Measuring Progress Through LEED

A Closer Look at the new School of International Service's Energy Use

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Abstract

American University's (AU's) new School of International Service (SIS) building opened in late 2010, filled with promise as an innovative, Leadership in Energy and Environmental Design (LEED) Gold, energy-saving building for AU's most prominent college. As the building approaches its second birthday, the performance of the SIS building is put to test. Have the many energy-saving features of the SIS building lived up to their promise?

Actual reduction in energy use as a result of following Leadership in Energy and Environmental Design (LEED) rating systems has been debated by previous scholars. The SIS building is compared to two standards: building performance compared to a standard building of its size and type, and to the building's predicted performance. The study utilized information recorded by building-level systems on electricity use, and key members of the design, planning, and maintenance teams were interviewed. Electricity use was analyzed by both overall intensity (kilowatt hours of electricity per square foot of building space) and measured performance in relation to modeling.

The innovative design of the building along with the University's commitment to sustainability has provided positive results for the building thus far. The SIS building is energy efficient in its design and operation, and has shown continued progress by decreasing energy use over time. Electricity use improved 9.4% between the first 12-months of building occupation and the most recent 12-month span (including 5 months of overlap), with consumption nearly 13% lower than building models predicted. The building highlights the many challenges of energy efficient buildings – design, operations, maintenance, and occupant behavior must all coalesce for AU's most iconic building to live up to its promise.

Introduction

Creating, designing, and constructing a green building is a jigsaw puzzle. Every piece, every system of the building, looks appealing and innovative compared to the previous norm of unsustainable systems. Almost every piece can fit together, but the finished product never seems quite right. When the puzzle is finished, and the theoretically perfect building is finished, there is no answer key to which to compare your solutions. There is no solution and no perfect green building. The ideal must adapt to impacts of climate, infrastructure, politics, and building use. To say there is no perfect solution for green buildings is an understatement.

The New School of International Service Building is a cornerstone for American's main quadrangle in both promise and practice. The innovative design and function for the building make it not only the most unique building on campus, but also a model for other Universities to emulate. The building innovates in appearance, function, and inspiration. It connects the established dogma of global and scholarly thinking that characterizes the School of International Service and connects it to the forthcoming: an integrated, sustainable future committed to improving the quality of life around the world.

This study adopts previous methods for measuring the energy performance of LEED for New Construction (LEED-NC) buildings and applies them to the new School of International Service building. The study bridges the gap between theory and performance for the building, allowing it to more fully realize the potential of a green building while becoming more confident in its performance over non-LEED construction. The analysis will focus on energy consumption before branching out into the broader goals of the SIS building: energy generation, sustainable systems, and LEED compliance. Modeled and predicted outcomes will be compared with actual performance measures, and cross-checked by testimony from individuals who played key roles in planning and implementation of the building. The inclusion of both comparisons then allows for further scrutiny of the effectiveness of building systems and/or building maintenance and use.

This study is a look at the whole building electricity usage for the new School of International Service building. It will compare the electricity use of the building to many reliable and readily standards including modeled energy use, standard commercial building stock, and previous scholarly estimates. The study will identify what areas of management, commissioning, and design the SIS building succeeded with, and where it can improve. This study is not to be confused with a statistically vigorous analysis of individual energy systems, nor of the overall energy performance of the SIS building. Energy types outside of electricity use were collected and included when viable, but did not play a large role in the overall study. Conclusions drawn from this study will contribute to and further understanding of the performance of LEED buildings, but does not establish a blueprint for buildings to be measured. As with all sustainability practices, lessons must be learned and applied locally, and improving the performance of green buildings is no different.

The LEED Promise: Is it kept?

The Good

The US Green Building Council (USGBC) began to develop LEED in 1994 as a rating system for sustainable methods to be applied to new construction. Since then, LEED programming has expanded in scope to include seven interrelated branches of green building. Interest in sustainable building has rapidly expanded in the years since LEED was introduced, and market uptake for LEED has increased dramatically over the past decade. However, interest in green building does not necessarily translate into improved building performance. LEED has received a lot of attention over the past few years, as measurable results from buildings designed with LEED in mind have gone from design to completion and recorded measurable data regarding their energy use. For the first time, green buildings are able to be evaluated and scrutinized in a more complete manner. For buildings to minimize their impact on the environment, the many challenges of energy efficient buildings – design, operations, maintenance, and occupant behavior -- must coalesce.

As global attention towards greenhouse gas emissions increases, the need for energy efficient buildings has increased. Commercial building use is related to 45% of green house gas (GHG) emissions in the United States, and account for up to 71% of electricity use.[1] While many systems exist to rate sustainably minded buildings, LEED has achieved the greatest market uptake. As the market leader, improvements to LEED have the greatest potential to mitigate GHG emissions of any building rating system.

LEED ratings systems are not wholly focused on energy. Through four iterations of the rating system (the release of the fifth, LEED 2012, is imminent) implemented over the past decade, energy and electricity use credits have only been one of the handful of categories included. It is not a fair judgment to say that LEED certification has guaranteed exemplary energy use; the only benchmark assured by LEED certification is that buildings meet the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 90.1, the basic energy standard adopted as code for all commercial buildings. Still, LEED is by far the most popular green building rating system, and certified buildings have the perception of being energy efficient – even if the underlying credits earned barely forecast improvement over baseline energy use. To avoid criticism and incite real improvement in building performance, LEED should take steps to bridge the gap between perception and

[1] Inventory of US Greenhouse Gas and Sinks: 1990-2005. US EPA

performance of certified buildings. It is important to judge the effectiveness of LEED in reducing greenhouse gases and to monitor the rating system's ability to adapt and adjust to criticism while learning from past oversights.

The long construction and design process for new buildings as well as limited initial interest in LEED limited the number of LEED buildings available for study. There were not many buildings constructed with the green building rating system in mind in early years, which limited the number of cases available for study. In 2006, Cathy Turner conducted one of the first studies on green building, when she analyzed 11 LEED certified buildings in the Pacific Northwest.[2] Despite the small sample size, a variety of building types were included in the study. Actual energy use was compared with baseline modeling, and energy use intensity (EUI, or energy use per square foot) was compared against the regional commercial building average. Turner found that most LEED certified buildings were saving energy compared to baseline models and commercial building stock in both overall energy use and according to energy use per square foot.[3] The study found that no single building had an actual EUI within 20% of its initial design model, and noted that a failure to meter individual building energy use severely limited the data available for study. As sustainable building gained more notoriety in the coming years, these early shortcomings continued to hamper analysis of green building rating systems.

As LEED continued to gain popularity, the USGBC contracted the New Buildings Institute (NBI) in 2008 to conduct the most comprehensive study on LEED building stock.[4] The new study was conducted by Turner and Frankel. Of the 552 buildings certified through LEED-

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[2] Turner, Cathy. "A Post-Occupancy Look at LEED Building Performance." *Heating/Piping/Air Conditioning Engineering* 78, no. 10 (October 2006): 26–33.
[3] Turner, 27.
[4] While the study was solicited and funded by the USGBC, who designs and develops the LEED standards, they are not the ones responsible for certifying buildings and accrediting professionals. That is their sister organization, the Green Building Certification Institute (GBCI).

