ 0.568		$ 0.599
10	$ 0.576	$ 0.629	$ 0.492	$ 0.517	$ 0.517		$ 0.546
11	$ 0.590	$ 0.637	$ 0.490	$ 0.534	$ 0.525		$ 0.555
12	$ 0.647	$ 0.665	$ 0.500	$ 0.547	$ 0.554		$ 0.583
Total	$ 0.595	$ 0.871	$ 0.517	$ 0.506	$ 0.582	$ 0.597	$ 0.615

Table 16

Consumption (therms)							
	2013	2014	2015	2016	2017	2018	Average
1		101,925	82,845	74,587	81,398	80,340	84,219
2		85,934	64,444	63,300	62,366	70,917	69,392
3		64,018	68,961	44,065	51,876	58,054	57,395
4		40,558	26,773	44,001	38,245	41,213	38,158
5		11,458	18,064	18,114	14,044		15,420
6	4,589	5,730	8,553	8,724	9,159		7,351
7	5,651	5,849	6,621	6,103	6,597		6,164
8	14,480	4,125	7,138	6,149	3,022		6,983
9	11,886	12,370	6,046	14,922	9,871		11,019
10	29,830	29,211	31,859	34,427	22,879		29,641
11	44,376	36,794	28,555	33,203	35,012		35,588
12	69,310	65,162	51,559	52,546	40,022		55,720
Total	180,122	463,134	401,418	400,141	374,491	250,524	417,050

Appendix A: Energy Conservation Opportunities Summary

ECO #		Estimated Savings: Electric (kWh)	Estimated Savings: Natural Gas (therms)	Estimated Savings: Utility Cost ($)	Potential Rebate ($)	Implementation Cost ($)	Simple Payback (Years)	Simple Payback (Years)
	Overall Project Evaluation	299,996	30,624	$ 37,023	$ 45,675	$ 105,980	2.9	1.6
	Retro-Commissioning Study	-	-	$ -	$ 24,550	$ 49,100	-	-
	Calculated Savings	1.9%	8.2%	3.0%				
	Calculated Savings	299,996	30,624	$ 37,023	$ 21,125	$ 56,880	1.5	1.0
1	SCHEDULE: AHU-7CC	44,434	6,343	$ 6,535	$ 3,490	$ 755	0.1	-0.4
1	SCHEDULE: AHU-8CC	83,386	4,382	$ 7,887	$ 5,046	$ 755	0.1	-0.5
2	DAT CONTROL: AHU-1CC	8,676	-	$ 555	$ 434	$ 3,205	5.8	5.0
2	DAT CONTROL: AHU-4CC	4,726	-	$ 302	$ 236	$ 3,205	10.6	9.8
3	OA DMPR: AHU-10CC	3,122	4,756	$ 2,968	$ 1,107	$ 2,980	1.0	0.6
4	ECONOMIZER: AHU-1V	4,377	-	$ 280	$ 219	$ 3,380	12.1	11.3
5	CWV : AHU-1V	6,609	-	$ 423	$ 330	$ 4,480	10.6	9.8
6	STMV: AHU-1V	13,294	1,159	$ 1,526	$ 897	$ 3,780	2.5	1.9
7	CWV CONTROL: VARIOUS AHUS	6,933	-	$ 444	$ 347	$ 4,980	11.2	10.4
8	DAT CONTROL: MAU	-	7,260	$ 4,225	$ 1,452	$ 9,080	2.1	1.8
9	DAT CONTROL: VAV	-	1,554	$ 905	$ 311	$ 6,380	7.1	6.7
10	VENTILATION RESET: AHU-5CC	4,957	404	$ 552	$ 329	$ 2,355	4.3	3.7
10	VENTILATION RESET: AHU-6CC	15,290	(6)	$ 975	$ 763	$ 2,355	2.4	1.6
11	CWV: AHU-6CC	70,906	1,018	$ 5,131	$ 3,749	$ 3,780	0.7	0.0
12	AFMS CALIBRATION: AHU-1CC	17,730	-	$ 1,135	$ 887	$ 1,500	1.3	0.5
13	DSP CONTROL: AHU-1CC	5,811	-	$ 372	$ 291	$ 130	0.3	-0.4
13	DSP CONTROL: AHU-4CC	1,171	-	$ 75	$ 59	$ 130	1.7	1.0
13	DSP CONTROL: AHU-5CC	1,158	-	$ 74	$ 58	$ 1,630	22.0	21.2
13	DSP CONTROL: AHU-6CC	2,033	-	$ 130	$ 102	$ 1,630	12.5	11.7
14	ECON: AHU-9CC	(10,282)	3,715	$ 1,504	$ 229	$ 130	0.1	-0.1
14	ECON: AHU-10CC	2,077	39	$ 156	$ 112	$ 130	0.8	0.1
15	SETPOINT: FCU UNITS	13,587	-	$ 870	$ 679	$ 130	0.1	-0.6

Appendix B: System Evaluation

This section shows the baseline data used in the creation of all the air handling unit energy consumption. The data represents how each unit operates based on outside air temperature.

OCCUPIED HOURS (EFF-OCC)

BIN RANGE	AVG OADB	TMY3 HOURS	OAD-O	MOAD-O	RAD1-O	RAD2-O	EAD-O	OA-CFM	SF-O	SF-CFM	RF-O	RF-CFM	DA-P	RA-T	MA-T	DA-T	EFF-DAT-SP	EAE-T	EA-LAT	EA-H	OA-LAT	RA-H	CC-T	HTG-O	CLG-O	HRW-O
-12.5--7.5	-10	4	47.0	47.0	53.0	53.0	47.0	4479.4	62.9	12275.1	51.8	12271.5	0.8	70.9	53.3	58.6	58.0	70.8	64.5	8.9	44.1	5.2	55.2	0.2	2.9	2.0
-7.5--2.5	-5	26	51.4	51.4	48.6	48.6	51.4	4897.9	67.7	12474.1	50.8	12373.0	0.8	70.6	51.2	57.4	58.0	70.4	63.0	8.7	41.5	4.9	53.8	1.0	3.5	5.8
-2.5-2.5	0	52	50.9	50.9	49.1	49.1	50.9	5051.6	66.8	12546.0	52.3	12493.9	0.8	70.3	52.7	58.0	58.0	70.2	63.6	10.2	44.8	6.6	54.1	1.4	7.8	3.3
2.5-7.5	5	90	53.2	53.2	46.8	46.8	53.2	5504.2	67.4	12336.4	51.0	12359.7	0.8	70.1	51.6	57.9	58.0	70.0	65.7	10.4	44.5	6.8	54.2	0.5	9.8	0.6
7.5-12.5	10	132	56.1	56.1	43.9	43.9	56.1	5825.4	66.3	11769.7	50.5	12044.3	0.8	70.3	52.0	57.7	58.0	70.1	64.3	11.7	46.4	8.1	53.6	0.7	11.3	1.5
12.5-17.5	15	195	56.1	56.1	43.9	43.9	56.2	5753.2	62.8	10754.0	46.8	11184.8	0.8	70.5	54.5	58.1	58.0	71.6	65.7	13.7	49.6	10.6	54.5	0.6	14.0	1.0
17.5-22.5	20	145	58.1	58.1	41.9	41.9	58.1	5844.3	63.3	10848.8	47.6	11412.4	0.8	70.5	55.3	58.2	58.0	71.3	65.9	14.9	51.4	11.7	54.6	1.2	15.4	2.4
22.5-27.5	25	238	59.3	59.3	40.7	40.7	59.3	6849.7	65.5	11648.9	50.1	12007.3	0.8	70.5	55.0	58.1	58.0	70.9	66.6	17.1	51.5	14.0	54.3	1.6	14.5	3.3
27.5-32.5	30	341	60.7	60.7	39.3	39.3	60.7	6885.7	65.3	11654.4	50.9	12126.9	0.8	70.7	55.7	58.1	58.0	70.6	66.6	21.5	53.2	18.4	53.8	2.3	16.8	5.6
32.5-37.5	35	494	61.6	61.6	38.4	38.4	61.6	7611.2	63.6	11854.8	49.9	12149.8	0.8	70.7	55.9	57.9	58.0	70.7	67.6	23.5	55.1	20.6	53.7	1.3	15.3	2.3
37.5-42.5	40	321	66.6	66.6	33.4	33.4	66.6	8685.1	64.6	12456.2	51.4	12557.5	0.8	70.7	56.9	57.7	58.0	70.6	67.6	25.9	56.7	23.0	53.3	1.1	9.7	1.9
42.5-47.5	45	347	73.6	73.6	26.4	26.4	73.6	9401.7	63.0	12031.5	48.9	12002.4	0.8	70.7	57.4	57.2	57.8	70.5	68.1	30.4	57.9	27.6	53.0	0.8	10.4	0.4
47.5-52.5	50	302	79.4	79.4	20.6	20.6	79.4	10069.9	62.3	12172.6	49.2	12199.8	0.8	70.7	59.5	56.0	56.5	70.6	68.5	32.7	60.6	30.1	51.7	0.9	20.3	0.1
52.5-57.5	55	308	85.8	85.8	14.2	14.2	85.8	11407.9	62.7	12405.1	49.1	12232.8	0.8	70.8	60.4	55.1	55.1	70.6	68.6	37.0	62.1	34.4	51.1	0.5	24.1	0.0
57.5-62.5	60	322	93.4	93.4	6.6	6.6	93.4	12149.5	61.6	12034.7	47.7	12120.7	0.7	71.0	63.2	53.2	53.5	70.8	68.8	42.9	65.1	40.5	48.7	0.3	39.4	0.0
62.5-67.5	65	346	90.0	90.0	10.0	10.0	90.0	12258.6	63.7	12765.0	50.6	12635.0	0.8	71.2	67.1	51.4	52.2	71.0	69.0	47.3	68.7	45.0	47.0	0.3	54.8	0.0
67.5-72.5	70	435	70.9	70.9	29.1	29.1	70.9	9597.2	64.2	12713.0	52.2	12363.7	0.8	71.5	71.1	50.6	52.0	71.4	69.4	49.3	72.4	47.3	45.9	0.4	62.2	0.0
72.5-77.5	75	389	52.9	52.9	47.1	47.1	52.9	7014.3	64.3	12752.5	54.0	12090.6	0.8	71.8	73.0	50.0	52.0	71.7	70.0	50.6	74.9	48.8	45.3	0.5	65.7	7.3
77.5-82.5	80	342	52.9	52.9	47.1	47.1	52.9	6861.0	65.4	12743.7	55.9	12023.4	0.8	72.0	74.1	49.3	52.0	71.9	72.7	51.8	76.4	50.1	44.7	0.4	69.5	50.6
82.5-87.5	85	232	52.2	52.2	47.8	47.8	52.2	6970.5	66.9	13448.3	59.5	12462.0	0.8	72.4	74.6	49.0	52.0	72.3	76.5	51.9	77.1	50.5	44.2	0.3	74.7	66.4
87.5-92.5	90	121	51.8	51.8	48.2	48.2	51.8	6975.9	67.9	13703.8	60.7	12354.4	0.8	72.5	74.5	48.1	52.0	72.5	81.9	51.3	77.0	50.1	43.3	0.2	77.6	85.4
92.5-97.5	95	17	52.4	52.4	47.6	47.6	52.5	7131.9	68.3	13796.3	61.6	12399.5	0.8	72.6	74.8	47.6	52.0	72.6	86.3	51.3	77.3	50.2	42.9	0.1	77.8	94.1
97.5-102.5	100	0	51.7	51.7	48.3	48.3	51.7	7273.2	69.1	14712.3	69.2	13674.3	0.8	72.9	75.1	47.4	52.0	72.9	87.9	51.0	77.3	50.0	42.4	0.1	79.3	87.5
		5198																								

UNOCCUPIED HOURS (EFF-OCC)

BIN RANGE	AVG OADB	TMY3	OAD-O	MOAD-O	RAD1-O	RAD2-O	EAD-O	OA-CFM	SF-O	SF-CFM	RF-O	RF-CFM	DA-P	RA-T	MA-T	DA-T	EFF-DAT-SP	EAE-T	EA-LAT	EA-H	OA-LAT	RA-H	CC-T	HTG-O	CLG-O	HRW-O
-12.5--7.5	-10	2	0.0	0.0	100.0	100.0	0.0	91.3	1.3	474.8	1.3	489.7	0.0	71.6	69.6	70.0		69.0	66.1	12.1	67.1	6.1	66.0	0.9	0.0	0.0
-7.5--2.5	-5	22	0.0	0.0	100.0	100.0	0.0	170.9	0.9	732.8	0.9	656.9	0.0	72.9	91.2	83.8		87.8	77.1	7.0	85.5	5.4	88.1	1.2	0.0	0.0
-2.5-2.5	0	29	0.0	0.0	100.0	100.0	0.0	153.7	0.0	449.4	0.0	374.6	0.0	73.5	95.7	83.8		90.0	78.0	7.5	89.9	6.8	90.4	0.3	0.0	0.0
2.5-7.5	5	86	0.0	0.0	100.0	100.0	0.0	147.3	0.3	428.2	0.3	368.2	0.0	71.9	95.5	79.3		89.8	76.6	8.4	88.6	7.7	87.3	1.0	0.0	0.0
7.5-12.5	10	75	0.0	0.0	100.0	100.0	0.0	149.7	0.2	419.4	0.2	356.8	0.0	72.7	92.4	79.1		87.8	76.4	9.2	86.9	8.2	85.9	0.7	0.0	0.0
12.5-17.5	15	83	8.4	8.4	91.6	91.6	8.4	182.4	3.7	561.9	3.7	1182.5	0.1	72.6	94.5	77.9		87.7	76.2	10.7	85.6	9.8	83.5	1.0	4.0	0.0
17.5-22.5	20	138	16.5	16.5	83.5	83.5	16.5	215.4	7.2	705.4	7.2	2006.7	0.1	72.4	91.2	75.5		84.2	74.9	13.3	81.1	12.2	78.8	1.5	7.4	0.0
22.5-27.5	25	151	19.6	19.6	80.4	80.4	19.6	238.7	8.5	741.2	8.5	2285.7	0.1	71.8	92.1	72.6		84.2	74.3	15.4	80.6	14.8	75.9	1.4	8.8	0.0
27.5-32.5	30	210	12.3	12.3	87.7	87.7	12.3	198.3	5.5	578.9	5.5	1520.4	0.1	72.1	87.3	73.4		82.1	73.5	20.2	80.2	20.3	76.4	1.4	5.5	0.0
32.5-37.5	35	362	13.9	13.9	86.1	86.1	13.9	251.8	6.3	605.2	6.2	1645.5	0.1	71.6	83.0	71.0		78.5	71.5	22.0	77.6	20.9	71.7	1.1	6.7	0.0
37.5-42.5	40	234	19.5	19.5	80.5	80.5	19.5	689.1	10.3	1180.3	10.0	2511.2	0.1	71.3	80.7	69.6		78.4	71.6	24.2	76.7	23.6	69.9	1.0	6.8	0.0
42.5-47.5	45	192	44.1	44.1	55.9	55.9	44.1	1601.8	23.2	2341.3	23.2	5562.8	0.3	71.0	74.0	63.4		73.6	69.5	31.1	70.4	29.1	59.8	1.1	15.1	0.8
47.5-52.5	50	188	54.1	54.1	45.9	45.9	54.1	2233.3	28.2	3060.4	28.2	6812.8	0.4	71.1	71.3	61.3		72.5	69.3	36.7	68.5	33.8	55.7	2.1	17.7	0.1
52.5-57.5	55	186	50.4	50.4	49.6	49.6	50.4	4106.6	30.9	4626.4	30.9	7317.9	0.4	71.3	66.3	61.6		70.3	68.6	47.3	66.5	41.8	55.2	0.7	15.7	0.0
57.5-62.5	60	246	48.0	48.0	52.0	52.0	48.0	4618.6	29.3	4842.1	29.3	6991.4	0.4	71.8	66.8	62.3		70.5	69.0	52.1	68.0	46.1	55.6	0.7	18.3	0.0
62.5-67.5	65	316	39.6	39.6	60.4	60.4	39.6	4232.7	26.0	4441.5	25.9	6106.9	0.3	72.6	68.4	63.1		70.8	69.5	57.1	69.8	51.0	55.6	0.7	21.0	0.0
67.5-72.5	70	370	28.8	28.8	71.2	71.2	28.8	3169.7	21.8	3838.9	21.6	4930.9	0.3	73.6	70.4	64.9		71.5	70.2	59.5	71.7	52.9	56.4	0.7	21.6	0.0
72.5-77.5	75	312	26.2	26.2	73.8	73.8	26.2	2722.4	26.6	4755.4	26.5	5662.8	0.3	73.9	71.8	62.7		72.0	70.8	58.0	73.3	51.9	54.2	0.8	29.0	2.2
77.5-82.5	80	211	35.8	35.8	64.2	64.2	35.8	3727.2	38.1	6736.6	38.1	7656.6	0.5	73.4	73.3	56.9		72.8	72.3	53.7	74.8	50.1	50.2	0.7	43.7	39.1
82.5-87.5	85	106	46.3	46.3	53.7	53.7	46.3	4818.7	49.8	8767.8	49.8	9785.0	0.6	73.3	74.1	51.2		73.1	74.9	52.3	75.8	50.2	45.7	0.4	61.3	65.1
87.5-92.5	90	34	51.2	51.2	48.8	48.8	51.2	5513.8	58.2	10760.5	58.2	11482.2	0.7	73.1	74.2	50.4		72.8	78.5	52.4	76.2	50.6	44.7	1.0	73.0	78.3
92.5-97.5	95	8	50.4	50.4	49.6	49.6	50.4	4982.7	52.0	8977.2	52.0	10061.3	0.6	73.4	74.4	51.1		73.3	80.2	52.4	76.1	50.3	44.8	0.3	59.7	77.0
97.5-102.5	100	0	53.3	53.3	46.7	46.7	53.3	3830.3	58.9	9877.5	58.9	11782.9	0.8	73.5	76.9	50.7		73.6	78.9	52.0	80.9	50.7	50.4	1.5	50.0	50.0

Figure 2: AHU-1CC Data

OCCUPIED HOURS (EFF-OCC)

BIN RANGE	OADB	TMY3 HOURS	ZN-T	ZN-H	RABYP-O	SABYP-O	HRW-O	EABYP-O	OABYP-O	SW-O	SF-O	SA-CFM	RF-O	RF-CFM	ZN-CO2	MOAD-O	OAD-O	OA-CFM	RAD1-O	RAD2-O	EAD-O
-12.5--7.5	-10	6	69.0	10.1	100.0	100.0	80.0	20.0	24.0	0.0	25.0	10628.8	34.1	9590.6	582.0	57.3	62.0	4020.0	38.0	38.0	61.7
-7.5--2.5	-5	46	69.2	11.0	92.1	92.1	50.7	49.2	58.0	4.9	25.0	10302.5	32.1	9323.8	681.3	46.1	48.7	3308.9	51.3	51.3	48.5
-2.5-2.5	0	71	68.6	11.1	88.4	88.4	53.3	46.5	50.4	11.0	26.3	10309.8	33.2	9302.9	593.0	40.4	43.9	2738.5	56.1	56.1	43.7
2.5-7.5	5	115	68.0	11.2	86.3	86.3	40.9	58.8	62.1	10.7	26.2	10197.5	33.3	9197.1	601.5	38.8	42.2	2926.0	57.8	57.8	42.3
7.5-12.5	10	116	69.0	14.1	88.7	88.7	80.1	19.9	40.6	8.1	31.7	10712.6	36.0	9729.4	504.8	45.7	47.4	3489.1	52.6	52.6	47.2
12.5-17.5	15	134	69.2	13.1	89.5	89.5	74.7	25.2	40.0	5.5	33.2	11274.6	35.0	10298.9	433.9	37.4	41.8	3119.7	58.2	58.2	41.8
17.5-22.5	20	125	68.3	14.0	97.1	97.1	39.4	57.2	61.5	1.0	36.8	12721.7	36.6	11713.6	377.9	24.0	30.9	2291.0	69.1	69.1	30.8
22.5-27.5	25	149	68.4	16.4	85.4	85.4	16.9	70.7	74.8	10.3	39.0	13091.3	41.8	12018.3	479.7	29.9	35.9	3720.2	64.1	64.1	35.9
27.5-32.5	30	260	68.4	19.3	91.2	91.2	15.2	78.1	80.6	7.4	39.7	13604.8	43.1	12556.7	444.5	29.2	34.1	3704.1	65.9	65.9	34.0
32.5-37.5	35	374	68.7	21.1	96.8	96.8	8.5	86.4	88.3	2.6	43.5	14657.7	46.2	13706.3	427.9	23.0	34.9	4056.3	65.1	65.1	34.9
37.5-42.5	40	202	68.7	22.8	95.6	95.6	9.0	87.2	88.0	2.8	45.1	15180.9	47.7	14271.6	411.0	19.8	33.4	4210.8	66.6	66.6	33.4
42.5-47.5	45	169	68.8	27.7	98.2	98.2	8.0	89.3	90.0	1.2	44.5	14908.9	46.1	13852.9	397.5	18.0	32.1	3982.1	67.9	67.9	32.1
47.5-52.5	50	148	68.8	30.2	99.7	99.7	3.0	96.4	96.6	0.2	45.3	14967.8	47.1	14051.1	408.7	14.1	35.9	4827.0	64.1	64.1	35.8
52.5-57.5	55	178	68.6	32.7	99.7	99.7	1.4	98.2	98.5	0.1	44.0	14228.1	44.9	13268.4	403.8	13.1	51.1	7056.8	48.9	48.9	51.1
57.5-62.5	60	227	68.4	36.0	99.7	99.7	0.2	99.6	99.8	0.2	42.5	13332.4	41.6	12475.1	405.4	12.0	65.6	9094.2	34.4	34.4	65.6
62.5-67.5	65	226	67.9	43.5	99.6	99.6	0.0	100.0	100.0	0.3	43.0	13142.6	40.9	12302.9	396.3	11.5	75.4	10649.8	24.6	24.6	75.4
67.5-72.5	70	191	68.1	47.3	98.8	98.8	0.0	100.0	100.0	1.0	42.9	13217.1	39.8	12447.7	420.1	18.6	44.9	6675.9	55.1	55.1	44.9
72.5-77.5	75	144	68.0	48.8	99.5	99.5	8.6	91.4	91.4	0.5	41.3	12895.2	38.3	12119.6	436.4	25.0	25.2	3737.5	74.8	74.8	25.2
77.5-82.5	80	116	67.8	50.8	99.8	99.8	44.6	55.4	55.4	0.2	41.3	12783.0	39.8	12085.3	452.6	27.8	27.8	3973.7	72.2	72.2	27.8
82.5-87.5	85	92	67.8	50.0	98.9	98.9	55.8	44.2	44.2	0.9	41.1	12692.7	39.6	12008.7	462.3	29.0	29.0	4204.9	71.0	71.0	28.9
87.5-92.5	90	38	68.1	52.6	99.2	99.2	79.9	20.1	20.1	0.8	40.6	12454.9	38.0	11806.2	449.1	27.6	27.6	3874.7	72.4	72.4	27.6
92.5-97.5	95	7	68.0	53.4	98.4	98.4	89.1	10.9	10.9	1.2	40.8	12472.2	30.8	11927.9	409.1	23.1	23.1	3110.8	76.9	76.9	23.0

