

Spatial Planning Conclusion:

With the ever increasing use of BIM software to design buildings there will be opportunities for contractors to also implement the software to handle their responsibilities. This analysis looked at the use of BIM software to complete a 4D spatial plan of trades. This process should not take a long period of time to complete and should be a simple workflow, in order for those with little computer experience but a lot of industry experience to complete. The suggested workflow took too long for the planning and therefore should not be implemented. Further problems include a loss of trade color differentiation. Research into the best practices and methods is extremely important to find for when BIM software is part of standard industry practice.

LEED:

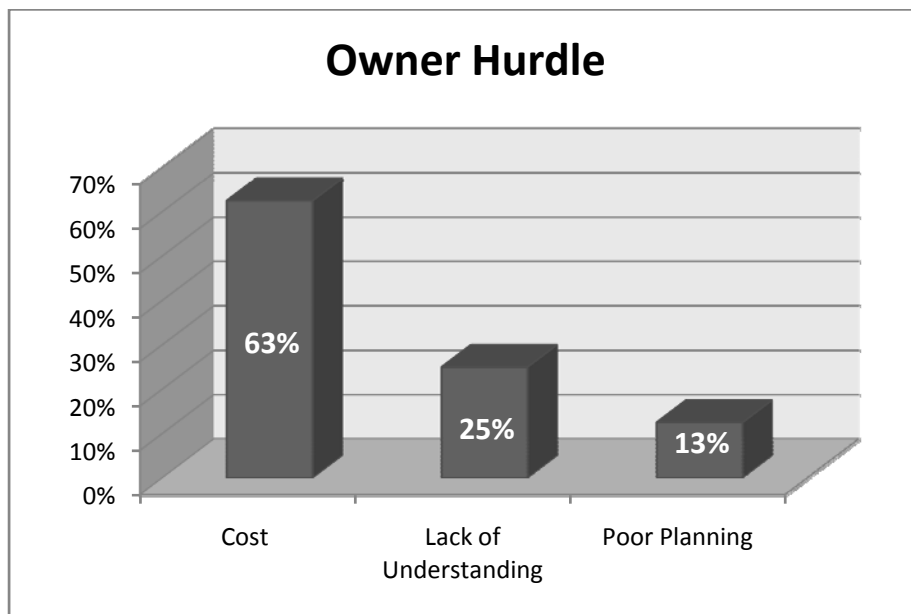
Leadership in Energy and Environmental Design or LEED is a rating system based on criteria to quantify green building design measures. LEED criteria focus on five important areas of building design and its effects on human and environmental wellbeing. These areas include site characteristics, water consumption, energy use, material selection, and interior environment. Certification levels are based on points and increase with a range of points from Certified, to Silver, to Gold, and to Platinum. Platinum is the highest rating that can be obtained. The purpose of this analysis is to understand the thoughts of industry members about owner involvement in LEED to determine where owners fall short and where they are being successful. To obtain the view of industry professional a questionnaire was sent asking for responses based on their professional experiences working on actual projects. Respondents included owners, contractors, LEED consultants, and designers.

LEED Research:

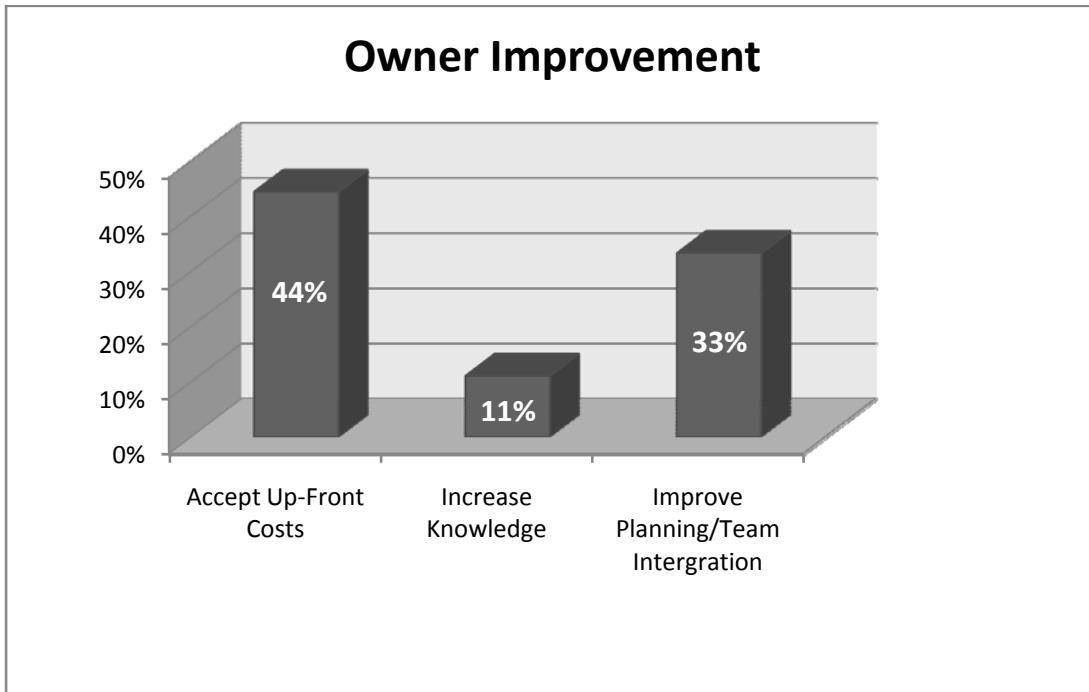
The goal of this research is to provide a useful tool to educate owners on practices that are key to sustainability success. In discussion with industry professionals at the *2008 PACE Roundtable Breakout Session: LEED Evolution* there was a consensus that owners were either too late in deciding to go LEED or not willing to commit to obtain certification. The best way to attain owner involvement on projects is to educate them and assure their understanding of what commitments will need to be made. The following report includes analysis of the LEED credit system highlighting important aspects for owners while tying in research gathered from industry professionals including owners, architects and contractors. The participants brought forth valuable information that owners wanting to develop a sustainable building should know. This research acknowledges that all owners should desire being sustainable, but that certification is not necessary to be sustainable. Nevertheless, the focus of this research has been on the LEED Criteria point system.

The following graphs are breakdowns of participants’ responses that had profound influence on the following document. It is important to note that the questions asked were open-ended and the participants did not have a bank of answers to choose from. The similarities of the answers are significant of similar thoughts across the industry. Although an attempt was made to include all regions of America most of the participants work in the Washington D.C. region. The graph will follow the corresponding question. A complete report of the questions and answers can be found in the appendix.

What problems do owners typically run into when trying to get their project LEED Certified?



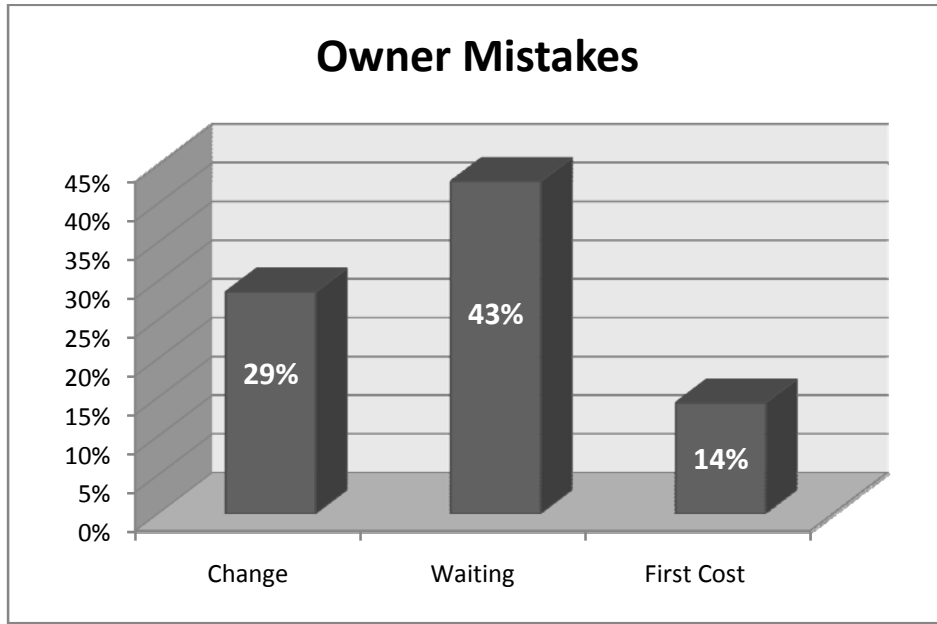
What do owners need to do differently?



