INCORPORATING GREEN-BUILDING DESIGN PRINCIPLES INTO CAMPUS FACILITIES PLANNING: OBSTACLES AND OPPORTUNITIES

A thesis presented to

the faculty of

the College of Arts and Sciences of Ohio University

In partial fulfillment

of the requirements for the degree

Master of Science

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June 2006

This thesis entitled

INCORPORATING GREEN-BUILDING DESIGN PRINCIPLES INTO CAMPUS FACILITIES PLANNING: OBSTACLES AND OPPORTUNITIES

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Abstract

BROWN, KYLE A., M.S., June 2006, Environmental Studies

INCORPORATING GREEN-BUILDING DESIGN PRINCIPLES INTO CAMPUS FACILITIES PLANNING: OBSTACLES AND OPPORTUNITIES (111 pp.)

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This thesis addresses the obstacles and opportunities of incorporating principles of the Leadership in Energy and Environmental Design (LEED) Green Building Rating System in a new building project, the Integrated Learning and Research Facility (ILRF), located on the Ohio University campus. Through review of ILRF project documents, interviews with Ohio University building planning and maintenance staff as well as design professionals from private firms, and a literature review, obstacles were identified. These obstacles include a lack of interest in LEED from project owners, an inadequate knowledge of LEED by the design team, insufficient funding mechanisms for green features, a lack of incentives for project architects to pursue LEED, and the need for more data regarding performance of existing buildings on campus. A literature review, a detailed examination of ILRF project meeting minutes, and interviews with Ohio University building planning and maintenance staff as well as design professionals from private firms, are used to make recommendations for future efforts to incorporate LEED into building design on the Ohio University campus.

Approved:

Mary W. Stoertz

Associate Professor, Geological Sciences

Acknowledgments

In the last 4 years I have been involved in some very special projects at Ohio University. These projects include the creation of an environmentally minded student organization; efforts that set the stage for a multi-million dollar biodiesel research project; founding of the OU Ecohouse; and finally, the drafting of this Master's Thesis document, focused on incorporating green design principles in campus buildings. Each development led to the next and I'm excited to see what's in store for the future at Ohio Universtiy.

Although she might not admit it, or even be aware, Dr. Mary Stoertz has personally opened more doors for these efforts than any other individual. I would like to express the deepest gratitude to her for offering what was so much more than just instruction and support. Dr. Stoertz offered wisdom, and she put herself out on the line a number of times to make things happen. She is also as much of a friend as she is an advisor. Thanks Mary.

I would also like to thank my parents. They generously provide what has always been my greatest backing. Their encouragement, guidance, and concern for my well-being have made many things possible in my life that would not have been otherwise.

Finally, I would like to acknowledge the Ohio University Planning and Implementation office (especially Pam Callahan); the Architects at Burgess and Niple; Sustainable Design Consulting LLC; Ron Chapman of OU facilities; Andy Sinozich of Cinergy Solutions; and committee members Dr. Castro and Dr. Stuart for answering questions and providing much needed direction for this thesis project.

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Chapter 1: Introduction

Green or "high performance" building has re-emerged recently as a way to reduce the energy demand of the built environment. To provide a framework for better green design, The United States Green Building Council unveiled their Leadership in Energy and Environmental Design (LEED) Green Building Rating System in 1999. LEED is the foremost system used in the United States for certifying green buildings and was estimated to have realized a 3% market penetration in new commercial construction by the year 2004 (realator.org). For this reason, my thesis will use the LEED system as a basis for the definition of "green design."

A number of comprehensive studies have proven the effectiveness of LEED at reducing long-term operational costs of the built environment. Ohio University recently set a goal to achieve a LEED Certified rating (the lowest level of LEED certification) for a new building project, the Integrated Learning and Research Facility (ILRF), on its main campus. However, Ohio University will not seek certification of the project by the USGBC, which requires verification of results by a third-party consultant.

Meeting LEED goals without pursuing project certification by the USGBC has become common among green building projects, as the actual certification costs money and does not directly contribute to long-term operational savings. However, it is possible that the absence of formal certification will diminish the overall consideration of LEED principles during the planning process. The ILRF project allows for examination of this question.

Purpose of Study

This thesis addresses the obstacles and opportunities of incorporating principles of the Leadership in Energy and Environmental Design Green Building Rating System in Ohio University's future building projects. Studies indicate that LEED offers financial, educational, and environmental benefits when incorporated into building design. A number of factors make these benefits desirable to Ohio University.

Long-term funding for higher education in the state of Ohio and future energy prices are both undetermined, so initiating budget-reducing programs that do not diminish educational quality should be an immediate priority. This thesis focuses on resource-use efficiency of the built environment as a means of generating long-term economic returns and increased financial stability at Ohio University.

Ohio University's mission statement declares intellectual and personal growth of students as its central focus. Ohio University awarded more than 5,000 degrees in the year 2004 (Ohio1, 2006). Providing the best possible environment for learning is also by implication a top priority for the University. Evidence is presented in the literature review regarding educational benefits of the LEED Green Building Rating System.

Environmental concerns are a part of running any business or institution. Ohio University has been a leader in environmental concern with its commitment to energy efficiency as well as its nationally recognized recycling program. The LEED system provides a template for creating cleaner and safer buildings. The system encourages reduced resource use, provides guidelines for sustainable land use, and outlines strategies for improved indoor environmental health and safety.

The continual process of campus construction, renewal, and maintenance presents an opportunity to examine numerous aspects of facilities and operation related to energy efficiency. The overall goal of this thesis is to set the stage for a much larger research project, which will use the planning process at Ohio University as well as University structures and energy data as tools for studying the implementation of high-performance building practices in design and construction.

Campus Description

Ohio University, a four-year public university, was founded in 1804, and accommodates over 19,000 students and approximately 1,000 full-time faculty members on its main campus. The main campus is set in rural southeast Ohio, spans 1,700 acres and comprises approximately 157 buildings, including dormitories, laboratories, lecture halls, office space, and support buildings.

Ohio University has been a state leader in implementing energy conservation measures since 1999 when it developed a performance contract with Vestar (now Cinergy Solutions), an energy services company. This project, called *The Campus Renewal Project*, improved the energy efficiency of Ohio University primarily through building retrofits and the addition of a chilled-water plant. Significant savings have been realized as a result of forgone energy costs.

Ohio University's annual budget totals approximately $525 million dollars and the University remains in good financial standing (OHIO JOB APP). However, energy price spikes and decreasing funding for higher education in Ohio's state budget have recently caused financial concern on campus. More than $300 million dollars was cut from the state budget for higher education between 1999 and 2003 (The Free Press). As state funding for higher education has declined, state universities have been forced to find other sources of revenue or retool their budgets. In some cases, tuition increases, budget cuts and other budget restructuring efforts have not been able to compensate for the recent reduction in state funding for higher education.

An unpredictable energy market caused concern at Ohio University during the winter of 2006 when natural gas prices rose 60% and the price of coal increased between 20 and 25%. Ron Chapman, Ohio University's Energy Management Director, stated that this increase amounted to a $1 to $1.2 million increase in Ohio University's energy costs during the 2006 fiscal year (Yates 2006).

Chapter 2: The Built Environment and Green Design

Environmental Impacts

The phrase “built environment” refers to human-made structures and settings that provide shelter, transportation, and other functions for human activity. America’s relatively high standard of living is partially a result of our highly developed built environment, which represents one of the country’s largest stores of physical wealth. Millions of structures have been built in the United States and each year new ones are added. In 2004, the U.S. Census (19,000 Place-Series) reported 2,052,100 permits for new residential construction (U.S. Census 2004). In 1998, the U.S. EPA reported that approximately 170,000 commercial buildings are constructed annually in the U.S. (Franklin Associates 1998). Although America’s sophisticated built environment contributes directly to human health and wellbeing, it also poses health risks, is a considerable stress to environmental systems, and draws substantially on the world’s natural resources.

Materials

New construction, renovation, and demolition of buildings in the United States impacts natural resources and environmental quality worldwide. According to a 1995 study by the World Watch non-profit group, buildings account for 40 percent of global virgin stone, gravel, and sand (approximately 3 billion tons) used on an annual basis (Roodman 1995). According to the same study building construction also consumes 25 percent of global virgin timber harvest on an annual basis.

Waste

According to a U.S. EPA document regarding impacts of the built environment, 245,000 houses and 44,000 commercial buildings are demolished annually in the U.S. (Franklin Associates 1998). This activity generates a wealth of recyclable and reusable material as well as a tremendous amount of waste. In 1998, construction and demolition activity in the U.S. generated 136 million tons of refuse. This refuse was generated by demolition (48%), renovation (44%), and new construction projects (8%), and excludes debris from excavation such as trees, rock, and earth (Figure 2.1). Only 20 to 30 percent of construction and demolition waste (mostly concrete, asphalt, metals and some wood) was recycled or reused (Franklin Associates 1998). According to The Eastern Research Group (2001), debris from construction and demolition of buildings fills 35 percent of total land-filled space in the United States every year. 13.8 million cubic yards of construction and demolition debris was deposited in Ohio landfills in 2003 (Ohio EPA 2004).

Energy

Compared to other developed nations such as Canada, Australia, Japan, China, Mexico and European nations, the United States consumes a relatively large amount of energy per capita (EIA1 2005). Of these nations, only Canada's per capita consumption rate is higher (Figure 2.2). In the year 2003, 98.1 Quads of energy (1 Quad is equal to 10^{15} Btu's) were consumed in America, marking the second highest rate of consumption in U.S. history (Figure 2.3). Only in 2000 did Americans use more energy, with 98.9 Quads consumed (EIA2 2005). Also, 2003 marked the highest rate of energy import (as ratio to total energy used) in the preceding decade and the largest total imported amount ever, as the United States imported 31.3 percent (31 Quads) of total energy used (Figure 2.4). Although only 4 percent (4 Quads) was natural gas, this marked the highest rate of natural gas import in the preceding decade (Figure 2.5) (EIA3). Combined use by residential, commercial, and electric-power producers represented approximately 59% of total natural gas consumption in 2004 (EIA4 2005).

The built environment consumes a substantial amount of energy. Commercial and residential buildings accounted for 19 percent of total primary U.S. energy use in 2003 (EIA5 2005). Five of the top six energy-consuming activities in commercial buildings include space heating, space cooling, water heating, ventilation, and lighting, which are all affected by building design (EIA6 2005). Remaining primary energy was consumed by the industrial sector (35%) and transportation (45%). It should be noted that total energy use of the entire built environment is higher than 19 percent because some of the energy consumed by the industrial sector is used for heating, cooling, or illuminating industrial buildings (Wilson 2001).

Because total energy use includes mobile energy use for transportation, a different category than stationary energy use, a better indicator of the built environment's impact on energy is total electricity consumption. Combined residential and commercial use of electricity accounted for 68.5 percent of total electricity use, with industry consuming 28.3 percent in the year 2003 (EIA7 2004). Again, total electricity use for buildings is higher than 68.5 percent because some of the electricity used by the industrial sector was used for building operation.

Considering the large amount of energy used specifically for building operation, environmental impacts of the built environment are sizeable. Combined production by renewable energy sources (geothermal, solar power, and wind, but not including hydroelectric dams) accounted for less than 5% of the total (Figure 2.6).

Fossil fuels account for most energy production in the United States. In 2003, coal-fired power plants supplied the largest portion of domestically produced energy (33 percent) followed by natural gas (28 percent) (EIA8 2005).

In 2001, energy consumed in Ohio, not including energy for transportation, was supplied by coal (50%), natural gas (31%), Nuclear (6%), and 1% or less of various renewable energies. In 2002, Ohio ranked 6th in net generation and 4th in the nation for retail electricity sales (EIA9 2004). Because Ohio operates some of the oldest coal power plants in the nation, which are not required to meet 1990 Clean Air Act regulations, the state has the highest emission rates in the country. In 2002, Ohio ranked 2nd in production of carbon dioxide and was the nation's top producer of nitrogen oxide (NO_x) and sulfur dioxide (SO_2) (EIA8 2004). Once emitted, NO_x and SO_2 can be transformed to acid components (H_2SO_4 and HNO_3) in the atmosphere, causing acid rain. Acid deposition causes acidification of water, harms fish populations and can decrease plant growth and yield. In the lower atmosphere, NO_x can create ground level ozone or "urban smog", which is a strong lung irritant. NO_x exposure can also result in both acute and chronic health effects. SO_2 is easily absorbed into the human upper respiratory system and can cause irritation, swelling, and constriction of the airway. Long-term exposure to high concentrations can lead to lung disease and aggravate cardiovascular disease (Allen 2002).

In a press release issued on July 8th, 2005, members of the G8 (leaders of the world's major industrial economies), including the United States of America, France, the Russian Federation, United Kingdom, Germany, Japan, Italy, and Canada, acknowledged that "climate change is a serious and long-term challenge that has the potential to affect every part of the planet". Although carbon dioxide is not listed as a Criteria Pollutant under the Clean Air Act, it is a known greenhouse gas (GHG). In 2003, U.S. carbon dioxide emissions from the production of electricity totaled 2,279.3 million metric tons. Residential and commercial electricity use accounted for 38.7 percent of total energy-related CO_2 production (EIA10 2004). In 1999, U.S. total greenhouse gas emissions associated with residential and commercial-sector energy consumption accounted for 30 percent of the total emissions. In 1991, 60 percent of the ozone-depleting materials used annually in the U.S. were used for building construction and systems (Wilson 2001).

Water

Buildings also account for a large percentage of annual U.S. water use. 1995 U.S. Geological Survey data indicate that commercial and residential water consumption accounts for 12.2 percent of annual water use (Wilson 2001). Remaining water use was accounted for by industrial purposes (8.2%), electricity generation (38.7%), and agriculture (40.9%). Because commercial and residential sectors, as well as industrial structures, account for more than 70% of total electricity demand, and electricity generation accounts for 38.7% of water use, total water use for those sectors is actually higher than 12.2 percent. According to Roodman (1995), water use in buildings accounts for 16 percent of total water withdrawals worldwide. In areas such as the Western States in the U.S., water use is an environmental issue. Even with the use of dams, some areas in the American West are now “mining” aquifers, meaning they are withdrawing more water than is naturally recharged each year (Vorosmarty, 2000).

In Ohio, too much water is more often a problem than too little. Flooding poses a threat to Ohio University, which owns many structures located in the floodplain of the Hocking River. Buildings are vulnerable to flooding but also play a role in increasing flooding. The built environment transforms naturally vegetated areas to impervious surfaces, increasing the volume of storm water generated during periods of precipitation, causing increased peak discharge and frequency of floods (Konrad 2003). The area of constructed, impervious surface in the United States is extensive. Parking and driveways in America total more than 10,900 square miles. Adding roadways and other compacted surfaces, this total increases to 35,400 square miles, which is roughly the size of Illinois (Konrad 2003). This figure doesn’t include building footprints (the ground surface covered by the building) and walkways, which would increase the total further. Because strategies exist to decrease storm water runoff without reducing building footprints, the nature of the footprint is also an important architectural issue. Konrad shows the effects of urban development on flood discharge and frequency by comparing data from Mercer Creek, an urban stream in western Washington, and a similar nearby rural stream, Newaukum Creek (Figures 2.7 and 2.8). Mercer Creek’s total discharge increases faster and has higher peaks than does Newaukum Creek’s discharge. Data also show a clear increase in annual maximum discharge on the Mercer Creek between 1960 and 2000 (presumably due to increased development) while Newaukum Creek did not exhibit the same trend.

Human Health

Indoor environmental quality is considered a critical component of the built environment, as it is estimated that people spend up to 90% of their time indoors (EPA1 2005). Spending so much time indoors presents a risk because of overexposure to sometimes unhealthy indoor environments. Common indoor pollution sources include combustion gasses from oil, gas, kerosene, coal, wood, and tobacco; off-gassing of building materials including insulation, carpet, and furniture; and fumes from cleaning products. These materials emit an array of fumes, some of which contain potentially carcinogenic, mutagenic, and/or endocrine-disrupting chemical compounds (McDonough 2003). Air within buildings can be more polluted than the outdoor air of large industrialized cities, posing a risk to human health. Specific building-related health risks include Legionnaires' disease, aggravated asthma, hypersensitivity pneumonitis, and humidifier fever (EPA1 2005).

Contemporary Green Design

Data on the impacts of the built environment on natural systems and human health has increased rapidly in the last decade. Scientists, engineers, environmental groups and building-industry professionals have never had a better understanding of the impacts of the built environment. In an effort to cut utility costs, conserve resources, and ensure human health, a number of studies have been done that indicate how we might construct a more efficient and healthy built environment. This design philosophy, dubbed "green design" or "sustainable design," puts an emphasis on human and environmental health, as well as profitability.

By many accounts, the modern sustainable design movement started in the mid 1970's as a result of the oil crisis during that time period. The original term for green design as we know it was "Energy Conserving Design" (Mclennan 2004). As indicated by its describing term, this movement didn't progress much beyond solar energy and conservation as the answer to a call for more efficient design. The field has progressed much since that time, and is now referred to by the all-encompassing term "sustainable design," implying no exhaustion of energy, material or human resources. The movement began to broaden in the 90's and now includes improving indoor environmental quality, conserving materials and resources, conserving prime habitat, promoting water efficiency, reducing emissions, and promoting the general welfare of human inhabitants.

