# AN ANALYSIS OF LEED AND BREEAM ASSESSMENT METHODS FOR EDUCATIONAL INSTITUTIONS

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## ABSTRACT

*This study examines the differences between two environmental assessment methods for the K-12 education sector: the United States Green Building Council's (USGBC) LEED Schools Version 3.0 and the British Research Establishment's (BRE) BREEAM Education issue 2.0. Credit requirements are compared side-by-side and against recommendations from researchers in areas such as acoustics, lighting and indoor environment quality. Strengths in the two schemes and areas for improvement are highlighted, with acknowledgement that each scheme offers components and techniques from which the other could benefit.*

## KEY WORDS

LEED, BREEAM, Environmental Assessment Methods, High Performance Schools

## INTRODUCTION

In the United States there are approximately 49 million students in the K-12 education system (US Dept. of Education 2006-07). A mid-1990's report by the United States General Accounting Office found 14 million students attend roughly 25,000 schools with substandard conditions (1995). Thus, improving the quality of schools has the ability to have a real and lasting impact on our communities.

In the last twenty years, methods of assessing green building design and sustainable living has received increased attention (NRC, 2007). Currently, there are seven states and seven counties or school districts that require LEED certification for new schools, and many more are considering joining suit (USGBC, 2009). The UK's Department for Children, Schools and Families has established mandatory sustainability targets with the intention that all new schools will be zero carbon by 2016 (minimum BREEAM '*Very Good*') (British Research Establishment (BRE) 2009).

The United Kingdom is credited with developing the first environmental assessment method in 1990, the British Research Establishment's Environmental Assessment Method (BREEAM) (Howard, 2005). This system was used by many countries, including the US in developing their assessment methods (Scheuer, 2002). BREEAM's latest version Issue 2.0 was introduced in summer 2008. In the United States the predominant environmental assessment method is the US Green Building Council's (USGBC) Leadership Energy and Environmental Design (LEED) system. LEED's latest version, v3.0 was released in May 2009.

Both BREEAM and LEED have specific schemes addressing school design, which prompt the questions: what are the similarities and differences in these two systems? And, what are the strengths and weaknesses in the two systems?

Several researchers have completed comparisons of environmental assessment methods, including LEED and BREEAM (Lee & Burnett, 2008;

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Haapio & Viitaniemi, 2008; Harputlugil & Hensen, 2006). BREEAM distributes such a comparison, published in Sustainability Magazine, on their BRE Global website (2006). These comparisons, however, have not been related specifically to LEED and BREEAM's education schemes.

Reports in the UK and US, such as the National Research Council's 2007 report, *Green Schools: Attributes for Health and Learning*, and UK's Department for Children and Families, *Schools for the Future* reports, have examined the social and environmental benefits of high performance schools [sustainable schools].

There are many similarities between the two schemes. For instance, both assessment models cover similar sections such as energy, sustainable sites, renewable materials, etc. and have similar points based rating systems and tiered certification systems (Pass, Good, Very Good, Excellent or Outstanding rating for BREEAM and Certified, Silver, Gold, Platinum for LEED). However, there are also notable differences. This study identifies specific strengths of the two systems to identify issues that are not fully or partially addressed, by one or both systems.

## LEED VERSUS BREEAM RATING SCHEMES

Since the development of LEED was influenced by BREEAM (Scheuer, 2002) the two schemes share many similarities. These include varying tiers of certification and point classification structures. Currently, they have the following tiers:

| LEED | BREEAM |
|---|---|
| Certified 40–49 points | Pass ≥ 30% |
| Silver 50–59 points | Good ≥ 45% |
| Gold 60–79 points | Very Good ≥ 55% |
| Platinum 80+ points | Excellent ≥ 70% |
| | Outstanding ≥ 85% |

Referencing Table 1, LEED and BREEAM have different definitions of their credit category parameters, for example; site selection is addressed by LEED in Sustainable Sites while BREEAM addresses it in Management. In order to compare the schemes, credits were realigned into the following categories so various issues could be compared side-by-side. New categories:

- Acoustics
- Design Planning & Bldg. Operation
- Energy & Atmosphere
- Indoor Air Quality
- Lighting & Daylighting
- Materials & Resources
- Site
- Transport
- Water Efficiency
- Innovation & Education

### *Building Certification*

To obtain LEED certification, projects must meet ten prerequisites (PR) across 5 of the categories; these do not provide points. BREEAM's prerequisites depend

**TABLE 1.** Categories into which LEED and BREEAM have divided their points.

| LEED | Points | % |
|---|---|---|
| Sustainable Sites-SS | 24 | 22% |
| Water Efficiency-WE | 11 | 10% |
| Energy & Atmosphere-EA | 33 | 30% |
| Materials & Resources-MR | 13 | 12% |
| Indoor Environmental Quality-IEQ | 19 | 17% |
| Innovation and Design | 6 | 5% |
| Regional Priority | 4 | 4% |

| BREEAM | %* |
|---|---|
| Land Use and Ecology-LE | 10% |
| Water-Wat | 6% |
| Energy-Ene | 19% |
| Materials-Mat | 12.5% |
| Health and Wellbeing-Hea | 15% |
| Transport-Tra | 8% |
| Waste-Wst | 7.5% |
| Pollution-Pol | 10% |
| Management-Man | 12% |
| Innovation | 10% |

*New buildings, extensions, major refurbishments

on the certification tier the project hopes to achieve. Wat 1 is not compulsory for 'Pass' projects, but for 'good' ones it becomes compulsory. Points are provided for compulsory credits. There are three credits required to achieve a pass rating, making them essentially prerequisites. LEED has 110 points possible and BREEAM has 110% possible.[1]

## LEED SCHOOLS VERSUS BREEAM EDUCATION CREDIT COMPARISON

The following sections compare LEED Schools v3.0 and BREEAM Schools Issue 2.0. Credit requirements are from LEED 2009 for Schools: New Construction and Major Renovations Rating System (USGBC, 2009) and the BREEAM Education 2008 Assessors Manual (BREEAM, 2008) with abbreviations where possible.

To provide a rational credit comparison to LEED, BREEAM's credits were weighted to reflect the BREEAM section weights. For example, the Water section has 8 points possible and a section weight of 6% so each credit earned in this category is worth 0.75 points taking the section weight into consideration.

### *Design Phase and Operation*

Table 2 and the discussion that follows cover the issues of engaging others in the design process and ensuring that the building operates smoothly once constructed.

Evident from Table 2, BREEAM emphasizes ensuring the building is easy to maintain and monitor for energy efficiency. It should be noted that only Ene 2 and Wat 2 are compulsory for 'very good' and

**TABLE 2.** Design Phase and Operation Comparison.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| | *Man 2 (.6-1.2) - Considerate Constructors:* Employ best practice site management principles. Point 2: Beyond best practice principles. |
| | *Man 8 (.6) - Security:* Consult with local police at the design stage and incorporate their recommendations into the building and parking design. |
| | *Man 11 (.6) - Ease of maintenance:* Use best practice methods for considering ease and efficiency of maintenance in building services/systems and landscaping specification. |
| | *Man 12 (.6-1.2) - Life cycle costing:* Conduct/implement a LLC analysis. |
| | *Ene 2 (.73) - Sub-metering of substantial energy uses (VG+):* Separate and accessible energy sub-meters for: Space Heating, Domestic Hot Water, Humidification, Cooling, Fans (major), Lighting, Small Power systems. Should have pulsed output to enable connection to a building management system. |
| | *Ene 3 (.73) - Sub-metering of high energy load and tenancy areas:* Sub-metering of energy consumption by tenancy/building function area. |
| | *Wat 2 (.75) - Water meter (G+):* Water meter with a pulsed output on the mains supply. |
| | *Wat 3 (.75) - Major leak detection:* Leak detection system on the main supply. |
| | *Wat 4 (.75) - Sanitary supply shut-off:* Proximity detection shut-off to the water supply to all toilet areas. |
| | *LE 7 (.83) - Consultation with students and staff:* Consult with staff and pupils, to determine their (i) educational and social requirements, (ii) ideas for the design and (iii) keep them informed of how their ideas are integrated. |
| | *LE 8 (.83) - Local wildlife partnerships:* For partnership with a local group with wildlife expertise. |
| | *Pol 2 (.71) - Preventing refrigerant leaks:* Refrigerant leaks detection system and the provision of automatic refrigerant pump down is made to a heat exchanger (or dedicated storage tanks) with isolation valves. Or where there are no refrigerants specified. |

'good' projects (or better), respectively. These credits are essential to ensuring the building is operating effectively after its construction, which is essential to student health and comfort (National Forum on Education Statistics, 2003).