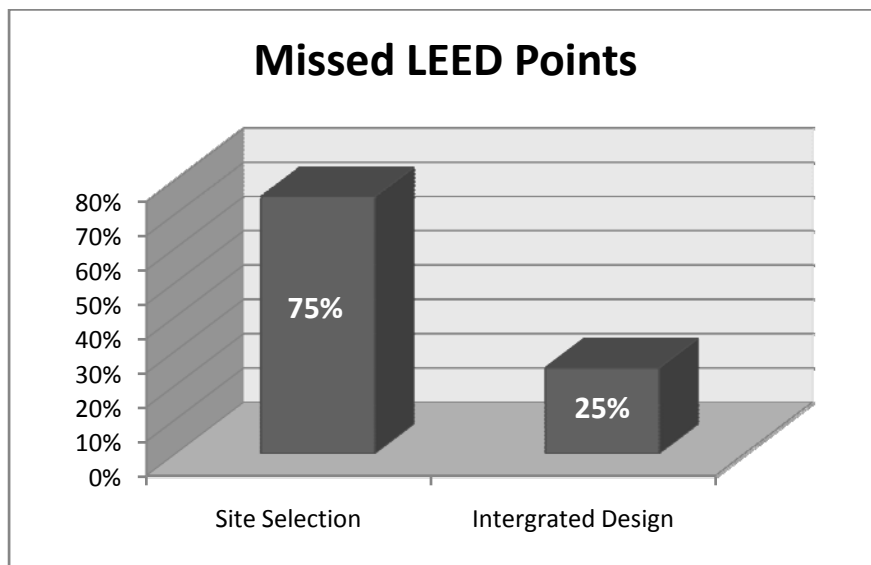
What do owners do that is successful and helps the overall project?



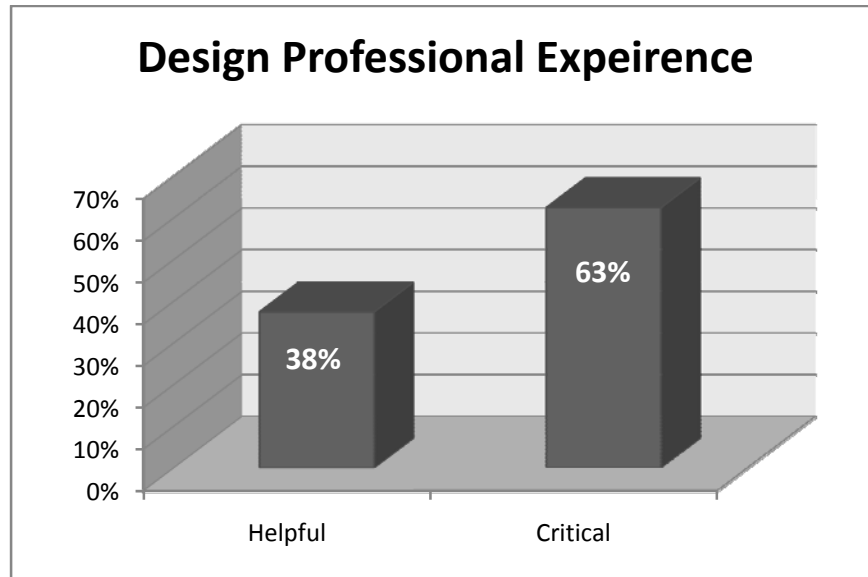
What mistakes do owners typically make that cause problems for the design/construction professionals for a project attempting a LEED Certification?



