2012 NECA/ELECTRI INTERNATIONAL GREEN ENERGY CHALLENGE
ENERGY AUDIT FOR HILTON COLISEUM

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Submitted on: April 15, 2012

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PROJECT SUMMARY

As Cyclone Energy, we performed a site assessment of Hilton Coliseum to identify the building's energy inefficiencies and provide possible solutions. After completing the site assessment, we determined the following to improve on: Lighting, Heating Ventilation and Air Conditioning, Building Envelope, and Wind Energy. This proposal focuses on the above areas and additionally includes a project schedule, estimate, financing plan and LEED EB review.

The Lighting Retrofit/Renovation proposes improvements on the seating areas, main floor, concession stands, lower level, and exterior lighting. The current fixtures will be replaced with a variety of innovative fixtures that will greatly reduce the lighting energy consumption.

During the energy analysis, we identified two areas to improve energy use and determined the feasibility of each solution. The first area is the dated HVAC system. The system needs replacement but does not provide adequate payback to justify the retrofit on energy use alone. A second, more feasible option is the installation of Variable Frequency Drives on the air handlers located in the attic. The VFD units will pay back quickly and save a significant amount of energy per year. The second area identified for improvement is the buildings window system. The original single pane windows will be replaced by triple pane, 3mm low-E insulated glass, argon filled windows that will reduce the building's heating and cooling cost by $170,293 per year.

Through the Photovoltaic and Wind analysis, we determined multiple green/renewable energy options for Hilton Coliseum and decided that a Windspire system will be the most effective. The Windspire system is able to provide 1% of Hilton's annual energy use. It will also be an effective tool for publicizing Iowa State's *Live Green!* initiative and commitment to green energy practices.

A LEED-EB analysis was conducted on how the newly renovated portions of the building will contribute to the achievement of LEED-EB points. Through this effort, we identified twenty-one possible points for our proposed project. During this investigation, we realized the full extent of Iowa State University's commitment to sustainability and decided to perform a full LEED-EB analysis. There are 66 possible points, which if pursued, will give Hilton Coliseum a LEED-EB Gold certification.

If the proposed schedule was approved and Notice to Proceed given by May 7, construction will be completed by July 23 so that there is minor interference with the owners' operations.

Cyclone Energy elects to weight the technical content analysis as follows: a 1.4 multiplier for Lighting Analysis, a 0.6 for Energy Use Analysis, and a 1.0 for PV/Wind Energy System Design.

CLIENT SUMMARY

Iowa State University of Science and Technology was originally established in 1858 as an agricultural college and model farm. It has since blossomed into a college campus offering one hundred different majors and catering to 28,000 students. Iowa State University is a leader in the community in promoting sustainability, green energy use, and LEED building practices. Iowa State currently employs the *Live Green!* sustainability initiative. *Live Green!* encourages all staff, faculty, and students to be fully committed to making ISU's campus, its operations, and initiatives as "green" as possible. In addition, Iowa State is actively pursuing LEED building in all of its new construction and building renovations. The two most recently completed buildings on Iowa State's campus are Hach Hall bio-renewables laboratory and the King Pavilion. Both received LEED Gold and Platinum, respectably. We believe that a Hilton Coliseum renovation/retrofit will be an effective way to further promote green energy and LEED building to the wide range of audiences that visit the space. This will be achieved while improving the building's energy usage, reducing its carbon footprint, and its operating cost.

Figure 1. Hilton Coliseum

Hilton Coliseum, shown in **Figure 1**, is an Iowa State University landmark and is home to the Iowa State Cyclone basketball, gymnastics, volleyball, and wrestling teams. In addition, it hosts many events, ranging from concerts to the Iowa State Engineering career fair. Hilton Coliseum is one of the few buildings on campus that every student will enter at least once in their Iowa State experience. Opening on December 2, 1971, Hilton Coliseum is named after the late Iowa State president Dr. James H. Hilton, who actively encouraged construction of the building. Hilton is a four-level building that includes an attic space and two levels of audience seating, capable of hosting up to 14,356 fans at a single event. It is recognized as one of the nation's top arenas for hosting collegiate basketball in the nation. Hilton has experienced some renovations in the past couple years. Some of the renovations were undertaken for improving energy efficiency and reducing yearly operating cost. However, there is still room for improvement. In this proposal, we will identify areas of concern and suggest improvements that will make Hilton LEED eligible.

Team Resumes

Eric Ryan: Junior, Construction Engineering

- Financing Plan, Energy Use Analysis

Paul Speed: Senior, Civil Engineering

- LEED Existing Buildings Review

Megan Vollstedt: Senior, English

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Alex Weiss: Senior, Electrical Engineering

- PV/Wind Energy System Design

Justin Wenger: Junior, Construction Engineering

- Lighting Analysis, Schematic Estimate and Schedule, Site Assessment

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- LEED Existing Buildings Review, Schematic Estimate and Schedule

Mission Statement

Cyclone Energy is dedicated to providing our clients with the best value in energy, lighting, and renewable energy consulting solutions, through cost analysis, feasibility studies, and innovative thinking. Our engineering professionals will find the solution that best fits our clients' needs.

LIGHTING RETROFIT

The current lighting in Hilton presents several opportunities to reduce the building's energy consumption. Iowa State has worked to maintain and update the building's lighting during additions and remodels, but there are still many lighting areas in Hilton that need to be retrofitted. We propose that Iowa State invest in a complete lighting retrofit in several main areas of Hilton Coliseum. Updating Hilton's current lighting system will allow for improvement of its lighting quality and its efficiency of energy use. **Figure 2** below shows an overview of the Hilton Coliseum floor plan.

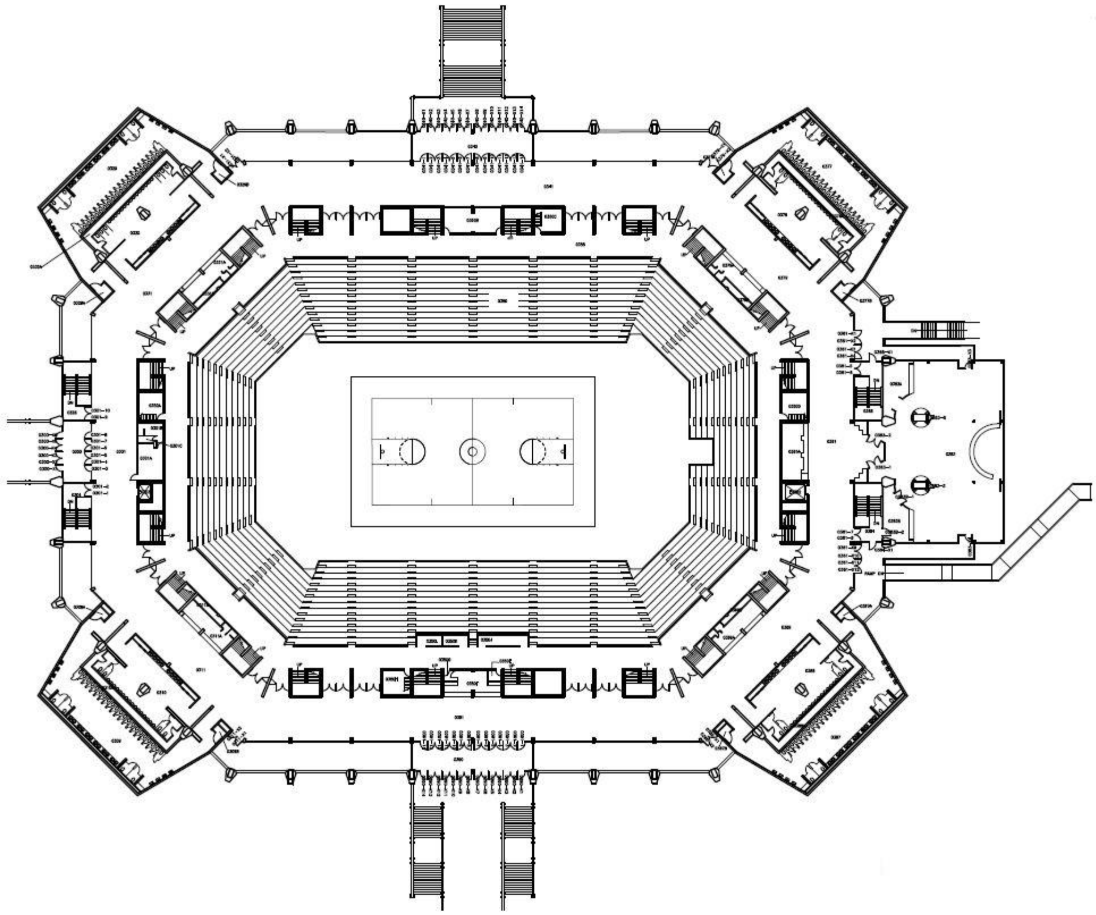

Figure 2. Floor Plan of Hilton Coliseum

Existing Conditions

As a sports arena, Hilton Coliseum has many levels of usage. During events that occur in the coliseum's main floor area, lighting functions are at full capacity. Even when there is not an event, Hilton is still occupied by many office employees and maintenance staff. During these times, many areas of the building are unnecessarily lit for the entirety of work day. For this reason it is crucial to optimize the energy usage in all areas of the building, providing a basis for our proposed retrofit.

The majority of the building is currently lit using a combination of incandescent and compact fluorescent can lights, along with T8 and T12 fixtures. During hours when there are no events, the majority of Hilton is efficiently lit using a minimum amount of fixtures. All of the offices and restrooms also utilize fluorescent lighting and occupancy sensors. Due to the type of building, there is little opportunity for the windows to provide beneficial daylight harvesting. Where there is natural light available, the outer concourse and stairwells are currently set to utilize daylight harvesting and so most of the fixtures are left off during the day.

Through our site analysis (**Figure 3**) and proposed retrofits, we have identified several key areas which can provide opportunities for substantial energy savings. In this proposal, we will expand on the different energy saving options and benefits in each of the following areas:

- Lower Level
- Concession Stands
- Seating Area
- Main Floor Area
- Exterior Lighting

Figure 3. Hilton Lighting Tour

LOWER LEVEL

The lower level of Hilton is composed of locker rooms, mechanical rooms, and storage area. Several of the existing lighting fixtures utilize T12 fixtures ranging from 2-4 lamps that are old, out of date, and in need of replacement. For our proposal, we have keyed in on the area in need of the most attention, which is identified in the floor plan of **Figure 4** below. The red box indicates areas containing T12 fixtures. We propose that these be replaced by LED and T8 fixtures with occupancy sensors.

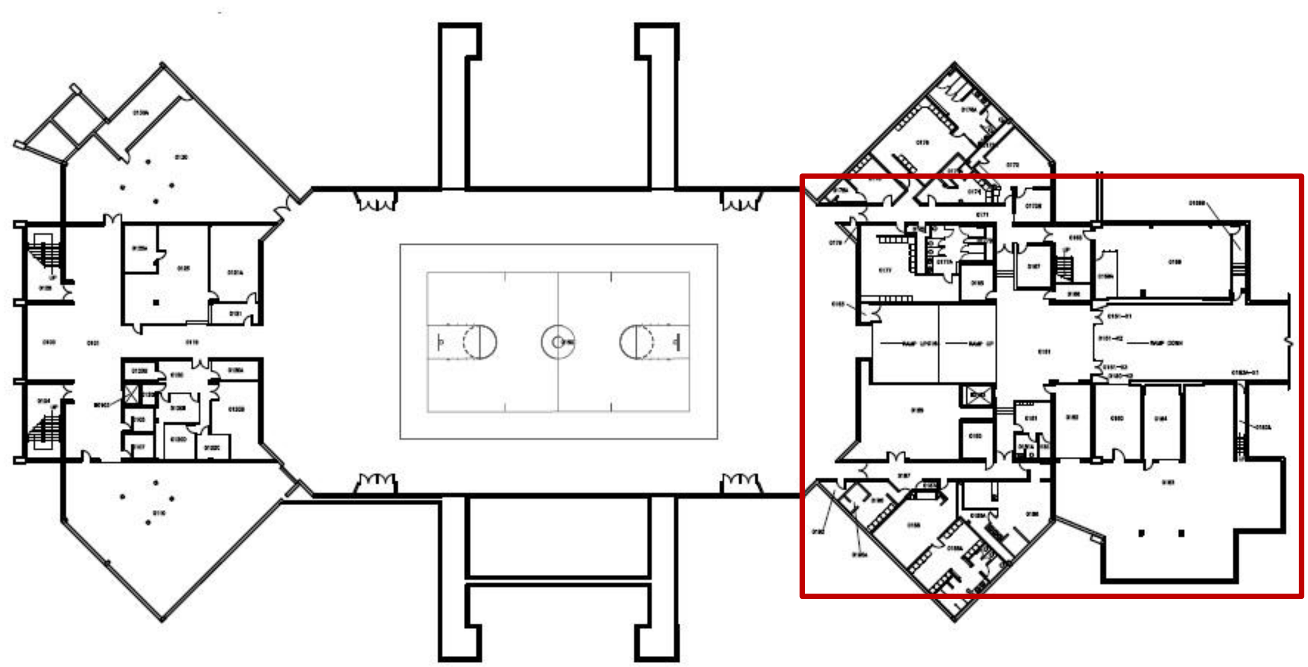

Figure 4. Lower Level Floor Plan

The current lights are used throughout the work day because of the activity of Hilton's staff. Nearly every day in Hilton, there is a variety of activities that the staff must prepare for. This may include setting up wrestling mats to erecting an entire stage for a concert. During game days, these areas are also open to all of the players, so the egress areas need to be clearly lit.

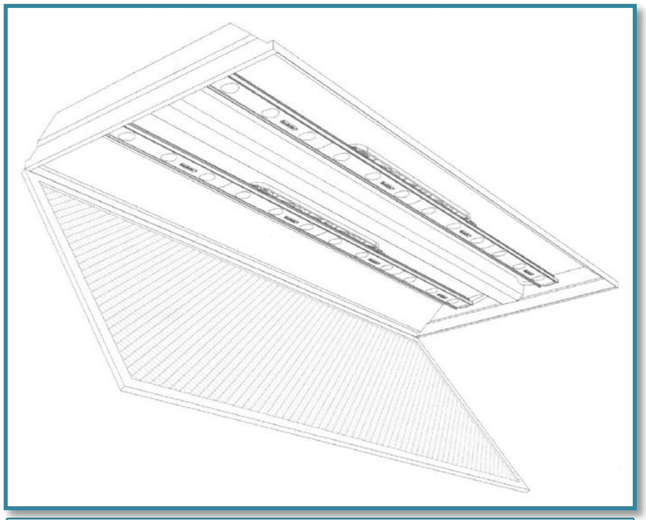

Figure 5. Innovative Lighting LED Conversion Kit

Several areas of this level have already been retrofitted during renovations after the flood. All of the locker rooms, restrooms, and mechanical rooms have modern T8 fixtures and occupancy sensors where applicable. The remaining spaces contain all T12 lamps. The T12 lamps contain magnetic ballasts, which are not as efficient. In more finished areas, we plan to replace the T12 fixtures with Innovative Lighting LED Conversion Kits, as shown in **Figure 5**. We propose utilizing the LED Conversion Kits, as a result of a site tour with Innovative Lighting, hosted by the Iowa State NECA student chapter. These replacements and other types of LED fixtures are used in offices, hallways, and storage areas. The LED replacement kits are mounted in place of the T12 lamps and wired to a power supply to allow for DC operation. These fixtures do not require ballasts and only have a driver. These LED replacements will allow for more energy efficient fixtures while maintaining luminaire output and producing a better quality of light.

Figure 6. Standard Industrial Rapid Start T8 Fixture

For the remaining mechanical and storage rooms, we plan to replace the T12 fixtures with more up-to-date Standard Industrial Rapid Start T8 fixtures, as in **Figure 6**. The T8 lamps operate with much lower mercury levels and use an electric ballast in place of the magnetic. In order to optimize the energy savings, existing ballasts will also be replaced with T8 operable ballasts. It is possible to leave the existing T12 ballasts to operate the T8 replacements, but in consideration of the long-term benefits, it is not a viable option. This is due to many benefits that will come with a new T8 operable ballast. The benefits that come from using new T8 operable ballasts include an increased lamp life and higher light output levels. Although the energy savings is not very high from the retrofit in these areas, we find that our changes will pay themselves off over time. See **Table 1** below for a summary of our proposed lighting. All replacements will be made using a one-for-one replacement in order to decrease labor/material costs and payback periods. A summary of the energy saving costs can be found in the Energy Savings Summary section.

Table 1. Existing Lower Level Lighting

Space Area	# of Fixtures	Existing Fixture Type	Wattage/ Fixture	Proposed Fixture Type	Wattage/ Fixture
Hall 0171	9	(3) T12 2'x4' Troffer	102	2'x4' LED Troffer Retrofit Kit	35
Room 0167	4	(4) T12 2'x4' Troffer	136	2'x4' LED Troffer Retrofit Kit	35
Undocking Area	19	(2) T12 1'x4' Surf. Mount	72	(2) T8 1'x4' Surf. Mounted Linear Floresce	64
Room 0180	4	(2) T12 1'x4' Surf. Mount	72	(2) T8 1'x4' Surf. Mounted Linear Floresce	64
Room 0181	2	(3) T12 2'x4' Troffer	102	2'x4' LED Troffer Retrofit Kit	35
Room 0182	4	(2) T12 1'x4' Surf. Mount	72	(2) T8 1'x4' Surf. Mounted Linear Floresce	64
Storage 0183	15	(2) T12 1'x4' Surf. Mount	72	(2) T8 1'x4' Surf. Mounted Linear Floresce	64
Hall 0187	7	(3) T12 2'x4' Troffer	102	2'x4' LED Troffer Retrofit Kit	35

The expected foot candle levels as per the proposed retrofit area were determined using Visual Lighting Design software. **Figure 7** below shows the levels generated by the software and **Figure 8** shows the generated foot candle data per space.

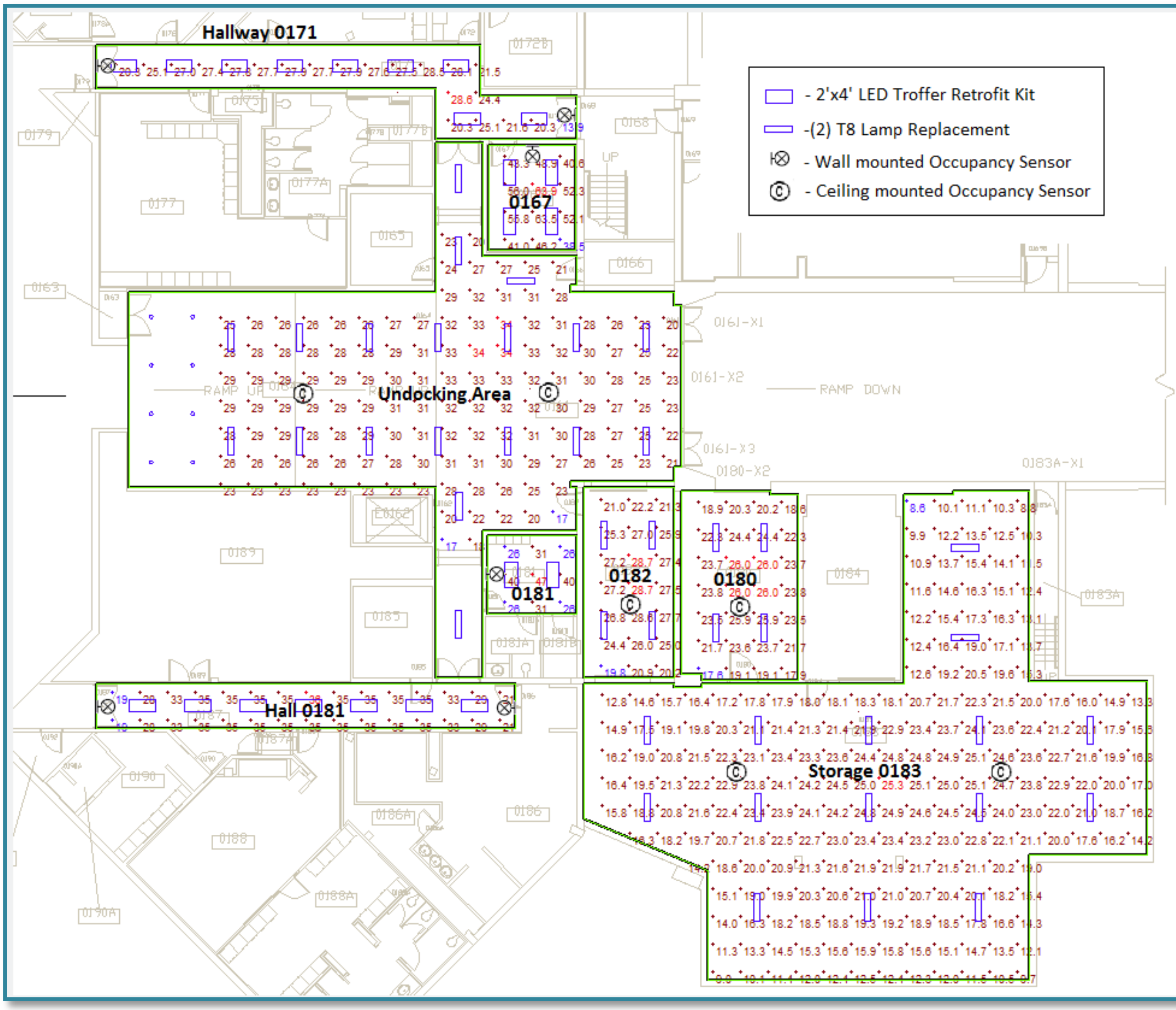

Figure 7. Proposed Lower Level Reflected Ceiling Plan

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	Hall 0171	Room 0181	Hall 0187	Room 0182	Room 0167	Storage 0183	Room 0180	Undocking Area
Average	23.6 fc	32.0 fc	32.5 fc	25.1 fc	49.3 fc	18.9 fc	22.6 fc	27.3 fc
Maximum	29.7 fc	45.7 fc	37.6 fc	28.9 fc	64.1 fc	25.3 fc	26.4 fc	33.8 fc
Minimum	8.9 fc	19.7 fc	16.8 fc	18.2 fc	30.0 fc	8.6 fc	16.4 fc	12.9 fc
Max/Min	3.3:1	2.3:1	2.2:1	1.6:1	2.1:1	2.9:1	1.6:1	2.6:1
Average/Min	2.7:1	1.6:1	1.9:1	1.4:1	1.6:1	2.2:1	1.4:1	2.1:1

Figure 8. Summary of Foot Candle Data per Space

During our site analysis, we were able to take existing foot candle level measurements of space types. The measurements are summarized in **Table 2** below

Table 2. Existing Average Foot Candle Measurement

Hall 0171	Room 0181	Hall 0187	Room 0182	Room 0167	Storage 0183	Room 0180	Undocking Area
40.44	46.38	41.23	19.3	55.89	20.23	20.15	18.29

According to our calculations, our proposed foot candle levels are suitable for their space types given a one-for-one replacement of the fixtures. On average, our values for each space are much closer to values put forth by the Illuminating Engineering Society of North America (IESNA) standards. The storage and open areas where T8 lamps will be used have light levels just above the existing levels. This can be expected as the new T8 lamps will be clean and have a higher luminaire output level.

OCCUPANCY SENSORS

Additional savings can be made by adding occupancy sensors to the storage room areas, hallways, and game tape rooms. The lights in these areas are usually left on while staff rearrange the main floor and adding these sensors will help eliminate unused light and save energy. For the larger areas, we propose using DT-300 Series Dual Technology Sensors mounted on the ceiling, as in **Figure 9**. In the small rooms and hallways we propose installing DW-100 Dual Technology wall-mounted sensors shown in **Figure 10**.

Figure 9. Watt Stopper Ceiling Sensors

Figure 10. Watt Stopper Wall Switch Sensor

CONCESSION STANDS

Currently, the concession stand spaces that surround the coliseum and face the outer concourse are lit using 100 Watt incandescent light bulbs. We propose a one-for-one replacement of all bulbs with equivalent 26 Watt compact florescent bulbs similar in lumens output and color. **Figure 11** shows the proposed 26 Watt GE Soft White Spiral T3 bulbs. As there are 65 incandescent lamps total in the concession stands, switching to florescent will create significant energy savings considering the low cost and time of the replacement.

Figure 11. Compact Fluorescent Bulb

Overhead Seating Area

The lighting over the seating area consists entirely of incandescent can lights. These lights range from 75 Watts to 300 Watts and are used for most of the events in Hilton Coliseum but not often used during nonevent hours. **Table 3** shows the amount of each type of bulb that exists in Hilton's seating areas (indicated in light blue in **Figure 12**). Though of limited use, these lights are equivalent to a 450 total high wattage lamp and can be replaced with a more efficient option. **Figure 12** represents Hilton's main coliseum reflected ceiling plan with can lights in blue and metal halide fixtures in green.

