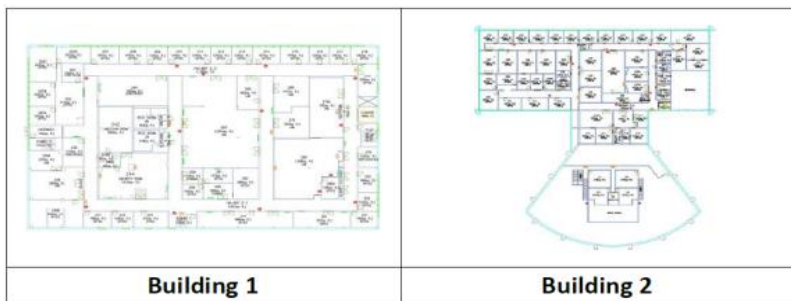


Post Occupancy Evaluation and Measurement (POE+M)

The next time your boss tells you your productivity is down, tell her it's because you're too uncomfortable in your workspace. Moreover, improving comfort can save energy. The Center for Building Performance and Diagnostics (CBPD) at Carnegie Mellon, a CBEI partner, uses Post Occupancy Evaluation and Measurement (POE+M) to identify the good and bad of today's workspaces and develops recommendations for upgrades that will make a difference for energy, human health and productivity.

At Fort Belvoir in Virginia, for example, three buildings were studied in a three-pronged approach: expert observations of the quality of building systems in place (HVAC, windows, lighting, etc.); user comfort and satisfaction through surveys; and 3) physical measurements of thermal, air, light, and acoustic quality of the indoor environment using the National Environmental Assessment Toolkit (NEAT) they developed for the General Services Administration over a decade.



The three buildings are very different in type of construction, layout, age and system configuration (see above). All three buildings have office and laboratory spaces in addition to some unique spaces including a Clean Room in Building 1, a large special assembly space in Building 2, and a shooting range in Building 3.

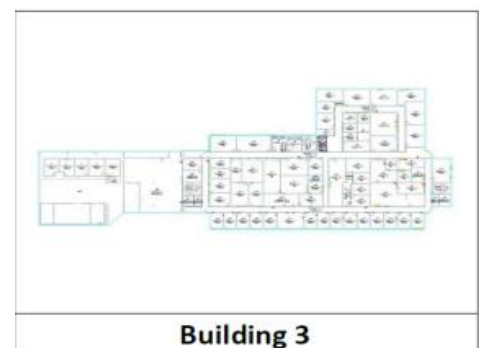
The HVAC and lighting analysis, on the following pages, is excerpted from a final report linking occupant acceptability with physical building performance measurements to deliver valuable insight into potential energy and performance improvements.

Research Finding: Post Occupancy Evaluation and Measurement

A holistic POE includes collection of field data on Indoor Environmental Quality (IEQ), user satisfaction assessment and recording the technical attributes of the building system. The traditional POE methodology is tedious and cumbersome. Simplifying IEQ measurement tools will help POE assessments become a key step in the commissioning of existing buildings. POE+M can deliver a sensible return on investment when properly done.

The Consortium for Building Energy Innovation

CBEI is focused on generating impact in the small- and medium-sized commercial buildings (SMSCB) retrofit market. CBEI is comprised of 14 organizations including major research universities, global industrial firms, and national laboratories from across the United States who collaborate to develop and demonstrate solutions for 50% energy reduction in existing buildings by 2030. The CBEI FINDINGS series highlights important and actionable technical, application, operation and policy research results that will accelerate energy efficiency retrofits when applied by various market participants. CBEI views these FINDINGS as a portal for stakeholders to access resources and expertise to implement change.