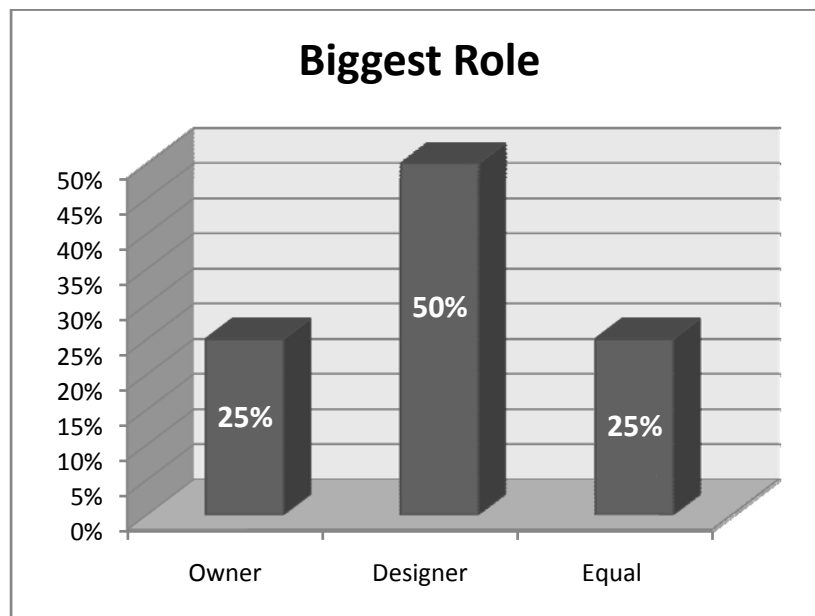
What design decisions are typically passed over without early owner commitment to LEED?



How important is the selection of a design professional that has experience and expertise with sustainable design?



Who plays the biggest role in a successful LEED Certified project?



Green Planning:

The following information provides insight to the key components in the success of designing and constructing a sustainable building. More and more owners are beginning to realize the benefits of sustainable design in terms of reduced operation costs and increased worker productivity increasing company profits. Following the guidance below will be imperative for an owner who has little experience but wants a green building. LEED is a widely accepted benchmarking tool to determine the level of sustainability. The concepts below reference LEED, but by no means is a LEED certification necessary to be sustainable.

Sustainability Goals:

Setting sustainability goals allow for the project team to measure their performance against the goals. Goals should assure that there is proper communication to provide an integration of building systems. Participants of this analysis indicated that an owner who knows their sustainability goals and are able to handle associated up-front costs are more successful than those who take a long time to make decisions or make decisions too late. Sustainability goals should be clear and concise but provide the criteria to be used to determine whether or not the design team has succeeded in meeting the goal. The best method in setting sustainability goals and communicating a commitment to the sustainability success of a project is by establishing a sustainability policy. A sustainability policy highlights the main sustainability concerns to the team. The very first part of a quality sustainability policy is announcing the owner's commitment to the environment. Sustainability goals with considerations for success should follow. The participants in this analysis also stated that integrated teams are vital to the success of sustainable buildings. Therefore, a statement stressing the importance of team members working together should be included in the policy. If there is an intention of using the LEED rating system than there should be an overview of mandatory credits that the project team must meet. Further statements on LEED can be found in the following sections. The more an owner knows what they want to achieve in terms of sustainability, the more likely that those goals will be accomplished. Furthermore, as materials and technologies change having a written policy will provide guidance for maintaining an owner's initiative of sustainability for future projects.