Table 3. Existing Can Lights

Lamp Data	Mounting	Manufacturer's #	Qty
(1) 75W -R-40 Flood	Recessed	Prescolite - 1122 - LQ	152
(1) 150W R-40 Flood	Recessed	Prescolite 1125 - LQ	136
(1) 300W - R-40 Flood	Recessed	Prescolite - 1128 - LQ	60
(1) 300W - PAR56, Med. Flood	Recessed	Prescolite - 1131 -LQ	52
(1) 300W - PAR56, Narrow Spot	Recessed	Prescolite - 1131 -LQ	44

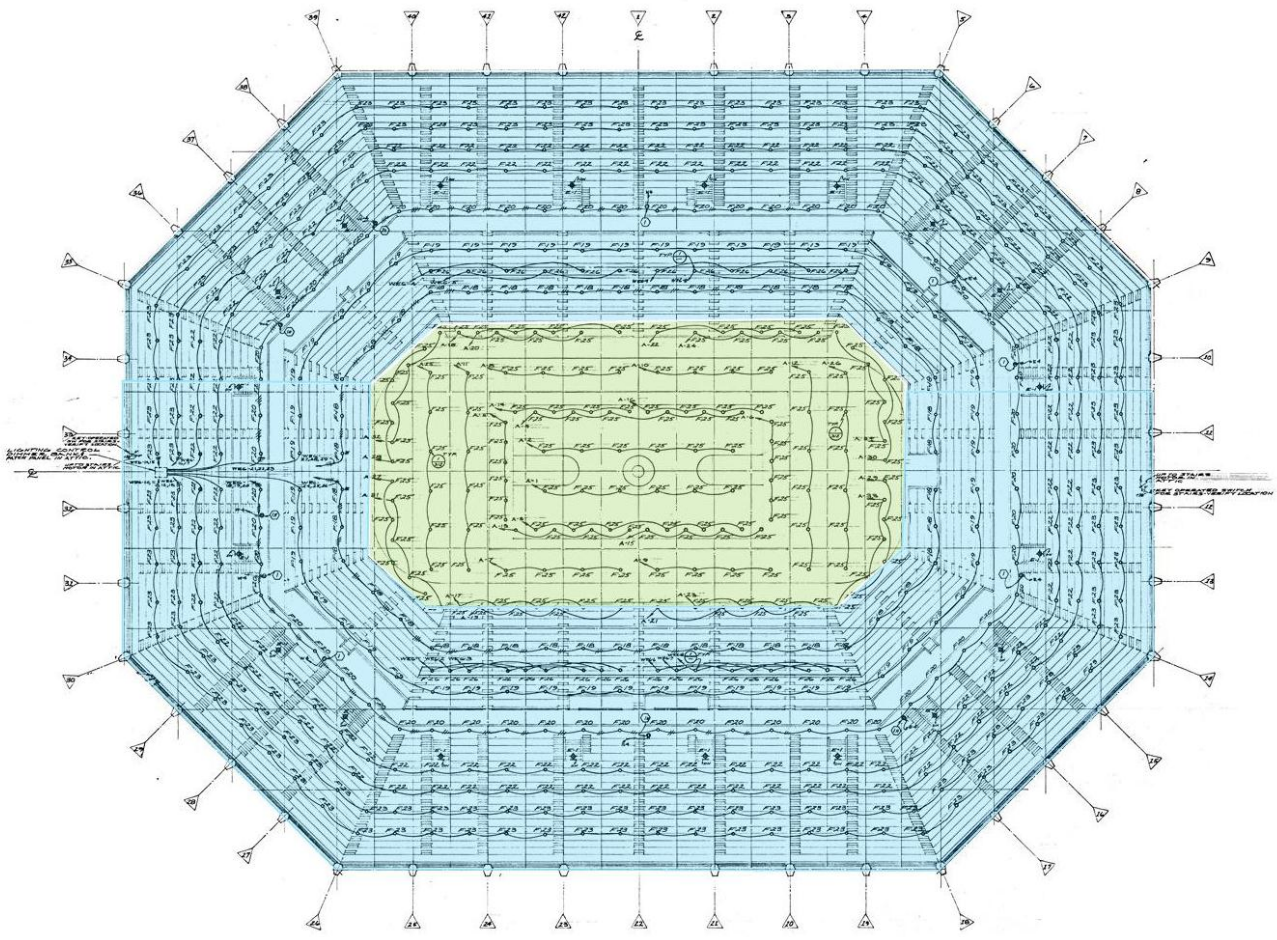

Figure 12. Arena Reflected Ceiling Plan

One of the benefits of using incandescent bulbs in the overhead seating area is their dimming capabilities. For this reason, we propose installing LED fixtures with the same dimming feature. Because the main coliseum area is such a complex space, we have selected our LED replacement fixtures based on the existing can lights' luminaire output. This will provide the proper amount of foot candles for the space. LED downlights achieve the multiple levels of lighting by containing different LED counts in each fixture. The LED lights will run at a much cooler temperature, have a longer life, and be more energy efficient than the existing can lights. All of the can lights can be switched from above the ceiling in the attic level. **Figure 13** is of one of our proposed fixtures. **Table 4** is a summary of the proposed replacements. A cut sheet of our proposed fixtures is included in **Appendix A** and the summary of energy saving costs is located in the Energy Savings Summary section.

Figure 13. Beta LED Architectural Downlight

Table 4. Proposed Replacements

Existing Fixture Type	Wattage /Fixture	Proposed Fixture Type	Wattage/ Fixture
(1) 75W -R-40 Flood	75	LED 8" Architectural Downlight - 28 LED's Wide	56
(1) 150W R-40 Flood	150	LED 8" Architectural Downlight - 42 LED's Wide	83
(1) 300W R-40 Flood	300	LED 8" Architectural Downlight - 56 LED's Wide	106
(1)300W Par56, Med. Flood	300	LED 8" Architectural Downlight - 56 LED's Wide	106
(1)300W Par56, Narrow Spo	300	LED 8" Architectural Downlight - 56 LED's Narro	106

OVERHEAD MAIN FLOOR

One of the largest lighting loads in Hilton Coliseum is the metal halide fixtures over the main floor, which exist as the original fixtures from construction. **Figure 14** shows the metal halide fixtures over the main floor and surrounding can lights over seating areas. Because of the extensive cool-down and heat-up time for these fixtures, they are left on nearly all day, especially since the building is utilized for athletes' and performers' practice and staff responsibilities. This provides an opportunity for savings in energy consumption.

Figure 14 .Overhead Lighting

Currently there are (156) 1000 Watt Metal Halide fixtures. Because this area of lighting is so specialized, Musco Lighting has assisted in determining a better and more energy efficient alternative to these fixtures. The highest level of NCAA broadcast lighting levels can be achieved using only (80) 1000 Watt Metal Halide Musco Lighting Green Generation Fixtures as shown in **Figure 15**.

Figure 15. Musco Metal Halide Fixures

These new fixtures consume the same amount of energy, but by reducing the number of required fixtures, significant energy and maintenance cost is saved. The proposed fixtures are quieter than the existing metal halides and have the shutter capability for quick darkening of the coliseum space. Once metal halide fixtures are turned off, they take approximately 15 minutes to cool down before they can be rebooted. This shutter eliminates that waiting time of any brief darkening of the space such as after halftime shows and introducing players.

We propose the removal of all 156 existing metal halide fixtures and their replacement with 80 new fixtures. These fixtures will be mounted in groups of 4 per suspended pole, with each fixture facing a different direction. For optimum lighting distribution, the lights will be placed symmetrically on both sides of the court. Our proposed reflected ceiling plan can be seen below in **Figure 16**, as well as foot candle levels on the basketball court in **Figure 17**. The new number of lights will match required horizontal foot candles necessary to meet the NCAA broadcast lighting levels. NCAA's table is included in **Appendix A** and a summary of the energy saving costs can be found in the Energy Savings Summary section.

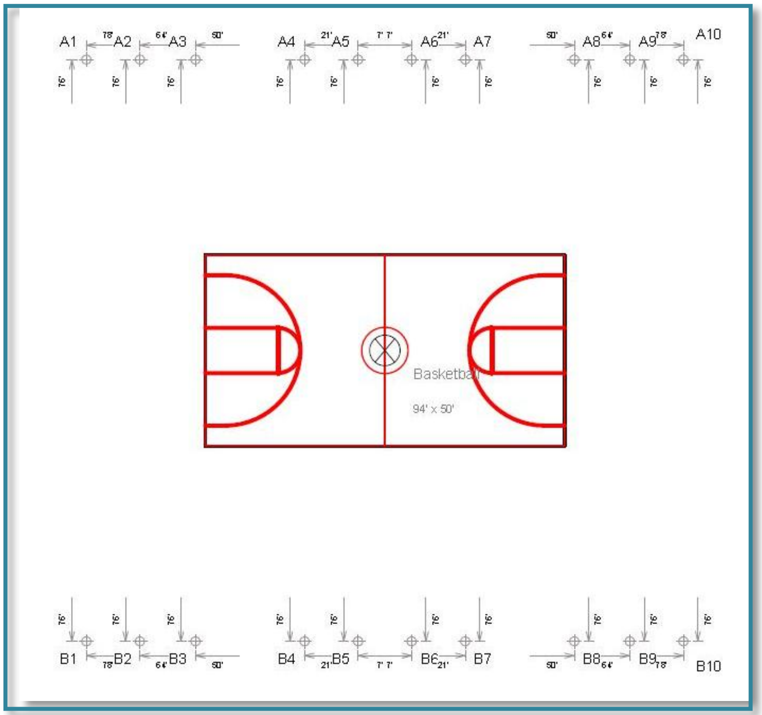

Figure 16. Metal Halide Fixture Mounting Pole Locations

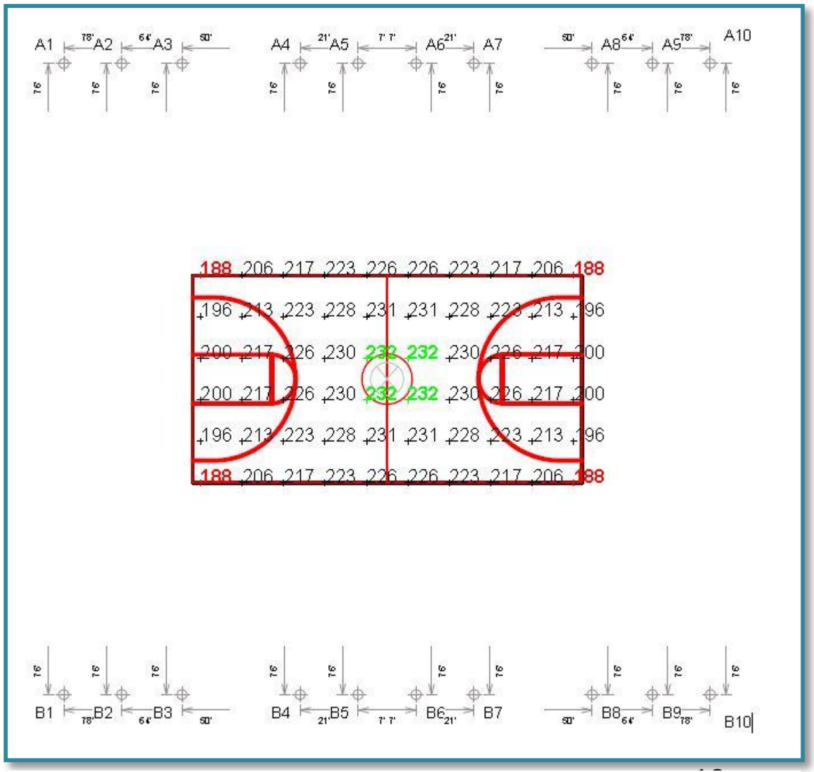

Figure 17. Proposed Foot Candles for Main Floor

PARKING LOTS

Another significant lighting load at the coliseum is the exterior lighting, which is continuously on for the entirety of each day. The University's Building Automation System serves all exterior lighting out of Hilton, using a remotely controlled master photocell. There are two main types of fixtures used in the Hilton parking lots. These are either 150 Watt or 250 Watt High Pressure Sodium Lamps. Wattage of the light varies on mounting type and location. **Table 5** below lists quantities of each type of fixture. Most fixtures are pole mounted, but there are several examples of wall mounted fixtures on Hilton's exterior. **Figure 18** shows all pole-mounted fixtures surrounding Hilton Coliseum.

Table 5. Exterior Light Quantities

Height	Lamp Data	Mounting	Quantity
14 ft tall	(1) 150 watt High Pressure Sodium	Pole	14
30 ft tall	(1) 250 watt High Pressure Sodium	Pole	20
30 ft tall	(2) 250 watt High Pressure Sodium	Double Pole	8
-	(1) 150 watt High Pressure Sodium	Wall Mounted	20

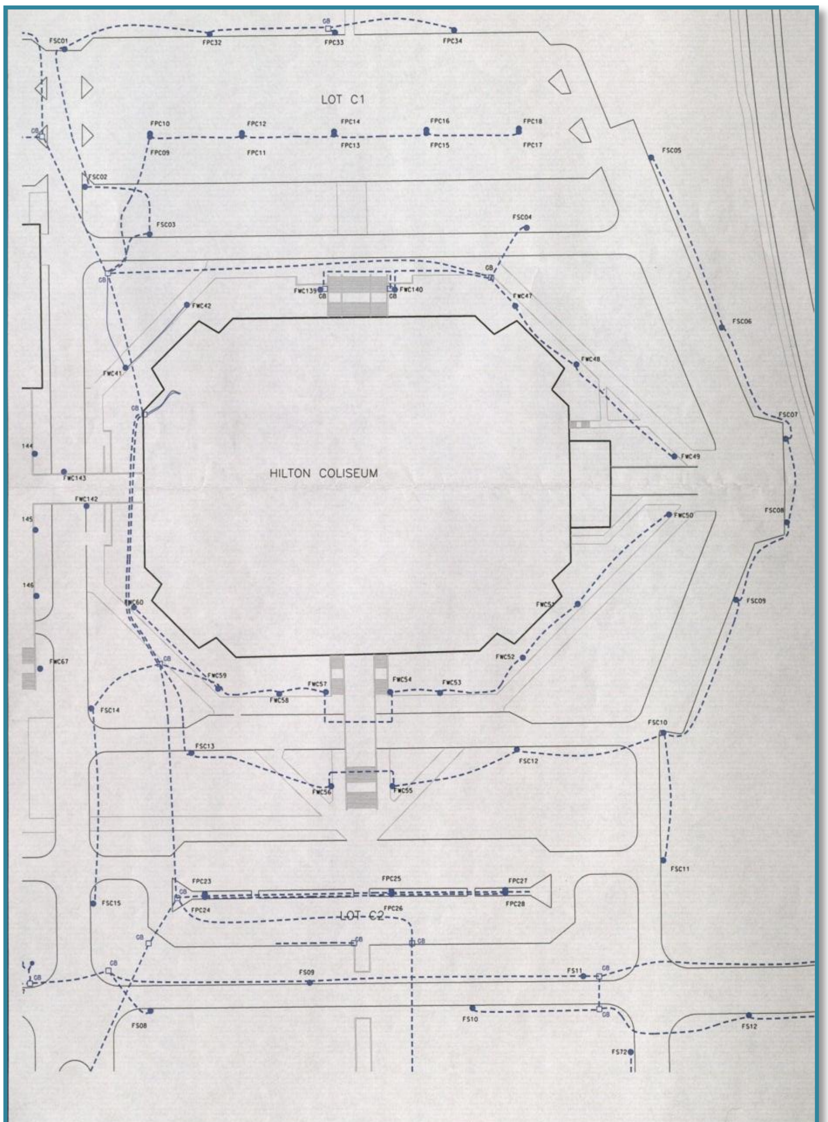

Figure 18. Existing Exterior Site Plan

Iowa State utilizes these same fixtures throughout the entire campus, while varying the wattage as necessary. **Figure 19** shows the existing lighting fixtures by Hilton's parking lot. Iowa State recently retrofitted an entire street of these fixtures with LED lamps instead of the high pressure sodium and plans to explore these as a realistic alternative. After speaking with Iowa State's Chief Electrical Engineer, and learning about the success of this trial, we propose that Hilton's parking lots lights be retrofitted in a similar fashion. The LED lights allow for improved energy consumption and use of directional light. The LED retrofit kit is provided by the same manufacturer as the existing high pressure sodium fixtures, so the existing poles do not need to be altered, which will allow for a quick and inexpensive exchange. **Figure 20** is of the proposed replacement lighting fixtures and poles. We have included a cut sheet of the retrofit kit in **Appendix A** and a summary of the energy saving costs can be found in the following section.

Figure 19. Existing Exterior Lighting

Figure 20. Replacement LED Upgrade Kit

ENERGY SAVINGS SUMMARY

After selecting new fixtures for each of the previous areas, we calculated our estimated energy savings based on the number of hours each type of fixture is used per day. The following **Tables 6 through 9** summarize our estimated savings for each fixture.

Table 6. Lower Level

Proposed Fixture Type		Energy Savings	
2'x4' LED Troffer Retrofit Kit		603	
2'x4' LED Troffer Retrofit Kit		404	
(2) T8 1'x4' Surf. Mounted Linear Florescent		152	
(2) T8 1'x4' Surf. Mounted Linear Florescent		32	
2'x4' LED Troffer Retrofit Kit		134	
(2) T8 1'x4' Surf. Mounted Linear Florescent		32	
(2) T8 1'x4' Surf. Mounted Linear Florescent		120	
2'x4' LED Troffer Retrofit Kit		469	
		1,946	Watts
Operating Hours/Day		10	Hours
Monthly Savings Based on $.25/kWh	**$**	**146**	

Table 7. Concession Stands

Proposed Fixture Type		Energy Savings	
26 Watt Compact Florescent		4,550	
		4,550	Watts
Operating Hours/Day		5	Hours
Monthly Savings Based on $.25/kWh	**$**	**171**	

Table 8. Seating Areas

Proposed Fixture Type	Energy Savings	
LED 8" Architectural Downlight - 28 LED's Wide	2,888	
LED 8" Architectural Downlight - 42 LED's Wide	9,112	
LED 8" Architectural Downlight - 56 LED's Wide	11,640	
LED 8" Architectural Downlight - 56 LED's Wide	10,088	
LED 8" Architectural Downlight - 56 LED's Narrow	8,536	
	42,264	Watts
Operating Hours/Day	6	Hours
Monthly Savings Based on $.25/kWh	**$ 1,902**	

Table 9. Main Floor Area

Space Area	# of Existing	# of Proposed	Proposed Fixture Type	Wattage /Fixtures	Savings (Watts)	
Floor Area	156	80	1000W Metal Halide ShowLight	1000	76000	
					76,000	Watts
				Operating Hours/Day	14	Hours
				Monthly Savings Based on $.25/kWh	**$ 7,980**	

Figure 21. Iowa State Cogeneration Power Plant

All of Iowa State's buildings, including Hilton Coliseum, are supplied with electricity, high pressure steam, and chilled water from the Iowa State cogeneration power plant, seen in **Figure 21**. The graphs below, provided by Facilities Planning and Management (**Figure 22 through 24**), show the average monthly consumption of energy, steam, and chilled water over the past three years. From the chilled water and steam consumption data, we have identified the peak cooling load during the month of August and the peak heating load during the month of December. We have used this gathered data for our maximum heating and cooling load calculations. The energy consumption graph peaks through the months of November and February. These months have the largest energy consumption due to the high usage of the facility by the winter season indoor sports. The graphs are the only metered data that are available for Hilton. The major energy loads for the building are the lighting, air handlers, and event equipment.

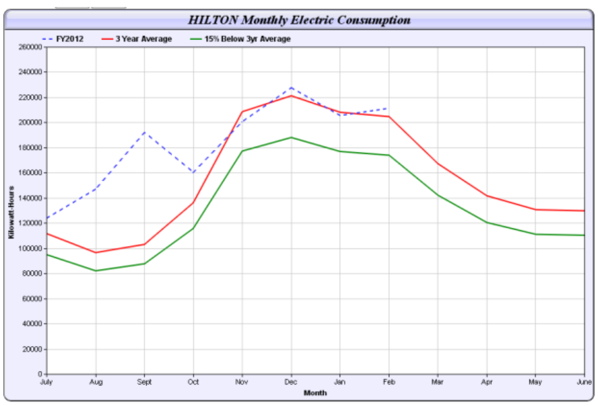

Figure 24. Electric Consumption

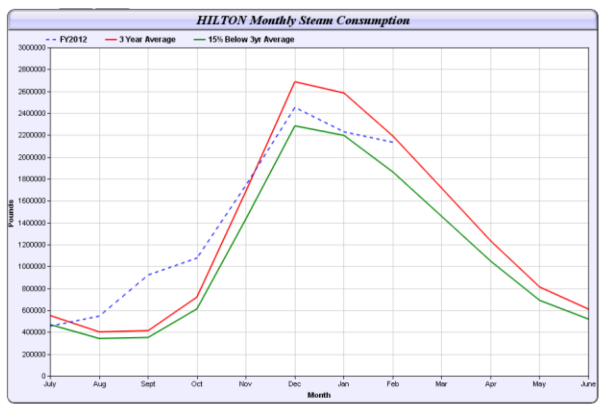

Figure 22. Steam Consumption

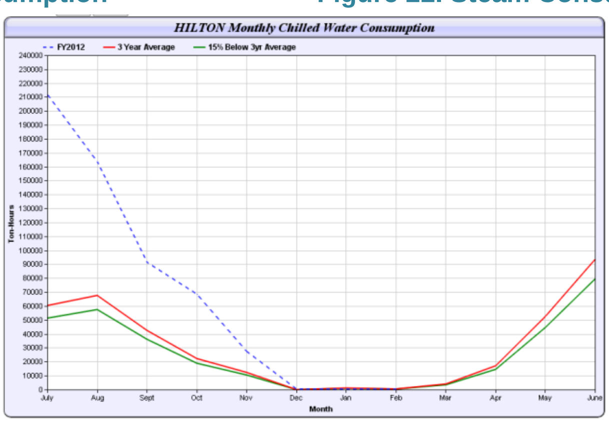

Figure 23. Chilled Water Consumption

HEATING, VENTILATION, AND AIR CONDITIONING

Figure 25. Existing HVAC System

Through the site visit, schedule research, and plan reading we determined areas for possible energy improvement at Hilton. **Figure 25** shows the existing system. We spoke with a representative from Facilities Planning and Management and the Facilities Manager at Hilton Coliseum about feasible projects for building improvement. We investigated the dated HVAC system and building envelope.

Hilton receives its heating and cooling by 40 air handling units of varying size. The heating for these units is provided by the power plant through high pressure steam. The cooling is provided by the power plant's four chilled water pumps. Twenty four air handlers are located in the mezzanine level below the upper seating level and supply air to the offices, locker rooms, and outer concourse. Additionally, sixteen units are located above the main floor ceiling and distribute conditioned air to the seating and playing areas. Few air handlers are non-functioning and are only used for replacement parts because the air handlers are no longer supported by their manufacturer. ISU Facilities plans to replace the dated system within the next ten years with a more efficient system. Replacing the outdated air handlers will be an improvement to the building's energy use. However, the return on investment is not enough that we could justify replacing the air handlers for energy efficiency alone. Instead, the replacement system will be focused on mechanical reliability and availability of replacement parts. We have determined that the building's total cooling load is 350,000 CFM from the air handler schedule in **Figure 26**. If Facilities were to replace the old system, it would be possible to replace the 40 dated air handling units with fewer, more efficient units.

SCHEDULE OF AC UNITS

SYSTEM	FAN		MOTOR			FACE	HTG. COIL			COOLING COIL					
										ENT. AIR		LEAVE. AIR		WATER	
	CFM.	SP	HP	ϕ	V	ϕ	ENT. °F	LV °F	STEAM PSI	DB	WB	DB	WB	GPM	ENT. °F
1 THRU 16	11,500	2	7½	3	440	27	35	55	5	89.2	74.0	60.5	55.0	125	48
17 AND 37	1250	1¾	¾	3	440	3	-15	60	5	95.0	78.0	60.0	57.0	20	48
18, 25, 29, 36	4500	2¼	3	3	440	9	-15	60	5	95.0	78.0	68.6	59.6	62	48
19, 24, 30, 35	6000	2¼	5	3	440	11.7	30	55	5	84.8	69.3	66.0	58.0	45	48
20, 21, 23, 31 33 & 34	8000	2	5	3	440	16.8	30	55	5	84.8	69.3	66.0	58.0	60	48
22, 32, 39	12,000	2	7½	3	440	24	35	60	5	84.0	69.0	60.0	58.0	88	48
26	1500	1½	1	3	440	3	-15	60	5	95.0	78.0	60.0	56.0	30	48
27	6000	3	7½	3	440	11.7	-15	60	5	95.0	78.0	65.0	56.6	94	48
28 & 40	10,000	2	7½	3	440	20.6	30	55	5	84.8	69.3	66.0	58.0	75	48
38	1700	2	1½	3	440	3	-15	60	5	95.0	78.0	61.4	58.6	25	48

Figure 26. Schedule of AC Units

Figure 27. Fan Motor Variable Frequency Drive

Hilton will benefit from implementation of a Variable Frequency Drive system. With Hilton Coliseum's primary purpose as an event center, it has very large fluctuations in heating and cooling loads, even on a day-to-day basis. Therefore, we recommend an addition of VFDs, similar to the Siemens SED2 VFD system (**Figure 27**) to the 16 air handlers that service the main arena. The Siemens SED2 VFD system has a relatively low initial cost and a short payback period. This is because the VFD provides 50-70% energy savings each year. If we were to install VFD's on the (16) 7.5 hp attic units that supply the arena area and run the fans at 80% speed for five of the seven days out of the week, the energy consumption will be reduced by 52%. As can be seen in **Table 10**, the VFD implementation is an effective energy investment as it has a short payback period of less than half a year.

Table 10. VFD Return on Investment

VFD Payback and Return on Investment		
Fan HP	(16) 7.5	hp
Estimated Annual Energy Use for 16 units	162,160	kWh
Annual Energy Usage with VFD's	87,566	kWh
Estimated Annual Energy Use Cost	$40,540	
Estimated Annual Energy Use Cost with VFD's	$21,892	
Total Cost of Installation	$42,964	
Payback Period	2.30	
Return on Investment	43%	

BUILDING ENVELOPE

Currently Hilton's building envelope consists of three enclosure systems. The first and most significant portion of the building's envelope is the precast concrete panel system. We calculated, based on known building material thermal resistances, that the precast system has a thermal resistance of four. We conducted a feasibility study on multiple insulation options that could be added to the precast panels. The improvements to the building's thermal resistance did not provide enough energy savings to pay back for the high construction and material cost, so the renovation is not feasible.

Another main component of the exterior envelope is the windows, which can be best visualized as a horizontal curtain wall system that spans most of the perimeter on the main level. The windows are quite old, are only single paned, and would be best if replaced.

The final exterior envelope system is the building's entrance doors. There are three main entryways into Hilton. The entrance doors are the original single pane glass doors installed on the building that have a high U-value rating and infiltration rate. Facilities Planning and Management conducted a study on the doors and entrance system to investigate if it was feasible to replace the old system and found that it was not cost effective to replace the existing entrances with better insulated, tighter sealing doors.

We propose a complete replacement of the exterior windows. A quantitative heat transfer analysis between the two window types, as shown in **Figure 28**, determines the feasibility and amount of energy savings from replacing the exterior windows.

