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Green Building:
A Proposal for Gertrude S. Pearson Residence Hall

The Buildings that are build on the Kansas University campus are extensions of the values its students and the administration encompass. Does the university want its structures to embody the values of inefficiency or values of conservation? The Gertrude S. Pearson Residence Hall (GSP) renovation proposal offers Kansas University the opportunity to reflect on this question and the question of whether KU wants to continue using orthodox building methods or forge a new path towards an innovative and environmentally conscious future. Economical factors and environmental considerations do not need to be seen as opposing forces in this equation. "Green Architecture" is the mean to achieve a harmony between social, economic and environmental concerns.

What is "Green architecture?" Green architecture is a building alternative that implements energy efficient building strategies and technologies to mitigate adverse environmental impacts by reducing energy, CO_2 emissions, water, and waste. Green architecture is quantified by the LEED (leadership in energy and environmental design) standards, and is regulated by the U.S Green Building Council (USGBC). The USGBC describes the LEED Rating System as a procedure that looks to "transform the built environment to sustainability by providing the building industry with consistent, credible standards for what constitutes a green building."[1] *The Economist* describes the LEED certification as a system designed to…

> "produce "the world's greenest and best buildings" by giving developers a straightforward checklist of criteria by which the greenness of a building can be judged. Points are awarded in various categories, from energy use (up to 17 points) to water-efficiency (up to five points) to indoor environment quality (up to 15 points); the total then determines the building's LEED rating. A building that achieves a score of 39 points earns a "gold" rating; 52 points earns a "platinum" rating. A gold-rated building is estimated to have reduced its environmental impact by 50% compared with an equivalent conventional building, and a platinum-rated building by over 70%.[2]

On the macroscopic level, American building account for 65% of electricity consumption, 36% of total energy used and 30% of greenhouse-gas emissions.[3] American buildings also account for 80% ($207 billion) of total U.S electricity expenditures.[4] These statistics prove that even small strides towards conservation could render profound reduction in energy consumption and consequently environmental degradation. GSP too has great potential to reduce its environmental footprint as well as reduce its energy costs. GSP Spent $83,000 and consumed 8,018 MMBtus of natural gas in 2006. It spent $108,400 and consumed 2,000,000 KWH of electricity in the same year. Given these statistics, if gas and electric prices remain stagnant, GSP will spend $2,000,000 on gas and electricity in the next 10 years, and $10,000,000 in 50 years (a very conservative number considering gas and

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1 www.usgbc.org
2 The Economist (Dec 2nd, 2004 edition)
3 The Economist (Dec 2nd, 2004 edition)
4 EIA, State Energy Data 2002: Consumption, June 2006.

electric prices are only going to increase). Hypothetically if GSP were to be LEED Certified Gold, it would reduce it's energy costs by 50%, cutting utility costs in half to $1,000,000 in 10 years and $5,000,000 in 50 years. A Platinum Certified building reduces energy consumption by 70%, reducing energy costs by $700,000 in 10 years, and $7,000,000 in 50 years. A LEED certified building has obvious economic benefit as well as ecological benefits.

This paper will now discuss some strategies the University of Kansas should consider for the GSP renovation in order to become LEED certified.

Reducing CO2 emission in GSP would have positive economic as well as environmental benefits. By evaluating CO2 emissions, primarily in the HVAC system systems (Heating, Ventilation and Air Conditioning), the identification of costly and environmentally adverse technologies can be quantified and some possible retrofits can be considered. The methodology used is a review of scientific literature as well as personal interviews with maintenance and, in particular, HVAC maintenance, as well as a tour of the facility. The significance of CO2 energy efficient systems is, again, for both for economic and environmental benefit to GSP.

