IMEG

CASE STUDY:
IOWA STATE UNIVERSITY MARSTON HALL
A concept-to-consumption approach to design

When Iowa State University undertook a comprehensive renovation of historic Marston Hall, it enlisted the project's MEPT engineer, IMEG Corp., to provide concept-to-consumption oversight to safeguard the building's improved energy performance.

Measurement and verification of the building's actual energy performance was a key objective for the 60,000-sf building, home of the College of Engineering – first opened in 1903 and one of the oldest structures on campus. Over the years Marston Hall had been modified piecemeal, resulting in a labrynth of small, mostly administrative spaces replacing the original classroom learning areas and laboratories. By the 21st century, sections of the building were not being used, many other sections were underused, and the outdated infrastructure was extremely inefficient and costly to operate.

The extensive renovation project would require the entire existing MEP infrastructure to be removed and replaced with new, highly efficient, state-of-the-art systems.

Throughout the project, IMEG served as the owner's consistent partner to keep the energy performance goal in focus, eliminating "cold hand-offs" between energy modelers, designers, builders, commissioning staff, ISU facilities staff, and occupants. This role ensured that the energy goal for the project was never simply theoretical or forgotten. All team members understood and worked collaboratively toward achieving the energy goal and eagerly awaited the first real world data to see how well they had done.

Key concept-to-consumption actions occurred along the entire project timeline:

CONCEPT ANALYSIS AND GOAL SETTING

Early discussions with Iowa State and design team stakeholders defined key project requirements for the building. This information identified the target energy goal and informed eventual system selections. The renovated building would need to:

- Achieve LEED Gold Certification and ISU's energy efficiency goal of 33.5% cost savings over code allowable (ASHRAE 90.1)
- Achieve the modeled site EUI goal of 53 kBtu/sf/year
- Be historically intact (i.e., all systems had to fit within the physical limitations of the building)
- Provide room-by-room zoning for temperature control

Guided by these parameters, IMEG provided early concept design and analysis – including early energy conceptual modeling – for the building renovation. This analysis, along with benchmarking against current Marston Hall performance and performance of similar buildings, identified potential MEP system and architectural improvements that could meet the 33.5% energy cost savings goal.

DESIGN

During this phase, IMEG refined the systems design and assumptions for the building's use (including programming, occupancy, and operating schedule) that would impact energy consumption.

Multiple mechanical system configurations – along with architectural strategies – were proposed and evaluated for different space types to determine the best combination of infrastructure and envelope to meet or exceed the energy savings goal. Since the building is served by campus steam and chilled water, opportunities were not available to improve upon the production of heating and cooling

efficiency within the building. Nor were opportunities available for on-site renewable energy.
After analysis of all identified solutions, the following key design strategies were adopted:

- Ventilation load was minimized by using a dedicated outside air system (DOAS). With the amount of ventilation air minimized, the peak heating and cooling loads associated with the ventilation air were then further reduced by energy recovery wheels in the DOAS air handling unit, as well as by fan-powered VAV boxes for meeting the chilled beam's minimum activation air.
- Ventilation air reheat and dehumidification was accommodated by using a passive desiccant dehumidification and reheat wheel in the DOAS unit. No steam energy is used for reheating ventilation air.
- Hydronic heating and cooling via active chilled beams and perimeter convectors were employed throughout most of the building to minimize air-based heating and cooling.
- Envelope loads were minimized by adding insulation to the exterior walls, along with a vapor barrier.
- Underfloor air distribution for cooling and ventilation was employed in the auditorium space, which has higher ceilings than practical for using chilled beams.
- Carbon dioxide sensing was employed to control the ventilation air supply to the auditorium.
- Lighting power density in the building was designed to be 27% less than code allowable.

LEED energy modeling analysis showed the designed building and systems would have an EUI of approximately 53 kBtu/SF/year – a 33.5% energy cost reduction over the code allowable 86 kBtu/sf/year. This equated to $38,850/year less energy cost than what the new code minimum would allow. At this point the team knew the target and finalized the measurement and verification plan. All that was left was to get it built, operate it for a few years, and see how it performed.

COMMISSIONING

IMEG supported the third-party commissioning provider as they conducted the typical commissioning activities during design, construction, testing and occupancy, and operation and warranty. The commissioning process was critical throughout the project, and especially during functional testing, to ensure the design concepts and sequences were put in place as intended. As is necessary for most concept-to-consumption projects, the Marston Hall renovation included measurement and verification (M&V) systems and submeters in addition to the main utility meters in the project design. The functionality of these devices was included in the commissioning work as the data they provide would be critical to knowing the project outcome.

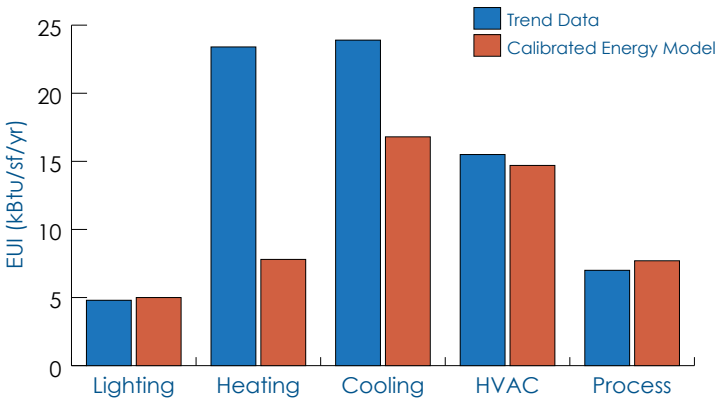
CONSUMPTION ANALYSIS AND OPTIMIZATION

As part of the LEED process, and as a key step in a true concept-to-consumption approach, IMEG authored a measurement and verification (M&V) plan to outline how actual energy use data would be gathered and analyzed once the building was occupied.

Consumption analysis using the first year of operations data showed that the building used approximately 75 kBtu/sf/year – higher than the modeled EUI of 53 kBtu/sf/year but still a 49 percent improvement over the building's pre-renovation three-year average EUI of 146 kBtu/sf/year.

With the first-year data not showing the results the team anticipated from the energy modeling, IMEG and Iowa State conducted further M&V analysis. The original LEED energy model was calibrated for actual weather data and changes in building occupancy schedule. The actual end use energy for chilled water, steam, lighting power, HVAC power, and plug load power was compared to the calculated values in the calibrated energy model (see chart at top right). This comparison revealed that a steam pre-heat coil control valve had (at some unknown time after construction and commissioning) been commanded open 100 percent at all times, inflating both chilled water and steam energy use unnecessarily. The university used this finding to correct the control valve operation.

End Use Energy vs. Calibrated Energy Model



Based on the M&V findings, the correction of the steam valve operation avoids about $24,000 ($.40/sf) annually in unnecessary energy use – which would have gone unnoticed had the project not placed a priority on high performance from concept to consumption. The building is also used much more than had originally been modeled, with significantly more hours of occupancy. Taking this into account, the most recent energy use data is within about 10 percent of what the calibrated energy model indicates.

The university continues to monitor Marston Hall's energy use to ensure optimal performance, and to identify and correct any future problems.

ADDITIONAL READING

Concept to Consumption: An executive guide to outcome-based oversight

Chilled beam design brings energy efficiency to century-old engineering hall