The United States Green Building Council

In 1993 the Washington-based, national non-profit, United States Green Building Council (USGBC) was created by building-industry professionals to develop programs, products and resources that promote environmentally responsible building practices worldwide. Merely 10 years later in 2003, approximately 4 percent of all building projects in the United States were pursuing green certification by the USGBC (Mclennan 2004). According to a report by Greg Kats (2003) of the energy consulting firm Capital E, a recent surge in green design can be attributed to a number of factors:

- The increasing cost of electric power;
- Problems associated with power quality and availability;
- Water shortage and wastewater-disposal costs;
- State and federal pressure to cut criteria pollutants;

- Growing concerns over global warming;
- An increase of asthma and allergy cases, especially in children;
- Concerns about health and productivity of workers;
- Psychological effects of the school environment on child development;
- Increasing operation and maintenance costs of buildings.

The United States Green Building Council (USGBC) continues to lead a new wave of green building activity. The USGBC is "the nation's foremost coalition of leaders from across the building industry working to promote buildings that are environmentally friendly and profitable" (USGBC, 2004). Members forge alliances among industry, research organizations and government agencies to transform the building industry. The goal of the USGBC is to lead the way to a national consensus for producing the next generation of buildings designed to deliver maximum operational efficiency while maintaining a healthy work environment and minimizing negative impacts on the larger environment.

USGBC membership is diverse, and includes representatives from across the building industry: engineers, architects, contractors, environmental consultants, interior designers, landscape architects, building-product manufacturers, financial and insurance firms, nonprofit organizations, state, local and federal governments, building control service contractors and manufacturers. All USGBC policy decisions require a 2/3 majority vote.

Leadership in Energy and Environmental Design (LEED)

The most successful program of the USGBC is its Leadership in Energy and Environmental Design Green Building Rating System (LEED). LEED is a "voluntary, consensus-based national standard for developing high-performance, sustainable buildings" (USGBC, 2004). This standard is the foremost system in the United States for certifying green buildings. For this reason, my thesis uses the LEED system as a basis for the definition of "green design" for analysis of the OU planning process. According to the Green Building Council, LEED was created to do the following (among other things):

- Facilitate positive results for the environment, occupant health and financial return;
- Define "green" by providing a standard for measurement;
- Prevent "greenwashing" (false or exaggerated claims about environmental friendliness);
- Promote whole-building, integrated design processes; and
- Provide a guideline for green design.

The LEED Green Building Rating System is essentially a comprehensive checklist for designing, constructing, operating and certifying energy-efficient, healthy buildings (Figure 2.9a,b). This evolving framework specifies building standards for "green" buildings in five environmental categories. These categories are Indoor Environmental Quality, Sustainable Site Selection, Water Efficiency, Energy & Atmosphere, and Materials & Resources. The five categories together are allocated 32 credits. The credits in turn are subdivided into 65 possible core points. Up to 4 points for

Design Process & Innovation are available for building strategies not mentioned in the LEED system that align with the overall principles of the system, and are subject to approval by the USGBC. For example, a campaign to educate building occupants on user strategies for conserving energy has been awarded points in previous projects.

Points are earned by meeting specific base requirements for each credit, and additional points are awarded for the level of performance met. However, seven prerequisites must be met before any points are awarded. Prerequisites are basic requirements most likely met by any traditional project, but they need to be verified according to LEED requirements. They include controlling sediment on the construction site, confirming proper function of building components, meeting minimum energy efficiency requirements, reducing CFC in HVAC systems, providing collection centers for recyclables, meeting base requirements for indoor air quality, and controlling for tobacco smoke within a building. The number of points a building receives for design and construction process ultimately determines what rating the building will receive. LEED currently offers 4 rating levels; Certified (26-32 points), Silver (33-38 points), Gold (39-51 points), and Platinum (52+ points).

LEED for Labs

Labs 21 was created by the Department of Energy and the U.S. Environmental Protection Agency to address the additional energy demand for laboratories. Health and safety concerns for laboratories require increased ventilation. This environment differs dramatically from non-lab building space and is not adequately addressed by LEED 2.1.

Labs 21 is used in conjunction with LEED 2.1 when lab space is included in a building program.

LEED-Related Research

Along with the new wave of green construction projects has been a surge of research and new data on the effectiveness of green building. The new studies explore economic, environmental, and educational benefits and costs of green design. Capital E's *The Cost and Financial Benefits of Green Buildings* was prepared for the state of California's Sustainable Building Task Force in 2003. It was the most detailed and comprehensive cost analysis of green buildings to date. The Davis Langdon Consulting Firm's 2004 *Costing Green: A Comprehensive Cost Database and Budgeting Methodology* draws on data from 600 different building projects in 19 different states to offer a detailed point-by-point credit evaluation of the LEED Green Building Rating System and a cost comparison of LEED vs. non-LEED construction. Steven Winter Associate's 400+ page *LEED Cost Study*, prepared for the U.S. General Services Administration, identifies the point-by-point cost of each LEED credit as it relates to the construction of two specific building types: A new mid-rise federal courthouse, and a mid-rise federal office-building modernization. Additionally, the *Environmental Building News Journal* and other sources, through individual case studies, offer sufficient data to effectively measure the value of green building design. All of these sources of information will be used as background research to evaluate the effectiveness of incorporating green design into Ohio University's planning process.

Capital Costs of LEED

Davis Langdon Consulting's *Examining the Cost of Green* (2005) determined that projects that do not strive to meet LEED certification requirements achieve between 15 and 25 points on average simply using traditional designs (29 points are required for basic LEED certification). About 12 of these points can be earned without any design changes, on the basis of a building's location. The study identified 18 points available with minimum effort and little or no additional cost (Davis Langdon Consulting 2005).

The same study indicates that comparably sized projects, built with the same function in mind, have standard cost deviations that vary widely. In a database of 138 projects (45 LEED-seeking and 93 non-LEED-seeking) normalized for time and location, LEED-project costs were evenly distributed among non-LEED-project costs on a cost scale (Figure 2.10). The database is also broken down by building type. LEED and non-LEED academic buildings included in the Langdon database were evenly distributed on the cost schedule comparing only these two types of buildings (Figure 2.11). More expensive building types such as lab (Figure 2.12) and wet lab space (Figure 2.13) are also included. In all of the cost comparisons, LEED Certified projects (colors correspond to certification level) were evenly mixed among non-LEED (blue bars) projects. This study, along with the Capital-E study, debunks the myth that LEED projects are considerably more expensive than non-LEED projects.

LEED and Life-Cycle Costs

Life-cycle-cost savings is perhaps the biggest advantage of building green. A primary argument for pursuing LEED certification is that investments in efficiency, although they may increase initial costs of building design and construction, will provide a financial return greater than the initial investment, over the lifetime of the building. According to Kats (2003), an efficiency investment of two percent of construction costs during the design and construction phase typically will yield life cycle savings of over ten times the initial investment. For example, an initial efficiency investment of $100,000 on a $5 million project would return savings of at least $1 million over a 20-year building life cycle. Note that 20 years is a conservative estimate of the building's life cycle. These returns result from a savings in a variety of categories including lowered energy use, decreased waste disposal, reduced water costs, lowered environmental and emissions costs, reduced operations and maintenance costs, and savings from productivity and health (Kats 2003).

LEED and the Learning Environment

Another benefit relevant to Ohio University's mission is an improved learning environment. Capital E outlines a number of studies that have investigated the health and productivity benefits of green environments. According to the Herschong Mahone Group (1999), children who learn in classrooms with high amounts of daylighting increase academic performance by up to 20% compared to children who learn in traditional physical environments.

Perhaps the most exciting advantages offered by LEED are ancillary benefit to the students. Green buildings offer physical space for professors and students to teach and learn, but they also have the capacity to be working laboratories for exploration, testing, and discussion. Much can be discovered when looking beyond the face value of a building. Students could use green buildings to explore topics ranging from multifaceted social justice issues to complex engineering problems.

LEED Impact on Worker and Student Health

A corporation's largest expense is worker salary, at an average of $130 per square foot, compared to $1.37 for maintenance and $1.81 for total energy costs per square foot. Therefore, the category standing to gain the most from green design is worker health and performance. A Herman-Miller study indicated that worker productivity increased 7% after workers moved into a day-lit, green facility (Heerwagen 2000). The broadest study in this area, conducted by the Lawerence Berkeley National Laboratory finds that U.S. businesses stand to gain as much as $58 billion in lost sick time and $200 billion in worker performance simply by improving indoor air quality (Fisk 2000).

Another application of M&V is to ensure proper functioning of HVAC equipment and adequate indoor air quality (IAQ). Malfunctioning HVAC equipment and inadequate IAQ pose a health threat to building occupants. Health concerns associated with the built environment include communicable respiratory illnesses, allergies and asthma, and sick building syndrome symptoms. A review of existing scientific literature and statistical analysis shows that indoor environments can be improved with monitoring and better design, leading to the following reductions in associated illnesses (Fisk 2000):

- An 18% to 25% reduction in acute respiratory symptoms, allergies, and asthma complications;
- A 20% to 50% reduction in acute building-related health symptoms or SBS; and

- Financial benefits derived from improved performance, fewer sick days, and reduced health costs (included in economic benefits of Kats study).

Criticisms of LEED

With all of the benefits noted in the previous sections, one questions why LEED has not been adopted wholeheartedly across the U.S. This section addresses that question, gleaning from the literature the ten most common reasons not to adopt the LEED philosophy and seek LEED certification.

LEED is Contradictory

Since LEED's unveiling in 2001, architects, engineers, and other design professionals have debated the contradictory nature of some of the system's credits. For example, E & A Credit 4 awards 1 point for early compliance with the Montreal Protocol. This means that no HCFC's or Halon can be used in building HVAC, fire suppression or refrigeration systems. However, HCFC's and Halon are more efficient than other thermal conduction chemicals. In effect, not using these chemicals will reduce the overall efficiency of a building. Also, some of these chemical compounds are not considered as dangerous to the environment as others that may be used under the LEED system. Other similar contradictions can be found in the LEED system.

LEED is Inappropriately Weighted

The Office of the Federal Environmental Executive released a report detailing their efforts to incorporate LEED into building design. The report *The Federal Commitment to Green Building: Experiences and Expectations* was critical of LEED's rating system (B 2003). This criticism is found in other literature as well. Critics note that some credits should be worth more points than others. For example, offering bicycle racks and changing rooms is worth the same amount of points as a building-wide 20% reduction in energy consumption (by design).

A Building Can Be Green without Being LEED

At a green building summit in 2004 Rick Fedrizzi, President and CEO of the USGBC stated, “If it isn’t LEED, it isn’t green.” The audience, mostly design professionals supportive of LEED, disagreed (Malin 2004). Many projects, including projects built before LEED was unveiled in 2001, incorporate green principles into design. One example is the R.J. Lewis Center at Oberlin College. This building was designed before the unveiling of LEED and received much attention for its green features.

LEED Costs Too Much

Despite LEED proponents’ claims that the system saves money over a building’s life-cycle, the fact is that the system often increases initial costs. Many LEED credits offer no short or long-term financial benefits. Also, LEED Certification costs money and offers the project no financial benefits other than PR. However, as LEED becomes more popular, PR benefits are reduced.

Diversion of Focus

LEED is one system that is applied to projects built in a range of climates and ecosystems. Some LEED strategies may not be appropriate for certain regions. For example, putting a high albedo roof on a ski lodge built in the highlands of Colorado isn't going to do much to reduce urban heat island effect (Schendler 2005). But it's still worth 1 LEED Credit according to the system. This demonstrates that there is potential to do things architecturally just to get LEED points for a higher rating, not because they make sense from a green standpoint.

Energy Modeling Unreliable

Predicting a building's energy use is subject to a number of variables that make accurate modeling very challenging. In addition, LEED's requirements for comparison have been criticized by architects as well as engineers as unduly complicated (ibid).

Rating System Does Not Account for Enough Green Design Strategies

LEED has also been criticized for supporting design options that promote a short building life. Recycled plastic wall paneling and recyclable plastic carpet is given preference over natural and durable materials such as slate. In the words of a representative from Athens based RVC Architects, "I fear that if you go with LEED you will end up with a plastic wrapped square box of a building." This representative also mentioned that natural, raw materials such as slate are preferable to materials like processed bamboo flooring, which contains formaldehyde (Callahan 2005). Other examples like this can be found in the LEED system.

Certification Process Takes Too Long

LEED takes time. It takes time to document credits. Submission documents often amount to a large binder full of paperwork. It also takes time to get these credits approved by 3rd party reviewers. Submissions can result in the need for clarification dependent on LEED requirements or preference of the reviewer. In one instance, a 44 credit submission by an LEED experienced designer resulted in a follow-up request regarding information for 31 of those credits (Schendler 2005).

LEED is an Extra Burden to Over-worked Professionals in an Over-regulated Field

To quote an RVC architects representative once more, "Architects are some of the most environmentally interested, but over-worked people." The architect noted that architectural design and engineering of buildings is complicated without the extra burden of LEED (Callahan 2005). LEED can be cumbersome and confusing as pointed out by previous criticisms in this section. It does offer additional constrictions for projects.

SUMMARY OF ESTIMATED BUILDING-RELATED C&D DEBRIS GENERATION, 1996*
(Roadway, Bridge, and Land Clearing Debris not included)
(Thousand Tons)

Source	Residential		Nonresidential		Totals	
	Thou tons	Percent	Thou tons	Percent	Thou tons	Percent
Construction	6,560	11	4,270	6	**10,830**	**8**
Renovation	31,900	55	28,000	36	**59,900**	**44**
Demolition	19,700	34	45,100	58	**64,800**	**48**
Totals	**58,160**	100	**77,370**	100	**135,530**	**100**
Percent	**43**		**57**		**100**	

* C&D debris managed on-site should, in theory, be deducted from generation. Quantities managed on-site are unknown.