The life cycle costing and ease of maintenance credits, provide the biggest potential for developing a sustainable and easily maintainable design, when paired with metering equipment which allows monitoring of the building systems by maintenance personnel. These credits also address key areas critics of LEED feel are weaknesses with LEED's scheme (Gifford, 2008).

LEED's lack of credits in this category is obvious from the blank space in Table 2. It has received criticism among practitioners and researchers (Santosa, 2007) for lacking metering credits or accountability post-construction for energy usage. Credits for metering would encourage projects to install metering equipment and complete post-construction monitoring so LEED and owners could assess consumption and the rigor of its energy and water conserving credit requirements over time.

### *Site Selection*

Table 3 and the discussion that follows cover the issues of reducing a project's impact on its site via selection, contamination cleanup, control of stormwater, and sharing facilities.

The glaring differences between the schemes are BREEAM's lack of credits for reducing the heat island effect and its lack of credit for producing a site master plan, as illustrated in Table 3. In London, the heat island effect is blamed for an increase of 6–8°C in the summer over outlaying areas (Greater London Authority, 2006). Addressing the heat island effect would help reduce air conditioning, irrigation requirements, and negative health effects.

The act of producing a site master plan helps encourage school officials and designers to examine the long-term needs of the community and how the site will need to adapt to those needs through time. This is a critical step in ensuring the school will meet the evolving needs of the community (Salvesen, Sachs & Engelbrecht, 2006). BREEAM does encourage design teams to seek input from students

**TABLE 3.** Site Selection Comparison.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *SS PR 1 (0) - Construction Activity Pollution Prevention:* Implement an erosion and sedimentation control plan for construction activities. | *See Management 3. |
| *SS PR 2 (0) - Environmental Site Assessment:* Conduct a Phase I ESA to determine whether contamination exists. If contamination is suspected conduct Phase II ESA. Former landfill sites are ineligible for certification. Remediate other contamination to local, state, or federal EPA region residential (unrestricted) standards, (most stringent).<br>*SS Credit 3 (1) - "Brownfield Redevelopment":* For remediating site contamination. | *LE3 (.83) - Ecological Value of site AND protection of ecological features:* Where the construction site's zone is defined as land of low ecological value and high ecological value areas protected from damage due from site preparation and construction.<br>*LE2 (.83) - Contaminated Land:* Remediate contamination pre-construction.<br>*Man 5 (.6) - Site investigation:* Complete a detailed site investigation. |
| *SS 1 (1) - Site Selection:* for not developing on:<br>• Prime farmland<br>• Undeveloped land whose elevation ≤5'+ the 100-year flood plane<br>• Endangered species habitat<br>• ≤100' of wetlands<br>• Undeveloped land ≤50' from a water body<br>• Public parkland prior to acquisition, unless ≥ land is accepted in trade by the public landowner. | *LE4 (.83-1.67) - Mitigating ecological impact (VG+):* For minimal change to the site's ecological value. 2 points: no negative change.<br>*Pol 5 (.71-1.43) - Flood Risk:* For a site with low flood risk or medium-high risk where the building and parking are above this level. Point 2: Ensure peak run-off rate from the site to watercourses does not increase post-development. Comply with Interim Code of Practice for Sustainable Drainage systems (CIRIA, 2004), or for at least a 1 year and 100 year return period event with 6 hour duration. |

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**TABLE 3.** Site Selection Comparison *(continued)*.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *SS 2 (4) - Development Density and Community Connectivity:* Previously developed site in a densely developed area (60,000+ $ft^2$ per acre net). OR a previously developed site 1/2 mile from a residential neighborhood with an average density of 10 units/acre net and ≤1/2 mile of 10+ accessible basic services. | *Tra 2 (.88) - Proximity to amenities:* Build within 500m (1/3 mile) of accessible local amenities appropriate to the building type/users. |
| *SS 5.1 (1) - Site Development- Protect or Restore Habitat:* Greenfield site: limit disturbance to ≤40' around building perimeter. Previously developed/graded site: protect/restore 50%+ of the site, excluding footprint, or 20% including footprint. | *LE6 (.83-1.67) - Long-term impact on biodiversity:* Appoint an ecologist prior to site activity, ecologist confirms compliance with UK and EU legislation on protection and enhancement of ecology during D&C phases, create a landscape and habitat management plan covering 5-years post-occupancy. Point 2: Appoint a 'biodiversity champion', train job crew on protecting site ecology, monitor plan effectiveness, minimizing site disturbance. |
| *SS 5.2 (1) - Site Development- Maximize Open Space:*<br>• With zoning: exceed zoning by 25%<br>• No zoning: equal to the building footprint.<br>• Zoning but no open space requirements: 20% of the site must be open space. | *LE1 (.83) - Reuse of Land:* Majority of footprint on previously developed site.<br>*LE5 (.83-2.49) - Land Use & Ecology:* Appoint a qualified ecologist to advise the designers on enhancing/protecting the site and implement their recommendations. Additional points: increase the ecological value of the site ≤5 species, or 6+ species. |
| *SS 6.1 Stormwater Design-Quantity Control:* Existing imperviousness ≤50%: no increase in discharge rate and quantity for 1 and 2-year 24-hour design storms. OR implement a plan that protects receiving stream channels from excessive erosion. Existing imperviousness ≥50%: reduce volume by 25% based on 2-year 24-hour design storm.<br>*SS 6.2 (1) - Stormwater Design-Quality Control:* Treat 90% of runoff and 80% of average annual post development total suspended solids. | *Pol 6 (.71) - Minimizing watercourse pollution:* Treat stormwater on site to reduce potential for silt, heavy metals, chemicals and oil into the site's habitat.<br>*See Pol 5 point 2: quantity control |
| *SS 7.1 (1 )- Heat Island Effect-Nonroof:* Reduce the heat island effect on 50% of hardscape surfaces. | |
| *SS 7.2 (1) - Heat Island Effect -Roof:* Use high SRI products on roof surfaces (29 or 78 depending on slope), a green roof or a combination of green and high SRI roof. | |
| *SS 9 (1) - Site Master Plan:* Develop a master plan in collaboration with school board. Must receive 4 of 7 credits: SS 1, SS 5.1, SS 5.2, SS 6.1, SS 6.2, SS 7.1 and SS 8. | |
| *SS 10 (1) - Joint Use of Facilities:* Consult with school board to provide 3+ spaces accessible/available to the public: auditorium, gymnasium, cafeteria, classrooms, playing fields, parking. | *Man 7 (.6-1.8) - Shared Facilities:* Provide shared facilities resulting from consultant feedback. Point 2: Enable access without compromising the safety/ security of building occupants. |

and teachers (see previous section) via LE 7. Where LE 7 does not directly appear to affect the sustainability of the building, LEED's SS 9, does help ensure sustainability is part of the discussion by requiring projects attempting the credit to receive four of seven other credits it deems important in the SS category.

### *Water Efficiency*

Table 4 and the discussion that follows cover the issues of potable water reduction in both landscaping and interior uses and innovative gray water/waste water strategies.

Water efficiency is essential to sustainability with regions in both the United States and UK suffering from water scarcity (Environment Agency, 2008 & Postel, 2000).