Design professionals:

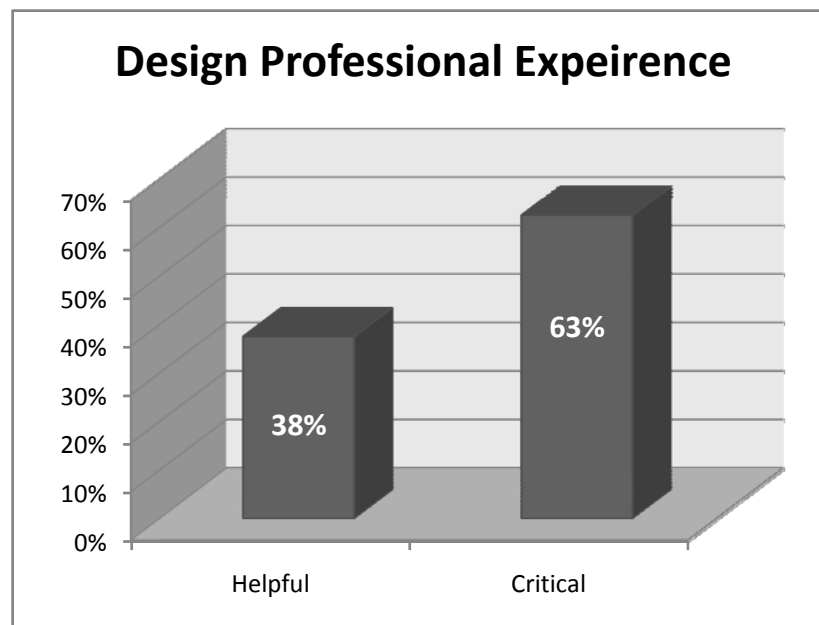
Participants in this analysis indicated that designer selection is an extremely important decision for sustainable success. The hard cost of sustainability come from the selection of materials that contain a premium for their sustainability but often pay for themselves in reduce life cycle cost. Premiums are also decreasing due to more manufactures producing material to meet demands. Nevertheless, the survey of industry professionals indicated that 63% of participant felt that the cost factor is a major hurdle for the owner to get over. In general owners are still discouraged by the notion of increased

expenses for sustainable projects. The important cost factor is the soft cost called brainpower of the design professional. Design professionals with more sustainable experience can charge less of a design fee because they have less of a burden. Therefore, as sustainable design becomes more commonplace design fees for sustainable projects will also start to decline. Professionals should demonstrate their commitment to maximizing building performance.

To appropriately select designers, look for team that:

- Are enthusiastic about sustainable design
- Are committed to maximizing building performance
- Are capable of meeting energy targets
- Contain energy/sustainability expert
- Are familiar with new materials
- Are familiar with new energy technology and analysis tools
- Proficient with sustainable rating criteria, such as LEED
- Understand code requirements
- Cite completed successful projects

The level of importance that a design professional has sustainable experience according to industry professionals is indicated by the graph L1 below.



Graph L1

An important design professional for a sustainable design is the mechanical engineer. The role of a mechanical engineer is to size the mechanical system, determine the best mechanical system strategies, and maintain an energy analysis during the development of the design. Energy modeling is an important aspect of the LEED rating criteria. As part of an option of Energy & Atmosphere prerequisite a 10% improvement must be shown with an energy model. Energy modeling can be accomplished with various software applications but all simulate the buildings energy performance. Energy modeling promotes a better understanding of the energy use and cost implications of system's design in a building. The factors that go into a useful model include building envelope, HVAC system, daylighting, lighting efficiencies and renewable energy supplies. As the design progresses, modifications must be maintained in the model. Meetings are necessary to communicate changes in energy results to the design team due to their design changes.

The cost associated with energy modeling greatly depends on the size and complexity of the project. Cost estimates range from \$0.15/SF to \$0.30/SF but generally greater than \$5,000. Performance based fees reward the effort for minimizing the project's life cycle cost and reward the designer for not over-sizing equipment. The implications involved with setting performance based fees are establishing clear goals along with how performance of those goals is to be measured, providing a fee schedule showing how the fee relates to success in meeting the goal, and a protocol for resolving disputes without expensive litigation. An owner should demonstrate their cooperation in sustainable design by establishing a minimum fee, to reduce the engineer's risk.

