CHAPTER/REGIONAL TECHNOLOGY AWARD - SHORT FORM

1. Category - Check one and indicate New, Existing, or Existing Building Commissioning (EBCx)

☐ Commercial Buildings	☐ New	☐ Existing or	☐ EBCx	
Institutional Buildings:				
☒ Educational Facilities	☐ New	☐ Existing or	☒ EBCx	
☐ Other Institutional	☐ New	☐ Existing or	☐ EBCx	
☐ Health Care Facilities	☐ New	☐ Existing or	☐ EBCx	
☐ Industrial Facilities or Processes	☐ New	☐ Existing or	☐ EBCx	
☐ Public Assembly	☐ New	☐ Existing or	☐ EBCx	
☐ Residential (Single and Multi-Family)				

2. Name of building or project: University of Chicago, Gordon Center for Integrative Science

City/State: Chicago, IL

3. Project Description: EBCx of a 427,000-square-foot laboratory building

Project Study/Design Period: 02/2018 (Begin date (mm/yyyy)) to 07/2020 (End date (mm/yyyy))

Percent Occupancy at time of submission: 100%

4. Entrant (ASHRAE member with significant role in project):

a. Name: Matsen (Last) Kurt (First) (Middle)

Membership Number: 8140356

Chapter: Illinois

Region: VI

b. Address (including country): Grumman/Butkus Associates, 820 Davis St., Suite 300

Evanston (City) IL (State) 60201 (Zip) USA (Country)

c. Telephone: (O) 847-328-3555 d. Email: kmatsen@grummanbutkus.com

e. Member's Role in Project: Project Manager

f. Member's Signature: Kurt Matsen Digitally signed by Kurt Matsen Date: 2020.09.17 14:09:54 -05'00'

5. Engineer of Record: Kurt Matsen

By affixing my signature above, I certify that the information contained in this application is accurate to the best of my knowledge. In addition, I certify that I have discussed this entry with the owner and have received permission from the owner to submit this project to the ASHRAE Technology Awards Competition.

UNIVERSITY OF CHICAGO (UC) — GORDON CENTER FOR INTEGRATIVE SCIENCE EBCx

Project Summary

Gordon Center for Integrative Science (GCIS) is a University of Chicago laboratory building that houses the biological and physical-sciences divisions, including the biochemistry and molecular biology and chemistry departments. The 427,000-gross-square foot facility was constructed in 2005. The building has eight floors: six above grade, a basement, and a sub-basement. It is generally occupied from 7 a.m. to 6 p.m., but researchers have 24/7 access and often work during off hours.

On the floors above grade, the east half of the building has high fume hood density, and laboratory airflow is driven by fume hood operation. The west half of the building has a lower fume hood density, and the airflow is driven by minimum air change rates. The basement and sub-basement are occupied by temperature/humidity critical spaces including laser labs and a vivarium. The building is served by eight main air-handling units (AHUs). All of these units are variable air volume (VAV) systems with 100% outside air. The AHUs utilize heat recovery from the general and lab exhaust.

Building heating systems include four heating hot water loops, heated by steam generated at a central plant; AHU heat recovery/preheat loop; building radiant hot water; building reheat hot water; and vivarium reheat hot water. Chilled water (CHW) required by the building is provided by four centrifugal chillers and two low-temperature chillers. This main chilled water loop serves the air-handling units, process chilled water, and instrument chilled water loops. The process chilled water loop provides condenser water for the low-temperature chillers.

Steam accounts for the majority of the energy use (59% at the time of assessment). At project initiation, building energy use intensity (EUI) was 456 kBtu/ft²/yr—significantly higher than the International Institute of Sustainable Labs' benchmark figure of 385 kBtu/ft²/yr for similar buildings.

As part of a large-scale facilities effort for the client (dubbed the Preventive Maintenance and Commissioning Process, or PM+Cx), the submitting engineer performed EBCx on this complex facility. The scope included an assessment phase, an investigation phase, and an implementation phase. The engineer developed two sets of measures: four Facility Improvement Measures (FIMs) to address issues with building systems, and 16 Energy Conservation Measures (ECMs) to address the university's focus on energy conservation, cost management, and environmental stewardship (see the Exhibit page).

Energy Efficiency

The engineer identified a total of 2,200,000 kWh in electricity savings and 35,000 Mlb in steam savings through 16 ECMs. The total estimated cost savings and project cost result in a bundled simple payback of 2.1 years (including utility incentives). Since implementing all these measures would have cost an estimated $1.3 million, some measures were selected for immediate implementation and others were selected for future implementation requiring additional budget.

Most of the steam savings stemmed from AHU heat recovery optimization. The baseline heat recovery system was only effective when the outside air temperature was less than 20°F due to various issues. This included bypass valve that was failed open, temperature control sequence, and the differential pressure sensor location. The revisions allow the system to operate with minimal steam input when the outside air temperature is greater than 30°F, which represents about 2,200 hours/year typically. Most of the electricity savings were the result of building-wide airflow reductions—especially from reducing minimum airflow rates for offices and conference rooms.