LEED has stricter irrigation requirements than BREEAM. As illustrated in Table 4, LEED requires achieving a 50% reduction in potable water for irrigation calculated from a mid-summer baseline or, for additional points, no potable water. BREEAM provides a point for potable water reduction but does not specify a specific percentage reduction in consumption, just that a low-water irrigation strategy has been installed, or that planting and landscaping is irrigated via rainwater or reclaimed water.

In addition to water conservation, BREEAM addresses water safety, which is an area not addressed by LEED. BREEAM HEA 12, "Microbial contamination" provides a credit to projects which demonstrate that the risk of waterborne and airborne legionella contamination has been minimized and Hea 16 addresses drinking water access, providing a point to projects where evidence demonstrates that mains-fed point of use water coolers are provided. A main's fed point of use water cooler is a directly plumbed-in water dispenser that provides chilled and ambient temperature mains-fed water to building users. BREEAM requires that they are attached "to both the wall and the floor to prevent vandalism, and contain security covers to protect all water and electrical connections."

### *Energy & Atmosphere*

Table 5 and the discussion that follows cover the issues of energy consumption and commissioning of the building.

**TABLE 4.** Water Efficiency Comparison.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *WE PR 1 (0) - Water use reduction:* 20% less water than the baseline calculated for the building (excluding irrigation). | *Wat 1 (.75-2.25) - Water consumption (G+):* Potable water reducing fixtures for taps, urinals, toilets and showers.<br>Points awarded for consumption of:<br>1: 4.5–5.5$m^3$ per person/year<br>2: 1.5–4.4 $m^3$ per person/year<br>3: <1.5 $m^3$ per person/year |
| *WE 1 (2-4) - Water Efficient Landscaping:* Reduce potable water needed for irrigation by 50% from calculated mid-summer baseline. Four points: no potable water. | *Wat 6 (.75) - Irrigation systems:* Install a low-water irrigation strategy/system or using non-potable water. |
| *WE 2 (2) - Innovative Wastewater Technologies:* Reduce potable water in building sewage conveyance by 50% through water-conserving fixtures or non-potable water. OR treat 50% of wastewater on-site to tertiary standards for use on site or infiltration. | *Wat 5 (.75) - Water Recycling:* For collecting, storing, and where necessary treating, rainwater or graywater for toilet and urinal flushing. |
| *WE 3 (2-4) - Water Use Reduction:* Reduce potable water consumption for toilets, urinals, sinks, showers, and pre-rinse spray valves. 30% 2 points, 35% 3 points, 40% 4 points. | *see Wat 1: Water consumption |
| *WE 4 (1) - Process Water Use Reduction:* No potable water for one-through cooling for refrigeration equipment, or garbage disposals. Water conserving process water appliances. | |

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**TABLE 5.** Energy Efficiency Comparison *(continued)*.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *EA PR 1 (0) - Fundamental Commissioning of Building Energy Systems:* Appoint CxA to lead, review and oversee commissioning.<br>• Experience in 2+ projects.<br>• Independent of the design and construction management team. May be a qualified employee or consultant of owner.<br>• Report results, findings and recommendations directly to owner.<br>• Projects ≤50,000 gross $ft^2$: can be a qualified person on the design or construction team with required experience.<br>• Owner must document the owner's project requirements. Design team must develop the basis of design. CxA: reviews for clarity/completeness.<br>• Develop/incorporate commissioning requirements into construction documents.<br>• Develop/implement a commissioning plan.<br>• Verify installation and performance of the systems for commissioning.<br>• Complete a commissioning report. | *Man 1 (.6-1.2) - Commissioning (P+: .6 O:1.2):* Appoint a project team member to monitor commissioning for the client to ensure commissioning will be completed to best practice standards. Point 2: Complete seasonal commissioning during the first year post-occupancy. |
| *EA PR 2 (0) - Minimum Energy Performance:* Establish an energy performance rating goal using EPA's Target Finder rating tool via one of three options:<br>• Whole Building Energy Simulation<br>• Prescriptive Compliance Path (Buildings ≤200,000 $ft^2$)<br>• Prescriptive Compliance Path (Buildings ≤100,000 $ft^2$) | *See Ene 1<br>*Ene 8 (.73-1.46) - Lifts:* Energy-efficient elevators.<br>*Ene 11 (.73) - Energy Efficient fume cupboards:* Study the most energy-efficient strategy for laboratory fume cupboard ventilation.<br>*Ene 12 (.73) - Swimming pool ventilation and heat loss:* Automatic or semi-automatic pool covers on pools. |
| *EA PR 3 (0) - Fundamental Refrigerant Management:* No CFC-refrigerants in building HVAC&R systems. Existing HVAC equipment must phase-out CFC-refrigerants before occupancy. | *Pol 1 (.71) - Refrigerant GWP - Building Services:* Refrigerants with a global warming potential (GWP) of <5. *OR* no refrigerants for building services.<br>*Ene 10 (.73) - Free cooling:* Incorporate a free cooling strategy that completely displaces need for conventional mechanical cooling system while achieving thermal comfort requirements of Hea 11. |

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**TABLE 5.** Energy Efficiency Comparison *(continued)*.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *EA 1 (1-19) - Optimize Energy Performance:* Select 1 of 3 compliance path options:<br>• Whole Building Computer Energy Simulation<br>**New / Renovations / Points**<br>12% / 8% / 1<br>14% / 10% / 2<br>16% / 12% / 3<br>18% / 14% / 4<br>20% / 16% / 5<br>22% / 18% / 6<br>24% / 20% / 7<br>26% / 22% / 8<br>28% / 24% / 9<br>30% / 26% / 10<br>32% / 28% / 11<br>34% / 30% / 12<br>36% / 32% / 13<br>38% / 34% / 14<br>40% / 36% / 15<br>42% / 38% / 16<br>44% / 40% / 17<br>46% / 42% / 18<br>48% / 44% / 19<br>• Prescriptive Compliance Path (1 point: <200,000 $ft^2$):<br>• Prescriptive Compliance Path (1–3 points: <100,000 $ft^2$) | *Ene 1 (.73-11.68) - Reduction of CO2 emissions (E:4.38 O:7.3):* Improve the energy efficiency of the building's fabric and services to lower CO2 emissions. Points determined by comparing the building's Energy Performance Certificate (EPC) with the table below:<br>CO2 Index (EPC Rating)<br>**New / Renovation / Points**<br>63 / 100 / .73<br>53 / 87 / 1.46<br>47 / 74 / 2.19<br>45 / 61 / 2.92<br>43 / 50 / 3.65<br>40 / 47 / 4.38<br>37 / 44 / 5.11<br>31 / 41 / 5.84<br>28 / 36 / 6.57<br>25 / 31 / 7.3<br>23 / 28 / 8.03<br>20 / 25 / 9.49<br>18 / 22 / 10.22<br>10 / 18 / 10.95<br>0 / 15 / 11.68<br><0 / ≤0 / Exemplar credit 1<br>True zero carbon building Exemplar credit 2<br>Building must be modeled using a method compliant with the National Calculation Method (NCM) and an Energy Rating and certificate produced using *Approved software* by an *Accredited Energy Assessor.* |
| *EA 2 (1-7) - On-site Renewable Energy:* Use on-site renewable energy to offset costs. Percentage of renewable energy compared to annual energy cost.<br>**Energy / Points**<br>1%: 1<br>3%: 2<br>5%: 3<br>7%: 4<br>9% 5<br>11% 6<br>13% 7 | *Ene 5 (.73-2.19) - Low or zero carbon technologies (E+:.73):*<br>.73 point: Carry out and implement feasibility study considering *on-site* and/or *near site* low or zero carbon (LZC) technologies.<br>1.46 points: 10% $CO_2$ reduction from installing a feasible local LZC technology. 2.19 points: 15% reduction. |

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**TABLE 5.** Energy Efficiency Comparison *(continued)*.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *EA 3 (2) - Enhanced Commissioning:* In addition to EA PR 1:<br>• Conduct 1+ commissioning design review of the owner's project requirements basis of design, and design documents prior to mid-construction documents phase and back-check the review comments in the subsequent design submission.<br>• Review contractor submittals for systems being commissioned. Verify compliance with the owner's project requirements and basis of design. Review must be concurrent with the review of the architect or engineer and submitted to the design team and owner.<br>• Create systems manual.<br>• Verify completion of training requirements for operators and occupants.<br>• Review operation with O&M staff and occupants <10 months after substantial completion. Develop a plan for resolving outstanding commissioning-related issues. | *Man 4 (.6) - Building User Guide (E+:1):* Create a simple guide covering information relevant to the tenant/occupants and non-technical building manager on the building's operation and performance. |
| *EA 4 (1) - Enhanced Refrigerant Management:* OPTION 1 No refrigerants. OR OPTION 2 Select refrigerants that minimize or eliminate emission of compounds that contribute to ozone depletion and global climate change. | *Pol 3 (.71) - Refrigerant GWP - Cold storage:* Refrigerants within cold storage systems with a global warming potential (GWP) of <5.<br>*Pol 4 (.71-2.13) - No NOx emissions from heating source:*<br>1: Where the dry NOx emissions from delivered space heating energy are ≤100 mg/kWh (at 0% excess O2).<br>2: Dry NOx emissions from delivered space heating energy are ≤70 mg/kWh (at 0% excess O2).<br>3: Dry NOx emissions from delivered space heating energy are ≤40 mg/kWh (at 0% excess O2) and emissions from delivered water heating energy are ≤100 mg/kWh (at 0% excess O2). |
| *EA 5 (2) - Measurement and Verification: Develop/implement M&V plan consistent with Option D:* Calibrated Simulation (Savings Estimation Method 2) OR Option B: Energy Conservation Measure Isolation, as specified in IPMVP Volume III. Cover 1+ year(s) of post-construction occupancy. Provide a corrective action process if results indicate energy savings are not being achieved. | |
| *EA 6 (2) - Green Power:* Engage in 2+ year energy contract for 35%+ of the building's electricity with Green-e Energy products. Based on quantity consumed, not cost. Districts can purchase power centrally and allocate the power to specific projects. | |

Commercial buildings in the UK account for 25% of $CO_2$ emissions (Dept. of Communities and Local Government (Communities & Local Government), 2009) and buildings account for 50% of the country's energy consumption (Communities & Local Government, 2009). In the US, they use 73% of the country's electricity and account for 38% of $CO_2$ emissions (Department of Energy (DOE), 2008). In schools, HVACR accounts for 76% of energy consumption (DOE, 2008). Improving energy performance of buildings is an important step to reducing carbon emissions.

The main difference between the schemes is that BREEAM encourages reduction in consumption to a zero carbon level, whereas LEED's highest level of energy consumption reduction is 48%. A study between LEED and BREEAM found that BREEAM's carbon reduction credit is more demanding for projects to achieve than LEED's energy consumption credit (LEE & Burnett, 2007).

LEED provides credit to projects which develop and implement a measure and verification (M&V) plan covering 1+ years of post-construction occupancy. BREEAM does not have a M&V credit, as shown in Table 5, but requires all 'Outstanding' projects obtain an 'In-Use Certification' of performance within three years of operation to maintain the rating. If the project does not get an In-Use certification within that time period, it is downgraded to Excellent on the post-construction certificate. It benefits all projects to monitor their energy use post-occupancy, though the first year following construction may not provide an accurate picture of the buildings energy use because the building may not be fully occupied the entire time and adjustments may be taking place on the building's mechanical systems which effect its consumption (Gifford, 2008). Therefore, a longer M&V period monitoring the building after year one, like BREEAM's, may produce more accurate results.

### *Indoor Air Quality*

Table 6 and the discussion that follows cover the issues of ventilation, VOCs in construction products used, and thermal comfort. Indoor air quality is critical in the design of schools because children breathe 50% more air per pound of body weight than adults. Inhaling fine particulate matter from idling vehicles has been associated with increased frequency of childhood illness according to the US Environmental Protection Agency (EPA, 2003).

LEED's PR 1, which is compulsory, requires 13–15 cfm/person (ASHRAE, 2007) for classrooms depending on the age of the students, while BREEAM requires 3–5 l/s per person (3.36–10.6 cfm/person) (Department for Children Schools and Families, 2006). BREEAM's rate is considerably lower than the Asthma Regional Council of New England recommendations of 20 cfm/person (Parker, 2005). LEED is consistent with the Collaborative for High Performance Schools[2] (CHPS) requirement of 15 cfm/person, though they encourage 20 cfm/person (2006).

BREEAM addresses air intake locations, and window openings in naturally ventilated buildings to ensure they are not located near external air pollution sources, which LEED does not address. This is a strategy CHPS recommends in their transportation standard SP3 (2006). These distances are regardless of the type or MERV air filter value as BREEAM does not consider filters to provide adequate protection from sources of external pollution.

Both BREEAM and LEED address thermal comfort via design, as illustrated in Table 6, but only LEED addresses verification. While not compulsory, IEQ 7.2 requires an anonymous survey of building occupants (adults and students grades 6+) within 6-18 months after occupancy to determine what percentage of occupants are satisfied with thermal comfort systems of the building and requires a corrective action plan if 20%+ of occupants are dissatisfied.

With 1–13 (7.7%) students affected by asthma, mold prevention is essential to reducing absenteeism (EPA, 2005). LEED's IEQ 10 addresses mold prevention by requiring humidity levels of ≤60% post-occupancy and that projects meet three other IEQ credits, including pre-occupancy flush-out and thermal comfort credits. IEQ prior pre-occupancy and mold prevention are not addressed directly by BREEAM.

### *Materials & Resources*

Table 7 and the discussion that follows cover the issues of construction waste management, sustainable and low VOC materials, reuse or salvaging of building elements, and sustainable timber harvesting.

**TABLE 6.** Indoor Air Quality Comparison.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *IEQ PR 1 (0) - Minimum Indoor Air Quality Performance:* Meet Sections 4-7 of ASHRAE Standard 62.1-2007 (with errata but without addenda). AND<br>CASE 1. Mechanically Ventilated Spaces: Design using the ventilation rate procedure or the applicable local code (most stringent).<br>CASE 2. Naturally Ventilated Spaces: Follow ASHRAE Standard 62.1-2007, Paragraph 5.1 (with errata but without addenda). | |
| *IEQ PR 2 (0) - Environmental Tobacco Smoke (ETS) Control:* Prohibit smoking indoors and <25′ from entries, air intakes, operable windows and provide appropriate signage. | |
| *IEQ 1 (1) - Outdoor Air Delivery Monitoring:* Install permanent ventilation monitoring systems to ensure design requirements are met. Must sound alarm when the airflow values or $CO_2$ levels vary by 10%+ from design values via a building automation system alarm.<br>AND<br>CASE 1. Mechanically Ventilated Spaces: Monitor $CO_2$ concentrations in spaces with a design occupant density of 25+ per 1,000 $ft^2$. $CO_2$ monitors must be between 3′–6′ AFF. Provide a direct outdoor airflow measurement device able to measure minimum outdoor air intake flow with an accuracy of ±15%, defined by ASHRAE 62.1-2007 (with errata but without addenda) where 20%+ of the design supply airflow serves non-densely occupied spaces.<br>CASE 2. Naturally Ventilated Spaces: Monitor $CO_2$ within all naturally ventilated spaces. Monitors must be 3′–6′ AFF. | |
| *IEQ 2 (1) - Increased Ventilation:*<br>CASE 1. Mechanically Ventilated Spaces: Increase breathing zone outdoor air ventilation rates to occupied spaces by 30%+ above ASHRAE Standard 62.1-2007 (with errata but without addenda).<br>CASE 2. Naturally Ventilated Spaces: Design natural ventilation systems for occupied spaces to meet the recommendations set forth in the CIBSE Applications Manual 10: 2005.<br>AND<br>OPTION 1: Use diagrams and calculations to show that the natural ventilation systems design meets the recommendations in CIBSE Applications Manual 10: 2005, CIBSE AM 13, or natural ventilation/mixed mode ventilation related sections of the CIBSE Guide B2.<br>OR<br>OPTION 2: Use a macroscopic, multizone, analytic model to predict room-by-room airflows will effectively naturally ventilate, defined as providing the minimum ventilation rates required by ASHRAE Standard 62.1-2007 Chapter 6 (with errata but without addenda1), for 90%+ of occupied spaces. | |