LEED Criteria Rating System:

On April 27th, 2009 the U.S. Green Building Council, the creator of LEED, will be implementing a new version of LEED called LEED v.3.0 or 2009. The exact name of this new version seems to change from document to document. This report uses the term v.3.0 to easily differentiate between LEED v.2.2. However, the restructuring and alignment of LEED provides an easier way to make multiple changes for updates similar to building codes. Therefore, it is believed that the actual name will be LEED 2009 so that the latest and most recent version will be highlighted. The changes to LEED include a restructuring of points such that more points can be awarded to more credits that provide a greater positive impact on the environment. The following analysis highlights the different credits.

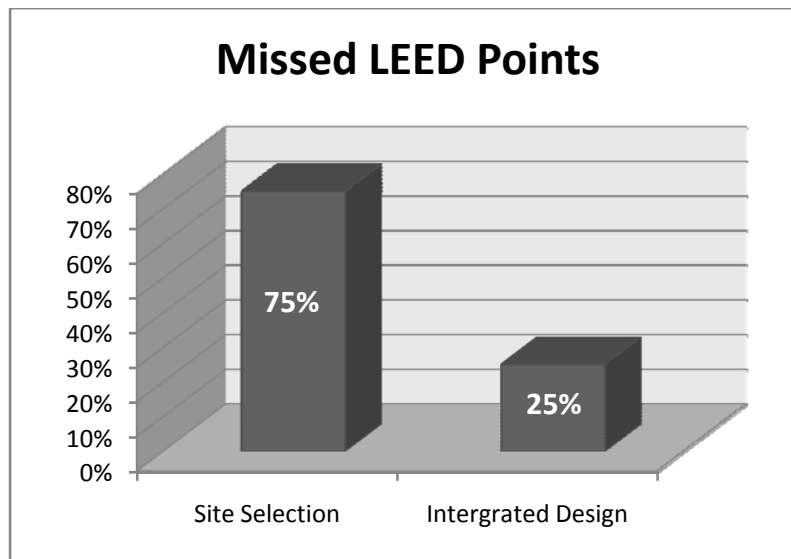
Site Selection:



The category of site selection rewards points for developing in a location that will minimize the effects on the local ecosystem. The prerequisite to obtain points for site selection includes reducing pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation. This is a rather simple and straight forward prerequisite to meet. The criteria for points of site selection includes not developing on environmentally sensitive areas, developing in urban areas, rehabilitation of damaged sites, reduction of pollution from automobile use, protecting natural habitats, reducing development effects on natural water flows, reduce the heat island effect, and reduce nighttime light pollution.

The following highlights the changes from LEED v2.2 to LEED v3.0. In the LEED v2.2 the development density and community connectivity credits, which recognizes development in urban areas, was only worth one point. In the version 3.0, meeting this credit is worth five points. In the v2.2 alternative transportation: public transportation access was worth one point and in the new v3.0 this credit is worth 6 points. Also, the credit for alternative transportation: low emitting & fuel efficient vehicles was worth one point under v2.2 and now is worth 3 points under v3.0.

The choice of where to locate a new building can have a major effect on its long term environmental impact. Participants in this analysis indicated that site selection is often overlooked, shown in graph L2 below.



Graph L2

This generally is because an owner is developing a preexisting land asset or LEED is considered after the fact. Furthermore, the overall efficiency of the building can be completely minimized if the building's site is causing harm to the environment, by interfering with natural water flows, displacing wetlands, or damaging local biodiversity. There are three best options for site development, these are building renovation, brownfield and infill development. Renovating existing buildings reduces

construction cost while salvaging existing materials. Brownfield sites are abandoned industrial areas that need certain level of remediation before new construction. Infill sites are vacant sites within an established urban area. These options are beneficial because they tend to have lower infrastructure costs because sewage, electric, gas are already in place. Also these sites are generally near other commodities such as schools, businesses, retail which enhances the convenience of occupants.

Water Efficiency:

The purpose of water efficiency is to reduce the amount of water supply required for a building and to reduce the amount of water entering storm and sewer lines. Prerequisite to obtain points for water efficiency is a water use reduction of 20%, which use to be worth a point in LEED v.2.2. Criteria to obtain points for water efficiency include reducing the amount of potable water for irrigation, reducing the amount of wastewater, and increasing the building efficiency to reduce the needed water supply and generated wastewater. Water efficiency is based on a point scale directly relating to the amount of efficiency. The new range rewards points for 30%, 35%, and 40% reduction in water use. A simple method to obtain these credits is to use low-flow water fixtures. A great resource to find a manufacture and product of these fixtures is the Water Sense program by the U.S. Environmental Protection Agency.