BIN RANGE	OADB	TMY3 HOURS	RHTG-O	CLG-O	HTG-O	OA-EAT	OA-LAT	MA-T	CC-T	SA-T	DA-T	RA-T	RAC-T	EAE-T	EA-LAT	DA-P	EA-CFM	EFFHTG-SP	EFFCLG-SP	MOAD-MINPOS	MOAFLOW-SP
-12.5--7.5	-10	6	78.2	0.0	94.3	-5.0	82.9	83.7	124.6	124.9	119.6	70.7	109.4	104.4	44.7	0.1	6308.2	70.0	73.0	10.0	6457.2
-7.5--2.5	-5	46	6.0	0.0	36.7	10.8	60.1	59.7	83.0	85.7	84.9	70.8	78.5	76.1	54.1	0.1	5501.9	68.6	71.5	10.0	8360.7
-2.5-2.5	0	71	15.6	0.0	37.2	13.7	64.3	65.8	85.8	88.2	86.4	70.3	79.5	76.9	52.0	0.1	5175.3	68.4	70.9	10.0	6745.1
2.5-7.5	5	115	17.6	0.0	20.4	16.3	60.4	61.5	71.6	76.0	75.4	69.9	78.3	75.3	54.6	0.1	4984.0	67.4	69.7	10.0	7054.7
7.5-12.5	10	116	7.9	0.0	12.9	17.5	63.8	63.7	72.6	75.5	75.0	70.6	73.1	71.2	43.7	0.1	5114.6	68.8	70.5	10.0	5031.8
12.5-17.5	15	134	5.6	0.0	11.2	21.8	64.1	65.2	70.7	73.8	73.7	70.9	72.5	71.0	45.7	0.2	4943.9	68.8	70.5	10.0	3509.8
17.5-22.5	20	125	0.2	0.0	2.7	31.5	60.8	63.2	65.2	68.5	69.0	69.9	68.8	68.1	55.2	0.2	3572.9	67.6	69.1	10.0	2377.6
22.5-27.5	25	149	0.0	0.0	1.4	33.6	56.9	58.5	58.8	64.0	64.3	70.1	68.8	67.3	60.5	0.2	5007.5	67.3	69.4	10.0	4407.1
27.5-32.5	30	260	5.0	0.0	7.6	38.4	60.0	61.8	64.0	68.2	68.4	70.4	71.0	69.6	64.7	0.2	4981.2	67.1	69.3	10.0	3772.0
32.5-37.5	35	374	3.6	0.0	6.5	42.9	60.7	62.1	63.5	67.3	67.7	70.6	70.5	69.8	67.3	0.3	5254.9	67.3	69.4	10.0	3418.6
37.5-42.5	40	202	3.6	0.0	6.5	47.1	62.7	64.3	64.7	68.3	68.9	70.7	70.7	70.1	67.6	0.3	5194.4	67.1	69.1	10.0	3125.8
42.5-47.5	45	169	1.0	0.3	3.0	50.3	63.1	64.5	64.0	67.5	68.1	70.6	69.5	69.0	67.8	0.3	4599.4	67.1	69.0	10.0	2892.3
47.5-52.5	50	148	0.5	1.1	2.8	54.7	63.8	64.7	63.4	66.8	67.4	70.7	69.4	69.1	69.2	0.3	5610.5	66.7	68.7	10.0	3058.9
52.5-57.5	55	178	0.4	3.5	1.6	57.3	63.6	64.0	60.7	64.3	64.9	70.6	69.2	68.9	69.4	0.3	7483.3	66.3	68.5	10.0	2926.2
57.5-62.5	60	227	1.0	9.8	1.6	61.8	65.3	65.6	58.6	62.1	62.8	70.6	69.3	69.0	69.7	0.3	9032.0	65.9	68.3	10.0	2937.2
62.5-67.5	65	226	0.4	18.7	1.3	64.9	66.8	66.9	55.4	59.4	60.3	70.5	68.7	68.3	69.2	0.3	10034.1	65.3	67.9	10.0	2772.3
67.5-72.5	70	191	0.4	25.7	2.0	69.0	69.5	69.4	53.8	57.9	58.7	70.8	68.9	68.4	69.5	0.3	5787.1	65.5	68.0	10.0	3265.6
72.5-77.5	75	144	1.5	25.4	2.7	73.1	71.4	71.0	54.0	57.8	58.5	70.8	69.1	68.7	70.4	0.3	2816.8	65.5	68.1	10.0	3566.8
77.5-82.5	80	116	3.0	24.2	4.0	77.3	72.6	71.6	54.0	57.9	58.6	70.8	69.0	68.6	73.1	0.2	3239.3	65.4	68.0	10.0	3891.9
82.5-87.5	85	92	4.1	28.8	6.0	82.0	74.5	72.8	54.0	57.7	58.5	70.8	69.4	69.1	76.5	0.2	3552.8	65.3	68.0	10.0	4095.6
87.5-92.5	90	38	9.3	27.8	10.6	86.8	76.0	73.1	55.1	58.8	59.5	71.2	69.5	69.3	81.7	0.2	2992.8	65.7	68.4	10.0	3812.3
92.5-97.5	95	7	8.2	27.6	9.6	92.1	79.8	74.8	55.6	58.5	59.3	71.1	70.1	70.2	85.8	0.2	1994.7	65.0	68.2	10.0	2948.7

Figure 3: AHU-2CC Occupied Data

UNOCCUPIED HOURS (EFF-OCC)

BIN RANGE	OADB	TMY3 HOURS	ZN-T	ZN-H	RABYP-O	SABYP-O	HRW-O	EABYP-O	OABYP-O	SW-O	SF-O	SA-CFM	RF-O	RF-CFM	ZN-CO2	MOAD-O	OAD-O	OA-CFM	RAD1-O	RAD2-O	EAD-O
-12.5--7.5	-10	0	68.9	10.0	100.0	100.0	0.0	100.0	100.0	0.0	25.0	10974.1	34.0	9357.6	617.0	0.0	0.0	3989.8	100.0	100.0	0.0
-7.5--2.5	-5	2	69.1	9.2	100.0	100.0	0.0	100.0	100.0	0.0	25.0	11014.0	20.0	9294.6	495.7	0.0	0.0	1852.1	100.0	100.0	0.0
-2.5-2.5	0	10	69.9	11.2	100.0	100.0	0.0	100.0	100.0	0.0	24.6	10128.5	2.0	8642.5	600.0	0.0	0.0	281.0	100.0	100.0	0.0
2.5-7.5	5	61	68.2	10.4	100.0	100.0	0.0	100.0	100.0	0.0	16.7	6812.0	1.2	5732.0	449.6	0.0	0.0	309.9	100.0	100.0	0.0
7.5-12.5	10	91	66.4	11.2	100.0	100.0	0.0	100.0	100.0	0.0	10.1	3514.7	0.0	2959.9	375.7	0.0	0.0	382.7	100.0	100.0	0.0
12.5-17.5	15	144	67.3	11.7	100.0	100.0	0.0	100.0	100.0	0.0	20.8	4614.0	0.3	3910.2	336.2	0.0	0.0	356.6	100.0	100.0	0.0
17.5-22.5	20	158	67.2	12.4	100.0	100.0	0.0	100.0	100.0	0.0	24.6	4608.6	0.1	3883.7	330.6	0.0	0.0	334.5	100.0	100.0	0.0
22.5-27.5	25	240	67.5	12.9	100.0	100.0	0.0	100.0	100.0	0.0	20.8	5032.9	0.1	4252.7	345.3	0.0	0.0	313.1	100.0	100.0	0.0
27.5-32.5	30	291	68.4	13.9	100.0	100.0	0.0	100.0	100.0	0.0	21.7	5657.1	0.3	4802.9	357.3	0.0	0.0	312.3	100.0	100.0	0.0
32.5-37.5	35	482	68.8	15.9	100.0	100.0	0.0	100.0	100.0	0.0	15.8	4134.2	0.1	3528.0	380.4	0.0	0.0	291.4	100.0	100.0	0.0
37.5-42.5	40	353	68.9	19.3	100.0	100.0	0.0	100.0	100.0	0.0	10.5	3298.1	0.7	2914.8	354.8	0.0	0.0	341.1	100.0	100.0	0.0
42.5-47.5	45	370	68.4	23.3	99.4	99.4	0.2	99.8	99.8	0.5	16.0	5023.6	7.8	4666.7	349.5	0.0	8.2	1248.3	91.8	91.8	8.4
47.5-52.5	50	342	68.5	25.0	99.6	99.6	0.0	100.0	100.0	0.4	23.7	7649.6	13.3	7162.8	353.5	0.0	7.4	1065.0	92.6	92.6	7.4
52.5-57.5	55	316	68.7	29.3	99.5	99.5	0.0	100.0	100.0	0.4	17.6	5228.2	8.2	4911.3	367.5	0.0	8.2	1169.6	91.8	91.8	8.2
57.5-62.5	60	341	68.8	36.1	100.0	100.0	0.0	100.0	100.0	0.0	13.8	4314.4	10.1	4255.6	364.4	0.0	14.9	2026.1	85.1	85.1	14.9
62.5-67.5	65	436	69.5	43.2	100.0	100.0	0.0	100.0	100.0	0.0	8.9	2877.9	6.4	2846.6	365.5	0.0	8.5	1168.4	91.5	91.5	8.5
67.5-72.5	70	614	70.9	46.3	100.0	100.0	0.0	100.0	100.0	0.0	3.9	1337.2	3.6	1420.1	360.2	0.0	0.7	182.3	99.3	99.3	0.7
72.5-77.5	75	557	71.4	47.3	100.0	100.0	0.0	100.0	100.0	0.0	3.6	1241.8	3.2	1326.2	355.6	0.0	0.1	124.3	99.9	99.9	0.2
77.5-82.5	80	437	71.2	48.0	100.0	100.0	0.0	100.0	100.0	0.0	3.9	1406.5	3.6	1513.9	347.3	0.0	0.0	186.9	100.0	100.0	0.0
82.5-87.5	85	246	71.2	47.7	100.0	100.0	0.0	100.0	100.0	0.0	3.5	1201.4	3.1	1281.9	342.8	0.0	0.0	279.8	100.0	100.0	0.0
87.5-92.5	90	117	71.1	47.5	100.0	100.0	0.0	100.0	100.0	0.0	3.4	1191.3	3.0	1274.3	342.4	0.0	0.0	367.8	100.0	100.0	0.0
92.5-97.5	95	18	71.3	48.5	100.0	100.0	0.0	100.0	100.0	0.0	2.7	971.7	2.5	1044.5	341.2	0.0	0.0	442.1	100.0	100.0	0.0

BIN RANGE	OADB	TMY3 HOURS	RHTG-O	CLG-O	HTG-O	OA-EAT	OA-LAT	MA-T	CC-T	SA-T	DA-T	RA-T	RAC-T	EAE-T	EA-LAT	DA-P	EA-CFM	EFFHTG-SP	EFFCLG-SP	MOAD-MINPOS	MOAFLOW-SP
-12.5--7.5	-10	0	0.0	0.0	0.0	-7.0	89.8	92.6	119.7	122.9	119.9	70.5	115.2	110.4	37.6	0.1	5658.3	60.0	76.0	10.0	7317.4
-7.5--2.5	-5	2	0.0	0.0	0.0	27.4	66.0	69.1	94.7	96.9	99.7	70.6	82.9	81.9	67.5	0.1	2038.9	60.0	76.0	10.0	4865.8
-2.5-2.5	0	10	0.0	0.0	0.0	59.9	71.2	72.1	74.4	77.1	78.3	71.2	72.4	71.4	67.6	0.1	26.1	60.0	76.0	10.0	6999.4
2.5-7.5	5	61	0.0	0.0	2.5	63.8	69.2	69.8	71.3	74.3	75.2	69.7	68.9	68.3	68.5	0.1	35.5	60.0	76.0	10.0	3961.2
7.5-12.5	10	91	0.0	0.0	0.0	66.0	67.9	68.0	68.4	71.3	71.6	68.7	67.7	66.8	67.3	0.1	39.0	60.0	76.0	10.0	2541.5
12.5-17.5	15	144	0.0	0.0	0.0	65.7	67.5	67.6	66.8	69.8	70.2	69.0	67.9	66.6	67.1	0.1	42.6	60.0	76.0	10.0	1804.7
17.5-22.5	20	158	0.0	0.0	0.0	65.6	67.1	67.3	66.4	69.4	69.9	68.7	67.5	66.2	66.7	0.1	24.5	60.0	76.0	10.0	1693.4
22.5-27.5	25	240	0.0	0.0	0.0	65.7	67.1	67.3	66.2	69.2	69.8	69.0	67.6	66.3	67.0	0.1	27.2	60.0	76.0	10.0	1844.6
27.5-32.5	30	291	0.0	0.0	0.0	66.4	67.9	68.1	67.2	70.1	70.7	69.7	68.4	67.2	67.7	0.1	43.4	60.0	75.9	10.0	2105.0
32.5-37.5	35	482	0.0	0.0	2.4	67.2	68.9	69.0	66.9	69.9	70.8	70.1	68.7	67.7	68.4	0.1	40.6	60.7	74.8	10.0	2450.5
37.5-42.5	40	353	0.0	0.0	11.7	68.7	72.1	72.4	63.6	66.9	68.3	70.2	68.9	69.4	70.2	0.1	151.6	61.9	72.7	10.0	1960.0
42.5-47.5	45	370	0.7	11.0	16.7	68.3	72.8	73.2	59.1	62.5	63.5	70.1	69.2	70.4	71.5	0.1	1140.9	62.7	71.3	10.0	1919.7
47.5-52.5	50	342	0.4	10.0	13.9	67.7	71.0	71.4	61.4	64.8	65.4	70.3	69.0	69.2	70.1	0.1	951.4	61.9	72.7	10.0	1992.9
52.5-57.5	55	316	0.3	10.4	15.9	68.3	71.5	71.9	60.4	63.7	64.5	70.3	68.9	69.3	70.3	0.1	1057.1	62.3	71.9	10.0	2190.3
57.5-62.5	60	341	0.0	18.1	21.0	68.1	71.0	71.3	56.5	60.1	61.4	70.7	68.7	69.1	70.2	0.1	1896.9	62.9	70.9	10.0	2222.3
62.5-67.5	65	436	0.0	12.4	14.7	69.2	71.0	71.0	59.2	62.7	64.3	71.1	68.8	69.1	70.2	0.1	1046.8	62.4	72.3	10.0	2171.4
67.5-72.5	70	614	0.0	7.1	11.8	70.8	72.0	72.0	61.7	65.1	67.6	72.2	69.8	70.0	71.2	0.1	108.9	62.3	73.1	10.0	2163.2
72.5-77.5	75	557	0.0	6.5	9.7	72.1	73.3	73.3	62.2	65.5	68.3	73.0	70.8	71.2	72.4	0.1	30.8	62.5	73.5	10.0	2130.1
77.5-82.5	80	437	0.0	8.1	9.9	72.8	74.1	74.0	62.0	65.2	67.9	73.3	71.2	71.8	73.1	0.1	29.1	62.9	73.3	10.0	1969.2
82.5-87.5	85	246	0.0	6.0	9.9	72.8	73.9	73.9	62.5	65.8	68.5	73.1	71.1	71.7	73.0	0.1	64.4	62.9	73.3	10.0	1889.2
87.5-92.5	90	117	0.0	5.2	10.6	72.7	73.7	73.6	62.3	65.6	68.2	73.0	70.9	71.5	72.9	0.1	114.9	63.1	73.0	10.0	1878.6
92.5-97.5	95	18	0.0	4.7	8.6	73.9	75.0	74.9	62.6	65.8	68.6	73.4	71.4	72.5	73.9	0.1	161.7	63.3	73.3	10.0	1867.5

Figure 4: AHU-2CC Unoccupied Data

OCCUPIED HOURS (EFF-OCC)

BIN RANGE	OADB	TMY3 HOURS	ZN-T	ZN-H	RABYP-O	SABYP-O	HRW-O	EABYP-O	OABYP-O	SW-O	SF-O	SF-CFM	RF-O	RF-CFM	ZN-CO2	MOAD-O	OAD-O	OA-CFM	RAD1-O	RAD2-O	EAD-O
-12.5--7.5	-10	3	68.4	10.1	100.0	100.0	36.5	63.3	63.7	0.0	49.7	17556.5	59.3	16539.2	623.1	35.2	35.2	4298.2	64.8	64.8	34.5
-7.5--2.5	-5	23	68.7	10.2	86.8	86.8	18.3	81.6	82.3	13.2	51.5	17590.0	57.7	16561.2	577.2	21.1	32.0	3443.6	68.0	68.0	32.1
-2.5-2.5	0	27	67.9	10.8	75.5	75.5	34.3	65.7	68.2	23.5	47.2	16252.4	55.7	15252.2	605.5	31.7	34.1	3837.2	65.9	65.9	34.0
2.5-7.5	5	29	68.2	11.0	84.9	84.9	43.8	56.2	58.5	15.1	45.6	16038.8	55.2	15064.3	519.2	35.6	37.2	4263.7	62.8	62.8	37.3
7.5-12.5	10	71	69.1	12.1	74.3	74.3	75.6	22.0	36.3	23.1	43.7	14749.3	53.5	13773.8	564.0	40.5	41.7	4988.3	58.3	58.3	41.6
12.5-17.5	15	110	69.3	12.0	66.7	66.7	69.5	24.9	35.6	30.8	44.0	14501.3	53.5	13464.6	555.6	43.3	44.4	5525.2	55.6	55.6	44.3
17.5-22.5	20	95	68.5	12.9	69.8	69.8	38.6	52.6	55.9	26.6	43.6	14344.1	51.6	13411.1	463.4	34.5	40.6	4447.6	59.4	59.4	40.6
22.5-27.5	25	146	68.5	15.3	69.8	69.8	28.0	57.9	62.2	27.0	45.8	14969.1	53.6	13978.2	559.8	37.6	44.3	6080.9	55.7	55.7	44.3
27.5-32.5	30	161	68.0	19.3	85.2	85.2	14.7	76.3	78.5	12.1	45.7	14917.2	52.6	13945.4	461.0	25.6	40.3	4800.2	59.7	59.7	40.3
32.5-37.5	35	271	68.3	20.9	84.7	84.7	14.6	76.4	78.9	10.8	44.2	14131.3	50.1	13166.4	514.1	25.9	46.8	6362.8	53.2	53.2	46.8
37.5-42.5	40	169	68.7	23.2	94.6	94.6	7.3	88.2	89.4	3.9	44.5	14558.4	51.0	13637.9	484.4	22.5	44.6	6004.1	55.4	55.4	44.6
42.5-47.5	45	195	68.5	27.4	99.7	99.7	1.8	96.5	97.3	0.2	42.3	13982.2	47.4	12994.6	412.1	16.7	47.0	5934.3	53.0	53.0	47.0
47.5-52.5	50	228	68.6	28.6	100.0	100.0	1.2	97.5	97.8	0.0	41.9	13821.3	47.5	12980.2	429.4	14.3	58.1	7986.1	41.9	41.9	58.1
52.5-57.5	55	236	68.4	32.8	99.9	99.9	0.9	98.2	98.5	0.1	42.2	14079.2	48.3	13239.4	438.0	15.9	62.0	8982.9	38.0	38.0	62.0
57.5-62.5	60	243	68.1	38.6	100.0	100.0	1.8	96.6	97.5	0.0	43.2	14483.4	50.2	13861.5	414.9	13.0	69.0	10687.0	31.0	31.0	69.0
62.5-67.5	65	216	68.0	44.5	99.9	99.9	0.0	99.9	100.0	0.1	43.8	14691.7	51.2	14133.9	415.7	14.0	70.6	11289.8	29.4	29.4	70.5
67.5-72.5	70	261	67.9	48.0	98.5	98.5	0.0	100.0	100.0	1.2	43.4	14795.7	51.5	14284.6	405.2	18.7	50.0	7435.9	50.0	50.0	49.9
72.5-77.5	75	210	68.1	49.0	97.9	97.9	2.9	97.1	97.1	1.3	41.9	14524.2	51.5	14012.5	435.0	27.6	28.6	3394.3	71.4	71.4	28.6
77.5-82.5	80	188	68.1	52.1	98.3	98.3	44.0	56.0	56.0	0.9	42.4	14497.0	50.9	13986.6	419.8	26.4	26.5	2976.1	73.5	73.5	26.5
82.5-87.5	85	154	68.1	53.2	98.4	98.4	64.5	35.5	35.5	0.9	41.4	14170.5	50.1	13718.9	404.6	25.9	25.9	2785.3	74.1	74.1	25.9
87.5-92.5	90	79	68.6	53.2	99.2	99.2	69.5	30.5	30.5	0.3	40.3	14132.8	49.6	13675.8	404.6	24.5	24.5	2466.6	75.5	75.5	24.5
92.5-97.5	95	14	68.6	54.6	100.0	100.0	86.0	14.0	14.0	0.0	40.0	14254.5	48.6	13736.8	331.3	20.4	20.5	1717.0	79.5	79.5	20.5