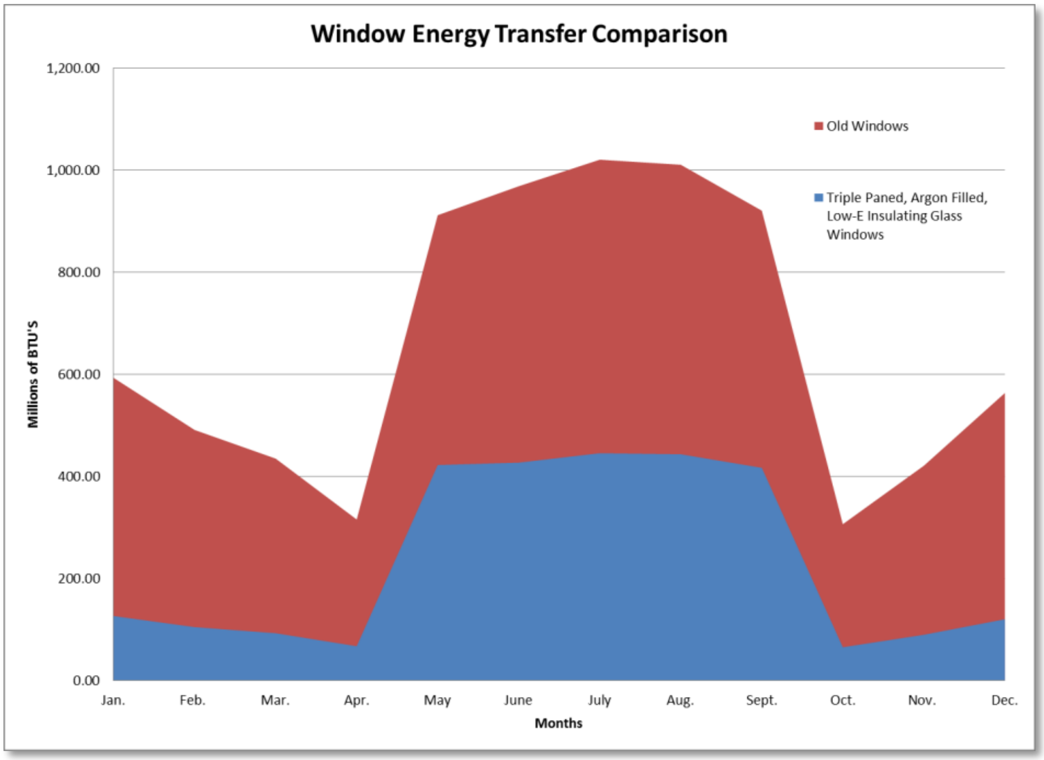

Figure 28. Window Energy Comparison

To carry out this analysis we used the formulas for heat transfer of windows, $Q_{Conduction}$ & Q_{Solar}. The windows have an average overall heat transfer coefficient, U-value, of an older single pane window of 0.9 with a shading coefficient of 0.88. The proposed are Triple Paned Low-E Insulating Glass with Argon and 3mm Low-E Hinged Glass Panels, as shown in Figure _. The more panes in a window, the greater insulation it will provide. This increase in insulation along with the Low-E, or low-emittance, glazing improves the thermal resistance provided by these windows. As in **Figure 29**, the Low-E coating helps absorb and reflect heat and transfers it either indoors or outdoors, depending on the climate. Pella Windows provides an ideal model of this type of window, which has a U-value of .16 and a shading coefficient of .41 (**Appendix B**).

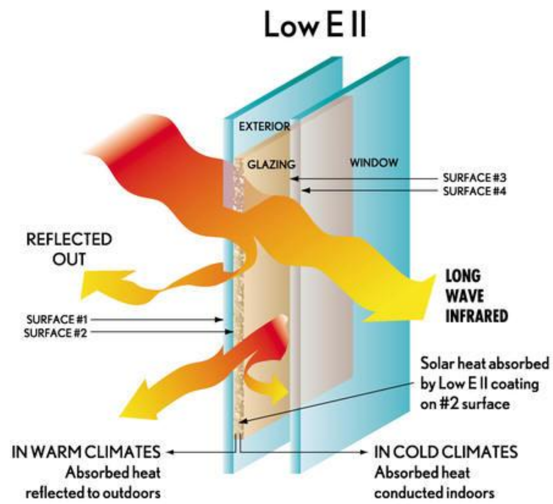

Figure 29. Low-E Hinged Glass Panels

We used the formulas (**Appendix B**) to calculate the heat transfer in British Thermal Units per Hour (BTU/HR) from the windows in each month of the year. The average high temperature in the heat gain months and the average low temperature in the heat loss months represent the loads (**Appendix B**). With these transfer rates calculated, we converted BTU/HR to Tons of energy per Hour (Ton/HR) with the conversion factor 12,000 BTU/HR=1 Ton/HR. With this calculation and knowledge that the air handling units convert 1 ton of energy by using 1.4 kilowatts of power, we calculated the hourly kilowatts of electricity usage (kWh) and multiplied by the amount of hours in each month to find the total kWh usage per month (**Appendix B**).

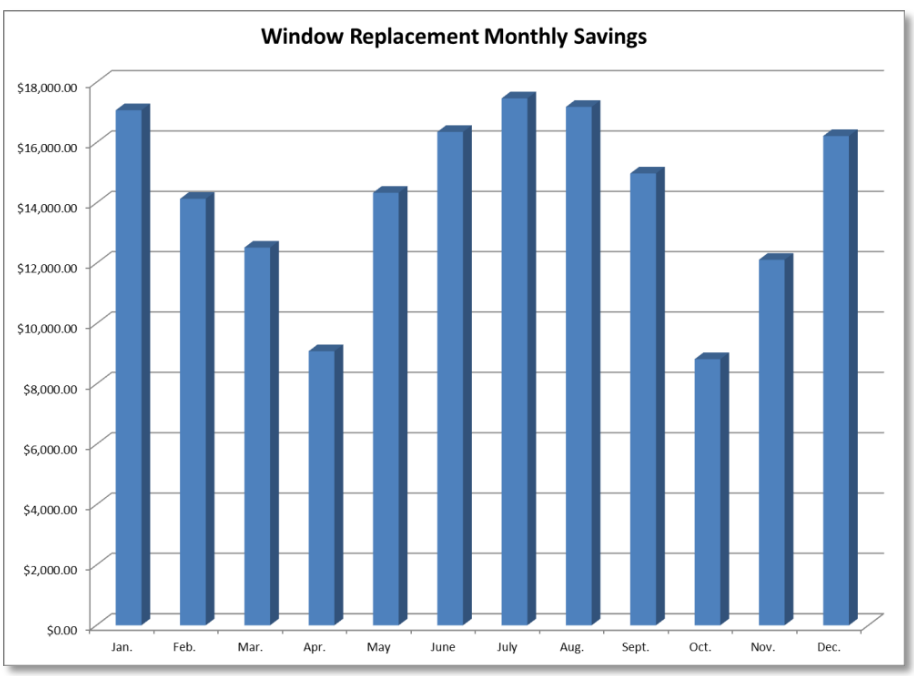

Figure 30. Monthly Savings for Window Replacement

By calculating the difference in kWhs between the existing and proposed windows with a minimum cost of energy at $0.25 cents a kWh, there is a substantial yearly savings, as shown in **Figure 30**. With this data, we were able to find material costs and conduct a return on investment analysis, the results of which are in **Table 11**. From the payback provided by the energy cost savings for these windows, there will be a payback in 21.03 years.

Table 11. Window Investment

Window System		
Demolition of Old System	$300	Per Window
Demolition	$24,000	Total
Window Wall, Aluminum Stock, Including Glaze	$155	Per SF
Add 25% for Triple Pane & Argon Gas	$39	Per SF
Labor	$7	Per SF
Installation	$201	Per SF
Total Window Area	17,720	SF
Installation	$3,561,720	Total
Installation & Demolition	$3,585,720	Total
Total with Overhead and Profit	$3,944,292	
Energy Savings	$170,293	Per Year
Payback Period	24	Years
Return on Investment	4.32%	

This is a short payback period for a retrofit of this size and budget. Also based on the believed longevity of Hilton Coliseum, the building should be utilized well beyond the 22.03 year payback period. In addition, if we couple the window retrofit with the other renovation projects. The payback period for the overall project will be significantly shorter. Based on these reasonable assumptions and justifications, a window retrofit is cost effective and feasible.

We also propose the implementation of air curtains over the main entrance and receiving doors to create a barrier, or "curtain," of air between the exterior and interior climates. This will help reduce the heating and cooling losses when doors are left open, which frequently occurs at events when there are large groups of people entering and exiting the building. This system of air curtains, an example of one is shown in **Figure 31**, will be a more efficient method for controlling the heating and cooling losses, resulting in cost savings for the coliseum.

Figure 31. Air Curtain

To calculate the amount of energy savings that could be gained from implementing the air curtains we used Bernier International Corporation's Energy Savings Calculator for Air Curtains and doors, both of which are located in **Appendix B**. From this, we calculated the monthly energy savings per Heat Gain and Heat Loss Season, as in **Figure 32**.

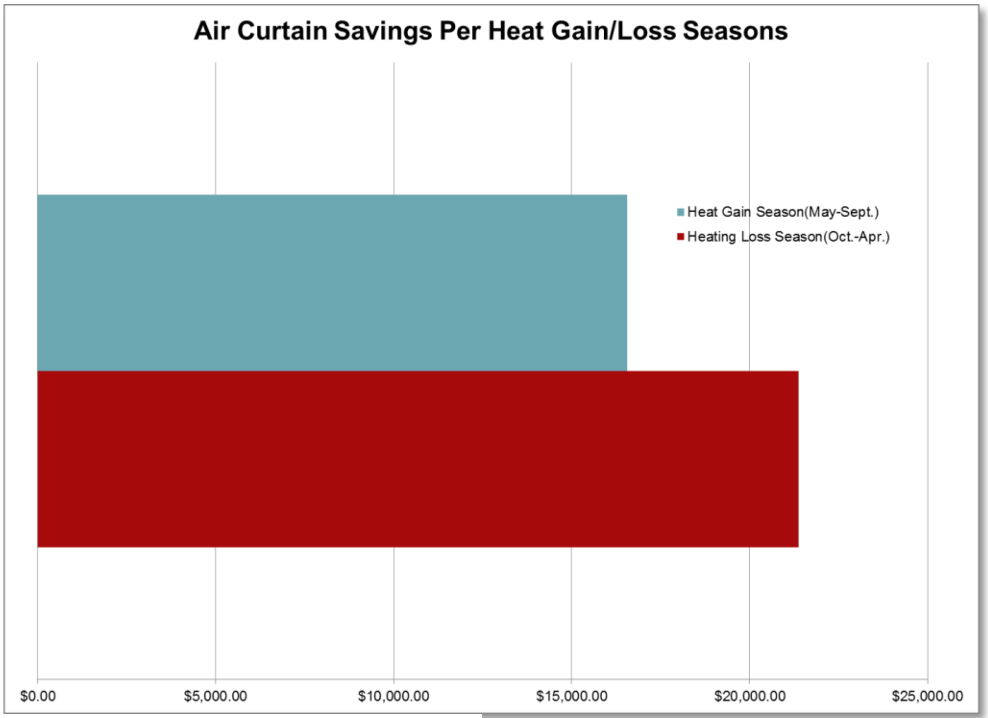

Figure 32. Air Curtain Savings

With this data there is a savings of $21,375 in the Heat Loss Season and a savings of $16,568 in the Heat Gain Season, for a yearly total savings of $37,943. This provides a payback period of less than 1 year for the cost of the system installed on all 19 of the main public entrance doors into Hilton.

PV/WIND ENERGY SYSTEM DESIGN

PHOTOVOLTAIC SYSTEM

The roof of Hilton Coliseum and the grassy unused areas surrounding the building provide abundant space where a photovoltaic system could be located. We considered placing an array of roof-mounted solar panels along the southern roof of Hilton or pole-mounted solar panels equipped with trackers to the southeast of the coliseum, both seen in **Figure 33**. Both systems will be connected to Iowa State's electrical grid and inverters that will log power generation. However, we have decided not to pursue any photovoltaic systems for the following reasons.

Roof-mounted solar panels cannot be viewed from ground level and could only be accessed for service and installation, which would limit the green energy awareness given to the public.

The disadvantage to installing pole-mounted solar panels is the relative cost and payback period of this type of system. Iowa lies in a middle-to-low intensity sunlight region of the United States, which means that less energy can be harvested from this system. We propose installing a wind-energy system for a higher rate of return that could also be used by the university as a promotional and educational tool.

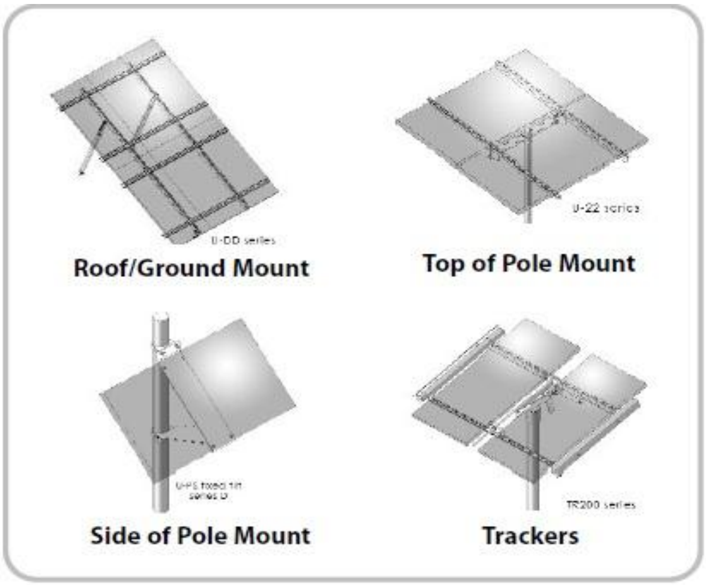

Figure 33. Pole-Mounted Solar Panels

Figure 34. WindCube

Hilton Coliseum, along with the surrounding parking lot and grass areas provide for several wind system options. WindCubes and Windspires are two such alternatives. Since Hilton Coliseum is a tall structure, a wind harvesting system such as WindCubes (**Figure 34**) could be placed on the roof with no obstructions. But, because a roof-mounted system would not be visible to the public, it is not an ideal method for energy awareness initiatives. Further, Wind Cubes require stable bases for mounting, as the intensity of harvesting the wind through the structure may lead to damage, which the roof of Hilton is not prepared for.

Figure 35. Windspire

We propose installing Windspires, which is shown in **Figure 35**. This 30ft tall and 4ft wide structure can easily be placed in the area surrounding Hilton Coliseum. This system rotates about a vertical axis instead of the traditional horizontal axis like many wind turbines. The Windspire is designed to operate in wind speeds greater than 10mph. According to the National Oceanic and Atmospheric Administration, the average wind speed in Ames is 10.7mph. **Figure 36** shows the wind speed data. Based on an average wind speed of 11mph, as shown in **Figure 37,** the annual output is 2,000kWhs. The turbines produce DC electricity and each unit contains a grid-tie inverter. The system will be connected to a service panel in Hilton Coliseum and the electricity would be used immediately. An internal wireless modem allows for the power production to be monitored.

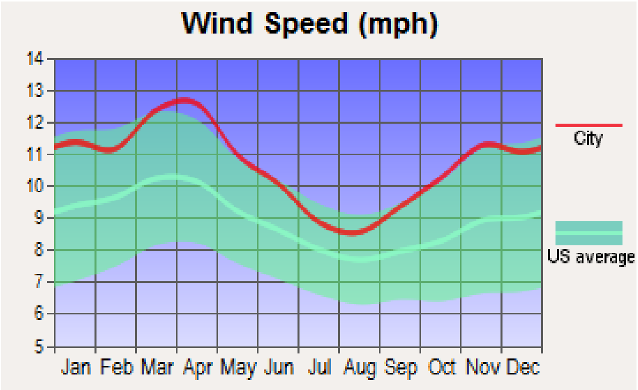

Figure 36. Average Wind Speed

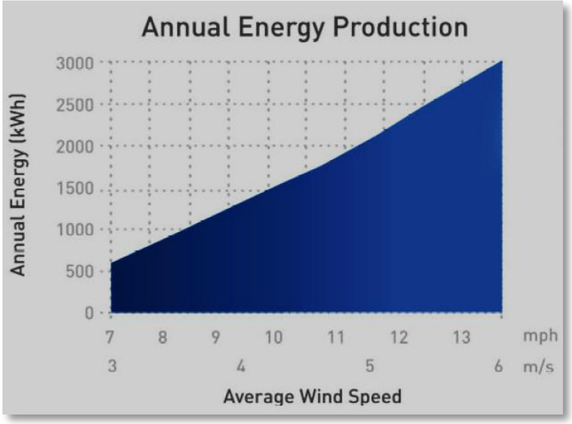

Figure 37. Annual Energy Production

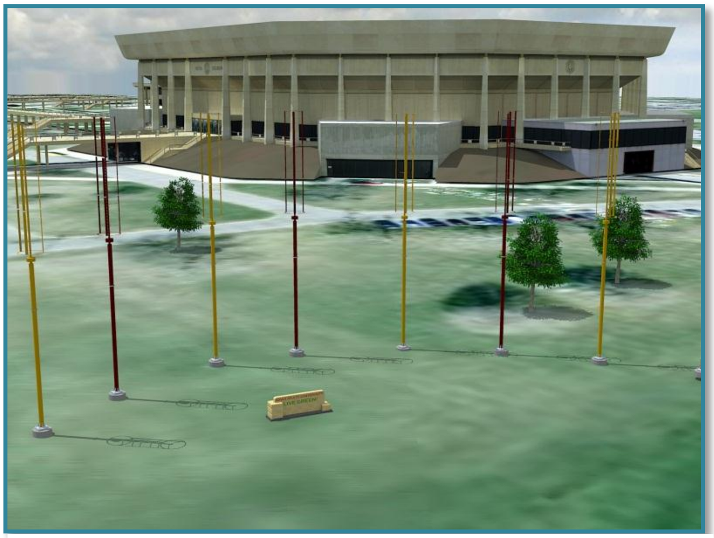

Figure 38. Proposed Windspire Installation

As shown in **Figure 38**, 10 Windspires will be placed in a U-shaped pattern in the grassy area to the southeast of Hilton Coliseum. A monument with NECA and Electri International plaques promoting the *Live Green!* initiative will be placed at the center of the layout, facing University Boulevard. This wind system will be visible to the public for more effective energy awareness.

In Windspire structures, extension poles are offered in the lengths of 5, 10, 15 and 20ft for increased height, raising the base of the rotor. Using the 20ft extension poles to raise the turbine into more turbulent air will help ensure maximum power generation, but the cost of the poles doesn't make this feasible.

The Windspire is a hardy unit designed to last over 20 years with very little maintenance. The units are rated for 2000 kWhrs per year, and ten Windspires will produce an average of 20,000 kWhrs per year, at 1% of Hilton Coliseum's annual energy consumption. Since the cost per kilowatt hour is $0.25, this system will save $5,000 per year in energy usage. As shown in **Table 12**, the total cost is $12,800 per unit, making the overall project $128,000. The payback period for the ten Windspires is 25.5 years. Because the design life of 20 years is less than the payback period, the quantitative value is not economically reasonable. However, marketing the *Live Green!* initiative has a much higher qualitative value than the quantitative value of the wind system. The benefit of the Windspire is in bringing a visual representation of what *Live Green!* and the Green Energy Challenge supports. The Windspire is an attractive structure that can add an artistic ambiance to any area and will be painted the school colors of cardinal and gold. Overall, the physical structure, color, and location of the Windspires all provide for excellent awareness and advertising for the *Live Green!* initiative at Iowa State.

Table 12. Windspire Cost per Unit

Unit	Cost
Windspire	$ 8,000
Concrete Foundation	$ 600
Labor/Installation	$ 3,400
Paint	$ 800
Total Cost:	$ 12,800

Iowa State University does not qualify for tax credits since it is a non-profit organization. However, in the state of Iowa there is no sales tax on the purchase of a green energy system.

SCHEMATIC ESTIMATE

In order to improve the efficiencies of Hilton's primary HVAC and lighting systems, the following changes should be made: upgrade light fixtures, installation of fan motor variable frequency drives, installation of air curtains, and replacement of windows. Along with these improvements, Windspires will be installed for green energy and awareness purposes.

The breakdown of costs for each of the three major upgrades for the project is outlined in **Table 13**. Each major upgrade is further divided, providing an even more detailed breakdown of costs, as seen in **Appendix C**. This estimate includes a 10 percent contractor markup, which is an accurate estimate for this project. The total cost of the project is $4,888,591, most of which is from the window replacements.

Table 13. Schematic Estimate Overview

	Total Material Cost ($)	Total Labor Cost ($)	Total Contract Cost (With O&P)
Lighting	$454,130	$210,540	$731,137
Energy Use	$3,494,644	$156,860	$4,016,654
PV and Wind	$94,000	$34,000	$140,800
		Total Contract	$4,888,591

This estimate includes all of the upgrades and retrofits that are the most feasible and useful to Iowa State University and Hilton Coliseum. The wind cube and new air handling units are among the proposed ideas that were excluded.

Lighting

In the lower level of the lighting renovation, the installation of the occupancy sensors is the bulk of the new work. The material cost for the sensors includes the sensors themselves as well as any wiring required to install them. The new fluorescent lights do not require any additional work but rather, new lamps in the existing fixtures, which will be the only material cost. There are 180 new LED fixtures that will be installed in the lower level. There is work required on the existing fixtures in order to retrofit the LED lamps to them. The material cost for the LED lights include the LED lights and the retrofitting kits as well as any wiring required to install the kits. The material cost for all parts of the lower level include the cost of the electrician and any lifts or small equipment needed.

The concession stand renovations simply require old lamps to be replaced with new. The material cost includes the new lamps and the labor cost of an electrician.

In the seating area, LED lights will replace all of the existing lamps, which require new fixtures. The material cost for the seating area includes the LED lights and fixtures. The labor cost is again only for the electrician to do the installation.

The work done on the main floor is the most expensive part of the lighting renovation and also the most time consuming. The estimates for the material and labor cost for the new metal halides were provided to us from Musco Lighting.

The exterior lighting renovation consists of replacement LED lights. These LEDs, like the other LEDs, require retrofit kits. The material cost includes the LED lights and the retrofit kits required to use the LEDs. The labor cost includes work of the electricians and the equipment they require to install the new exterior lights.

Energy Use

The windows in the Energy Use section are the most expensive part of the project due to material price and labor. The estimate for the material cost was calculated by adding the base cost of triple pane windows with an argon fill. The windows are also the most time consuming and so the installation of the windows has the second highest labor cost out of any other item.

Another cost factor in Energy Use is the air curtains. The material cost for the air curtains includes the fans and the wiring they require. The labor cost is simply the cost of hiring electricians to install the air curtains.

The VFDs are another rather expensive item in this project. The material cost includes the Variable Frequency Drive as well as the sensors in the duct that feed it information. There are 16 air handling units and we need a VFD for each air handling unit. The labor cost includes the cost to install the VFD next to the fan with the sensors.

PV and Wind

The only item from the PV and Wind section that we are proposing is the installation of Windspires. In the estimate, the material cost for this item includes the Windspire itself, paint, and pre-cast concrete for its base. The labor cost includes the machines and labor needed to excavate the base, pour the base, and install the Windspire.

Schematic Schedule

Hilton Coliseum is the home to Iowa State's basketball, gymnastics, volleyball, and wrestling teams. The building is also used to host concerts, career fairs, and several other large events. This makes construction during the summer ideal due to low building use. Construction will commence on May 7, the first week after spring classes end. Construction will be complete by July 23 and will not interfere with the start of the fall sports seasons. **Figure 39** below was generated through the use of SureTrak and displays the proposed schedule for the project.

Act ID	Description	Orig Dur	Early Start	Early Finish	Successors
1000	Start Milestone	0	07MAY12		1010, 1030, 1040, 1050, 1060
1030	Install Air Curtains	2d4h	07MAY12	09MAY12	1120
1040	Install VFDs	5d	07MAY12	11MAY12	1120
1050	Install Wind Spires	6d	07MAY12	14MAY12	1120
1010	Remove Existing Windows	15d	07MAY12	25MAY12	1020
1060	Replace Main Floor Lights	17d	07MAY12	29MAY12	1070
1020	Install New Windows	40d	28MAY12	23JUL12	1120
1070	Replace Seating Area Lights	5d	30MAY12	05JUN12	1080
1080	Replace Consession Stand Lights	1d	06JUN12	06JUN12	1090
1090	Replace Lower Level Lights	4d	07JUN12	12JUN12	1100
1100	Install Exterior Lights	5d	13JUN12	19JUN12	1110
1110	Install Occupancy Sensors	3d	20JUN12	22JUN12	1120
1120	Finish Milestone	0		23JUL12	

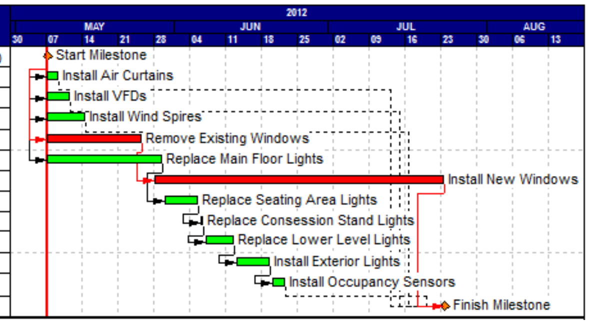

Figure 39. Construction Schedule

One of the biggest improvements that Hilton will be receiving is new triple pane windows. As illustrated in the schedule, this part of the renovation is the most time consuming and will last the duration of the project. Installation of the air curtain, Windspires, and VFDs are independent of the other aspects of the project. These three parts of the renovation will be finished approximately two weeks into the project.

The lighting replacements and retrofits will last half of the summer but will be complete well before project closeout. Most of the work to be done on the lights is simple replacement of lamps and is time consuming due to the sheer volume of work required. The occupancy sensors and LED retrofits are the only parts of the lighting portion that will require labor other than replacing lamps.

Installation of the variable frequency drives will take approximately 1 week to complete. This process will not take a significant amount of time due to the small number of air units (16) to be installed. The only other time associated with this installation is the calibration, which will need to occur after the VFDs have been placed on the units.

Before the new triple pane windows can be installed to the building envelope, the existing windows must be replaced. Window removal will take approximately 3 weeks and installation 8. The replacement of the windows occurs along the critical path, which therefore governs the project completion date.

FINANCING PLAN

Iowa State is a nonprofit organization and as a university, is tax exempt at the federal and local level. Therefore, it is not eligible for many of the various tax incentives that are generally lucrative for owners' use in funding their sustainable projects. What Iowa State does have the ability to take advantage of in being a nonprofit educational school is three low to no interest loan programs.