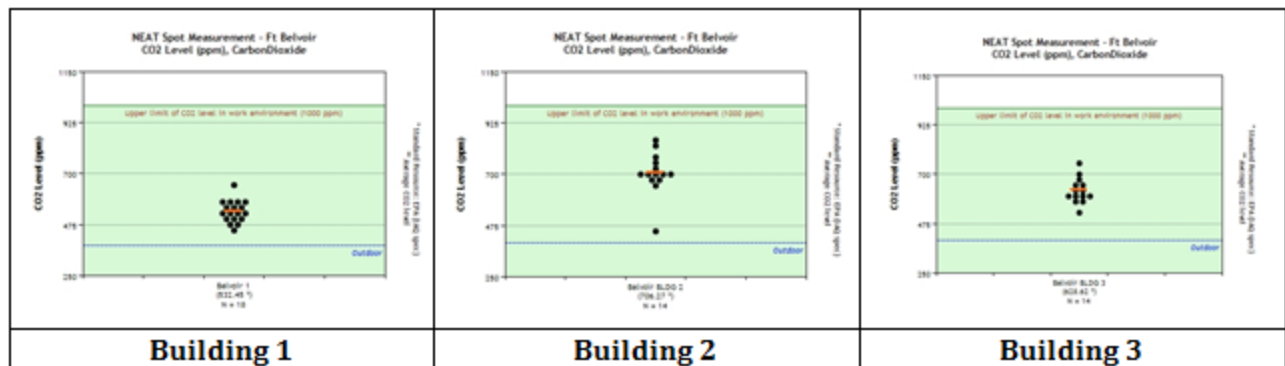


Survey Results

On a series of cold winter days, the field team measured, surveyed and recorded the relative quality of workspaces and mechanical, lighting and space defining systems. User comfort and satisfaction surveys quickly revealed that occupants in Building 2 were really cold, and field measurements revealed that this was due poor quality window frames and inadequate mechanical system zoning with hidden controls. The consequences are time wasted in coping and strip heaters everywhere, at significant energy expense. But don't take them away unless the problems are fixed.



Measurements in the three buildings also revealed that Building 2 had poorer ventilation effectiveness, with CO₂ levels averaging 700 ppm rather than the 500 found in the other buildings. While these levels are not alarming, this was a particularly cold day with leaky facades, and it is very possible that CO₂ levels during the swing seasons could exceed the 1,000 ppm standard that is desired.

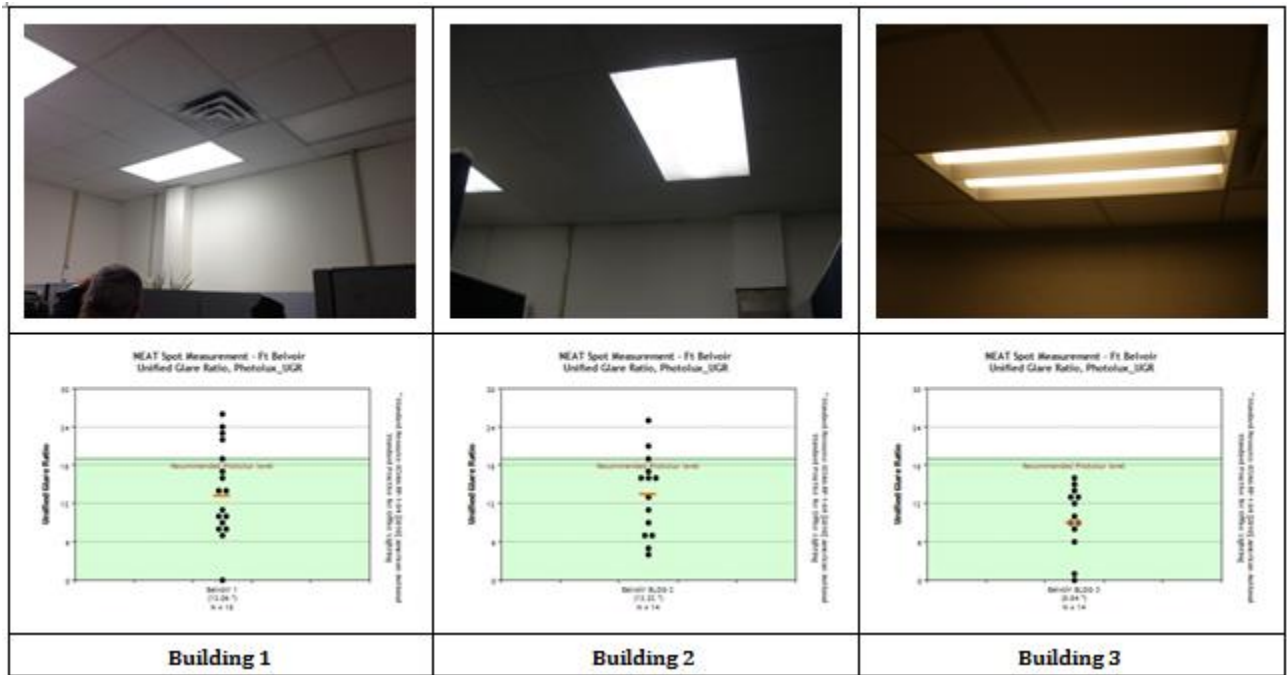


This is how POE sets retrofit priorities for the facility manager faced with multiple buildings to update. For building 2, POE yielded several recommendations for updating the HVAC system:

- Correct inadequacies in the central system and the zone controls to ensure that all spaces can meet code requirements for thermal comfort.
- Consider constant volume ventilation with large volume low velocity delivery and terminal reheat/recool with individual room controls.
- Upgrade the windows and window frames to adequately provide thermal comfort in a building without perimeter heating or cooling (minimum R4 for the assembly). Ensure the windows are operable, using a smart thermostat to shut off air supply and reheat.
- Introduce revolving doors for more effective airlocks, or explore air curtains for existing doors.
- Purchase the most energy efficient personal heaters and fans that are effective at providing localized, occupant comfort.