BIN RANGE	OADB	TMY3 HOURS	RHTG-O	CLG-O	HTG-O	OA-EAT	OA-LAT	MA-T	CC-T	SA-T	DA-T	RA-T	RAC-T	EAE-T	EA-LAT	DA-P	EA-CFM	OA-H	RA-H	EFFHTG-SP	EFFCLG-SP	MOAD-MINPOS	MOAFLOW-SP
-12.5--7.5	-10	3	0.9	0.0	1.9	6.9	54.7	58.9	58.7	60.3	62.4	69.1	69.4	70.2	49.9	0.2	5933.1	59.8	10.3	68.0	70.0	10.0	7230.0
-7.5--2.5	-5	23	0.1	0.0	0.4	21.6	53.1	57.0	56.6	60.2	62.1	69.3	69.7	68.9	63.6	0.2	5229.4	59.5	10.0	67.5	68.9	10.0	6539.5
-2.5-2.5	0	27	1.0	0.0	4.1	17.9	52.3	56.5	57.9	62.1	63.7	69.0	69.7	67.5	58.3	0.2	5467.9	52.3	11.0	67.4	69.0	10.0	7089.9
2.5-7.5	5	29	1.6	0.0	15.0	17.9	55.9	61.3	67.6	70.2	71.9	69.5	70.9	69.6	55.5	0.2	6273.3	40.3	10.7	67.5	69.6	10.0	5486.9
7.5-12.5	10	71	3.9	0.0	7.3	17.6	59.8	62.5	65.3	69.3	70.5	69.8	71.4	69.0	45.7	0.2	6516.7	51.2	12.5	68.9	71.0	10.0	6311.9
12.5-17.5	15	110	3.4	0.0	4.2	21.9	60.0	62.4	63.8	68.2	69.7	70.0	71.3	68.8	45.4	0.2	6857.8	49.6	12.9	69.0	71.0	10.0	6156.7
17.5-22.5	20	95	0.4	0.0	2.8	31.2	57.9	60.7	61.8	65.8	67.3	69.8	69.7	67.8	56.6	0.2	6162.6	47.7	13.6	68.1	69.7	10.0	4281.8
22.5-27.5	25	146	0.0	0.0	1.7	34.4	56.3	58.6	58.8	63.6	65.2	69.8	69.3	67.4	59.0	0.2	7437.9	52.8	16.6	68.0	69.9	10.0	6092.6
27.5-32.5	30	161	1.7	0.0	2.2	40.4	57.9	60.1	59.9	63.3	64.9	69.7	69.2	68.6	64.6	0.2	6539.8	57.8	21.4	66.8	68.6	10.0	4095.6
32.5-37.5	35	271	0.8	0.0	2.7	43.9	58.1	59.8	59.9	63.2	64.8	70.1	69.4	68.9	65.8	0.2	7956.7	56.6	23.2	66.8	68.7	10.0	5241.0
37.5-42.5	40	169	0.0	0.0	1.2	48.3	59.4	61.2	60.4	63.1	64.6	70.3	69.5	69.7	69.2	0.2	7780.2	55.4	25.6	67.1	69.1	10.0	4626.6
42.5-47.5	45	195	0.0	1.2	0.0	52.3	60.1	62.0	60.2	62.3	63.8	70.3	69.2	69.6	70.6	0.2	7612.9	57.5	30.3	66.8	68.8	10.0	3147.2
47.5-52.5	50	228	0.0	4.2	0.0	55.2	60.4	62.2	59.2	61.4	62.7	70.5	69.4	69.8	70.9	0.2	9778.2	51.2	31.6	66.7	68.8	10.0	3144.2
52.5-57.5	55	236	0.0	9.6	0.1	58.4	61.9	63.6	58.8	60.9	62.2	70.6	69.2	69.6	70.9	0.2	10526.7	51.0	35.8	66.5	68.5	10.0	3278.9
57.5-62.5	60	243	0.0	14.7	0.1	62.4	64.1	65.8	58.9	60.8	62.1	70.8	69.0	69.5	70.9	0.2	12363.7	51.1	41.6	66.1	68.3	10.0	2576.2
62.5-67.5	65	216	0.0	20.9	0.0	65.9	66.3	67.9	57.7	59.7	61.1	71.0	69.0	69.4	70.9	0.2	12853.4	53.3	47.6	66.1	68.1	10.0	2502.6
67.5-72.5	70	261	0.0	26.5	0.6	69.5	68.5	70.0	56.7	58.8	59.8	71.4	68.9	69.2	70.8	0.2	8670.7	55.4	51.1	65.7	67.9	10.0	2596.2
72.5-77.5	75	210	0.0	27.6	0.8	72.9	69.9	71.0	55.7	57.8	58.9	71.8	69.1	69.4	71.1	0.2	4465.1	49.7	52.0	66.0	68.2	10.0	3267.8
77.5-82.5	80	188	0.0	34.0	0.6	77.5	70.7	71.3	52.9	55.2	56.2	72.3	69.2	69.5	73.9	0.2	3614.3	51.6	55.2	65.9	68.1	10.0	3016.8
82.5-87.5	85	154	0.0	36.7	0.2	82.2	71.3	71.7	52.1	54.4	55.7	72.5	69.3	69.6	77.3	0.2	3294.9	48.4	56.2	65.7	68.1	10.0	2811.3
87.5-92.5	90	79	0.0	26.3	0.1	87.0	72.4	72.5	55.1	57.2	58.5	72.6	69.8	70.2	80.8	0.2	2993.7	41.3	56.0	65.7	68.7	10.0	2493.4
92.5-97.5	95	14	0.0	19.8	0.0	91.5	72.1	71.6	56.3	58.3	59.3	72.6	69.7	70.1	85.5	0.2	2132.9	37.0	57.2	65.6	68.7	10.0	1770.3

Figure 5: AHU-3CC Occupied Data

UNOCCUPIED HOURS (EFF-OCC)

BIN RANGE	OADB	TMY3 HOURS	ZN-T	ZN-H	RABYP-O	SABYP-O	HRW-O	EABYP-O	OABYP-O	SW-O	SF-O	SF-CFM	RF-O	RF-CFM	ZN-CO2	MOAD-O	OAD-O	OA-CFM	RAD1-O	RAD2-O	EAD-O
-12.5--7.5	-10	3	69.6	10.3	100.0	100.0	0.0	100.0	100.0	0.0	1.2	572.8	1.4	538.7	506.1	0.0	0.0	395.4	100.0	100.0	0.0
-7.5--2.5	-5	25	68.2	8.8	100.0	100.0	0.0	100.0	100.0	0.0	0.9	454.1	1.0	418.4	455.3	0.0	0.0	379.4	100.0	100.0	0.0
-2.5-2.5	0	54	66.2	10.7	100.0	100.0	0.0	100.0	100.0	0.0	0.0	184.7	0.0	158.6	381.4	0.0	0.0	397.4	100.0	100.0	0.0
2.5-7.5	5	147	66.4	10.9	100.0	100.0	0.0	100.0	100.0	0.0	0.2	264.5	0.2	231.1	425.0	0.0	0.0	389.2	100.0	100.0	0.0
7.5-12.5	10	136	67.4	10.9	100.0	100.0	0.0	100.0	100.0	0.0	0.1	211.5	0.2	190.8	393.1	0.0	0.0	349.2	100.0	100.0	0.0
12.5-17.5	15	168	68.5	12.3	100.0	100.0	0.0	100.0	100.0	0.0	0.0	96.4	0.0	77.9	407.8	0.0	0.0	349.4	100.0	100.0	0.0
17.5-22.5	20	188	68.2	14.4	100.0	100.0	0.0	100.0	100.0	0.0	0.1	88.5	0.1	68.6	411.2	0.0	0.0	331.0	100.0	100.0	0.0
22.5-27.5	25	243	68.5	15.7	100.0	100.0	0.0	100.0	100.0	0.0	0.2	162.2	0.2	141.0	441.2	0.0	0.0	323.0	100.0	100.0	0.0
27.5-32.5	30	390	69.2	19.4	100.0	100.0	0.0	100.0	100.0	0.0	0.2	108.4	0.2	86.8	435.5	0.0	0.0	302.1	100.0	100.0	0.0
32.5-37.5	35	585	69.3	19.7	100.0	100.0	0.0	100.0	100.0	0.0	0.0	59.7	0.0	41.2	417.2	0.0	0.0	272.3	100.0	100.0	0.0
37.5-42.5	40	386	69.3	21.6	100.0	100.0	0.0	100.0	100.0	0.0	0.1	73.4	0.1	54.7	405.3	0.0	0.0	251.8	100.0	100.0	0.0
42.5-47.5	45	344	69.0	25.2	100.0	100.0	0.0	100.0	100.0	0.0	0.2	123.2	0.3	102.8	377.2	0.0	0.0	238.2	100.0	100.0	0.0
47.5-52.5	50	262	68.8	30.5	100.0	100.0	0.0	100.0	100.0	0.0	0.2	148.3	0.3	127.8	384.9	0.0	0.1	227.7	99.9	99.9	0.1
52.5-57.5	55	258	69.1	35.9	100.0	100.0	0.0	100.0	100.0	0.0	0.0	64.5	0.0	40.7	414.9	0.0	0.0	185.1	100.0	100.0	0.0
57.5-62.5	60	325	69.8	40.8	100.0	100.0	0.0	100.0	100.0	0.0	0.0	57.5	0.0	37.0	378.2	0.0	0.0	140.8	100.0	100.0	0.0
62.5-67.5	65	446	70.7	43.1	100.0	100.0	0.0	100.0	100.0	0.0	0.0	50.9	0.0	32.1	382.0	0.0	0.0	91.1	100.0	100.0	0.0
67.5-72.5	70	544	71.5	44.7	100.0	100.0	0.0	100.0	100.0	0.0	0.0	52.4	0.0	33.4	360.9	0.0	0.0	42.1	100.0	100.0	0.0
72.5-77.5	75	491	71.8	45.7	100.0	100.0	0.0	100.0	100.0	0.0	0.0	48.7	0.0	34.4	356.7	0.0	0.0	32.6	100.0	100.0	0.0
77.5-82.5	80	365	72.0	45.7	100.0	100.0	0.0	100.0	100.0	0.0	0.0	56.7	0.0	46.6	364.1	0.0	0.0	85.8	100.0	100.0	0.1
82.5-87.5	85	184	72.5	46.0	100.0	100.0	0.0	100.0	100.0	0.0	0.0	40.4	0.0	31.6	350.0	0.0	0.0	149.1	100.0	100.0	0.0
87.5-92.5	90	76	72.5	46.2	100.0	100.0	0.3	99.7	99.7	0.0	0.1	83.6	0.1	76.2	341.2	0.1	0.1	221.3	99.9	99.9	0.1
92.5-97.5	95	11	72.3	47.4	100.0	100.0	1.2	98.8	98.8	0.0	0.5	238.9	0.6	229.3	349.4	0.2	0.2	282.3	99.8	99.8	0.2

BIN RANGE	OADB	TMY3 HOURS	RHTG-O	CLG-O	HTG-O	OA-EAT	OA-LAT	MA-T	CC-T	SA-T	DA-T	RA-T	RAC-T	EAE-T	EA-LAT	DA-P	EA-CFM		RA-H	EFFHTG-SP	EFFCLG-SP	MOAD-MINPOS	MOAFLOW-SP
-12.5--7.5	-10.0	3	0.0	0.0	1.8	62.6	66.3	66.5	63.4	65.1	68.5	68.8	66.8	66.8	68.1	0.1	60.0		10.7	60.0	77.0	10.0	5100.4
-7.5--2.5	-5.0	25	0.0	0.0	0.7	64.7	66.9	67.5	65.3	66.9	69.2	68.6	66.9	67.1	68.6	0.1	27.6		9.5	60.0	77.0	10.0	2441.1
-2.5-2.5	0.0	54	0.0	0.0	0.0	68.5	68.7	69.7	67.6	69.1	69.9	68.4	67.6	68.6	70.0	0.1	28.0		11.5	60.3	77.0	10.0	1855.4
2.5-7.5	5.0	147	0.0	0.0	0.2	67.6	68.2	69.3	67.2	68.7	69.5	68.7	67.7	68.2	69.5	0.1	32.2		11.3	60.2	77.0	10.0	2064.4
7.5-12.5	10.0	136	0.0	0.0	0.0	67.0	68.0	68.9	68.0	69.6	70.7	69.3	68.1	67.9	69.1	0.1	29.0		11.1	60.3	77.0	10.0	2928.5
12.5-17.5	15.0	168	0.0	0.0	0.0	67.9	68.4	69.4	67.5	69.1	70.7	69.8	68.4	68.5	69.9	0.1	29.1		13.3	60.3	77.0	10.0	3263.6
17.5-22.5	20.0	188	0.0	0.0	0.0	67.9	68.4	69.4	67.0	68.6	70.1	69.8	68.5	68.6	70.0	0.1	21.6		15.8	60.5	76.9	10.0	2878.7
22.5-27.5	25.0	243	0.0	0.0	0.1	67.5	68.0	69.0	66.8	68.5	70.3	69.9	68.4	68.3	69.7	0.1	39.3		17.8	60.5	76.4	10.0	3317.6
27.5-32.5	30.0	390	0.0	0.0	0.1	67.2	67.7	68.7	66.4	68.1	70.5	69.9	68.0	68.1	69.6	0.1	28.7		23.3	60.5	75.5	10.0	3768.0
32.5-37.5	35.0	585	0.0	0.0	0.1	67.6	68.0	69.0	66.6	68.3	70.6	69.9	68.2	68.5	69.9	0.1	26.3		23.3	60.5	74.8	10.0	3320.8
37.5-42.5	40.0	386	0.0	0.0	0.0	67.6	67.9	68.9	66.6	68.3	70.5	70.0	68.2	68.4	69.9	0.1	27.6		25.4	60.6	75.5	10.0	3093.6
42.5-47.5	45.0	344	0.0	0.2	0.1	67.5	67.7	68.8	66.3	68.1	70.3	70.2	68.4	68.5	69.9	0.1	29.5		28.4	60.7	76.3	10.0	2471.8
47.5-52.5	50.0	262	0.0	0.1	0.4	67.0	67.4	68.4	65.8	67.6	69.6	70.5	68.5	68.4	69.9	0.1	68.4		34.6	60.9	76.4	10.0	2123.9
52.5-57.5	55.0	258	0.0	0.0	0.0	67.4	67.4	68.5	66.1	68.0	70.4	70.8	68.6	68.5	70.1	0.1	32.5		42.2	61.4	76.9	10.0	1994.2
57.5-62.5	60.0	325	0.0	0.0	0.0	68.2	68.2	69.2	66.6	68.5	71.2	71.6	69.3	69.3	70.9	0.1	12.7		49.7	61.6	77.0	10.0	2005.0
62.5-67.5	65.0	446	0.0	0.0	0.0	68.7	68.7	69.7	66.9	68.9	72.3	72.1	69.7	69.7	71.3	0.1	12.5		54.2	61.6	77.0	10.0	2212.3
67.5-72.5	70.0	544	0.0	0.0	0.0	69.1	69.0	70.0	67.2	69.3	73.1	72.4	70.0	70.0	71.6	0.1	17.6		56.5	61.8	77.0	10.0	2064.2
72.5-77.5	75.0	491	0.0	0.0	0.1	69.5	69.5	70.4	67.1	69.2	73.4	72.8	70.3	70.4	72.1	0.1	28.0		58.3	62.1	77.0	10.0	2054.7
77.5-82.5	80.0	365	0.0	0.0	0.3	69.9	70.0	70.9	67.1	69.2	73.4	73.0	70.6	70.8	72.5	0.1	74.6		59.0	62.4	77.0	10.0	2058.6
82.5-87.5	85.0	184	0.0	0.0	0.3	70.5	70.4	71.3	67.7	69.8	74.2	73.4	71.1	71.3	72.9	0.1	129.8		60.2	62.9	77.0	10.0	1856.0
87.5-92.5	90.0	76	0.0	0.1	0.0	71.3	71.1	72.0	67.8	69.9	73.9	73.4	71.5	72.0	73.7	0.1	204.4		60.9	63.4	77.0	10.0	1826.7
92.5-97.5	95.0	11	0.0	0.5	0.0	72.4	72.1	72.6	66.7	68.7	72.2	73.3	71.4	72.6	74.5	0.1	285.2		61.0	63.5	76.9	10.0	2058.3

Figure 6: AHU-3CC Unoccupied Data

OCCUPIED HOURS (EFF-OCC)

BIN RANGE	AVG OADB	TMY3 HOURS	OAD-O	MOAD-O	RAD1-O	RAD2-O	EAD-O	OA-CFM	SF-O	SF-CFM	RF-O	RF-CFM	DA-P	RA-T	MA-T	DA-T	EFFDAT-SP	EAE-T	EA-LAT	EA-H	OA-LAT	CC-T	HTG-O	CLG-O	HRW-O
-12.5--7.5	-10	3	32.1	32.1	67.9	67.9	32.1	3016.8	66.0	15067.3	53.6	13109.3	1.5	70.0	56.2	59.4	60.0	68.0	67.2	6.4	129.8	56.7	0.2	0.7	0.0
-7.5--2.5	-5	26	33.8	33.8	66.2	66.2	33.8	3387.1	67.3	16192.0	57.8	14090.1	1.5	70.1	55.8	59.4	60.0	68.0	67.3	6.3	98.4	56.4	0.2	0.2	0.1
-2.5-2.5	0	52	36.2	36.2	63.8	63.8	36.2	3857.9	66.7	15553.3	57.2	13713.5	1.5	69.7	55.8	59.0	60.0	68.6	65.0	7.9	127.9	55.9	0.3	0.9	1.0
2.5-7.5	5	90	40.3	40.3	59.7	59.7	40.3	4580.0	69.2	15606.4	58.6	13878.0	1.6	69.5	55.3	58.7	60.0	68.6	63.1	8.1	133.0	55.4	0.2	0.8	1.1
7.5-12.5	10	127	42.6	42.6	57.4	57.4	42.6	4893.5	70.3	14505.9	56.1	13264.2	1.7	70.0	55.0	58.9	60.0	69.4	64.6	9.3	135.0	55.7	0.2	0.5	0.6
12.5-17.5	15	192	46.2	46.2	53.8	53.8	46.2	5677.5	70.5	14118.2	55.7	12981.5	1.7	70.5	54.0	58.9	60.0	70.1	64.9	11.6	136.5	55.5	0.4	0.5	0.3
17.5-22.5	20	152	48.1	48.1	51.9	51.9	48.1	6000.0	67.2	13536.7	54.0	12449.0	1.6	70.5	55.4	59.0	60.0	70.2	64.7	13.2	116.6	55.7	0.3	0.8	1.1
22.5-27.5	25	257	51.5	51.5	48.5	48.5	51.5	7386.9	69.7	14278.7	57.0	13024.6	1.6	70.5	55.3	59.2	60.0	70.4	65.3	14.8	90.7	55.9	0.7	0.8	0.9
27.5-32.5	30	349	49.4	49.4	50.6	50.6	49.4	7140.9	68.3	14290.4	56.9	12894.5	1.5	70.8	56.1	59.5	60.0	70.7	66.1	19.2	90.9	56.0	1.0	1.6	1.0
32.5-37.5	35	514	50.8	50.8	49.2	49.2	50.8	8545.5	69.4	15644.6	61.5	14005.2	1.6	70.7	58.3	59.8	60.0	70.8	67.2	21.5	96.4	56.6	0.4	1.6	0.2
37.5-42.5	40	331	56.9	56.9	43.1	43.1	56.9	9876.2	69.5	15963.3	63.2	14159.1	1.6	70.6	59.8	59.9	60.0	70.7	67.1	23.9	85.0	56.8	0.3	0.9	0.2
42.5-47.5	45	346	68.1	68.1	31.9	31.9	68.1	11362.4	69.0	15490.4	62.8	13651.1	1.5	70.7	59.0	59.8	59.8	70.8	67.4	28.1	82.2	56.4	0.3	1.3	0.2
47.5-52.5	50	299	88.6	88.6	11.4	11.4	88.6	14191.6	69.9	15945.0	63.5	13922.5	1.5	70.7	58.6	58.1	58.0	70.9	67.3	30.4	77.3	54.1	0.3	5.5	0.0
52.5-57.5	55	309	94.4	94.4	5.6	5.6	94.4	14262.4	68.8	15147.8	60.7	13335.2	1.5	70.9	60.0	56.3	56.1	71.0	67.7	34.7	76.3	52.2	0.3	11.7	0.0
57.5-62.5	60	327	96.7	96.7	3.3	3.3	96.7	14771.2	69.2	15246.2	61.7	13486.3	1.5	71.1	63.4	53.5	54.0	71.2	68.5	40.6	74.5	49.2	0.3	29.7	0.0
62.5-67.5	65	356	91.2	91.2	8.8	8.8	91.2	14450.4	70.0	15838.4	64.5	13977.4	1.6	71.4	66.9	51.9	52.2	71.5	69.4	44.8	73.8	47.7	0.3	44.8	0.0
67.5-72.5	70	447	71.7	71.7	28.8	28.8	71.7	11834.4	69.6	16115.0	65.7	14072.1	1.6	71.8	70.4	51.5	52.0	72.0	70.5	46.7	75.8	47.3	0.4	49.7	0.1
72.5-77.5	75	386	50.9	50.9	49.2	49.2	50.8	8919.9	69.3	16237.1	67.0	14015.7	1.6	72.3	72.3	51.0	52.0	72.5	71.3	48.1	78.3	46.9	0.3	53.9	2.4
77.5-82.5	80	342	51.2	51.2	49.1	49.1	51.2	8338.9	71.0	16773.4	70.4	14441.2	1.7	72.6	73.4	50.8	52.0	72.8	73.1	49.4	80.0	46.6	0.3	57.8	46.5
82.5-87.5	85	234	51.2	51.2	49.2	49.2	51.2	7746.7	71.2	16554.3	71.3	14253.7	1.7	73.1	74.1	50.4	52.0	73.4	75.6	49.6	80.8	46.1	0.4	61.2	68.6
87.5-92.5	90	122	51.7	51.8	49.4	49.4	51.7	7648.2	73.4	17163.4	76.4	14737.5	1.7	73.6	74.4	50.5	52.0	73.9	79.1	49.1	80.7	46.1	0.5	62.4	89.2
92.5-97.5	95	17	51.3	51.3	48.7	48.7	51.3	7885.4	74.2	17136.6	77.3	14678.0	1.7	73.8	74.8	50.2	52.0	74.2	81.8	48.9	81.1	45.8	0.6	62.1	96.4

UNOCCUPIED HOURS (EFF-OCC)

BIN RANGE	AVG OADB	TMY3 HOURS	OAD-O	MOAD-O	RAD1-O	RAD2-O	EAD-O	OA-CFM	SF-O	SF-CFM	RF-O	RF-CFM	DA-P	RA-T	MA-T	DA-T	EFFDAT-SP	EAE-T	EA-LAT	EA-H	OA-LAT	CC-T	HTG-O	CLG-O	HRW-O
-12.5--7.5	-10	3	0.0	0.0	100.0	100.0	0.0	3300.6	31.8	1846.3	31.8	4592.9	0.9	70.3	94.8	91.3		70.2	68.9	6.7	115.2	99.4	27.6	0.0	0.0
-7.5--2.5	-5	22	0.0	0.0	100.0	100.0	0.0	3216.8	31.9	1744.9	31.9	4378.8	0.9	69.8	92.5	92.4		69.7	68.4	6.3	167.3	98.6	24.2	0.3	0.1
-2.5-2.5	0	29	0.0	0.0	100.0	100.0	0.0	2883.1	25.0	1148.1	25.0	3593.6	0.7	69.5	90.8	89.1		69.2	67.8	8.2	162.2	93.7	24.9	0.2	0.0
2.5-7.5	5	86	0.0	0.0	100.0	100.0	0.0	2194.3	15.3	798.7	15.3	2662.7	0.4	70.0	81.6	81.2		69.8	67.8	9.1	133.6	79.6	15.6	0.1	0.0
7.5-12.5	10	80	0.0	0.0	100.0	100.0	0.0	1490.3	3.6	280.5	3.7	1535.6	0.1	70.4	74.3	73.1		70.2	67.6	10.3	146.7	66.2	5.9	0.4	0.0
12.5-17.5	15	86	7.3	7.3	92.7	92.7	7.3	1060.2	2.4	226.2	2.4	1515.2	0.1	70.7	70.6	69.7		70.2	67.4	11.9	140.0	60.1	2.0	6.5	0.1
17.5-22.5	20	131	16.9	16.9	83.1	83.1	16.9	935.0	7.4	958.8	7.4	2444.9	0.2	70.9	70.7	69.4		70.8	68.6	14.1	106.9	60.1	3.1	15.9	0.1
22.5-27.5	25	132	22.6	22.6	77.4	77.4	22.6	911.0	8.3	588.1	8.3	2571.7	0.2	71.0	71.3	67.8		70.8	68.6	16.6	99.4	58.4	2.6	19.4	0.1
27.5-32.5	30	202	12.1	12.1	87.9	87.9	12.1	885.5	4.4	442.7	4.3	1763.4	0.1	70.7	70.4	69.0		70.2	67.3	21.2	102.0	59.3	1.9	9.3	0.5
32.5-37.5	35	342	12.7	12.7	87.3	87.3	12.7	830.6	4.3	377.1	4.3	1721.4	0.1	70.5	69.6	68.5		70.0	67.6	22.5	94.1	59.3	2.0	11.7	0.2
37.5-42.5	40	224	19.4	19.4	80.6	80.6	19.4	896.8	6.8	600.3	6.7	2199.8	0.2	70.4	69.5	67.3		70.3	67.9	24.8	89.3	58.7	1.5	14.5	0.2
42.5-47.5	45	193	41.9	41.9	58.1	58.1	41.9	575.1	13.4	764.3	13.4	3360.0	0.3	70.6	69.4	64.4		70.6	68.3	30.1	80.9	54.1	1.4	33.3	0.4
47.5-52.5	50	191	39.7	39.7	60.3	60.3	39.7	632.3	13.2	851.8	13.2	3236.4	0.3	70.8	69.3	64.1		70.9	68.7	34.3	76.8	53.8	1.6	31.5	0.3
52.5-57.5	55	185	24.7	24.7	75.3	75.3	24.7	548.9	8.7	612.5	8.7	2176.0	0.2	71.4	68.7	66.8		70.4	69.0	41.3	72.2	54.6	1.6	16.9	0.0
57.5-62.5	60	241	10.2	10.2	89.8	89.8	10.2	405.8	3.9	314.9	3.9	1120.3	0.1	72.2	68.5	69.0		70.0	69.3	44.7	72.0	54.9	4.2	5.9	0.0
62.5-67.5	65	306	4.3	4.3	95.7	95.7	4.3	279.2	1.5	159.1	1.5	592.4	0.1	73.1	67.5	70.6		69.6	69.7	48.0	71.3	55.1	1.7	0.9	0.0
67.5-72.5	70	358	2.4	2.4	97.9	97.9	2.4	216.3	0.7	114.3	0.7	404.4	0.1	74.3	68.2	72.1		70.4	70.6	50.1	72.0	55.0	0.8	0.4	0.0
72.5-77.5	75	315	2.9	2.9	98.0	98.0	2.9	214.4	0.7	113.0	0.7	421.2	0.1	75.2	70.7	72.1		72.8	73.2	54.1	74.6	55.5	0.9	0.4	0.0
77.5-82.5	80	211	0.4	0.4	99.9	99.9	0.4	303.9	0.5	124.2	0.5	453.3	0.1	76.7	74.1	71.1		76.1	76.6	59.8	77.8	56.6	1.8	0.1	0.1
82.5-87.5	85	104	0.0	0.0	100.0	100.0	0.0	374.3	0.2	78.4	0.2	504.5	0.1	78.9	77.2	71.4		79.3	80.4	61.8	80.8	58.7	1.3	0.0	0.0
87.5-92.5	90	33	0.0	0.0	100.0	100.0	0.0	454.4	0.0	77.1	0.0	517.9	0.1	80.0	80.6	69.2		82.1	83.9	57.8	83.9	59.6	0.9	0.0	0.0
92.5-97.5	95	8	0.0	0.0	100.0	100.0	0.0	566.8	0.0	100.1	0.0	615.2	0.1	79.9	83.0	65.5		83.8	86.5	61.7	86.3	59.7	0.5	0.0	0.0