Figure 2.1: Construction and Demolition Debris

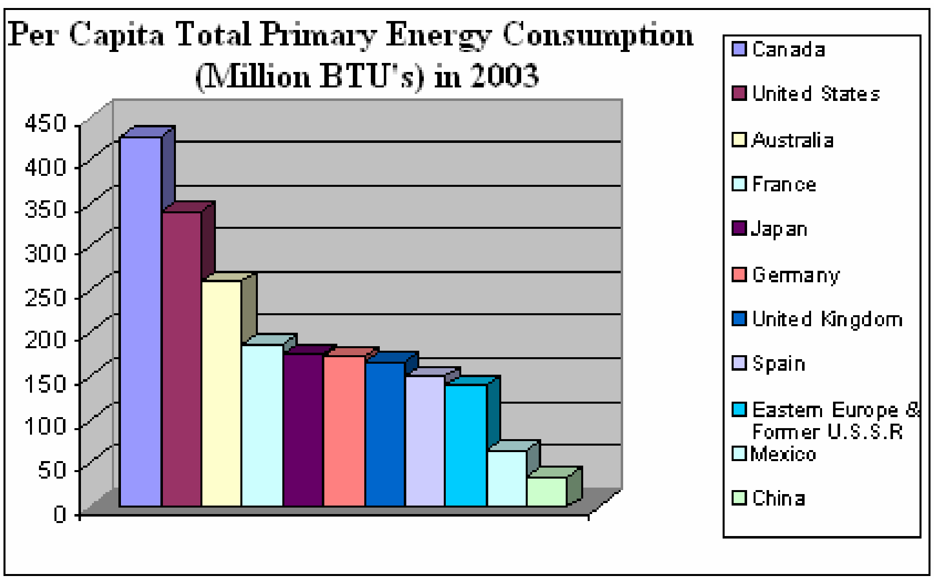

Figure 2.2: Per Capita Primary Energy Consumption

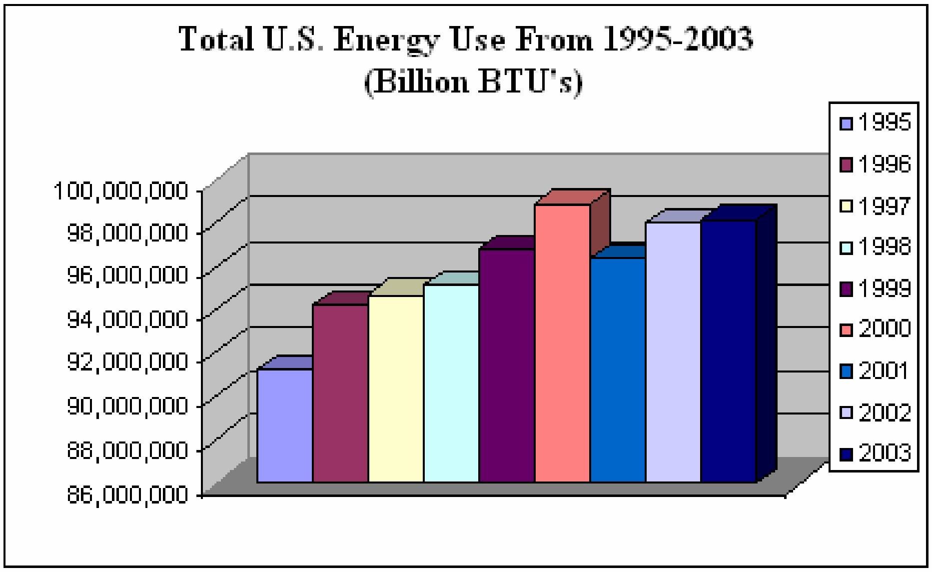

Figure 2.3: Total U.S. Energy Use From 1995-2003

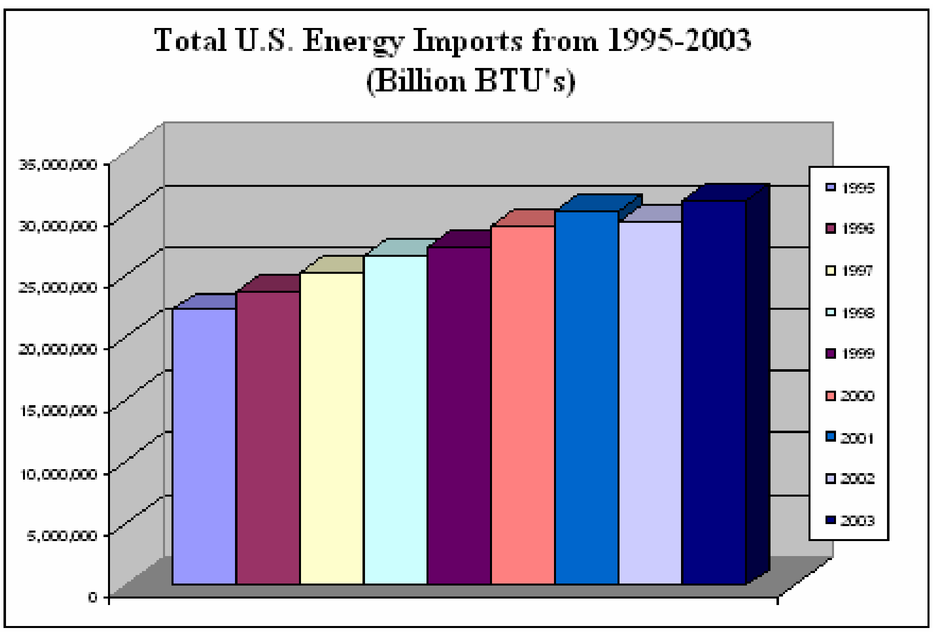

Figure 2.4: Total U.S. Energy Imports From 1995-2003

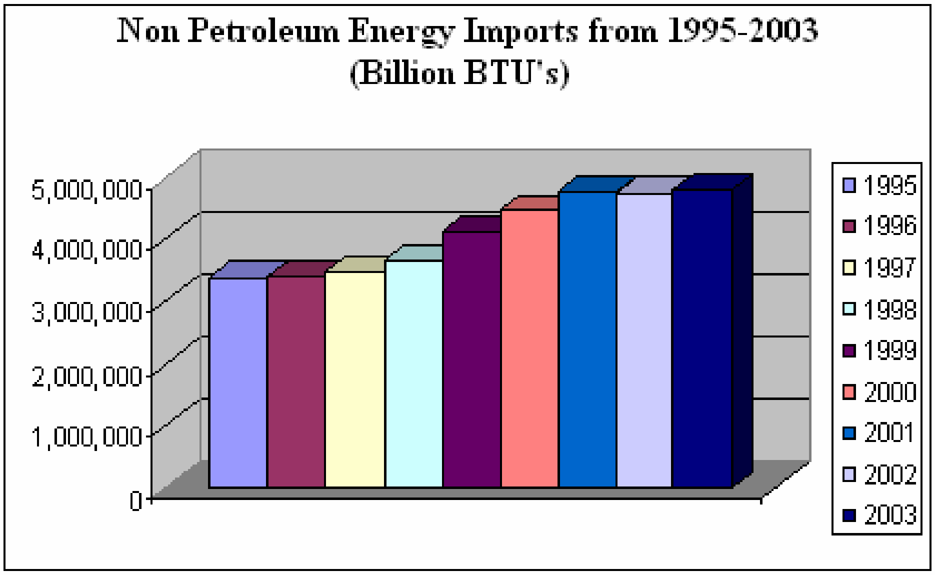

Figure 2.5: Non-Petroleum Energy Imports From 1995-2003

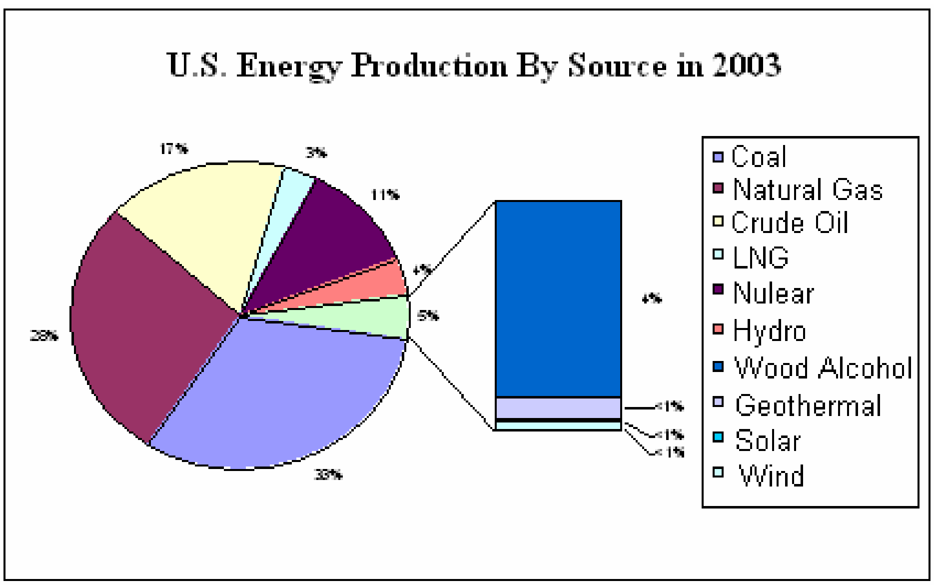

Figure 2.6: U.S. Energy Production by Source in 2003

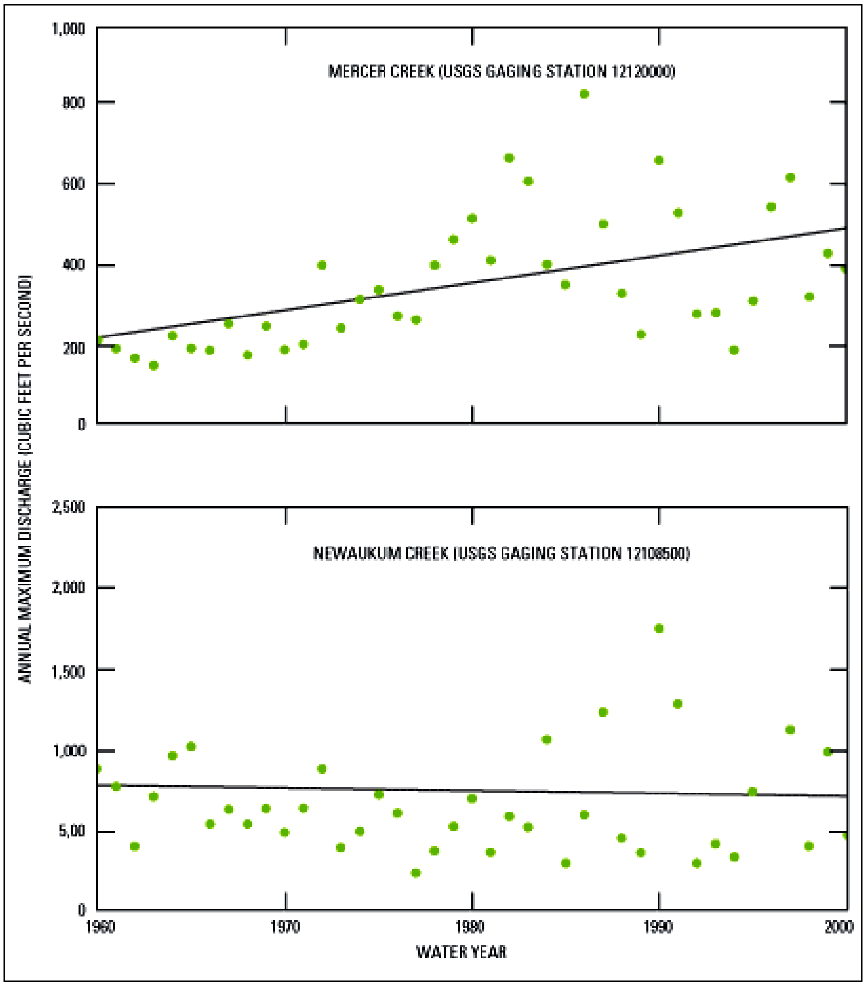

Figure 2.7: Annual Maximum Discharge for Mercer Creek and Mewaukum Creek

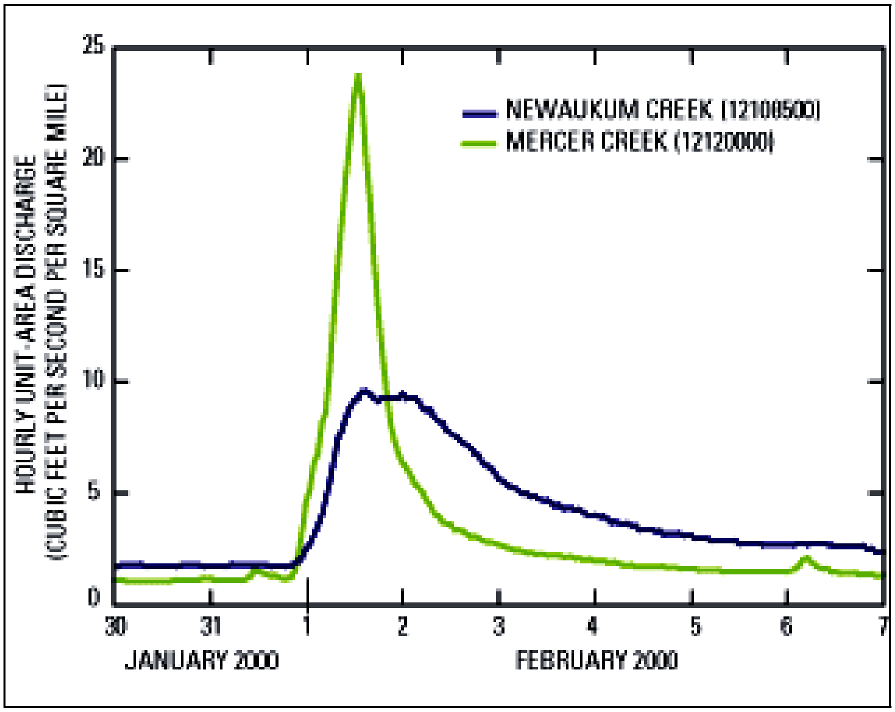

Figure 2.8: Hourly Unit-Area Discharge for Newaukum Creek and Mercer Creek

LEED-NC Version 2.1 Registered Project Checklist
NKC High School

Yes	?	No			
	1		**Sustainable Sites**		**14** Points
Y			Prereq 1	**Erosion & Sedimentation Control**	Required
			Credit 1	**Site Selection**	1
			Credit 2	**Development Density**	1
			Credit 3	**Brownfield Redevelopment**	1
			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
			Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	1
			Credit 4.4	**Alternative Transportation**, Parking Capacity and Carpooling	1
			Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
			Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
			Credit 6.1	**Stormwater Management**, Rate and Quantity	1
			Credit 6.2	**Stormwater Management**, Treatment	1
			Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
			Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
			Credit 8	**Light Pollution Reduction**	1

Yes	?	No			
			Water Efficiency		**5** Points
			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
			Credit 2	**Innovative Wastewater Technologies**	1
			Credit 3.1	**Water Use Reduction**, 20% Reduction	1
			Credit 3.2	**Water Use Reduction**, 30% Reduction	1

Yes	?	No			
			Energy & Atmosphere		**17** Points
Y			Prereq 1	**Fundamental Building Systems Commissioning**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**CFC Reduction in HVAC&R Equipment**	Required
			Credit 1	**Optimize Energy Performance**	1 to 10
			Credit 2.1	**Renewable Energy**, 5%	1
			Credit 2.2	**Renewable Energy**, 10%	1
			Credit 2.3	**Renewable Energy**, 20%	1
			Credit 3	**Additional Commissioning**	1
			Credit 4	**Ozone Depletion**	1
			Credit 5	**Measurement & Verification**	1
			Credit 6	**Green Power**	1

continued…

Figure 2.9a: LEED 2.1 Checklist (USGBC 2006)

Yes	?	No			
			Materials & Resources		**13** Points
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
			Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
			Credit 1.2	**Building Reuse**, Maintain 100% of Shell	1
			Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
			Credit 2.1	**Construction Waste Management**, Divert 50%	1
			Credit 2.2	**Construction Waste Management**, Divert 75%	1
			Credit 3.1	**Resource Reuse**, Specify 5%	1
			Credit 3.2	**Resource Reuse**, Specify 10%	1
x			Credit 4.1	**Recycled Content**, Specify 5% (post-consumer + ½ post-industrial)	1
x			Credit 4.2	**Recycled Content**, Specify 10% (post-consumer + ½ post-industrial)	1
x			Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
x			Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
x			Credit 6	**Rapidly Renewable Materials**	1
x			Credit 7	**Certified Wood**	1
Yes	?	No			
			Indoor Environmental Quality		**15** Points
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
			Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
			Credit 2	**Ventilation Effectiveness**	1
			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
x			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
x			Credit 4.2	**Low-Emitting Materials**, Paints	1
			Credit 4.3	**Low-Emitting Materials**, Carpet	1
x			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber	1
			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
			Credit 6.1	**Controllability of Systems**, Perimeter	1
			Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
			Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
			Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
			Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1
Yes	?	No			
			Innovation & Design Process		**5** Points
x			Credit 1.1	**Innovation in Design**: Provide Specific Title	1
			Credit 1.2	**Innovation in Design**: Provide Specific Title	1
			Credit 1.3	**Innovation in Design**: Provide Specific Title	1
			Credit 1.4	**Innovation in Design**: Provide Specific Title	1
			Credit 2	**LEED™ Accredited Professional**	1
Yes	?	No			
	1		**Project Totals** **(pre-certification estimates)**		**69** Points
			Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points		

Figure 2.9b: LEED 2.1 Checklist (USGBC 2006)