Energy and Atmosphere:

The purpose of Energy and Atmosphere criteria is to optimize building energy performance. Prerequisites for energy and atmosphere include basic commissioning on energy related systems, establishing a minimum level of energy efficiency, and refrigerant management. Criteria to obtain points for energy and atmosphere includes reducing the required building energy, generating on-site renewable energy, enhanced commissioning, enhanced refrigerant management, measurement and verification plan, and obtaining energy from renewable energy providers. LEED v. 3.0 places a greater emphasis on energy efficiency by making more points available, compared to LEED v.2.2. In LEED v3.0 32% of the points available come from energy and atmosphere criteria compared to 24% of LEED v.2.2.

Energy Optimization:

In LEED v 3.0 points for optimized energy performance have 19 points available based on amount of increased performance. This is a section of high importance to the U.S. Green Building Council. Performance is based on a baseline performance set by ASHRAE Standard 90.1-2007 building project simulation. The number of points acquired is determined by the level of energy performance.

Renewable Energy:

On-Site renewable energy can obtain up to 7 points based on the percentage of energy produced. This is a change over LEED v.2.2 which only offered a maximum of three points. Using photovoltaics and wind turbines are common methods of creating renewable energy.

Measurement and Verification Plan:



The points obtainable for an ongoing measurement and verification plan have increased from one to three points to increase the incentive to assure building system performance. Rapidly rising energy costs provide a direct incentive to assure building systems are functionally properly.

Energy Programs:

LEED offers the opportunity to buy power from a utility company that generates renewable energy. Green-e Energy is a certification program that assures funds go to the development of new energy generating project.

Materials and Resources:

Materials and Resources credits are awarded for reduction in waste from the selection and use of sustainable materials. Prerequisite for materials and resources include recycling of paper, corrugated cardboard, glass, plastics and metals. Criteria to obtain material and resources points include reuse of existing building structure, recycling of construction waste, reuse building materials, use of recycled material, use of locally manufactured materials, and use of rapidly renewable materials.

Materials and Resource section has not received too many changes in the need v3.0 version. The main point change came from an increase points awarded to higher percentages of building reuse. The selection of material and where to obtain them have an important impact to the sustainability of a new building. Buildings that use renewable resources or recycled resources are more sustainable than those that do not. Materials should also be manufactured locally and should not include harmful toxins. Greenguard Environmental Institute operates a certification program of building products with low toxins. The selection of the right materials can be easy points. The design professionals should have the experience and knowledge to determine the best sustainable materials for the building. There are several programs that aid in the material selection. These programs include the global ecolabing network, green seal, and green spec listed. During construction extra attention may be needed to assure contractors are complying with waste recycling. Compliance is most effective by the owner, superintendent and other upper management stressing the issue.

Indoor Environmental Quality:

The purpose indoor environmental quality credits are to maximize occupant health and comfort. Prerequisites for obtaining indoor environmental quality credits include establishing a minimum indoor air quality performance which meets ASHRAE 62.1-2007 Ventilation for Acceptable Indoor Air Quality and reducing tobacco smoke to the interior of the building. Criteria for obtaining indoor environmental quality credits include monitoring ventilation system, increasing ventilation, reducing construction contamination, use nontoxic materials, minimize exterior hazards from entering building, zonal control of lighting, zonal control of air temperature, thermal comfort, and daylighting interior spaces. ASHRAE 62.1-2007 is an important standard regarding the design of the ventilation system. It is referenced often as minimum design standard needed to be reached to obtain points. Another important standard is ASHRAE Standard 55-2004 which sets the requirements for thermal comfort. Air quality should be

protected by ensuring adequate ventilation and locating air intakes away from exhaust vents and loading docks. Carbon dioxide monitors should be installed to ensure adequate ventilation. Heat recovery ventilators can capture heat from the exhausted air. During construction it is important to ventilate finishes and building materials to improve indoor air quality. Indoor environment has the largest impact on the occupants. Points are given for the increased capacity of an individual to determine what their own zonal conditions, including thermal comfort and lighting comfort. Daylighting is a cost effective lighting solution to reduce the need of artificial light resulting in energy and cost savings. Daylighting has an additional benefit in that occupants of daylit space are more productive and have a greater satisfaction in their work.