*(continued on next page)*

**TABLE 6.** Indoor Air Quality Comparison *(continued)*.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *IEQ 3.1 (1)- Construction Indoor Air Quality Management Plan-During Construction:* Develop/implement an IAQ plan for the construction and preoccupancy phases:<br>• During construction meet or exceed control measures of SMACNA IAQ Guidelines For Occupied Buildings Under Construction, 2nd Edition 2007 (Chapter 3).<br>• Protect stored on-site and installed absorptive materials from moisture damage.<br>• Permanently installed air handlers used during construction: Use MERV 8 filter at return air grilles, as determined by ASHRAE Standard 52.2-1999 (with errata but without addenda). Replace filtration media prior to occupancy.<br>• Prohibit smoking inside the building and <25' from entrances once the building is enclosed. | |
| *IEQ 3.2 (1) - Construction Indoor Air Quality Management Plan-Before Occupancy:* Develop/implement an IAQ plan after all finishes are installed and building has been cleaned. Compliance options:<br>• Pre-Occupancy Flush Out: supply air volume of 14,000 $ft^3$ of outdoor air per $ft^2$ of floor area. Maintain internal temperature of 60°+ F and relative humidity ≤60%.<br>• Post-Occupancy Flush-Out: The space may be occupied following delivery of 3,500 $ft^3$+ of outdoor air per $ft^2$ of floor area. Post-occupancy: 0.30+ cfm per $ft^2$ of outside air or the design minimum outside air rate determined in IEQ Prerequisite 1, whichever is greater.<br>• Air Testing: Conduct baseline IAQ testing, using protocols consistent with the EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air and as additionally detailed in the LEED Reference Guide, 2009 Edition. Contaminants for which a maximum concentration must not be exceeded include: Formaldehyde, Particulates, Total VOC, 4-Phenylcyclohexene, Carbon monoxide. | |
| *IEQ 4 (1-4) - Low-Emitting Materials:* Choose from the following (4 maximum):<br>• Adhesives and Sealants (1 point)<br>• Paints and Coatings (1 point)<br>• Flooring Systems (1 point)<br>• Composite Wood and Agrifiber Products (1 point)<br>• Furniture and Furnishings (1 point)<br>• Ceiling and Wall Systems (1 point) | *Hea 9 (.88) - Volatile Organic Compounds:* Demonstrate emissions and substances from internal finishes and fittings comply with best practice levels:<br>• Wood panels<br>• Timber structures<br>• Wood Flooring<br>• Resilient, textile and laminated floor coverings<br>• Suspended ceiling tiles<br>• Flooring adhesives<br>• Wall-coverings<br>• Adhesives for hanging-flexible wall-coverings<br>• Decorative paints and varnishes |

*(continued on next page)*

**TABLE 6.** Indoor Air Quality Comparison *(continued)*.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *IEQ 5 (1) - Indoor Chemical and Pollutant Source Control:* Minimize/control the entry of pollutants into the building and cross-contamination through:<br>• Permanent entryway system 10′+ at exterior entrances.<br>• Sufficiently exhaust each space where hazardous gases or chemicals may be present or used to create negative pressure with respect to adjacent spaces when room doors are closed.<br>• Mechanically ventilated buildings: install new air filtration media in regularly occupied areas prior to occupancy: MERV 13+ for both return and outside air that is delivered as supply air.<br>• Provide containment for disposal of hazardous liquid wastes in places where water and chemical concentrate mixing. | *Hea 8 (.88) - Indoor air quality:* Avoid sources of external pollution and recirculation of exhaust air in air intake by:<br>• AC/mixed-mode buildings: Air intakes and exhausts are over 10m (33′) AND intakes are over 20m (66′) from *sources of external pollution*.<br>• Naturally-ventilated buildings: Operable windows/ventilators are 10m+ from *sources of external pollution*.<br>Provide fresh air and minimize internal pollutants (and ingress of external polluted air into the building) according to Building Bulleting 101 *Ventilation of School Buildings.* |
| *IEQ 6.2 (1) - Controllability of Systems - Thermal Comfort:* Provide individual comfort controls for 50%+ of occupant workspaces. Operable windows may be used instead of controls for occupants located 20′ inside and 10′ to either side of the operable window. Operable window areas must meet ASHRAE Standard 62.1-2007 paragraph 5.1 Natural Ventilation (with errata but without addenda) requirements. Provide comfort system controls for shared multi-occupant spaces to enable adjustments that meet group needs. Comply with ASHRAE Standard 55-2004 (with errata but without addenda) and include the primary factors of air temperature, radiant temperature, air speed and humidity. | *Hea 7 (.88) - Potential for natural ventilation:* Demonstrate that fresh air is capable of being delivered to the occupied building spaces via a natural ventilation strategy, with sufficient user-controlled fresh air supply.<br>*Hea 11 (.88) - Thermal zoning:* For providing local occupant control is available for temperature adjustment in each *occupied space* to reflect differing user demands. |
| *IEQ 7.1 (1) - Thermal Comfort-Design:* Design HVAC systems and building envelope to meet ASHRAE Standard 55-2004. Demonstrate design compliance in accordance with the Section 6.1.1 documentation. | *Hea 10 (.88) - Thermal comfort:* Assess thermal comfort levels in occupied spaces at the design stage to evaluate appropriate servicing options, ensuring appropriate thermal comfort levels are achieved. |
| *IEQ 7.2 (1) - Thermal Comfort-Verification:* Conduct thermal comfort survey of building occupants (adults and students in grades 6+) 6-18 months post-occupancy in accordance with ASHRAE Standard 55-2004 (with errata but without addenda), via anonymous responses about thermal comfort in the building, including an assessment of overall satisfaction with thermal performance and identification of thermal comfort problems. Develop a correction plan if results indicate 20%+ of occupants are dissatisfied. | |
| *IEQ 10 (1) - Mold Prevention:* Achieve: IEQ 3.1, IEQ 7.1, IEQ 7.2. HVAC systems and controls are designed to limit space relative humidity to ≤60% during all load conditions. Develop and implement an IAQ program for buildings based on the EPA document, Building Air Quality: A Guide for Building Owners and Facility Managers. | |
| | *Hea 17 (.88) - Specification of Laboratory Fume Cupboards:* Design fume cupboards and microbiological safety cabinets in accordance with the appropriate British Standard. |