LIVE GREEN! 0% INTEREST LOAN

The first is a loan program funded by Iowa State's sustainability *Live Green!* Initiative. This is a $1 million dollar revolving door loan program set up so that different departments on campus, which are independently run and funded with the overshadowing of the university, can use this 0% interest loan program to fund "green" projects of their own. The principle is that everything funded for by this program must have tangible savings so that the payback is achieved through the savings and not from the budget. The full $1 million dollars will be obtainable for this project, pending approval from the loan advisory council and president of the university. The main restriction is that anything funded must have a payback within 5 years in order to pay off the loan.

ALTERNATE ENERGY REVOLVING LOAN PROGRAM

For any funds that are not met with the initial *Live Green!* Loan or for any items that need to be financed outside of the 5 year payback period, there are two other potential loan programs. The first is the Alternate Energy Revolving Loan Program (AERLP). This is a loan program administered by the Iowa Energy Center and funded by Iowa's investor owned utilities, and is meant to provide funds to organizations that plan to build renewable production facilities in Iowa. The utilities in Hilton are non-regulated as they come from the campus power plant. The maximum loan that is available is $500,000 dollars with 50% being 0% interest and 50% at a lender market rate. The loan has a maximum term of 20 years and as it is for renewable energy production facilities only it could be used to fund the PV/Wind systems that will be implemented.

IOWA ENERGY BANK LOAN

The last loan program that could be used to fund the project, particularly for our non-energy production retrofits with payback periods of over 5 years, there is a Low Cost Financing loan fund available for public facilities. This fund is state-sponsored by the department of administrative services and is $12.5 million state revolving fund with no exact individual loan maximum. The loan's terms are that it has 1% interest, a 2% closing costs rate, and a 0.25% annual outstanding balance servicing cost. Beyond that, it can be used for capital necessary for cost-effective energy projects that will save money, improve building, or enhance local economies and must be paid back within fifteen years. All of the expenses in the Cyclone Energy retrofit should fit the criteria for this loan.

With these three loan programs available, the capital needed to do all of the proposed renovations will be covered. The loans will primarily be paid back by the energy savings but also any additional year end excess budgeting by the athletic department, which will be put towards paying off the revolving loans.

Table 14. Payback Analysis

System	Total Initial Cost	Yearly KWH Savings	Yearly Savings	Payback Period (Years)	Loan to Finance
Windspires	$ 140,800	20,000	$ 5,000	29	AERLP
Windows	$ 3,944,292	681,172	$ 170,293	24	Iowa Energy Bank Loan
Air Curtains	$ 10,010	151,772	$ 37,943	1	Live Green
VFD	$ 47,260	354,605	$ 88,651	1	Live Green
Lighting	$ 731,137	519,648	$ 129,912	6	Live Green
Overall	$ 4,873,499	1,727,197	$ 431,799	12	

Since Iowa State University owns its own power plant, which provides all of its electricity, a Power Purchase agreement is not an option. Further, after contacting the Windspire dealer, we have determined that leasing is not an option. However, there are other loan programs that will cover the cost.

LEED-EB SUMMARY

We identified twenty-one (Yes) points were attainable in the LEED-EB Rating System for our proposed retrofits and renovations. **Figure 40** provides a summary of the points achievable by category. This summary includes thirteen points under Energy and Atmosphere, three points in Materials and Resources, three points in Indoor Environmental Quality, and two points in Innovation in Operations.

In order to fully analyze this building, we researched current practices performed at Iowa State University. We identified sixty-six (Yes) points, with an additional 10 possible (Maybe) points achievable through our proposed retrofits and current practices performed by Iowa State University. **Figure 41** illustrates the breakdown of these points by category.

We have provided LEED-EB checklists in this section to highlight specific credits and points attainable. Additionally, a credit-by-credit narrative is provided in the **Appendix D**.

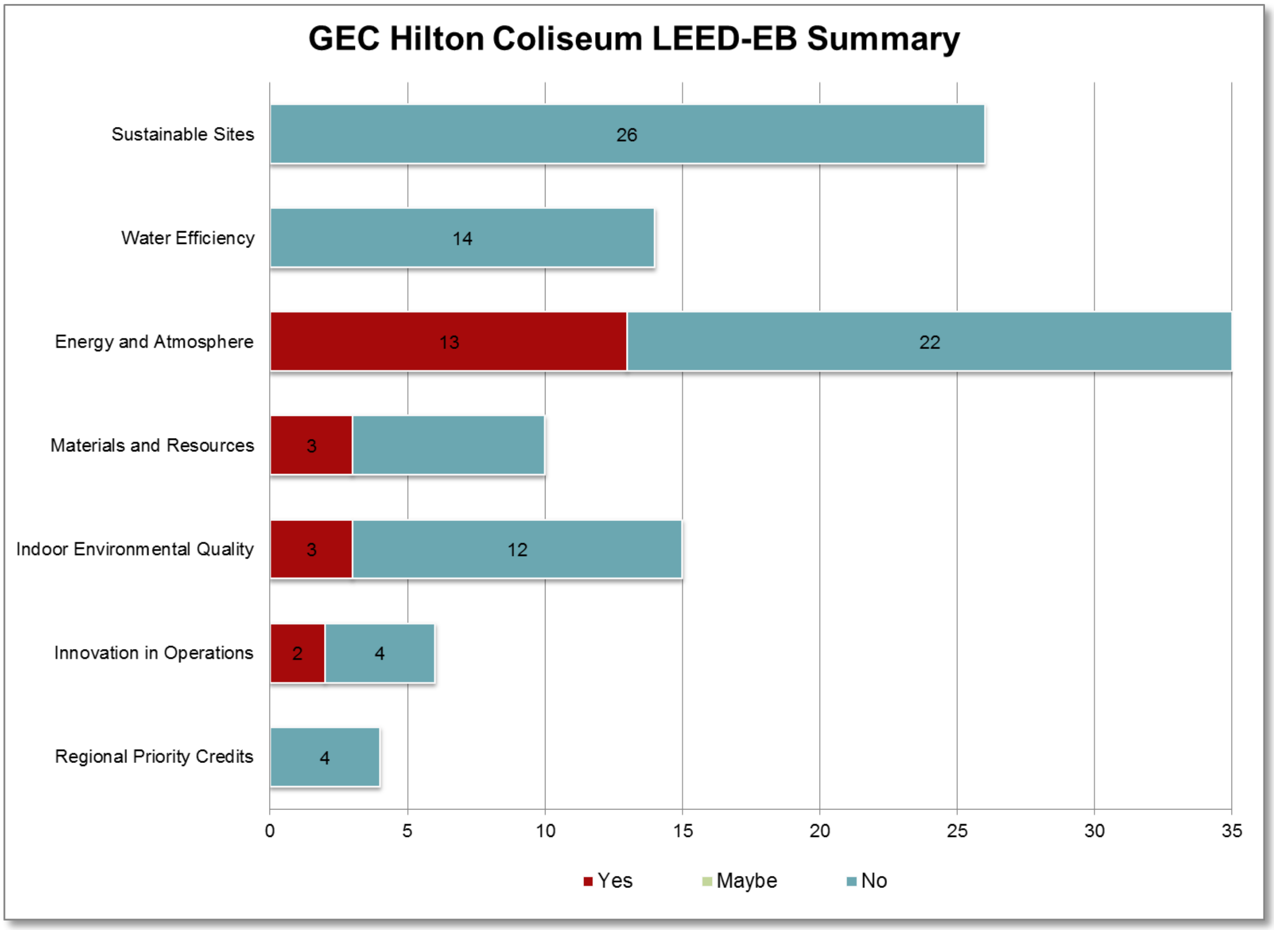

Figure 40. LEED EB-Summary, Green Energy Challenge Scope

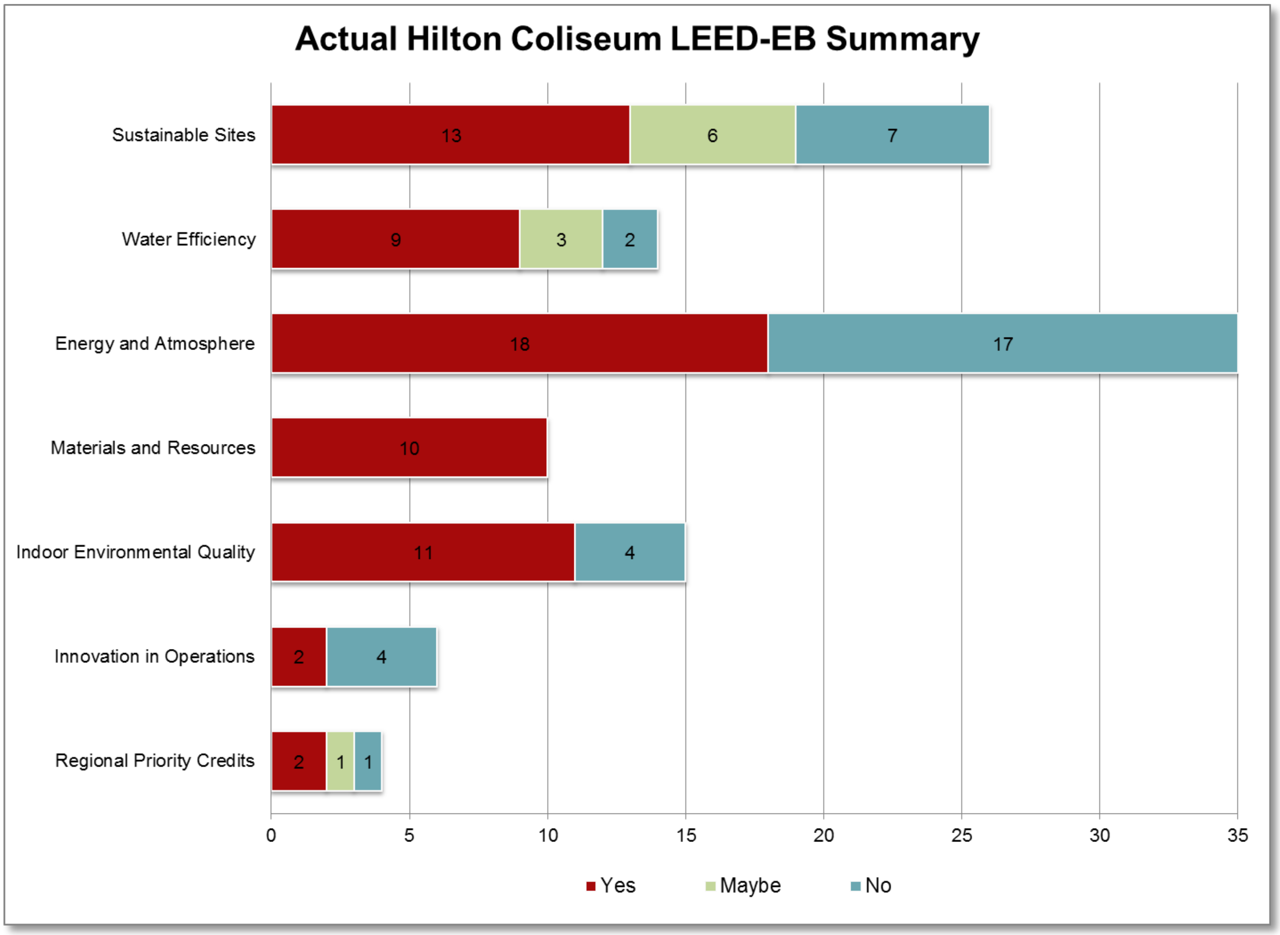

Figure 41. LEED-EB Summary, GEC and Current Practices

SUMMARY OF CATEGORIES

Sustainable Sites

Iowa State is already implementing many environmentally friendly practices. These practices include using environmentally friendly pesticides and cleaning products. The CyRide bus system on campus is very popular. Not only does use of CyRide cut down on emissions by eliminating the use of single passenger vehicles, but Iowa State has also recently started to purchase buses that are 25% more efficient. Iowa State is currently experimenting with LED lighting for street lights. Since LED lights give a very direct light, light pollution will be cut down significantly since the lights will be hung high and pointed down. Overall, Iowa State has a number of policies that make earning these credits very easy.

Water Efficiency

Iowa State does not irrigate its grounds, which minimizes potable water consumption. Also, the university meters the utility usage of each building. Hilton Coliseum was recently renovated in which most of the plumbing fixtures were replaced with automatic fixtures. Iowa State currently uses LEED's best management practices (BMPs) concerning cooling towers. However, Iowa State does not measure its potable water usage for cooling towers.

Energy and Atmosphere

Hilton Coliseum, as part of the Iowa State campus, receives its power from the on-campus cogeneration plant. With this plant currently operating at a high efficiency compared to other coal burning plants, Iowa State keeps this same standard true for its buildings on campus. Therefore, in addition to keeping the number of pollutants released to a minimum, a nearby wind-farm produces wind energy to help power the campus. Also, with a building automation system already in place across campus, minimizing the amount of energy used helps improves the efficiency across campus. This, along with the energy use analysis provided in this report, will help develop an ongoing commissioning plan for the building which can in the future serve as a basis to replace major equipment.

Material and Resources

Iowa State's current green initiative program stipulates both the purchasing and waste removal programs located on campus. Therefore, the University's current practices already exceed the requirements laid out by the credits in the materials and resources section of LEED-EB making all of these credits easily obtainable.

Indoor Air Quality

For LEED Indoor Air Quality the project could achieve 4 out of the fifteen points possible. Plans for the project include installing indoor lighting control systems. The new air handlers will also have adequate air filters to reduce the number particulates in the system. During construction the building could also meet construction environment air quality standards to earn a credit.

Innovation in Operations

For LEED Innovation in Operations the project could earn 2 out of the 6 points possible. The project could easily achieve credits for having LEED accredited professionals on the project team as multiple employees of ISU are LEED certified. It is also possible to earn credit for documenting building performance over the next five years and possibly for documenting building improvement in operation as well.

Regional Priority Credits

For Regional Priority Credits in the 50011 zip code, it is possible to achieve the credits for sustainable purchasing and solid waste management. These credits could not be earned under the scope of the Green Energy Challenge, but have been documented in the additional checklist.

LEED-EB CHECKLISTS

The LEED-EB Checklists are provided to highlight the specific credits we identified during the Green Energy Challenge. **Figure 42** is the project checklist showing the twenty-one credits identified by our team as achievable with the proposed Green Energy Challenge retrofits and renovations.

LEED 2009 for Existing Buildings: Operations & Maintenance
Project Checklist

GEC Hilton Coliseum
April 15th, 2012

Y	?	N			Points
		26		**Sustainable Sites**	Possible Points: 26
		4	Credit 1	LEED Certified Design and Construction	4
		1	Credit 2	Building Exterior and Hardscape Management Plan	1
		1	Credit 3	Integrated Pest Mgmt, Erosion Control, and Landscape Mgmt Plan	1
		15	Credit 4	Alternative Commuting Transportation	3 to 15
		1	Credit 5	Site Development—Protect or Restore Open Habitat	1
		1	Credit 6	Stormwater Quantity Control	1
		1	Credit 7.1	Heat Island Reduction—Non-Roof	1
		1	Credit 7.2	Heat Island Reduction—Roof	1
		1	Credit 8	Light Pollution Reduction	1
		14		**Water Efficiency**	Possible Points: 14
Y			Prereq 1	Minimum Indoor Plumbing Fixture and Fitting Efficiency	
		2	Credit 1	Water Performance Measurement	1 to 2
		5	Credit 2	Additional Indoor Plumbing Fixture and Fitting Efficiency	1 to 5
		5	Credit 3	Water Efficient Landscaping	1 to 5
		2	Credit 4	Cooling Tower Water Management	1 to 2
13		22		**Energy and Atmosphere**	Possible Points: 35
Y			Prereq 1	Energy Efficiency Best Management Practices	
Y			Prereq 2	Minimum Energy Efficiency Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
4		14	Credit 1	Optimize Energy Efficiency Performance	1 to 18
2			Credit 2.1	Existing Building Commissioning—Investigation and Analysis	2
		2	Credit 2.2	Existing Building Commissioning—Implementation	2
		2	Credit 2.3	Existing Building Commissioning—Ongoing Commissioning	2
		1	Credit 3.1	Performance Measurement—Building Automation System	1
		2	Credit 3.2	Performance Measurement—System-Level Metering	1 to 2
6			Credit 4	On-site and Off-site Renewable Energy	1 to 6
		1	Credit 5	Enhanced Refrigerant Management	1
1			Credit 6	Emissions Reduction Reporting	1
3		7		**Materials and Resources**	Possible Points: 10
Y			Prereq 1	Sustainable Purchasing Policy	
Y			Prereq 2	Solid Waste Management Policy	
		1	Credit 1	Sustainable Purchasing—Ongoing Consumables	1
1			Credit 2.1	Sustainable Purchasing—Electric-Powered Equipment	1
		1	Credit 2.2	Sustainable Purchasing—Furniture	1
1			Credit 3	Sustainable Purchasing—Facility Alterations and Additions	1
1			Credit 4	Sustainable Purchasing—Reduced Mercury in Lamps	1
		1	Credit 5	Sustainable Purchasing—Food	1
				Materials and Resources, Continued	
		1	Credit 6	Solid Waste Management—Waste Stream Audit	1
		1	Credit 7	Solid Waste Management—Ongoing Consumables	1
		1	Credit 8	Solid Waste Management—Durable Goods	1
		1	Credit 9	Solid Waste Management—Facility Alterations and Additions	1
3		12		**Indoor Environmental Quality**	Possible Points: 15
Y			Prereq 1	Minimum IAQ Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
Y			Prereq 3	Green Cleaning Policy	
1			Credit 1.1	IAQ Best Mgmt Practices—IAQ Management Program	1
		1	Credit 1.2	IAQ Best Mgmt Practices—Outdoor Air	1
		1	Credit 1.3	IAQ Best Mgmt Practices—Increased Ventilation	1
1			Credit 1.4	IAQ Best Mgmt Practices—Reduce Particulates in Air Distribution	1
1			Credit 1.5	IAQ Mgmt Plan—IAQ Mgmt for Facility Alterations and Additions	1
		1	Credit 2.1	Occupant Comfort—Occupant Survey	1
		1	Credit 2.2	Controllability of Systems—Lighting	1
		1	Credit 2.3	Occupant Comfort—Thermal Comfort Monitoring	1
		1	Credit 2.4	Daylight and Views	1
		1	Credit 3.1	Green Cleaning—High Performance Cleaning Program	1
		1	Credit 3.2	Green Cleaning—Custodial Effectiveness Assessment	1
		1	Credit 3.3	Green Cleaning—Sustainable Cleaning Products, Materials Purchases	1
		1	Credit 3.4	Green Cleaning—Sustainable Cleaning Equipment	1
		1	Credit 3.5	Green Cleaning—Indoor Chemical and Pollutant Source Control	1
		1	Credit 3.6	Green Cleaning—Indoor Integrated Pest Management	1
2		4		**Innovation in Operations**	Possible Points: 6
		1	Credit 1.1	Innovation in Operations: Specific Title	1
		1	Credit 1.2	Innovation in Operations: Specific Title	1
		1	Credit 1.3	Innovation in Operations: Specific Title	1
		1	Credit 1.4	Innovation in Operations: Specific Title	1
1			Credit 2	LEED Accredited Professional	1
1			Credit 3	Documenting Sustainable Building Cost Impacts	1
		4		**Regional Priority Credits**	Possible Points: 4
		1	Credit 1.1	Regional Priority: WE Credit 2	1
		1	Credit 1.2	Regional Priority: SS Credit 4	1
		1	Credit 1.3	Regional Priority: SS Credit 6	1
		1	Credit 1.4	Regional Priority: SS Credit 7.2	1
21		89		**Total**	Possible Points: 110

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

Figure 42. LEED-EB Checklist for GEC

As discussed earlier, because of Iowa State's commitment to sustainability, we determined a full analysis for LEED-EB was warranted. **Figure 43** highlights the sixty-six (Yes) points and 10 (Maybe) points identified by our team if our project was combined with the current green practices ongoing at Hilton Coliseum.

LEED 2009 for Existing Buildings: Operations & Maintenance

Project Checklist

Actual Hilton Coliseum

April 15th, 2012

Y	?	N	Credit	Description	Possible Points
14	6	6		**Sustainable Sites**	Possible Points: 26
		4	Credit 1	LEED Certified Design and Construction	4
1			Credit 2	Building Exterior and Hardscape Management Plan	1
1			Credit 3	Integrated Pest Mgmt, Erosion Control, and Landscape Mgmt Plan	1
10	5		Credit 4	Alternative Commuting Transportation	3 to 15
1			Credit 5	Site Development—Protect or Restore Open Habitat	1
		1	Credit 6	Stormwater Quantity Control	1
		1	Credit 7.1	Heat Island Reduction—Non-Roof	1
1			Credit 7.2	Heat Island Reduction—Roof	1
	1		Credit 8	Light Pollution Reduction	1
9	3	2		**Water Efficiency**	Possible Points: 14
Y			Prereq 1	Minimum Indoor Plumbing Fixture and Fitting Efficiency	
1		1	Credit 1	Water Performance Measurement	1 to 2
4	1		Credit 2	Additional Indoor Plumbing Fixture and Fitting Efficiency	1 to 5
4	1		Credit 3	Water Efficient Landscaping	1 to 5
	1	1	Credit 4	Cooling Tower Water Management	1 to 2
18		17		**Energy and Atmosphere**	Possible Points: 35
Y			Prereq 1	Energy Efficiency Best Management Practices	
Y			Prereq 2	Minimum Energy Efficiency Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
4		14	Credit 1	Optimize Energy Efficiency Performance	1 to 18
2			Credit 2.1	Existing Building Commissioning—Investigation and Analysis	2
2			Credit 2.2	Existing Building Commissioning—Implementation	2
2			Credit 2.3	Existing Building Commissioning—Ongoing Commissioning	2
1			Credit 3.1	Performance Measurement—Building Automation System	1
		2	Credit 3.2	Performance Measurement—System-Level Metering	1 to 2
6			Credit 4	On-site and Off-site Renewable Energy	1 to 6
		1	Credit 5	Enhanced Refrigerant Management	1
1			Credit 6	Emissions Reduction Reporting	1
10				**Materials and Resources**	Possible Points: 10
Y			Prereq 1	Sustainable Purchasing Policy	
Y			Prereq 2	Solid Waste Management Policy	
1			Credit 1	Sustainable Purchasing—Ongoing Consumables	1
1			Credit 2.1	Sustainable Purchasing—Electric-Powered Equipment	1
1			Credit 2.2	Sustainable Purchasing—Furniture	1
1			Credit 3	Sustainable Purchasing—Facility Alterations and Additions	1
1			Credit 4	Sustainable Purchasing—Reduced Mercury in Lamps	1
1			Credit 5	Sustainable Purchasing—Food	1
				Materials and Resources, Continued	
1			Credit 6	Solid Waste Management—Waste Stream Audit	1
1			Credit 7	Solid Waste Management—Ongoing Consumables	1
1			Credit 8	Solid Waste Management—Durable Goods	1
1			Credit 9	Solid Waste Management—Facility Alterations and Additions	1
11		4		**Indoor Environmental Quality**	Possible Points: 15
Y			Prereq 1	Minimum IAQ Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
Y			Prereq 3	Green Cleaning Policy	
1			Credit 1.1	IAQ Best Mgmt Practices—IAQ Management Program	1
1			Credit 1.2	IAQ Best Mgmt Practices—Outdoor Air	1
		1	Credit 1.3	IAQ Best Mgmt Practices—Increased Ventilation	1
1			Credit 1.4	IAQ Best Mgmt Practices—Reduce Particulates in Air Distribution	1
1			Credit 1.5	IAQ Mgmt Plan—IAQ Mgmt for Facility Alterations and Additions	1
1			Credit 2.1	Occupant Comfort—Occupant Survey	1
		1	Credit 2.2	Controllability of Systems—Lighting	1
1			Credit 2.3	Occupant Comfort—Thermal Comfort Monitoring	1
		1	Credit 2.4	Daylight and Views	1
1			Credit 3.1	Green Cleaning—High Performance Cleaning Program	1
1			Credit 3.2	Green Cleaning—Custodial Effectiveness Assessment	1
1			Credit 3.3	Green Cleaning—Sustainable Cleaning Products, Materials Purchases	1
1			Credit 3.4	Green Cleaning—Sustainable Cleaning Equipment	1
		1	Credit 3.5	Green Cleaning—Indoor Chemical and Pollutant Source Control	1
1			Credit 3.6	Green Cleaning—Indoor Integrated Pest Management	1
2		4		**Innovation in Operations**	Possible Points: 6
		1	Credit 1.1	Innovation in Operations: Specific Title	1
		1	Credit 1.2	Innovation in Operations: Specific Title	1
		1	Credit 1.3	Innovation in Operations: Specific Title	1
		1	Credit 1.4	Innovation in Operations: Specific Title	1
1			Credit 2	LEED Accredited Professional	1
1			Credit 3	Documenting Sustainable Building Cost Impacts	1
2	1	1		**Regional Priority Credits**	Possible Points: 4
1			Credit 1.1	Regional Priority: MR Credit 5	1
1			Credit 1.2	Regional Priority: MR Credit 7	1
	1		Credit 1.3	Regional Priority: SS Credit 4	1
		1	Credit 1.4	Regional Priority: SS Credit 6	1
66	10	34		**Total**	Possible Points: 110

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

Figure 43. LEED-EB Checklist for GEC and Actual

As discussed earlier, because of Iowa State's commitment to sustainability, we determined a full analysis for LEED-EB was warranted. **Figure 43** highlights the sixty-five (Yes) points and 10 (Maybe) points identified by our team if our project was combined with the current green practices ongoing at Hilton Coliseum.

We have provided a credit-by-credit narrative in the **Appendix D** to further expound these credits and how we intend to achieve them.

CAMPUS ENERGY AWARENESS

We will create and implement a three-part plan tailored to Iowa State University and our client's interests in order to increase student awareness of energy usage on campus. We will be partnering with existing green organizations on campus such as the *Live Green!* Initiative, to promote the improvements to Hilton and reach out to the Cyclone community with information regarding energy efficiency on campus. We have held conference with Merry Rankin, Director of Sustainability at Iowa State University and Kerry Dixon-Fox, Coordinator of Sustainable Design and Constructions at ISU for feedback on the Campus Energy Awareness plan.