Lighting upgrades save energy and improve occupant environments

Lighting, daylighting and visual quality are also carefully studied in a POE, with physical measurements, user satisfaction surveys and expert walkthroughs. In lighting, Building 1 was most in need of investment, especially for interior shared offices with antiquated ambient and task lights, and no daylight. The recessed light fixtures typical in Buildings 1 and 2 have stippled plastic lenses which create a direct and reflected glare for computer based work, as shown in the uniform glare graphs of measured brightness contrasts. With over 2 watts/square foot of connected lighting, investment in better lights will save 50-75% of the lighting energy used and improve conditions for productivity.



POE helps to prioritize lighting investments for both energy and productivity.

- Reduce lighting power density to less than 1 watt/ft² with fewer fixtures, individually addressable, high-CRI LED lamp sources for energy and improved satisfaction. Select ambient lighting with both up and down distribution. At an existing demand of 2 watts/ ft² or more in all three buildings, the payback for this retrofit with energy alone should be less than 5 years based on the garrison’s 9.3¢/kWh.
- Where needed, purchase articulated arm 4-6W LED task lights (relocatable by the user) and eliminate under-bin lights. NEAT measurements reveal as many as 50% of workstations do not have adequate lighting for paper-based work.
- Train users to set venetian blinds in horizontal position in winter and 45° angle in summer to reduce direct glare east and west and seasonally manage heat gain. When blind replacement is necessary, move to inverted blinds that will move daylight to the ceiling and reduce glare. Do not switch to roller shades that reduce daylight, view and winter solar heat gain.
- In Building 1, the 48% who are not satisfied to view of the outside when seated could be significantly addressed by adding windows in the blank west wall of the building for additional offices instead of turning core lab spaces into offices.

Lessons Learned

We still think of buildings as investments in things: real estate, land, technology. Yet, we build to provide an environment for people to work, live, learn, play and recover from illness.

Investing in people requires a dual approach of reducing risks and promoting positive experience. At the present time, building practices and standards focus on avoiding health and safety risk, such as illnesses and absenteeism associated with poor indoor air quality.

The concept of POE originated as one-off case study evaluation during its introduction in the 1960's, later, evolving into a cross-sectional evaluation in the 1970's.

User satisfaction with the building can give detailed information about the characteristics of the building, which architects, engineers and facilities management could miss. The slow speed at which this information reaches the right people at present is shocking. To understand how best to capture this information around the country and apply it is the role that POE plays.

POE commences with one fundamental question, how does one introduce the much-needed development and upgrade of buildings successfully?

CBEI has also found that IEQ is undervalued by the market when energy decisions are made. This is because human productivity valuation with respect to human comfort is not currently a financial factor in decision-making.

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CBEI is a research and demonstration center that works in close partnership with DOE's Building Technologies Office.

Moving Forward

There are many stakeholders that need to be educated about the benefits POE+M. These practices are not widely adopted within the SMSCB retrofit market.

The fundamental barrier to market adoption of POE+M is the cost of performing the occupant survey combined with the required instrument package is too high given the perceived benefits. CBEI is attacking this value proposition from both the cost and benefit side.

The target market for POE+M is energy auditing. The key cost element is the measurement of physical IEQ parameters. Current IEQ parameters are measured using laptop sensors that custom systems. CBEI is investigating smartphone /tablet-like Apps for direct measurement and/or wireless measurement to reduce the setup cost for energy auditors. This low cost approach would add value to energy audit at a low cost.



The second part of the value proposition focuses on the benefits of POE+M. The principle problem is that the energy benefits alone realized by performing POE+M do not justify the added cost. One needs to factor in improved occupant comfort and somehow translate this into a monetary benefit through reduced absenteeism and/or increased productivity. This is not a new problem, CBEI researchers are working with the large body of literature and studies focusing on the [IEQ/productivity](#) nexus.

CBEI intends to compile the IEQ/productivity data and create a compelling case to be presented to key stakeholders including: energy auditors, energy service companies, utilities, municipalities and other policymakers. CBEI plans to demonstrate cost reduced approaches and enhanced value propositions in future research.

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