**TABLE 7.** Materials & Resources Comparison.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *MR PR 1 (0) - Storage and Collection of Recyclables:* Provide an easily-accessible dedicated area for the storage of recycling, including: paper, corrugated cardboard, glass, plastics and metals. | *Wst 3 (.63-1.89) - Recycled waste storage:* provide a central, dedicated space for the storage of recyclables.<br>Two points: for creating policies/procedures which:<br>a. Include procedures for collection and recycling of consumables<br>b. Are endorsed at the school governor level<br>c. Will be operational at a local level |
| *MR 1.1 (1-2) - Building Reuse - Maintain Existing Walls, Floors and Roof:* Reuse existing building structure and envelope (excluding windows and nonstructural roofing material). 75%+ 1 point, 95%+ 2 points. | *Mat 3 (.83) - Reuse of building façade:* 50% of the total final façade (by area) in situ and at least 80% of the reused façade (by mass) comprises in-situ reused material.<br>*Mat 4 (.83) - Reuse of building structure:* Reuse 80%+ of existing primary structure and, for part refurbishment/part new build, the volume of the reused structure comprises 50%+ of the final structure's volume. |
| *MR 1.2 (1) - Building Reuse-Maintain Existing Interior Nonstructural Elements:* Reuse interior nonstructural elements in 50%+ (area) of the completed building including additions. | |
| *MR 2 (1-2) - Construction Waste Management:* Recycle and/or salvage nonhazardous construction and demolition debris. Calculated by weight or volume (must be consistent). 50%+ 1 point, 75%+ 2 points. | *Wst 1 (.63-1.89) - Construction Site Waste Management:* Non-hazardous construction waste ($m^3$/100$m^2$ or tonnes100$m^2$) generated on site is equal or better than good or best practice levels.<br>Two points: Significant majority of nonhazardous construction waste generated is diverted from landfill and reused or recycled. |
| *MR 3 (1-2) - Materials Reuse:* Salvaged, refurbished or reused materials, for 5%+ or 10%+ (based on cost), of the total value of project materials. | *Wst 2 (.63) - Recycled aggregates:* Significant use of recycled or secondary aggregates in 'high-grade' building aggregate uses. |
| *MR 4 (1-2) - Recycled Content:* Materials with recycled content such that the sum of postconsumer recycled content plus 1/2 of the pre-consumer content constitutes 10%+ or 20%+, based on cost, of the total value of the project's materials. | *Mat 1 (.83-4.98) - Materials specification (major building elements):* Determined by the BRE *Green Guide to Specification* ratings for the major building/finishing elements.<br>*Mat 2 (.83) - Hard landscaping and boundary protection:* 80%+ of external hard landscaping and boundary protection area specifications earn a BRE Green Guide *to Specification rating A or A+.* |
| *MR 5 (1-2) - Regional Materials:* Materials or products extracted, harvested or recovered, and manufactured, ≤500 miles of the project site for 10%+ or 20%+, of the total materials value. | |

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**TABLE 7.** Materials & Resources Comparison *(continued)*.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *MR 6 (1) - Rapidly Renewable Materials:* Rapidly renewable material made from plants harvested within a ≤10-year for 2.5% of the total value of all building materials and products used in the project. | *Mat 5 (.83-2.49) - Responsible sourcing of materials:* 80% of the assessed materials in the following elements are responsibly sourced:<br>• Structural Frame<br>• Ground floor<br>• Upper floors (including separating floors)<br>• Roof<br>• External and internal walls<br>• Foundation/substructure<br>• Staircase<br>100% of timber must be legally sourced.<br>*Mat 6 (.83-1.67) - Insulation:* Thermal insulation products with low embodied impact relative to their thermal properties, determined by the BRE *Green Guide to Specification* ratings. 2 Points: Responsibly sourced thermal insulation products. |
| *MR 7 (1) - Certified Wood:* 50%+ (cost) for FSC certified wood-based materials/ products. Components include (minimum), structural framing and general dimensional framing, flooring, sub-flooring, wood doors and finishes. | *see Mat 5 and Man 3 |
| | *Man 3 (.83-2.49) - Construction Site Impacts:* One point 2+ items. Two points: 4+ items. Three points: 6+ items.<br>• Monitor, report and set targets for $CO_2$ or energy arising from site activities<br>• Monitor, report and set targets for $CO_2$ or energy arising from transport to and from site<br>• Monitor, report and set targets for water consumption arising from site activities<br>• Implement best practice policies in respect of air (dust) pollution arising from the site<br>• Implement best practice policies in respect of water (ground and surface) pollution occurring on the site<br>• Main contractor has an environmental materials policy, used for sourcing of construction materials to be utilized on site<br>• Main contractor operates an Environmental Management System.<br>One point for demonstrating that 80%+ of site timber is responsibly sourced and 100% is legally sourced. |

Both LEED and BREEAM place emphasis on the reuse of elements in an existing building during a major renovation. The big difference between the two is that BREEAM does not award credit for reusing interior elements and that LEED encourages reuse of materials for much larger additions than BREEAM.

BRE produces two guides, the Green Book, and Green Guide to Specification, which provide valuable information for designers. These tools allow a quick sustainability comparison for specification options and a Life Cycle Analysis of building products. LEED does not produce a product guide. For a designer seeking to earn credits MR 4-7, designers must find products which meet the credit criteria either through manufacturers or by looking to the organizations that evaluate products for their environmental and health claims such as the Forest Stewardship Council, Green Seal, etc.

BREEAM's Man 3 awards credits to projects where contractors have a sustainable materials sourcing policy, use legally harvested timber and monitor their $CO_2$ offsets on the construction site. Contractors must also set targets and record their water consumption, monitor dust arising at the site, and take care to minimize pollution of ground and surface water sources. The objectives of this credit is commendable, however it fails to set strict targets (except requiring 80% of timber be reclaimed, reused or responsibly sourced). While a contractor can track this information there is no incentive to do more, which is a weakness of the credit.

### *Lighting, Daylighting and Views*

Table 8 and the discussion that follows cover the issues of daylighting and glare control, lighting, light pollution and occupant views to the building's exterior.

Proper design of lighting and daylighting systems is crucial to school design since much of the curricula of schools require visual tasks such as looking at a screen or blackboard, or reading and writing. While additional research is needed in this area, it is theorized that specifically for students and teachers who do not have properly corrected vision, lighting levels are critical to their learning and teaching (National Research Council, 2007).

BREEAM addresses daylighting and glare control via separate credits unlike LEED which combines the two. This means that a BREEAM project can receive a credit for providing daylighting to 80%+ of its classrooms but not address glare control, creating problems for the users.

BREEAM addresses internal and external lighting levels via Hea 5. These are consistent with recommendations of the US National Research Council's Green School report, which recommends that lighting levels standards be addressed by schemes such as LEED (National Research Council, 2007).

In addition to recommending internal lighting levels for LEED's scheme, both LEED and BREEAM would both benefit from addressing the energy efficiency of luminaries and lamps, which could dramatically impact energy efficiency of the building project.

Projects receiving daylighting credits could benefit from adding sensors monitoring both occupancy and daylight levels. This stands to significantly impact energy usage, and ensure adequate light levels are maintained. According to the US Department of Energy, schools can save 8%–20% of their lighting energy by turning off lights in unoccupied rooms (DOE, 2004).

### *Acoustics*

Table 9 and the discussion that follows address the issue of acoustics in schools. Acoustics help make learning easier for students by providing them with quiet classrooms where they can clearly hear the lessons at hand, and reduce vocal fatigue for teachers (National Research Council, 2007).

BREEAM and LEED both set a 35 dB standard for classrooms, where students spend the majority of their time. LEED however, also addresses noise generating from HVAC design, with criteria that meets the recommendations of the National Research Council's Green School's report (National Research Council, 2007). The major difference between the two is that LEED's acoustical prerequisite impacting classrooms is compulsory, whereas BREEAM's is not.