NC version 2 through 2006, 121 (22%) buildings were able to provide at least one full year of energy data, measured after the building was fully occupied. Measured energy performance was compared to the same two standards of the previous study, through baseline models and commercial building stock. Commercial building averages were taken from CBECS, the Commercial Buildings Energy Consumption Survey taken by the Energy Information Administration. A third standard for measurement was added via ENERGY STAR ratings assigned to each LEED building. By including ENERGY STAR ratings, LEED buildings were judged by an independent, third-party rating system, providing a further layer of confidence to studies. Turner found that LEED buildings were saving substantial energy, 25-30% better than the national average by all three measurements. Measured EUI's continued to deviate substantially from projections, as half the projects misjudged their EUI by more than 25%.[5] The worst offenders were high-energy use buildings. Turner found minimal energy savings within these building types.

The Bad

The NBI study was the first large-scale study to confirm the positive results insinuated by achieving LEED certification. Henry Gifford, a New York City-based energy efficiency specialist, analyzed the NBI report and concluded that LEED buildings use more, rather than less, energy than comparable buildings. The importance of green building was again stressed, as Gifford noted that buildings use 71% of electricity and 40% of energy in the US.[6] Meanwhile, Montanya and Keith found that LEED credits were focused on reducing cost rather than carbon, and that on-site energy generation was heavily weighted by the rating system compared to

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[5] Turner, Cathy, and Mark Frankel. *Energy Performance of LEED for New Construction Buildings*. Final. Seattle, Washington: New Buildings Institute, March 4, 2008.

[6] Gifford, H. "A Better Way to Rate Green Buildings." *EnergySavingsScience. Com* (2008).

purchasing renewable energy power.[7] Gifford took issue the with LEED certification's loose standards for certified building energy reporting – as the LEED v2 rating system did not require energy use to be either reported or even tracked at all (LEED v3 requires energy use data sharing with the USGBC). While his point on energy is valid, Gifford overlooks that LEED is aimed at improving holistic sustainable performance. The LEED rating system makes it clear that indoor space, habitat destruction and water management are green building priorities, together with energy use. The criticism is valid, but misplaced as a response to the NBI study. This criticism was relevant long before the NBI study was released.

Gifford attacked the NBI report for over-reporting the positive findings of the study and for making unfair comparisons between commercial building stock and LEED buildings. The NBI study compared the median EUI for LEED buildings to the mean EUI for commercial building stock. While Turner sought to explain this by noting that high-energy building types proved especially problematic for green building (and because median values were not available for commercial building stock), it does not change the fact that comparing a mean to median value is not statistically robust, and to a lesser extent, unfair.

Despite the charged tone of Gifford's work, the NBI report and Gifford are in agreement on a number of shortcomings in green building studies. Sample size continues to be a huge issue, as only a limited number of buildings that chose to monitor and report their energy use could be included in studies. The role of energy modelers and their predictive power is doubted, as more feedback is needed between the two groups. This fact in particular plays a role in the analysis of the SIS building. CBECS and LEED building data must be streamlined for easier and more

[7] Cubi Montanya, Eduard, and David W. Keith. "LEED, Energy Savings, and Carbon Abatement: Related but Not Synonymous." *Environ. Sci. Technol.* 45, no. 5 (2011): 1757–1758.

consistent analysis. Comparisons between the two are vital to improve future performance. Patience is necessary for apt comparisons so that LEED buildings, which are relatively new, can identify their actual full occupancy energy use levels over a legitimate timescale.

Newsham et al. found that LEED buildings had an EUI 18-39% lower than conventional building stock.[8] The study followed up on Turner and Frankel, applying statistical tests to the data provided by the NBI. Discrepancies in building types and climate zones were reconciled, and t-tests were conducted to ensure that observed variation in LEED building types was legitimate. Differences in energy use based on the achieved LEED certification level were found to be statistically significant for medium energy use buildings (such as SIS), and the energy performance of LEED buildings was confirmed as correlated to LEED energy credits received.

The Newsham et al. study conveyed alarm at the continued fluctuation in performance for individual LEED buildings. Newsham writes that "despite average savings, 28-35% of LEED buildings used more energy per floor area than their individually matched CBECS building."[9] In this case, the matched CBECS building was the building type closest to the LEED building studied. Without individual case studies, the cause for each building using excess energy is unclear; are sustainable systems working incorrectly, is the building being commissioned improperly, or are occupants irresponsibly wasting energy? Newsham et al. recognized that the study had no response to the criticism that the NBI LEED sample was heavily self-selected.[10] Buildings could choose to hide their energy use if they identified unflattering usage patterns.

[8] Newsham, G. R., S. Mancini, and B. J. Birt. "Do LEED-certified Buildings Save Energy? Yes, But…." *Energy and Buildings* 41, no. 8 (2009): 897–905.
[9] Newsham, 899.
[10] Newsham, 901.

Scofield examined the NBI data and found minimal energy savings from LEED buildings.[11] Instead of using on-site energy use as a benchmark, Scofield measured source energy in an attempt to better quantify the overall impact of each building. Site energy measures the amount of energy consumed at the building location, regardless of any external factor. Source energy calculations predict how much actual energy has to be generated for each building to receive an appropriate amount of site energy, based upon generation type, location, and transmission. The study found no statistically significant difference in source energy between LEED and non-LEED buildings. However, Scofield validates that LEED buildings use less site energy than their non-LEED peers. Scofield calculated source energy based upon the fuel-types used for on-site energy. He assumes US averages for the fuel mix used to generate electricity as well as for electricity distribution efficiency – effectively ignoring the benefits of sourcing energy through renewable technology or purchasing Renewable Energy Credits (RECs) to offset energy use. The SIS building generates up to 5% of its electricity on-site and offsets the rest of consumption through RECs. The argument for source energy is difficult to make in this case.

Scofield's final criticism of the Newsham study was through its method of weighting building energy use. Newsham calculated the EUI of each individual building and gave each building equal weight when calculating overall savings. This method does not account for the different size of each building, and provides a value of total purchased site energy about 14% lower than values Scofield found.[12] Scofield weights EUI by square footage, so larger buildings have more influence. While this is a robust method to determine the overall impact of LEED buildings, it does not do a better job of considering the ability a building has to outperform its

[11] Scofield, John H. "Do LEED-certified Buildings Save Energy? Not Really…." *Energy and Buildings* 41, no. 12 (December 2009): 1386–1390.
[12] Scofield, 1391.

peers. As Scofield notes, 5% of US buildings contribute to 50% of the total square footage for the entire building stock.[13] If the vast majority of LEED buildings save energy, but a few large buildings prove to be wasteful, does that discount the effectiveness of the rating system? This concern is especially relevant when considering the small sample sizes used to draw these conclusions.