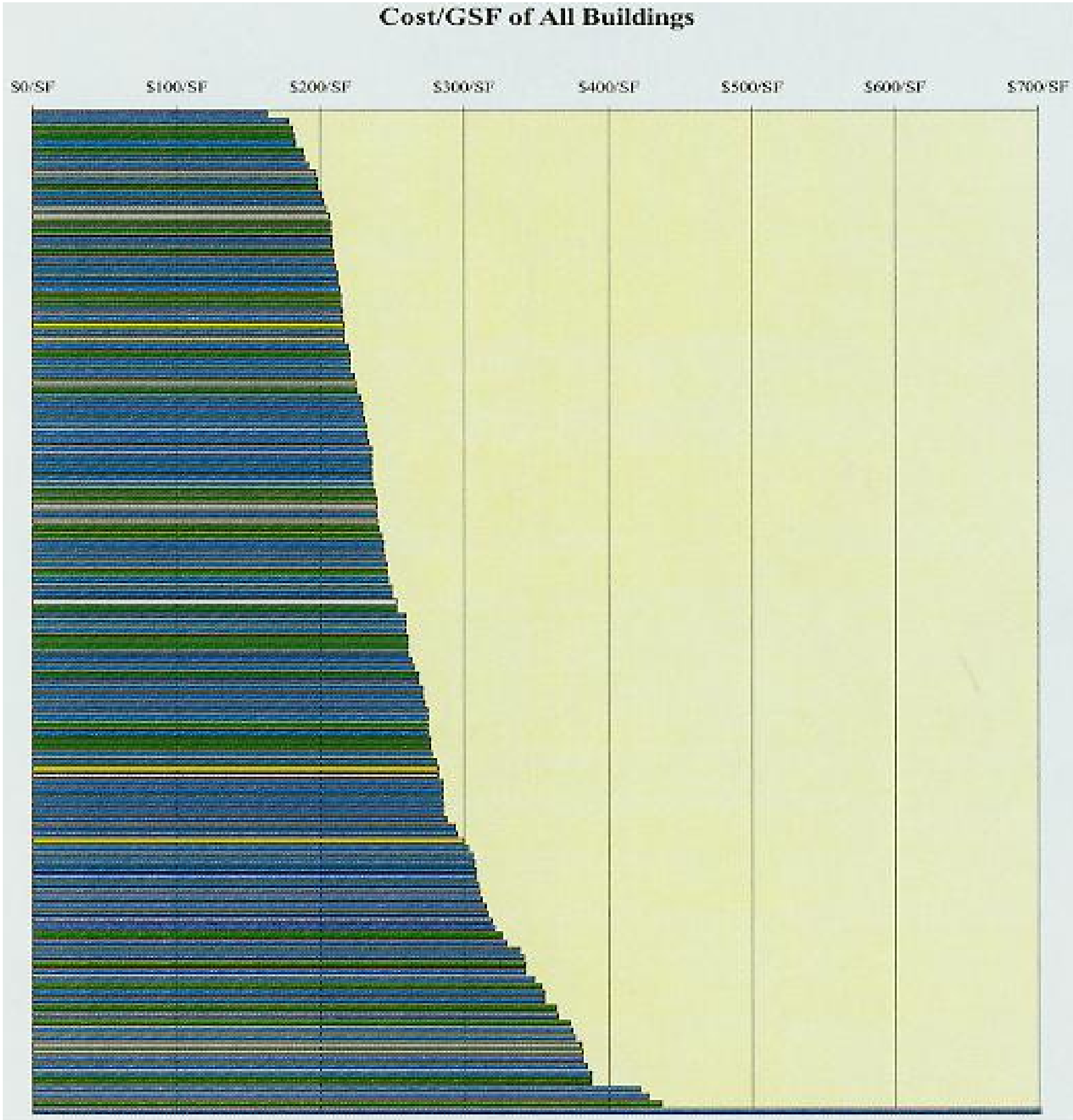

Figure 2.10: Langdon Database Cost/GSF for All Buildings

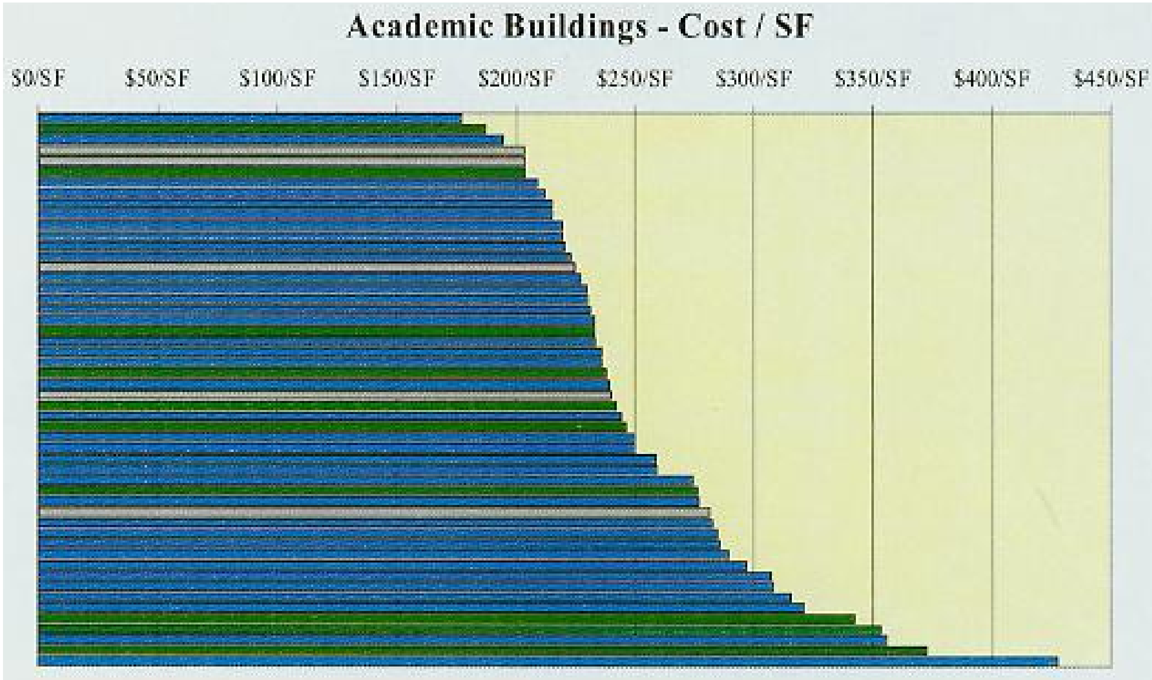

Figure 2.11: Langdon Database Cost/SF - Academic Buildings

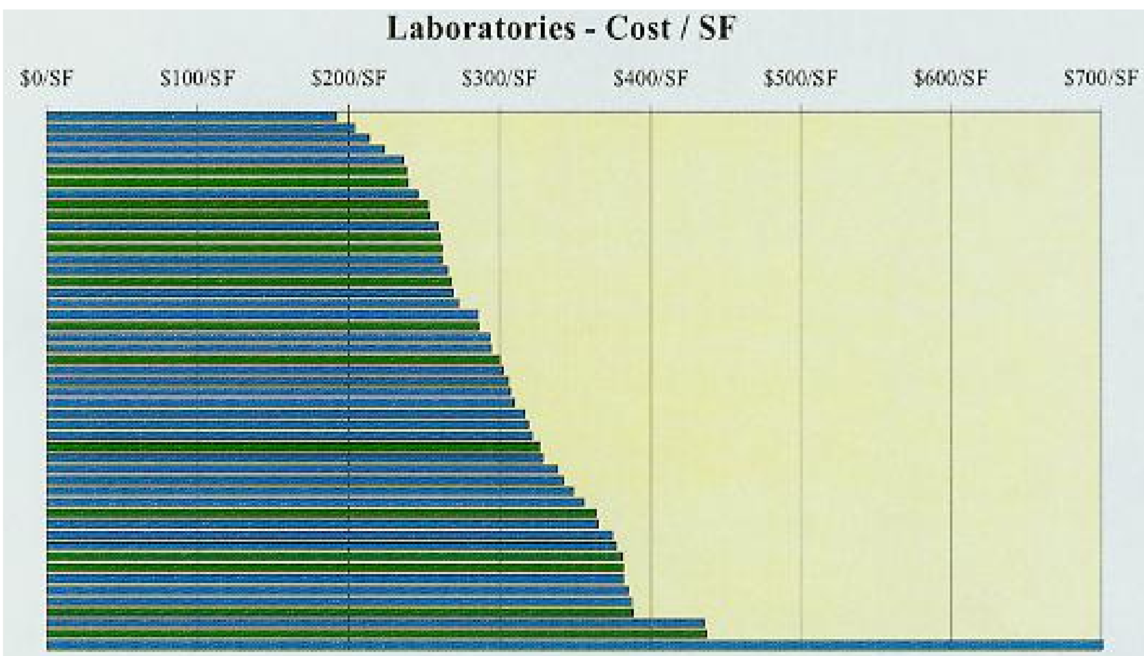

Figure 2.12: Langdon Database Cost/SF - Laboratories

Figure 2.13: Langdon Database Cost/SF – Wet Laboratories

Chapter 3: Methodology

Research Questions

The purpose of this study is to evaluate the effectiveness of the incorporation of green design into facilities planning at Ohio University. My thesis asks this question:

What are the identifiable obstacles and opportunities associated with the incorporation of green design into facilities planning at Ohio University?

This general question is addressed through the following sub-questions:

1. What are current guidelines for energy efficiency of new buildings built on the Ohio University campus?
2. How effectively were LEED standards incorporated into Ohio University's Integrated Learning and Research Facility (ILRF), a building under design with the stated goal of achieving a LEED Certified Equivalent rating?
3. Are barriers to green design that have been identified in published literature, observed in the ILRF project planning process? Are there additional observed barriers to green design that have not been identified in current literature?

Interviews with Ohio University planners and officials from the state architect's office are used to answer question 1. Interviews and an observational study of the planning for the planned ILRF building (an Ohio University building intended to meet LEED Certified standards, though without third party verification) are used to answer questions 2 and 3. A literature search and comparison of planning documents for the ILRF building with documents for successful LEED-certified buildings, are also used to answer Questions 2 and 3.

Hypothesis

The research proceeded on the hypothesis, based on published work, that many opportunities for the incorporation of LEED standards in the ILRF project would be missed, and that those lost opportunities would be revealed through examination of project-meeting minutes. Specifically, observation of meetings and a study of the planning documents would reveal documented and some new barriers to green design in the ILRF planning.

Existing Efficiency Guidelines

The University's Planning and Implementation Office and Facilities and Auxiliaries Office are the primary entities responsible for space management at Ohio University. University Planning and Implementation houses planners, space managers, project managers, contract specialists, architects and engineers and others, who together supervise construction and renovation of buildings, infrastructure, and grounds. University Facilities and Auxiliaries Office is primarily responsible for operations: custodial services, maintenance and operation of buildings and grounds, and energy management. Staff members from both offices were consulted during the development of this thesis.

Existing efficiency guidelines at Ohio University were gathered through interviews with Pam Callahan and Mike West of the University Planning and Implementation Office, and Oscar Zanganeh from the State Architect's Office.

Planning-Process Assessment

The University Planning and Implementation Office specified LEED Certification standards as an added desired feature of the Integrated Learning and Research Facility (originally the “Stocker Addition”) in their “request for design services” announcement. The winning project bidder, Burgess and Niple, agreed to address this request and included a LEED-related design-services cost of $40,000 in their project bid. Ohio University’s ILRF contract with Burgess and Niple states the following:

> The University desires that the proposed building be evaluated using the LEEDS (sic) format. Achieving LEEDS Certification (the lowest level) is a goal, but not a requirement. Documentation of the steps taken and the score achieved will be prepared. The cost for achieving silver level will also be estimated with the expectation that a donor may be found who would be willing to fund the necessary construction elements.

In assessing the design process minutes from 16 ILRF planning meetings, held bi-weekly from September 2005 to May 2006, were examined with respect to LEED- standard inclusion in accordance with project goals. Assessment involved plotting the contents of meeting minutes onto a chart (Table 4.1), which lists topics discussed at individual meetings. Topics were divided into the following categories: LEED; Budget Issues; Schedule Issues; Space Programming and Floor Plan; Aesthetics (Fenestration, Massing, and Interior Treatments); Building Materials; Lighting, Electrical and Energy Use; and Plumbing and Water Use. These topics were chosen because they roughly represent general areas of concern that addressed by the 5 LEED Categories which include Indoor Environmental Quality; Sustainable Sites; Water Efficiency; Energy and Atmosphere; and Materials and Resources. This chart indicates whether or not issues relevant to

LEED Categories were discussed, and whether or not LEED was actually addressed during the meeting.

Second, meeting minutes were examined to determine if planning items were discussed that presented an opportunity to address the possible attainment of LEED credits, in accordance with the project goal of achieving the lowest level of LEED certification. This assessment was accomplished through a qualitative comparison of meeting topics and their relevance to individual LEED credits. Although the USGBC has recently unveiled LEED New Construction Version 2.2, the USGBC's LEED New Construction Version 2.1 was used for this comparison because it was current when ILRF planning began. The lowest level of certification can be achieved with any combination of LEED credits, so all opportunities for credit attainment were listed in terms of topics discussed at meetings.

Although the LEED system is fairly self-explanatory, one needs to be sufficiently familiar with the system to recognize opportunities and strategies in design projects, and these opportunities may not be obvious. LEED was unveiled only 4 years ago, so less than 200 LEED-certified projects have been completed in the U.S. Most professional architects, aside from LEED consultants, have worked on few LEED projects. Although I have only been involved in the professional planning of one architectural project (the ILRF), I prepared myself for observing the planning by examining documents from more than 20 LEED projects. Moreover, LEED accreditation is offered by the USGBC to individuals wishing to be certified to work on LEED projects as consultants, so it does not have prerequisites such as architectural or engineering degrees or certification. (Such degrees and certification are of course helpful.) The USGBC recommends that individuals complete a training workshop before taking the accreditation test. I completed the USGBC's LEED 2.1 Technical Review Workshop in October of 2004.

In step three of the assessment, meeting minutes from "Project Y", a design project where formal LEED Certification will be pursued via the USGBC, were examined for comparison with the ILRF planning minutes. The minutes were plotted on the same charts used to document meeting contents for ILRF in step one of the assessment (Table 4.2). Project Y is not meant to be a generalization of all planning processes for LEED Certified projects. It is only used as an example of what one such planning process may look like.

Observing ILRF Planning Meetings

I began attending planning meetings for a building that was originally referred to as the "Stocker Addition" on 6/20/05. This $15-million facility was being built by the Russ College of Engineering to provide educational space for engineering students. The Center was to be unique in that it was designed to facilitate collaboration and innovation by encouraging greater interaction between faculty members and among students. A goal set by the Planning and Implementation Office was that the facility be built to LEED Certified standards (the least stringent of four certification levels). The project had begun to transition from the schematic design phase to design development, where a site plan, building features, floor plans, and specific details regarding the building exterior were solidifying. The building location had been chosen and details as specific as the floor plan of the Dean's Suite were being discussed.

In August of 2005, Ohio University's College of Osteopathic Medicine received a $10-million grant from the Osteopathic Heritage Foundation for the creation of a research facility in conjunction with the Russ College of Engineering. At this point, the $15-million facility nearly doubled in budget and size requirements and the College of Osteopathic Medicine and the Russ College of Engineering began planning for what would be referred to as the "Integrated Learning and Research Facility" or "ILRF." Planning for the new facility began on 9/1/05.

As the project acquired additional stakeholders, additional needs were added to project requirements. Donors from the Osteopathic Heritage Foundation as well as donors for the Stocker Center had given financial assistance but had also provided a list of constraints. Stipulations for funding were made by both of the primary donors. These stipulations required certain features to be included in the building design such as a focus on a progressive learning environment for engineering (and other) students as well as a focus on integrated research between the College of Engineering and the College of Osteopathic Medicine. To ensure that these new constraints were met in addition to requirements of the College of Osteopathic Medicine, the programming phase began again.

As of April 27, 2006, the ILRF design team included representation from the Office of Planning and Implementation, Russ College of Engineering, College of Osteopathic Medicine, Health and Human Services, Office of the Vice President for Research, College of Arts and Sciences; the State Architect's Office of Ohio; ,Burgess & Niple (principal designer); RVC Architects; WHJW Technology Design Consulting;

B&H Structural Engineers; Fuller & Associates Electrical Engineers; ARX Design, Learning Space Designers; and Butz Ltd., Lab Space Planning.

The entire planning process for ILRF spans summer 2005 through 2006, with construction scheduled for completion in 2009. Completion of construction documents takes place after the completion of my thesis (Spring 2006). However, I was able to attend nearly all of the first 3 of the 4 phases. These phases include the Program Phase, the Schematic Design Phase, and the Design Development Phase, which are described below with their approximate time periods. I was able to observe meetings September 2005 through May of 2006.

Program Phase- (August 2005 through November 2005) The existing program developed during the spring and summer of 2005 was revised. The program describes design character, work scope, and major project elements.

Schematic Design Phase- (November 2005 to March 2006) Site plan, building features, and floor plans are produced. This part of the plan is described in narrative specifications that outline general building construction and mechanical/electrical systems. During this stage an estimate of probable construction cost is developed.

Design Development Phase- (March 2006 through June 2006) Specific details of the building exterior are determined, a final revision of the floor plan is produced, and specific building systems are selected. Cost estimations are also revised.

Construction Documents Phase- (July 2006 to December 2006) Drawings are created for different components of the building, for specific trades. During this phase the plan evolves to its most specific form. A final cost estimate is prepared.

During the meetings, I observed with the intent of identifying barriers to design. However, I was careful not to “participate” in the meetings. I did not want to bias the process by offering my input. On a few occasions, I answered questions when asked directly, but these questions were about issues unrelated to green design.

Analyzing and Comparing Planning Documents

Meeting minutes from a LEED-Certified design project were examined for comparison with the ILRF planning minutes. Because building owners consider design details proprietary, obtaining planning documents for LEED-Certified building projects was difficult. However, on the condition that the building owner remains anonymous, Sustainable Design Consulting, LLC, provided planning information for a LEED-Certified project on another college campus.

Sustainable Design Consulting, of Richmond, Virginia, offers a variety of services to its clients. Services offered for projects applying for LEED Certification include; feasibility assessment, goal setting, integrated design, technical consulting, project management, and LEED documentation and submission for Certification (Sustainable Design Services, 2006). Clearly, SDC has much experience with LEED and it would be expected that attention to LEED issues will be increased in projects that solicit their services.

The comparison project is a 200,000 square-foot mixed-use building located on a college campus in Maryland. The building contains administrative office space, a library, a cafeteria, and a bookstore. Sustainable Design Consulting worked with the project from the beginning of Design Development (phase 3 of 4 planning phases) through construction. The project's goal was to achieve a Silver rating, but it is borderline Gold. The facility was completed recently, in Spring 2006.

Identifying Barriers to LEED

As part of the assessment, ILRF's planning process was examined for barriers to LEED that have been reported in the literature. Barriers were identified in three ways: 1) Through a review of existing literature on the subject of barriers in green design (Table 3.1) personal observation of ILRF's planning process during the first 6 months of the project planning; and 3) a 9-question survey (Table 3.2) distributed to Project Team members to document their opinions regarding any barriers to the incorporation of LEED in the ILRF planning process. The survey was developed using published, and with guidance from the Planning and Implementation Office. Regarding published literature on barriers to design, 1-8 were sourced from Cooper (1990) and 9-16 from Thurmond (2002).

The survey was approved for distribution by Ohio University's Institutional Review Board and distributed to the entire ILRF Project Team, consisting of 32 members, on Friday, April 21, 2006. The survey was sent via e-mail and the participants were asked to reply, via e-mail, by May 3, 2006. As only 4 surveys had been returned by May 3rd, the survey was re-distributed at that time and an additional 2 weeks was given for completion. A total of 1 month was given to project participants for completion of the Project Team survey and during this period only 5 surveys were returned. Project architects Burgess & Niple did not return a survey. Although this is a short survey period, Project Team members were accustomed to responding to Burgess & Niple surveys for the ILRF project, and those surveys had similar delivery mechanism and response windows.

A number of factors may have contributed to the poor survey response. One respondent claimed that the survey was flawed and answers needed too many qualifiers. This respondent later agreed to an interview. The response was noted and it is agreed that survey question #4 needed too many qualifiers for accurate quantitative analysis. However, a quantitative analysis was not conducted and ratings given were not used for the conclusions contained in this thesis. A qualitative analysis was conducted and the survey responses, interviews, and observation of the planning process contributed to the identification of barriers as well as opportunities found within the ILRF planning process.