Student Housing has identified that GSP is slated for major renovations sometime in the next 2 – 5 years. A current proposal has been put together by The Department of Student Housing Office of Design and Construction Management (KU Project No. 078-8243), that identifies a number of design criteria and goals including addressing "energy conservation and sustainability issues in the building's design." The project team will evaluate the current system with plans to install more energy efficient systems. [5]

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[5] I would like to give special thanks to Ms. Natalie Timson of student housing, Mr. Vince Avila, Associate Director, Mr. Joe Edmonds, Custodial, and Dr. Stan Loeb, Environmental Programs Specialist for helping gathering this information. –Jill Benson

Current HVAC System: *Cooling*

GSP is cooled by an outside, above ground air cooled chilled water air conditioning system. The manufacturer is Carrier and is currently about 9 to 10 years old. The refrigerant used is HAR 134A, which is considered to be more environmentally friendly than some refrigerants that have been used in the past.[6] Water is used in cooling systems to reduce the heat from the refrigerant and not overtax the compressor. It generally leaves the system and returns to the building 10 degrees cooler than when it left the building.

Every air conditioning system essentially has 4 parts: (1) the compressor uses the refrigerant (it enters as a gas) by compressing it, which increases its temperature and creates energy. Once it is compressed, it enters the (2) condenser/radiator. Here, it condenses the refrigerant converting it to a liquid. It then goes to the (3) evaporator. The pressure drops and it converts to a gas and evaporates. These unites are stored above ground and create a lot of noise pollution for the GSP residents.[7]

Each floor of GSP has its own air handler. The air handlers distribute the hot and cold air throughout the rooms via a duct system. Uptake vents in the rooms then take the "old" air, which is returned to the air handler, filtered, then enters the coils to repeat the process.

This system is inefficient in 4 main ways: First, because the air conditioning system is above ground, it takes more energy to heat and cool. Second, there is a certain amount of noise pollution with this system and has caused complaints from neighbors. This unit sits at the back of GSP, and an insulating wall has had to be built to reduce noise. Initially, this caused inefficiencies because the system was taking in some of the warm air it was venting

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[6] Selvaraju

[7] Source: Mr. Vince Avila—HVAC

from the condenser. And third, because there are no thermostats in the rooms—students do not have the ability to reduce the amount of airflow into the room should she desire to do so. And fourth, the age of the unit compromises its efficiency.

Suggested HVAC System: *Cooling*

An underground geothermal system is more efficient and more environmentally sound in five main ways: First, they are more efficient. An underground geothermal system will take advantage of underground temperatures as the wells can tap 350- 400 feet below ground, reducing the energy needed, and in turn saving money. Second, they are quite—it produces no noise pollution. Third, there are no chemicals needed to clean condensers. Fourth, since the system is essentially underground, the space above ground can be utilized as, for example, open space. Finally, as a benefit to the individual student, this system would also mean that each room would have a small heat pump and compressor, providing a huge amenity for students—the ability to control their own heat and air within parameters. Additionally, another simple fix that could save energy now, would be to provide flip vent systems in each room, so that a student has the option of closing the vent if there is too much air coming into the room.

Current HVAC System: *Heating*

There are two large boilers in the mechanical room that provide the hot water and heat to GSP with a total capacity of about 1 million BTU's. Their ages are about 8 and 17 years old respectively. The boilers produce steam for the kitchen, provides domestic hot water (for showers, sinks, laundry, etc), and provides heat in winter using the same duct system into the rooms. The boilers send the steam to the Instantaneous hot water heater, which in turn, condenses and supplies hot water throughout the building. It also sends condensate to a return tank.

<u>2-pipe versus 4-pipe system</u>

In evaluating both the heating and cooling systems, it is important to recognize that GSP (as well as most dorms) are set up on 2 pipe systems, which can only run air conditioning and heating separately. A 4 –pipe system has 4 pipes, one with chill water in, one with chill water out (for a/c), and one with hot water in, one with hot water out (for heat). Most homes have 4-pipe, but dorms do not. This means that a student could not turn on the heat, and then get too hot, then turn on the air. This is important to understand because thermostats in every room would allow the student some control as to their individual room temperature, yet still protect GSP from potential misuses of the system.

<u>Suggested HVAC System: *Heating*</u>

Using only large boiler systems is often times inefficient. A more efficient system might be to install 4 smaller boilers at 250,000 BTU's each. You may need to run all 4 boilers for initial heat, but may need only 1 or 2 to maintain heat levels. The total capability would still be able to produce 1,000,000 BTU's when the demand call for it, but the option to use fewer boilers would always be an option to conserve energy.