Figure 7: AHU-4CC Data

OCCUPIED HOURS

BIN RANGE	AVG OADB	TMY3	SF-CFM.	DA-P.	DA-T.	RF-CFM.	RA-T.	MA-T.	CC-T.	SF-O.	RF-O.	OAD-O.	RAD-O.	EAD-O.	HTG-O.	CLG-O.	DAP-SP.	EFFDAT-SP	OAD-MINPOS
-12.5--7.5	-10	3	10311.9	1.3	59.8	9245.0	66.9	51.4	57.5	91.1	86.0	28.5	71.5	28.5	14.0	0.0	1.3	58.8	8.0
-7.5--2.5	-5	25	8195.9	1.0	61.0	7322.4	66.5	54.1	59.6	73.0	68.4	24.6	75.4	24.5	9.1	0.0	1.3	58.5	8.0
-2.5-2.5	0	57	9528.9	1.2	61.8	8479.3	66.9	54.0	60.1	86.4	82.7	26.6	73.4	26.6	8.1	0.0	1.3	60.4	8.0
2.5-7.5	5	113	7646.8	1.0	63.0	6819.5	66.1	55.6	60.9	70.2	67.6	20.4	79.6	20.4	4.1	0.0	1.3	61.0	8.0
7.5-12.5	10	126	8934.5	1.1	59.3	7988.3	67.4	55.3	57.2	79.7	75.0	26.4	73.6	26.4	1.3	0.0	1.3	58.0	8.0
12.5-17.5	15	208	8740.3	1.1	59.2	7774.3	66.6	54.2	57.1	78.7	72.8	30.3	69.7	30.3	2.4	0.1	1.3	58.0	8.0
17.5-22.5	20	160	8509.0	1.1	59.6	7570.4	66.9	55.1	57.3	76.6	71.1	30.8	69.2	30.8	1.1	0.0	1.3	58.0	8.0
22.5-27.5	25	262	8246.0	1.1	59.1	7291.3	67.7	55.1	56.7	75.3	68.2	36.5	63.5	36.5	0.5	0.0	1.3	58.0	8.0
27.5-32.5	30	325	8233.8	1.2	59.1	7223.6	69.3	55.7	56.7	76.3	67.4	42.1	57.9	42.1	0.2	0.0	1.3	58.0	8.0
32.5-37.5	35	536	7661.8	1.1	59.5	6730.3	68.7	55.7	56.6	71.4	63.3	42.4	57.6	42.4	0.3	0.0	1.3	58.0	8.0
37.5-42.5	40	363	7348.3	1.1	59.7	6422.5	69.2	56.0	56.5	69.3	61.1	45.8	54.2	45.8	0.3	0.0	1.3	58.0	8.0
42.5-47.5	45	373	7212.8	1.1	59.2	6263.3	69.5	55.9	55.8	69.0	60.0	53.8	46.3	53.7	0.0	0.0	1.3	57.8	8.0
47.5-52.5	50	326	6856.5	1.1	58.4	5943.0	70.0	55.7	54.8	66.6	58.5	67.1	33.7	66.3	0.0	0.7	1.3	56.5	8.0
52.5-57.5	55	341	7027.6	1.1	57.1	6078.0	70.6	56.7	53.6	68.9	61.2	83.9	16.1	83.8	0.0	6.6	1.3	55.1	8.0
57.5-62.5	60	358	7214.3	1.1	55.6	6275.8	71.1	61.2	51.9	70.4	63.0	85.6	14.4	85.6	0.1	26.8	1.3	53.5	8.0
62.5-67.5	65	392	6983.5	1.1	55.1	6074.7	71.5	66.0	51.1	68.0	60.3	72.5	27.5	72.5	0.2	40.8	1.3	52.2	8.0
67.5-72.5	70	501	7007.6	1.1	54.7	6093.3	71.9	70.4	50.6	68.3	56.4	42.6	57.4	42.6	0.2	47.4	1.3	52.0	8.0
72.5-77.5	75	473	6593.1	1.0	55.8	5751.4	72.6	72.4	51.3	64.4	47.8	13.3	86.7	13.3	0.2	45.6	1.3	52.0	8.0
77.5-82.5	80	439	6071.8	1.0	56.4	5284.4	73.2	74.0	51.6	59.7	43.6	12.6	87.4	12.6	0.4	44.6	1.3	52.0	8.0
82.5-87.5	85	291	6508.4	1.0	55.9	5683.9	73.9	75.8	51.4	64.5	42.5	13.0	87.0	13.0	0.3	48.3	1.3	52.0	8.0
87.5-92.5	90	154	6574.3	1.0	55.8	5773.9	74.4	77.6	51.2	65.5	38.5	11.5	88.5	11.5	0.4	52.4	1.3	52.0	8.0
92.5-97.5	95	25	5847.9	0.9	56.6	5160.9	74.9	79.6	51.7	58.8	29.7	9.6	90.4	9.6	0.9	49.4	1.3	52.0	8.0

UNOCCUPIED HOURS

OADB	AVG OADB	TMY3	SF-CFM.	DA-P.	DA-T.	RF-CFM.	RA-T.	MA-T.	CC-T.	SF-O.	RF-O.	OAD-O.	RAD-O.	EAD-O.	HTG-O.	CLG-O.	DAP-SP.	EFFDAT-SP	OAD-MINPOS
-12.5--7.5	-10	3	3439.4	0.9	78.3	3054.8	67.0	62.7	78.6	40.2	39.9	8.9	91.1	8.9	19.1	0.0	1.3	72.3	8.0
-7.5--2.5	-5	23	1234.3	0.7	83.5	1040.2	66.2	65.5	83.5	23.9	24.4	0.0	100.0	0.0	18.6	0.0	1.3	75.4	8.0
-2.5-2.5	0	24	2600.0	0.7	77.9	2239.6	65.5	61.4	77.2	32.9	31.9	5.6	94.4	5.6	15.9	0.0	1.3	71.4	8.0
2.5-7.5	5	63	898.1	0.4	75.8	763.1	64.6	60.6	73.9	15.4	15.7	0.5	99.5	0.5	10.4	0.0	1.3	68.4	8.0
7.5-12.5	10	81	2408.4	0.5	69.4	2133.8	65.1	59.4	66.9	25.2	24.4	7.0	93.0	7.0	5.5	0.0	1.3	63.1	8.0
12.5-17.5	15	70	1049.8	0.2	66.4	983.9	64.5	59.0	63.1	9.5	9.1	3.3	96.7	3.3	1.0	0.0	1.3	58.7	8.0
17.5-22.5	20	123	1192.8	0.2	65.4	1141.0	63.6	58.2	61.8	10.8	10.1	4.2	95.8	4.2	0.3	0.0	1.3	58.3	8.0
22.5-27.5	25	127	1561.8	0.2	65.3	1464.3	65.2	58.4	61.6	14.2	13.2	6.8	93.2	6.8	0.8	0.0	1.3	58.1	8.0
27.5-32.5	30	226	1483.1	0.2	65.8	1375.2	66.6	60.1	62.1	13.7	12.3	7.7	92.3	7.7	0.0	0.0	1.3	58.0	8.0
32.5-37.5	35	320	987.9	0.2	66.6	925.6	67.0	61.2	62.8	9.1	8.1	5.6	94.4	5.6	0.0	0.0	1.3	58.0	8.0
37.5-42.5	40	192	1092.5	0.2	66.9	1038.3	67.7	61.3	62.8	10.1	9.2	6.6	93.4	6.6	0.0	0.0	1.3	58.0	8.0
42.5-47.5	45	166	709.3	0.1	67.7	678.5	67.4	62.0	63.1	6.7	5.9	5.2	94.8	5.2	0.0	0.0	1.3	57.8	8.0
47.5-52.5	50	164	1101.3	0.2	67.5	1013.6	68.6	62.4	62.1	10.6	9.5	10.3	90.3	9.7	0.0	0.1	1.3	56.5	8.0
52.5-57.5	55	153	551.2	0.1	69.4	519.9	71.1	65.9	63.5	5.3	4.6	6.7	93.3	6.7	0.2	0.5	1.3	55.1	8.0
57.5-62.5	60	210	366.3	0.1	70.4	360.3	72.1	68.1	63.7	3.5	3.2	4.3	95.7	4.3	0.1	1.4	1.3	53.5	8.0
62.5-67.5	65	270	439.6	0.1	71.1	421.4	73.3	70.0	63.7	4.2	3.8	5.0	95.0	5.0	0.5	2.8	1.3	52.2	8.0
67.5-72.5	70	304	471.1	0.1	72.6	446.0	74.7	72.2	64.7	4.5	3.8	3.3	96.7	3.3	0.2	3.1	1.3	52.0	8.0
72.5-77.5	75	228	288.9	0.1	73.7	286.3	75.7	73.9	65.5	2.7	2.2	0.9	99.1	0.9	0.2	1.8	1.3	52.0	8.0
77.5-82.5	80	114	380.7	0.1	74.5	384.1	77.1	77.0	66.5	3.5	2.9	1.3	98.7	1.3	0.3	3.1	1.3	52.0	8.0
82.5-87.5	85	47	281.5	0.0	76.5	309.5	78.4	78.9	68.9	2.5	2.2	0.9	99.1	0.9	0.1	2.0	1.3	52.0	8.0
87.5-92.5	90	1	4.8	0.0	79.9	203.1	81.6	80.6	71.6	0.0	0.0	0.0	100.0	0.0	0.1	0.0	1.3	52.0	8.0

Figure 8: AHU-5CC Data

OCCUPIED HOURS

BIN RANGE	AVG OADB	TMY3 HOURS	SF-CFM	DA-P	DA-T	RF-CFM	RF-CFM2	RA-T	MA-T	CC-T	SF-O	RF-O	OAD-O	RAD-O	EAD-O	HTG-O	CLG-O	DAP-SP	EFFDAT-SP	OAD-MINPOS
-12.5--7.5	-10	3	8520.6	1.0	58.2	4676.9	2774.0	66.0	65.6	55.3	85.7	81.6	0.0	100.0	0.0	4.0	0.0	1.0	58.0	8.0
-7.5--2.5	-5	25	6926.3	0.8	59.1	3811.3	2269.6	66.6	75.4	54.6	69.5	66.6	0.0	100.0	0.0	8.9	0.0	1.0	58.0	8.0
-2.5-2.5	0	57	7839.9	0.9	58.4	4312.8	2555.1	66.0	66.7	55.2	79.0	76.4	1.5	98.5	1.5	5.5	0.0	1.0	58.0	8.0
2.5-7.5	5	113	6154.8	0.7	59.7	3398.0	2028.6	65.5	79.0	54.3	62.1	59.8	1.1	98.9	1.2	12.3	0.0	1.0	58.0	8.0
7.5-12.5	10	126	7393.3	0.9	58.7	4047.5	2417.0	66.1	67.5	55.0	75.7	71.2	9.2	90.8	9.2	9.3	0.0	1.0	58.0	8.0
12.5-17.5	15	208	7332.7	0.9	58.6	4009.1	2386.9	66.5	67.1	54.8	75.8	70.2	18.2	81.8	18.2	12.1	0.0	1.0	58.0	8.0
17.5-22.5	20	160	7372.9	0.9	58.8	4035.9	2409.3	66.8	69.5	54.7	76.0	70.9	13.4	86.6	13.4	10.5	0.0	1.0	58.0	8.0
22.5-27.5	25	262	7015.3	0.9	58.8	3801.6	2275.3	67.1	68.4	54.7	74.2	65.8	18.1	81.9	18.1	11.5	0.0	1.0	58.0	8.0
27.5-32.5	30	325	6996.1	0.9	58.6	3742.4	2246.0	67.7	64.9	55.2	76.7	62.9	16.8	83.2	16.7	8.1	0.0	1.0	58.0	8.0
32.5-37.5	35	536	6450.2	0.9	58.9	3446.0	2075.1	67.8	66.9	55.0	71.5	57.9	19.3	80.7	19.3	10.2	0.0	1.0	58.0	8.0
37.5-42.5	40	363	6270.0	0.8	59.1	3364.4	2029.3	67.9	69.3	54.9	69.5	56.8	19.1	80.9	19.1	11.9	0.0	1.0	58.0	8.0
42.5-47.5	45	373	6448.6	0.9	58.6	3437.0	2071.5	68.3	68.1	54.7	72.4	57.5	21.8	78.2	21.7	9.0	0.1	1.0	57.9	8.0
47.5-52.5	50	326	5809.3	0.8	58.5	3079.2	1875.0	68.6	68.5	54.0	66.8	51.0	28.2	71.8	28.3	8.5	0.3	1.0	57.3	8.0
52.5-57.5	55	341	6159.9	0.9	57.5	3254.8	1973.3	69.1	66.7	53.4	71.3	54.4	38.3	61.7	38.2	6.0	0.6	1.0	56.5	8.0
57.5-62.5	60	358	6164.8	0.9	56.5	3291.7	1993.8	69.5	66.3	51.9	71.1	56.9	61.5	38.5	61.5	4.9	9.6	1.0	55.7	8.0
62.5-67.5	65	392	5941.9	0.8	56.2	3205.2	1934.8	69.9	69.6	50.7	68.1	56.0	63.8	36.2	63.8	5.3	22.0	1.0	55.1	8.0
67.5-72.5	70	501	6021.5	0.8	55.3	3246.1	1957.6	70.2	70.9	50.0	67.9	55.8	34.6	65.4	34.6	6.1	28.6	1.0	55.0	8.0
72.5-77.5	75	473	5747.8	0.8	55.5	3105.8	1881.4	70.6	72.1	49.4	63.9	53.1	18.8	81.2	18.8	8.8	30.3	1.0	55.0	8.0
77.5-82.5	80	439	5433.5	0.7	55.5	2934.1	1793.2	71.1	74.0	48.9	60.7	50.1	18.2	81.8	18.2	12.1	30.1	1.0	55.0	8.0
82.5-87.5	85	291	5971.6	0.8	54.9	3242.1	1988.2	71.7	77.0	48.7	65.5	56.2	19.1	80.9	19.1	11.7	34.9	1.0	55.0	8.0
87.5-92.5	90	154	6182.4	0.8	54.9	3378.5	2084.6	72.1	79.4	48.6	66.4	59.4	18.7	81.3	18.7	13.3	33.3	1.0	55.0	8.0
92.5-97.5	95	25	5241.4	0.7	54.5	2852.1	1791.7	72.6	80.7	48.1	57.2	49.8	15.9	84.1	15.9	20.0	32.6	1.0	55.0	8.0

UNOCCUPIED HOURS

BIN RANGE	AVG OADB	TMY3 HOURS	SF-CFM	DA-P	DA-T	RF-CFM	RF-CFM2	RA-T	MA-T	CC-T	SF-O	RF-O	OAD-O	RAD-O	EAD-O	HTG-O	CLG-O	DAP-SP	EFFDAT-SP	OAD-MINPOS
-12.5--7.5	-10	3	2004.2	0.3	61.8	1337.2	722.1	65.9	78.1	54.3	20.0	19.1	0.0	100.0	0.0	6.7	0.0	1.0	58.0	8.0
-7.5--2.5	-5	23	55.7	0.0	60.6	123.8	88.1	63.8	107.6	49.9	0.0	0.4	0.0	100.0	0.0	46.8	0.0	1.0	58.0	8.0
-2.5-2.5	0	24	1471.1	0.2	60.6	934.5	596.7	63.9	99.8	50.8	14.5	13.9	0.0	100.0	0.0	39.1	0.0	1.0	58.0	8.0
2.5-7.5	5	63	155.4	0.0	61.6	202.5	199.1	63.6	112.6	50.1	1.1	1.3	0.0	100.0	0.0	44.7	0.0	1.0	58.0	8.0
7.5-12.5	10	81	1990.1	0.3	61.1	1120.6	737.4	64.6	97.1	51.6	20.9	18.3	6.2	93.8	6.2	32.7	0.0	1.0	58.0	8.0
12.5-17.5	15	70	1307.2	0.2	63.3	773.4	556.7	64.2	101.5	51.3	13.8	12.1	5.1	94.9	5.1	36.1	0.0	1.0	58.0	8.0
17.5-22.5	20	123	1016.6	0.2	64.3	633.9	468.5	65.2	101.8	51.6	10.6	9.4	1.4	98.6	1.4	30.7	0.0	1.0	58.0	8.0
22.5-27.5	25	127	1033.2	0.2	64.7	637.3	484.3	66.1	98.9	52.1	11.0	9.5	3.2	96.8	3.2	27.4	0.0	1.0	58.0	8.0
27.5-32.5	30	226	1342.2	0.2	64.7	760.3	557.2	66.3	93.7	52.2	14.7	12.1	2.7	97.3	2.7	24.8	0.0	1.0	58.0	8.0
32.5-37.5	35	320	984.4	0.2	65.3	594.7	441.7	66.6	93.6	52.0	11.0	8.7	2.4	97.6	2.4	27.3	0.0	1.0	58.0	8.0
37.5-42.5	40	192	831.9	0.1	65.9	526.8	405.8	67.3	102.4	51.1	9.2	7.4	2.1	97.9	2.1	35.6	0.0	1.0	58.0	8.0
42.5-47.5	45	166	623.7	0.1	65.9	432.6	366.9	67.0	96.4	51.5	7.6	5.0	2.1	97.9	2.1	32.1	0.0	1.0	57.9	8.0
47.5-52.5	50	164	756.8	0.1	66.3	485.5	402.7	68.1	92.2	51.9	8.8	6.5	3.5	96.5	3.5	29.0	0.1	1.0	57.3	8.0
52.5-57.5	55	153	529.9	0.1	67.7	379.1	295.5	69.8	94.3	50.9	5.9	4.8	3.2	96.8	3.2	35.8	0.0	1.0	56.5	8.0
57.5-62.5	60	210	309.3	0.1	67.5	267.0	167.5	69.7	75.6	51.1	3.6	2.6	3.4	96.6	3.4	31.3	1.0	1.0	55.7	8.0
62.5-67.5	65	270	354.1	0.1	68.3	261.0	162.0	70.6	71.6	51.1	4.0	3.3	4.2	95.8	4.2	32.0	0.7	1.0	55.1	8.0
67.5-72.5	70	304	376.6	0.1	69.0	250.1	164.5	71.4	73.0	50.3	4.1	3.5	2.4	97.6	2.4	40.3	1.0	1.0	55.0	8.0
72.5-77.5	75	228	245.1	0.1	69.0	192.3	158.0	73.4	77.3	49.7	2.7	2.3	0.9	99.1	0.9	44.8	1.5	1.0	55.0	8.0
77.5-82.5	80	114	311.4	0.1	69.8	236.3	260.2	76.6	93.0	49.9	3.4	2.8	1.3	98.7	1.3	42.7	1.8	1.0	55.0	8.0
82.5-87.5	85	47	226.5	0.1	70.8	210.1	300.6	78.8	99.9	49.1	2.5	2.0	0.7	99.3	0.7	52.1	1.2	1.0	55.0	8.0
87.5-92.5	90	1	3.6	0.0	68.0	49.2	231.2	79.4	70.6	48.4	0.0	0.0	0.0	100.0	0.0	61.5	0.0	1.0	55.0	8.0

Figure 9: AHU-6CC Data

BIN RANGE	AVG OADB	TMY3 HOURS	SF-O	CLG-O	HTG-O	RA-T	DA-T	EFFDAT-SP	RAT-SP	CHWE-T	CHWL-T
-12.5--7.5	-10	6	100.0	0.0	100.0	60.3	89.6	135.0	71.0	70.5	73.9
-7.5--2.5	-5	48	100.0	0.0	100.0	60.1	89.5	135.0	71.0	71.0	74.3
-2.5-2.5	0	81	99.7	0.0	99.7	62.7	91.5	134.8	71.0	72.3	75.3
2.5-7.5	5	176	100.0	0.0	99.9	63.5	92.0	135.0	71.0	73.1	76.0
7.5-12.5	10	207	100.0	0.0	100.0	64.9	93.0	134.8	71.0	73.9	76.7
12.5-17.5	15	278	100.0	0.0	95.7	65.8	92.3	130.8	71.0	73.8	76.9
17.5-22.5	20	283	100.0	0.0	89.2	67.6	93.0	124.3	71.0	73.5	77.3
22.5-27.5	25	389	100.0	0.1	75.7	68.6	91.5	114.8	71.0	73.2	77.5
27.5-32.5	30	551	100.0	0.9	64.1	69.0	87.8	109.0	71.0	67.9	75.9
32.5-37.5	35	856	100.0	1.1	48.5	69.4	84.6	96.9	71.0	66.3	75.3
37.5-42.5	40	555	100.0	1.0	44.4	69.5	83.6	93.6	71.0	65.5	75.0
42.5-47.5	45	539	100.0	1.1	34.1	69.8	81.9	88.1	71.0	64.1	74.6
47.5-52.5	50	490	100.0	2.1	25.1	69.9	78.3	82.7	71.0	59.3	73.3
52.5-57.5	55	494	98.7	4.5	14.7	69.9	74.4	77.6	71.0	53.1	71.5
57.5-62.5	60	568	97.7	10.4	6.0	70.0	69.8	72.7	71.0	46.8	69.0
62.5-67.5	65	662	96.7	18.4	3.1	70.0	66.9	68.9	71.0	45.3	66.4
67.5-72.5	70	805	97.6	28.9	0.5	70.0	63.7	64.0	71.0	43.3	63.6
72.5-77.5	75	701	98.0	43.1	0.1	70.1	60.7	60.4	71.0	42.5	60.6
77.5-82.5	80	553	98.4	59.9	0.0	70.2	58.0	56.9	71.0	41.9	57.9
82.5-87.5	85	338	99.9	77.2	0.0	70.5	56.3	54.0	71.0	41.1	56.0
87.5-92.5	90	155	99.9	91.5	0.0	71.2	55.6	51.6	71.0	41.1	54.9
92.5-97.5	95	25	100.0	98.7	0.0	72.0	55.5	50.2	71.0	40.9	54.8