Another possible explanation for the poor survey response may be the inherent risk involved in completing the survey. Although confidentiality was given as an option, this cannot be guaranteed. There is always a possibility that a responder's identity may become known through an accidental breach or otherwise. It will be made clear in the body of this thesis that LEED was not a goal the Project Team actively pursued. It is possible that Project Team members did not want to engage in what they might have thought as condemnation of any particular party's shortcomings. This is especially so if an individual wished to level complaints against his or her own department or against co-workers. Such comments, regardless of whom they are directed towards, may have also complicated the design process, which was still in progress.

Survey respondents included the Dean of the College of Engineering, Dean of the College of Arts and Sciences, Chair of the Ohio University Faculty Senate, a representative from the UPI office, and one anonymous responder.

Barriers to Green Design Found in Published Literature
1. Lack of expressed interest from clients (owners/developers)
2. Recovery of long-term savings not reflected in service fee structure
3. Perceived cost: sustainable building options too expensive
4. Lack of technical understanding on the part of the project team members
5. Lack of technical understanding on the part of subcontractors
6. Insurance/liability problems with offering warranty on non-standard materials or methods
7. Owners require very short payback periods for efficiency investments
8. Schedule has a large impact on project considerations and LEED may cause schedule problems
9. Clients don't want the risk of a new untested product or method
10. The actual LEED certification documentation costs money and time and does not offer savings
11. Owners not aware or convinced of economic savings associated with green design
12. Unfamiliarity of green products by owners and architects
13. People like to do what they've always done or a resistance to change
14. Lack of trust in untried or unproven quality of green building material
15. Operating budgets and construction budgets come from different sources, so savings realized from operations can't be transformed to construction.

Table 3.1: Barriers to Green Design Found in Published Literature

<table>
<tr><th colspan="3">ILRF Project Team Survey</th></tr>
<tr><td colspan="3">The “Project Responsibilities and Scope of Services” section of Ohio University’s ILRF project contract with Burgess and Niple states the following:

The University desires that the proposed building be evaluated using the LEEDS format. Achieving LEEDS Certification (the lowest level) is a goal, but not a requirement. Documentation of the steps taken and the score achieved will be prepared. The cost for achieving silver level will also be estimated with the expectation that a donor may be found who would be willing to fund the necessary construction elements.</td></tr>
<tr><td colspan="2">Most of the following 8 items were taken from published literature regarding barriers to incorporating LEED design principles in building design. Please rate the accuracy of the following items as they pertain to the ILRF Project Team’s efforts to include LEED in project planning. Please include comments to explain your rating for individual items.</td><td>Rating System:

1-very inaccurate
2-moderately inaccurate
3-indifferent
4-moderately accurate
5-very accurate</td></tr>
<tr><td>1</td><td colspan="2">The Project Team was aware of aforementioned project goals regarding LEED.</td></tr>
<tr><td>2</td><td colspan="2">The Project Team was sufficiently familiar with LEED rating system and LEED requirements to work toward aforementioned project goal.</td></tr>
<tr><td>3</td><td colspan="2">The Project Team was familiar with the Department of Energy and the United States Environmental Protection Agency’s Labs 21 for Laboratory Efficiency.</td></tr>
<tr><td>4</td><td colspan="2">The Project Team sufficiently addressed the LEED project goal during project planning.</td></tr>
<tr><td>5</td><td colspan="2">The ILRF project budget provided adequate funding for the incorporation of LEED into project design.</td></tr>
<tr><td>6</td><td colspan="2">The ILRF project schedule provided an adequate timeframe for the incorporation of LEED into project design.</td></tr>
<tr><td>7</td><td colspan="2">ILRF stakeholders (College of Engineering, College of Osteopathic Medicine, Arts and Sciences, Health and Human Services, University Planning) expressed an interest in LEED during project meetings, in accordance with stated project goals, and the Project Team adequately addressed this interest.</td></tr>
<tr><td>8</td><td colspan="2">LEED issues were addressed outside of Planning Meetings. If so, please list time, location, and meeting participants.</td></tr>
<tr><td>9</td><td colspan="2">Please state any additional comments regarding the Project Teams efforts at meeting the aforementioned project goal regarding the incorporation of LEED in ILRF design.</td></tr>
</table>

Table 3.2: ILRF Project Team Survey

Chapter 4: Results & Discussion

Existing Efficiency Guidelines

The National Energy Policy Act of 1992 mandates that state and local governments update commercial building energy efficiency codes to be at least as stringent as ASHRAE Standard 90.1. ASHRAE 90.1 is building code that outlines cost-effective design practices and technologies that minimize energy consumption (DOE, 1995).

House Bill 261 requires all state agencies to send architectural plans to the State Architect's Office (SAO). Once received by the State Architects Office, the plans are sent to energy departments within each state such as the Ohio Office of Energy Services. The energy departments are supposed to review the plans and assure quality with respect to the energy mandates. However, the State Architect's Office does not strictly enforce this rule. Oscar Zanganeh, Energy Specialist with the Office of Energy Services, noted that his department is severely understaffed and is physically unable able to conduct a review of architectural plans for all new state buildings (Zanganeh 2006).

Despite a lack of enforcement of House Bill 261, Ohio University designs all buildings to meet or exceed ASHRAE Standard 90.1 and submits all plans to the SAO for review. Field Representatives from the SAO also attend design meetings for new projects at Ohio University in order to assist with project design. Tom Kovacs, Chief Construction Officer with SAO, is the current on-site construction manager. Ohio University does not have written policy regarding minimum efficiency requirements aside from meeting ASHRAE Standard 90.1 as required by the SAO. However, Ohio

University highly values energy efficiency and invests in energy efficiency measures when possible.

ILRF Planning Process Evaluation and Comparison

ILRF Planning Meeting Contents

In a tabulation of the topics discussed at 15 planning meetings (Table 4.2.1), the topic of LEED Certification was directly mentioned by at Project Team member at only 2 meetings during the first 8 months of project planning. One could argue that these meetings were not appropriate times for discussion of LEED, and instead were about administrational concerns such as the filing of project-related paperwork or the project schedule. However, that was not the case: Given the topics that were discussed, there should have been opportunities for the Project Team to consider LEED issues.

During Meeting 5 where LEED was discussed, a member of Ohio University's Office of Academic Advancement briefly mentioned the possibility of applying for a grant to fund LEED efforts. During Meeting 10, a Project Team member suggested that the group should have a discussion about adjusting lighting levels according to building orientation in accordance with LEED.

Opportunities to Address LEED Rating System in ILRF Planning

A goal of this project is to determine if LEED was adequately addressed during planning for ILRF, in accordance with the project goals, so meeting minutes were more closely examined to identify any *opportunities* to address LEED. Note that LEED was explicitly mentioned only twice during project planning, once in Meeting 5 and again in Meeting 10.

The LEED checklist (Table 2.1.1a,b) serves as a useful reference for topics that provide opportunities to consider LEED credits. Not all items on the checklist are appropriate for the ILRF project, of course: Some might not align with the ILRF's program. These items are only listed as points of possible discussion regarding the consideration of LEED in project planning. Note that not every credit is addressed during this review. There are a number of LEED Credits that may have been appropriate for this project, but an opportunity to address them is not found within the current planning meetings. It is assumed that project issues relating to these potential credits will be discussed at a later date, as project planning was less than ¾ complete at the completion of this thesis, and they would more appropriately be addressed at a later stage in the planning process.

Meeting 1

This meeting dealt primarily with programming issues. The meeting was used to discuss visions of the stakeholders regarding space usage. It was agreed that three major elements would dominate the focus of this building: Engineering and Learning; College of Osteopathic Medicine Research; and Inter-disciplinary collaboration. In a way, this meeting was a goal-setting session. The College of Osteopathic Medicine suggested that an objective of this facility was to provide state-of-the-art research space to achieve the goals of improving research in the field of Osteopathic Medicine and attracting nationally renowned researchers to Ohio University. The College of Engineering suggested that an objective of this building would be to expose undergraduate students to research projects to reach the goal of improving undergraduate education at Ohio University.

Discussion: During this meeting LEED could have been introduced to the Project Team. The Planning and Implementation Office represents one of the stakeholders in the group (i.e., Ohio University), so they could have added LEED as one of their project objectives. Identifying the goals associated with LEED at this point could have changed the Project Team's approach to major issues such as the project budget. For example, a particular goal associated with the incorporation of LEED standards into project design is a reduction in long-term building operation costs. Realizing this goal requires a shift in financial thinking from a focus on initial costs to considerations of life-cycle costs. In other words, a financial model for the project could have been determined that more accurately aligned with the LEED system. A LEED-compatible financial model may become an important issue later in the project as project features begin to stress the budget and rectifying strategies such as add-alternates and value engineering are used to alter project components. For example, certain project features, such as a heat recovery wheel, that provide long-term savings but are not critical to the short term functionality of a building may be removed from project designs during the value engineering process to fix a short-term financial problem. A financial model that protects long-term investments may be substituted for models that do not give these features preference for inclusion in project plans.

Meeting 2

The first discussions regarding space layout took place in the second meeting. The discussion focused on themes, rather than actual layout. The building would be a "showcase" building, to expose technology to engineering students. Actual building components and design trends would be literally exposed to users and visitors through glass partitions and with signage.

Discussion: The second meeting was primarily a design philosophy meeting and LEED could have been identified as an important part of the philosophy. Successful LEED projects begin incorporating green design into project planning early in the planning process, treating the system as a design philosophy, rather than a project component. Moreover, the overarching goal of the LEED Green-Design System is to create high-performance, technologically advanced buildings. This goal seems to dovetail with the College of Engineering's "showcase" philosophy. LEED could have been introduced here as an opportunity to advance the College of Engineering's educational mission.

Meeting 3

During the third meeting, project planning moved from purely philosophical planning to the first stages of physical project design. Site options for the building were discussed as well as a general estimation of the building's square footage needs based on requirements identified in preliminary programming.

Discussion: A number of LEED credits could have been discussed during this meeting. The Sustainable Sites (SS) category of the LEED rating system offers up to 14 points towards project certification. SS Credit 1.1 awards 1 point developing space on appropriate building sites. In this case, the Hocking River's 100-year floodplain falls in the category of sites considered inappropriate. ILRF was built in the 35-year floodplain but the first floor will not be developed to avoid possible damage from flooding.

Although some precautions were taken to minimize potential damages from floods, the possibility of achieving LEED SS credit 1.1 by moving the building to another location was not discussed. SS Credit 2 awards one point for development of sites located in highly populated areas such as downtown Athens. SS Credit 4.1 awards points for locating a building within ¼ mile of two or more bus lines. In conjunction with SS credits, the Materials and Resources (M&R) category Credits 1.1, 1.2, and 1.3 give as many as three points for building reuse.

The point to be made is not that the building was poorly sited, but that there was no discussion of the LEED standards and possible alternative locations. Inasmuch as LEED sets standards that give credence to larger issues such as flood risk, urban sprawl and transportation, such a discussion would have been valuable. A possible alternative would have been to reuse the currently abandoned PSAC building on Presidents Street, adjacent to Bentley Annex and the Research and Technology Center, but such alternatives were not discussed.

Also appropriate for consideration at this point would have been Energy and Atmosphere (E&A) Credits 1.1, 1.2, 1.3, 1.4, and 1.5 as well as Indoor Environmental Quality (IEQ) Credits 8.1 and 8.2. The E&A Credits award up to 10 points (2 points each) for optimized energy performance, and the IEQ Credits award up to 2 points for providing the building with natural light and views for building occupants. As substituting natural lighting for electrical lighting can reduce building energy loads, these credits are important to one another. Also, opportunities for day lighting are directly affected by building layout, and building sites affect opportunities for variations in layout. At this stage in project planning, a building site was selected that allowed little to no variation in building layout given the building's size requirement (100,000 square feet). The building is limited to the North by the Oxbow corridor and to the South, East, and West by existing buildings on the West Green. Little flexibility may have been possible, but the point is that the matter was not discussed and the lack of flexibility in siting acknowledged.

Meeting 4

The Project Team was viewed two site "footprints" at the fourth meeting. One option was a 30,000 square foot three-story footprint, totaling 90,000 total square feet. The other option was a 45,000 square foot two-story footprint.

Discussion: The two options present different challenges and opportunities to incorporation of many of the aforementioned LEED Credits including E&A credits 1.1-1.5 and IEQ credits 8.1 and 8.2.

Meeting 5

The fifth project meeting was held on December 8, 2005, four months into project planning. At this point, the incorporation of LEED into project design had not been discussed at a single design meeting. A major component of this meeting was the project budget. At this meeting the building's total space allocation was reduced to bring the project back within the budget. As this meeting was adjourning, a representative from Ohio University's Division of University Advancement brought up some questions regarding LEED. The representative noted that a Kresge Foundation grant was available to provide 1/5 of total building cost for academic buildings pursuing LEED Certification. This particular grant was not pursued. A member of the project team questioned if LEED

Certification was even possible given the nature of research (including some biohazards) conducted in the building. This question prompted another member of the project team to inquire about the status of LEED for inclusion in a report being prepared by the College of Osteopathic Medicine for the Osteopathic Heritage Foundation, a project donor. This second question sparked a brief conversation on the virtues of the LEED system. A representative from the Ohio University planning department commented, “LEED is huge, LEED is expensive (Planning Office Representative 2005).” An architect from Burgess and Niple stated that “LEED is a very convoluted system”, but that they would continue to pursue LEED-compatible design strategies (B&N Architect 2005). These comments in effect portrayed LEED in a negative light.

Discussion: Although many LEED features can be incorporated into project design at little to no cost, some features require less modest investments in capital costs. However, some of the most expensive LEED credits often provide the best returns through long-term operational cost savings. It can be deduced that, from this point on, incorporation of LEED features requiring any amount of capital cost increase will not be included in the ILRF project without elimination of other cost-equivalent program items to free the project budget.

Achieving a LEED-Certified rating (or better) is possible in buildings with labs where research involves biohazards. LEED does not address hazards posed by research, because pre-existing, outside safety regulations cover lab safety. Many projects with lab components have achieved LEED Certification.

Meeting 6

Lab planning was already underway outside of the Project Team meetings. Project team members most focused on researchers met with lab planning consultant Jim Butz. Lab issues became a larger part of the Project Team meeting during the sixth meeting as the group discussed how labs would be oriented to the rest of the space in ILRF.

Discussion: The sixth meeting would have been an appropriate time to address the issue of lab impacts on the building's overall LEED goals. As previously mentioned, lab space is compatible with LEED Certification, although it poses special challenges: Laboratory equipment adds to electricity use, and fume-hood ventilation increases energy use for air heating and cooling. The energy demand is enough of an issue that the Department of Energy and the U.S. Environmental Protection Agency developed their Labs 21 program to reduce the energy impact of laboratory spaces. This special protocol for lab development, as described earlier, in the literature review, can support efforts to achieve LEED Certification, specifically impacting E&A credits 1.1-1.5. By selecting refrigeration and fire-suppression equipment without HCFC's or halons, E&A Credit 4 could be earned.

Meeting 7

Transportation to and from the building for students and faculty was discussed during the sixth and seventh meetings. It was also noted during this meeting that loading dock and other access routes to the building should be considered a part of building design and that the Project Team should consider the extension of Depot Street to Oxbow

Drive. Finally, meeting minutes indicate it was desired by the Project Team to preserve a grove of sycamore trees immediately adjacent to Stocker if possible.

Discussion: A number of potential LEED credits could have been discussed at this point. First, SS Credit 4.2, which allows one point for providing shower and changing facilities as well as a bike rack for 5% of regular occupants, could have been discussed here in conjunction with transportation issues. This credit promotes the use of bicycles as a means of personal transportation.

In conjunction with the project Team's desire to preserve certain aspects of the site, SS Credits 5.1 and 5.2, which offer points for reducing site disturbance, could have been discussed here. Not discussed was SS Credit 5.2, which awards 1 point for designating an area adjacent to the building site as open space, equal in size to the building footprint. Also not discussed was attaining credit 5.1, which awards a point for restoring 50% of the site area's impervious surface area to native vegetation. Although it is not possible to do that at this particular site, given the size requirements of the building, the possibility was not discussed.

The issue of loading docks and other access routes to the building could have incorporated a discussion about SS Credits 6.1, 6.2, 7.1, and 7.2 as well as Water Efficiency (WE) Credits 1.2, 2, 3.1 and 3.2. Runoff quantity and quality are addressed by SS Credit 6.1, which addresses the quantity of storm-water runoff, and 6.2, which addresses the quality of storm-water runoff. Each credit is worth one point. Increasing the footprint of impervious surfaces will increase the quantity of storm-water runoff. Strategies to reduce the overall footprint of building access routes and the materials used for providing these routes (permeable surfacing is available) could have been discussed regarding credit 6.1. Strategies to removed Total Suspended Solids and Phosphorous from storm-water runoff could have been discussed regarding credit 6.2.

SS Credit 7.1 gives a point for strategies related to reduction of the “heat-island” effect. Using light-colored/high-albedo materials and/or open-grid pavement for at least 30% percent of a site’s non-roof impervious surfaces would earn the project a point. SS 7.2 offers an additional point for using high reflectivity AND high emissivity roofing for a minimum of 75% of the roof surface.

A total of four points are available from WE Credits 1.2, 2, 3.1 and 3.2. Points are awarded for using captured rainwater as a substitute for potable water where appropriate, as well as a total reduction in water use for the entire facility. It should be noted that rainwater capture is connected to a total of 6 potential points.

Meeting 8

The eighth meeting focused on discussion of the floor plans presented by B&N. Several comments were made regarding natural lighting of interior space.

Discussion: This meeting would have been an opportunity to review the day-lighting and views provided to offices and other interior spaces in conjunction with previously mentioned IEQ Credits 8.1 and 8.2.