Solar power would also be an excellent alternative for hot water heating. There are generally 3 types of collectors used with solar power: flat plate, evacuated tube and concentrating. Flat plates contain absorber plates with which to heat water, evacuated tubes are made up of glass tubes to absorb solar energy, and concentrating tubes generally use mirrored surfaces to collect the sun's energy into an absorber.[8] Of the three systems, an evacuated tube system would be most appropriate for GSP.

Additional considerations for cooling and heating efficiencies include high quality insulation, energy efficient windows to maximize solar heating during winter and minimize during heating during winter.

Heating and cooling are the primary sources of CO_2 emissions in buildings.[9] To calculate the total emissions at GSP: take the average monthly electricity and natural gas usage over the last 2 years, and then use the on-line CO_2 emissions calculators to get the final number.[10*] The CO_2 emissions calculator calculated that GSP consumes a total of 2,520 tons of CO_2 per year. This would equate to about 250 new SUV's on the road each year.[11*]

<u>Alternative Energy Considerations</u>

Alternative energy sources and energy conservation provide viable opportunities to reduce costs and environmental impacts. As part of the LEED certification, points can be awarded for various methods and technologies that help reduce energy consumption and utilize sustainable energy production. For the Gertrude S. Pearson Residence Hall renovation, an energy audit should be conducted initially to determine the distribution of

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[8] Martin, 2004
[9] Cole, 2000
[10] To determine electric CO2 emissions visit:
Environmental Protection Agency, "Power Profiler"; available from
http://www.epa.gov/cleanenergy/powpro/screen1.html; internet; accessed May 9 2007.
To determine natural gas CO2 emissions visit:
The National Energy Foundation, "CO2 Calculator"; available from
http://www.nef.org.uk/energyadvice/co2calculator.htm; internet; accessed May 9 2007.

[11] www.epa.gov
*See appendix for calculations

energy consumption so that appropriate energy solutions may be evaluated for feasibility and practicality.

The mechanical engineering department at Southern University, for example, conducted a university campus technical assistance energy audit (UCTAEA) to discover and resolve environmental and energy problems at the Baton Rouge, Louisiana campus.[12] The study identified several energy conservation opportunities (ECOs) that, based on A Simplified Energy Analysis Method (ASEAM), would save Southern University $568,732 per year.[13] The cost of the energy conservation measures equated to $2,002,572, with only a four-year period to recuperate the up-front costs of implementation.

This frames the problem of initial capital investment for energy conservation, and the objections that may arise within the University. The initial costs of these ECOs would require significant funding. The administration must, however, take into consideration the potential savings that would result, especially with energy cost only expected to increase in the future.

In order for energy conservation to be effective, the staff and residents at GSP most be conscious of their energy use, and behavioral measure to reduce energy consumption should be encouraged. At the beginning of each semester, the Department of Student Housing requires all staff to attend a week-long training session. During this training period, the staff should be educated on the energy conservation technologies and methods so that they may then educate the residents in their residence hall. Each resident assistant is required to put on floor programs that educate their residents, which provides a great opportunity for an "energy liaison" to talk with residents about our energy management

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[12] Eng, 1
[13] Eng, 2

system. RAs are also required to fill the floor bulletin board with educational material. This would provide an opportunity to post informative material about the energy conservation.

Education will need to be supplemented with technology and improved architectural design in order for GSP to become more energy efficient. Architectural design modifications during renovation should accommodate for more natural lighting to reduce space-heating demands. Addition of overhangs to reduce unwanted solar heating and better insulation to help maintain indoor temperature would also help control the indoor ambient temperatures would help make the building more efficient. Improved insulation will also decrease and stabilize heating and cooling demands. Cellulose insulation can reduce energy demands for heating and cooling between 26%-38%. This type of insulation is also made from 75% recycled material.[14] Technologies such as geothermal heat pumps, solar water heating, and light sensors would also help mitigate energy consumption. Architectural designs such as the use of overhangs over windows to decrease solar heating during the summer and the use of windows orientation to create a passive heating system to warm the building during the winter months would decrease the demand on heating for cooling and heating. It would also reduce energy costs during peak hours when energy costs are most expensive.

As stated earlier, traditional HVAC systems are inefficient and expensive. Geothermal heat pumps, on the other hand, use the more stable temperature of the earth to maintain air temperature as opposed to outside air, which can increase heating and cooling efficiency between 300%-600%. If properly equipped, GHP systems can also heat water and reducing energy demands and costs.[15] A GHP system can reduce energy consumption by as

[14] Cellulose Insulation Manufacturers Association
[15] Department of Energy: Geothermal

much as 50%. The GHP units produce less noise than conventional HVAC systems and have a lifetime of 25-50 years.[16]

To supplement the geothermal heat pump system, a solar water heater system could also be installed to supplement or eliminate the need for electric or gas heating. These systems use solar radiation to heat a solar collector that water is pumped through and then saved in a storage tank. A solar water heater system can reduce water-heating bills by 50-80%.[17] All of these measures mentioned can substantially reduce energy cost and provide LEED points towards certification.

Occupancy and light sensors are another technology that can help reduce energy needs. The occupancy sensor utilizes either passive infrared or ultrasonic technologies to determine when a room is empty. After a preset delay time, the lights will turn off if no occupancy is detected. This technology is best used in public areas where lights are often left on with no occupancy. The light level sensors use a photoelectric "eye" that determines the amount of light in a room, and then it either dims or brightens the lighting of the room accordingly.[18] An energy audit of public areas before and after would help determine the actual energy savings of this technology.

Technology coupled with education can help the university conserve energy and cut facility energy costs. The initial expenses of these technologies will undoubtedly surpass that of traditional technologies, but it must be kept in mind that these techniques and technologies do pay for themselves in as little as 4 years.[19]

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[16] Department of Energy: Geothermal
[17] Department of Energy: Economics
[18] Department of Energy: Daylighting
[19] Eng, 1

Green Roofs

According to the design criteria and goals outlined in the GSP renovation proposal, a green roof would fulfill numerous objectives that are trying to be obtained. A green roof is vegetated roof cover. The two different types of green roofs are extensive and intensive. This section will explain the differences in these roof types, the benefits of implementing them onto conventional roofs, and what their application to GSP could gain in line with the established goals for the renovation.

An extensive green roof requires little maintenance, has a low level of soil and media depth (2 ½" to 6"), is lighter on the building structure, can be fairly inexpensive (as low as $9/sq.ft. for 3" and a common range of $14-$25/sq.ft.), and are designed principally for their environmental benefits.[20] The extensive roof is not purposed for human access and involvement. They are able to function on sloped roofs up to 30[21].degrees

An intensive green roof requires regular maintenance because they're accessible to the public and are used for educational and recreational purposes. They are able to contain a deeper media depth starting at 8" to 12" and increasing depending on structural support. With this additional depth there can also be an increase in vegetation variety/diversity. Because of the additional weight these work best on flat roofs. The price for an intensive roof has a great range because of many different variables involved in the landscaping. They have a common range between $25-$40/sq.ft.[22]

Any type of green roof has great benefits. They provide insulation for the building, saving on energy consumption, last longer than conventional roofs, filter air pollutants, provide species habitat, reduce surface and air temperatures, decrease storm water run-off

[20] Swanson
[21] www.greenroofs.com
[22] www.greenroofs.com

and aid in filtering and therefore purifying water pollutants.[23] Green roofs also provide barriers aiding in the absorption of noise pollution.[24] One of the most obvious benefits is the aesthetic improvement. They are a great connection between people and the environment.

The design criteria and goals for GSP list such objectives as attracting and retaining students, competitive amenities with other campus residence halls, an improvement on the aesthetic appeal, a sense of place, reduction of noise, and improvement in the landscaping and site amenities. Green roofs can help achieve all of these goals. The "the crossbar" roof section of GSP could potentially be transformed into a green roof. By the current access onto this roof, little would need to be done to physically alter the exterior building design. This would provide a great recreational area for students to engage with the nature that surrounds them and have easy access for maintenance. The centrality of this part of the roof would be visual to many rooms and could be a great symbol for the newer greener GSP. This green roof would enhance the courtyard landscaping and be inviting to the students.

In order to gain the full benefits of what green roofs are able to do, after the implementation of "the crossbar" area, the University would then be able to determine the feasibility of adding extensive green roofs on the adjoining roofs. Then the other environmental benefits would have greater opportunity to be realized. Green roofs can add up to 15 points towards LEED standards; either specifically or by their contribution to other LEED elements.