Figure 10: AHU-7CC Data

BIN RANGE	AVG OADB	TMY3 HOURS	CLG-O	PH-O	OAD-O	RAD-O	RA-T	MA-T	PH-T	DA-T	OAD-MINPOS	SF-C
-12.5--7.5	-10	6	0.0	100.0	10.0	90.0	61.0	55.2	75.5	77.9	10.0	100%
-7.5--2.5	-5	48	0.0	100.0	8.7	91.3	62.9	57.5	77.4	79.9	8.7	100%
-2.5-2.5	0	81	0.0	63.0	5.3	58.0	41.2	38.0	50.0	51.4	7.0	100%
2.5-7.5	5	176	0.1	97.7	6.7	93.3	66.4	62.2	78.9	81.1	3.4	100%
7.5-12.5	10	207	0.1	91.1	8.1	91.9	66.3	61.2	76.2	78.0	6.6	93%
12.5-17.5	15	278	0.1	85.9	8.9	91.1	66.8	62.1	75.8	77.7	8.3	92%
17.5-22.5	20	283	0.1	81.0	8.5	91.5	67.1	63.1	75.9	77.2	8.7	88%
22.5-27.5	25	389	0.6	67.0	8.7	91.3	67.7	64.4	75.0	76.5	9.0	86%
27.5-32.5	30	551	0.2	60.1	10.9	89.1	68.2	65.2	74.7	76.4	9.7	90%
32.5-37.5	35	856	1.0	46.7	11.5	88.5	68.3	65.2	72.7	74.2	9.2	86%
37.5-42.5	40	555	0.8	40.2	13.3	86.7	68.4	64.9	71.6	73.3	9.4	87%
42.5-47.5	45	539	0.9	33.9	16.2	83.8	68.8	65.3	70.7	72.5	9.6	93%
47.5-52.5	50	490	0.0	21.9	19.0	81.0	69.1	66.2	68.6	70.6	10.0	95%
52.5-57.5	55	494	0.0	9.0	24.6	75.4	69.8	66.2	67.9	69.9	10.0	96%
57.5-62.5	60	568	1.7	23.6	34.1	65.9	69.7	65.5	66.0	68.1	10.0	97%
62.5-67.5	65	662	7.5	8.2	59.8	40.2	71.2	66.1	63.6	66.1	10.0	96%
67.5-72.5	70	805	15.3	15.0	17.0	83.0	71.8	71.5	64.1	66.9	10.0	98%
72.5-77.5	75	701	16.7	23.5	10.0	90.0	72.2	72.8	63.3	66.3	10.0	99%
77.5-82.5	80	553	23.7	30.9	10.0	90.0	72.2	73.2	60.6	63.8	10.0	100%
82.5-87.5	85	338	29.7	33.7	10.0	90.0	72.4	74.0	58.3	61.6	10.0	100%
87.5-92.5	90	155	45.9	44.8	10.0	90.0	72.9	74.9	56.3	59.6	10.0	100%
92.5-97.5	95	25	56.7	46.2	10.0	90.0	73.7	75.6	55.0	58.4	10.0	100%

Figure 11: AHU-8CC Data

OCCUPIED (EFF-OCC)

BIN RANGE	AVG OADB	TMY3 HOURS	Sum of SF-C	SF-C HOURS	EF-C HOURS	ZN-T	RA-T	MA-T	PH-T	DA-T	OAD-O	RAD-O	PH1-O	PH2-O	CLG-O	EFFDAT-SP
-2.5-2.5	0	12	33	8	0	68.0	59.0	57.8	65.1	63.7	6.3	93.7	18.0	0.0	0.0	66.0
2.5-7.5	5	27	17	4	0	67.8	58.4	58.3	66.7	63.9	6.3	93.7	22.6	0.0	0.0	66.0
7.5-12.5	10	38	123	31	0	69.4	61.9	61.4	66.3	66.6	5.6	94.4	19.2	0.0	0.0	67.3
12.5-17.5	15	101	175	44	0	69.2	62.1	61.6	70.3	68.2	6.0	94.0	31.6	0.0	0.1	68.9
17.5-22.5	20	112	206	52	0	69.3	63.6	62.8	70.6	69.4	6.2	93.8	30.2	0.0	0.1	69.7
22.5-27.5	25	92	289	72	0	69.3	64.9	63.2	69.8	68.6	9.2	90.6	23.5	0.0	3.1	68.5
27.5-32.5	30	131	416	104	0	69.3	65.5	63.6	69.1	68.3	11.8	88.1	17.4	0.0	1.9	68.3
32.5-37.5	35	203	599	150	0	69.7	66.3	63.9	69.3	68.3	12.1	87.4	18.6	2.5	5.5	68.0
37.5-42.5	40	307	671	168	0	69.7	67.1	65.1	69.9	67.8	14.1	85.7	13.3	2.7	7.9	67.0
42.5-47.5	45	151	751	188	0	69.7	68.1	64.7	68.3	66.5	23.0	76.8	5.2	2.8	13.7	65.3
47.5-52.5	50	122	741	185	0	69.3	68.3	64.3	67.2	65.7	29.0	71.0	3.8	2.4	14.9	64.6
52.5-57.5	55	94	552	138	0	69.4	68.9	64.1	67.5	66.2	38.8	60.6	5.6	2.9	10.6	65.6
57.5-62.5	60	98	457	114	0	68.8	68.8	62.7	64.7	64.6	60.0	39.0	1.9	1.9	16.4	63.7
62.5-67.5	65	144	423	106	0	68.2	69.0	63.5	64.9	64.0	74.0	25.0	2.7	1.3	34.1	63.1
67.5-72.5	70	169	685	171	0	68.7	70.0	67.1	68.1	64.8	41.2	58.1	0.0	0.0	63.1	60.5
72.5-77.5	75	204	790	198	0	69.0	70.7	68.3	69.5	65.4	15.5	83.9	0.2	0.1	63.0	62.3
77.5-82.5	80	172	714	179	0	69.1	71.3	69.0	70.1	65.6	11.9	88.1	0.6	0.5	66.7	62.3
82.5-87.5	85	163	537	134	0	69.1	71.5	69.2	70.3	65.4	10.3	89.7	0.5	0.2	67.9	61.9
87.5-92.5	90	117	333	83	0	69.0	71.7	69.5	70.6	65.2	10.0	90.0	0.3	0.3	70.3	61.4
92.5-97.5	95	50	207	52	0	69.3	72.2	70.1	71.1	65.4	9.9	90.1	1.4	1.4	74.0	59.8
97.5-102.5	100	8	45	11	0	69.4	72.3	70.2	71.3	65.9	9.7	90.3	4.4	4.4	69.0	63.9

UNOCCUPIED (EFF-OCC)

RANGE	AVG OADB	TMY3 HOURS	Sum of SF-C	SF-C HOURS	EF-C HOURS	ZN-T	RA-T	MA-T	PH-T	DA-T	OAD-O	RAD-O	PH1-O	PH2-O	CLG-O	EFFDAT-SP
-12.5--7.5	-5	6	0	0	0	66.0	50.0	49.4	50.9	64.5	0.0	100.0	0.0	0.0	0.0	66.0
-7.5--2.5	0	36	1	0	0	66.4	50.7	50.6	53.5	65.2	0.0	100.0	2.0	1.8	0.0	66.0
-2.5-2.5	5	54	0	0	0	66.2	50.9	51.3	54.8	65.2	0.0	100.0	0.0	0.0	0.0	66.0
2.5-7.5	10	138	0	0	0	66.7	51.6	50.8	53.1	65.0	0.0	100.0	0.0	0.0	0.0	66.0
7.5-12.5	15	106	1	0	0	66.6	56.0	54.9	57.1	66.2	0.0	100.0	0.8	0.6	0.0	66.0
12.5-17.5	20	166	3	1	0	66.8	56.1	55.2	57.2	66.5	0.0	100.0	1.2	0.9	0.0	66.0
17.5-22.5	25	191	3	1	0	67.2	57.0	55.8	57.8	66.9	0.4	99.6	0.7	0.6	0.0	66.0
22.5-27.5	30	258	2	1	0	68.1	59.4	58.0	60.1	67.9	0.7	99.3	0.5	0.4	0.0	66.0
27.5-32.5	35	348	5	1	0	68.9	61.3	59.6	61.4	68.9	1.8	98.2	0.6	0.5	0.0	66.0
32.5-37.5	40	549	2	1	0	69.5	62.5	60.8	62.4	69.5	1.9	98.1	0.2	0.1	0.0	66.0
37.5-42.5	45	404	4	1	0	70.5	64.9	63.0	65.0	70.7	2.0	98.0	1.3	1.2	1.1	66.0
42.5-47.5	50	417	4	1	0	70.7	65.7	63.2	64.3	70.9	1.5	98.5	0.2	0.2	0.1	66.0
47.5-52.5	55	396	4	1	0	71.0	65.7	63.0	64.0	71.0	2.4	97.6	0.0	0.0	0.2	66.0
52.5-57.5	60	396	1	0	0	71.3	67.3	64.5	65.6	71.5	1.0	99.0	0.6	0.6	1.7	66.0
57.5-62.5	65	424	0	0	0	71.6	68.6	65.4	66.4	71.8	0.6	99.4	0.5	0.5	3.4	66.0
62.5-67.5	70	493	0	0	0	71.8	70.0	66.3	66.8	72.2	0.3	99.7	0.0	0.0	4.6	66.0
67.5-72.5	75	601	1	0	0	72.1	71.4	67.6	67.9	72.5	0.1	99.9	0.0	0.0	2.8	66.0
72.5-77.5	80	529	1	0	0	72.5	72.4	68.6	68.8	73.1	0.0	100.0	0.0	0.0	4.1	66.0
77.5-82.5	85	390	0	0	0	72.7	73.1	69.3	69.6	73.7	0.0	100.0	0.0	0.0	3.5	66.0
82.5-87.5	90	221	4	1	0	72.8	73.1	69.3	69.6	73.7	0.0	100.0	0.0	0.0	2.8	66.0
87.5-92.5	95	105	0	0	0	73.0	73.4	69.5	69.8	74.0	0.0	100.0	0.0	0.0	2.7	66.0
92.5-97.5	100	17	0	0	0	73.1	74.0	70.2	70.4	74.4	0.0	100.0	0.0	0.0	2.9	66.0

Figure 12: AHU-9CC Data

OCCUPIED (EFF-OCC)

BIN RANGE	AVG OADB	TMY3 HOURS	ZN-T	RA-T	MA-T	PH-T	DA-T	OAD-O	RAD-O	PH1-O	PH2-O	CLG-O	SF-O	CFM	EFFDAT-SP
-12.5--7.5	-10	1	70.5	68.7	60.2	76.9	76.2	5.3	94.7	51.4	0.0	0.0	61.5	18455	77.0
-7.5--2.5	-5	13	70.6	69.0	62.4	76.4	77.5	5.1	94.9	47.7	1.8	0.0	60.1	18025	77.6
-2.5-2.5	0	22	70.5	69.3	62.8	76.4	74.4	3.9	94.8	40.6	0.0	0.0	68.6	20582	74.3
2.5-7.5	5	23	70.4	69.3	63.9	78.7	76.1	2.6	85.1	49.0	0.6	0.0	78.5	23537	76.6
7.5-12.5	10	60	69.9	68.3	64.1	73.1	72.2	1.4	97.3	34.0	7.3	0.4	54.5	16340	74.8
12.5-17.5	15	123	69.7	68.4	64.6	73.5	71.6	1.0	98.9	24.6	1.2	3.0	50.5	15139	71.8
17.5-22.5	20	79	69.6	68.4	69.1	81.7	71.6	1.8	98.0	34.2	10.1	11.5	49.5	14844	71.5
22.5-27.5	25	118	69.8	68.6	65.7	72.1	67.5	3.5	96.2	18.2	8.1	5.8	51.9	15556	67.8
27.5-32.5	30	142	70.0	69.0	66.6	69.9	65.8	3.6	95.6	9.6	4.2	9.0	54.7	16411	65.5
32.5-37.5	35	215	70.7	69.7	67.5	72.3	66.1	4.8	94.2	11.0	8.4	11.4	50.3	15101	64.1
37.5-42.5	40	122	70.5	69.7	68.0	71.3	63.8	2.7	97.0	7.1	6.2	23.7	54.3	16302	61.0
42.5-47.5	45	127	70.2	69.8	68.2	68.7	62.5	3.7	96.1	1.0	0.8	25.2	53.9	16184	60.6
47.5-52.5	50	120	70.0	69.3	67.5	67.6	61.7	7.4	92.4	0.1	0.0	35.9	48.0	14398	60.7
52.5-57.5	55	103	69.9	69.3	67.5	67.6	62.2	8.1	91.7	0.0	0.0	32.5	44.9	13480	62.1
57.5-62.5	60	131	69.8	69.6	68.5	68.5	62.9	5.0	95.0	0.0	0.0	39.7	51.2	15358	60.9
62.5-67.5	65	155	70.0	69.8	68.2	68.0	65.2	10.9	89.1	0.0	0.0	40.3	59.2	17756	59.0
67.5-72.5	70	227	70.1	69.8	68.7	68.3	65.0	5.9	94.1	0.0	0.0	50.4	55.6	16668	61.2
72.5-77.5	75	194	70.4	70.3	69.3	68.7	65.0	4.3	95.7	0.0	0.0	56.8	52.0	15593	60.0
77.5-82.5	80	197	70.7	70.7	70.1	70.1	66.4	4.9	95.1	2.0	0.0	54.4	58.3	17488	60.8
82.5-87.5	85	120	70.9	70.8	69.8	69.8	66.0	3.4	96.6	2.5	0.0	64.2	53.2	15969	61.9
87.5-92.5	90	68	71.8	71.7	69.7	69.8	68.4	0.9	99.1	4.0	0.0	67.2	49.5	14838	63.8
92.5-97.5	95	12	71.1	71.1	68.8	69.7	66.6	0.4	99.6	8.8	0.0	86.8	51.7	15500	64.8

UNOCCUPIED (EFF-OCC)

BIN RANGE	AVG OADB	TMY3 HOURS	ZN-T	RA-T	MA-T	PH-T	DA-T	OAD-O	RAD-O	PH1-O	PH2-O	CLG-O	SF-O	CFM	EFFDAT-SP
-12.5--7.5	-10	5	67.3	51.0	51.5	55.8	66.0	0.0	100.0	2.2	1.9	0.0	1.5	454	66.0
-7.5--2.5	-5	35	65.9	52.2	50.3	53.9	65.3	0.0	100.0	0.9	0.7	0.0	0.5	159	66.0
-2.5-2.5	0	59	65.6	53.4	50.0	53.0	64.3	0.0	100.0	0.0	0.0	0.1	0.0	0	66.0
2.5-7.5	5	153	66.2	55.5	52.9	55.8	65.1	0.0	100.0	0.5	0.4	0.1	0.4	119	66.0
7.5-12.5	10	147	67.0	55.7	54.0	56.8	65.4	0.0	100.0	1.0	0.8	0.1	0.5	144	66.0
12.5-17.5	15	155	66.6	57.3	55.7	58.3	66.1	0.3	99.7	0.1	0.0	0.1	0.2	68	66.1
17.5-22.5	20	204	67.9	58.8	57.9	61.0	67.3	0.1	99.9	2.0	2.0	1.8	0.2	46	66.0
22.5-27.5	25	271	68.7	61.2	59.5	61.3	68.1	0.8	99.2	0.6	0.5	0.0	0.3	100	66.0
27.5-32.5	30	409	69.8	63.6	61.5	62.6	69.2	0.6	99.4	0.4	0.3	4.9	0.2	74	66.0
32.5-37.5	35	641	70.1	64.1	61.3	62.0	69.2	2.1	97.9	0.2	0.2	9.1	0.1	30	66.0
37.5-42.5	40	433	70.4	65.1	61.9	62.3	69.6	1.6	98.4	0.0	0.0	9.4	0.0	12	66.0
42.5-47.5	45	412	70.8	66.5	63.1	62.9	70.1	0.9	99.1	0.0	0.0	10.6	0.1	26	66.0
47.5-52.5	50	370	71.3	67.6	63.8	63.1	71.2	0.3	99.7	0.0	0.0	15.8	0.1	40	66.0
52.5-57.5	55	391	71.5	68.0	64.5	63.8	71.8	0.3	99.7	0.0	0.0	13.8	0.1	17	66.0
57.5-62.5	60	437	71.8	69.1	65.8	64.7	72.6	0.0	100.0	0.0	0.0	17.0	0.0	5	66.0
62.5-67.5	65	507	72.2	70.4	67.9	66.9	73.3	0.0	100.0	0.0	0.0	11.7	0.0	0	66.0
67.5-72.5	70	578	72.5	71.5	69.9	68.9	73.8	0.0	100.0	0.0	0.0	8.6	0.0	12	66.0
72.5-77.5	75	507	72.8	72.7	71.6	70.4	74.1	0.0	100.0	0.0	0.0	6.9	0.3	96	66.0
77.5-82.5	80	356	72.9	72.9	72.3	71.1	73.1	0.0	100.0	0.0	0.0	11.4	4.9	1480	66.0
82.5-87.5	85	218	73.0	73.0	72.6	71.4	72.9	0.0	100.0	0.0	0.0	17.4	12.2	3665	66.0
87.5-92.5	90	87	72.3	72.5	72.2	71.4	70.7	0.0	100.0	0.0	0.0	25.6	25.4	7624	66.0
92.5-97.5	95	13	71.5	71.9	72.1	71.5	69.0	0.0	100.0	0.0	0.0	35.6	43.4	13012	66.0

Figure 13: AHU-10CC Data

OCCUPIED (EFF-OCC)

BIN RANGE	AVG OADB	TMY3 HOURS	ODA-H	MA-T	DA-T	ZN-T	RA-T	RA-H	ODA-FLOW	DPR-O	CLG-VLV	STM-VLV	DA-STPT
-12.5--7.5	-10	2	35.0	64.1	67.9	62.9	65.8	1.7	12152.0	0.0	73.5	0.0	60.0
-7.5--2.5	-5	14	35.0	65.2	69.1	63.2	66.8	3.0	12169.5	0.0	91.3	0.0	60.0
-2.5-2.5	0	42	35.0	65.8	70.7	66.7	67.4	3.6	12164.2	0.0	92.9	0.0	60.0
2.5-7.5	5	81	35.0	66.7	74.4	68.7	68.3	3.9	12159.2	0.0	100.0	0.0	60.0
7.5-12.5	10	94	35.0	67.6	72.9	68.4	69.1	5.9	12160.0	0.0	97.7	0.0	60.0
12.5-17.5	15	154	35.0	68.7	73.8	70.7	70.2	9.0	12158.6	0.0	99.0	0.0	60.6
17.5-22.5	20	118	35.0	69.2	74.2	71.3	70.7	10.9	12168.9	0.0	99.9	0.0	60.8
22.5-27.5	25	177	35.0	70.2	76.5	72.8	71.8	12.2	12171.0	0.0	99.7	0.0	62.0
27.5-32.5	30	253	35.0	71.3	77.8	73.9	72.8	15.2	12170.1	0.0	99.6	0.0	61.9
32.5-37.5	35	376	35.0	71.8	78.0	74.2	73.1	18.2	12167.0	0.0	99.2	0.0	61.1
37.5-42.5	40	265	35.0	71.9	77.9	74.1	73.2	21.2	12172.9	0.0	94.0	0.0	61.8
42.5-47.5	45	274	35.0	72.0	77.4	74.4	73.4	25.2	12179.9	0.0	87.9	0.0	63.9
47.5-52.5	50	228	35.0	72.3	76.2	74.5	73.6	28.5	12186.6	0.0	83.5	0.0	63.7
52.5-57.5	55	254	35.0	71.9	72.8	74.7	73.2	32.8	12186.2	0.0	73.1	0.1	63.7
57.5-62.5	60	270	35.0	71.5	65.5	74.1	72.8	41.6	12194.2	0.0	55.7	0.0	61.8
62.5-67.5	65	304	35.0	71.0	60.6	73.6	72.4	48.6	12199.0	0.0	52.9	0.0	59.0
67.5-72.5	70	376	35.0	70.9	57.1	73.2	72.3	53.0	12201.3	0.0	49.9	0.0	57.1
72.5-77.5	75	348	35.0	71.0	56.6	73.2	72.4	55.9	12201.0	0.0	48.9	0.0	56.8
77.5-82.5	80	277	35.0	71.1	54.7	73.2	72.5	59.7	12202.6	0.0	46.4	0.0	55.0
82.5-87.5	85	193	35.0	71.7	54.7	74.0	73.0	63.0	12201.5	0.0	43.8	0.0	55.1
87.5-92.5	90	105	35.0	72.0	54.7	74.5	73.2	65.3	12200.4	0.0	39.1	0.0	55.3
92.5-97.5	95	13	35.0	71.6	53.8	75.2	72.9	68.4	12201.6	0.0	36.7	0.0	55.0

UNOCCUPIED (EFF-OCC)

BIN RANGE	AVG OADB	TMY3 HOURS	ODA-H	MA-T	DA-T	ZN-T	RA-T	RA-H	ODA-FLOW	DPR-O	CLG-VLV	STM-VLV	DA-STPT
-12.5--7.5	-10	4	35.0	39.1	62.5	63.0	57.2	21.8	12164.2	0.0	0.0	0.2	60.0
-7.5--2.5	-5	34	35.0	44.1	74.3	57.6	59.0	12.2	12164.8	0.0	0.0	0.4	60.0
-2.5-2.5	0	39	35.0	46.0	77.3	62.5	60.8	8.5	12169.0	0.0	0.0	0.2	60.0
2.5-7.5	5	95	35.0	52.3	98.2	64.5	63.6	7.0	12164.6	0.0	0.0	0.1	60.0
7.5-12.5	10	113	35.0	52.7	80.9	67.6	65.5	14.3	12158.8	0.0	0.0	0.1	60.0
12.5-17.5	15	124	35.0	55.2	79.2	67.2	66.3	14.2	12159.5	0.0	0.0	0.0	60.6
17.5-22.5	20	165	35.0	57.8	86.2	68.3	66.4	16.0	12168.4	0.0	0.0	0.0	61.5
22.5-27.5	25	212	35.0	63.6	100.8	70.7	70.1	15.7	12170.9	0.0	0.0	0.0	62.0
27.5-32.5	30	298	35.0	63.6	91.8	71.3	70.0	21.0	12168.5	0.0	0.0	0.0	61.2
32.5-37.5	35	480	35.0	66.2	104.4	71.6	71.2	21.5	12166.1	0.0	0.0	0.0	61.1
37.5-42.5	40	290	35.0	67.3	98.9	71.6	72.0	24.0	12174.0	0.0	0.0	0.0	61.9
42.5-47.5	45	265	35.0	68.7	108.2	72.3	73.5	27.0	12182.8	0.0	0.0	0.0	64.4
47.5-52.5	50	262	35.0	70.5	121.0	73.0	74.6	29.3	12187.6	0.0	0.0	0.0	64.2
52.5-57.5	55	240	35.0	68.3	111.1	73.5	74.5	35.0	12193.4	0.0	0.0	0.0	63.7
57.5-62.5	60	298	35.0	66.2	105.3	74.3	75.1	39.1	12195.6	0.0	0.0	0.0	60.6
62.5-67.5	65	358	35.0	63.7	100.0	74.9	75.8	41.1	12199.4	0.0	0.0	0.0	58.6
67.5-72.5	70	429	35.0	60.7	89.3	75.1	76.0	41.6	12201.9	0.0	0.0	0.0	56.8
72.5-77.5	75	353	35.0	60.8	88.8	75.4	76.4	43.0	12201.7	0.0	0.0	0.0	56.0
77.5-82.5	80	276	35.0	61.8	90.0	75.7	76.8	45.7	12201.5	0.0	0.0	0.0	55.4
82.5-87.5	85	145	35.0	60.0	83.7	76.1	77.0	47.3	12201.9	0.0	0.2	0.0	55.1
87.5-92.5	90	50	35.0	59.3	76.6	76.8	77.3	47.4	12199.1	0.0	0.2	0.0	55.3
92.5-97.5	95	12	35.0	58.7	74.6	76.6	76.5	51.3	12199.3	0.0	0.0	0.0	55.0

Figure 14: AHU-1V Data

Appendix C: Variable Air Volume Box Data Summary

Historical trend data from sixty-nine (69) Variable Air Volume Boxes in 10-minute increments between 3/1/17 and 3/26/18. The raw data was refined down to determine heating energy consumed, identify malfunctioning boxes, and quantify overheated supply air.

UINIT SERVED	AHU-5	AHU-5	AHU-5	AHU-6	AHU-6	AHU-5	AHU-5	AHU-5	AHU-5	AHU-5	AHU-6	AHU-6	AHU-6	AHU-6	AHU-6	AHU-5	AHU-5	AHU-5	AHU-6	AHU-6	AHU-4	AHU-4	AHU-4
TAG	TAB-101	TAB-102	TAB-103	TAB-104	TAB-105	TAB-106	TAB-107	TAB-108	TAB-109	TAB-110	TAB-111	TAB-112	TAB-113	TAB-114	TAB-115	TAB-201	TAB-202	TAB-203	TAB-204	TAB-205	TAB-206	TAB-207	TAB-208
ZN-T																							
2Q2017 AVERAGE	69.6	75.6	74.5	69.9	70.5	69.5	71.8	68.9	68.9	71.0	69.8	72.2	71.9	68.8	69.3	68.4	69.7	69.3	68.6	68.1	69.9	69.2	68.5
3Q2017 AVERAGE	71.4	76.7	77.1	69.0	71.0	70.5	71.8	70.6	69.8	71.3	70.6	71.8	72.1	69.0	69.3	71.3	71.5	70.7	69.7	68.5	69.8	70.1	69.3
4Q2017 AVERAGE	66.6	72.7	70.3	69.6	69.8	67.9	70.4	66.3	68.1	70.8	68.8	71.0	71.2	69.6	68.6	66.8	67.1	67.7	67.2	66.8	69.1	68.1	68.5
1Q2018 AVERAGE	68.5	74.1	72.9	69.0	70.3	69.0	71.1	67.2	69.0	71.3	69.5	71.6	71.6	69.3	69.2	67.9	68.4	68.3	67.7	67.1	69.1	68.5	68.2
DA-T																							
2Q2017 AVERAGE	67.8	64.6	65.1	61.2	72.9	129.5	64.5	68.9	71.9	70.6	68.6	64.9	64.7	65.8	66.0	64.9	69.6	67.7	104.2	68.1	62.7	63.1	64.4
3Q2017 AVERAGE	63.6	64.4	65.3	61.9	67.3	135.0	64.1	64.3	72.2	70.8	66.3	64.3	64.0	65.3	64.2	62.8	93.9	64.7	77.4	64.7	62.1	61.9	63.4
4Q2017 AVERAGE	70.8	63.3	64.3	64.2	68.0	124.9	64.2	70.8	65.5	69.9	69.9	64.7	64.3	66.6	65.3	67.0	93.5	71.8	90.5	81.7	63.0	64.9	64.8
1Q2018 AVERAGE	70.2	65.5	66.6	62.3	70.2	130.5	64.6	72.9	70.2	70.6	71.8	64.8	64.5	66.3	65.3	65.7	86.0	71.4	91.6	71.9	62.5	63.4	64.6
HTG-O																							
2Q2017 AVERAGE	7.9	0.1	0.9	1.6	0.4	4.3	0.0	10.7	3.7	0.3	3.1	0.0	0.0	1.0	5.3	10.7	20.2	11.5	21.0	14.3	0.4	3.0	6.2
3Q2017 AVERAGE	0.7	0.0	0.0	13.2	0.0	0.0	0.0	0.0	2.1	0.3	0.0	0.0	0.0	0.8	1.0	0.5	0.0	1.7	5.9	10.6	0.2	2.4	7.1
4Q2017 AVERAGE	19.3	0.1	3.8	19.3	4.5	7.1	0.4	15.9	0.7	0.4	5.5	0.4	0.3	0.3	1.6	15.5	0.0	18.5	43.2	38.1	3.3	5.4	7.8
1Q2018 AVERAGE	15.6	2.4	6.0	9.8	2.0	7.5	0.5	19.9	2.9	0.3	7.8	0.5	0.2	1.0	2.6	11.5	6.3	17.9	28.8	23.6	1.6	4.0	9.2
DMPR-O																							
2Q2017 AVERAGE	53.6	56.3	49.1	14.8	7.2	31.4	13.6	17.1	5.9	4.5	58.2	53.0	75.0	10.8	5.4	19.6	17.1	32.1	20.4	24.3	20.6	43.6	20.7
3Q2017 AVERAGE	51.6	57.0	56.4	17.9	10.3	31.8	13.2	19.9	5.4	4.2	57.5	50.5	75.0	17.7	7.6	32.5	25.8	19.7	20.2	24.1	17.1	36.6	19.3
4Q2017 AVERAGE	57.9	57.4	46.2	20.2	11.2	29.5	14.3	19.6	6.4	8.3	60.7	56.4	74.5	60.7	6.3	13.3	29.1	31.6	25.6	39.5	25.7	43.9	24.4
1Q2018 AVERAGE	57.2	54.6	46.2	17.7	9.5	31.8	14.0	28.7	6.5	5.9	60.4	52.6	74.9	36.2	6.7	20.3	24.8	33.3	23.1	28.8	20.7	40.6	22.1
ZN-SP																							
2Q2017 AVERAGE	69.4	69.6	69.4	68.1	69.8	69.4	69.6	68.7	69.0	68.4	69.6	69.5	69.5	67.7	69.8	68.4	69.1	68.9	68.6	68.7	68.1	68.4	68.2
3Q2017 AVERAGE	69.4	69.4	69.4	68.5	68.6	69.4	69.4	68.6	69.4	69.4	68.6	68.5	68.5	68.5	68.2	69.1	67.8	69.4	68.5	68.5	68.4	69.5	68.7
4Q2017 AVERAGE	67.9	67.9	67.9	70.3	68.1	68.3	67.9	66.9	67.9	68.1	68.1	68.1	68.1	68.2	69.0	68.3	68.2	68.3	69.0	69.4	68.1	68.4	68.4
1Q2018 AVERAGE	68.9	69.1	69.0	68.4	69.0	69.1	69.1	68.1	68.9	68.7	69.0	68.9	68.9	68.4	69.1	67.9	67.9	68.2	68.1	68.2	67.6	68.1	67.8
MAX DA-T	200.0																						
2Q2017 MAX	112.3	139.0	113.7	80.2	117.6	402.7	75.7	111.2	188.3	85.0	138.2	71.7	72.6	94.3	96.7	135.9	243.4	123.4	393.8	135.3	96.4	82.1	101.1
3Q2017 MAX	78.6	83.3	87.5	79.0	81.7	452.1	77.2	77.9	266.0	81.0	73.5	72.7	73.5	86.0	74.7	82.2	248.4	93.6	404.5	92.9	77.9	79.2	94.9
4Q2017 MAX	138.1	135.8	120.0	95.2	107.9	427.6	122.5	140.1	171.5	97.9	138.4	100.8	89.7	101.6	90.1	116.5	249.8	131.6	142.5	161.9	98.2	103.8	106.6
1Q2018 MAX	138.1	141.6	145.6	95.2	280.7	517.4	125.6	151.0	266.0	102.2	148.1	100.8	91.2	107.6	96.7	135.9	250.0	132.8	404.5	163.6	107.3	103.8	106.6
DA-T > 92																							
2Q2017	192	40	59	0	581	13977	0	1426	681	0	640	0	0	1	2	111	2378	1387	9618	749	2	0	13
3Q2017	0	0	0	0	0	11452	0	0	645	0	0	0	0	0	0	0	5697	2	1720	1	0	0	1
4Q2017	968	36	360	31	626	9622	76	2235	30	2	745	50	0	20	0	389	4937	2433	5848	4152	1	7	16
1Q2018	2935	1432	2141	0	933	9746	222	7361	551	4	3346	117	0	140	0	899	4985	5432	6131	2411	14	5	41
TOTAL COUNT	4095	1508	2560	31	2140	44797	298	11022	1907	6	4731	167	0	161	2	1399	17997	9254	23317	7313	17	12	71
% OF TOTAL	7%	3%	5%	0%	4%	80%	1%	20%	3%	0%	8%	0%	0%	0%	0%	2%	32%	16%	41%	13%	0%	0%	0%
ANNUAL HOURS	683	251	427	5	357	7466	50	1837	318	1	789	28	0	27	0	233	3000	1542	3886	1219	3	2	12

UINIT SERVED	AHU-4	AHU-4	AHU-4	AHU-4	AHU-4	AHU-4	AHU-4	AHU-4	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-4	AHU-4	AHU-4	AHU-4	AHU-4	AHU-4
TAG	TAB-209	TAB-210	TAB-211	TAB-212	TAB-213	TAB-214	TAB-215	TAB-216	TAB-217	TAB-218	TAB-219	TAB-220	TAB-221	TAB-222	TAB-223	TAB-224	TAB-225	TAB-226	TAB-227	TAB-228	TAB-229	TAB-230	TAB-231
ZN-T																							
2Q2017 AVERAGE	69.6	69.5	69.0	68.5	69.5	69.5	69.6	68.5	68.8	69.3	67.4	68.5	68.5	69.3	68.1	67.9	69.3	69.3	68.8	68.5	69.0	69.1	69.2
3Q2017 AVERAGE	69.6	69.5	69.1	69.3	69.4	71.5	69.6	69.3	69.1	70.1	69.0	68.8	68.9	70.1	68.7	68.6	70.1	69.3	69.1	69.3	69.2	69.5	69.6
4Q2017 AVERAGE	68.8	68.7	68.3	68.5	68.8	67.9	68.7	68.5	68.4	68.8	68.0	68.1	68.1	68.8	68.5	68.4	68.8	68.7	68.6	68.5	68.7	68.8	68.8
1Q2018 AVERAGE	68.8	68.7	68.2	68.2	68.8	68.9	68.8	68.2	67.1	66.8	66.1	66.9	66.9	66.8	66.9	66.9	66.8	67.1	67.0	66.2	67.0	67.1	68.3
DA-T																							
2Q2017 AVERAGE	62.5	65.3	66.5	62.5	62.1	64.8	63.2	64.2	58.2	56.9	63.4	58.8	58.0	56.5	44.2	61.5	56.3	62.4	62.4	64.4	62.9	61.0	61.1
3Q2017 AVERAGE	61.9	65.3	66.7	61.4	61.6	61.9	62.6	63.1	60.3	58.0	65.8	61.6	60.4	58.1	61.6	64.9	64.5	62.2	62.4	63.5	63.9	61.9	62.2
4Q2017 AVERAGE	63.5	69.2	68.4	63.1	62.5	75.4	63.3	65.1	62.0	64.8	76.7	61.9	61.6	65.1	65.9	67.0	70.2	62.8	64.1	65.8	64.4	63.9	62.6
1Q2018 AVERAGE	62.5	66.3	66.7	62.8	62.0	67.1	62.9	64.6	61.5	64.4	79.6	61.9	61.1	65.4	61.3	62.6	68.8	62.2	62.4	68.5	62.2	62.1	62.6
HTG-O																							
2Q2017 AVERAGE	0.6	1.1	8.9	6.2	0.7	2.0	0.4	4.3	1.1	0.3	7.8	3.8	2.9	0.2	4.7	10.9	0.3	0.8	1.5	6.2	2.0	1.8	1.2
3Q2017 AVERAGE	1.3	1.5	14.1	7.1	1.6	0.0	1.2	5.1	2.7	0.5	9.8	5.7	5.2	0.4	6.0	16.7	0.5	1.9	3.3	7.1	5.8	2.2	2.1
4Q2017 AVERAGE	5.7	3.5	14.4	7.8	1.9	6.6	4.1	7.3	0.6	14.9	20.3	0.9	0.9	14.3	12.1	15.0	15.8	1.8	4.1	7.8	5.0	3.8	0.6
1Q2018 AVERAGE	2.5	2.1	10.8	9.2	1.5	3.0	1.8	7.6	1.8	19.0	26.4	3.9	2.7	18.9	2.8	3.5	19.0	2.0	2.6	17.6	2.1	1.7	0.2
DMPR-O																							
2Q2017 AVERAGE	21.6	18.1	42.6	19.3	16.8	23.5	19.0	17.5	25.9	31.0	40.6	22.2	22.9	21.5	22.9	20.1	40.3	17.4	23.4	14.7	17.7	17.3	16.9
3Q2017 AVERAGE	19.8	15.1	44.7	17.9	13.9	23.9	19.5	17.1	52.6	58.9	66.8	50.6	51.8	52.5	52.0	50.0	86.7	14.0	20.0	13.1	15.0	14.9	14.9
4Q2017 AVERAGE	29.2	21.8	51.5	22.7	19.6	20.4	30.0	22.6	61.3	56.7	69.8	57.2	60.6	48.4	58.1	51.8	99.5	22.7	26.8	17.1	22.0	22.5	23.0
1Q2018 AVERAGE	22.7	18.7	47.0	20.7	17.3	22.1	22.6	19.8	54.2	52.6	66.6	50.0	51.8	43.3	52.1	47.3	96.9	22.3	35.9	18.5	24.5	21.0	59.6
ZN-SP																							
2Q2017 AVERAGE	67.9	68.0	69.0	68.2	68.0	68.7	68.1	68.2	68.0	68.1	67.5	68.0	67.9	68.1	67.6	67.5	68.1	68.1	68.1	68.2	68.1	68.3	68.3
3Q2017 AVERAGE	68.4	68.4	69.6	68.7	68.4	69.6	68.6	68.7	68.8	68.5	69.5	68.7	68.8	68.5	68.8	68.9	68.5	68.8	68.9	68.7	69.1	69.0	69.3
4Q2017 AVERAGE	68.0	67.9	68.8	68.4	67.8	68.8	67.8	68.4	67.2	69.0	69.0	67.2	67.2	69.0	68.4	68.6	69.0	67.8	68.2	68.4	68.2	68.2	67.9
1Q2018 AVERAGE	67.5	67.5	68.3	67.8	67.5	68.2	67.6	67.8	65.6	66.1	66.1	65.6	65.6	66.1	65.6	65.6	66.1	65.6	65.6	65.8	65.4	65.7	65.5
MAX DA-T																							
2Q2017 MAX	89.9	95.9	95.5	98.8	90.1	128.2	96.2	106.7	100.9	87.2	117.8	84.1	86.0	95.7	93.7	100.9	90.5	97.1	100.7	109.2	93.8	95.2	109.5
3Q2017 MAX	83.9	87.2	94.7	92.0	84.7	80.4	87.7	81.8	94.0	81.6	94.4	89.6	82.7	86.3	90.4	117.5	73.1	87.6	86.5	102.8	84.2	83.5	87.3
4Q2017 MAX	115.3	177.7	113.8	104.0	103.3	128.5	98.4	107.7	116.7	108.1	137.9	90.5	91.6	162.6	109.9	109.2	75.3	102.7	117.0	110.4	111.0	112.1	102.5
1Q2018 MAX	101.5	100.7	110.1	101.8	108.5	127.1	99.7	107.5	123.0	128.7	145.6	110.5	101.9	166.5	104.7	122.2	76.6	104.2	99.4	116.8	101.1	97.7	99.2
DA-T > 92																							
2Q2017	0	2	1	10	0	451	8	104	1	0	971	0	0	3	1	5	0	13	13	411	2	1	10
3Q2017	0	0	1	0	0	0	0	0	1	0	3	0	0	0	0	6	0	0	0	1	0	0	0
4Q2017	31	485	25	13	5	2724	36	428	43	241	2669	0	0	144	342	172	0	56	136	967	130	51	9
1Q2018	76	112	21	36	50	917	191	275	144	361	4111	6	71	358	121	106	0	185	151	2038	43	41	6
TOTAL COUNT	107	599	48	59	55	4092	235	807	189	602	7754	6	71	505	464	289	0	254	300	3417	175	93	25
% OF TOTAL	0%	1%	0%	0%	0%	7%	0%	1%	0%	1%	14%	0%	0%	1%	1%	1%	0%	0%	1%	6%	0%	0%	0%
ANNUAL HOURS	18	100	8	10	9	682	39	135	32	100	1292	1	12	84	77	48	0	42	50	570	29	16	4

UINIT SERVED	AHU-4	AHU-4	AHU-4	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-1	AHU-5	AHU-5	AHU-4	AHU-5	AHU-6	AHU-1	AHU-6	AHU-6	AHU-5	AHU-6
TAG	TAB-232	TAB-233	TAB-234	TAB-235	TAB-236	TAB-237	TAB-238	TAB-239	TAB-240	TAB-241	TAB-242	TAB-243	TAB-244	TAB-301	TAB-302	TAB-303	TAB-304	TAB-305	TAB-306	TAB-307	TAB-308	TAB-309	TAB-310
ZN-T																							
2Q2017 AVERAGE	68.3	68.4	69.2	67.8	67.8	69.3	68.0	67.9	68.1	69.2	67.7	67.9	69.5	69.6	70.5	70.3	68.6	69.9	70.0	69.8	68.2	68.8	68.4
3Q2017 AVERAGE	69.5	69.8	70.1	68.9	68.7	70.1	68.7	68.6	68.3	69.5	69.8	68.9	70.1	71.8	71.7	71.5	70.2	71.1	71.3	71.9	70.9	70.0	70.1
4Q2017 AVERAGE	68.4	67.2	68.4	68.3	68.4	68.8	68.4	68.3	68.0	68.5	67.1	68.2	69.3	67.5	68.8	68.6	67.3	68.9	68.6	68.0	66.7	67.9	68.1
1Q2018 AVERAGE	66.6	65.0	65.7	66.3	67.0	66.8	67.0	66.9	66.8	66.7	64.1	66.3	67.0	66.7	68.6	68.6	66.5	68.7	68.5	67.0	65.6	67.5	67.6
DA-T																							
2Q2017 AVERAGE	64.6	116.9	62.1	58.9	84.7	55.9	58.6	59.3	498.7	60.0	66.7	61.6	55.1	69.1	124.2	61.3	69.7	66.9	57.3	70.1	75.0	70.8	75.0
3Q2017 AVERAGE	62.4	118.6	60.8	60.7	99.4	57.3	60.8	61.0	208.1	59.4	59.7	64.0	57.4	63.6	129.9	60.0	64.2	63.8	59.0	64.9	65.3	66.1	64.1
4Q2017 AVERAGE	64.9	144.6	63.9	61.5	96.3	65.8	62.8	62.7	111.0	62.8	89.0	70.8	64.1	80.8	110.8	60.7	76.7	69.6	60.6	75.6	82.2	79.1	75.9
1Q2018 AVERAGE	63.9	121.3	66.1	60.3	97.0	64.6	61.7	61.2	111.3	62.3	96.1	74.9	66.0	86.3	96.4	66.5	79.2	74.5	64.4	82.2	88.5	83.3	78.1
HTG-O																							
2Q2017 AVERAGE	6.4	9.2	2.3	10.3	8.4	0.3	6.0	8.1	15.3	7.9	18.2	3.3	0.0	15.3	3.9	2.4	22.4	8.4	4.7	14.8	36.3	20.0	33.0
3Q2017 AVERAGE	0.4	3.8	0.0	10.5	10.7	0.5	6.3	8.1	11.4	1.9	0.3	5.3	0.0	0.0	0.0	0.0	8.9	0.0	0.0	0.0	0.2	3.8	1.2
4Q2017 AVERAGE	3.7	13.9	8.0	1.3	2.2	15.5	2.0	3.1	5.2	6.6	54.5	12.5	9.9	29.4	2.4	2.4	26.0	11.5	3.2	28.0	43.7	26.5	25.6
1Q2018 AVERAGE	3.7	20.2	21.6	3.0	3.3	19.0	2.5	2.5	5.6	8.7	77.6	19.7	21.1	45.5	17.8	16.0	32.4	21.8	15.3	48.7	60.4	32.4	28.9
DMPR-O																							
2Q2017 AVERAGE	14.5	16.9	21.9	17.4	14.8	30.5	23.2	21.8	24.3	29.8	21.1	19.6	54.9	32.5	16.1	32.6	38.8	13.7	24.3	23.8	33.6	29.7	43.7
3Q2017 AVERAGE	12.6	13.3	22.8	47.2	44.9	58.3	53.7	51.1	52.5	52.2	48.7	48.2	62.9	33.2	17.8	51.5	29.4	17.1	35.3	27.8	29.8	18.2	28.8
4Q2017 AVERAGE	14.8	18.2	15.0	55.6	48.4	56.9	56.6	55.3	54.1	55.8	53.7	52.4	58.5	34.4	18.1	20.5	38.9	14.0	24.0	24.8	34.4	32.6	32.8
1Q2018 AVERAGE	16.5	20.2	16.1	44.3	43.9	52.5	51.4	49.5	49.6	51.7	49.4	48.6	49.0	44.8	16.3	28.5	44.7	15.5	24.9	31.6	39.7	37.4	36.5
ZN-SP																							
2Q2017 AVERAGE	68.4	68.5	68.3	67.6	67.6	68.1	67.8	67.9	68.2	68.9	67.6	67.9	67.7	69.4	69.6	68.8	69.4	0.0	69.2	69.6	69.3	69.4	69.1
3Q2017 AVERAGE	69.6	69.6	68.7	69.0	68.8	68.5	68.6	68.7	68.9	69.5	69.5	69.5	68.5	69.5	69.3	68.1	69.5	0.0	68.8	68.6	68.6	69.4	68.6
4Q2017 AVERAGE	68.6	68.7	68.6	67.3	67.9	69.0	67.9	68.0	68.1	69.0	69.0	69.0	68.9	69.0	68.0	68.2	69.0	0.0	68.0	69.0	68.9	68.9	69.1
1Q2018 AVERAGE	65.5	65.6	65.7	65.1	65.6	66.1	65.6	65.6	65.9	66.1	66.1	66.2	66.2	68.8	69.3	69.2	68.6	0.0	69.0	69.2	68.9	68.9	68.9
MAX DA-T																							
2Q2017 MAX	120.0	580.9	94.6	100.0	239.6	100.6	90.4	105.4	270994.1	112.0	125.3	129.5	71.5	125.9	250.0	118.7	116.9	117.4	100.1	124.4	120.4	126.0	136.0
3Q2017 MAX	89.3	497.4	76.2	103.5	244.9	86.3	100.7	98.6	270994.1	109.9	87.6	100.4	77.9	80.6	250.0	80.1	84.0	80.5	82.1	82.5	80.1	94.9	103.4
4Q2017 MAX	119.9	598.8	100.2	101.3	246.8	116.5	103.2	108.3	623.8	116.5	159.3	130.4	134.6	137.3	249.8	119.6	129.6	114.8	137.7	118.3	118.4	138.7	134.1
1Q2018 MAX	123.3	533.0	102.8	115.2	249.9	125.1	122.6	122.1	681.1	125.2	165.6	135.9	134.1	128.2	249.8	116.5	130.3	122.3	115.1	121.2	119.3	134.9	136.7
DA-T > 92																							
2Q2017	892	13953	1	5	5176	10	0	18	8499	4	3127	428	0	2072	12908	241	1282	1011	2	1744	3813	1186	3421
3Q2017	0	9361	0	4	7360	0	1	2	9498	4	0	354	0	0	11827	0	0	0	0	0	0	83	34
4Q2017	394	11324	6	11	6913	1135	16	52	6296	60	6255	1522	500	5124	8751	184	2888	1703	19	3898	5276	2848	2841
1Q2018	432	8834	31	59	6448	1042	48	55	7153	79	7715	2530	793	6481	5374	781	3806	2763	84	5429	6981	3604	3163
TOTAL COUNT	1718	43472	38	79	25897	2187	65	127	31446	147	17097	4834	1293	13677	38860	1206	7976	5477	105	11071	16070	7721	9459
% OF TOTAL	3%	77%	0%	0%	46%	4%	0%	0%	56%	0%	30%	9%	2%	24%	69%	2%	14%	10%	0%	20%	29%	14%	17%
ANNUAL HOURS	286	7245	6	13	4316	365	11	21	5241	25	2850	806	216	2280	6477	201	1329	913	18	1845	2678	1287	1577