Neither BREEAM nor LEED address the impacts of locating a school in an area away from excessive noise from air, train or vehicular traffic, etc. while BREEAM does address noise pollution

**TABLE 8.** Lighting, Daylighting and Views Comparison.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *IEQ 6.1 (1) - Controllability of lighting systems:* 90%+ of regularly occupied spaces have individual lighting controls. Classrooms have 2+ operational modes: general and A/V. | *Hea 6 (.88)- Lighting zones and controls:* Appropriately zoned and occupant controllable lighting with the option for commonly required lighting settings to be selected quickly and easily.<br>*Health credit 4 (.88) - High frequency lighting:* Install high frequency ballasts on fluorescent and compact fluorescent lamps. |
| | *Hea 5 (.88) - Internal and external lighting levels:* Internal and external lighting, where relevant, is specified according luminance levels (in lux) recommended by CIBSE and internal luminance levels outlined in Building Bulletin 90. |
| *IEQ 8.1 (1-3) - Daylight and Views-Daylight:* Use 1 of 4 options; computer simulation, prescriptive, measurement, or a combination to achieve daylighting of:<br>**Classroom Spaces** **Points**<br>75% 1<br>90% 2<br>Daylighting levels are ≥25 fc but not >500 fc in clear sky conditions.<br>Provide glare control devices. | *Hea 1 (.88) - Daylighting:* 80%+ of floor area in each space is adequately daylit with an average daylight factor of 2%+. PLUS either (b) OR (c AND d):<br>b. A uniformity ratio of at least 0.4 or a minimum point daylight factor of 0.8%+ (spaces with glazed roofs, such as atria, must achieve a uniformity ratio of 0.7+ or a minimum point daylight factor of 1.4%+).<br>c+d. A view of sky from desk height is achieved and the room depth criterion d/w +d/HW < 2/(1-RB) is satisfied.<br>*Hea 3 (.88) - Glare control:* Provide an occupant-controlled shading system in relevant areas. |
| *IEQ 8.2 (1) - Daylight and Views-Views:* Achieve a direct line of sight to the exterior between 30"-7'6" AFF for occupants in 90% of regularly occupied areas. | *Hea 2 (.88) - View out:* Where relevant building areas have an adequate view out. Defined as within 7m (23') of a wall with a window or permanent opening providing an adequate view out, where the window is ≥20% of the total inside wall area. |
| *SS 8 (1) - Light Pollution Reduction:*<br>Option 1: For interior lighting reduce input power (by automatic device) for nonemergency interior luminaries with a direct line of site to any translucent or transparent openings in the building envelope by 50% between 11 p.m. – 5 a.m.<br>Option 2: Use automated shields over translucent or transparent openings with a direct line to non-emergency luminaries between 11 p.m. and 5 a.m. if transmittance is <10%.<br>For exterior lights, only light areas as required for safety and comfort. Power densities must not exceed ANSI/ASHRAE/IESNA Standard 90.1-2007 (with errata but without addenda) for the classified zone. Meet exterior lighting control requirements from ANSI/ASHRAE/IESNA Standard 90.1-2007 (with errata but without addenda1), Exterior Lighting Section, without amendments. Classify the project under 1 of the following zones, as defined in IESNA RP-33, and follow all of the requirements for that zone.<br>Physical education spaces are exempt from complying with the lighting power density requirements of this credit. | *Pol 7 (.71) - Reduction of night light pollution:* External lighting designs that are in compliance with the Institution of Lighting Engineers (ILE) Guidance Notes for the reduction of obtrusive lighting, between 11:00 p.m. and 7:00 a.m. Can be achieved via timer or reducing lighting levels at or before 11:00 p.m.<br>*Ene 4 (.73) - External lighting:* Where energy-efficient external lighting is specified for all fittings and controlled for the presence of daylight. |

**TABLE 9.** Acoustics Comparison.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *IEQ PR 3 (0) - Minimum Acoustical Performance* and *IEQ 9 - Enhanced Acoustical Performance:* Maximum background noise level from HVAC systems in classrooms equals 45 dBA. The sound-absorptive finishes in these spaces must comply with reverberation time requirements of ANSI Standard S12.60-2002.<br>100% of ceilings (or a combination of acoustic applications equal to the ceiling area) in classroom under 20,000 $ft^2$ must have a noise reduction coefficient of 0.70+. Classrooms 20,000+ $ft^3$ must have a reverberation time of ≤1.5s per ANSI Standard S12.60-2002. | *Hea Credit 13 (2.64) - Acoustic Performance:* For following Building Bulletin 93 and performing follow-up testing prior to occupancy to verify that the requirements have been met or are being remedied prior to occupancy. |
| *IAQ 9 (1) - Enhanced Acoustical Performance:* Building shell and partitions must meet sound transmission class requirements of ANSI Standard S12.60-2002, except windows, which must meet an STC rating of ≥35 and to reduce background noise level to ≤40 dBA from HVAC systems in classrooms. | |
| | *Pol 8 (.71) - Noise attenuation:* Address noise impact from the site will have on the surrounding neighborhood (800m radius). Assessed according to British Standard 4142:1997, by a qualified acoustician. |

emanating from the school. The National Research Council's Green School's report recommended that future green school guidelines require that new schools be located away from areas of high outdoor noise (National Research Council, 2007).

Due to the importance of acoustics in school for the health and wellbeing of the students and teachers, making all of the acoustic credits compulsory is an important change that would benefit both schemes.

### *Transportation*

Table 10 and the discussion that follows cover the issues of increasing public transportation use, encouraging walking and cycling, which reduces $CO_2$ emissions and encourages fitness (Cooper, Anderson, et al, 2005).

BREEAM's public transport credit's sliding scale, based on accessibility, this makes the credit more rigorous than LEED's. LEED's credit fails to take into account the route of the transport service, hours of service, and frequency of service; important characteristics that influence how often users of the building may use the stop.

BREEAM also places greater emphasis on cycling than LEED at a primary school level. BREEAM requires 5 cycle storage places per primary school class (grade level) while LEED requires spaces serving 5% of students and staff above third grades. For a class smaller than 80 students this means BREEAM requires more spaces.

BREEAM addresses the importance of creating and maintaining programs which encourage use of these alternative transport options, which seems vital to their success in its credit Tra 5. Otherwise, a project may have close access to public transportation nodes, cyclist storage and changing rooms without users. LEED would benefit from establishing such a credit.

### *Innovation & Education*

This section addresses credits for exemplary performance and innovative sustainable designs.

LEED has an "Innovation in Design" section while BREEAM's innovation and exemplary credits do not have a special category, and are totaled at the end of the evaluation, un-weighted. Both LEED

**TABLE 10.** Transportation Comparison.

| LEED Schools version 3.0 | BREEAM Education Issue 2.0 |
|---|---|
| *SS 4.1 (4) - Alternative Transportation- Public Transportation Access:*<br>OPTION 1. Rail Station Proximity: Build ≤1/2-mile of an existing or planned/funded commuter rail, light rail or subway station.<br>OPTION 2. Bus Stop Proximity: Build ≤1/4-mile of 1+ stop(s) for 2+ public, campus, or private bus lines usable by occupants. A school bus system counts as 1 line.<br>OPTION 3. Pedestrian Access: Show the attendance boundary means 80%+ of students live ≤3/4 mile for grades 8-, and ≤1.5 mile for grades 9+. Allow pedestrian access to the site from all residential neighborhoods that house the planned student population.<br>ALL OPTIONS: Provide dedicated walking or biking lanes to transit lines that extend from the building at least to the end of the property in 2+ directions without any barriers. | *Tra 1 (2.64) - Provision for Public Transport:* Sliding scale based on the buildings' accessibility to the public transport network measured by the Accessibility Index (AI) which measures:<br>• The distance (m) from the *main building entrance* to each *compliant public transport node*<br>• The public transport type e.g. bus or rail<br>• The *average number of services* stopping per hour at each *compliant node* during the standard *operating hours* of the building for a *typical day*<br>• One credit for a school bus system. |
| *SS 4.2 (1) - Alternative Transportation-Bicycle Storage and Changing Rooms:* Storage for 5% of students and staff grades 4+ and changing facilities for .5% of staff. Bike lanes must extend 2 directions from the property. | *Tra 3 (.88-1.78)- Cyclist Facilities:* 5+ storage spaces for each class in any one year group for primary schools and between 5%-10% of users in secondary schools depending on the school's capacity. Point 2: Provide changing rooms.<br>*Tra 4 (.88) - Pedestrian and cyclist safety:* Design site layout in accordance with best practice to ensure safe and adequate pedestrian and cycle access. |
| *SS 4.3 (2) - Alternative Transportation - Low-Emitting and Fuel-Efficient Vehicles:* Provide preferred parking to Low-Emitting and Fuel-Efficient vehicles or provide 20% (percent by vehicles, fuel, or both) fuel-efficient or low-emitting busses for students.<br>*SS 4.4 (2) - "Alternative Transportation - Parking Capacity":* Addresses parking capacity of the site. | *Tra 5 (.88) - Travel Plan:* Develop a travel plan strategy for managing travel/transport within the school. Must contain physical and behavioral measures to increase travel choices and reduce reliance on single-occupancy car travel.<br>*Tra 8 (.88) - Deliveries and Maneuvering:* Design vehicle access areas to ensure adequate space for maneuvering delivery vehicles and provide space away from maneuvering area for garbage bins and pallets. |

and BREEAM provide prescriptive requirements for exemplary performance such as providing 95% FSC certified lumber under Mat 8 in LEED, when the requirement for Mat 8 is 50% FSC Certified lumber. LEED has a maximum of four innovation and exemplary credits which are tallied under Innovation In Design Credits 1.1-1.4. BREEAM has nine credits which outline exemplary performance guidelines, an additional fee is charged when a project attempts to achieve an Innovation credit application in BREEAM.