Meeting 9

Floor plans, lab space, massing, and fenestration were discussed at the ninth meeting.

Discussion: As these plans are focused, issues relating to E&A Credits 1.1-1.5 could be discussed to determine eligibility for these credits. This topic could also include discussion of alternative energy systems such as solar hot water heating systems. Solar hot water systems have relatively quick payback periods and reduce the overall energy load for the building for progress towards E&A Credits 1.1-1.5.

Meeting 10

More floor plan issues were discussed during the tenth meeting as well as elevations, and mechanical space.

Discussion: During this meeting, the Construction Administrator (CA), who is a consultant from a local architectural firm, raised the issue of LEED as related to elevations. The CA said, “We’ve talked about LEED. Maybe we need to have a conversation about north and south lighting.” This comment refers to a number of LEED credits, including E&A credits as well as IEQ credits. However, there was no discussion. B&N architects agreed that a conversation would be helpful but it did not take place at this meeting. Callahan confirmed that the conversation did not take place at a subsequent date (Callahan 2006).

Meeting 11

The eleventh meeting was an all-day review attended by on- and off-campus stakeholders and contractors. This meeting addressed site issues, interior finishes, building access, building HVAC, plumbing and electrical issues, information technology, and the learning environment.

A number of issues were addressed during the first half of the all-day review. For example, University officials requested that terrazzo floors be used due to ease of maintenance. They indicated that Fritztile or carpet tile is not an acceptable floor finish.

They also noted that unfinished, colored concrete is an acceptable finish for lab areas. Specific carpet with sealed backing was also noted as an acceptable floor finish.

During the second half of the all-day review, B&N consultants as well as Ohio University's Facilities Management Office discussed the building's HVAC system at length. It was determined that a dual duct system, utilizing a combination of steam and hot water reheat coils as well as chilled water, will be used to regulate temperature in ILRF. It was also noted that the chilled water plant does not have the capacity to meet the additional demands for ILRF at this time.

Fire suppression was also discussed at this review. The campus recycling manager attended the meeting and requested that space be provided for recycling containers.

Discussion: This was not an official meeting of the Project Team, but LEED-related items could have been noted and then addressed at a subsequent Project-Team meeting. One LEED-related item is flooring: IEQ Credits 4.1-4.4 award points for low- or no-VOC (volatile organic compound) emitting adhesives & sealants, paints, carpet, and composite wood. Additionally, M&R Credits 4.1 and 4.2 apply to the types of flooring that were mentioned. Credits 4.1 and 4.2 award 1 point each for use of building materials with recycled content. Terrazzo flooring can include recycled glass and other material. Also, concrete made from fly-ash is also available for flooring. This issue also directly relates to M&R Credits 5.1 and 5.2. These credits give 1 point each for specified amounts of locally manufactured building materials. As power generation is prevalent along the Ohio River, it is possible that locally manufactured fly-ash concrete is available.

The HVAC details are relevant to E&A credits 1.1-1.5, 3, 4, and 5. IEQ Credits 1, 6.2, 7.1 and 7.2 are relevant as well. This meeting would have been a good time to perform or update a whole-building energy simulation in conjunction with E&A Credits 1.1-1.5. It is possible that strategies such as increased insulation, Labs 21 recommendations, energy capture systems, and so on could reduce the overall energy needs of the building. It cannot be determined whether enough adjustments could be made to mitigate the need for a chiller plant upgrade, but that is the point of the exercise. This type of thinking is not only consistent with, but also part of the LEED philosophy.

At this point, designers could also be thinking about EQ Credits 2 and 3 (one point each). EQ Credit 2 simply states that ventilation systems need to be designed to provide air change effectiveness of 0.9 or greater, as required by ASHRAE 129-1997. Credit 3 mandates that someone other than the designer review the project design prior to preparation of Construction Documents, review the Construction Documents prior to completion, and also review selected equipment submittals. The credit also stipulates that an energy management manual be completed as well as a post-occupancy review of building functionality. It is not clear whether or not Ohio University Facilities Management could complete this entire list for LEED Credit.

Related to the issue of commissioning is the issue of Measurement and Verification (M&V). This issue is discussed in detail in the “Building Efficiency Analysis” section of this thesis. EA Credit 5 offers a point for the creation of a M&V plan to provide for long-term accountability of building resource consumption and performance. Ohio University already sub-meters a number of utilities, but additional sub-metering would be required to achieve this credit. Monitoring of building CO_2

levels, temperature and humidity could also be included in a M&V plan, which would satisfy requirements for EQ Credits 1, 7.1 and 7.2.

The element of controllability (temperature and lighting) for 50% of occupants in non-perimeter spaces satisfies EQ Credit 6.2 and is also relevant to this discussion. Although dual duct systems offer a high degree of controllability by room, this credit is awarded for giving individual occupants the ability to control temperature. According to the LEED Rating System, this level of controllability is almost exclusively afforded by under floor air system (USGBC 2005).

On the topic of fire suppression, EA Credit 4 (one point) mandates that HCFC and halon-free fire-suppression systems be used. Provision of recycling containers is a LEED prerequisite in the M&R Category, but LEED was not discussed at the meeting.

Meeting 12

The twelfth meeting addressed aesthetic issues regarding exterior entries, exterior detailing, and views of the building from different points on campus.

Discussion: No LEED-related issues were presented.

Meeting 13

Meeting 13 addressed building entries, parking, floodplain issues, and exterior aesthetics. The budget was again questioned: B&N architects expressed discomfort with a project contingency of less than 7% of the total budget, and asked for a 10% contingency fund. In other words, they asked that the budgeted building construction cost be no more than 90% of the total available funds.

Discussion: The only new LEED-related issue discussed in this meeting was parking. The Project Team considered siting a below-building parking lot at ground level, currently empty due to flooding concerns. However, this would add an additional $500,000 to the project's total cost. It was ruled out because the project budget is already too high. If the 23 parking spots proposed by the plan were less than 50% of total parking needed for the new facility, and the below-building option was pursued, the project would have earned a point in conjunction with SS Credit 7. Also, SS Credit 4.4 gives a point for meeting but not exceeding minimum local zoning requirements for parking and providing preferred parking for carpools capable of serving 5% of the building's full time occupants.

Meeting 14

Meeting 14 addressed minor aesthetic and site issues. A final layout regarding fenestration was discussed.

Discussion: Fenestration has an impact on many credits (already detailed) including E&A Credits as well as IEQ Credits, though these were not discussed. Specifically, IEQ Credit 6.1 could have been discussed as fenestration plans were finalized. IEQ Credit 6.1 stipulates that one lighting-control zone per every 200 sq ft. of regularly occupied areas AND one operable window be offered for all regularly occupied areas within 15 feet of the perimeter wall.

Meeting 15

The budget took precedence at this meeting. Project Architects noted that they were not comfortable with the small contingencies buffer and requested that changes be made to building size or design to allow for more slack in the budget.

Discussion: No LEED-related matters were discussed.

Credits Not Mentioned in this Review

I did not include a number of credits in this review because they were either not relevant to the project; didn't need to be addressed during this time period; will be addressed due to minimum standards required by Federal Regulations, the State of Ohio, City of Athens, or Ohio University; or because issues relating to their inclusion were not included in project notes. They are as follows:

SS Prerequisite 1: Erosion and Sediment Control

SS Credit 3: Brownfield Redevelopment

SS Credit 4.3 Alternative Transportation: Alternative Fuel Refueling Stations

SS Credit 8 Light Pollution Reduction

WE Credit 1.1 Water Efficient Landscaping

E&A Prerequisite 1: Fundamental Building Systems commissioning

E&A Prerequisite 2: Minimum energy Performance

E&A Prerequisite 3: CFC Reduction in HVAC&R Equipment

E&A Credit 2.1 Renewable Energy 5%

E&A Credit 2.1 Renewable Energy 10%

E&A Credit 2.1 Renewable Energy 20%

E&A Credit 6 Green Power

M&R Credit 2.1 Construction Waste Management: Divert 50%

M&R Credit 2.2 Construction Waste Management: Divert 75%

M&R Credit 3.1 Resource Reuse: Specify 5%

M&R Credit 3.1 Resource Reuse: Specify 10%

M&R Credit 6 Rapidly Renewable Materials

M&R Credit 7 Certified Wood

IEQ Prerequisite 1 Minimum IAQ Performance

IEQ Prerequisite 2 Environmental Tobacco Smoke Control

IEQ Credit 3.1 Construction IAQ Management Plan: During Construction

IEQ Credit 3.1 Construction IAQ Management Plan: Before Occupancy

IEQ Credit 5 Indoor Chemical & Pollutant Source Control

Inovation & Design Credits 1.1-1.4

Campus Building Y Planning Document Contents

A random LEED-Certified project's planning documents were analyzed to determine if and how LEED was addressed during project planning Table 4.2.2 & 4.2.3). It in fact was. LEED was addressed at 8 of 10 project meetings and Credits in 4 of 5 LEED Categories were discussed.

This data cannot be used to establish trends of meeting contents for LEED-Certified projects because it only represents one sample project. It does however offer an example of what ILRF planning might have looked like if LEED was emphasized during project planning. It also suggests the need for additional studies, which will be detailed in the discussion section of this thesis.

Barriers to LEED in ILRF Project

This section presents responses to a 9 question survey regarding the incorporation of LEED in ILRF project planning from 5 ILRF Project Team members (Table 3.1). The second section outlines personal observations regarding barriers to LEED in the planning process based on planning-project meeting minutes and a list of barriers to green design sourced from two Master's Thesis projects.

Survey Results

The following questions were posed to members of the Project Team to gather their input on a number of issues related to incorporating LEED in the ILRF project. Again, the survey was not designed to provide a quantitative evaluation of the group's opinion. It was only meant to allow the group members to voice their opinion regarding the goal of incorporating LEED in the ILRF project and to allow their input regarding improvements that may be made in future LEED planning projects. These results will be used to develop the discussion section of this thesis.

Of the 32 members of the Project Team, four responded. Statement evaluations and comments are included from all respondents. The rating system, survey questions, and responses (in their entirety) are listed. Note that "aforementioned project goals" refers to the following clause in the design contract for ILRF:

> The University desires that the proposed building be evaluated using the LEEDS format. Achieving LEEDS Certification (the lowest level) is a goal, but not a requirement. Documentation of the steps taken and the score achieved will be

prepared. The cost for achieving silver level will also be estimated with the expectation that a donor may be found who would be willing to fund the necessary construction elements.

Rating system:

1-very inaccurate

2-moderately inaccurate

3-indifferent

4-moderately accurate

5-very accurate

Survey Question 1: The Project Team was aware of aforementioned project goals regarding LEED.	
Rating	Comments
4	This topic was presented and briefed during project program and schematic design phases.
2	The original Russ College team had some knowledge, but not the current team.
4	I and some others of the project team were aware of these goals, tho' only a handful of us read the contract.
5	I believe the Project Team (PT) was aware of the goals regarding LEED. However, it was not heavily discussed.
4	Aware but not stressed.

Table 4.1: Survey Question 1 - Project Goals

Survey Question 2: The Project Team was sufficiently familiar with LEED rating system and LEED requirements to work toward aforementioned project goal.	
Rating	Comments
1	The intimate details for LEED evaluation were not covered by the group, and the general concensus was to allow the designers to coordinate LEED as much as feasible, and create responses for accreditation purposes.
1	LEED info was one document, probably ignored by most.
1	I don't think any of us, except the experts at B/N were familiar with the LEED system.
2	I do not believe that some members of the PT are familiar with LEED rating system
2	Only had a general understanding of requirements.

Table 4.2: Survey Question 2 – Knowledge of LEED

Survey Question 3: The Project Team was familiar with the Department of Energy and the United States Environmental Protection Agency's Labs 21 for Laboratory Efficiency.	
Rating	Comments
1	I am not aware of any details being presented.
1	Unknown to me, at least.
1	Ditto above. (Note: This Refers to Comment 3 from question # 2)
2	Again, I do not believe that some members of the PT have ever seen Labs 21.
1	Never heard of it.

Table 4.3: Survey Question 3 – Knowledge of Labs 21

Survey Question 4: The Project Team sufficiently addressed the LEED project goal during project planning.	
Rating	Comments
4	If the team goal was to incorporate as much of LEED discipline into the design as feasible, based on costs and designer's intent, then the strategy to allow the designers to coordinate and communicate should suffice without additional input.
1	No discussion to my knowledge.
1	We really haven't been doing any LEED discussing. Maybe a little, but I can't remember what.
3	LEED goals were addressed. Sufficiency depends on whether LEED was an expectation. I do not believe LEED was an expectation.
1	Never addressed.

Table 4.4: Survey Question 4 – Addressing LEED

Survey Question 5: The ILRF project budget provided adequate funding for the incorporation of LEED into project design.	
Rating	Comments
1	The budget does not allow funding for any non-critical features, so any LEED initiatives would have to also be the lowest cost alternative.
3	Don't know.
4	I think we do have funds to do the rating and to incorporate LEED principles in the design.
3	If LEED was a goal there is not inadequate funding; but it is not clear that LEED is a goal for the building.
1	Budget too tight to cover required programming.

Table 4.5: Survey Question 5 – Project Budget

Survey Question 6: The ILRF project schedule provided an adequate timeframe for the incorporation of LEED into project design.	
Rating	Comments
1	The schedule does not allow time or costs of design of any non-critical features, so any LEED initiatives would have to also be the lowest cost alternative.
3	Don't know.
4	I think we have a very reasonable schedule overall.
4	The LEED discussion was minimal, and depending on the desirability of LEED, inadequate timeframe may have been allowed.
1	Not included.

Table 4.6: Survey Question 6 – Project Schedule

Survey Question 7: ILRF stakeholders (College of Engineering, College of Osteopathic Medicine, Arts and Sciences, Health and Human Services, University Planning) expressed an interest in LEED during project meetings, in accordance with stated project goals, and the Project Team adequately addressed this interest.	
Rating	Comments
4	The team goal was to incorporate as much of LEED discipline into the design as feasible, based on costs and designer's intent, and so communications were managed without additional input being required.
4	The stakeholders expressed the interest, but the team hasn't said much.
3	Engineering and UPI were the most vocal.
4	I believe there was some interest in LEED, and the PT did may not have adequately address LEED.
2	Some interest expressed at the very beginning of the first version of this project with the Russ College only.

Table 4.7: Survey Question 7 – Addressing Project Team Interests

Survey Question 8: LEED issues were addressed outside of Planning Meetings. If so, please list time, location, and meeting participants.	
Rating	Comments
4	All cost constraints and significant design factors were addressed in specific communications between the UPI office and the Associate. LEED issues were often part of this discussion as to anticipated costs for various alternatives. No records for LEED specific items are available.
-	Unknown
2	At the beginning of the process, say, a year to 6 months ago we discussed LEED issues.
3	All LEED discussions I had were during the meeting times in Walter Hall (sometimes at the very end of the meeting, and were more informal.) I was not a part of LEED discussion outside the regular meeting.
1	Not in my experience.

Table 4.8: Survey Question 8 – Additional Project Meetings

Survey Question 9: Please state any additional comments regarding the Project Teams efforts at meeting the aforementioned project goal regarding the incorporation of LEED in ILRF design.
Responses
If project owners are truly serious about making LEED initiatives part of the basic design, as opposed to a option when only cost-effective, then a substantial cost increase would have to be incorporated into the budget development to show long-term gains (offsets) for energy conservations and environmental advances. The current budget model does not include these options, and so any additional costs for LEED initiatives are unsupported.
This is, so far, a side issue that has not really been addressed.
Thanks for bringing this to our attention. I think it is time for us to get the LEED conversation going again.
LEED certification received some attention. I believe the level of desire for LEED certification was low. Indeed it can be quite expensive to build to LEED certification.
-

Table 4.9: Survey Question 9 – Additional Comments

Barriers to LEED observed in ILRF planning

A total of 15 barriers were considered for identification in the ILRF planning process. A total of five of these barriers were identified as having a negative impact on the ILRF planning process. Ten barriers considered were found to have not had a direct impact on project planning.

Lack of Expressed Interest From Clients (Owners/Developers)

Perhaps the biggest barrier to LEED in project planning for ILRF was the lack of expressed interest in LEED from the client. In this case the "client" is the College of Engineering, College of Osteopathic, College of Arts and Sciences, etc… Ohio University in general is also considered the client. The first step of any building project at Ohio University is development of a program of requirements. During this stage, building owners set minimum requirements such as space needs, and also create a list of philosophical goals. These issues are included in the bid for a project contract.

Once planning starts, building owners convey their wishes to the project architects. For example, building owners may desire the building space to be bright and airy, yet distinguished looking. They may also want to create a design that facilitates occupant interaction yet allows for privacy. Building owners may create endless lists like these, but they will only be realized to the extent that there is time and energy to address them in the planning process. These issues are re-visited by architects while they are translating them into a design, but the issues that dominate planning meetings are those that building owners emphasize.

Burgess & Niple always came to project meetings with an agenda, but the building owners came with their own agenda. Burgess & Niple rarely closed discussion of an item until building owners were satisfied and wished to move on. It appears that LEED issues were addressed during project planning before the College of Osteopathic Medicine was involved in the project (according to survey responses). However, they were not addressed during meetings after September of 2006. This shift is important because an entirely different building site and plan was developed. It seems that Burgess & Niple dropped LEED at the implicit wishes of the building owners, who did not keep the issue on their own agenda. This particular issue is further explained in the following section.