Appendix D: Fan Coil Unit Data Summary

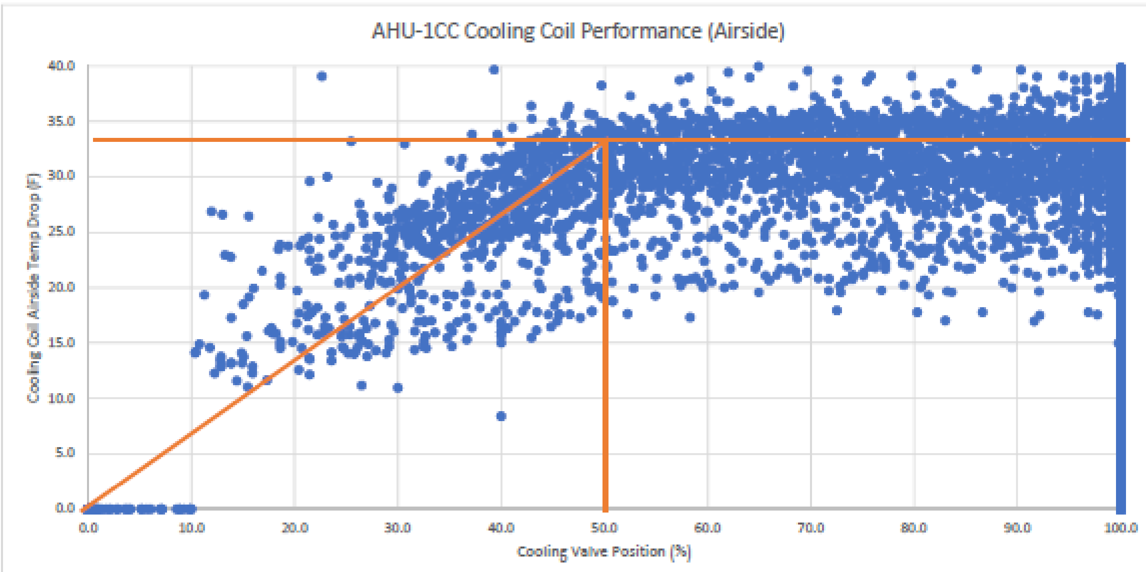
Historical trend data from twenty-six (26) Chilled Water/Hot Water Fan Coil Units in 10-minute increments between 3/1/17 and 3/26/18. The raw data was refined down to determine heating energy consumed, identify malfunctioning boxes, and quantify overheated supply air.

CLG-O	FCU-1	FCU-2	FCU-3	FCU-4	FCU-5	FCU-6	FCU-7	FCU-8	FCU-9	FCU-10	FCU-11	FCU-12	FCU-13
2Q2017 AVERAGE	65.0	7.6	14.8	9.4	17.0	18.4	14.0	32.5	6.3	NO	10.7	60.5	15.4
3Q2017 AVERAGE	68.5	16.6	15.3	10.3	18.3	15.7	16.4	31.7	8.8	DATA	11.9	61.1	16.3
4Q2017 AVERAGE	21.1	6.5	10.0	5.9	15.9	14.7	12.5	30.4	3.8		7.5	54.9	15.2
1Q2018 AVERAGE	43.2	7.8	11.5	8.3	16.8	15.6	13.3	31.2	5.2		9.1	57.6	15.6
OVERALL AVG	49.5	9.6	12.9	8.5	17.0	16.1	14.1	31.5	6.0	#DIV/0!	9.8	58.5	15.6
HTG-O													
2Q2017 AVERAGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
3Q2017 AVERAGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
4Q2017 AVERAGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
1Q2018 AVERAGE	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
ZNT-SP													
2Q2017 AVERAGE	70.0	70.0	69.4	70.0	65.0	70.0	70.0	65.0	70.0		70.0	60.0	70.0
3Q2017 AVERAGE	70.0	70.0	69.6	70.0	65.0	70.0	70.0	65.0	70.0		70.0	60.0	70.0
4Q2017 AVERAGE	70.0	70.0	70.0	70.0	65.0	70.0	70.0	65.0	70.0		70.0	60.0	70.0
1Q2018 AVERAGE	70.0	70.0	69.7	70.0	65.0	70.0	70.0	65.0	70.0		70.0	60.0	70.0
DA-T													
2Q2017 AVERAGE	71.4	69.6	69.8	69.7	64.4	65.7	70.5	58.8	70.9		70.8	50.4	68.1
3Q2017 AVERAGE	70.7	68.7	69.9	69.3	64.3	63.7	70.4	59.2	70.3		70.7	48.9	66.8
4Q2017 AVERAGE	69.6	69.0	70.6	69.7	64.5	66.8	70.2	58.9	69.7		70.6	50.1	67.6
1Q2018 AVERAGE	70.6	68.7	70.2	69.8	64.6	66.1	70.5	58.9	70.3		70.8	50.0	67.6
ZN-T													
2Q2017 AVERAGE	72.1	69.9	70.3	71.0	66.0	71.0	71.0	66.1	70.9		71.0	61.3	71.0
3Q2017 AVERAGE	71.7	71.0	70.5	71.0	66.0	70.9	71.0	66.0	71.0		71.0	61.1	71.0
4Q2017 AVERAGE	70.6	68.3	69.8	70.6	65.6	70.5	70.5	65.7	70.0		70.4	60.8	70.6
1Q2018 AVERAGE	71.4	68.8	70.0	70.9	65.9	70.8	70.9	66.0	70.5		70.8	61.1	70.9

CLG-O	FCU-14	FCU-15	FCU-16	FCU-17	FCU-18	FCU-19	FCU-20	FCU-21	FCU-22	FCU-23	FCU-24	FCU-25	FCU-26	FCU-27
2Q2017 AVERAGE	39.7	12.6	16.0	28.1	4.4	100.0	7.8	8.1	12.8	20.1	22.3	10.1	16.0	15.1
3Q2017 AVERAGE	2.1	20.2	19.4	23.3	9.3	100.0	18.4	19.9	29.4	44.2	28.6	21.0	48.0	16.5
4Q2017 AVERAGE	0.0	13.6	14.9	6.5	2.2	100.0	0.1	1.5	0.4	0.4	18.0	47.4	0.6	10.8
1Q2018 AVERAGE	12.9	14.5	16.0	16.9	6.4	100.0	6.8	7.6	11.0	16.8	20.2	30.4	16.5	12.3
OVERALL AVG	13.7	15.2	16.6	18.7	5.6	100.0	8.3	9.3	13.4	20.3	22.3	27.2	20.3	13.7
HTG-O														
2Q2017 AVERAGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	13.8	0.0	0.0	30.9	0.2
3Q2017 AVERAGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.1	0.0
4Q2017 AVERAGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.6	51.8	0.0	0.0	37.0	0.5
1Q2018 AVERAGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.6	33.7	0.0	0.0	29.0	1.9
ZNT-SP														
2Q2017 AVERAGE	62.7	69.4	67.4	70.0	70.0	65.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
3Q2017 AVERAGE	70.0	70.0	68.0	70.0	70.0	65.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
4Q2017 AVERAGE	70.0	70.0	68.0	70.0	70.0	65.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
1Q2018 AVERAGE	67.0	69.2	67.2	70.0	69.2	65.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
DA-T														
2Q2017 AVERAGE	60.2	68.9	65.7	62.2	71.2	66.5	67.7	67.9	69.7	71.2	69.2	70.2	78.6	68.0
3Q2017 AVERAGE	70.6	68.8	64.0	62.2	72.1	66.5	66.6	66.6	62.7	60.1	68.5	68.5	57.8	66.7
4Q2017 AVERAGE	70.1	68.6	65.5	61.6	70.8	65.6	66.8	67.2	84.0	95.0	69.1	47.2	91.4	68.4
1Q2018 AVERAGE	66.8	68.3	64.9	62.0	70.5	66.1	66.8	67.0	75.4	82.3	69.1	59.5	81.5	68.3
ZN-T														
2Q2017 AVERAGE	63.4	70.8	68.8	70.8	70.8	70.6	68.8	69.6	70.0	69.9	69.9	71.0	69.8	70.9
3Q2017 AVERAGE	69.6	70.6	68.6	71.0	71.0	71.2	70.9	71.0	70.9	70.9	69.5	71.0	71.0	71.0
4Q2017 AVERAGE	68.6	70.6	68.7	70.8	70.6	69.9	65.9	68.0	69.1	68.9	68.9	71.1	69.1	70.3
1Q2018 AVERAGE	66.9	70.3	68.3	70.8	70.0	70.3	67.8	68.9	69.7	69.6	69.4	71.1	69.7	70.7

Appendix E: Air Handler Cooling Coil Profiles

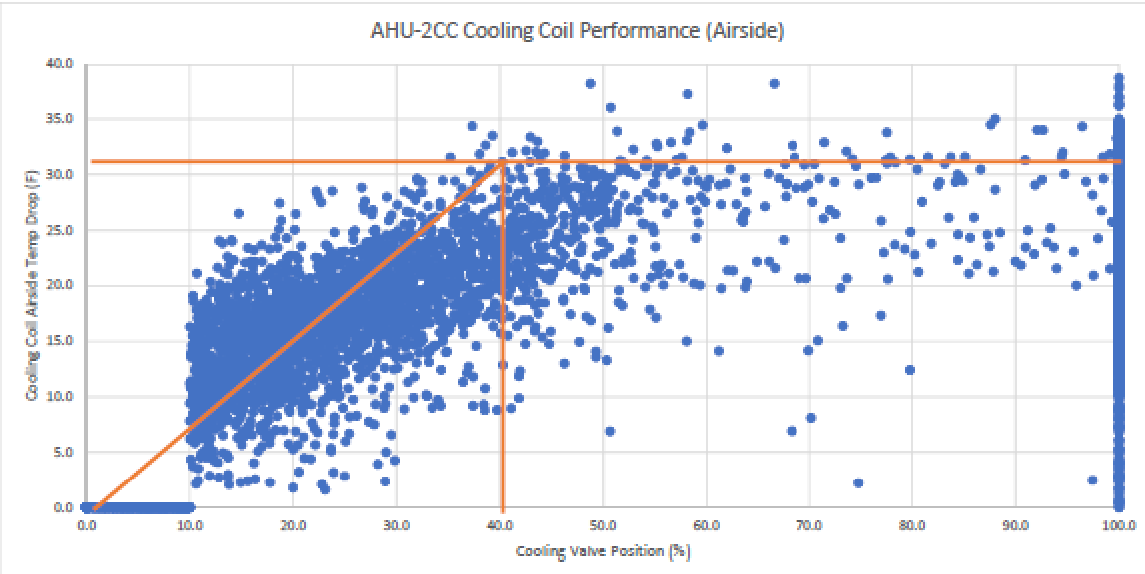
Energy Conservation Opportunity #7 identifies and quantifies wasted pumping energy by analyzing historical trend data for each air handling unit. By plotting cooling coil temperature drop versus cooling control valve position, the point at which each coil is effectively “maxed out” becomes visually obvious. The following plots indicate where the cooling coils max out cooling performance and provide an estimate as to the potential top-end limits of the control valves.



DESIGN CONDITIONS	
CC EAT	81
CC LAT	48
CC DT	33
ECWT	39
LCWT	55
DT	16

OBSERVATIONS	
MIN % TO ACHIEVE DT	50%
RECOMMENDED LIMIT	60%

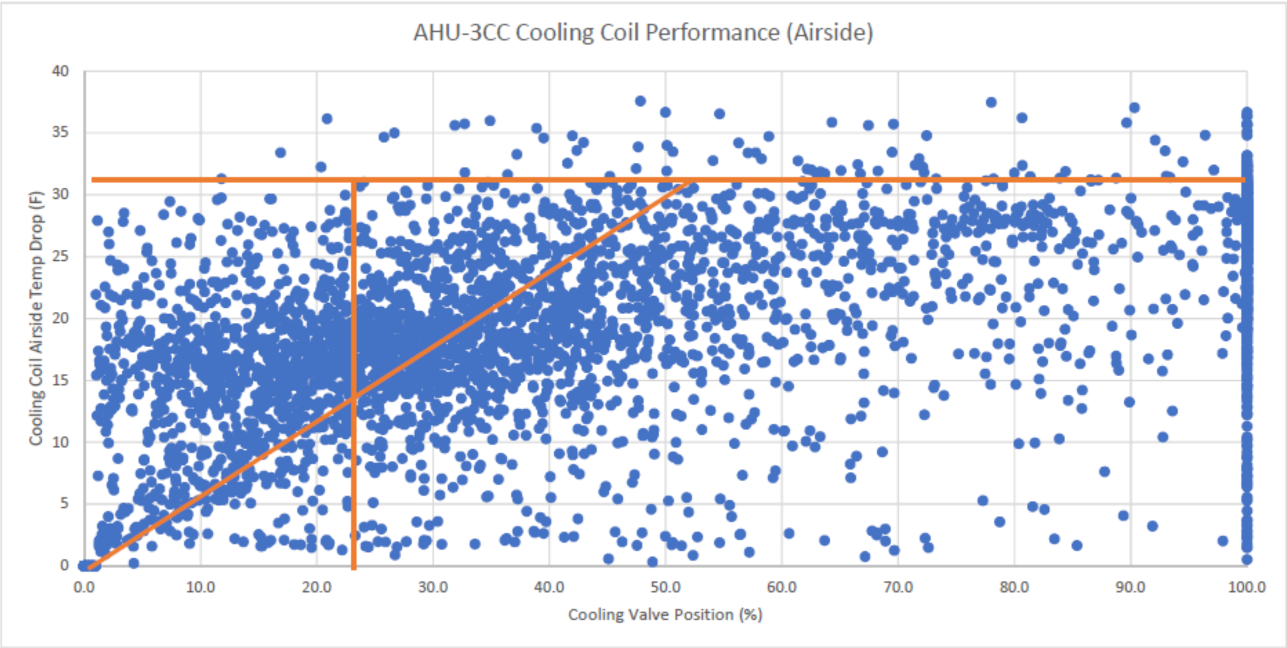
Figure 15: AHU-1CC Cooling Performance Profile



DESIGN CONDITIONS	
CC EAT	79
CC LAT	48
CC DT	31
ECWT	39
LCWT	55
DT	16

OBSERVATIONS	
MIN % TO ACHIEVE DT	40%
RECOMMENDED LIMIT	50%

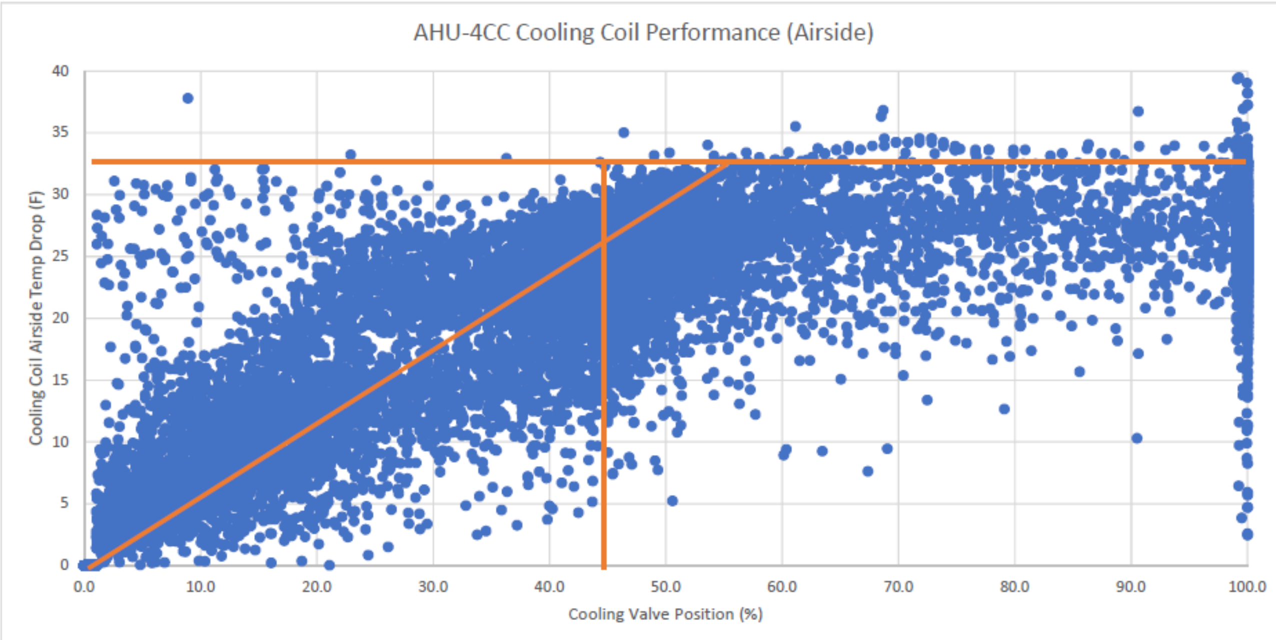
Figure 16: AHU-2CC Cooling Performance Profile



DESIGN CONDITIONS	
CC EAT	79
CC LAT	48
CC DT	31
ECWT	39
LCWT	55
DT	16

OBSERVATIONS	
MIN % TO ACHIEVE DT	25%
RECOMMENDED LIMIT	50%

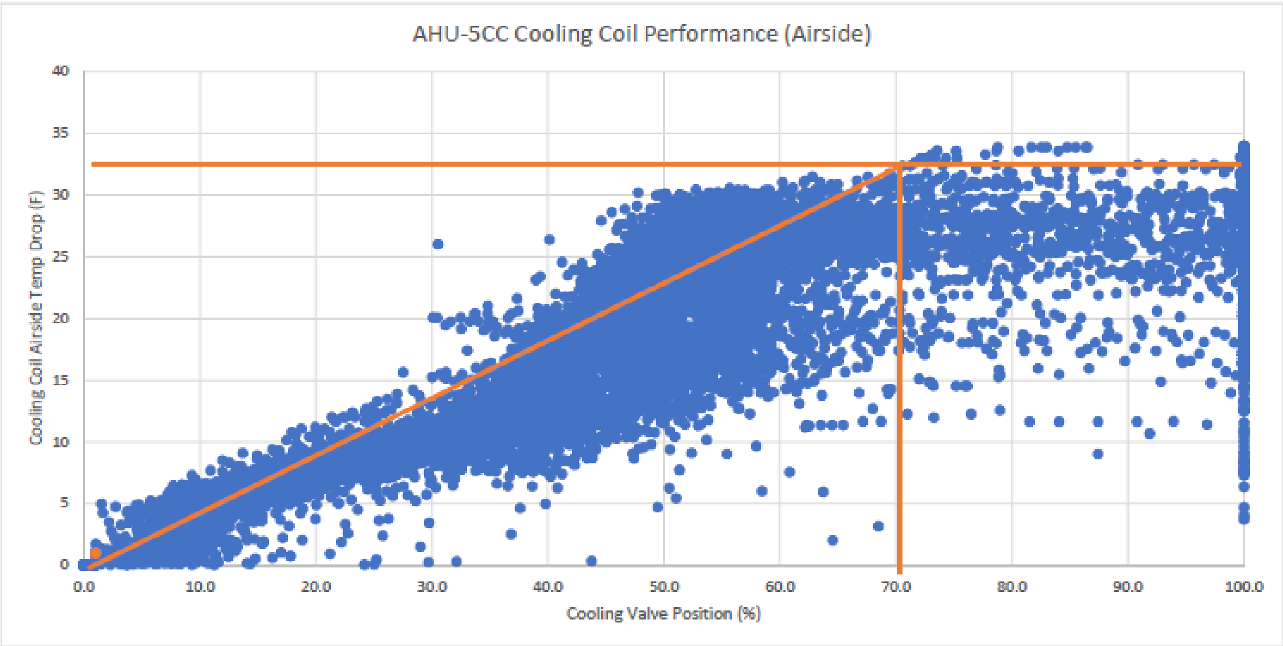
Figure 17: AHU-3CC Cooling Performance Profile