At the time of the award submission, the client is still implementing ECMs but has already realized a 21% reduction in last 12-month EUI, only seven months after implementation. An additional 9% of savings is anticipated upon implementation of all measures, decreasing annual energy usage by a total of about 30%. The anticipated final EUI after the project is complete will be 336 kBtu/ft².

Indoor Air Quality (IAQ)

The building was previously significantly over-ventilated. The project suggested and implemented demand-based ventilation strategies to reduce ventilation rates during periods of reduced occupancy.

Innovation

In addition to typical existing building commissioning investigation strategies, a monitoring-based commissioning application was implemented. This allowed for repetitive data review and continuous monitoring, quickly pulling data from 450 terminal units and 250 fume hoods.

Operations & Maintenance (O&M)

Several FIMs addressed O&M issues, including several VAV box controllers that were no longer operating properly. An ECM recommends removing redundant air-handling unit pre-filters, which will reduce fan energy and reduce filter replacement costs. By optimizing the heat recovery operation, the building steam demand was reduced significantly, which will reduce maintenance for associated boilers, condensate pumps, and heat exchangers. In addition to identifying issues, another deliverable of the project was a systems manual explaining controls sequences and design intent for major HVAC systems.

Cost Effectiveness

The bundled payback of the project is 2.1 years including a potential incentive from the natural gas utility. The simple payback of the measures already implemented is only four months. No-cost and low-cost measures included:

- Revise glycol water loop control: Changes include modifying the control sequence, modifying the DP sensor configuration, and correcting the frost bypass valve operation.
- Reduce fume hood face velocity: Reduce face velocity required from 100 fpm to 80 fpm.
- Improve occupant fume hood sash closure: A monitoring-based commissioning platform was implemented to regularly identify the fume hoods that are left open.
- Reduce airflow in labs to maintain 8 ACH: The design intent was to operate the labs at eight air changes per hour (ACH). The supply airflow setpoints achieve 8 ACH, but the exhaust airflow actually exceeded 8 ACH.
- Reduce VAV minimum airflow: Reduce the minimum airflow for the VAV boxes that serve offices and lab support spaces to reduce the amount of reheat energy used during unoccupied periods. Rooms identified by high reheat usage.
- Reduce CHW secondary DP minimum setpoint for reset sequence.
- Reduce condenser water delta T on low-temperature chillers.
- Remove redundant AHU pre-filters.
- Resolve individual zone issues: Several issues were identified with individual zones, including failed reheat valves, failed fume hood zone presence sensor, and failed VAV controllers.
- Chiller mech room AHU cooling: Install chilled water valves on AC-11 and AC-12 to control chilled water flow.

ECMs requiring capital planning included demand control ventilation for laboratories and cooling coil condensate collection.

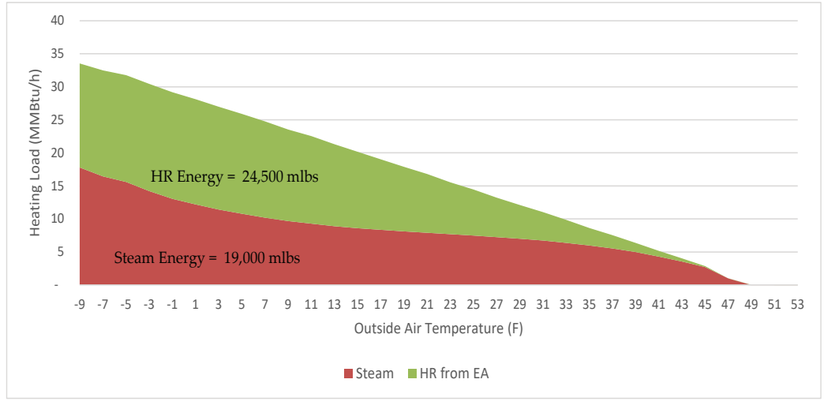
Environmental Impact

Reducing a building's energy consumption by 30% will clearly have a beneficial environmental impact and is expected to reduce greenhouse gas emissions by 3,500 equivalent metric tons of CO_2. In addition to the energy savings, air handling unit cooling coil condensation recovery was implemented to reduce makeup water required for the cooling towers.

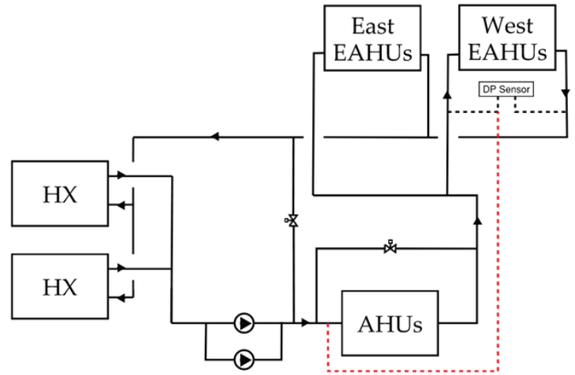
Table 1: Energy Conservation Measures

ECM	Description	Electric Savings (kWh)	Steam Savings (Mlb)	Equivalent CO_2 Reduction (tons)	Simple Payback (yrs)*
1.1	Revise Glycol Water Loop Control	71,000	16,000	1,036.3	0.2
1.2	Reduce Fume Hood Face Velocity to 80 fpm	17,000	100	18.1	2.5
1.3	Improve Occupant Fume Hood Sash Closure	304,000	2,500	367.8	0.0
1.4	Reduce Airflow in Labs to Maintain 8 ACH	87,000	600	98.2	0.2
1.5	Reduce VAV Minimum Airflow	364,000	2,800	428.5	0.1
1.6	Night Zone Volume Setback	2,000	30	3.3	0.4
1.7	Chilled Water Plant Optimization	73,000	0	51.3	0.1
1.8	Increase Low Temp Chiller Condenser Flow	44,000	0	30.9	6.1
1.9	AHU-5 Minimum CHW Valve Command	38,000	0	26.7	0.1
1.10	Revise AHU Filter Strategy	169,000	0	118.8	1.4
1.11	Resolve Individual Zone Issues	67,000	800	96.4	1.0
1.12	Chiller Mech Room AHU Cooling	22,000	0	15.5	6.6
2.1	Winter CHW Heat Recovery with Heat Exchanger	78,000	7,800	535.7	4.6
2.2	Demand Control Ventilation for Labs	591,000	5,200	736.1	4.1
2.3	Cooling Coil Condensate Recovery	(1,200)	0		4.9
2.4	Add VFD to Chiller	269,000	0	189.1	6.8
Total	**Implemented Measures**	**768,000**	**20,230**	**1,787**	**0.3**
Total	**All Measures**	**2,194,800**	**35,830**	**3,753**	**2.1**
	Total MMBtu	**2,620**	**20,230**		

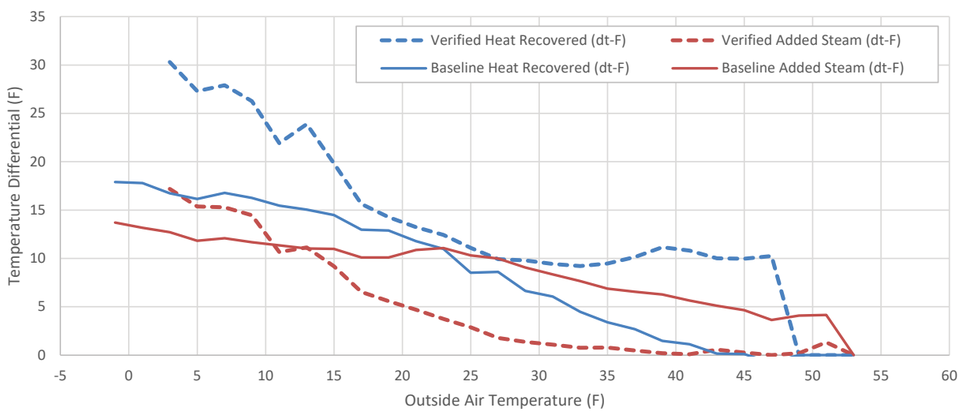
*Simple Payback includes potential utility incentives. Gray rows denote measures that have been implemented and verified.



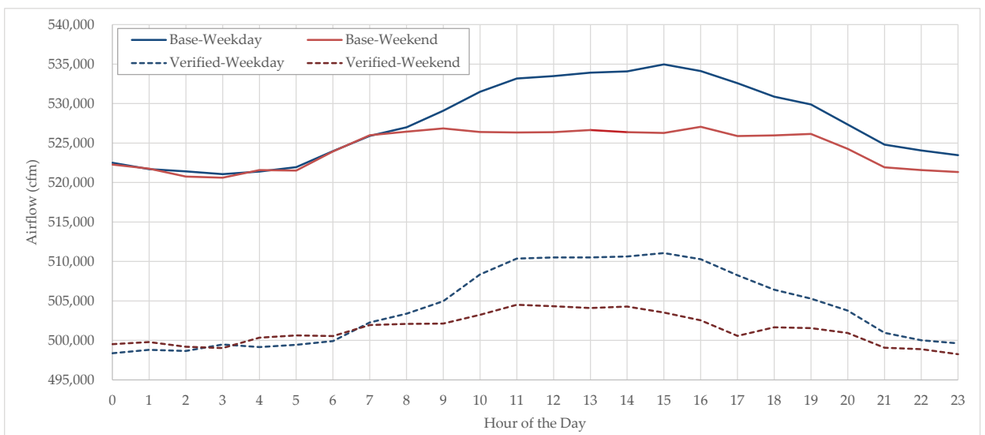
Baseline heat recovery energy and steam energy (top) vs. post-project metrics (above).



Building heat recovery loop schematic.



Verified heat recovery and verified steam use (dashed lines) show considerably better performance than baseline (solid lines).



At baseline, the building was considerably over-ventilated. After EBCx, ventilation levels were more reflective of actual conditions and safety needs.