Project Team Doesn't Understand LEED

The project team was not familiar with LEED in the case of ILRF. Members of the original Project Team were given one-page LEED handouts at the start of the original

Stocker Center project. However, LEED was not re-addressed to the project team when the project was expanded. Although College of Engineering professors were members of the Project Team, none of these engineers specialize in architecture or green design. A majority of the remaining members of the project team were research directors, staff from the College of Osteopathic Medicine, and administrative staff from Ohio University. If LEED actually was an implicit goal of the Project Team, they were not likely familiar enough with green-design or LEED principles to know what to ask for from project architects.

Additionally, the University Planning and Implementation office does not have a LEED-accredited staff member. Had the Planning and Implementation office been able to offer leadership and project members been briefed on the LEED system, LEED credits could have been discussed at the appropriate times in the planning meetings. The staff member could have held the architect to the LEED goal, as well.

Lack of Project Funding for Green Design Features

A theory on barriers to LEED is that LEED is less likely to be pursued in cases where operating funds and construction funds are budgeted and accounted separately. In that case, long-term operational savings from LEED cannot offset construction costs in a single project budget. As a consequence, there is little incentive for incorporating efficiency into the design. Ideally, future building operational savings, calculated during design, should provide justification for using some operational money up front for efficiency investments.

At Ohio University, the Planning and Implementation Office (responsible for building design) and the Facilites Management Office (responsible for paying utility bills) are in separate buildings, located a mile apart on campus. Although Facilities Management representatives attended, design meetings when issues such as HVAC or other large aspects of building mechanics are discussed that relate to efficiency, operational savings are not used for new building construction projects on campus.

Design Fee-Structure

Burgess & Niple charged Ohio University $40,000 for LEED-related design services. According to Tim Oliver, the Burgess & Niple Project Manager for ILRF, this figure was calculated in part as $1,000 each for the 26 points required for minimum certification. This charge was for credit documentation, which takes a significant effort in some cases. The remaining $14,000 of the LEED fee was used for additional design services, above the typical scope of design, for preparing documents and specifications to meet LEED standards.

Project architects had little incentive to put extra effort into incorporating LEED in ILRF design because it was not required and they were not rewarded for doing so. It is sometimes the case that green design results in a cost increase up front, even if this cost increase will result in long-term savings. However, architects are not responsible for paying a project's utility bills: Efforts to design efficient buildings, without strong support of the client/owner, do not benefit the designer. In fact, such efforts may hurt the designer inasmuch as their ability to address other project issues (from a time and money standpoint) is compromised.

Cost Perceptions

During building planning (Meeting 5) a representative from the University Planning Office stated, "LEED is huge. LEED is expensive." This is true. LEED increases capital costs. Many LEED credits do not offer any type of *financial* incentive, either short- or long-term. On the whole, however, long-term financial benefits do outweigh costs, as has been proven in a number of studies (see literature review earlier).

Building Efficiency Analysis

Another barrier to the design process can be generally described as the inability to quantify the potential benefits of LEED. Although Ohio University does closely certain types of energy use on campus, sufficient information to allow detailed energy-use comparisons among existing buildings does not exist. Without such information, the potential gains to be realized in a LEED building are harder to argue. Ohio University values energy efficiency and already incorporates many energy-efficient design strategies into buildings. However, it is unclear how Ohio University buildings perform relative to LEED buildings. It should be noted that OU does not gather energy use information for the entire campus in such detail. Such sub-metering is expensive, and the process for conducting detailed analyses is complicated and time consuming. This issue is further explained in the appendix to this thesis.

New Barriers to LEED Observed in ILRF Planning Process

The Non-Binding Contract

The contract details for ILRF, arguably the largest barrier to incorporating LEED in the project, present a new set of issues regarding LEED that has not been identified in literature. ILRF's LEED contract is unique in that the project was used as a test case for LEED and the contract accurately reflects this. However, the contract is written as such that LEED is not a requirement. Monetary incentives were provided to B&N in the form of an upfront payment. However, there are no stated consequences if ILRF does not achieve a LEED equivalent rating. The Project Team had nothing to do with LEED's insertion into the project contract and was not adequately briefed on the topic to address it. University Planning and Implementation may have relied too heavily on B&N to address LEED outside of project meetings. Because incremental progress reports were not provided by B&N regarding LEED, its progress could not be judged by UPI.

The "Multi-Stakeholder Effect"

The "multi-stakeholder effect" describes a situation where multiple stakeholders, with varying interests, are engaged in project design. Because there is only so much that can be accomplished in building design under time and budget constraints, stakeholders struggle to ensure that their interests are included.

Project planning for buildings is only linear to the extent that certain design features build upon others. For example, a building's site is typically selected before the footprint is developed and the footprint is developed before the floor-plan is created. However, well established design features can be changed or even dropped altogether at virtually any point in design.

In the case of ILRF, stakeholders included the Russ College of Engineering, the College of Osteopathic medicine, and others. The Russ College was primarily interested creating new classroom space, and a unique learning environment. The College of Osteopathic Medicine was interested in creating laboratories for research. Both of these stakeholders were also given grants and were required by donors to protect these interests. An additional stakeholder, OU Health and Human Services, wanted a "body mechanics" lab to be incorporated into design, which required specific structural design that minimizes building vibration.

It was observed that during project meetings, stakeholders primarily emphasized their own goals, and not the goals of other stakeholders. For example, the College of Osteopathic Medicine team members routinely addressed lab issues and rarely addressed issues related to the learning environment. Dennis Irwin, Dean of the Russ College noted on a number of occasions that he wanted to make sure the project team kept in mind the goal of creating a unique learning environment.

In addition, Health and Human Services, actually stated at one point that their interests had been completely dropped from the program. This happened as they were present during early programming meetings, but absent from a number of subsequent planning meetings. As the space was filled and the budget began to tighten, their interests were replaced with those of stakeholders present at the meetings. Consequently there exists a need for constant reaffirmation of project goals in planning, especially in a scenario where there are competing interests.

LEED was actually one of the original interests of the Russ College. However, as additional stakeholders, and stakeholder interests, were added to the project, resources to address them remained constant. Meetings did not increase in frequency or length, and the Burgess & Niple design team was not expanded. As a result of diminished resources, The Russ College was forced to prioritize their goals and protect those that were most important. The Russ College may have pushed the LEED issue more if they weren't busy protecting their core interests.

Negative Perceptions of LEED as Vocalized by Project Architects

Misconceptions of the LEED system, such as the common belief that green design is drastically more expensive than traditional design, become a larger issue when they are vocalized by design professionals during the planning process. Negative comments about LEED were made by both the UPI office and architects from Burgess & Niple. During meeting 5 a representative from UPI said “LEED is huge, LEED is expensive.” During the same meeting a member of the Burgess & Niple team also stated that LEED is a “very convoluted system.” These comments were made in response to a project team member who was inquiring as to the status of LEED in project planning. A B&N architect said that although LEED was convoluted, many of the architectural strategies used by B&N align with the LEED system and that they would continue incorporating LEED into project design.

Comments made about LEED during meeting 5 were made at the end of the meeting and were only heard by a few people on the Project Team. The project team member who inquired about LEED was also not a regular attendee of meetings. This Team Member was a representative from the College of Osteopathic Medicine and was preparing a report for donors. The member mentioned that they had heard about LEED at a speaking event on campus where a green building owner presented LEED in a positive light. Response to the team member’s inquiry about LEED by design professionals present at the meeting was negative and slightly discouraging. Project team members who witnessed this exchange may have taken on a negative perception of LEED. Team members may have also been dissuaded from pushing the LEED for fear of looking incompetent by project architects who were not supportive of LEED.

Established Barriers *not* Identified in ILRF Design Process

A number of barriers to green design identified in current literature did *not* appear to be issues with the ILRF planning. For completeness, these barriers are listed below. They are worth mentioning because in a future LEED project, they could be factors. Like the recommendations above, additional recommendations might be made relative to these barriers:

- Subcontractors may lack technical understanding of LEED components. Therefore, it is incumbent on the client/owner to have sufficient knowledge of LEED to contract with able contractors.
- Banks may resist financing non-standard projects. This should not be a problem because of Ohio University should not be building something so radically different that it will not be approved by the Board of Regents or the State Architect's Office.
- Owners require very short payback periods for efficiency investments. The State Architect's Office recommends any efficiency investment with a payback of 5 years or less. As a rule of thumb, investments with similar paybacks make sense. However, OU may want to consider efficiency projects with longer paybacks because of long-term ownership of buildings.
- In some cases, the schedule is critical, being an important project consideration. LEED may cause schedule problems because it is innovative. Contingencies should be allowed.
- Clients don't want to assume the risk of a new untested product or method. Universities are the ones to do this; they are all about innovation, and in fact can

assess building performance through student engagement in such programs as Mechanical Engineering and Environmental Monitoring (see below).

- Owners and architects in many cases are unfamiliar with green products. Therefore, the previous recommendations are reiterated: It is critical to have a LEED accredited staff member, and to select experienced architects.
- The actual LEED certification documentation costs money and time and does not offer savings. Although the certification process costs money, a large portion of this fee is used to pay for 3rd party verification and this process ensures quality of work. If OU does not want to invest in external 3rd party verification, the existing internal system of verification of work may be altered to address LEED issues specifically.
- A related barrier is that an institution may already incorporate energy-efficient measures, and the LEED certification in that case may offer nothing but a seal of approval. Ohio University does indeed incorporate energy efficiency into all project designs. However, LEED is more than energy efficiency. The entire philosophy is worth examination. Moreover, if LEED standards are in fact being met, then it may be worth getting the certification simply for the positive publicity, especially at a university that wants to show that it is at the forefront to potential students and staff.
- People like to do what they've always done or a resistance to change. Professionals in any field should explore new ideas and strategies. This does not mean that a new strategy should be adopted just because it is the current "trend." University Planning and Implementation is already exploring and beginning to

actively implement LEED. Again, OU should consider hiring a LEED accredited staff member.

Ohio University ILRF Project – Meeting Summaries										
Meeting #	LEED	Budget Issues	Schedule Issues	Space Programming / Floor Plan	Aesthetics / Fenestration, Massing, Interior Treatments	Building Materials	Lighting, Electrical	Plumbing, Water Use	HVAC, Thermal Efficiency, Fenestration	Building Site, Landscape Issues
1	-	-	-	x	-	-	-	-	-	-
2	-	-	x	x	-	-	-	-	-	x
3	-	x	-	x	-	-	-	-	-	x
4	-	-	-	x	x	-	-	-	x	x
5	x	x	x	x	-	-	-	-	-	-
6	-	-	x	x	x	-	-	-	-	x
7	-	x	x	x	x	-	x	x	x	x
8	-	-	-	x	-	-	x	-	-	x
9	-	-	x	x	x	-	-	-	-	x
10	x	-	x	x	x	-	x	x	x	-
11	-	-	-	x	x	x	x	x	x	x
12	-	-	x	x	x	-	-	x	x	x
13	-	x	x	x	x	-	-	-	-	x
14	-	-	x	x	x	x	-	-	-	x
15	-	x	x	x	-	-	-	-	-	-

Table 4.10 Ohio University ILRF Project Meeting Summaries

Anonymous Campus Building – Meeting Summaries										
Summary#	LEED	Budget Issues	Schedule Issues	Space Programming / Floor Plan	Aesthetics / Fenestration, Massing, Interior Treatments	Building Materials	Lighting, Electrical / Energy Use	Plumbing, Water Use	HVAC, Thermal Efficiency, Fenestration	Building Site, Landscape Issues
1	x	-	-	x	-	-	x	-	-	-
2	x	x	-	-	-	-	x	-	x	x
3	x	-	-	x	x	x	-	-	x	-
4	x	-	-	x	-	-	-	-	-	x
5	-	-	-	x	x	x	-	-	-	x
6	x	-	x	x	x	x	x	-	x	x
7	x	x	x	x	-	-	x	-	x	-
8	x	-	-	-	x	x	-	-	x	x
9	x	x	x	-	x	x	x	-	x	-
10	-	x	-	x	x	x	-	-	x	-

Table 4.11 Anonymous Campus Building Meeting Summaries

Anonymous Campus Building – LEED Category Referenced					
Meeting #	Indoor Environmental Quality	Materials & Resources	Energy & Atmosphere	Water Efficiency	Sustainable Sites
1	-	-	x	-	-
2	x	x	x		x
3	-	x	-	-	-
4	-	x	-	-	-
5	-	-	-	-	-
6	-	x	x	-	-
7	x	-	x	-	-
8	-	x	-	-	-
9	-	x	x	-	-
10	-	x	x	-	-

Table 4.12 Anonymous Campus Building LEED Category Referenced

Chapter 5: Conclusions & Recommendations

ILRF design and construction is not yet complete, so it is not known if the project will achieve a LEED Certified (equivalent) rating. Therefore it is impossible for this thesis project to ascertain whether or not planning for LEED, whether done inside or outside of regularly scheduled project meetings, was adequate. However, based on this observer's knowledge of the LEED system, it is unlikely that the building will score enough points to be LEED Certified equivalent.

This thesis has clearly identified that LEED was not a goal actively pursued by the Project Team, at least during regularly scheduled planning meetings. One explanation may be that Burgess & Niple was viewed as being solely responsible for the incorporation of LEED in ILRF design and they were to handle this outside of project meetings. However, if this was the case, it is not likely that a high number of LEED credits will be attained because many of these features require at least some discussion by the project team because they increase a building's cost; affect a building's aesthetes; etc… It is also possible that because LEED was presented to Burgess & Niple as a project goal, and not a requirement, they assumed LEED was to be treated like other project goals, which were incorporated into design to the degree that project stakeholders pushed for them.

This thesis indicates that substantial improvements can be made in Ohio University's approach to the incorporation of green design into campus buildings regardless of ILRF's final LEED rating. Through observation, interviews and a survey, a number of obstacles to the incorporation of green design were identified in the planning process. If addressed, these obstacles represent opportunities for improvement in the Ohio University design process.

Acknowledge the Value of LEED and Convey to Project Team

First, the value of Leadership in Energy and Environmental Design must be recognized by Ohio University policy makers (the President, Vice Presidents and Deans, among others) and the Planning and Implementation and Facilities Management offices, so that there is commitment to LEED principles. There is much to be gained, as demonstrated in the literature review and summarized here. A growing body of research indicates that LEED-certified buildings can be built at comparable price to traditional buildings. Although LEED is often perceived to be very expensive, research by Kats (2003) indicates that average capital cost increases actually range between 0 and 6% of total project cost. The same study noted that an efficiency investment of two percent of construction costs during the design and construction phase will typically yield life cycle savings of over ten times the initial investment.

In addition to financial benefits, LEED may improve the learning and working environment at Ohio University. The 1999 Herschong Mahone Group study indicates that children who learn in classrooms with high amounts of day lighting increase academic performance by up to 20% compared to children who learn in traditional physical environments. A Herman-Miller study indicated that worker productivity increased 7% after workers moved into a new facility that incorporated high amounts of daylighting (Heerwagen 2000). The Lawerence Berkeley National Laboratory finds that

U.S. businesses stand to gain as much as $58 billion in lost sick time and $200 billion in worker performance simply by improving indoor air quality (Fisk 2000).

Global environmental gains are also realized, as described in the literature review in Chapter 2.

Institutional commitment is of course necessary, but in addition the project teams working on LEED buildings need to be informed of the importance of LEED, so that there is team understanding and support. An information session about the benefits of LEED and importance of its incorporation into project's program should be held early in the design process.

LEED-Accredited Professional

A well-informed consumer makes better purchases than an uninformed consumer does. In the building design process, the building owner is the consumer. The owner buys design services from architects and engineers. In the case of ILRF, Ohio University bought LEED design principles for $40,000. In all other aspects of design (other than LEED), input was given by the University Planning and Implementation (UPI) office on behalf of the building owners. UPI representatives have been involved in the planning of a number of buildings and are able to negotiate a better building design because of their experience. However, UPI has no experience with LEED, so it relies entirely on the architect's (Burgess & Niple's) experience. UPI should acquire LEED accreditation for staff members. LEED accreditation is offered by the U.S. Green Building Council, which ensures that a planner has adequate knowledge of the LEED system to make appropriate and timely recommendations regarding its implementation. Accreditation is not an onerous task. The USGBC offers three (1 day) workshops but does not require them. Course material for LEED can be purchased online or at workshops. Accreditation is awarded after successful completion of a test over the LEED rating system. Currently there are more than 20,000 LEED accredited design professionals in the United States.

Contract Changes

The ILRF project marked the first time LEED was inserted into a project contract at Ohio University. The ILRF project contract was written to allow flexibility in addressing LEED in the project design. The contract requires the architects to tally a LEED score; including documentation of the steps taken to pursue credits and to estimate the cost for achieving LEED Silver for ILRF (should the project team decide to pursue this rating). However, the contract specifically states that achieving a LEED Certified rating is not required and only a project “goal.”

Many project goals were considered for ILRF and the first nine months of project planning was not unlike trying to fit an elephant into a doghouse. Financial, schedule, and other project constraints limit the features that can be incorporated into a project. Although it is the responsibility of architects to incorporate as many project-owner goals as possible, the owner must prioritize goals. In the absence of a clear mandate, project goals that dominated design sessions were those with champions who kept their priorities at the forefront throughout the planning process. For example, the College of Health and Human Services raised issues about being left out of the ILRF program. Their project goals were expressed at an early project meeting but they did not follow up with their requests during subsequent meetings. Consequently, their desire for specific project features was not included in the program. Under the current contract structure, it is less likely that LEED will be incorporated into project design if not mandated from the outset and then actively pursued by the Project Team.