The School of International Service

Motivation to study the SIS building is further drawn from the literature. A joint report from the National Institute of Building Sciences, New Buildings Institute, and the National Environmental Balancing Bureau released in January 2012 calls for analyzing energy use at the individual building level as a critical step to closing the gap between building energy prediction and performance.[14] Gifford emphasizes that buildings that claim to be green must be held accountable for their performance to close the gap between perception and performance.[15] Scofield finds a disconnect between LEED credit categories and actual GHG reduction.[16] This study attempts to identify and reconcile differences between these three categories – perception, prediction, and performance.

The construction of the SIS building marked a new stage in sustainable development for American University. Shortly after the building broke ground, President Neil Kerwin signed the ACUPCC (American College and University Presidents Climate Commitment). The University is now a full member of the ACUPCC Sustainability Committee, and has signed on to further pledges, including taking the DC Mayor's College and University Sustainability Pledge (CUSP)

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[13] Scofield, 1389.
[14] *Data Needs for Achieving High-Performance Buildings*. National Institute of Building Sciences, New Buildings Institute, and the National Environmental Balancing Bureau, January 3, 2012. Tuner has also provided written testimony supporting the NBI in this call for information.
[15] Gifford, H. "A Better Way to Rate Green Buildings." 2008.
[16] Scofield, 1390.

in early 2012.[17] The building represented a new vision for the University, grounded in sustainable development and creating an enjoyable campus atmosphere.

An understanding of the form and function of the SIS building is necessary to fully comprehend its energy performance. Purcell describes the design and building process of the SIS building, giving unusual insight into this particular case.[18] Even with renowned architect Bill McDonough on board as the building architect, the design team struggled from the beginning to find ways to physically show that the building was green.[19] The design team "followed the book on LEED," providing an optimal case to study how LEED compliance influences energy performance. The building was designed with LEED in mind as a method to be sustainable, as opposed to building green and applying LEED credits later in the process.

The SIS building calls for a variety of innovative, local solutions to its design and usage challenges to make it a truly sustainable structure. The multiple systems installed on the SIS roof illustrate the level of detail necessary to have the building perform up to its potential. Purcell describes how the design plan for the roof evolved over time. Initially, the roof was only supposed to have solar PV panels installed after building completion. However, as the project continued the team decided to include a solar hot water heating system and a solar re-heat transpiration wall – the latter being the first of its kind in DC. The roof case is one example of how the SIS design team "examined and re-examined every detail."[20] A rainwater collection system was added via cisterns placed in the parking garage to improve water management, and beehives were housed on the roof for a period to increase biodiversity and encourage plant growth. These many green systems exemplify the potential a space has for multi-faceted

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[17]Purcell, Michael. "Building the Green Dream." *Journal of Green Building* 6, no. 4 (2012): 26–36.
[18] Purcell, 27.
[19] A giant plaque in the lobby must not have been enough.
[20] Purcell, 30.

sustainability. The building evolves from its initial vision to its completion as systems are changed and replaced according to need to create a structure that excels in its environment and outpaces design. The disciplined vision, expert design team, and attention to detail that the SIS building received positioned it well to become a truly sustainable building.

The SIS building is unique in its function and form. One of the wonderful aspects of the structure is the way its use changes over the course of a year. Energy performance is affected by events, the Davenport Coffee Lounge, the flood of students in the building during finals week, and other difficult to predict changes in the occupancy and function of the building.[21] This presents a problem for developing accurate energy models and making comparisons to other LEED buildings, as the function of SIS is not comparable to many other buildings.

How the Building Expected to Perform

Given that the building was designed with LEED in mind, it makes sense to begin an analysis of the SIS building by looking at building's LEED scorecard. The project was registered with LEED in June 2006, applying for certification through the LEED for New Construction rating system, version 2.2. The building is officially listed by LEED as a 192,651 sf (square feet), with 70,000 sf above ground and the majority of the 120,000 below ground space taken up by the parking garage. The project earned 44 out of 69 possible points, earning a LEED Gold rating that was confirmed in March 2011.

The LEED-NC rating system, as of version 2.2, is organized into five environmental categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality. A sixth category exists for Innovation in Design. Each category is weighted differently and contains a unique number of credits. These credits are

[21] As one of those many students, I can personally attest that students are deprived of energy in the early morning.

weighted differently, containing varying amounts of points. The overall tally of points contributes to the LEED score of a building. The breakdown of the School of International Service Building's scorecard is seen in Figure 1.

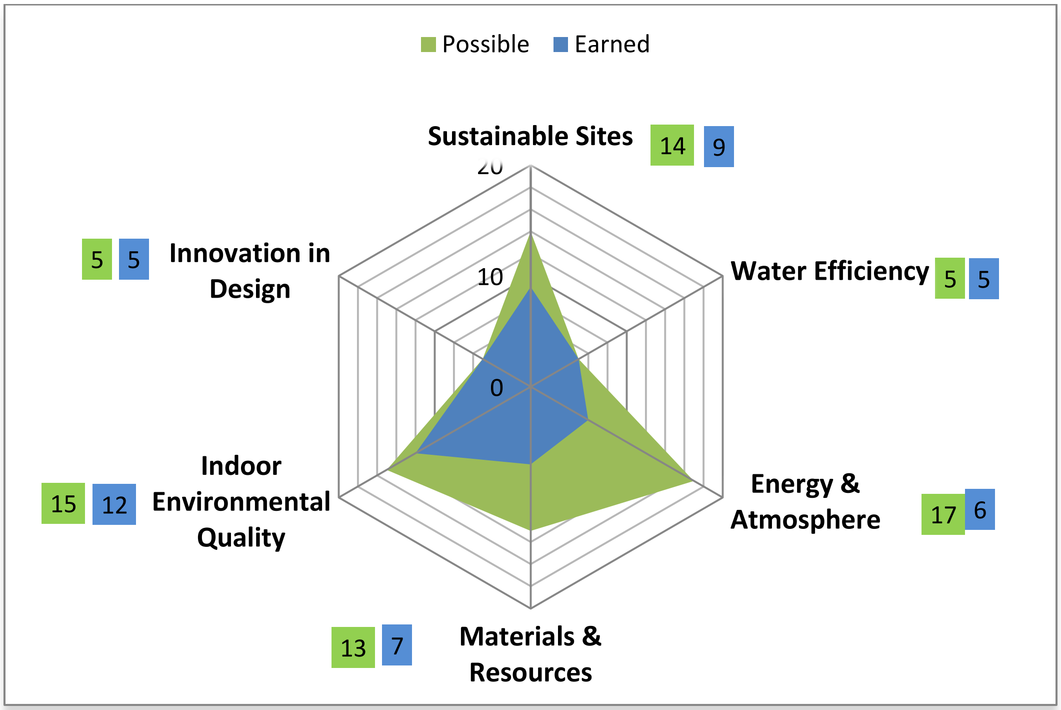

Figure 1 - LEED-NC 2.2 Credits Earned, By Category

In LEED-NC 2.2, the most points (17) are available through the Energy & Atmosphere (EA) credit category. The new SIS building pursued only six points within EA, earning more points in three other categories. The proportion of available points to points earned is substantially lower for EA than any other category. Yet, due to the building's LEED Gold rating, previous scholars held the structure to a higher standard than both commercial building stock and buildings with a lower LEED certification level. This is a flaw of earlier analysis, and brings more attention to the need for either individual case study. Future analysis should recognize that points and credits earned in EA are perhaps a better predictor for energy reduction than LEED certification rating.[22]