Other additional changes that could benefit GSP include water use efficiency for both outdoor and indoor use. Landscaping impacts water use outdoors. The current drainage system is gutters attached to down spouts that empty at the base of the building.

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[23] Saiz
[24] VanWoert

Recapturing the storm water and using it for watering vegetation could reduce soil saturation, leaks and flooding to the basement, and a reduction of maintenance costs. Increasing vegetation also reduces runoff into neighboring residences. Using native plants to buffer the runoff would provide a noise barrier as well. Indoor water use reductions could be obtained by using front-loading washing machines, low flow toilets, and motion-censored faucets. All of these suggestions add LEED points to a building.

Fundraising Considerations

Building a LEED certified building could immensely benefit the fundraising effort needed to supplement public funds need to get the GSP renovation off the ground. Benefactors who fund a "green building" would be recognized not only as supporters for Kansas University, but also as supporters of environmental sustainability. During the fundraising process for a GSP renovation, potential donors could be sold on the idea that they would be a supporter of a proactive project that will raise the bar for future developments at KU. It would set a new standard for any new campus development that has sustainability as its goal. Money donated toward a LEED certified building would prove a donors support for not only the physical need for a renovated, it would also prove his or her support for a mindset that galvanizes the idea that environmental issues are bound to economic and social issues.

Conclusions

One of the most important goals for GSP is to attract and retain students. A green building can achieve this goal. By making GSP a green building, it can create a healthier environment for students by reducing potentially harmful microbes, which in turn would create a safe atmosphere for residents to live.[25] Green building is viewed as "forward thinking," and many students want to be part of movements that are geared toward designs of the future.

A green building can be marketed as a proactive approach to mitigating environmental concerns, lowering energy costs, creating a learning environment for students, and as a aesthetically pleasing atmosphere. This can also serve as an educational area that expresses the innovativeness of the building. Up front cost in an institution like KU is of obvious importance, but it should not be the only factor in choosing how the renovation of GSP should be carried out. Taking a myopic approach towards the renovation decision of GSP, one that only looks at upfront costs, will prove less economically viable in the long run. Kansas University is a subsidized state institution. The economic factors concerning a GSP renovation should be conscious of all the cost and all the benefits of the proposal. This fiscal consciousness means not only looking at initial cost, but also cost ten, twenty, and even fifty years down the road. This foresight, in these author's opinions, will prove economically and environmentally beneficial.

A "green building" has these benefits: it has less operating costs, it causes less ecological harm on the macroscopic as well as the microscopic scale, it provides a more enjoyable and aesthetically pleasing atmosphere, it provides a learning atmosphere, it is proactive, it will generate positive public relation and positive press for KU, and lastly, it would help recruit and maintain residents at GSP. The question in brief: does Kansas University want to endorse a proactive project that has both environmental and economic benefits, or does Kansas University want to weight short-sighted goals against long-run

[25] Heerwagen, 2000

economic and environmental advantages? If the answer is the former, then a LEED certified building is the means to achieve this goal.

Appendix:

CO2 calculations

1. Electricity usage in KWH
   - 2005 fiscal is 1,672,020 kwh
   - 2006 fiscal is 2,011,000 kwh
   - 2-year average is 1,841,510 KWH
   - per month usage is 153,459.
   - Using the calculator at http://www.epa.gov/cleanenergy/powpro/screen1.html, annual CO2 is 4,036,863 pounds or 2, 018 tons per year.

2. Natural Gas in mmBTU's (British Thermal Units)
   - 2005 fiscal is 8,542 BTUs
   - 2006 fiscal is 8,018 BTU's
   - 2-year average is 8,280 BTUs
   - Then, take 8,280 and multiply by 1,000,000, then divide by 100,000 to get answer in therms.
     Using the calculator at (http://www.nef.org.uk/energyadvice/co2calculator.htm, to get 455,400kg, then multiply by 2.20462 to get 1,003,983 pounds, or an annual emission of 502 tons per year.

* The next two pages contain the LEED certification checklist for lodging. It can be found at: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=276

easy	mod	diff	Total Project Score	Possible Points 69
			LEED Certified: 26 - 32 points, LEED Silver: 33 - 38 points, LEED Gold: 39 - 51 points, LEED Platinum: 52 - 69 points	

easy	mod	diff	Sustainable Sites		Possible Points 14
			Prereq 1	Erosion and Sedimentation Control	0
			Credit 1	Site Selection	1
			Credit 2	Urban Redevelopment	1
			Credit 3	Brownfield Redevelopment	1
			Credit 4.1	Alternative Transportation, Locate Near Public Transportation	1
			Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
			Credit 4.3	Alternative Transportation, Alternative Fuel Refueling Stations	1
			Credit 4.4	Alternative Transportation, Minimum or No New Parking	1
			Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
			Credit 5.2	Reduced Site Disturbance, Reduce Footprint & Increase Open Space	1
			Credit 6.1	Stormwater Management, No Net Increase or 25% Decrease	1
			Credit 6.2	Stormwater Management, Treatment Systems	1
			Credit 7.1	Landscape & Exterior Design to Reduce Heat Islands, Site Surfaces	1
			Credit 7.2	Landscape & Exterior Design to Reduce Heat Islands, Roof Surfaces	1
			Credit 8	Light Pollution Reduction	1

easy	mod	diff	Water Efficiency		Possible Points 5
			Credit 1	Water Efficient Landscaping, 50% Reduction to Potable Free System	2
			Credit 2	Innovative Wastewater Technologies	1
			Credit 3	Water Use Reduction, 20-30%	2

easy	mod	diff	Energy & Atmosphere		Possible Points 17
			Prereq 1	Fundamental Building Systems Commissioning	0
			Prereq 2	Minimum Energy Performance	0
			Prereq 3	CFC Reduction in HVAC&R Equipment	0
			Credit 1	Optimize Energy Performance, 20-60% New 10-50% Existing	10
			Credit 2	Renewable Energy, 5-20%	3
			Credit 3	Additional Commissioning	1
			Credit 4	Ozone Depletion	1
			Credit 5	Measurement and Verification	1
			Credit 6	Green Power	1

			Materials & Resources		Possible Points 13
easy	mod	diff			
			Prereq 1	Storage & Collection of Recyclables	0
			Credit 1	Building Reuse, Maintain 75-100% of Existing Shell & 0-50% of Non-Shell	3
			Credit 2	Construction Waste Management, Salvage or Recycle 50-75%	2
			Credit 3	Resource Reuse, Specify 5-10%	2
			Credit 4	Recycled Content, Specify 25-50%	2
			Credit 5.1	Local/Regional Materials, 20% Manufactured Locally	1
			Credit 5.2	Local/Regional Materials, of 20% Above 50% Harvested Locally	1
			Credit 6	Rapidly Renewable Materials	1
			Credit 7	Certified Wood	1

			Indoor Environmental Quality		Possible Points 15
easy	mod	diff			
			Prereq 1	Minimum IAQ Performance	0
			Prereq 2	Environmental Tobacco Smoke (ETS) Control	0
			Credit 1	Carbon Dioxide (CO_2) Monitoring	1
			Credit 2	Increase Ventilation Effectiveness	1
			Credit 3.1	Construction IAQ Management Plan, Prior	1
			Credit 3.2	Construction IAQ Management Plan, During	1
			Credit 4.1	Low-Emitting Materials, Adhesives	1
			Credit 4.2	Low-Emitting Materials, Paints	1
			Credit 4.3	Low-Emitting Materials, Carpet	1
			Credit 4.4	Low-Emitting Materials, Composite Wood	1
			Credit 5	Indoor Chemical and Pollutant Source Control	1
			Credit 6.1	Controllability of Systems, Operable Window	1
			Credit 6.2	Controllability of Systems, Individual Controls	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 and Views, Diffuse Sunlight to 90%	1
			Credit 8.2	Daylight and Views, Direct Line of Site to 90%	1

			Innovation & Design Process		Possible Points 5
easy	mod	diff			
			Credit 1.1	Innovation in Design	1
			Credit 1.2	Innovation in Design	1
			Credit 1.3	Innovation in Design	1
			Credit 1.4	Innovation in Design	1
			Credit 2	LEED™ Accredited Professional	1

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