Although Burgess & Niple (B&N) will likely include LEED in ILRF's design, they were given sole discretion as to which LEED features will be pursued. It is not clear which credits will be pursued by B&N, but it is clear that they were not given an incentive to pursue credits beyond those that can be achieved at the least (design) cost to the firm. The construction costs for LEED credits will also compete with other possible project features. If LEED is not mandated, project stakeholders will not surrender their project goals for LEED features (especially if they are unaware of LEED features). To rectify these issues, contract language and incentives should be changed for future LEED projects. Specifically, project funding mechanisms and the design pay scale should be altered. Instead of charging $1,000 for each of the 26 LEED credits and $14,000 for additional design services up front, the pay scale could be prorated. For example, $14,000 could have been given to Burgess & Niple up front and a project bonus could have been offered to Burgess & Niple equal to approximately $1,538 per LEED point earned, consistent with the pay scale they provided. Such a contract provides B&N with an incentive to work towards LEED credits during project planning. To take this concept a step further, B&N could have also been offered a cut of long-term operational savings. Also, some credits that are available with minimum effort and little or no additional cost should not be paid for. According to Davis Langdon Consulting (2005), 18 points in the LEED system require minimal effort.

The ILRF project contract left LEED too open ended. A specific LEED rating should be required by the project contract. If the project is left open ended to allow flexibility, the Planning and Implementation office should take a stronger role and actively push LEED during project meetings.

Financing LEED Projects

LEED buildings cost less to *operate* than traditional structures, according to published analyses described in the literature review. However, LEED buildings tend to cost more to *construct* than traditional buildings. Harvard University's solution to covering the extra cost of LEED was to create a "Green Fund." The Green Fund is a pool of money that can only be used for efficiency projects on the Harvard campus. A portion of the financial savings from these projects is used to pay back initial withdraws and the fund is self-sustaining. Ohio University actually used a similar strategy before hiring an energy services company (ESCO) to complete efficiency retrofits on campus. As of April, 2006, Ohio University's contract ESCO work has ended. Ohio University may want to consider reverting to a revolving efficiency fund for implementing efficiency measures. This fund should be available for new construction as well.

Building Efficiency Analysis

Measurement and verification (M&V) of building functionality is vital for validating energy efficient design at the component and project level, identifying operation savings of energy efficient design, and determining the proper functioning of building design and equipment. This information can be used to calibrate building equipment for ideal efficiency, ensure indoor environmental quality for occupants, and to improve building design and design processes (IPMVP III.).

At Ohio University, complete information regarding the current efficiency of design is not gathered at sufficient detail to allow accurate comparisons among buildings with regard to efficiency. For example, the effectiveness of energy-efficient designs on long-term operational costs at Ohio University is not known. While tracking energy and costs is useful in its own right, it also offers an educational opportunity: Students can learn about efficiency as they research and report on the function of their own dormitories, dining halls, classrooms, labs, and athletic buildings. That process could begin now, because the University's new Innovation Center was built with an emphasis on energy efficiency. Comparison of life-cycle energy costs and related savings due to investments in efficiency could be made between the Innovation Center and other buildings on campus. Classifying the high- efficiency buildings that already exist on campus would allow planners and researchers to identify green strategies that have been successfully integrated into the campus buildings without compromising the existing design / aesthetic framework, important because some efficiency strategies affect aesthetics.

Protocols for conducting analysis of building efficiency already exist and are available to the public free of charge via the World Wide Web. This thesis proposes that the Department of Energy's *International Performance Measurement and Verification Protocol* (IPMVP) be used for collecting and analyzing data for a building efficiency analysis. IPMVP is the preferred measurement and verification (M&V) protocol for many electric utilities, Energy Services Companies (ESCO's) and other entities including the United States Green Building Council. This protocol also draws upon other well-established protocols such as those created by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). Key components of IPMVP are provided in Appendix 1.

To summarize this recommendation, actual energy data is essential for performance verification, for performance optimization, and for estimating gains that have been or can be made. Collecting energy data on existing buildings will establish what energy-conserving measures are effective. Finally, the buildings serve as ongoing experiments that could provide OU students with the opportunity to learn about energy efficiency through service learning.

3rd Party Review

One of LEED’s greatest strengths is the process of 3rd party review. This ensures that LEED buildings are actually “green” and not just “green washed.” Documentation by project architects of LEED credits incorporated into ILRF’s design was required by the ILRF contract. The UPI also reviews all design plans and serves as a measure of quality control. However, this does not amount to 3rd party review, which stipulates that an outside party, having no stake in project design, reviews plans to certify claims.

3rd party review may not be feasible, given financial constraints of projects. However, a low cost alternative would be to post documentation of LEED credits incorporated into building designs on the UPI website for each new building project. This detailed information could be viewed by anyone and would add a level of transparency to building projects, roughly equivalent to 3rd party review.

Follow the Example of Others

The University of Cincinnati created *Process Guide: Applying Sustainability to UC Projects* (2004) to serve as a roadmap for including green design in building projects at the University of Cincinnati. This guide was created after UC leaders mandated that sustainable design be incorporated into all construction projects, using the USGBC's LEED Green Building Rating System as the standard for measuring performance (University of Cincinnati 2004). The University President approved this planning measure in October of 2001.

UC also require architects to give a LEED progress report at the end of every design stage. The University of Cincinnati's *Agreement for Professional Design Services* contract reads as follows:

> 2.3.6 Sustainable Design. Upon completion of the ___________ for each phase of the Project or appropriate portion thereof, the Associate shall submit to the University documentation and proof, in a format approved by the University, that the design has incorporated the concepts of sustainable design, as stated in the "University Design Guidelines and Standards", consistent with LEED "_______" Certification Level.

The University of California recently required that all buildings be built to LEED standards as well. Because actual LEED Certification costs money, and provides no financial benefit other than PR, the University is looking into developing its own certification system. Ohio University might consider developing a similar system to more accurately reflect and encourage sustainable design strategies most relevant to the region. For example, although LEED offers a number of points for water conservation, the issue isn't as critical in southeast Ohio as it is in Arizona, as Ohio receives abundant rainfall.

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Appendix

The IPMVP consists of three documents detailing M&V for different types of construction projects and project measurement needs. Volume I details M&V for renovation projects. Volume II outlines strategies to measure and improve indoor air quality. Volume III details M&V for new construction projects, but uses Volume I as a reference where additional detail is required. Protocols such as ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) *Guideline 14: Measurement of Energy and Demand Savings* are also used as a resource, as suggested by the IPMVP. Guideline 14 is preferred by Energy Services Companies (ESCO's), utilities, and engineers to calculate energy savings in power production and building support equipment.

There are four options for M&V in new construction projects as described in IPMVP Volume III. They are applied as follows:

> **Option A: Partially Measured ECM Isolation-** This option determines the post-construction savings of ECM's (energy conservation measures) by measuring relevant energy flows of isolated components. This option is used for determining efficiency gains in a single building and the projected baseline is calculated by estimating energy use for baseline equipment (equipment not specifically designed for energy conservation) under post occupancy conditions during the M&V period. For example, calculating energy savings where a variable speed motor was installed as opposed to a fixed speed motor would be an appropriate scenario for this option.

Option B: ECM Isolation- Option B is identical to option A aside from the fact that option B eliminates needs for estimation of energy use by requiring additional and continuous metering of energy flows.

Option C: Whole Building Comparison- This option uses utility meters and/or submeters to determine post occupancy energy use of an entire building. Baseline energy data is calculated by determining energy use of a "control group" of similar buildings. The control group should be physically and operationally similar to the subject building. It should be noted that Option C often requires normalization for differences in control and subject buildings, therefore increasing the likelihood for error. The IPMVP only recommends this option for projects that do not require high rigor or accuracy of results. Specifically, this option would not be appropriate for projects where savings need be determined for compensation purposes. However, useful results from this option can be obtained.

Option D: Whole Building Calibrated Simulation- Option D determines post occupancy energy use of an entire building (featuring ECM's) with utility data and/or sub-metering. A baseline is calculated by simulating energy use of same project (without ECM's) using climatic and operating conditions of the M&V period.

The IPMVP M&V strategy most appropriate for an efficiency analysis of existing buildings at Ohio University is *Option C: Whole Building Comparison*. However, *Option D: Whole Building Calibrated Simulation* is appropriate if conducted by a qualified practitioner.

To illustrate the measurement and verification procedure, following is a description of required information and necessary steps for conducting an efficiency comparison analysis for four buildings at Ohio University. (For statistically significant results, the number of buildings for baseline calculation would need to be larger.) Buildings examined include the Innovation Center, Human Resources and Training, Walter Hall, and Bentley Annex . All are new construction and all were completed less than 24 months apart. However, building size, cost per square foot, and use type vary (Table 6.1).

Building Information					
	Cost / Sq. Ft.	**Square Ft.**	**Use Type**	**Construction Type**	**Year Completed**
Walter Hall	$175.70	47,074	Lecture	New	2004
Bentley Annex	$113.48	54,502	Mixed	New	2003
Human Resources	$89.34	24,960	Mixed	New	2003
Innovation Center	$76.24	36,728	Mixed	New	2003

Table 6.1 Building Information

The most important element in making a successful comparison with Option C is the availability of a control group that is similar in use and operation to the subject building. Differences in control and subject buildings increase the likelihood that an erroneous analysis will be made. Even when similar buildings are available, adjustments to the baseline still need to be made. This process of controlling for differences is called *normalization*.

This example study proposes the Innovation Center as the subject building, while Bentley Annex, Walter Hall and the Human Resources building serve as the baseline group. A logical assumption is that the Innovation Center, a green building built with a number of energy conservation measures in its design, will be more efficient than the control group. However, a look at water and electricity consumption of the subject and baseline buildings (Figure 6.1) suggests that the Innovation Center consumes more electricity per square foot than any of the subject buildings. It is possible that the Innovation Center uses far more electricity per square foot than subject buildings, but it is more likely that differences in use, operational hours, and building equipment are skewing results in a raw data comparison.

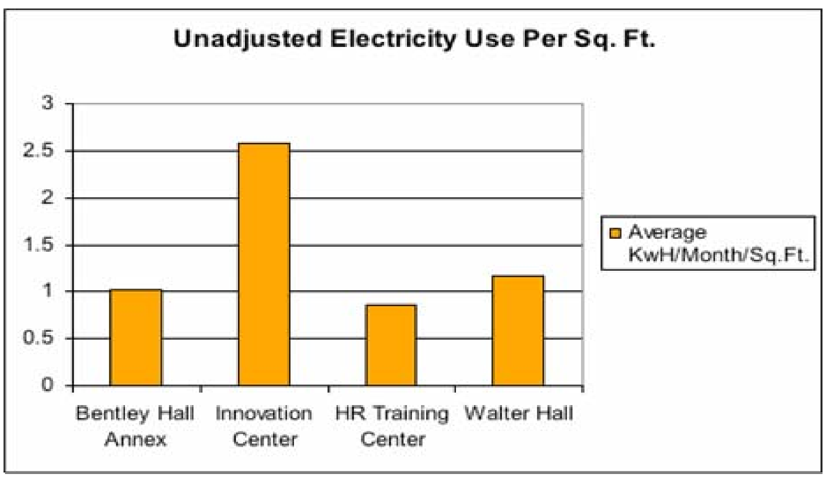

Figure 6.1: Unadjusted Electricity Use Per Sq. ft.

The goal of normalization is to account for differences in climate, occupancy and scheduling, building use (laboratory, office, etc…), envelope configuration, HVAC configuration, and differences in the general configuration (siting), between subject and control buildings. The overall objective of normalization is to adjust building data so that differences in scheduling, use type, building equipment, and so on, are neutralized. For example, the Innovation Center is located far enough away from campus that it could not be connected to the campus water chiller that provides chilled water to most buildings on campus, including all buildings in the control group. The Innovation Center chills its own water on-site, using electricity that is drawn through the building's electricity meter. Although electricity is required to chill water for baseline buildings too, that use is not included in their sub-metered electric bill, as it is chilled at a remote location and piped to the buildings. These factors illustrate the need for normalization.

A number of variables would have to be taken into consideration when normalizing for differences in baseline and subject buildings with regard to the water chiller. At least six factors govern a building's need for chilled water for the purpose of cooling: Solar gains through windows; heat gains and losses through the building envelope as a whole; internal gains from occupants; internal gains from building equipment; climate; and outside air loads. These factors also govern heating loads.

Because two types of water chilling systems are used in the building group, efficiencies for the individual systems need to be established. The first step in a normalization process using chilled water as an example would be to establish water-chiller efficiency at the Innovation Center and for the baseline buildings. Chiller efficiency at the Innovation Center could be established by consulting manufacturer specifications for the specific chilling hardware used. However, the point of M&V is to ensure building components are operating at suggested efficiency levels, so the equipment should be sub-metered to verify efficiency. Central chiller efficiency would need to be determined as well. More complicated would be determining how much chilled water is used per baseline building because chilled water is not sub-metered for all buildings on campus. This sub-metering would need to be done to make a building comparison of electricity used for water chilling. It is possible that sub-metering could be bypassed if thermal efficiencies of buildings were determined. A building's thermal efficiency and HVAC efficiency could be used to make an estimation of chilled-water use. However, sub-metering will give a more accurate reading and lead to a better overall comparison. This data also needs to be rectified with building use and scheduling.

Use and scheduling will likely present the biggest challenge to making building efficiency comparisons on campus. Internal heat gains from lighting equipment, occupants, office equipment, and HVAC equipment will vary between buildings due to building use type and scheduling differences. For example, the Innovation Center may be occupied mainly between the hours of 7:00 am and 5:00 pm, whereas lecture hall buildings may be populated from 8:00 am to 10:00 pm. This difference in occupancy would mean that cooling loads for lecture hall buildings may be increased due to heat generated by occupants as well as lighting for a longer period of the day than the subject building. This difference in scheduling would skew results of a building comparison if it were not taken into consideration during the normalization process.

Laboratories cannot be compared with lecture halls without making appropriate adjustments. Laboratories may contain equipment that produces heat and have more stringent ventilation requirements than lecture halls. In general, laboratories should not be compared with lecture halls at all because it is very difficult to make proper adjustments for the differences in energy requirements for the two spaces. However, in the case of the Innovation Center, laboratories are present. Sub-metering may allow a building evaluation to be made that subtracts extra laboratory energy requirements.

Water consumption data for subject and baseline buildings would need to be normalized for differences as well. Unadjusted utility data for water consumption (Figure 6.2) indicates that Walter Hall and Bentley Annex consume much more water per square foot than Human Resources and the Innovation Center. However, these figures need to be adjusted to make an accurate comparison.

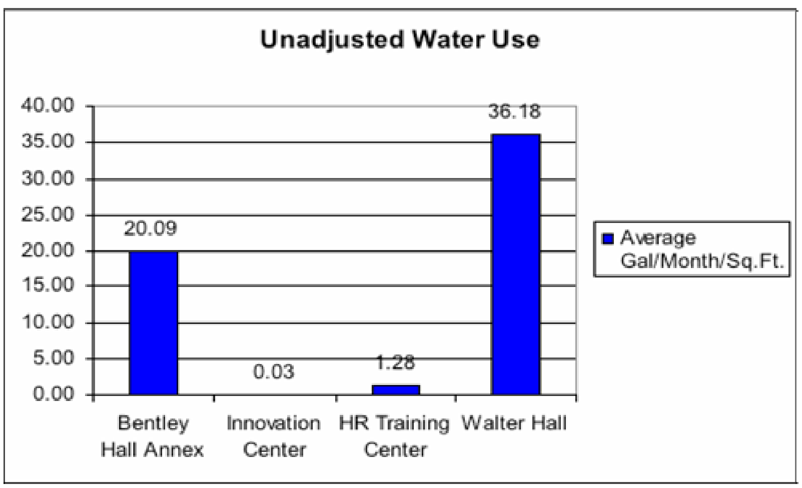

Figure 6.2: Unadjusted Water Use

A difference in building water use is likely due to differences in occupancy and scheduling. Hundreds of students visit Walter Hall on an hourly basis for classes held in the building. Many students use the restroom or get a drink from the water fountain. The population of the Innovation Center is relatively static and is likely limited to no more than a hundred over the course of an entire day. Accordingly, a baseline reflecting utility consumption, normalized for building use differences, must be developed.

To conduct a meaningful building evaluation with IPMVP Option C, certain data are required (Table 6.2). The information is divided into three categories; *Available*, *Partially Available*, and *Need to Meter*. Information marked *Available* can be obtained from the campus energy director, University Planning and Implementation, Facilities and Auxiliaries, and Scalia Labs, or by observation. Information marked *Partially Available* can be attained from the aforementioned sources with the addition of the original project engineers or architects. Obtaining this information may require interpretation of technical documents, and/or additional metering. The *Need to Meter* category indicates that little or no metering of this item is done. In any case, the IPMVP suggests an information database of 12 months, with a monthly measurement interval as a minimum.

IPMVP Required Data			
	Available	Partially Available	Need to Meter
Sub-Metered Steam Use Data			x
Detailed Sub-Metered Electric Use Data		x	
Water Use Data	x		
Weather Data	x		
Use, Occupancy and Scheduling Data		x	
Envelope Configuration		x	
HVAC Configuration		x	
General Configuration	x		

Table 6.2: IPMVP Required Data