Despite the lack of focus on energy, to what standard for energy savings can the SIS building be held? The answer lies within the LEED credits and prerequisites. Every LEED certified building must meet a number of prerequisites in order to be eligible for certification. There are three prerequisites for EA in LEED-NC 2.2, two of which have a direct relationship with building energy usage. The first requires that a building complete fundamental commissioning to ensure that efficient systems are working as intended. The second requires that buildings meet ASHRAE 90.1, the minimum energy performance standard for all buildings. Neither of the prerequisites guarantees any sort of energy savings, yet the SIS building could have achieved its Gold rating without going beyond these prerequisites; this is why Lstiburek calls for LEED to create a system that creates “real” green buildings, instead of “social statements that sap money, time and resources from the real problems facing the planet.”[23]

Looking closer at the scorecard, one sees that moderate energy reduction was predicted. The SIS building earned three out of ten possible points for EAc1, titled Optimize Energy Performance. LEED documentation predicted an energy cost savings of 18.8% over the baseline established by ASHRAE 90.1. It is important to realize that energy cost savings are not analogous to savings in energy consumption. Key energy efficiency measures listed were “an improved thermal envelope, high efficiency glazing, reduced interior lighting power density,

[22] Turner and Frankel and others did mention that predicting energy reduction should be done using the specific credit. However, Turner and Frankel were the only scholars to run analysis based upon the number of credits achieved for energy performance within LEED.
[23] Lstiburek, J. W. 2008. “Why Green Can Be Wash.” *ASHRAE Journal* 50 (11): 28–36.

occupancy sensors, and demand control ventilation."[24] These listed features all point to the building's heavy reliance on large, efficient windows.

Classrooms, hallways, offices, and the majority of the roof are made of glass. Ninety-eight glass panels line the ceiling of the 3,600 sf atrium, providing ample natural light while the sun is out. Offices have 12-foot ceilings, 9 of which are covered by glass. These windows can, for the most part, be easily opened for temperature and air quality control. This last feature is touted by building architect Bill McDonough as a key feature of enjoyable and sustainable buildings. Lstiburek, a green architect himself, finds that many green buildings have a copious amount of windows and curtain walls. He argues that windows harm energy performance by providing inferior insulation compared to walls.[25] Windows and day lit spaces earn LEED credits for indoor air quality while insulation and energy performance is sacrificed (although day lit spaces use less energy for lighting, as fewer indoor lights are needed). The tradeoff is obvious, and the direction the new SIS building chose is similarly clear.

LEED appears to be placing greater emphasis on building energy performance as time has gone on. The official LEED review team for the SIS Building gave substantial feedback for EAc1. The eight corrections and suggestions listed in the review were the most complete and detailed of any credit included the in LEED review for the SIS building.[26] This sort of comprehensive review for EAc1 is typical of LEED construction reviews. EAc1 has the greatest number of potential credits to be earned (10) of any credit area in LEED-NC v2.2 and each subsequent version of LEED-NC has continued to place more emphasis on the optimizing energy

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[24] 2011. *LEED-NC V2.2 Construction Application Review: A.U. School of International Service*. U.S. Green Building Council.

[25] Lstiburek, 28.

[26] After accounting for the corrections listed in the LEED application review, revised modeling demonstrated a 19.7% reduction in energy use.

performance credit. The credit and energy performance of LEED buildings is important to the USGBC. At the very least, their response to criticism has been strong.

Unfortunately, one of the standards used by the NBI study to measure building performance is not available. ENERGY STAR ratings are only available for a limited variety of space types that have substantial building stock and energy information available for which to measure the building against. Remember, the ENERGY STAR rating compares a building to other buildings of the same type. Thus, the innovative nature of the SIS building as well as the comparatively small number of University buildings across America limits the ENERGY STAR comparison.

As far as the author could tell, there were no energy targets set for the SIS building during the design and construction of the building. Energy targets could have been set for overall consumption, EUI, or on a per occupant basis. Setting targets for these values would have been both a great motivator for sustainable design as well as a useful tool to evaluate actual performance. It is unfortunate that these targets were not set, or at the very least were not well known and communicated to the numerous individuals interviewed by the author.

Overall, the building was expected to perform well, but expectations for the building are easily overstated due to the building's LEED Gold rating. Still, a nearly 20% improvement in energy cost savings over code baseline shows significant expectations in energy reduction. This prediction most closely aligns with the savings predicted by Newsham et al.

Models & Data

Modeled Energy Use

Energy modeling for the SIS building was done by EMO Energy Solutions, based in Falls Church, VA. A building model was done for baseline and predicted usage. The baseline model predicted an annual site energy consumption of 2,048,230 kilowatt hours (kWh) and source energy consumption of 5,504,332 kWh.[27] The model for the building as-designed, also called the DEC model, predicted annual site energy consumption of 1,516,203 kWh and source energy consumption of 3,826,410 kWh. The rest of the values, separated by energy type and by month, are seen below.

Month	**Predicted Metered Electricity Demand (kWh)**	**Predicted Energy Cost ($)**
January	109,148	8,194
February	100,040	7,506
March	117,956	8,916
April	122,827	9,291
May	136,797	10,395
June	151,730	11,650
July	166,658	12,784
August	166,639	12,967
September	145,728	11,055
October	128,427	9,781
November	111,975	8,448
December	109,651	8,190
Total	1,567,576	**$**119,177

Figure 2 A.U. SIS Building Predicted & Actual Electricity Demand & Cost

Source: EMO Energy Solutions

Source	**Lights**	**Task Lights**	**Vent Fans**	**Space Heating**	**Space Cooling**	**Misc Equipment / Other**	**Total**
Electricity (kWh)	507481	0.0	196562	0.0	307373	5350042	6361458
Steam (kWh)	65355	62717	0.0	473456	0.0	6829	9608357
Total	**572836**	**62717**	**196562**	**473456**	**307373**	**5356871**	**15969815**

[27] Baseline models did not include chilled water used for space cooling while DEC models did. As such, chilled water was not included in the baseline to DEC comparison.

Figure 3 A.U. SIS Building Performance Rating Method, Predicted Energy Outputs, kWh
Source: EMO Energy Solutions

Measured Energy Use

The SIS building publically reports electricity consumption and generation for the majority of on-campus buildings online with the Lucid Design Group's Building Dashboard®.[28] The building dashboard is an excellent tool for monitoring energy usage in real time. Energy information can be categorized by a variety of timescales and uses, and data can be quickly converted to show savings in terms of money or greenhouse gas (GHG) reductions.

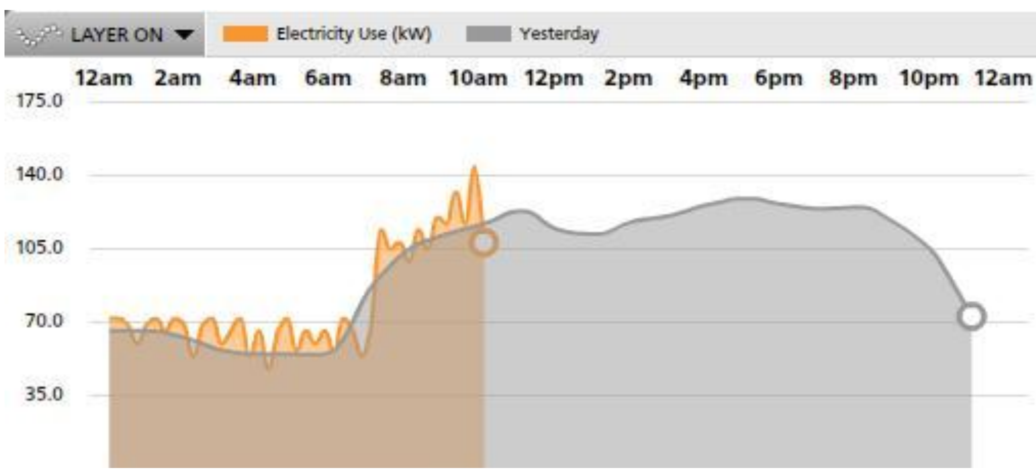

Figure 4 - *Lucid* Design Group's Building Dashboard publishes real-time data online for public engagement. The shown photo is a snapshot of real-time electricity use for the SIS building (orange) compared against the electricity use of the previous day (grey).

Using the Building Dashboard to monitor and publish energy data has a variety of benefits. Building use can be monitored more easily, increasing the efficiency of building managers. The graphic display makes it easy to see the "shape" of energy use over the course of a day, so that electricity use can be maximized at the ideal times. For example, Figure 4 shows electricity use ramping up around 6 am, around the time building occupants arrive. Consumption remains relatively flat while the building is fully occupied before curbing consumption beginning

[28] The dashboard for the SIS building is available at http://buildingdashboard.net/american/#/american/sis.

at 8 pm. For an occupant of the building, this consumption pattern makes intuitive sense, as a full schedule of classes ends at 8 pm and no class runs later than 10:40 pm. While the building often has an appealing daily energy use curve, there are still improvements to nighttime lighting, optimal space usage, and other building controls that could improve the performance of the building. Still, rises and falls in energy consumption that mirror occupancy are a signal the building is using energy efficiently.

Publically available data for electricity consumption increases accountability for the University. Any person or scholar interested in tracking the energy use of the building is privy to information that is often privately withheld, or worse, screened before release. Turner, Newsham, and Scofield all wrote that increased reporting of energy consumption by buildings was necessary to realize continued improvements to building energy use. The Building Dashboard can also be accessed via touch-screens installed in the SIS atrium. Engaging the occupants of the SIS building is important for continued success in minimizing energy use, as occupant behavior is responsible for about 25% of building energy consumption.[29] Using a tool like the Building Dashboard to monitor and report energy use helps mitigate consumption through engaging occupants, aiding building managers, and increasing accountability.

Electricity use and generation has been submetered at the building level since the building opened in May 2010, while steam and chilled water have been submetered as of December 2011. Below, the monthly energy use of the SIS building is shown compared to the baseline and DEC models. The next chart removes the baseline model to better show the differences between modeled and measured use. A full table of values, including available steam data, is in Appendix A.

[29] Turner & Frankel, 3.

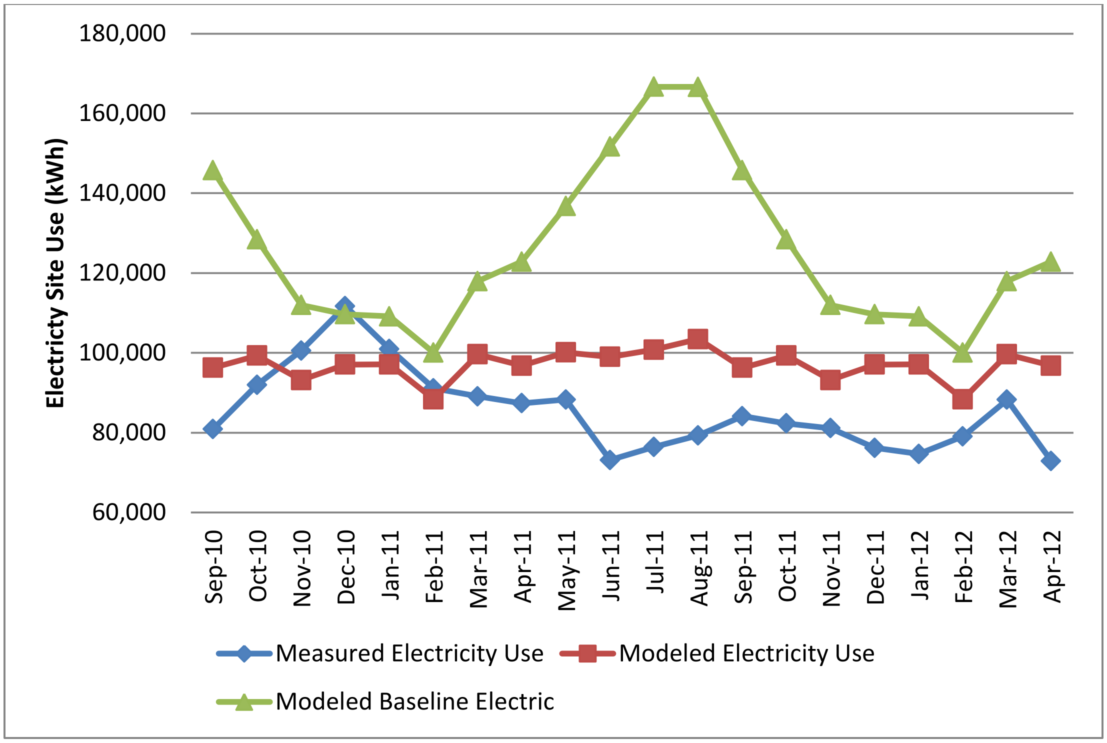

Figure 5 – Measured, Modeled and Baseline Electricity Use, SIS building
Source: EMO Energy Solutions (Model), Lucid Technologies Building Dashboard (Measured)

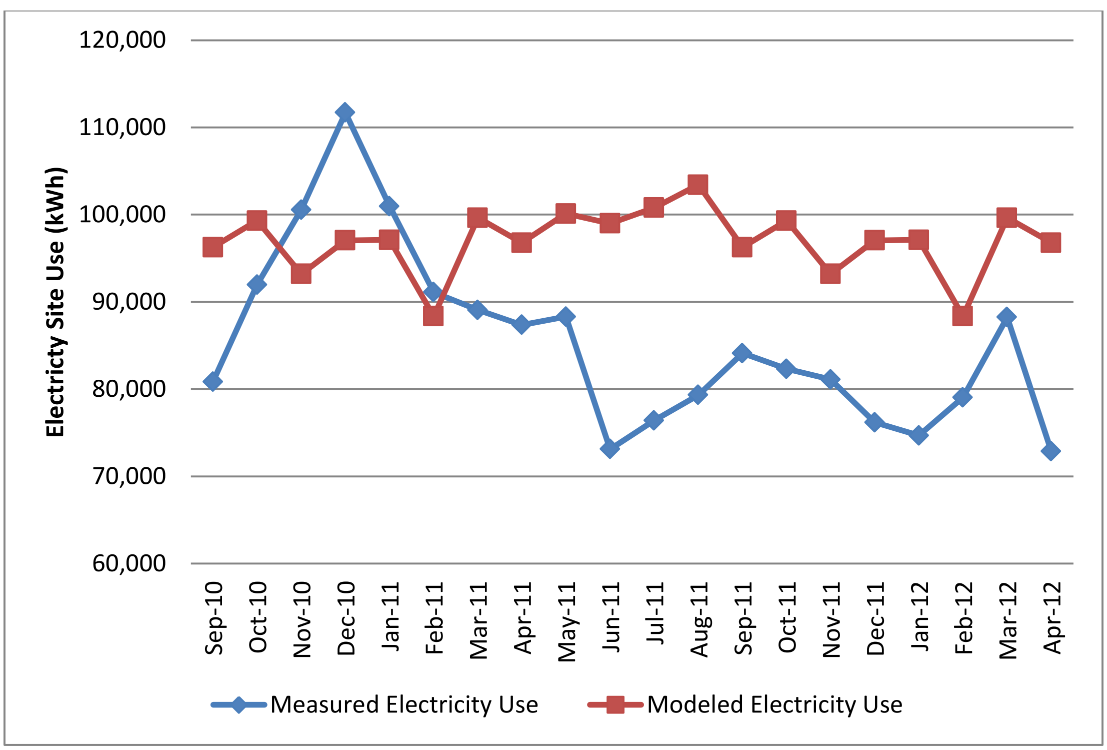

Figure 6 - Measured vs Design Electricity Use, SIS building
Source: EMO Energy Solutions (Model), Lucid Technologies Building Dashboard (Measured)

Figures 5 and 6 show the SIS building has outperformed both its baseline and DEC models. The building consumed less energy than the DEC model every month except for December of 2010. These savings can be interpreted in two ways: the optimist finding that the SIS building has reduced energy use more than expected, while the cynic finds the building model to be either inaccurate or have conveniently high predictions.

The figures show that the SIS building has outperformed its design models overtime, while slowly improving energy performance over the long term. The building struggled with energy performance during its first winter in operation, as energy use spiked in December 2010 and remained above modeled consumption throughout the winter months. Drops in occupancy after May 2010 helped the building drastically improve its performance, as students, faculty, and staff left after the spring term. In December 2011, the University tried a different approach to reducing energy during this cold part of the year through a “campus shutdown” that occurred over the winter break. For a week, faculty, staff, and students were not allowed in most of the buildings on campus. Electronics were unplugged, HVAC temperatures were lowered, and many steps were taken to minimize campus energy use for the last week of December. Through the campus shutdown and other improvements over the course of the year, the building’s site electricity use for December 2011 was 31% lower than December 2010. The campus shutdown shows how the SIS building can become a leader in energy performance, even when compared to other LEED buildings. The term scheduling and limited occupancy of the building allow the University to take progressive steps towards reducing the building’s impact. The building’s performance has improved due to short-term fixes like the campus shutdown, and long-term alterations to lighting schedules, temperature control, and other aspects of building commissioning.

From the data in the figures, one can easily calculate the performance of the SIS building over its models. The SIS LEED Construction Application Review calculated a 19.7% reduction in overall energy cost savings. According to building energy models, the annual proposed reduction in electricity was 25.3%. Through the first year of building operation, the building used 31.7% less electricity than the baseline model, and saw an 8.6% reduction over the DEC model. The data available for the most recent twelve months shows a reduction of 9.4% over the first year of operation. Using this most recent year of available data, energy reduction improves to 38.1% over the baseline model and 17.2% over the designed model. Regardless of the accuracy of the building's energy models, it is clear that the SIS is reducing electricity consumption over time.

The slow decline in consumption over time indicates a combination of proper management, commissioning, occupant use, and other behaviors that influence the buildings energy performance. Ideally, consumption would be compared annually to measure how building performance has changed over time. However, the SIS building is less than two years old, so annual performance data cannot directly compared at this time without overlap between the two performance periods. Instead, to provide insight into how the building has changed its energy use over time, the analysis uses overlapping 12-month periods to compare annual consumption. Even annual consumption can be expected to vary somewhat due to variance in average temperature and changes in building use and occupants. The author concedes that this analysis is less than optimal, but it represents a starting point for further analysis.

Placing the SIS building in context with the NBI study gives greater insight into the building's operation. Turner found that while energy modeling is a good predictor of average energy performance, "there is wide scatter among the individual results that make up the average savings."[30] Turner compared the measured energy consumption of the 121 buildings used in the NBI study to predicted energy savings and to the ASHRAE 90.1 baseline. When the SIS building's electricity consumption is considered with this stock of green buildings, its exemplary performance is made clear. There was a potential for bias with this inclusion, as the SIS building does not provide enough information about steam heating or chilled water data at the time. To account for this, another point was included assuming no reduction in steam heat or chilled water use for heating and cooling of the building.