Innovation & Design:

These credits are assigned to stimulate new ideas and uses of new materials and products to design better and better buildings. The purpose of these credits is to seek improvement instead of replicating what worked last time.

Regional Priorities:

Regional priority credits are new in LEED v3.0. They have been created to address geographic specific environmental priorities. U.S. Green Building Council regional committees are working to establish a database of priorities. Rod Letonja of Envision Design and committee member of The Metropolitan Washington Council of Governments Intergovernmental Green Building Group, identified six priorities for the Washington D.C. area. These priorities are listed below:

- Watershed protection and stormwater management
- Energy efficiency and renewable energies
- Public transportation, density, and sprawl
- Heat island effect
- Waste management (construction and long term)
- Indoor air quality

LEED Point Change Summary



The table below has been created to better highlight the changes mentioned above.

Credit	LEED v2.2	LEED v3.0
SSc2 Development Density & Community Connectivity	1 point	5 points
SSc4.1 Alternative Transportation, Public Transportation Access	1 point	6 points
SSc4.3 Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	1 point	3 points
SSc4.4 Alternative Transportation, Parking Capacity	1 point	2 points
WEp1 Water Use Reduction, 20%	1 point	New Prerequisite
WEc1.1 Water Efficient Landscaping, Reduce by 50%	1 point	2 points
WEc1.2 Water Efficient Landscaping, No Potable Use or No Irrigation	1 point	2 points
WEc2 Innovative Wastewater Technologies	1 point	2 points
WEc3 Water Use Reduction, 30%	1 point	2 points
WE c3 Water Use Reduction, 35%	N/A	3 points
WE c3 Water Use Reduction, 40%	N/A	4 points
EAc1 Optimize Energy Performance	1 – 10 points	1 – 19 points
EAc2 Onsite Renewable Energy	1 – 3 points	1 – 7 points
EAc3 Enhanced Commissioning	1 point	2 points
EAc4 Enhanced Refrigerant Management	1 point	2 points
EAc5 Measurement & Verification	1 point	3 points
EAc6 Green Power	1 point	2 points
MRC1.1 Building Reuse, Maintain 55% of Existing Walls, Floors & Roof	N/A	1 point
MRC1.1 Building Reuse, Maintain 75% of Existing Walls, Floors & Roof	1 point	2 points

MRC1.1 Building Reuse, Maintain 95% of Existing Walls, Floors & Roof	2 points	3 points
IEQc4.3 Low-Emitting Materials, Carpet Systems		Low-Emitting Systems, Flooring Systems 1 point
Regional Priority Credits	N/A	1 – 4 points

Table L1

To provide a convenient and easily accessible way to view the information presented in the above sections a pamphlet has been created. This pamphlet encourages owner involvement through basic education of LEED points and useful resources. This pamphlet contains information to guide owners with sustainability goals pertaining to buildings. It also steps through the different LEED criteria highlighting the basic requirements.

LEED Conclusion:

This analysis shows the areas of improvements for owners. Owners need to understand the cost factors associated with sustainable systems. First costs are generally higher; however the life cycle costs are lower. Also, sustainable choices will lead to happier occupants. This can translate to higher rental revenue or increased worker productivity, depending on building type. The choice of design professionals is also extremely important. Professionals who know the best sustainable products and systems that can be implemented and know how their decisions may affect others will bring invaluable experience to the project. This analysis shows that industry professionals feel that the design professional plays the largest role in a successful project. Finally, this analysis shows that owners can improve the likelihood of success for a project by clearly stating their sustainability goals and being committed to sustainable products and systems in their building.

C. Acknowledgements:

