DESALES UNIVERSITY

Technical Report 3

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Executive Summary

The Reverend James G. Gambet Center for Business and Healthcare is the latest addition to the campus at DeSales University. The new $27 million facility, which is the new home of the Business, Nursing, and Physician Assistant Programs, will be state of the art and include technologically advanced labs and classrooms. DeSales' continual growth and ever increasing quality in education has caused these programs to reach their maximum potential in the current facilities. Construction of the 77,000 square foot building is managed by Alvin H. Butz, Inc., and is scheduled to complete in November 2012.

DeSales University has recently made large strides to integrate practices in sustainability throughout the campus, and the McShea Student Center was the University's first LEED® rated building. This led the owner to set a minimum LEED® Silver requirement for the design and construction of the Gambet Center. The Gambet Center is expected to achieve 50 LEED® credits, and reaches Silver status through a sustainable site, water efficiency, low energy consumption, indoor environmental quality, and sustainable materials.

The critical path of the project is discussed with regard to schedule acceleration scenarios that helped make up for early delays due to weather. Increasing labor hours, using BIM planning, and finding ways to increase production are all considered to help ease delays in the schedule. Value engineering of mechanical, lighting, and curtain wall systems were all considered and chosen based on the value added to the project, not necessarily a decreased cost.

The PACE Roundtable gathered for the 21st time at the Penn Stater Hotel and Conference Center on November 6, 2012. The focus of this year's roundtable was "Improving Efficiency Through Innovation." Students and industry members discussed supply chain management techniques in procurement, sequencing, and modularization during two breakout sessions. The professionals also helped students develop areas that may be good research topics.

Further in depth analyses on the effects of prefabricating system sections to decrease the schedule, implementing building information modeling to improve coordination between trades, developing a short interval production schedule for improved construction of offices, and methods of increasing energy efficiency to achieve a LEED® Gold rating are considered to demonstrate depth and breadth in the AE curriculum.

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LEED® Evaluation

**Please see Appendix A-1 for the LEED® 2009 New Construction and Major Renovation Scorecard*

DeSales University has recently become a strong proponent of green practices in sustainability by introducing a variety of initiatives across the campus including university wide recycling, student education, and sustainable building practices. Awarded with the 2011 Lehigh Valley Green Campus Sustainability Award, DeSales is proving the effectiveness of their green programs. In 2010, the McShea Student Center was the first building to obtain a LEED® Silver Certification. The Gambet Center is also designed to achieve an equal certification to maintain the University's position in the region as a leader in sustainability.

The United States Green Building Council (USGBC) implemented the first metric to analyze the incorporation of sustainable practices in new construction in 1998. The system has since evolved into a more comprehensive program awarding points on various categories including sustainable sites, water efficiency, energy and atmosphere, indoor environmental quality, innovation in design, and regional priority credits. Based on the requirements set by the owner and the constraints of the building, the project team can assess which LEED® credits are necessary, optional, or impossible to achieve a certain certification.

The complete LEED® Evaluation analysis is located below; specifically describing how the Gambet Center hopes to receive a silver certification. Please see Appendix A-1 for the LEED® 2009 New Construction and Major Renovations Scorecard.

Sustainable Sites

One constraint of the project is the building site. The location of the building was pre-planned per DeSales' Campus Master Plan, and therefore relocation of the Gambet Center was not possible in order to gain additional LEED® credits. Only 7 of the available 26 credits for this category can be pursued because of the limitations set by the site location. Four of these points are achieved through promoting sustainable transportation practices by providing showers to reduce driving elsewhere, four bicycle racks, and nine parking spaces dedicated to fuel-efficient vehicles. The remaining three credits are from implementing quantity and quality stormwater management controls and increasing the reflectiveness of the roof to reduce the heat island effect.

It is important to note that because the Gambet Center is located on an undeveloped, greenfield site; it is automatically disqualified from up to 9 points. Another major inhibitor of the Gambet Center performing well under the sustainable sites category is the lack of public transportation in the area. This excludes the building from receiving 6 LEED® points, and because of the rural location it is not likely that public transportation services will be provided in the near future. Local zoning requires a minimum number of parking spaces, which exceed the capacity defined by LEED®, which eliminates this credit for consideration.

Two areas of this category have potential to meet the requirements set by LEED®. An extra point can be obtained considering a change from paved to concrete parking lots, helping to reduce the heat island effect by increasing the reflectiveness of the material. Another point is available if the building does not add to light pollution. It is still unclear whether the minimum lighting requirements of the Gambet Center disqualify it from meeting this goal, however a further evaluation of the potential for earning this credit will be conducted if imperative for silver certification.

As described above, selecting a non-sustainable site can severely impact the ability to reach LEED® certification. If the site prevents a large gain of points in the sustainable sites category, the designers and project team must work hard to find ways to implement a large portion of credits from the remaining categories.

Water Efficiency

Out of the five main categories of LEED® 2009 for New Construction, water efficiency is the category with the least amount of possible points. Although only ten credits are available, the Gambet Center is able to acquire eight of these by using only non-potable water for landscaping, and by using low-flow plumbing fixtures to reduce water consumption by 40%.

The final two credits are available for innovative wastewater technologies, which are not currently considered for the Gambet Center. Rainwater collection and harvesting technologies that reduce potable water use for sewage by at least 50% can be considered to reach a perfect score for water efficiency. The high cost of the system relative to the gain of only two credits is probably the reason this system was not included on the project, but on the chance the building cannot meet the requisites for silver certification, there is potential to incorporate this solution.

Energy and Atmosphere

The Energy and Atmosphere of the LEED® 2009 Rating System is used to ensure a building is designed and operated to reduce energy consumption with regard to the environmental impacts associated with procuring the energy. Under Energy and Atmosphere, a total of 35 points are available. Energy and Atmosphere has the largest amount of achievable credits, which is a measure of the effect this category can have on the overall sustainability of the project.

Through a reduction in energy consumption, a maximum of 19 points can be obtained based on the percentage of improved energy performance over the baseline ASHRAE/IESNA requirements. High efficiency boilers, electronically controlled VAV boxes, and lighting control systems used in conjunction with mechanical pipe and exterior insulation, specialized glazing, and sun control devices help to reduce the Gambet Center's energy use by at least 18% – allotting 4 out of 19 credits.

An additional five points are awarded for enhanced commissioning, using R410A refrigerant, and by DeSales agreeing to share the building's energy and water usage with the USGBC through the ENERGY STAR® Portfolio Manager. The owner was not interested in including on-site renewable energy such as solar and wind power due to a high initial cost and unfavorable payback period of less than five years. For this reason, geothermal heat pumps were also not considered, leaving up to seven points unqualified for credit.

Two credits for providing at least 35% of the building's energy from green power are currently targeted by the architect to count towards LEED® accreditation. It is still unclear whether this requirement can be met, but the architect is soliciting proposals to use green sourced power on the job.

Materials and Resources

The inherent energy consumed during construction accounts for a substantial portion of the total energy used over the lifetime of the building. Under Materials and Resources, methods of procuring sustainable, local materials and the handling of waste during construction are assessed. Up to 14 credits can be achieved through integrating these concepts into the building design and construction.

The Gambet Center receives two points for including a construction waste management plan that clearly identifies practices that save a minimum of 75% of construction debris from disposal. Through using 20% of recycled materials or materials manufactured within 500 miles of the building site, four credits are expected.

Because the Gambet Center is a new construction project, it is not eligible for six credits awarded to projects that reuse existing systems or materials for reuse. Credits for incorporating rapidly renewable materials are also not available for this project. It is uncertain if at least 50% of wood construction in the facility utilizes certified wood. The architect would only consider targeting this credit if costs were not greatly affected.

Indoor Environmental Quality

All buildings require some level of thermal comfort and indoor air quality, however, LEED® will award points to buildings that exceed these basic requirements set by code. Indoor Environmental Quality measures the extent to which an owner will go to provide users with a healthy environment by using non-hazardous materials and allowing individual control. A total of 15 credits are available for this category.

The Gambet Center reaches most requirements in this category, scoring ten points. Using non-toxic materials and coatings for all finishes contributes four points. The remaining credits are added by monitoring outdoor air delivery, indoor air quality management during construction and before occupancy, lighting control, and design and verification for thermal comfort.

The last five points not awarded are all due various limits set by the project. It is not logical to include user controlled ventilation as this increases HVAC loads and requires larger equipment, which in turn reduces efficiency and loses LEED® credits in the Energy and Atmosphere section. A MERV 13 filter is required to receive credits for indoor chemical and pollutant source control, but the filter is also not practical for the selected system for similar reasons. Three points for user temperature controls and daylighting/views are not included because there are not enough spaces in the building to meet LEED® requirements.

Innovation and Design Process/Regional Priority Credits

The prior categories comprise the major ways available to construct a sustainable building. LEED® also recognizes that all buildings are not the same, and each project may have its own integration of green concepts in a unique way. Innovation and Design Process and Regional Priority Credits are the last two categories for LEED® certification. These provide the opportunity for six and four additional credits, respectively. In many cases, as it is with the Gambet Center, these categories decide what certification a project ultimately receives.

The Gambet Center was able to gain all six points for Innovation and Design Process. A comprehensive, university wide recycling program, user education program in sustainability, the use of blended cement, water bottle fill stations, and surpassing the 95% threshold for management of construction waste all provide opportunities for the Gambet Center to receive additional credits.

Regional Priority Credits were harder to obtain, and must show incentives that address region-specific environmental priorities. Two extra credits are targeted for the control of the quantity of stormwater and implementing construction waste management techniques to reduce at least 50% of waste. Again, the choice of a natural site restrains a lot of possible avenues to consider for Regional Priority Credits.

LEED® 2009 Scorecard and Evaluation

The LEED® Scorecard included in Appendix A-1 shows the Gambet Center expects to achieve a total of 50 credits. This just barely reaches the cutoff and makes the building eligible for the targeted LEED® Silver certification. It's important to remember that the checklist scores points based on what is believed to be obtainable, and there is no guarantee all points speculated would be accepted during the review process. With a minimum of 50 points needed for LEED® Silver, a rejection of any credit places it down in the LEED® Certified category.

After evaluation of the scorecard, it can be predicted that all but two credits are likely to be accepted. The two credits that could possibly fail are the two awarded for using green power sources for 35% of electricity. The architect thinks this is possible, but if it is not the owner will not get the expected certification. It is advantageous to analyze the areas not originally targeted for credit to find ways to include them in the project. It is best to start out with the most cost-efficient options, until it is necessary for the owner to decide how much they are willing to spend to receive the desired LEED® Rating.

A point could be added to sustainable sites if the paved parking lots were changed to concrete. Concrete surfaces have a higher initial cost, but can last longer if properly maintained. The freeze/thaw cycle in the area makes maintaining concrete a challenge, and is probably not the best option for getting additional points. If the building proves to not add to light pollution, another point could be awarded, but due to the campus environment and site lighting requirements, this is also not likely.

The final options to consider when trying to gain additional LEED® credits are more expensive to implement. Depending on the level of incorporation, on site solar panels could be installed to produce at least 3% of the energy requirements to obtain two credits. A higher portion of on-site renewable energy reaches a maximum of seven points (13% renewable energy). Two additional points can be granted by improving the energy efficiency of the building by at least 4%. The last option would be to install a rainwater collection and harvesting system to use less potable water for sewage.

These options all have a high initial cost to implement, but improving energy efficiency and producing on-site power have payback periods. The rainwater harvesting may possibly have a lower first cost, but future savings are not as significant, and lifecycle cost analyses help determine the best possible solution. The final decision is up to the owner, and it is not likely DeSales would invest in these options for LEED® Rating alone.

Many considerations were made to reach the project goal to achieve LEED® Silver certification, but the final result depends on every projected credit to be accepted by the review board. Breslin Ridyard Fadero Architects remains confident the Gambet Center will obtain a minimum of LEED® Silver, despite only expecting to receive the minimum of 50 credits.

Schedule Acceleration Scenarios

The critical path of construction on the Gambet Center began with mobilization in early August 2011. After site setup and erosion controls were completed, topsoil was stripped and excavation was started. Three days after excavation started, concrete footings were constructed so the next week the foundation walls and piers could start to form. Foundation work concluded with masonry foundations, while underslab utilities were roughed in.

After a small portion of the slab on grade was cast, the critical path continued onward to erection of the structural steel frame. Lagging behind the superstructure was construction of mechanical curbs, roof blocking, and the built-up roofing membrane. Once completed, interior framing, electrical rough in, drywall, and ceiling grids were installed.

Installation of carpet and MEP fixtures were the next activities affecting the critical path, and as these approach completion, the acoustical tiles were dropped into place. From here, the final punchlist was created while the HVAC system was purged, and the Gambet Center reached substantial completion.

Any delays in these activities would affect the project completion date. Although the schedule requirement set by the owner was not strict, delays resulted in increased general conditions of approximately $2,800 per day, and it is the contractor's responsibility to minimize this risk to remain profitable.

Increased Labor Hours

The schedule throughout the construction process remained relatively on track despite adverse weather conditions pushing the start of some critical activities behind early in the project. A total of about two weeks were lost due to rain affecting the excavation, and it was up to the project team to decide how to increase productivity.

A common solution to making up for lost time is increasing crew sizes and/or working hours to raise production enough to offset schedule setbacks. This method was utilized during construction of the masonry foundation walls. A typical foundation crew on this project was four men, and it was increased to six. This had an effect of saving about 3 days on the schedule, and brought the completion of the masonry foundations more in line with the finish of CIP foundation walls and piers.

Similar techniques including extending working hours and overtime could have been implemented during other stages of the critical path as well. Increasing production of underslab utility rough in would allow steel erection to begin earlier. Implementing overtime during steel erection while improving on efficiency would also provide a lot of opportunity to gain back lost time on the schedule.

Offering overtime is not always the optimal solution to fixing delays in the schedule. There are corresponding deficiencies inherent by increasing crew size or using overtime. Overtime can be an effective tool when scheduled for a period of five to six weeks. As overtime schedules approach eight weeks, theoretical gains of production start to become outweighed by productivity loss, with no difference to a normal 40-hour workweek starting around 15 weeks.

Because the superstructure takes about 10 weeks to construct, a combination of these methods could have been utilized to create a plan to increase production without losses in productivity. Scheduling overtime for the first and last five-week periods would result in higher output before the affects from production losses occur. Increasing crew size in the middle of the process gives the normal crew a break, while continuing to make gains on the schedule.

Building Information Modeling

BIM was not a requirement on the Gambet Center, but the mechanical contractor, H.T. Lyons, had previous experience and created a 3D model to evaluate constructability concerns. Although more time is needed in the planning phases to implement BIM on a project, the added time invested in the planning process can have a much larger impact on the project schedule. H.T. Lyons was able to model the entire system and run clash detection software to provide insight on many areas that would encounter costly coordination errors in the field. Their previous experiences with BIM planning have proven to shorten the schedule with the added benefit of minimizing costs.

Although DeSales does not require the use of BIM on new construction projects, it is largely becoming common practice in the industry. As described above, 3D modeling allows individual subcontractors to layout systems with a high level of detail before construction; however, coordination between trades provides a significant opportunity to capitalize on these gains. Merging the mechanical model with the structural and electrical models could have highlighted areas where steel requires a mechanical pass through. This can be done during the fabrication of the steel, which takes less time than to fix the problem in the field.

The structural model could also be used to sequence the construction of the steel frame to cut time from the schedule. Adding time to the components creates a 4 dimensional model that requires foresight to plan the construction process and can visually show crews how to sequence construction. This can sometimes take the place of physical mockups that can be expensive and increase waste.

Prefabrication/Increased Production

The Gambet Center had many ways to use prefabrication of select systems to increase production and reduce the schedule. The largest way to reduce the critical path would be prefabricating racks of electrical conduit to quickly assemble the system in the field. Though not directly affecting the critical path, various prefabricated components of the duct network such as the large central trunks and turns with complex angles could be constructed in a warehouse and shipped in larger sections to the building.

Traditional construction of steel stud exterior walls and sheathing is a process that can be greatly reduced if prefabricated and installed in large sections at a time. With additional planning, electrical conduit and fixtures could be integrated with insulation to further reduce the critical path. Preassembling the curtain wall as opposed to stick building can also decrease construction time and provide quality control testing of each panel.

Increased production is an obvious proponent of prefabrication, but it is not the only way to achieve these results. Analyzing construction activities to find repetition in processes can lead to more efficient construction. Maintaining pressure on the foremen to keep their crews on task and productive throughout the shift also accelerates the schedule. Instating and maintaining safety initiatives and other incentives provide indirect benefits to the schedule by motivating workers to remain productive, without unnecessarily further delaying other activities. Lastly, tight site security is another indirect technique to prevent the theft of important materials or equipment.

Value Engineering Topics

Mechanical System VAV Heating Source

The design of the Gambet Center was required by the owner to receive at minimum a LEED® Silver rating. It is up to the design team to find ways to balance obtaining a certain LEED® rating with the expectations of cost for the owner. Initial considerations for choosing a geothermal mechanical system were abandoned due to the high initial cost and long payback period over five years rejected by the owner. The obvious option to select a VAV combination air and water system with high efficiency boilers became apparent in order to provide energy savings within a budget favorable to the owner.

The decision to use hot water coils in the VAV boxes instead of electric coils are another instance of value engineering in the mechanical design. The final factors in the determination were the first cost to install versus the payback period. Despite the higher installation cost, the hot water heating coil option, when paired with heat recovery, was less expensive and more energy efficient than using electric reheat coils.

Shading Control System

When designing the lighting control system it was initially decided not to incorporate automatic shading due to the higher cost. As it became more clear users would need some form of shading solution, DeSales reconsidered and decided to implement the automatic shades, which helped attain additional LEED® points. Powered shades that automatically determine the sun's location and adjust to the correct position optimize daylight and save energy during the summer to reflect heat radiating from the sun. The shades also automatically reduce glare increasing both productivity and comfort. Use of recycled fabrics for the shades also contributed to a LEED® point for exceeding the minimum use of 20% recycled content.

Lighting Fixtures

Alvin H. Butz was brought on as the construction manager as the contract documents were developed. After studying the initial design, alternate lighting fixtures went through a value engineering process. Butz found several alternative luminaires that achieved the same performance as the existing fixtures at a lower cost. The architect was asked to review the different options, and they found the aesthetics and lighting qualities of the proposed luminaires acceptable. The change was approved and amounted to a savings of approximately $50,000.

Curtain Wall System

Butz also asked the architect to consider switching the aluminum curtain wall system to a storefront resulting in significant savings because of the large amount of curtain wall on this project. After the investigation, the architect decided the designed curtain wall system was a better value despite the higher cost. The large amount of curtain wall does make the opportunity for substantial savings by slightly reducing square foot costs or reducing the schedule, but a lower quality storefront would promote higher infiltration and leakage. The building's energy cost would have increased and the thermal comfort lowered, both of which possibly affect LEED® credits. This example shows that the lowest cost system is not always the best option in every particular application.

Critical Industry Issues

The 21st Annual PACE Roundtable commenced on November 6, 2012 at the Penn Stater Hotel and Conference Center. Professors, students, and professionals gathered to discuss the current state of construction industry and how it is improving efficiency through innovation. Breakout sessions focusing on supply chain management, efficient delivery of services, and operations and maintenance. It was determined focusing on supply chain during the PACE Roundtable would help understand how logistical planning and modularization can possibly improve efficiency on the Gambet Center.

Integrating Strategies and Technologies

During the first breakout session, practices of integrating strategies and technologies to manage the supply chain were discussed. The conversation quickly turned to focus on how project teams handle various challenges associated with logistics. Many procurement strategies were discussed including managing owner supplied equipment by assisting the owner to ensure correct ordering and delivery. Some projects with sensitive security measures may need additional time for all deliveries to be inspected. In the case of the Pentagon renovation, all deliveries including the large amount of prefabricated mechanical equipment must be shipped early to account for the added inspection time.

Interesting considerations in material ordering and storage were also conveyed through anecdotes shared by the industry professionals. In multi-phase projects, it can be cost effective to order all curtain wall materials during the first phase and pay to store the rest if the storage costs are less than the expected rate inflation. Also, in the case of many healthcare projects, the design is completed years before the building is ready for occupancy. This poses a problem because it is often necessary to design for sophisticated equipment that will not be available for several years. Understanding how technology will evolve over time can be extremely important to facilitate a smart design that minimizes risks to the contractor.

One point of interest from this breakout session that can be applied to the Gambet Center is the use of barcode or RFID scanning to track the fabrication, shipment, delivery, and installation of materials and equipment. A more comprehensive BIM implementation plan on the project would also allow these tags to interface with the 3D model and a database to track construction, increase quality, and assist with facility management.

Modularization

Methods of prefabrication and modularization were explored during the second breakout session, which included industry professionals from Southland Industries, Truland Systems Corp., and Clark Construction. Multi-trade modularization is a rising trend in the construction industry due to the cost and labor savings, positive quality impact, and reduction in material waste. Repetitious design including trades that would not typically prefabricate (drywall) allows greater process efficiency, and the work is placed faster with less labor. Choosing to use modularization requires substantially more planning, and early subcontractor involvement is a must. For projects with delivery constraints that do not promote integrated design or a short schedule, prefabrication may not be possible.

The discussion moved toward popular ways prefabrication is applied in the industry today. Prefabrication of exterior masonry, curtain walls, electrical conduit, and mechanical ducts are becoming increasingly popular. Commercial bathrooms and headwalls that are prefabricated come in larger sections that shorten the plumbing schedule. Prefabricated exterior metal studs and sheathing could be introduced on the Gambet Center project to accelerate the rough building enclosure date. A potential research topic is to evaluate the benefits of prefabricating electrical conduit to decrease the critical path and save on costs. The industry professionals then made it clear that prefabrication/modularization is not always cheaper, and the project team has to weigh the options. Packaging and transportation costs must also be evaluated. Even if prefabrication or modularization breaks even on cost or schedule, it can still have less associated risks than traditional construction, can save on potential safety fines, and reduce waste.

There are many other options for savings from modularization in addition to the examples described above; however, there are several downfalls as well. These include the extra planning and preconstruction required to manage extensive prefabrication initiatives. In many cases, the owner may not be comfortable with the integrated project delivery that is basically required to successfully coordinate this type of construction. Lastly, modular size limitations, damage during transportation, and issues with code and inspection are other important consequences of using modular construction techniques.

Problem Identification and Technical Analysis Options

Technical Analysis #1 – Prefabrication of Building Systems

Prefabrication is an effective tool in reducing labor costs and schedule. An analysis of successfully introducing prefabricated sections of mechanical ducts, electrical conduit, and piping into construction will be conducted to show a substantial savings in schedule and construction costs. More in depth research into planning and procurement strategies, along with the associated supply chain management would further develop a viable prefabrication program for the Gambet Center. It may be possible to redesign these systems to incorporate more repetitiveness for increased productivity gains during fabrication. Case studies of past projects where companies implemented prefabrication could be used to outline a training program to mitigate a subcontractor's barrier of entry. A SWOT analysis will also be performed to measure the appropriateness of prefabrication on the project, focusing specifically on changes required to project delivery. In addition to MEP systems, the exterior metal stud and sheathing assembly and curtain wall will also be considered for prefabrication.

Technical Analysis #2 – BIM Implementation

There were no BIM requirements set by the owner, and only one subcontractor took initiative to create a 3D model. There is an opportunity to assess smaller scale implementations of BIM on the subcontractor level to coordinate construction of the MEP systems. Virtual models of laboratory spaces can be created to estimate the cost savings of catching errors before they're issues in the field. These models can also be used for the prefabrication of some sections, as described above in Technical Analysis #1, by generating shop drawings from the models and creating 4D simulations of the construction sequence of the SIPS schedule created in Technical Analysis #3. These models can also be used to create virtual mockups for design reviews from the Business and Healthcare Departments at DeSales University.

Technical Analysis #3 – SIPS Application to Offices

The third technical analysis will consider the execution of a short interval production schedule for the offices. The similarity between offices can benefit the construction schedule when SIPS is implemented. Some redesign may be necessary to increase the repetitiveness in the offices to make SIPS possible. Integrating techniques of prefabrication explored in Technical Analysis #1, and the 4D construction sequence from Technical Analysis #2 can be used to further illustrate how to plan these activities for the Gambet Center. There will also be a calculation of how much time can be shaved from the schedule and the implications it has on the project.