In addition to innovation and design, LEED provides projects a point in Innovation 2 "LEED AP" for having a LEED Accredited Professional on the design team.

Both LEED and BREEAM provide credits for using the school building as a teaching tool. LEED provides this credit under Innovation 3 "The school as a teaching tool" and BREEAM provides points for the publication of information about the building's systems and its performance in a detailed case study format under Management 9 "Publication of

Building Information" and under Management 10 "Development as a Learning Resource."

## CONCLUSIONS

There are several key differences between BREEAM Education and LEED Schools identified in this study. Each scheme has strengths and weaknesses. By looking towards the other for ideas, both schemes stand to benefit in increasing the rigor of their schemes to ensure that students, teachers and school districts get the best value for their money.

### *Strengths of BREEAM*

- *Tiered Prerequisites:* BREEAM's tiered prerequisite system, which changes based on the level of certification a project is aiming to achieve (very good, excellent, etc.), allows scheme administrators the ability to set key priorities of sustainable design in schools. The tiers ensure a project receiving an 'excellent' or 'outstanding' rating use credits that have the most impact on the building's sustainability.
- *Accountability:* In addition to earning a score and meeting the necessary prerequisites an 'outstanding' building must obtain a BREEAM In Use Certification of Performance within three years of operation (with regular reviews in accordance with that scheme) in order to maintain its rating. Projects that fail this final step are downgraded to 'excellent.' This requirement is good for all: it demands accountability which protects the owner of the project and ensures the building is operating as promised. It also provides BREEAM with valuable information about its best projects and how they are functioning post-occupancy. 'Excellent' buildings must also submit information for a case study on the buildings, or risk being downgraded. This information also serves to help researchers understand how these buildings are performing and identify potential weaknesses in the scheme.
- *Metering:* Metering of electrical uses and water consumption are important features which enable monitoring post-construction in order to identify problems, and monitor energy consumption over time. LEED would benefit from requiring sub-metering of substantial electrical equipment and meters for water efficiency and BREEAM would benefit from making it compulsory for all tiers.
- *Life Cycle Analysis (LCA):* BRE's Green Guide to Specification and Green Book Live offer designers and specification writers and designers a side-by-side comparison of the environmental impact of their specifications. These tools also allow quick comparison of products, unlike LEED which requires designers to find information themselves. These guides make identifying, specifying and selecting environmentally friendly products easy for designers and means that projects may be more likely to achieve credits related to these guides.
- *Transport:* While both schemes encourage various forms of alternative transport through their credits, BREEAM's Transport credit 5 - Travel Plan, provides a point for projects that develop a travel plan strategy for managing travel and transport within a school containing both physical and behavioral measures to combat single-occupancy car travel. Without developing and enacting such a plan the design features which were credited may go unused or underused.

### *Strengths of LEED*

- *Training:* A well-designed building may not operate to its highest efficiency if proper commissioning and training are not completed. LEED requires training of key maintenance personnel via EA 3 which is imperative to ensuring that the building operates efficiently and as it was designed.
- *Utility Monitoring and Use:* LEED requires projects to share whole-building energy and water use data with the USGBC for a period of five years post-occupancy (USGBC, 2009). This will enable LEED to analyze how these buildings are performing compared to their projected energy use and to non-certified buildings. In order to enhance the integrity of EA 1, Wat PR 1 and Wat 3, which are based on energy modeling tools, follow-through to measure the actual energy use after one year of occupancy would enable LEED to hold designers accountable for their efficiency claims and help ensure projects

which are not performing as designed do not have higher ratings than they deserve.

- *Clear Thresholds:* In setting thresholds for project to meet in the areas of energy, water consumption, and materials LEED provides projects with tangible goals for designers to achieve. BREEAM, provides credits in areas for reducing potable water in landscaping, for example, but does not set a clear threshold which defines the amount of reduction needed to qualify for the points. LEED, conversely, demands a minimum potable water reduction of 50%.
- *Lighting and Daylighting:* LEED addresses daylighting and glare control in one credit, ensuring that projects do not have substantial daylighting schemes without addressing glare issues. BREEAM does not, and should combine its daylighting and glare control credits to ensure schools are not designed with extensive daylighting features but without glare control devices.

  LEED should specify the minimum lighting levels needed in school spaces to ensure that students are getting enough light in the classroom for the tasks they are completing.
- *Indoor Air Quality:* LEED offers credits which cover IAQ during construction and pre-occupancy, an area BREEAM does not cover. These credits help protect the building from mold and mildew growth and ensure IAQ levels are satisfactory upon occupancy.
- *Heat Island Effect:* LEED addresses the heat island effect via two credits. BREEAM's lack of credits tackling the heat island effect is a serious omission which impacts both the health of occupants and energy consumption and should be corrected.

### *Room for improvement*

Both schemes could benefit from developing a specific scheme which addresses ongoing operation in areas such as pesticide use, pest control, waste management and housekeeping as they relate to schools. These topics addressed by other sustainable schools programs, such as the American Collaborative for High Performance Schools group via their Maintenance and Operations Manual (CHPS, 2004).

Neither BREEAM nor LEED address lamp and luminaries efficiency from an energy efficiency perspective. Providing credit for the installation of combined daylighting/occupant sensors would also help reduce energy costs and ensure adequate lighting levels are maintained.

Educating the community at large about the schemes and sustainability in general is critical to these schemes' success. It is not enough that the public has heard of LEED and BREEAM but that they recognize the different levels or rigor a project must undergo to achieve certification. Project owners and stakeholders must understand the risk of just ticking boxes to achieve a score and understand the importance of undertaking a whole-building approach on sustainability. One method projects can utilize to help educate the public is their websites by listing key information about their building such as: envelope performance, energy consumption, responsible material sourcing, and sustainable design techniques accompanied by graphics which help convey these concepts to a wider audience. In order to advance the cause of both LEED and BREEAM by making increasing awareness of green buildings laypeople must be able to recognize a building's 'green' features, and understand how the features work together to create a sustainable project.

Schools are an excellent place to focus on sustainability due to educational mission and because everyone in society has contact with schools at various stages in their life. The building can become a teaching example of sustainable design with graduates serving as ambassadors and champions of sustainable design or leaving with ideas for their refinement. This generation will prove critical to developing further technologies and solutions to curb reliance on fossil fuels and other natural resources.

As additional schools are certified under these schemes additional research should be completed to determine the added costs associated with certifying projects as well as the performance of these schools post-construction.

## NOTES

1. BREEAM's core credits are weighted out of 100% possible. An addition of 10% points can be achieved above this threshold for exemplary or innovative credits. Each innovation credit is worth 1% each.
2. The Collaboration for High Performance Schools (CHPS) is an organization formed in 1999 which specifically addresses environmentally conscious school environments. In 2002

CHPS created the first building rating system for K-12 schools. The organization now has a six volume best practices manual covering a variety of issues related to the design and operation of high performance schools with six, state-specific manuals: CA-CHPS, WA-CHPS, TX-CHPS, CO-CHPS, NY-CHPS and MA-CHPS (CHPS, 2009).

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