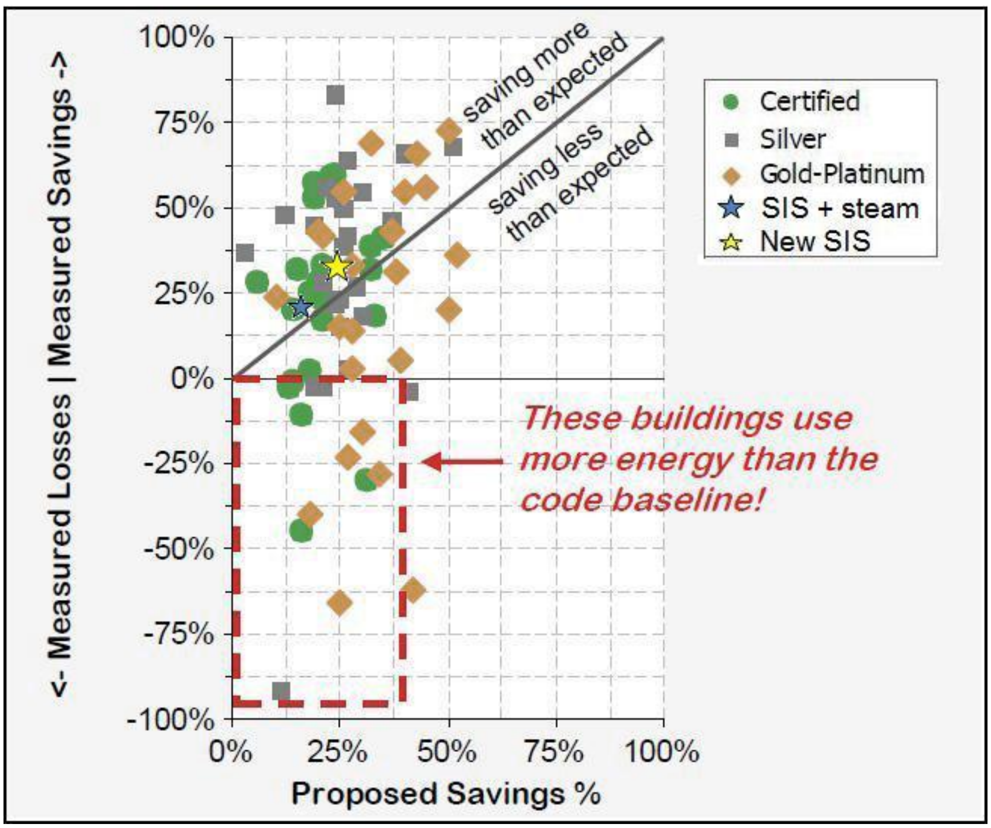

Figure 7 - The SIS building outperforms design models
Source: Turner and Frankel, *Energy Performance of LEED for New Construction Buildings,* New Buildings Institute, 2008. SIS information added by author.

In both cases, the SIS building performs well compared to its peers. With steam and chilled water included, the SIS building was predicted to reduce consumption by 14.7% over

[30] Turner and Frankel, 23.

ASHRAE 90.1, while measured performance was 20.3% better than code. When considering electricity only, these same values change to 25.3% and 34.9%, respectively.

The site electricity use of the SIS building is outperforming the standards it is held to as a LEED Gold building. However, the limited credits earned through EAc1 indicate that the SIS building is being held to a relatively low standard. Furthermore, the performance of the building is judged with respect to energy models, and comparisons are legitimate only if the models are legitimate. These multiple caveats leave much to be desired for energy performance analysis of the SIS building. Yet, the building is still new, and energy performance over the next few years with all systems sub-metered will be central to more complete analysis in the future. In the near future, conducting a Post-Occupancy Evaluation (POE) is suggested to benchmark performance and identify operational problems. Considering its improving performance and young age, the SIS building looks well equipped to remain a model green building.

Suggestions for Future Studies

The following topics are the author's best suggestions for future topics to improve our understanding of the SIS building:

1. Dig deeper into daily energy use data to see if certain days of the week, month, or semester are wasteful. The SIS building is well occupied Monday through Thursday, but there are no classes after 4 pm on Friday and none on the weekend. Does electricity use reflect this? Further studies should leverage the real time monitoring of the Building Dashboard to more efficiency micromanage the energy use of the SIS building.

2. Identify how EUI can and should be calculated for the building. To calculate a meaningful EUI, a method for determining overall consumption based on the limited data for steam and chilled water usage should be determined. The square footage used in calculations must be made clear. The SIS building has a parking garage around 1.5 times as large as the usable space inside the building. Is it a fair comparison to include the parking garage in EUI calculations for the building? This will help it significantly outperform a similarly sized building. However, the fact that SIS includes on-site parking should not count against its overall EUI, and the consumption of the LED lighting in the garage is included in the building's overall electricity consumption. Lastly, the type of space the SIS building will be compared against should be measured. Is it educational buildings in general, or just those for higher education? Can labs be included? Resolve the questions around EUI calculations and comparisons to calculate and contextualize this important benchmark for the SIS building.

3. Determine the number of FTE occupants of the building. The Building Dashboard determines energy use per person by assuming 131 FTE in the building throughout the day. However, the building has over 10 classrooms that are filled throughout most of the day. Faculty and staff are in the building all day; the Davenport Coffee Lounge has constant staff and occupants, while the atrium is almost always filled with students. Intuition says the number of FTE is higher than the 131 figure cited by the Building Dashboard. A more accurate FTE number will be useful for figuring out energy consumption per person and help understand usage shifts throughout the day.

4. Extend analysis to comparisons with other buildings on campus, especially those similar in size and building use type. All buildings are tracked by the Building Dashboard, and many of these buildings will soon be certified through American's participation in USGBC pilot for LEED Volume Certification.[31] Looking forward, all new buildings or renovations are required to receive a minimum of LEED Silver certification. Will existing building practices at American help or hinder compliance with the LEED 2012 rating systems? Are there lessons to be learned from efficient or wasteful buildings on campus?

5. Is the building in full compliance with other LEED credits? A deeper examination into each of the 44 credits earned can deepen our understanding of both the building and the effectiveness of LEED. For example, LEED compliance requires that 15 preferred parking spots be provided for electric or compact cars in the SIS garage. Are these spots are poorly marked, or are used by all vehicles? Moving beyond the question of compliance lies another looming question: How can credits like the parking requirement be considered equivalent to improving energy performance, and does AU have a responsibility to pursue tough credits that can provide greater societal benefits?

Lessons for the SIS Building

As the first LEED building on American's campus, building the new School of International Service was a learning experience for many involved in the process. The initial vision of the building was driven forward by Louis Goodman, former Dean of SIS, and focused on saving energy and creating a sustainable experience for occupants. As the design process

[31] Purcell, 28.

moved along, University Architect Michael Purcell found that the green building process taught the design team a lesson in inspiring comfort. He is proud that in the new building, "people don't find it distasteful to go to work. We have created an environment for people to enjoy."[32] The SIS building today represents a meshing of creating an ideal environment for occupants and implementing strategies for sustainability. The building is energy efficient and relatively sustainable, while occupants have a positive experience interacting with the building. The building is a pleasant space and one of the most popular locations on American's campus.

The electricity use of the building over the course of the day is often less than perfect. At times, daily electricity consumption from the SIS building is ideal. Usage ramps up in the morning, drops slightly in the middle of the day when natural light is strongest, and slowly drops back to a low level as occupants leave. Yet, much of the time the daily electricity use does not reflect this.[33] Electricity consumption occasionally remained at a high level for an entire night, or behaved erratically in the early morning. This shows a need for ongoing commissioning of building systems moving forward.