Technical Analysis #4 – LEED® Gold Certification

The Gambet Center is expected to barely gain a LEED® Silver Rating. An assessment of how integrating more advanced sustainable systems into the building can help to achieve LEED® Gold certification will be conducted. A water-source geothermal heat pump system will be analyzed to see gains in energy efficiency versus the initial cost of the system compared to the current VAV system. Also, the addition of photovoltaic solar panels and other on-site renewable energy will help to reduce net energy consumption and result in additional LEED® points. A cost to benefit analysis will be conducted for both systems to assess the practicality for the owner. Also a redesign of the lighting control system may provide ways to further decrease the energy consumption of the building. The role of supply chain on sustainable building will also be analyzed, and how to properly plan the logistics of a sustainable project. Lastly ways of incorporating concepts from the first three technical analyses will be researched further.

| Appendix A-1 |

LEED® 2009 New Construction and Major Renovation Scorecard

LEED 2009 for New Construction and Major Renovations

Project Checklist

Y	?	N			
7		19	**Sustainable Sites**	Possible Points:	26
Y			Prereq 1	Construction Activity Pollution Prevention	
		1	Credit 1	Site Selection	1
		5	Credit 2	Development Density and Community Connectivity	5
		1	Credit 3	Brownfield Redevelopment	1
		6	Credit 4.1	Alternative Transportation—Public Transportation Access	6
1			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
3			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
		2	Credit 4.4	Alternative Transportation—Parking Capacity	2
		1	Credit 5.1	Site Development—Protect or Restore Habitat	1
		1	Credit 5.2	Site Development—Maximize Open Space	1
1			Credit 6.1	Stormwater Design—Quantity Control	1
1			Credit 6.2	Stormwater Design—Quality Control	1
		1	Credit 7.1	Heat Island Effect—Non-roof	1
1			Credit 7.2	Heat Island Effect—Roof	1
		1	Credit 8	Light Pollution Reduction	1
8		2	**Water Efficiency**	Possible Points:	10
Y			Prereq 1	Water Use Reduction—20% Reduction	
4			Credit 1	Water Efficient Landscaping	2 to 4
		2	Credit 2	Innovative Wastewater Technologies	2
4			Credit 3	Water Use Reduction	2 to 4
11		7	**Energy and Atmosphere**	Possible Points:	35
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
4			Credit 1	Optimize Energy Performance	1 to 19
		7	Credit 2	On-Site Renewable Energy	1 to 7
2			Credit 3	Enhanced Commissioning	2
2			Credit 4	Enhanced Refrigerant Management	2
1			Credit 5	Measurement and Verification	3
2			Credit 6	Green Power	2
6	1	7	**Materials and Resources**	Possible Points:	14
Y			Prereq 1	Storage and Collection of Recyclables	
		3	Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
		1	Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
2			Credit 2	Construction Waste Management	1 to 2
		2	Credit 3	Materials Reuse	1 to 2

Y	?	N			
			Materials and Resources, Continued		
2			Credit 4	Recycled Content	1 to 2
2			Credit 5	Regional Materials	1 to 2
		1	Credit 6	Rapidly Renewable Materials	1
	1		Credit 7	Certified Wood	1
10		5	**Indoor Environmental Quality**	**Possible Points:**	**15**
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
1			Credit 1	Outdoor Air Delivery Monitoring	1
		1	Credit 2	Increased Ventilation	1
1			Credit 3.1	Construction IAQ Management Plan—During Construction	1
1			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
1			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
1			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
1			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
1			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
		1	Credit 5	Indoor Chemical and Pollutant Source Control	1
1			Credit 6.1	Controllability of Systems—Lighting	1
		1	Credit 6.2	Controllability of Systems—Thermal Comfort	1
1			Credit 7.1	Thermal Comfort—Design	1
1			Credit 7.2	Thermal Comfort—Verification	1
		1	Credit 8.1	Daylight and Views—Daylight	1
		1	Credit 8.2	Daylight and Views—Views	1
6			**Innovation and Design Process**	**Possible Points:**	**6**
1			Credit 1.1	`	1
1			Credit 1.2	Innovation in Design: Use of Blended Cement	1
1			Credit 1.3	Innovation in Design: Develop an Educational Program	1
1			Credit 1.4	Innovation in Design: Use of Waterbottle Filling Stations	1
1			Credit 1.5	Innovation in Design: 95% Threshold for Construction Waste Management	1
1			Credit 2	LEED Accredited Professional	1
2		2	**Regional Priority Credits**	**Possible Points:**	**4**
1			Credit 1.1	Regional Priority: Stormwater Quantity Control	1
1			Credit 1.2	Regional Priority: 50% Construction Waste Management	1
		1	Credit 1.3	Regional Priority: Parking Capacity	1
		1	Credit 1.4	Regional Priority: Site Selection	1
50	1	42	**Total**	**Possible Points:**	**110**

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110