The first part of the plan involves establishing a social media campaign centered on the work being done to Hilton Coliseum. Using a team Facebook page, we will provide regular updates on the project progress, facts and statistics about Iowa State University's energy usage and the projected efficiency of the new Hilton, and quotes from coaches, players, and fans in regards to the improvements to Hilton and support of energy awareness on campus. We will interact with the social media pages for *Live Green!*, Cystainability, the Green Umbrella, and other student organizations' pages to strengthen relationships and increase an audience base.

The second is to promote the increased energy efficiency that will result from the planned renovations to Hilton through traditional methods. We will utilize the scrolling marquee on the interior advertising the improvements: "The home of Cyclone sports is getting greener." When work is completed on Hilton, a larger interactive display will be placed in the building for visitors to learn more. Outside of Hilton we will install a monument, as seen in **Figure 44**, in the area with Windspires to draw more attention to the project. This will reach a wide audience and spark interest in the project and energy awareness in other areas of campus.

Finally, we will work with Cyclone Alley to create an event at a men's basketball game held in Hilton where student members of the Alley will wear green shirts, turning that section of the coliseum "green," to increase awareness through a very visual and public event. This will be co-sponsored by Cyclone Alley and ISU *Live Green!*.

Figure 44. Monument

FEEDBACK LETTER FROM CLIENT

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Facilities Planning and Management
Sustainable Design and Construction
General Services Building
Ames, IA 50011-4021
Phone: (515) 294-8028
Fax: (515) 294-2764
E-mail: kdixon@iastate.edu

Interoffice Communication

DATE: April 11, 2012

TO: Iowa State University NECA Team
Civil, Construction and Environmental Engineering
394 Town Engineering

FROM: Kerry Dixon-Fox
Coordinator of Sustainable Design and Construction

RE: Hilton Coliseum – Green Energy Challenge

On behalf of Iowa State University and the team of faculty and staff working with you on the NECA submission regarding Hilton Coliseum, I would like to thank you for all your work. The existing building study, including energy audits and LEED-EBOM readiness, as well as your proposals for improvements to the building demonstrates a genuine understanding of the overall building operation. The proposal is a thorough assessment of the building and the projects recommended consider the impact that this facility has on the campus and to the Ames community at large.

The lighting retrofit, HVAC improvements, and the installation of photovoltaic and wind energy systems are practical for the needs of Hilton, and fit into your established financing and scheduling goals. The fact that you have taken into account the campus and athletic communities and work to educate fans and visitors to Hilton's potential upgrades for efficiencies demonstrates your dedication to Iowa State's goal to Live Green!

We look forward to supporting your team in the Green Energy Challenge and working further on these potential upgrades to Hilton Coliseum.

Best Regard

Kerry Anne Dixon-Fox

Kerry Anne Dixon-Fox

ARTICLE FOR DEPARTMENT NEWSLETTER

Student members of the ISU chapter of the National Electrical Contractors Association, team Cyclone Energy, have selected Hilton Coliseum as their client in the 2012 Green Energy Challenge. Home to men's and women's basketball, volleyball, gymnastics, and wrestling teams, Hilton is a major center for Cyclone sports. The building is also used to host concerts, career fairs, and other large events, furthering the relationship between the community, fans, and the university.

Hilton Coliseum has undergone many renovations and improvements since its addition to Iowa State University's campus in 1971. Most recently, the building saw renovations after water damage from severe flooding in the summer of 2010. The ISU Green Energy Challenge team will be evaluating the current energy efficiency of the Coliseum and creating a proposal to improve the efficiency in several areas of the building, including lighting, energy use, and PV/wind energy system design.

Team members include: Justin Wenger (Construction Engineering), Eric Ryan (Construction Engineering), Alex Weiss (Electrical Engineering), Bryan Whitson (Civil Engineering), Paul Speed (Civil Engineering), and Megan Vollstedt (English), Nyudu Bagnabana (Electrical Engineering), William Hennings (Civil Engineering), Erik Johnson (Construction Engineering), Andy Rondon (Construction Engineering), Brandon Schwinghammer (Construction Engineering), Caitlin Weber (Civil Engineering). Cyclone Energy is coached by Beth Hartmann, PE, LEED AP. Hartmann is a registered professional civil engineer and a Construction Engineering and Civil Engineering Lecturer.

Sponsors for the ISU Green Energy Challenge team are: NECA of Iowa, Metro Electric, Baker Electric Inc., and Nelson Electric Co.

The team's final submission, due by April 15, in the Challenge will be scored on the technical content, project management, experience and outreach, and professionalism in executing the project. Three finalist teams will receive up to $2000 in travel and accommodation support to the NECA Convention, a plaque, and a check for the university program. Finalists receive complimentary registration to the September convention in Las Vegas, where team presentations are made and final standings awarded.

Local NECA Chapter Interaction

Robert Dandurand *Project Manager* Metro Electric Sioux City, Iowa	
Chad Layland *Project Manager* Baker Electric Des Moines, Iowa	
TJ Meiners *Project Manager* Nelson Electric Cedar Rapids, Iowa	
Jonathan Perrone *Assistant Director* Iowa NECA Des Moines, Iowa	

Cyclone Energy thanks the following additional team members for their work:

- **Nyudu Bagnabana**: (Junior, Electrical Engineering), Lighting Analysis
- **William Hennings**: (Senior, Civil Engineering), PV/Wind Energy System Design, Outreach
- **Erik Johnson**: (Senior, Construction Engineering), Energy Use Analysis
- **Andy Rondon**: (Junior, Construction Engineering), LEED Existing Buildings Review, Schematic Estimate and Schedule
- **Brandon Schwinghammer**: (Junior, Construction Engineering), Site Assessment, Financing Plan
- **Caitlin Weber**: (Senior, Civil Engineering), Project Manager

The team is grateful for the valuable input provided by the following contributors:

- **Jenny Baker, PE, LEED AP**: Lecturer, Civil, Construction & Environmental Engineering Department, Iowa State University
- **Kerry Dixon-Fox, LEEP AP**: Coordinator of Sustainable Design and Constructions, Facilities Planning and Management, Iowa State University
- **Tim Drost**: Musco Sports Ligthing (Rep)
- **Dave Fritz**: Innovative Lighting
- **Randy Larabee, PE**: Electrical Engineer, Facilities Planning and Management, Iowa State University
- **Matt McLeod**: Athletic Department, Iowa State University
- **Jason Odefey**: Mayfield Lighting (Rep for Beta LED)
- **Brad Perkins, PE, LEED AP**: Lecturer, Civil, Construction & Environmental Engineering Department, Iowa State University
- **Merry Rankin**: Director of Sustainability, Iowa State University
- **Jon Schrobilgen**: (Senior, Construction Engineering), President, ISU NECA Student Chapter
- **Kossi Sessou**: (Senior, Electrical Engineering), Vice President, ISU NECA Student Chapter
- **Katherine Whisler**: (Junior, Architecture), Logo Design

Cyclone Energy

Sources

Other resources used

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- http://www.innovativelight.com/ecobrite.html
- http://www.gelighting.com/na/
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- http://www.livegreen.iastate.edu/loan/docs/objectives.pdf (*Live Green!* 0% interest loan)
- http://www.energy.iastate.edu/AERLP/index.htm (Alternate Energy Revolving loan program)
- http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IA05F&re=1&ee=1 (Iowa Energy Bank Load)

- http://das.gse.iowa.gov/energybank/index.html (Iowa Energy Bank Loan)
- http://www.dsireusa.org (Energy Loan Database)
- http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IA01F&re=1&ee=1
- Mechanical and Electrical Systems in Buildings, 4th Edition, by: Richard R. Janis & William K.Y. Tao (r-value exterior wall and SHGF)

PROPOSED LIGHTING FIXTURE CUT SHEETS

INNOVATIVE LIGHTING inc.

EcoBrite® C-SERIES

2' X 4'

CONVERSION KITS

The EcoBrite C-Series LED troffer utilizes patented Precision Optical Performance technology for efficient light distribution. The LED C-Series kit allows for a seamless conversion of the existing fluorescent lighting. Quick and easy installation using provided materials.

2'x2' LED Conversion kits also available.

Intended Use
The EcoBrite® C-Series LED troffers are designed for new construction or conversion projects.

Construction & Materials
High quality aluminum rail incorporating heat sink technology. Shatter proof optics. High impact resistant mounting clips.

Optical System
Patented Precision Optical Performance (P.O.P) technology. Several different wide and narrow light distribution options available.

Electrical System
Class 2 low voltage power supply; Input voltage 110V-277V

Installation
Quick and easy installation using the existing troffer shell and prismatic door.

Listings
UL Classified LED Conversion Kit

Warranty
The EcoBrite® lighting products come with a five year warranty for parts manufactured and furnished by Innovative Lighting, Inc. Standard terms and conditions apply.

P.O.P.® Technology

PHOTOMETRIC DATA

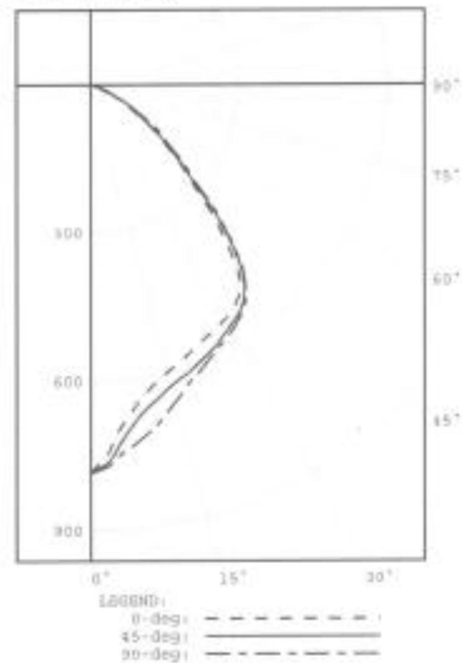
Utilization of Lumens - Zonal Cavity Method

ITL Test Number 66291

Effective Floor Cavity Reflectance 20%

CEILING CAVITY REFLECTANCE	80				50			30		
WALL REFLECTANCE	70	50	30	10	50	30	10	50	30	10
ROOM CAVITY RATIO (RCR)	Values are expressed as Lumens delivered to the task surface									
0	119	119	119	119	111	111	111	106	106	106
1	111	108	105	102	101	99	97	98	96	94
2	104	97	92	87	92	88	84	89	85	82
3	96	87	81	76	83	78	74	81	76	72
4	89	79	72	66	75	70	65	73	68	64
5	83	72	64	58	69	62	58	67	61	57
6	77	66	58	52	63	56	52	64	56	51
7	72	60	52	47	58	51	46	56	50	46
8	67	55	48	42	53	47	42	52	46	42
9	63	51	44	39	49	43	38	48	42	38
10	59	47	40	35	46	39	35	45	39	35

Polar Plot (Candela)



Zonal Lumen Summary

Zone (degrees)	Lumens	% of Lamp	% of Luminaire
0-30	515	N/A	38.8
0-40	845	N/A	63.6
0-60	1248	N/A	93.9
0-90	1329	N/A	100.0
90-180	0	N/A	00.0
0-180	1329	N/A	100.0

Average Luminance Table (cd/m²)

Horizontal Angle (degrees)

Vertical Angle (degrees)	0	45	90
0	783	783	783
45	311	334	348
55	149	153	173
65	55	63	44
75	24	13	14
85	2	3	5

Summary of Results

ITL Test 66292

Input Voltage:	11.3 Volts DC	Chromaticity (x):	0.3307
Input Current:	1.56 Amps DC	Chromaticity (y):	0.3564
Input Power:	17.6 Watts	CRI (Ra):	73
CCT:	5576 K	Duv:	0.008

THE ABOVE TESTING DATA IS FOR ONE (1) FOUR FOOT LED FIXTURE.

EcoBrite® LED C-Series Conversion Kits are available with two or three fixture combinations.

PART NUMBER INFORMATION

7	4	0	—	5	2	2	4	—	4
EcoBrite		OUTPUT		LED COLOR	RAIL COLOR	LENS TYPE	APPROX. LENGTH		PACKAGING TYPE
		0=400 mA		5=COOL WHITE	2=ALUMINUM	2=COVE 4=TRI-OPTIC 6=COVE(ORIGINAL)	2=2 FT 4=4 FT		1=BULK 4=KIT

Notes:

- Multi-circuit power supplies available
- Dimmer info available upon request
- IES files available upon request
- Standard kit includes; (2) LED luminaires, (4) mounting clips, (2) mounting spacers, (1) power supply, mounting hardware
- Replacement prismatic doors available

ESSENTIA™ INTERIOR LED

LED Architectural Downlight – Round 8" Aperture

ESA-ADR-856-C

DESCRIPTION

Downlight luminaire with 8" round aperture, designed for 56 high output LEDs maximum. Two piece optical assembly provides a broad, even light distribution, combining low brightness, with maximum visual cutoff and efficiency. Three light distributions available – narrow, medium, and wide.

FEATURES

- Luminaire uses 28, 42, or 56 high output LEDs, tolerance to be within a 2-step McAdam Ellipse. See table for specific color tolerance (at right).
- Axial and Tilted Axial TIR nano optic on each individual LED to maximize light delivered through aperture.
- Light distribution available in narrow, medium, or wide.
- Low brightness parabolic spun Alzak aluminum cone, 0.06" thick with polished radius and continuous self-flange.
- Soft satin Glow Clear finish, standard.
- Precision nickel plated cone retainers assure that the lower cone is held in position.
- Formed cone blackout baffle to minimize stray light.
- 2" aperture throat to accommodate all standard and extra-thick ceilings and provide flexibility in mounting within grid.
- Custom heatpipe to optimize cooling of LEDs.
- Provided with quick mounting brackets for optional carrying channels.
- High Efficiency constant current drivers, 120-277VAC input, 525mA drive current.
- 0-10V dimming, standard. 100%-10% full-range continuous dimming.
- Light engine, optics, and driver(s) accessible from below ceiling.
- UL/CUL listed for thru-wiring 8#12AWG-90°C and damp location.
- Thermally protected.

COMPANION LUMINAIRES

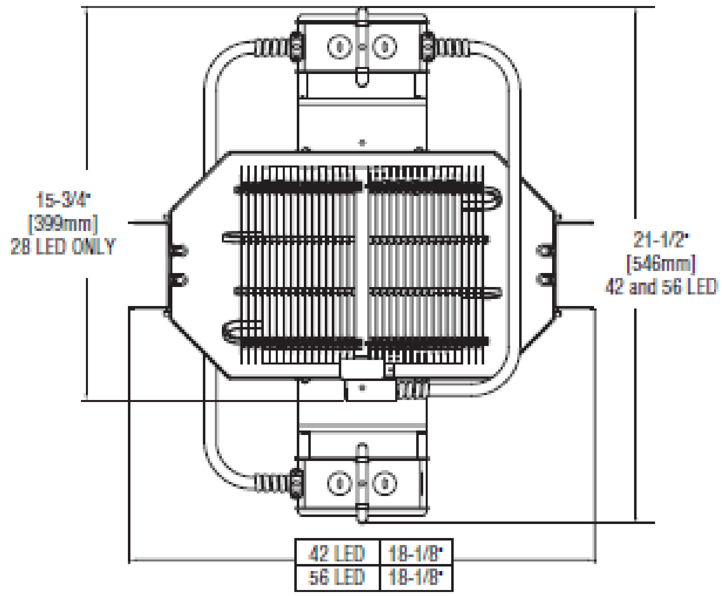
LED Adjustable Downlight

ESA-ADR-828-C-NDADJ-SGCFF

LED Lensed Wallwash

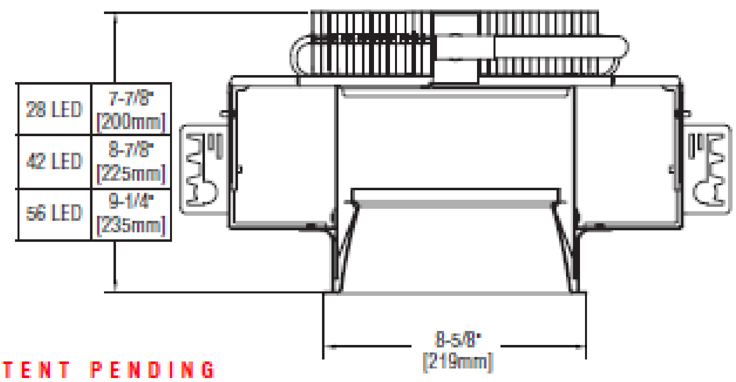
ESA-ADR-828-C-LWW-SGCFF

Notes:



Recommended Ceiling Cutout 8-1/4"

Color Tolerance	
2700K	+/- 42K
3000K	+/- 50K
3500K	+/- 63K
4250K	+/- 95K



PATENT PENDING

RECESSED LED

Family/ Series	Product	Aperture (inches)	LED Count (# of LEDs)	LED Performance Generation	Optic	Reflector/Cone Finish	Flange Finish	Voltage	Drive Current	Options
ESA	ADR	___	___	C	___	___	___	___	___	___
		8	28	C	WD Wide	SSGC Soft Satin Glow Al Clear	FF Flat Flange	120 120V	525 525mA	27K 2700K (90 Nominal CRI)
			42		MD Medium	SSGGR Soft Satin Glow Al Graphite	WF White Flange	277 277V		30K 3000K (85+ CRI)
			56		ND Narrow	SSGBR Soft Satin Glow Al Bronze	XF Custom Color Flange			35K 3500K (80+ CRI)
						SSGCG Soft Satin Glow Al Champange Gold				43K 4250K (70+ CRI)
						SSGPE Soft Satin Glow Al Pewter				DH Dimming Lutron HiLume* (525mA)
						SSGWH Soft Satin Glow Al Wheat				LM Lens Media
						SSGB Soft Satin Glow Al Black				FS Fusing
						W White Paint				SCA Slope Ceiling Adapter
										MC Mounting Channels
										WL Wet Location
										ES Flangeless
										TR Top Access

Options: Please type additional options in manually on the lines provided below.

*Consult Factory for 42 & 56

Example:

ESA	ADR	8	56	C	WD	SSGC	FF	120	525	___

RECESSED LED

ESSENTIA™ INTERIOR LED

LED Architectural Downlight – Round 8" Aperture

PHOTOMETRICS

LED COLOR MULTIPLIER

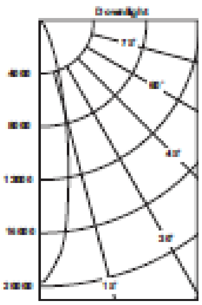
COLOR TEMPERATURE	LUMEN MULTIPLIER	COLOR TEMPERATURE	LUMEN MULTIPLIER
2700K	0.93	3500K	1.00
3000K	1.00	4250K	1.14

ESAADR856CNDSGCFF12052535K

LED Count: 56
Efficacy: 45.5 Lm/W
S/M: 0.41
Color Temperature: 3500K
Drive Current: 525mA
Delivered Lumens: 4863
Test No.: LTL20277

LUMINANCE DATA candela/meter²

VERTICAL ANGLE	AVERAGE
45°	1533
55°	886
65°	561
75°	262
85°	0



CANDELA DISTRIBUTION

DEGREES	CD
0°	19690
5°	17529
15°	7269
25°	2153
35°	518
45°	32
55°	15
65°	7
75°	2
85°	0
90°	0

CONE OF LIGHT

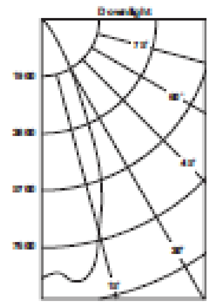
DISTANCE FROM WORKPLANE	FOOTCANDLES	BEAM DIAMETER
8'	308	3.4'
10'	197	4.2'
12'	137	5.0'
14'	100	5.8'

ESAADR856CMDSGCFF12052535K

LED Count: 56
Efficacy: 46.7 Lm/W
S/M: 0.77
Color Temperature: 3500K
Drive Current: 525mA
Delivered Lumens: 5002
Test No.: LTL20518

LUMINANCE DATA candela/meter²

VERTICAL ANGLE	AVERAGE
45°	2151
55°	1188
65°	750
75°	345
85°	364



CANDELA DISTRIBUTION

DEGREES	CD
0°	8626
5°	8570
15°	7334
25°	3437
35°	832
45°	45
55°	20
65°	9
75°	2
85°	1
90°	0

CONE OF LIGHT

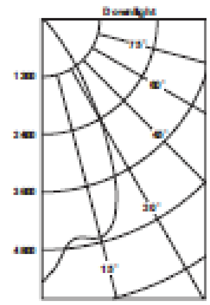
DISTANCE FROM WORKPLANE	FOOTCANDLES	BEAM DIAMETER
6'	240	4.6'
8'	135	6.0'
10'	86	7.6'
12'	60	9.0'
14'	44	10.6'

ESAADR856CWDSGCFF12052535K

LED Count: 56
Efficacy: 41.2 Lm/W
S/M: 0.92
Color Temperature: 3500K
Drive Current: 525mA
Delivered Lumens: 4413
Test No.: LTL20728

LUMINANCE DATA candela/meter²

VERTICAL ANGLE	AVERAGE
45°	5398
55°	2306
65°	1398
75°	616
85°	215



CANDELA DISTRIBUTION

DEGREES	CD
0°	5453
5°	4915
15°	4698
25°	3556
35°	1369
45°	117
55°	39
65°	17
75°	5
85°	1
90°	0

CONE OF LIGHT

DISTANCE FROM WORKPLANE	FOOTCANDLES	BEAM DIAMETER
6'	151	5.6'
8'	85	7.4'
10'	55	9.2'
12'	38	11.0'
14'	28	12.8'

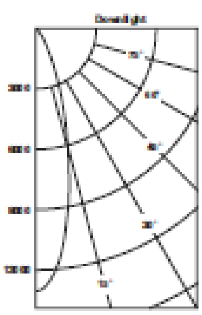
PHOTOMETRICS - LENSED

ESAADR856CNDSGCFF12052535KLM

LED Count: 56
Efficacy: 41 Lm/W
S/M: 0.48
Color Temperature: 3500K
Drive Current: 525mA
Delivered Lumens: 4384
Test No.: LTL20275

LUMINANCE DATA candela/meter²

VERTICAL ANGLE	AVERAGE
45°	6707
55°	2396
65°	944
75°	257
85°	0



CANDELA DISTRIBUTION

DEGREES	CD
0°	13033
5°	11923
15°	6212
25°	2237
35°	644
45°	140
55°	40
65°	12
75°	2
85°	0
90°	0

CONE OF LIGHT

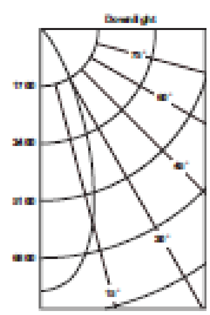
DISTANCE FROM WORKPLANE	FOOTCANDLES	BEAM DIAMETER
6'	362	2.8'
8'	204	3.8'
10'	130	4.8'
12'	91	5.8'
14'	66	8.0'

ESAADR856CMDSGCFF12052535KLM

LED Count: 56
Efficacy: 42.1 Lm/W
S/M: 0.71
Color Temperature: 3500K
Drive Current: 525mA
Delivered Lumens: 4519
Test No.: LTL20516

LUMINANCE DATA candela/meter²

VERTICAL ANGLE	AVERAGE
45°	9496
55°	2812
65°	1063
75°	358
85°	0



CANDELA DISTRIBUTION

DEGREES	CD
0°	7765
5°	7616
15°	5922
25°	2994
35°	939
45°	198
55°	48
65°	13
75°	3
85°	0
90°	0

CONE OF LIGHT

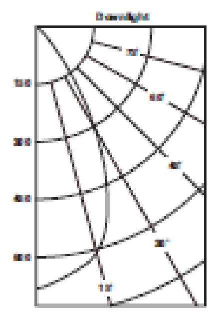
DISTANCE FROM WORKPLANE	FOOTCANDLES	BEAM DIAMETER
6'	216	4.2'
8'	121	5.6'
10'	78	7.0'
12'	54	8.4'
14'	40	9.8'

ESAADR856CWDSGCFF12052535KLM

LED Count: 56
Efficacy: 36.3 Lm/W
S/M: 0.9
Color Temperature: 3500K
Drive Current: 525mA
Delivered Lumens: 3883
Test No.: LTL20726

LUMINANCE DATA candela/meter²

VERTICAL ANGLE	AVERAGE
45°	10781
55°	3572
65°	1637
75°	805
85°	308



CANDELA DISTRIBUTION

DEGREES	CD
0°	4487
5°	4382
15°	4018
25°	2837
35°	1237
45°	366
55°	62
65°	20
75°	4
85°	0
90°	0

CONE OF LIGHT

DISTANCE FROM WORKPLANE	FOOTCANDLES	BEAM DIAMETER
6'	125	5.4'
8'	70	7.2'
10'	45	9.0'
12'	31	10.8'
14'	23	12.6'

All photometric files available for your convenience at our web site: www.betaled.com

Show•Light GREEN™

Constant Light™, Maintenance Free . . . Guaranteed!

Musco's Show-Light Green™ is an indoor lighting system with blackout capability that is affordable to own and operate. Featuring superior glare control, optional special effects, and important safety features, Show-Light Green is the benchmark for all indoor lighting systems with blackout feature.

Show-Light Green combines Musco's newest Green Generation Lighting® technologies and Constant 10™ product assurance and warranty program to give you up to 25% in life-cycle cost savings compared to previous technologies. Show-Light Green is simply the most reliable, cost-effective solution for your professional indoor lighting needs.

- **Guaranteed light** — Smart Lamp® technology provides guaranteed constant light for 12,000 hours through timed power adjustments, resulting in consistent lighting for each game and broadcast.
- **Constant 10 product assurance and warranty program** — provides 10 years of covered maintenance, including both labor and materials for spot and group lamp replacements, supported by a fully-staffed group of warranty specialists and factory-trained technicians.
- **Blackout capability** — opens or closes in two seconds and can remain closed indefinitely without heat build-up or lamp damage.
- **Lamp extinguish feature** — if shutter fails to close, lamp extinguishes within three seconds to maintain the blackout effect.
- **Advanced light control** — minimizes glare for players and spectators, and prevents excess light on scoreboard.
- **Special effects programming options** — special effects are possible with a variety of control methods via a simple dry contact closure interface.
- **Encapsulated ballast** - minimizes noise potential from ballast and extends ballast life.

Open Position

Closed Position

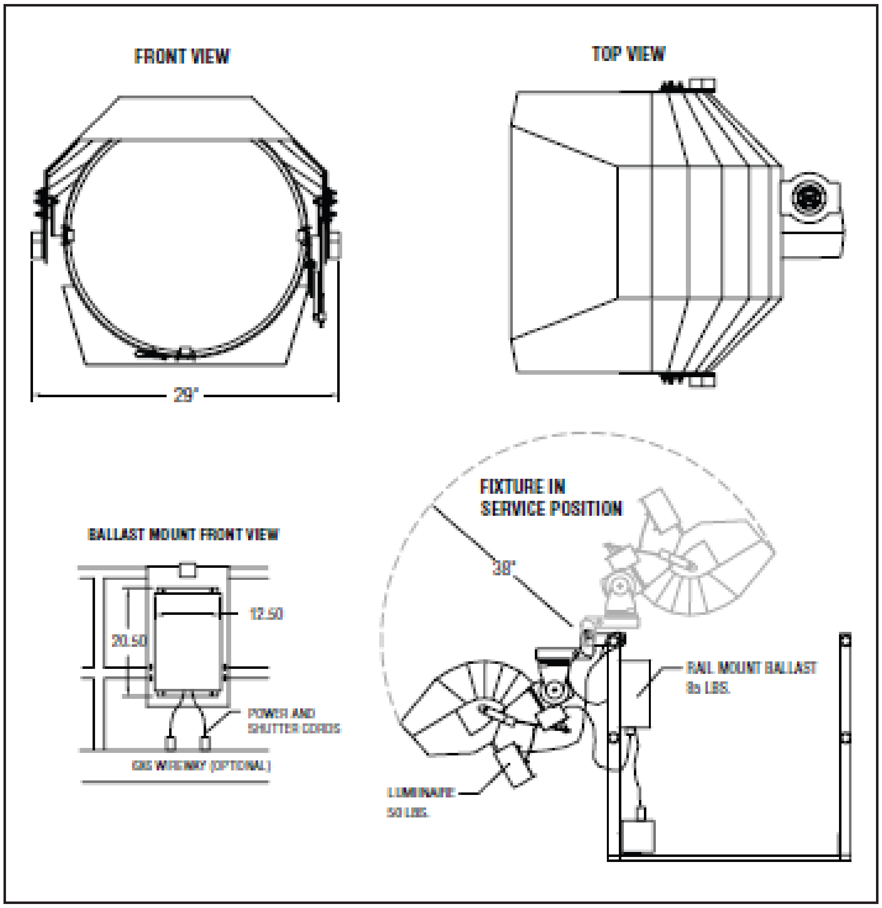
800/825-6020

www.musco.com

e-mail: lighting@musco.com

We Make It Happen.

Show•Light GREEN™



- 12 volts DC power source provided for hood operation
- UL Listed for indefinite operation in closed position while operating at 100% capacity
- Three-second lamp extinguish feature if shutter fails to close
- Pivot mounting for safe and easy maintenance from the catwalk
- Custom mounting design options to meet site specific installation requirements
- Worklight and egress lighting options available

UL LISTED No. E33316

Ballast Specifications				0.9 minimum power factor					
Single phase voltage (also applicable to each single phase of a 3 phase system)	**208** (60Hz)	**220/240** (50Hz)	**240** (60Hz)	**277** (60Hz)	**347** (60Hz)	**380** (50Hz)	**400** (50Hz)	**415** (50Hz)	**480** (60Hz)
1000 watt Metal Halide Lamp operating line amperage per fixture, maximum draw	6.5	5.9	5.8	4.9	4.0	3.6	3.4	3.2	2.9
1000 watt Metal Halide Lamp operating line amperage per fixture, starting amps	5.8	5.2	5.3	4.2	3.6	3.1	3.0	2.9	2.4

We Make It Happen.

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e-mail: lighting@musco.com

641/673-0411 • Fax: 641/672-1996 • 100 1st Avenue West/PO Box 808 • Oskaloosa, Iowa 52577

China Patent 200680008830.2. United States Patents: D587433, D574098, 5860733, 6036388, 6203176, 7176635, 7452108, 7527393, 7547118, 7675251, 7736024, 7797117, 7798680.
U.S. and foreign patents pending.

NCAA Broadcast Lighting Levels

NCAA Best Lighting Practices

Goals: 1. **Quality TV Broadcasts:** To establish best practices for lighting televised NCAA events, providing quality broadcasts within a reasonable budget. The light level expectations are applicable for both SD and HD broadcast.
2. **Value-based Lighting System:** To provide recommended best practices for lighting college level sporting events with considerations for quality lighting for player safety; reduced energy, maintenance and life-cycle costs; and environmental sensitivity.

Considerations: 1. Size of facility, 2. Level of TV broadcast, 3. Validation of light levels, and 4. Cost consciousness.

		Baseball Infield / Outfield	Basketball*	Football	Ice Hockey	Lacrosse	Soccer	Softball Infield / Outfield	Swimming / Water Polo	Tennis	Track & Field		Volleyball	Wrestling / Boxing**
											Track	Field		
Intercollegiate Play (no broadcast)	Horizontal Footcandles:	70 / 50	80	50	100	50	50	70 / 50	50	75	30	50	80	80*
	Horizontal Uniformity:	2:1 / 2.5:1	2:1	2:1	2.5:1	2:1	2:1	2:1 / 2.5:1	2.5:1	1.7:1	3:1	3:1	2:1	2:1
	Typical Seating:	N/A	N/A	Under 5K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Pole position:	6+ poles	N/A	4+ poles	N/A	4+ poles	4+ poles	4+ poles	N/A	4+ poles	4+ poles	4+ poles	N/A	N/A
Regional Broadcast	Horizontal Footcandles:	100 / 70	80	75	100	75	75	100/70	75	75	75	75	80	80*
	Horizontal Uniformity:	1.5:1 / 2:1	2:1	2:1	2:1	2:1	2:1	1.5:1 / 2:1	2:1	1.7:1	2:1	2:1	2:1	2:1
	Camera #1	1st & 3rd Bases	Center main side	50 yd line	Center main side	Center main side	Center main side	1st & 3rd Bases	Center main side	High End	Center main side	Center main side	Center main side	Center main side
	Vertical Footcandles:	70 / 40	75	75	75	75	75	70 / 40	75	75	75	75	75	75
	Vertical Uniformity:	N/A	2:1	2:1	2:1	2:1	2:1	N/A	2:1	2:1	2:1	2:1	2:1	2:1
	Camera #2	High Home Plate	End	End Zone	End	End	End	High Home Plate	End	Net	N/A	N/A	End	End
	Vertical:	70 / 40	45	45	45	45	45	70 / 40	45	45	N/A	N/A	45	45
	Typical Seating:	N/A	N/A	5 - 25K	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Pole position:	6+ poles	N/A	6+ poles	N/A	6+ poles	6+ poles	6+ poles	N/A	4+ poles	6+ poles	6+ poles	N/A	N/A
National Broadcast	Horizontal Footcandles:	Same as Regional Broadcast	100	100	100	100	100	Same as Regional Broadcast	100	100	100	100	100	100
	Horizontal Uniformity:		1.7:1	1.7:1	1.7:1	1.7:1	1.7:1		1.7:1	1.7:1	1.7:1	1.7:1	1.7:1	1.7:1
	Camera #1		Center main side	50 yd line	Center main side	Center main side	Center main side		Center main side	High End	Center main side	Center main side	Center main side	Center main side
	Vertical Footcandles:		100	100	100	100	100		100	100	100	100	100	100
	Vertical Uniformity:		1.7:1	1.7:1	1.7:1	1.7:1	1.7:1		1.7:1	1.7:1	1.7:1	1.7:1	1.7:1	1.7:1
	Camera #2		End	End Zone	End	End	End		End	Net	N/A	N/A	End	End
	Vertical Footcandles:		60	60	60	60	60		60	60	N/A	N/A	60	60
	Typical Seating:		N/A	25 - 45K	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	N/A
	Pole position:		N/A	6+ poles	N/A	6+ poles	6+ poles		N/A	4+ poles	6+ poles	6+ poles	N/A	N/A
National Championship Final Site	Horizontal Footcandles:	125 / 100	125	125	125	125	125	125 / 100	125	125	125	125	125	125
	Horizontal Uniformity:	1.3:1 / 1.7:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.3:1 / 1.7:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1
	Camera #1	1st & 3rd Bases	Center main side	50 yd line	Center main side	Center main side	Center main side	1st & 3rd Bases	Center main side	High End	Center main side	Center main side	Center main side	Center main side
	Vertical Footcandles:	90 / 50	125	125	125	125	125	90 / 50	125	125	125	125	125	125
	Vertical Uniformity:	N/A	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	N/A	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1
	Camera #2	High Home Plate	End	End Zone	End	End	End	High Home Plate	End	Net	N/A	N/A	End	End
	Vertical Footcandles:	90 / 50	75	75	75	75	75	90 / 50	75	75	N/A	N/A	75	75
	Vertical Uniformity:	N/A	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	N/A	2.5:1	1.7:1	N/A	N/A	2.5:1	2.5:1
	Typical Seating:	N/A	N/A	45K+	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Pole position:	6+ poles	N/A	6+ poles	N/A	6+ poles	6+ poles	6+ poles	N/A	4+ poles	8+ poles	6+ poles	N/A	N/A

*Refer to NCAA Basketball Championships Best Lighting Practices for television broadcast located under the Basketball link

**Competition is typically held at the same venue as basketball or volleyball

Notes:
1. All footcandle levels are target minimum averages
2. New lighting system designs are recommended to use 0.7 Recoverable Light Loss Factor or Constant Illumination
3. Lamp Characteristics
   a. Minimum color temperature must be 3600 degrees Kelvin
   b. Minimum Color Rendering Index (CRI) must be 65
4. Refer to the NCAA Broadcast Lighting Requirements for additional information
5. Refer to sport and broadcast specific documents for design examples and verification forms

Contact NCAA at 317/917-6222 or www.NCAA.com with questions.

Corporate: 100 1st Ave West - PO Box 808 - Oskaloosa, IA 52577 - 641/673-0411 - 800/825-6020 - Fax: 641/673-4852
Manufacturing: 2107 Stewart Road - PO Box 260 - Muscatine, IA 52761 - 563/263-2281 - 800/756-1205 - Fax: 800/374-6402
Web: www.musco.com - **Email:** lighting@musco.com

Bill of Materials

Iowa State University – Hilton Coliseum Re-Light
Ames, IA
April 13, 2012

Sports Lighting Package

- (80) - 1000 Watt Metal Halide ShowLight Green Shuttered Sports Fixtures
- All mounting hardware and custom mounting brackets for fixtures and remote ballast enclosures.
- Musco Project Manager on site for assistance during critical times of the installation
- Aiming Technician at completion of installation to ensure fixtures are properly aimed and lighting targets are achieved.
- Musco's Constant 10 Warranty and Services Agreement as outlined below.

Included Warranty Package

- Musco's Constant 10 Warranty and Services Agreement
- Guaranteed constant light levels to meet design criteria for 10 Years or 36,000 hours, whichever comes first
- Two (2) full group relamps at the completion of 12,000 hours and 24,000 hours, or if light levels fall be low targets +/- 10% per IESNA
- Eliminates 100% of customers maintenance costs for 10 years
- Agreement includes parts and labor for the life of the warranty (including lamps)

Notes

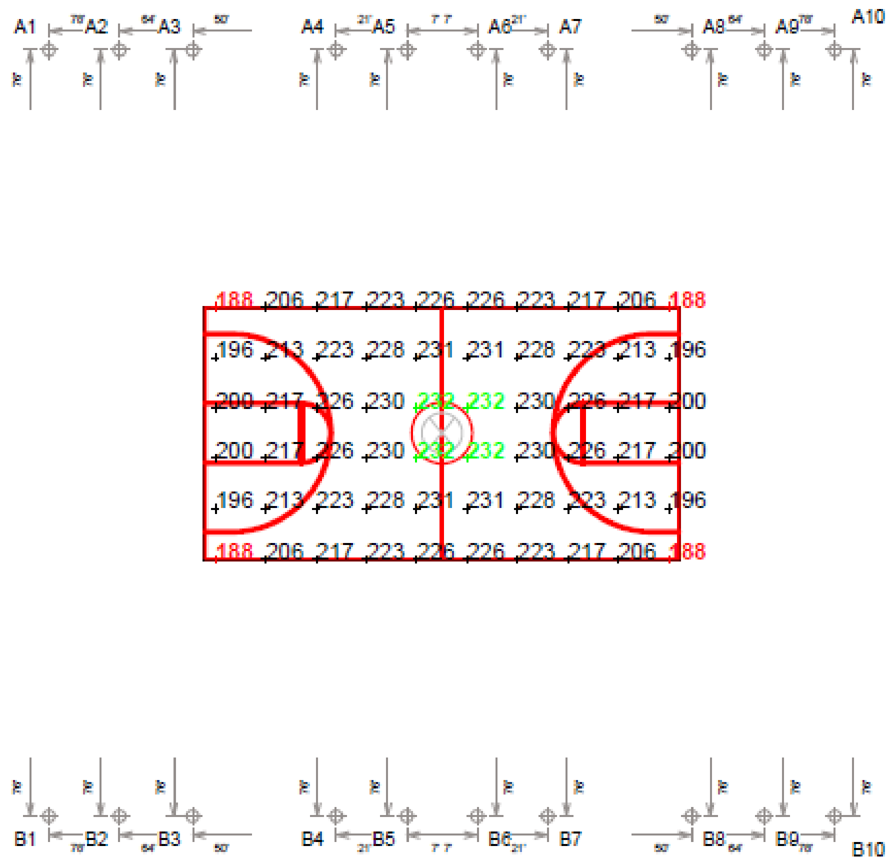
- This design will achieve the NCAA National Broadcast Requirements for Wrestling, Basketball, and Volleyball.
- Lighting Controls, Emergency Lighting, and Maintenance Lighting are not included.

Thanks,

Tim Drost
Key Accounts
Musco Lighting, LLC.
tim.drost@musco.com
800-825-6020 office
641-660-7390 mobile

EQUIPMENT LIST FOR AREAS SHOWN

Pole				Luminaires				
QTY	LOCATION	SIZE	GRADE ELEVATION	MOUNTING HEIGHT	LAMP TYPE	QTY / POLE	THIS GRID	OTHER GRIDS
4	A1, A10, B1 B10		76'	76'	1000W MZ	4	4	0
4	A2, A9, B2 B9		76'	76'	1000W MZ	4	4	0
12	A3-A8 B3-B8		76'	76'	1000W MZ	4	4	0
20	TOTALS					80	80	0



SCALE IN FEET 1 : 30

0' 30' 60'

Pole location(s) ⊕ dimensions are relative to 0,0 reference point(s) ⊗

MUSCO GREEN GENERATION LIGHTING™

GUARANTEED PERFORMANCE

ILLUMINATION SUMMARY

Basketball
Hilton Coliseum Iowa State University
Ames,IA

Basketball
- Size: 94' x 50'
- Grid Spacing = 10.0' x 10.0'
- Values given at 3.0' above grade

- Luminaire Type: Green Generation
- Rated Lamp Life: 12,000 hours
- Avg Lumens/Lamp: 86,000

CONSTANT ILLUMINATION
HORIZONTAL FOOTCANDLES

	Entire Grid
No. of Target Points:	60
Average:	217.08
Maximum:	232
Minimum:	188
Avg/Min:	1.15
Max/Min:	1.23
UG (Adjacent Pts):	1.09
CV:	0.06

Average Lamp Tilt Factor:	1.000
Number of Luminaires:	80
Avg KW over 12,000:	89.6
Max KW:	104.0

Guaranteed Performance: The CONSTANT ILLUMINATION described above is guaranteed for the rated life of the lamp.

Field Measurements: Averages shall be +/-10% in accordance with IESNA RP-6-01 and CIBSE LG4. Individual measurements may vary from computer predictions.

Electrical System Requirements: Refer to Amperage Draw Chart and/or the **"Musco Control System Summary"** for electrical sizing.

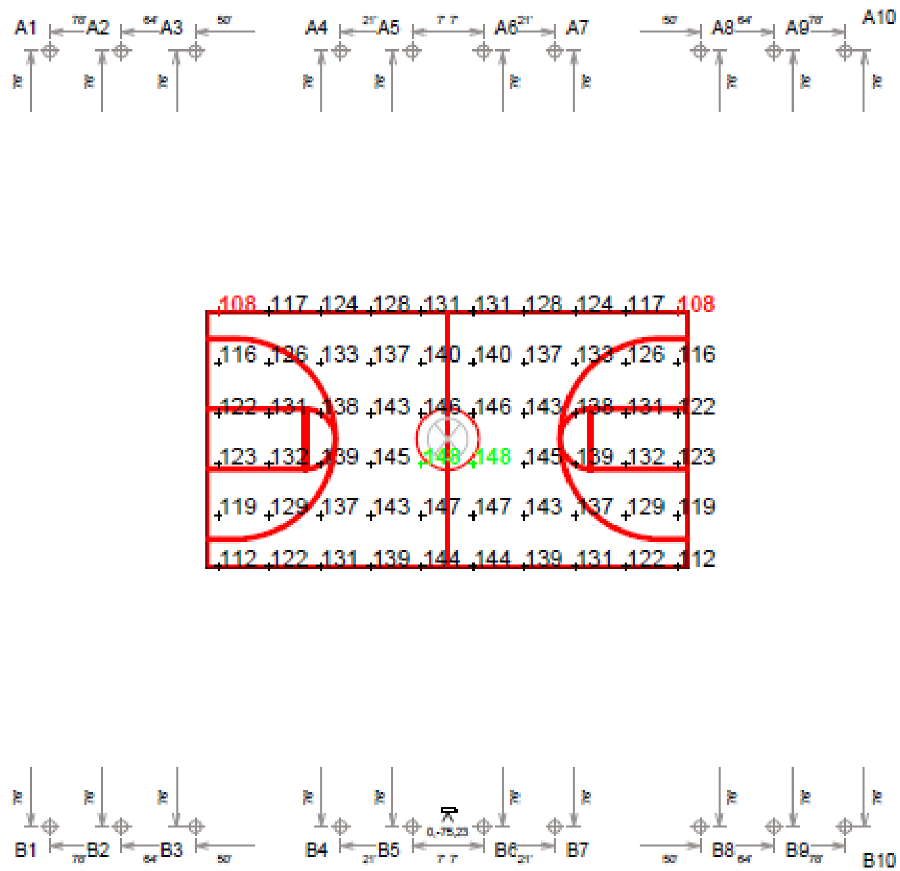
Installation Requirements: Results assume +/- 3% nominal voltage at line side of the ballast and structures located within 3 feet (1m) of design locations.

By: Ben Drost
File #: 119530a Date: 05-Jan-12

Print Date (05/Jan/2012) & Time (11:20)

EQUIPMENT LIST FOR AREAS SHOWN

Pole				Luminaires				
QTY	LOCATION	SIZE	GRADE ELEVATION	MOUNTING HEIGHT	LAMP TYPE	QTY / POLE	THIS GRID	OTHER GRIDS
4	A1, A10, B1 B10		76'	76'	1000W MZ	4	4	0
4	A2, A9, B2 B9		76'	76'	1000W MZ	4	4	0
12	A3-A8 B3-B8		76'	76'	1000W MZ	4	4	0
20	← TOTALS →					80	80	0



SCALE IN FEET 1 : 30

0' 30' 60'

Pole location(s) ⊕ dimensions are relative to 0,0 reference point(s) ⊗

MUSCO. GREEN GENERATION LIGHTING™

GUARANTEED PERFORMANCE

ILLUMINATION SUMMARY

Basketball
Hilton Coliseum Iowa State University
Ames,IA

Basketball
- Size: 94' x 50'
- Grid Spacing = 10.0' x 10.0'
- Values given at 3.0' above grade

- Luminaire Type: Green Generation
- Rated Lamp Life: 12,000 hours
- Avg Lumens/Lamp: 88,000

CONSTANT ILLUMINATION
TV FOOTCANDLES: Main Camera

	Entire Grid
No. of Target Points:	60
Average:	131.76
Maximum:	148
Minimum:	108
Avg/Min:	1.22
Max/Min:	1.37
UG (Adjacent Pts):	1.09
CV:	0.08

Average Lamp Tilt Factor:	1.000
Number of Luminaires:	80
Avg KW over 12,000:	89.6
Max KW:	104.0

Guaranteed Performance: The CONSTANT ILLUMINATION described above is guaranteed for the rated life of the lamp.

Field Measurements: Averages shall be +/-10% in accordance with IESNA RP-6-01 and CIBSE LG4. Individual measurements may vary from computer predictions.

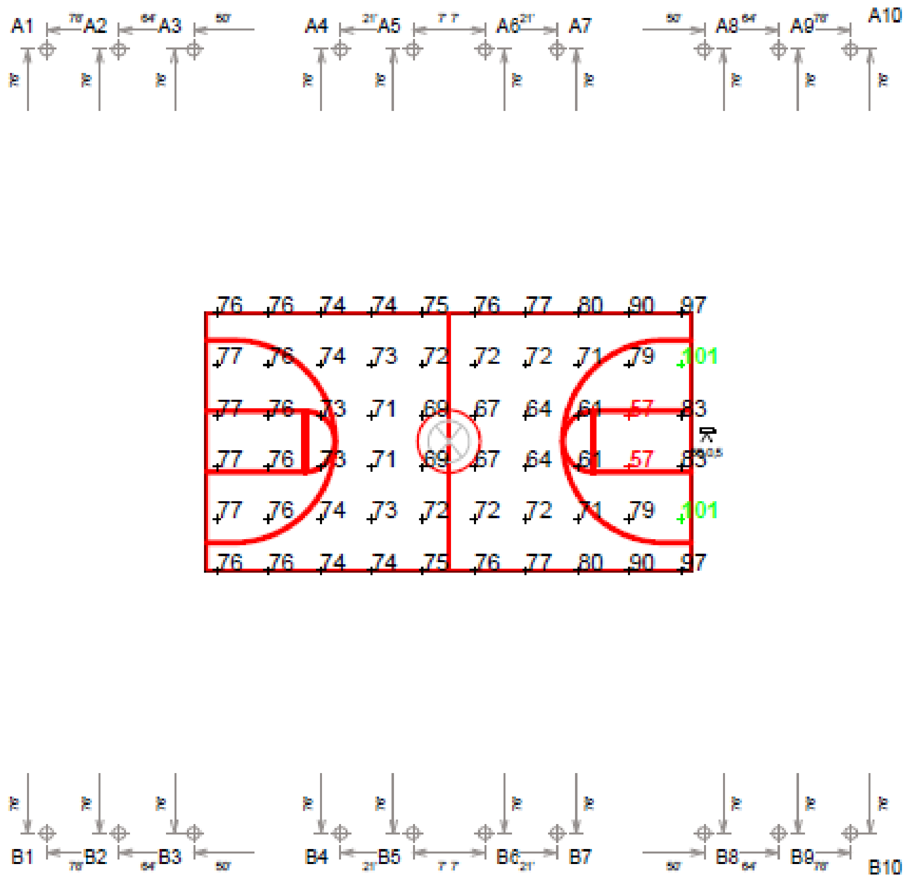
Electrical System Requirements: Refer to Amperage Draw Chart and/or the **"Musco Control System Summary"** for electrical sizing.

Installation Requirements: Results assume +/- 3% nominal voltage at line side of the ballast and structures located within 3 feet (1m) of design locations.

By: Ben Drost
File #: 119530a Date: 05-Jan-12

Print Date (05/Jan/2012) & Time (11:20)

EQUIPMENT LIST FOR AREAS SHOWN								
Pole				Luminaires				
QTY	LOCATION	SIZE	GRADE ELEVATION	MOUNTING HEIGHT	LAMP TYPE	QTY / POLE	THIS GRID	OTHER GRIDS
4	A1, A10, B1 B10		76'	76'	1000W MZ	4	4	0
4	A2, A9, B2 B9		76'	76'	1000W MZ	4	4	0
12	A3-A8 B3-B8		76'	76'	1000W MZ	4	4	0
20	TOTALS					80	80	0



SCALE IN FEET 1 : 30

0' 30' 60'

Pole location(s) ⊕ dimensions are relative to 0,0 reference point(s) ⊗

MUSCO

GREEN GENERATION LIGHTING™

GUARANTEED PERFORMANCE

ILLUMINATION SUMMARY

Basketball
Hilton Coliseum Iowa State University
Ames,IA

Basketball
- Size: 94' x 50'
- Grid Spacing = 10.0' x 10.0'
- Values given at 3.0' above grade

- Luminaire Type: Green Generation
- Rated Lamp Life: 12,000 hours
- Avg Lumens/Lamp: 88,000

CONSTANT ILLUMINATION
TV FOOTCANDLES: End Camera

	Entire Grid
No. of Target Points:	60
Average:	75.36
Maximum:	101
Minimum:	57
Avg/Min:	1.31
Max/Min:	1.77
UG (Adjacent Pts):	1.45
CV:	0.12

Average Lamp Tilt Factor:	1.000
Number of Luminaires:	80
Avg KW over 12,000:	89.6
Max KW:	104.0

Guaranteed Performance: The CONSTANT ILLUMINATION described above is guaranteed for the rated life of the lamp.

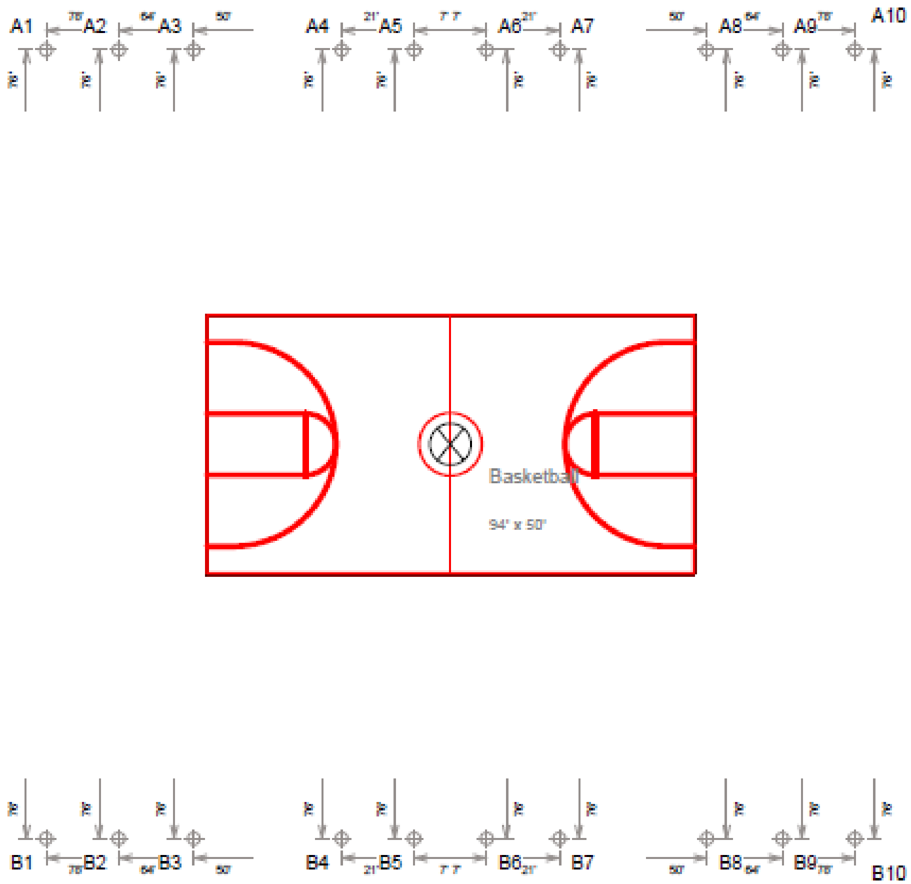
Field Measurements: Averages shall be +/-10% in accordance with IESNA RP-6-01 and CIBSE LG4. Individual measurements may vary from computer predictions.

Electrical System Requirements: Refer to Amperage Draw Chart and/or the **"Musco Control System Summary"** for electrical sizing.

Installation Requirements: Results assume +/- 3% nominal voltage at line side of the ballast and structures located within 3 feet (1m) of design locations.

By: Ben Drost
File #: 119530a Date: 05-Jan-12

Print Date (05/Jan/2012) & Time (11:20)



MUSCO
GREEN GENERATION LIGHTING™

GUARANTEED PERFORMANCE

EQUIPMENT LAYOUT

Hilton Coliseum Iowa State University
Ames,IA

INCLUDES:
· Basketball

Electrical System Requirements: Refer to Amperage Draw Chart and/or the **"Musco Control System Summary"** for electrical sizing.

Installation Requirements: Results assume +/- 3% nominal voltage at line side of the ballast and structures located within 3 feet (1m) of design locations.

EQUIPMENT LIST FOR AREAS SHOWN

Pole				Luminaires		
QTY	LOCATION	SIZE	GRADE ELEVATION	MOUNTING HEIGHT	LAMP TYPE	QTY / POLE
4	A1, A10 B1, B10		76'	76'	1000W MZ	4
4	A2, A9 B2, B9		76'	76'	1000W MZ	4
12	A3-A8 B3-B8		76'	76'	1000W MZ	4
20	←TOTALS→					80

SINGLE LUMINAIRE AMPERAGE DRAW CHART

Ballast Specifications (.90 min power factor)	Line Amperage Per Luminaire (max draw)						
Single Phase Voltage	208 (60)	220 (60)	240 (60)	277 (60)	347 (60)	380 (60)	480 (60)
1000 watt MZ	5.4	4.8	4.8	4.1	3.3	-	2.4

SCALE IN FEET 1 : 30
0' 30' 60'

Pole location(s) ⊕ dimensions are relative to 0,0 reference point(s) ⊗

By: Ben Drost
File #: 119530a Date: 05-Jan-12

KIM LIGHTING

SET-LED-KIT

Entablature® Small, LED Upgrade Kit

1/30/12 • kim_setledkit_spec.pdf

Type:
Job:
Catalog number:

/ /

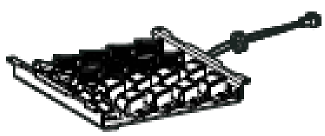
LED Kit | Electrical Module | Option

Approvals:

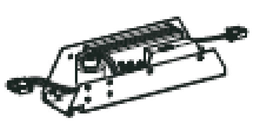
Date:

Specifications

SET-LED-KIT
60 Light Emitting Diodes



LED EmitterDeck™



Electrical Module

Electrical Module: All electrical components are UL recognized, mounted on a single plate and factory prewired with quick-disconnect plugs. Module includes a driver, LifeShield® temperature control device and surge protector. Electrical module attaches to housing with no-tool hinges and latches, accessible by opening the lens frame only. Driver is rated for -40°F starting and has a 0-10V dimming interface for multi-level illumination options.

Optical Module: Precision, replaceable MicroEmitters™ are positioned to achieve directional control toward desired task. The entire EmitterDeck fastens to the housing as a one-piece module.

Warranty: Kim Lighting warrants LED Upgrade Kit products ("Product(s)") sold by Kim Lighting to be free from defects for (i) a period of six (6) years for LED Light Engines (MicroEmitters), (ii) a period of five (5) years for LED power components (LED Driver, LifeShield device, Surge Protector) and (iii) for a period of one (1) year for the re-used metal housing components of the existing luminaire from the date of sale of the LED Upgrade Kit to the buyer as specified in Kim Lighting shipment documents for each Product(s).

NOTE: Existing product conditions are taken as the base point. Participation rules apply. See complete warranty provisions for further details.

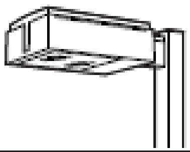
IMPORTANT: Disable all power to the luminaire before conducting any maintenance or upgrade activity. Failure to do so will create a hazardous working environment.

Listed To: UL 1598 Standard for Luminaires - UL 8750 Standard for Safety for Light Emitting Diode (LED) Equipment for use in Lighting Products and CSA C22.2#250.0 Luminaires.

CAUTION: Fixtures must be grounded in accordance with national, state and/or local electrical codes. Failure to do so may result in serious personal injury.

Suggested Tools:
• Flat Blade Screw Driver

HUBBELL
HUBBELL LIGHTING, INC.



Standard Features

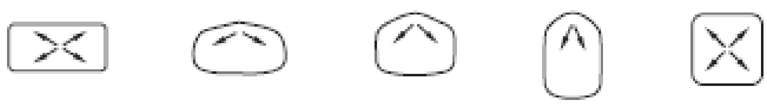
Fixture
Cat. No. designates fixture and distribution

SET-LED-KIT _ x _

Upgrade Kit:
SET-LED-KIT

Distribution:
- ☐ 1 = Type I
- ☐ 2 = Type II
- ☐ 3 = Type III
- ☐ 4 = Type IV
- ☐ 5 = Type V
- ☐ R = Type R Right
- ☐ L = Type L Left

Light Distribution:



TYPE I TYPE II TYPE III TYPE IV TYPE V

TYPE R
One-Way Right

TYPE L
One-Way Left

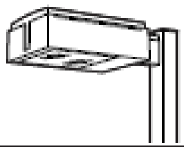
KIM LIGHTING

SET-LED-KIT
Entablature® Small, LED Upgrade Kit

1/30/12 • kim_setledkit_spec.pdf

Type:

Job:



Standard Features

Electrical Module

Cat. Nos. for Electrical Modules available:

120L — xK — x

Source:
120L = 120 LED's

Color Temperature:[1]
☐ 3K = 3500K
☐ 5K = 5100K
☐ 2K = 580nm - Amber

Voltage:
☐ 120 = 120V
☐ 208 = 208V
☐ 240 = 240V
☐ 277 = 277V
☐ 347 = 347V
☐ 480 = 480V

[1]4300K and 6500K are also available on an "Engineered-to-Order" (ETO) basis.

Fixture	Total System Watts*	Volt	Operating Amps
SET LED	68.1	120	0.61
SET LED	68.1	208	0.35
SET LED	68.1	240	0.30
SET LED	68.1	277	0.26
SET LED	68.1	347	0.21
SET LED	68.1	480	0.15

*Estimated

Optional Feature

Fusing
Cat. No. **(see right)**
☐ **No Option**

High temperature fuse holders factory installed inside the fixture housing. Fuse included.

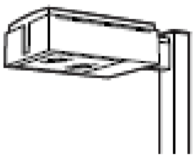
Line Volts:	120V	208V	240V	277V	347V	480V
Cat. No.:	☐ **SF**	☐ **DF**	☐ **DF**	☐ **SF**	☐ **SF**	☐ **DF**


Single Fuse

 • P.O. BOX 60080, CITY OF INDUSTRY, CA 91716-0080 • TEL: 626/968-5666 • FAX: 626/369-2695

KIM LIGHTING

Type:
Job:

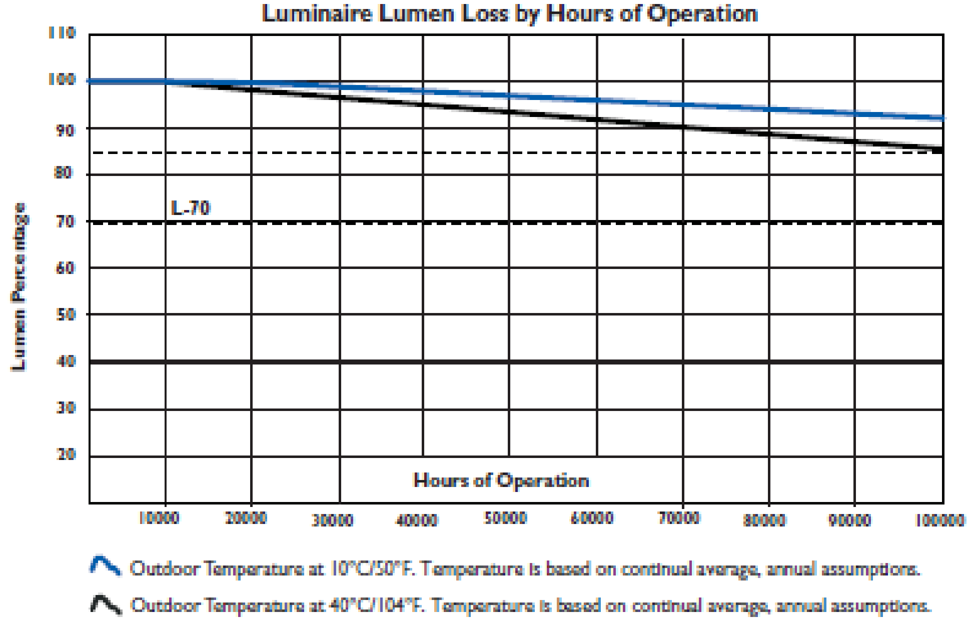


Lumen Performance Charts

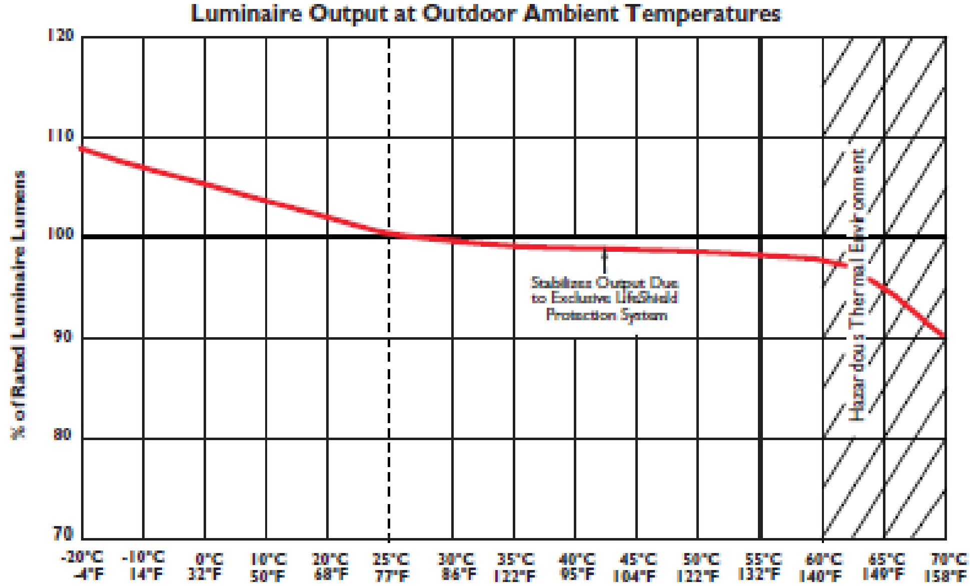
NOTES:

1. Lumen loss stablization is a result of Kim Lighting's MicroEmitter™ luminaires exclusive LifeShield® Protection System and Dual Heat Management.
2. The LifeShield Protection System will lower the current to the LEDs significantly if the luminaire is exposed to direct heat (sun) or excessive abnormal conditions.
3. Luminaire Lumen Loss assumptions are based on LM-80 results and an actual outdoor product testing based upon 5100K CCT, 350mA drive current. 25°C/77°F tab ambient and cathode temperature at 85°C/185°F. Assumptions past 6,000 hours are interpolated.
4. Cathode temperature baseline is at 85°C/185°F. If cathode temperature increases during ambient changes and abnormal environment conditions, % of rated lumens will slightly decrease.
5. Outdoor ambient temperatures are assumed SITU average by geographic region.
6. As Solid State Lighting technology and thermal management systems continually advance, lumen loss projections are subject to improvement.

Luminaire Lumen Loss by Hours of Operation



Luminaire Output at Outdoor Ambient Temperatures



Appendix B

New Window Performance Table

CENTER GLASS PERFORMANCE GUIDE	WINTER U-FACTOR	SOLAR HEAT GAIN (SHGC)	% UV TRANSMISSION	% VISIBLE LIGHT TRANSMISSION
5/8" INSULATING GLASS (IG)				
Clear IG (3mm glass)	0.51	0.76	56	81
Low-E Insulating Glass with Argon[1] (3mm glass)	0.26	0.41	16	72
Bronze, Low-E IG (5mm/3mm glass)	0.36	0.35	8	47
Gray, Low-E IG (5mm/3mm glass)	0.36	0.32	7	40
Green, Low-E IG (5mm/3mm glass)	0.36	0.39	9	63
DUAL GLAZING				
3mm Clear with 3mm Clear Hinged Glass Panel	0.49	0.76	56	81
3mm Clear with 3mm Low-E Hinged Glass Panel	0.36	0.72	45	75
3mm Solar-E with 3mm Clear Hinged Glass Panel	0.36	0.48	39	54
3mm Solar-E with 3mm Low-E Hinged Glass Panel	0.34	0.46	32	50
3mm Bronze with 3mm Clear Hinged Glass Panel	0.49	0.62	32	61
3mm Bronze with 3mm Low-E Hinged Glass Panel	0.36	0.57	25	57
3mm Gray with 3mm Clear Hinged Glass Panel	0.49	0.58	29	55
3mm Gray with 3mm Low-E Hinged Glass Panel	0.36	0.52	24	51
3mm Green with 3mm Clear Hinged Glass Panel	0.49	0.60	34	75
3mm Green with 3mm Low-E Hinged Glass Panel	0.36	0.54	27	69
TRIPLE GLAZING				
Low-E Insulating Glass with Argon[1] with 3mm Clear Hinged Glass Panel	0.20	0.38	14	65
Low-E Insulating Glass with Argon[1] with 3mm Low-E Hinged Glass Panel	0.16	0.36	11	60
Bronze, Low-E IG, 5mm/4mm and 3mm Clear Hinged Glass Panel	0.27	0.32	7	43
Bronze, Low-E IG, 5mm/4mm and 3mm Low-E Hinged Glass Panel	0.21	0.29	6	40
Gray, Low-E IG, 5mm/4mm and 3mm Clear Hinged Glass Panel	0.27	0.29	7	36
Gray, Low-E IG, 5mm/4mm and 3mm Low-E Hinged Glass Panel	0.21	0.26	5	33
Green, Low-E IG, 5mm/4mm and 3mm Clear Hinged Glass Panel	0.27	0.35	8	57
Green, Low-E IG, 5mm/4mm and 3mm Low-E Hinged Glass Panel	0.21	0.32	7	53

Note: 3mm = 1/8"
1. High altitude Low-E insulating glass does not contain argon gas.
2. Not available on Precision Fit® or sliding patio doors.

WINDOW HEAT TRANSFER EQUATIONS

$Q_{Conduction} = U_{Value} * A * TD$

$A = Area\ of\ Windows$

$TD = Temp.\ Difference\ between$

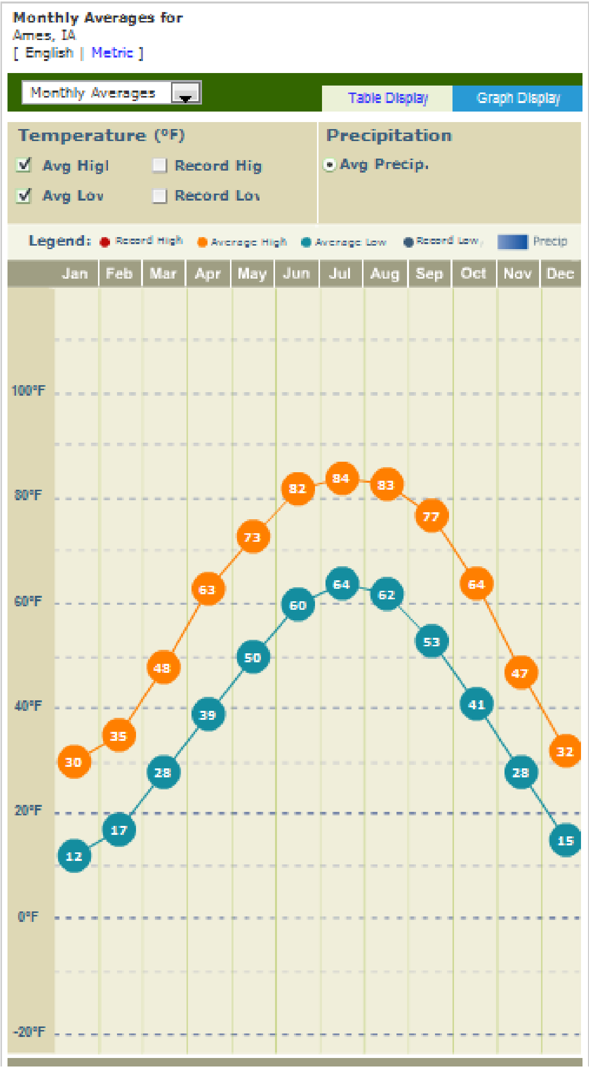
$Inside\ Air\ and\ Outside\ Air$

$Q_{Solar} = SC * A * SHGF$

$SC = Shading\ Coefficient$= SHGC/.87

$SHGF = Solar\ Geat\ Gain\ Factor$

AVERAGE HIGH AND LOW TEMPERATURES



Heat Gain Months' Loads

May	Outside Temp: 73° F	Inside Temp: 72° F			
Current	A(SF)	SC	SHGF	U	TD
N	3,385.00	0.88	32.00	0.90	1.00
NW	1,687.00	0.88	40.00	0.90	1.00
W	2,099.00	0.88	149.00	0.90	1.00
SW	1,706.00	0.88	187.00	0.90	1.00
S	3,381.00	0.88	116.00	0.90	1.00
SE	1,695.00	0.88	34.00	0.90	1.00
E	2,092.00	0.88	32.00	0.90	1.00
NE	1,675.00	0.88	32.00	0.90	1.00
New	A(SF)	SC	SHGF	U	TD
N	3,385.00	0.41	32.00	0.16	1.00
NW	1,687.00	0.41	40.00	0.16	1.00
W	2,099.00	0.41	149.00	0.16	1.00
SW	1,706.00	0.41	187.00	0.16	1.00
S	3,381.00	0.41	116.00	0.16	1.00
SE	1,695.00	0.41	34.00	0.16	1.00
E	2,092.00	0.41	32.00	0.16	1.00
NE	1,675.00	0.41	32.00	0.16	1.00

Total Cooling Load		
New Windows		567,791.83 BTU/HR
Old Windows		1,228,537.84 BTU/HR
	Difference	660,746.01 BTU/HR
		55.06 Tons/HR

Energy Savings
55.06 Ton/HR
77.09 KW/HR
$19.27 Per Hour
$14,338.19 For Month

June	Outside Temp: 82° F	Inside Temp: 72° F			
Current	A(SF)	SC	SHGF	U	TD
N	3,385.00	0.88	32.00	0.90	10.00
NW	1,687.00	0.88	40.00	0.90	10.00
W	2,099.00	0.88	149.00	0.90	10.00
SW	1,706.00	0.88	187.00	0.90	10.00
S	3,381.00	0.88	116.00	0.90	10.00
SE	1,695.00	0.88	34.00	0.90	10.00
E	2,092.00	0.88	32.00	0.90	10.00
NE	1,675.00	0.88	32.00	0.90	10.00
New	A(SF)	SC	SHGF	U	TD
N	3,385.00	0.41	32.00	0.16	10.00
NW	1,687.00	0.41	40.00	0.16	10.00
W	2,099.00	0.41	149.00	0.16	10.00
SW	1,706.00	0.41	187.00	0.16	10.00
S	3,381.00	0.41	116.00	0.16	10.00
SE	1,695.00	0.41	34.00	0.16	10.00
E	2,092.00	0.41	32.00	0.16	10.00
NE	1,675.00	0.41	32.00	0.16	10.00

Total Cooling Load		
New Windows		593,308.63 BTU/HR
Old Windows		1,372,069.84 BTU/HR
	Difference	778,761.21 BTU/HR
		64.90 Tons/HR

Energy Savings
64.90 Ton/HR
90.86 KW/HR
$22.71 Per Hour
$16,353.99 For Month

July	Outside Temp: 84° F	Inside Temp: 72° F			
Current	**A(SF)**	**SC**	**SHGF**	**U**	**TD**
N	3,385.00	0.88	32.00	0.90	12.00
NW	1,687.00	0.88	40.00	0.90	12.00
W	2,099.00	0.88	149.00	0.90	12.00
SW	1,706.00	0.88	187.00	0.90	12.00
S	3,381.00	0.88	116.00	0.90	12.00
SE	1,695.00	0.88	34.00	0.90	12.00
E	2,092.00	0.88	32.00	0.90	12.00
NE	1,675.00	0.88	32.00	0.90	12.00
New	**A(SF)**	**SC**	**SHGF**	**U**	**TD**
N	3,385.00	0.41	32.00	0.16	12.00
NW	1,687.00	0.41	40.00	0.16	12.00
W	2,099.00	0.41	149.00	0.16	12.00
SW	1,706.00	0.41	187.00	0.16	12.00
S	3,381.00	0.41	116.00	0.16	12.00
SE	1,695.00	0.41	34.00	0.16	12.00
E	2,092.00	0.41	32.00	0.16	12.00
NE	1,675.00	0.41	32.00	0.16	12.00

Total Cooling Load		
New Windows		598,979.03 BTU/HR
Old Windows		1,403,965.84 BTU/HR
	Difference	804,986.81 BTU/HR
		67.08 Tons/HR

Energy Savings
67.08 Ton/HR
93.92 KW/HR
$23.48 Per Hour
$17,468.21 For Month

August	Outside Temp: 83° F	Inside Temp: 72° F			
Current	**A(SF)**	**SC**	**SHGF**	**U**	**TD**
N	3,385.00	0.88	32.00	0.90	11.00
NW	1,687.00	0.88	40.00	0.90	11.00
W	2,099.00	0.88	149.00	0.90	11.00
SW	1,706.00	0.88	187.00	0.90	11.00
S	3,381.00	0.88	116.00	0.90	11.00
SE	1,695.00	0.88	34.00	0.90	11.00
E	2,092.00	0.88	32.00	0.90	11.00
NE	1,675.00	0.88	32.00	0.90	11.00
New	**A(SF)**	**SC**	**SHGF**	**U**	**TD**
N	3,385.00	0.41	32.00	0.16	11.00
NW	1,687.00	0.41	40.00	0.16	11.00
W	2,099.00	0.41	149.00	0.16	11.00
SW	1,706.00	0.41	187.00	0.16	11.00
S	3,381.00	0.41	116.00	0.16	11.00
SE	1,695.00	0.41	34.00	0.16	11.00
E	2,092.00	0.41	32.00	0.16	11.00
NE	1,675.00	0.41	32.00	0.16	11.00

Total Cooling Load		
New Windows		596,143.83 BTU/HR
Old Windows		1,388,017.84 BTU/HR
	Difference	791,874.01 BTU/HR
		65.99 Tons/HR

Energy Savings
65.99 Ton/HR
92.39 KW/HR
$23.10 Per Hour
$17,183.67 For Month

September	Outside Temp: 77° F	Inside Temp: 72° F			
Current	**A(SF)**	**SC**	**SHGF**	**U**	**TD**
N	3,385.00	0.88	32.00	0.90	5.00
NW	1,687.00	0.88	40.00	0.90	5.00
W	2,099.00	0.88	149.00	0.90	5.00
SW	1,706.00	0.88	187.00	0.90	5.00
S	3,381.00	0.88	116.00	0.90	5.00
SE	1,695.00	0.88	34.00	0.90	5.00
E	2,092.00	0.88	32.00	0.90	5.00
NE	1,675.00	0.88	32.00	0.90	5.00
New	**A(SF)**	**SC**	**SHGF**	**U**	**TD**
N	3,385.00	0.41	32.00	0.16	5.00
NW	1,687.00	0.41	40.00	0.16	5.00
W	2,099.00	0.41	149.00	0.16	5.00
SW	1,706.00	0.41	187.00	0.16	5.00
S	3,381.00	0.41	116.00	0.16	5.00
SE	1,695.00	0.41	34.00	0.16	5.00
E	2,092.00	0.41	32.00	0.16	5.00
NE	1,675.00	0.41	32.00	0.16	5.00

Total Cooling Load	
New Windows	579,132.63 BTU/HR
Old Windows	1,292,329.84 BTU/HR
Difference	713,197.21 BTU/HR
	59.43 Tons/HR

Energy Savings
59.43 Ton/HR
83.21 KW/HR
$20.80 Per Hour
$14,977.14 For Month

Heating Loss Months' Loads

October	Outside Temp: 41° F	Inside Temp: 72° F	
	U	A	TD
Old	0.90	17,720.00	31.00
New	0.16	17,720.00	31.00

Total Heating Load		
New Windows	87,891.20	BTU/HR
Old Windows	494,388.00	BTU/HR
Difference	406,496.80	BTU/HR
	33.87	Tons/HR

Energy Savings
33.87 Ton/HR
47.42 KW/HR
$11.86 Per Hour
$8,820.98 For Month

November	Outside Temp: 28° F	Inside Temp: 72° F	
	U	A	TD
Old	0.90	17,720.00	44.00
New	0.16	17,720.00	44.00

Total Heating Load		
New Windows	124,748.80	BTU/HR
Old Windows	701,712.00	BTU/HR
Difference	576,963.20	BTU/HR
	48.08	Tons/HR

Energy Savings
48.08 Ton/HR
67.31 KW/HR
$16.83 Per Hour
$12,116.23 For Month

December	Outside Temp: 15° F	Inside Temp: 72° F	
	U	A	TD
Old	0.90	17,720.00	57.00
New	0.16	17,720.00	57.00

Total Heating Load		
New Windows	161,606.40	BTU/HR
Old Windows	909,036.00	BTU/HR
Difference	747,429.60	BTU/HR
	62.29	Tons/HR

Energy Savings
62.29 Ton/HR
87.20 KW/HR
$21.80 Per Hour
$16,219.22 For Month

January	Outside Temp: 12° F	Inside Temp: 72° F	
	U	A	TD
Old	0.90	17,720.00	60.00
New	0.16	17,720.00	60.00

Total Heating Load		
New Windows	170,112.00	BTU/HR
Old Windows	956,880.00	BTU/HR
Difference	786,768.00	BTU/HR
	65.56	Tons/HR

Energy Savings
65.56 Ton/HR
91.79 KW/HR
$22.95 Per Hour
$17,072.87 For Month

February	Outside Temp: 17° F	Inside Temp: 72° F	
	U	A	TD
Old	0.90	17,720.00	55.00
New	0.16	17,720.00	55.00

Total Heating Load		
New Windows	155,936.00	BTU/HR
Old Windows	877,140.00	BTU/HR
Difference	721,204.00	BTU/HR
	60.10	Tons/HR

Energy Savings
60.10 Ton/HR
84.14 KW/HR
$21.04 Per Hour
$14,135.60 For Month

March	Outside Temp: 28° F	Inside Temp: 72° F	
	U	A	TD
Old	0.90	17,720.00	44.00
New	0.16	17,720.00	44.00

Total Heating Load		
New Windows	124,748.80	BTU/HR
Old Windows	701,712.00	BTU/HR
Difference	576,963.20	BTU/HR
	48.08	Tons/HR

Energy Savings
48.08 Ton/HR
67.31 KW/HR
$16.83 Per Hour
$12,520.10 For Month

April	Outside Temp: 39° F	Inside Temp: 72° F	
	U	A	TD
Old	0.90	17,720.00	33.00
New	0.16	17,720.00	33.00

Total Heating Load		
New Windows	93,561.60	BTU/HR
Old Windows	526,284.00	BTU/HR
Difference	432,722.40	BTU/HR
	36.06	Tons/HR

Energy Savings
36.0602 Ton/HR
50.48 KW/HR
$12.62 Per Hour
$9,087.17 For Month

AIR CURTAIN ENERGY SAVINGS CALCULATOR

BERNER INTERNATIONAL CORP.

Air Curtains/Air Doors

Energy Savings Calculator

Home >
Sales Support
> Energy Savings Calculator

Heating

This calculator will estimate the cost savings of a Berner air door when used to keep warmer air inside and cooler air outside. This is a typical application during winter months.

Heat Loss from Temperature	60,236 BTU/HR
Heat Loss from Wind	574,235 BTU/HR
Total Heat Loss	556,438 BTU/HR
Heat Loss per Season	156 MMBTU/HR
Heat Saved by Air Door	109 MMBTU/HR
Cost of Heat Lost without Air Door	1,246 $/MMBTU
Cost of Heat Saved with Air Door	872 $/MMBTU
Cost to purchase/install Air Door $	281.30
Cost to run Air Door $	17.39 per season
Airdoor will pay for itself in	0.32240856994807 years (not including annual operating cost)

BERNER INTERNATIONAL CORP.

Air Curtains/Air Doors

Energy Savings Calculator

Home >
Sales Support
> Energy Savings Calculator

Air Conditioning

This calculator will estimate the cost savings of a Berner air door when used to keep cooler air inside and warmer air outside. This is a typical application during summer months.

Sensible heat load	9,735 BTU/HR
Latent heat load	38,356 BTU/HR
Total heat gain rate	48,091 BTU/HR
Cost of heat gain:	$ 1,613 per season
Cost to purchase/install Air Door	$ 281.30
Cost to run Air Door	$ 6.22 per season
Airdoor will pay for itself in	0.2505604249564 years (not including annual operating cost)

Appendix C

Detailed Breakdown of Cost

	Description	Unit Material Costs ($/Unit)	Number of Units	Total Material Cost	Total Labor Cost	Total Material & Labor Cost ($)	Total Contract Cost (With O&P)
PV and Wind	Windspires	$ 9,400	10 Ea.	$ 94,000	$ 34,000	$ 128,000	$ 140,800
						Total Contract	**$ 140,800**
Energy Use	Windows	$ 195	17720 SF	$ 3,455,400	$ 144,040	$ 3,599,440	$ 3,959,384
	Air Curtains	$ 155	19 Ea.	$ 6,700	$ 2,400	$ 9,100	$ 10,010
	VFD's	$ 2,034	16 Ea.	$ 32,544	$ 10,420	$ 42,964	$ 47,260
						Total Contract	**$ 4,016,654**
Lighting	Lower Level - 2'x4' LED Troffer Retrofit Kit	$ 180	22 Ea.	$ 3,960	$ 1,440	$ 5,400	$ 5,940
	Lower Level - T8 1'x4' Surf. Mounted Linear Florescent	$ 120	42 Ea.	$ 5,040	$ 2,400	$ 7,440	$ 8,184
	Lower Level - DW -100 Wall Mounted Occupancy Sensor	$ 118	6 Ea.	$ 708	$ 2,000	$ 2,708	$ 2,979
	Lower Level - DT -300 Ceiling Mounted Occupancy Sensor	$ 96	6 Ea.	$ 576	$ 1,600	$ 2,176	$ 2,394
	Concession Stand - 26 Watt Compact Florescent	$ 20	65 Ea.	$ 1,300	$ 480	$ 1,780	$ 1,958
	Seating Area - LED 8" Architectural Downlight - 28 LED's	$ 419	152 Ea.	$ 63,688	$ 12,160	$ 75,848	$ 83,433
	Seating Area - LED 8" Architectural Downlight - 42 LED's	$ 469	136 Ea.	$ 63,784	$ 10,880	$ 74,664	$ 82,130
	Seating Area - LED 8" Architectural Downlight - 56 LED's	$ 679	156 Ea.	$ 105,924	$ 12,480	$ 118,404	$ 130,244
	Main Floor - Musco Lighting 1000W Metal Halide ShowLight	$ 2,000	80 Ea.	$ 160,000	$ 165,000	$ 325,000	$ 357,500
	Ext Light - ET Entablature Large LED Retrofit Kits - 60LED's	$ 625	34 Ea.	$ 21,250	$ 1,020	$ 22,270	$ 24,497
	Ext Light - ET Entablature Large LED Retrofit Kits - 120LED's	$ 775	36 Ea.	$ 27,900	$ 1,080	$ 28,980	$ 31,878
						Total Contract	**$ 731,137**
						Total Contract	**$ 4,888,591**

APPENDIX D

LEED-EB CREDIT-BY-CREDIT NARRATIVE

The credit-by-credit narrative is provided to explain in more detail how each credit may be attained or why we cannot attain them. Credits highlighted in **RED** correlate to those credits achievable with the Green Energy Challenge retrofit and renovations. Credits highlighted in **TEAL** correlate to those credits attainable by current practices at Iowa State University. Those credits unattainable will remain in **BLACK**.

Sustainable Sites

SS Credit 1: *LEED Certified Design and Construction*

0/4 points

We will be unable to get this credit because Hilton has no prior LEED accreditation. This credit is unattainable and is outside the scope of the Green Energy Challenge.

SS Credit 2: *Building Exterior and Hardscape Management*

1/1 point

Iowa State currently uses environmentally friendly cleaning products and ice removal methods. Iowa State also does a well good job of maintaining its hard surfaces including Sidewalks and Pavements.

SS Credit 3: *Integrated Pest Management, Erosion Control and Landscape Management Plan*

1/1 point

Iowa State currently uses environmentally friendly pest management products. The natural areas on campus are very well protected also.

SS Credit 4: *Alternative Commuting Transportation:*

10/15 points (Yes); 5/15 points (Maybe)

At Hilton Coliseum, most of its occupants use the CyRide, a campus and city wide bus system, to travel to and from the building. On game days, most occupants either walk or ride the CyRide. A very small minority drives and those who do usually car pool. 10 of the 15 credits will be easily attainable. The remaining 5 credits will depend on how many occupants LEED allows to claim with CyRide.

SS Credit 5: *Protect or Restore Open Habitat*

1/1 point

Iowa State currently uses native vegetation or a native “hybrid” everywhere on campus. The building might be able to get 25% vegetation coverage excluding the building footprint. Obtaining the 5% vegetation coverage counting the building footprint is a lot more attainable.

SS Credit 6: *Storm water Quantity Control*

0/1 point

Iowa State does not collect storm water. Storm water collection is very rare in Iowa due to water not being scarce in Iowa.

SS Credit 7.1: *Heat Island Reduction-Non-Roof*

0/1 point

Hilton Coliseum's parking lot will not be covered.

SS Credit 7.2: *Heat Island Reduction – Roof*

1/1 point

Hilton Coliseum's roof is white and has an SRI exceeding that required for this credit.

SS Credit 8: *Light Pollution Reduction:*

1/1point (Maybe)

Most of the outdoor lights are covered as specified in this credit. However, it is unclear whether or not Hilton will be able to pass the after-hours portion of this credit which requires lights be off during after-hours. Since Hilton is an arena, a good portion of its usage is during the night when games are being played. This credit might be attainable and is outside the scope of the Green Energy Challenge.

Water Efficiency

WE Credit 1: *Water performance Measurement*

1/2 points (Yes); 1/2 (No)

Iowa State meters its utility usage including potable water. However, Iowa State does not track the specific usage for which potable water is being used.

WE Credit 2: *Additional Indoor Plumbing Fixture and Fitting Efficiency*

4/5 points (Yes); 1/5 points (Maybe)

Automatic fixtures are present throughout the building.

WE Credit 3: *Water Efficient Landscaping*

4/5 points (Yes); 1/5 points (Maybe)

Iowa State does not irrigate its grass or vegetation.

WE Credit 4.1-4.2: *Cooling Tower Water Management*

1/2 points (Maybe); 1/2 points (No)

Iowa State has a central plant that has cooling towers. Although there is no cooling tower on site, Hilton does use a cooling tower. Iowa State has made upgrades to the cooling towers on campus that increase water efficiency. Also, Iowa State addresses chemical treatment, bleed-off, and biological control in accordance to this this credit. Iowa State does not measure non-potable water usage in its cooling towers. Therefore, the first part of this credit (1 credit) is attainable and the other part is unattainable.

Energy and Atmosphere

EA Credit 1: *Optimize Energy Efficiency Performance*

4/18 points (Yes); 14/18 points (No)

As part of the Green Energy Challenge competition, at least 4 points are obtainable. Using EPA's Energy Star Portfolio Manager for Hilton Coliseum, it was found that this facility had a Performance Rating of 75. This corresponds to 4 points in LEED-EB; however, more points are believed to be obtainable as most of the inputted data itself was conservative. The summary of the rating provided by the Portfolio Manager can be found later in this Appendix (D).

EA Credit 2.1: *Existing Building Commissioning—Investigation and Analysis*

2/2 points

An energy use analysis was performed for the heating, cooling, and lighting systems from the facility. From this assessment, it could be determined if the building system/equipment was being utilized to its potential. If an item was not, it was replaced by a piece of equipment which would perform in a more efficient manner. In addition to this, an ongoing commissioning plan for the building will be developed based off the energy use analysis provided in this report.

EA Credit 2.2: *Existing Building Commissioning—Implementation*

2/2 points

It is desirable to implement low-cost operational improvements to promote sustainability, as well as to reduce costs for the owner. The energy use analysis was performed to develop a basis to replace major pieces of equipment. Using that analysis, a retrofit was performed which in time would both save the owner money as well as allow the system to operate more efficiently.

EA Credit 2.3: *Existing Building Commissioning—Ongoing Commissioning*

2/2 points

By creating an ongoing commissioning program, it will ensure that all installed equipment is performing as expected. Additionally, it will provide a good determination of when future development should be considered, saving both time and money. The energy use analysis provided in this report will serve as the basis of creating the ongoing commissioning program.

EA Credit 3.1: *Performance Measurement—Building Automation System*

1/1 points

Across campus, Iowa State University already has installed a building automation system. This system is operated using Johnson Controls. With this system already in place, this credit is easily obtainable.

EA Credit 3.2: *Performance Measurement—System-Level Metering*

0/2 points

To achieve this credit, each system for the building along with each system's components must be monitored. Although installing a system-level metering system is a possible, it would come at a great cost for the owner and therefore is not recommended.

EA Credit 4: *On-site and Off-site Renewable Energy*

6/6 points

Based upon the PV/Wind energy system design, it is expected that XX% of the total energy consumed at Hilton will be produced on-site through renewable sources. In addition to this, Iowa State University owns its own wind farm which has the capability of producing 10% of the total amount of consumed energy by the University in January. Therefore, with these two systems in place, 6 points will easily be obtained.

EA Credit 5: *Enhanced Refrigerant Management*

0/1 point

Hilton receives all of its power from the Cogeneration plant located on Iowa State University's campus. Using option 2 provided by the LEED-EB handbook, the plant's current operations produce slightly above the limit of ozone-depleting substances. However, currently the plant has scheduled to replace an existing generator which when installed, will reduce this number making this credit obtainable.

EA Credit 6: *Emissions Reduction Reporting*

1/1 point

Since Hilton Coliseum receives its power from Iowa State's University's cogeneration plant, the pollutants here are monitored. With the cogeneration power plant operating at an efficiency of 65%, when compared to the national average efficiency of 45%, it is considered to be one of the nation's cleanest coal plants making this point easily obtainable.

Materials and Resources

MR Credit 1: *Sustainable Purchasing—Ongoing Consumables*

1/1 Point

Iowa State University's current purchasing program already exceeds the requirements apart of this credit, thus easily achieving this credit.

MR Credits 2.1: *Sustainable Purchasing*

1/1 point

As determined in the energy use analysis/retrofit, it was estimated that a number of new components should be added to Hilton's system. In order to achieve this credit, 40% of the total electric-powered equipment purchases will be either Energy Star qualified or replace conventional gas-powered equipment. Iowa state University's green initiative program contains purchasing requirements which already satisfy this credit.

MR Credit 2.2: Furniture

1/1 point

Although the scope of the Green Energy Challenge project does not include this credit, if this project was to be completed, 1 point would be obtained. As part of Iowa State University's current green initiative program, the requirements for this credit will easily be satisfied.

***MR Credit 3:** Sustainable Purchasing—Facility Alterations and Additions*

1/1 point

As part of the Green Energy Challenge competition, 1 point is obtainable. Again, based upon Iowa State University's current purchasing program, the requirements laid out in this credit will easily be met.

***MR Credit 4:** Sustainable Purchasing—Reduced Mercury in Lamps*

1/1 point

As part of the Green Energy Challenge competition, 1 point is obtainable. Since there are currently no lamps which contain mercury, none will need to be phased out. Then, as mentioned in the lighting retrofit, with many lights being phased out and replaced by LEDs and other less energy consuming lamps, this will decrease the operating costs and reduce the amount of energy used.

MR Credit 5: Sustainable Purchasing—Food

1/1 point

Although the scope of the Green Energy Challenge project does not include this credit, if this project was to be completed, 1 point would be obtained. Use of concessions at Hilton Coliseum is quiet frequent due to the many events which are held here. Apart of Iowa State University's current food buying policy with vendors, the requirements in this policy meet those specified in this credit.

MR Credit 6: Solid Waste Management—Waste Stream Audit

1/1 point

Although the scope of the Green Energy Challenge project does not include this credit, if this project was to be completed, 1 point would be obtained. Again, a part of Iowa State University's current green initiative program, the requirements for this credit will easily be satisfied.

MR Credit 7: Solid Waste Management—Ongoing Consumables

1/1 point

Although the scope of the Green Energy Challenge project does not include this credit, if this project was to be completed, 1 point would be obtained. Again, a part of Iowa state University's current green initiative program, the requirements for this credit will easily be satisfied.

MR Credit 8: Solid Waste Management—Durable Goods

1/1 point

Although the scope of the Green Energy Challenge project does not include this credit, if this project was to be completed, 1 point would be obtained. Again, a part of Iowa state University's current green initiative program, the requirements for this credit will easily be satisfied.

MR Credit 9: Solid Waste Management—Facility Alterations and Additions

1/1 point

Although the scope of the Green Energy Challenge project does not include this credit, if this project was to be completed, 1 point would be obtained. Again, a part of Iowa state University's current green initiative program, the requirements for this credit will easily be satisfied.

Indoor Environmental Quality

***IEQ Credit 1.1:** IAQ Best Management Practices – IAQ Management Program*

1/1 point

Iowa State University could develop an IAQ management program for the building.

IEQ Credit 1.2: IAQ Best Management Practices – Outdoor

1/1 point

Iowa State University already has Johnson Controls in place that continuously monitor systems for outdoor ventilation flow rates.

IEQ Credit 1.3: IAQ Best Management Practices – Increased Ventilation

0/1 point

This project would not be able to provide the necessary increase in ventilation required to earn this credit. The nature of the use of the building does not allow for a practical solution in an attempt to earn this credit.

***IEQ Credit 1.4:** IAQ Best Management Practices – Reduce Particulates in Air Distribution*

1/1 point

This project does include the installation of equipment with particle filters that have a MERV of 13 or greater. We can include this credit.

***IEQ Credit 1.5:** IAQ Best Management Practices – IAQ Management for Facility Alterations and Additions*

1/1 point

This credit could be earned easily by doing particulate testing during the construction phase of this project.

***IEQ Credit 2.1:** Occupant Comfort – Occupant Survey*

1/1 point

Iowa State University already gives an occupant survey for building efficiency performance. This credit can be earned.

IEQ Credit 2.2: Controllability of Systems – Lighting

0/1 point

This credit is not an option give the nature of the general use of the building. Because the building often hosts visitors lighting controls are not a practical alternative.

IEQ Credit 2.3: Occupant Comfort – Thermal Comfort Monitoring

1/1 point

The building already has a continuous tracking and monitoring system of indoor comfort and conditions in occupied spaces.

IEQ Credit 2.4: Daylight and Views

0/1 point

We cannot achieve day lighting in at least 50% of the building’s regularly occupied spaces because of the nature of the use of the building. We cannot earn this credit.

IEQ Credit 3.1: Green Cleaning – High Performance Cleaning Program

1/1 point

We can earn this credit as Iowa State University has a high performance cleaning program.

IEQ Credit 3.2: Green Cleaning – Custodial Effectiveness Assessment

1/1 point

We can earn this credit as Iowa State University uses periodic custodial assessments.

IEQ Credit 3.3: Green Cleaning – Sustainable Cleaning Products, Materials Purchased

1/1 point

We can earn this credit as Iowa State University uses sustainable green cleaning products.

IEQ Credit 3.4: Green Cleaning – Sustainable Cleaning Equipment

1/1 point

We can earn this credit as Iowa State University uses sustainable green cleaning equipment.

IEQ Credit 3.5: Green Cleaning – Indoor Chemical and Pollutant Source Control

0/1 point

No, we are unable to achieve this credit because the vestibules are not large enough to accommodate the required length mats.

IEQ Credit 3.6: Green Cleaning – Indoor Integrated Pest Management

1/1 point

Iowa State University does use a pest management plan. We can achieve this credit.

Innovation in Operations

IO Credit 1.1: Innovation in Operations: Specific Alternative

0/4 points

We are unable to earn these credits.

IO Credit 2: *LEED Accredited Professional*

1/1 point

We have multiple LEED accredited professionals that could be assigned to the project at Iowa State University.

IO Credit 3: *Documenting Sustainable Building Costs Impacts*

1/1 point

We can achieve this credit by documenting building operation costs over the first five years after the project to demonstrate improved energy usage.

Regional Priority Credits

WE Credit 2: Additional Indoor Plumbing Fixture and Fitting Efficiency

0/1 point

30% reduction – No, we cannot achieve this credit. The building already uses efficient water fixtures and would not be able to achieve a 30% reduction in water consumption.

SS Credit 4: Alternative Commuting Transportation

1/1 point

50% reduction – It is unlikely that the project will be able to claim enough regular building occupants as using alternative transportation despite the community providing a useful Cyride bus system.

SS Credit 6: Storm water Quantity Control

0/1 point

Iowa State University does not collect storm water and is unlikely to change its practices due to the practicality of the climate.

SS Credit 7.2: Heat Island Reduction –Roof

0/1 point

While structures for the roof system that may improve the necessary credentials to meet this credit were considered, they were not chosen to be implemented. This credit is not able to be earned.

MR Credit 5: Sustainable Purchasing—Food

1/1 Point

This credit could be earned but it is outside the scope of the project. Current practices already include the sustainable purchasing of food for the concessions and vending in the building.

MR Credit 7: Solid Waste Management—Ongoing Consumables

1/1 Point

The building currently has a solid waste management plan that would earn this credit. However it is outside the scope of the Green Energy Challenge.

EPA STATEMENT OF ENERGY PERFORMANCE

STATEMENT OF ENERGY PERFORMANCE
Hilton Coliseum

Building ID: 3105331
For 12-month Period Ending: December 31, 2011[1]
Date SEP becomes ineligible: N/A

Date SEP Generated: April 13, 2012

Facility
Hilton Coliseum
1700 Lincoln Way
Ames, IA 50011

Facility Owner
Iowa State University
200 General Services
Ames, IA 50011

Primary Contact for this Facility
Cyclone Energy
Town Engineering Building
Ames, IA 50011

Year Built: 1971
Gross Floor Area (ft^2): 138,144

Energy Performance Rating[2] (1-100) N/A

Site Energy Use Summary[3]	
District Chilled Water - Electric-Driven Chiller(kBtu)	9,513,000
District Steam (kBtu)	20,191,734
Electricity - Grid Purchase(kBtu)	6,908,072
Natural Gas - (kBtu)[4]	0
Total Energy (kBtu)	36,612,806

Energy Intensity[4]	
Site (kBtu/ft^2/yr)	265
Source (kBtu/ft^2/yr)	416

Emissions (based on site energy use)
Greenhouse Gas Emissions ($MtCO_2e$/year) 3,075

Electric Distribution Utility
Ames Municipal Electric System

National Median Comparison	
National Median Site EUI	46
National Median Source EUI	94
% Difference from National Median Source EUI	343%
Building Type	Entertainment/Culture

Stamp of Certifying Professional

Based on the conditions observed at the time of my visit to this building, I certify that the information contained within this statement is accurate.

Meets Industry Standards[5] **for Indoor Environmental Conditions:**

Ventilation for Acceptable Indoor Air Quality	**N/A**
Acceptable Thermal Environmental Conditions	**N/A**
Adequate Illumination	**N/A**

Certifying Professional
Cyclone Energy
Town Engineering Building
Ames, IA 50011

Notes:
1. Application for the ENERGY STAR must be submitted to EPA within 4 months of the Period Ending date. Award of the ENERGY STAR is not final until approval is received from EPA.
2. The EPA Energy Performance Rating is based on total source energy. A rating of 75 is the minimum to be eligible for the ENERGY STAR.
3. Values represent energy consumption, annualized to a 12-month period.
4. Values represent energy intensity, annualized to a 12-month period.
5. Based on Meeting ASHRAE Standard 62 for ventilation for acceptable indoor air quality, ASHRAE Standard 55 for thermal comfort, and IESNA Lighting Handbook for lighting quality.

FOR YOUR RECORDS ONLY. DO NOT SUBMIT TO EPA.

Please keep this Facility Summary for your own records; do not submit it to EPA. Only the Statement of Energy Performance (SEP), Data Checklist and Letter of Agreement need to be submitted to EPA when applying for the ENERGY STAR.

Facility
Hilton Coliseum
1700 Lincoln Way
Ames, IA 50011

Facility Owner
Iowa State University
200 General Services
Ames, IA 50011

Primary Contact for this Facility
Cyclone Energy
Town Engineering Building
Ames, IA 50011

General Information

Hilton Coliseum	
Gross Floor Area Excluding Parking: (ft²)	138,144
Year Built	1971
For 12-month Evaluation Period Ending Date:	December 31, 2011

Facility Space Use Summary

Offices	
Space Type	Office
Gross Floor Area (ft²)	9,744
Weekly operating hours	40
Workers on Main Shift d	22
Number of PCs d	21
Percent Cooled	50% or more
Percent Heated	50% or more

Retail	
Space Type	Retail
Gross Floor Area (ft²)	6,008
Weekly operating hours	30
Number of open or closed refrigeration/freezer cases	10
Number of walk-in refrigeration/freezer units	2
Workers on Main Shift d	6
Number of PCs d	1
Number of Cash Registers	10
Percent Heated	100
Percent Cooled	100
Exterior Entrance to the Public	No

Assembly	
Space Type	Other - Entertainment/Culture
Gross Floor Area (ft²)	122,392
Number of PCs o	10
Weekly operating hours o	20
Workers on Main Shift o	150

Energy Performance Comparison

	Evaluation Periods		Comparisons		
Performance Metrics	**Current (Ending Date 12/31/2011)**	**Baseline (Ending Date 12/31/2011)**	**Rating of 75**	**Target**	**National Median**
Energy Performance Rating	N/A	N/A	75	N/A	N/A
Energy Intensity					
Site (kBtu/ft²)	265	265	151	N/A	46
Source (kBtu/ft²)	416	416	238	N/A	94
Energy Cost					
$/year	N/A	N/A	N/A	N/A	N/A
$/ft²/year	N/A	N/A	N/A	N/A	N/A
Greenhouse Gas Emissions					
$MtCO_2e$/year	3,075	3,075	1,757	N/A	534
$kgCO_2e$/ft²/year	22	22	13	N/A	4

More than 50% of your building is defined as Entertainment/Culture. This building is currently ineligible for a rating. Please note the National Median column represents the CBECS national median data for Entertainment/Culture. This building uses 343% more energy per square foot than the CBECS national median for Entertainment/Culture.

Notes:
o - This attribute is optional.
d - A default value has been supplied by Portfolio Manager.