Continued monitoring and improvement by building managers and occupants is vital for potential energy reduction to translate into actual savings. SIS Assistant Dean of Facility & Administration Joe Clapper works on continually improving building performance. Clapper monitors new technology in lighting and electricity reduction and applies new technology to the building as need and payback periods permit. In particular, Clapper found that in the period since the building opened, LED lights have emerged as an ideal lighting system for the building. The lights were prohibitively expensive at the time of building construction and design, but have

[32] Purcell, Michael. "Interview." Interview by Andrew Feierman, April 2012.
[33] Daily building energy use was monitored and recorded from January to April 2012.

dropped in price to be viable for current and future installations, constantly improving the efficiency of the building.

Occupancy sensors illustrate how the SIS building has been slowly improving its energy use over time. Initially, the entire building was supposed to be outfitted with occupancy sensors. However, many areas did not have the sensors installed when the building was constructed. For a period, one light switch controlled an entire row of hallway lights. This over lit the area during the day and illuminated the building throughout the night. The problem was noticed by Clapper, and he developed a plan with the University Electrician to give additional control to the hallway lights. Now, every hallway is equipped with multiple switches and one out of every five lights the majority of the time. One observation led to an 80% reduction in the energy used to light the hallways. Continued small improvements to the building such as the reduction in hallway lighting can have a measurable impact in the overall performance of the building in years to come.

The collaborative nature of the LEED design process helped the different visions of each member of the design team converge. Some members of the design team had decades of green building experience while others were designing a sustainable project for the first time. SIS Professor Paul Wapner found that, "in the beginning of the design process, there was no appreciation for sustainable building."[34] However, driven by the vision of Dean Goodman and Bill McDonough, a cohesive vision for the SIS building slowly emerged.

The LEED design process calls for frequent interaction between the building design team and contractors. The goal is to create a more interconnected and well-functioning building. In

[34] Wapner, Paul. "Interview." Interview by Andrew Feierman, April 2012.

personal interviews, Purcell and Wapner both referred to the continued presence of McDonough as a driver of the building's sustainable design. However, Wapner was not completely convinced of the benefits from the LEED process. The constant meeting required by LEED ideally raises building standards for sustainability. But, the LEED process in this case was run through an external LEED consultant, and is thus subject to the vision and dedication of an external member of the design team. While the LEED process brings the design team together to create a cohesive building plan, it is not clear that it raises the standards for sustainable performance.

When asked how where the building could improve, members of the design team felt that the building could have both improved its physical design and sustainable vision. Wapner asked, "Did we shoot high enough? There are other steps that could have taken us to a higher level."[35] From a physical standpoint, Purcell noted that the use of the building was misjudged. Many more occupants come in with laptops and electronics that need to be plugged in to maximize building use and occupant productivity. While not agreeable with a vision of reducing electricity use, the building must meet a high standard of providing an enjoyable workspace before focusing on sustainable features. In this case, meeting code for outlet density was not enough to create an optimally function space. As always, it is detail and attention that could have improved the building's design further.

The unique design and function of the building inspire the future of buildings and spaces on campus. Purcell describes the building and its occupants as a moving art exhibit. Walking through the atrium is a constant joy, as students, faculty, staff and visitors enjoy the pleasant space. There really is no need for permanent art, as the building is a beautiful by design. As American University prepares to break ground on the North Hall dormitory, rebuild the

[35] *Ibid.*

Washington College of Law on Tenley Campus, and build a new quadrangle on Nebraska Ave, it should draw from the SIS building and push the envelope to create more energy efficient, sustainable, and pleasant spaces on campus. The new School of International Service building is sustainable, energy efficient, and innovative, a perfect setting to inspire students preparing their launch into global affairs.

Appendices & Tables

Appendix A: SIS Energy Use

	Measured Metered Electric (kWh)	Modeled Metered Electric (kWh)	Modeled Baseline Electric (kWh)	Steam (kWh)
Sep-10	80,851	96,258	145,728	-
Oct-10	91,961	99,310	128,427	-
Nov-10	100,561	93,193	111,975	-
Dec-10	111,697	97,059	109,651	-
Jan-11	100,961	97,100	109,148	-
Feb-11	91,095	88,351	100,040	-
Mar-11	89,074	99,642	117,956	-
Apr-11	87,360	96,775	122,827	-
May-11	88,297	100,116	136,797	-
Jun-11	73,123	98,990	151,730	-
Jul-11	76,412	100,800	166,658	-
Aug-11	79,317	103,423	166,639	-
Sep-11	84,104	96,258	145,728	-
Oct-11	82,311	99,310	128,427	-
Nov-11	81,108	93,193	111,975	-
Dec-11	76,186	97,059	109,651	20,626
Jan-12	74,670	97,100	109,148	N/A
Feb-12	79,046	88,351	100,040	N/A
Mar-12	88,244	99,642	117,956	N/A

Appendix B: Improper Electricity Consumption by the SIS Building

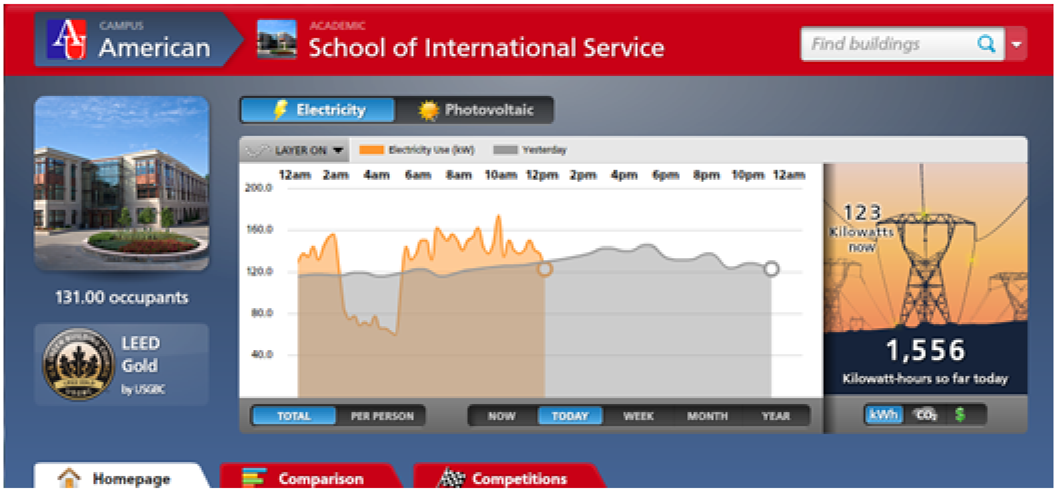

Figure 8 - Less than ideal energy consumption for the SIS building. Building managers and occupants must identify these gaps in performance. Showing March 19th (gray) and 20th (orange) of 2012.

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