DESIGN CONDITIONS	
CC EAT	80.5
CC LAT	48
CC DT	32.5
ECWT	39
LCWT	55
DT	16

OBSERVATIONS	
MIN % TO ACHIEVE DT	45%
RECOMMENDED LIMIT	60%

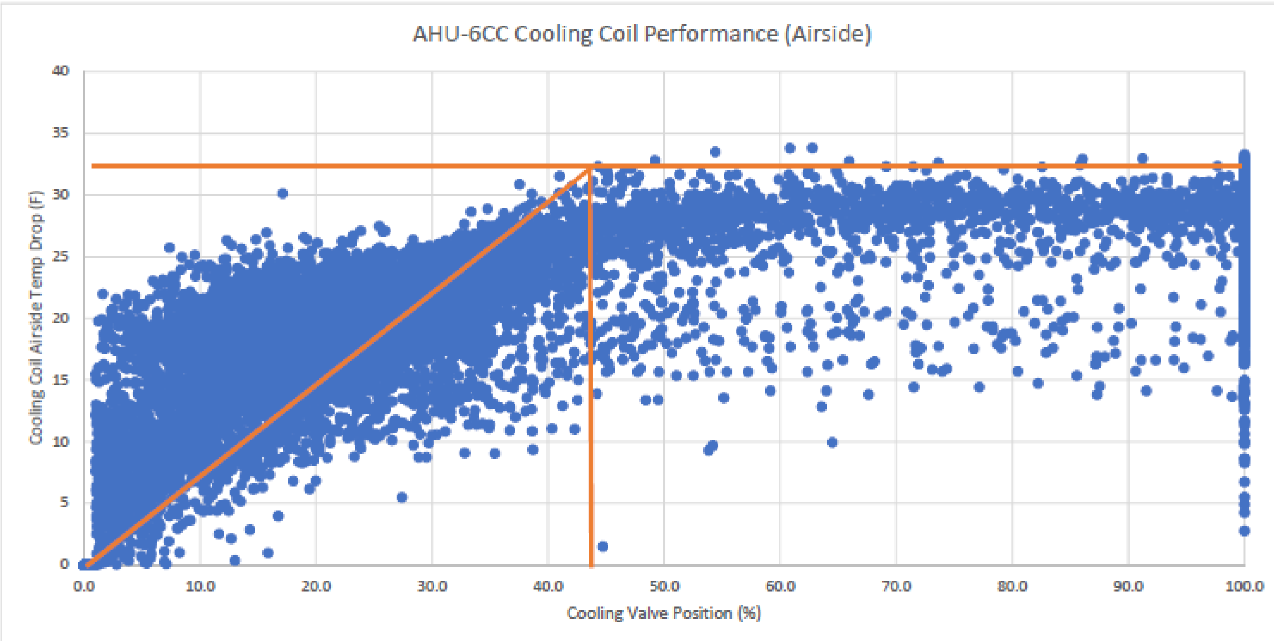
Figure 18: AHU-4CC Cooling Performance Profile



DESIGN CONDITIONS	
CC EAT	82.2
CC LAT	50
CC DT	32.2
ECWT	39
LCWT	55
DT	16

OBSERVATIONS	
MIN % TO ACHIEVE DT	70%
RECOMMENDED LIMIT	80%

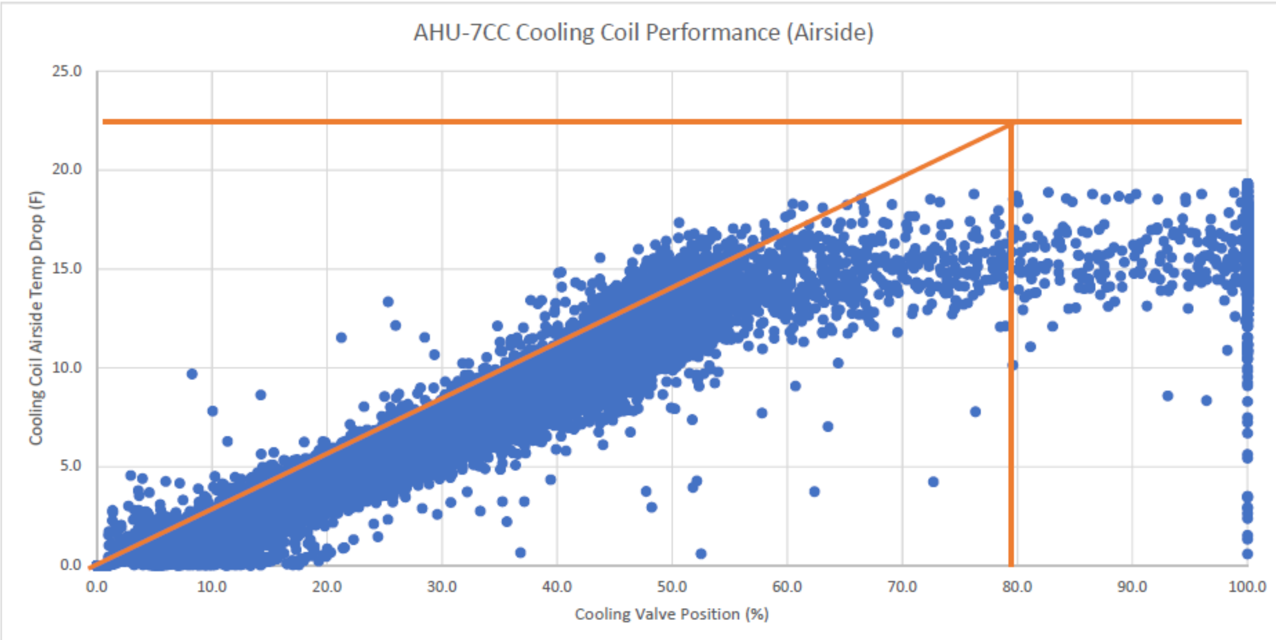
Figure 19: AHU-5CC Cooling Performance Profile



DESIGN CONDITIONS	
CC EAT	82.3
CC LAT	50
CC DT	32.3
ECWT	39
LCWT	55
DT	16

OBSERVATIONS	
MIN % TO ACHIEVE DT	45%
RECOMMENDED LIMIT	60%

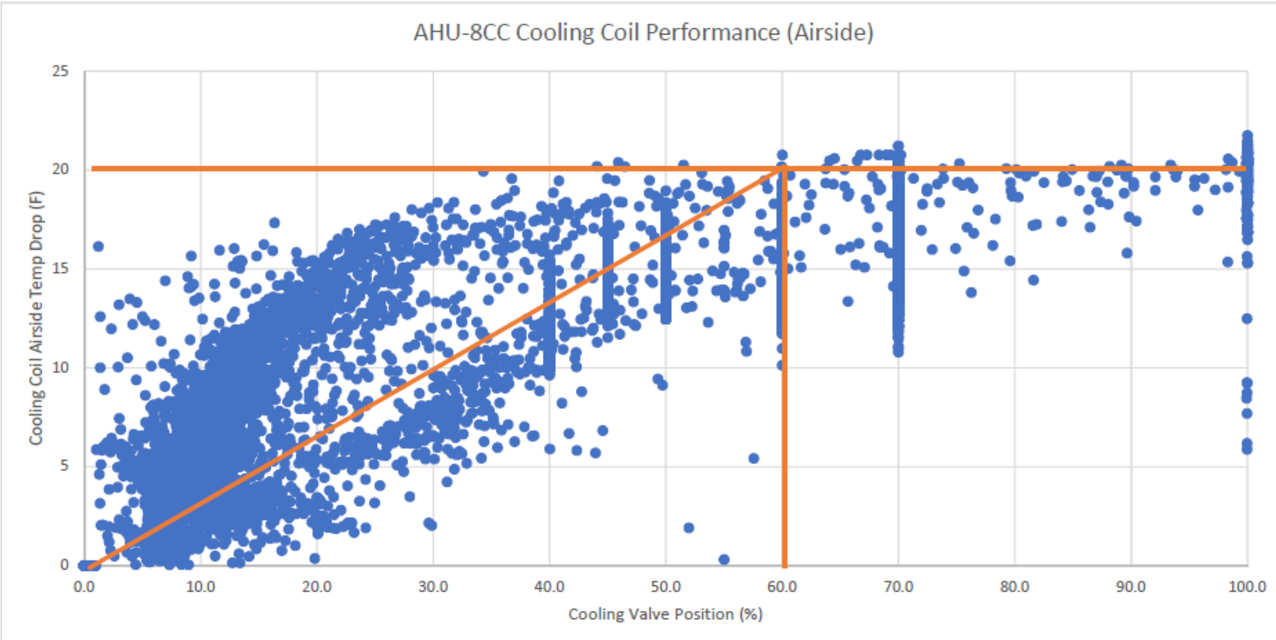
Figure 20: AHU-6CC Cooling Performance Profile



DESIGN CONDITIONS	
CC EAT	78
CC LAT	55
CC DT	23
ECWT	39
LCWT	55
DT	16

OBSERVATIONS	
MIN % TO ACHIEVE DT	NEVER
RECOMMENDED LIMIT	80%

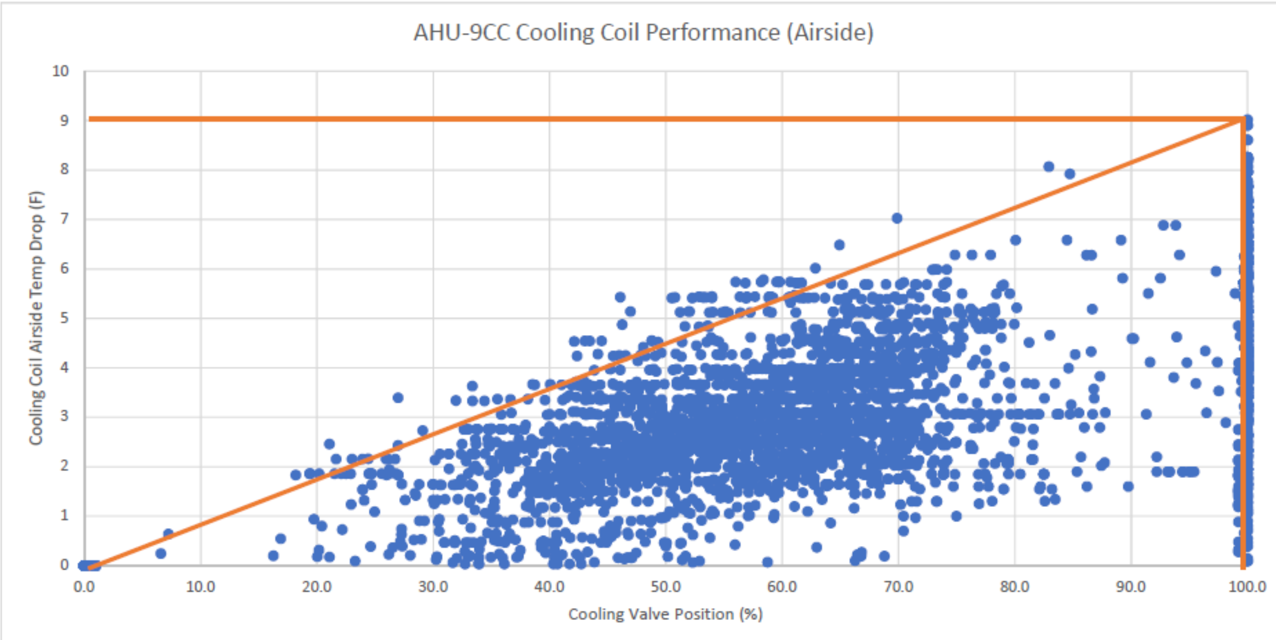
Figure 21: AHU-7CC Cooling Performance Profile



DESIGN CONDITIONS	
CC EAT	75
CC LAT	55
CC DT	20 ESTIMATED
ECWT	45
LCWT	55
DT	10 ESTIMATED

OBSERVATIONS	
MIN % TO ACHIEVE DT	60%
RECOMMENDED LIMIT	70%

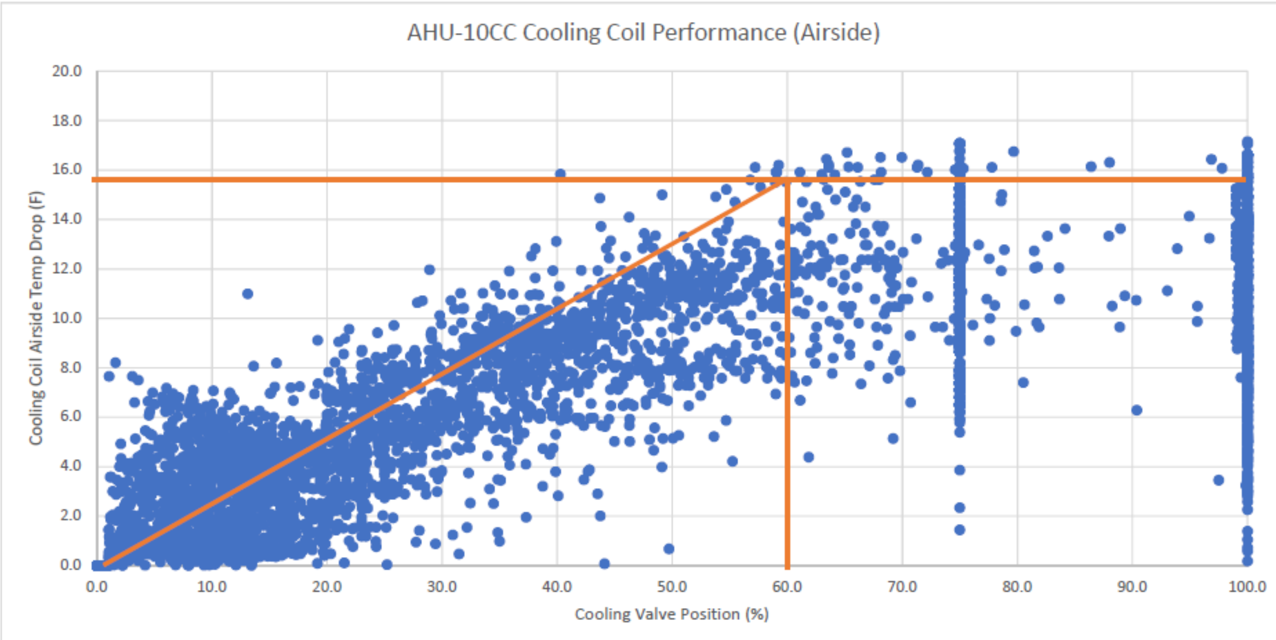
Figure 22: AHU-8CC Cooling Performance Profile



DESIGN CONDITIONS		
CC EAT	???	
CC LAT	???	
CC DT		9 AS RECORDED
ECWT	???	
LCWT	???	
DT	???	

OBSERVATIONS	
MIN % TO ACHIEVE DT	NEVER
RECOMMENDED LIMIT	100%

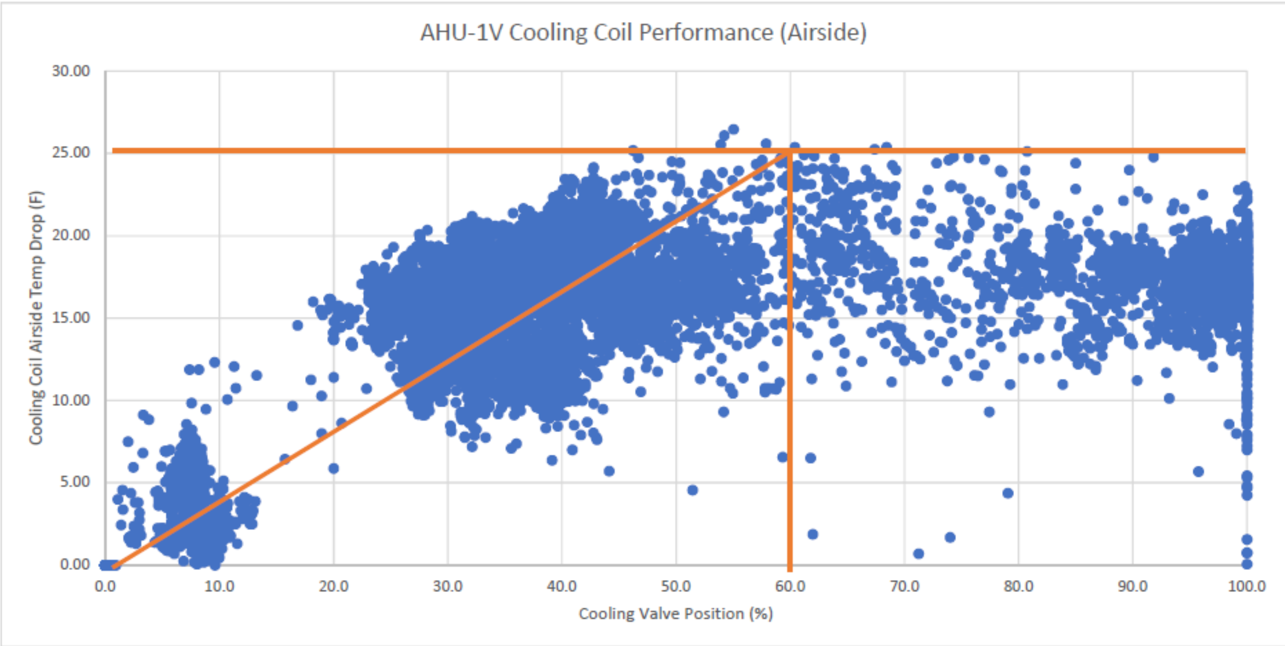
Figure 23: AHU-9CC Cooling Performance Profile



DESIGN CONDITIONS		
CC EAT	???	
CC LAT	???	
CC DT		16 AS RECORDED
ECWT	???	
LCWT	???	
DT	???	

OBSERVATIONS	
MIN % TO ACHIEVE DT	60%
RECOMMENDED LIMIT	100%

Figure 24: AHU-10CC Cooling Performance Profile



DESIGN CONDITIONS		
CC EAT	???	
CC LAT	???	
CC DT		25 AS RECORDED
ECWT	???	
LCWT	???	
DT	???	

OBSERVATIONS	
MIN % TO ACHIEVE DT	60%
RECOMMENDED LIMIT	70%

Figure 25: AHU-1V Cooling Performance Profile

Department of Administrative Services

Empowering People
Collaboration
Customer Service

Governor Kim Reynolds
Lt. Governor Adam Gregg

Adam Steen, Director

May 3, 2021

To: All Potential Respondents
From: Bobbi Pulley, Purchasing Agent
Re: RFP1821005278 – Retro-Commissioning Services

ADDENDUM ONE

Please amend the subject RFP to include the following schedule change:

RFP written questions, requests for clarification, and suggested changes from Respondents due	May 7, 2021/2:00pm

Please acknowledge receipt of this addendum by signing in the space provided below, and <u>return this letter with your offer (do not send back separately)</u>.

I hereby acknowledge receipt of this addendum.

Andrew Bennett

Signature

05/21/2021

Date

Andrew Bennett

Typed or Printed Name

Exhibit 18 – Signed Addendum 2

iowa Department of Administrative Services
Empowering People
Collaboration
Customer Service

Governor Kim Reynolds
Lt. Governor Adam Gregg
Adam Steen, Director

May 10, 2021

To: All Potential Respondents
From: Bobbi Pulley, Purchasing Agent
Re: RFP1821005278 – Retro-Commissioning Services

ADDENDUM TWO

Please amend the subject RFP to include answers to the following timely received questions:

Q1. Is there a list of buildings that the state has identified as requiring M&V services?
A1. The resulting contract will be available to all state agencies and political subdivisions. Use will be dependent upon need and budget.

Q2. Is there an expected total square footage per year?
A2. The resulting contract will be available to all state agencies and political subdivisions. Use will be dependent upon need and budget. When agencies and/or political subdivisions have a need for retro-commissioning services, they will contact one of the providers on the master agreement and request a quote based on services needed.

Q3. Is there an expected maximum contract value per year?
A3. The resulting contract will not have a minimum or maximum.

Q4. In section 3.3 Cost Proposal, the RFP states: "Cost Proposal shall include an all-inclusive, itemized, total cost in U.S. Dollars (for the proposed services)." Can you clarify what the expectations are for the cost proposal section? More information would be needed such as number of buildings, size of buildings, systems being retro-commissions and scope of retro-commissioning to provide an accurate total cost.
A4. Cost proposals must include the following:

- Provide hourly rates and descriptions for all staff grades.
- Equipment costs (specify equipment rental costs).
- Any other costs associated with proposed solution.
- Pricing for options.

Cost proposals do not need to include a total cost for a retro-commissioning project. The quote amount for any future retro-commissioning projects will be determined using rates provided in the proposal multiplied by the number of hours (and equipment and/or other costs) anticipated to be needed.

Q5. What is the anticipated schedule for retro-commissioning? Is there a target to retro-commission a certain number of buildings by a certain date?
A5. The resulting contract's use will be dependent upon participating agencies requests, needs, and budget.

Q6. Can you expand on the requirements of Exhibit 16 – Performance-Based Criteria or provide an example?
A6. Respondents should provide recommendations for standard measurement that can be used to monitor Contractor performance. At-risk amounts should be included.

Q7. Page 14, Section 3.2 Technical Proposal, Exhibit 16 – Performance-Based Criteria: Should the performance-based measures referenced in Exhibit 16 be applied to building performance or the performance of the Contractor during the course of delivery of contractual services?
A7. Performance-based measures should be applied to Contractor performance.

Q8. Section 3.2 Exhibit 13 – Will the State be willing to allow the RCx provider to implement an edge device to the building automation system to gather performance data for third party software cloud storage and analysis?
A8. Yes.

Q9. Will you accept Past Performance Questionnaires for the letters of reference requirement under Exhibit 5?
A9. No.

Q10. Do the requirements under Exhibit 16 indicate a preference for an ESCO company as the provider of retro-commissioning services?
A10. No.

Please acknowledge receipt of this addendum by signing in the space provided below, and <u>return this letter with your offer (do not send back separately)</u>.

I hereby acknowledge receipt of this addendum.

Andrew Bennett 05/21/2021

Signature Date

Andrew Bennett

Typed or Printed Name

Department of Administrative Services
Empowering People
Collaboration
Customer Service

Governor Kim Reynolds
Lt. Governor Adam Gregg
Adam Steen, Director

May 17, 2021

To: All Potential Respondents
From: Bobbi Pulley, Purchasing Agent
Re: RFP1821005278 – Retro-Commissioning Services

ADDENDUM THREE

Please amend the subject RFP to include answers to the following timely received questions:

Q1. Would a Qualified Commissioning Process Provider (QCxP) certification be acceptable for meeting section 4.2.1? https://epd.wisc.edu/certificates/qualified-commissioning-process-provider-certificate/

A1. No.

Please acknowledge receipt of this addendum by signing in the space provided below, and <u>return this letter with your offer (do not send back separately)</u>.

I hereby acknowledge receipt of this addendum.

Andrew Bennett — 05/21/2021

Signature — Date

Andrew Bennett

Typed or Printed Name

Department of Administrative Services
Empowering People
Collaboration
Customer Service

Governor Kim Reynolds
Lt. Governor Adam Gregg

Adam Steen, Director

May 21, 2021

To: All Potential Respondents
Re: RFP1821005278 – Retro-Commissioning Services

ADDENDUM 4

1. Further breakdown of the evaluation criteria and points for this RFP include:

Technical Scored Points	700
Cost Points	300
TOTAL POINTS AVAILABLE	**1,000**

2. The minimum technical score required is 400 points.

Technical Criteria	RFP Section	Possible Points
Background and Experience	Exhibits 4 &5	*150*
Retro-Commissioning Approach and Methods	Exhibit 12	*150*
Existing Systems Investigation and Plan	Exhibit 13	*150*
Retro-Commissioning Report	Exhibit 14	*150*
Customer Service	Exhibit 15	*100*
Total Possible Technical Scored Points		**700**

Hoover State Office Building 1305 East Walnut Street Des Moines, IA 50319 (515) 281-5360 http://das.iowa.gov

Part 1 – No Confidential Information Provided

Confidential Treatment Is Not Requested
Respondent acknowledges that proposal response contains no confidential, secret, privileged, or proprietary information. There is no request for confidential treatment of information contained in this proposal response.

This Form must be signed by the individual who signed the Respondent's Proposal. The Respondent shall place this Form completed and signed in its Proposal.

- ***Fill in and sign the following if you have provided no confidential information. If signing this Part 1, do not complete Part 2.***

SystemWorks, LLC	1821005278	Retro-Commissioning Services
Company	RFP Number	RFP Title
Andrew Bennett	Principal	05/21/2021
Signature (required)	Title	Date

(Proceed to the next page only if Confidential Treatment is requested.)