# CASINO GOLD EAST COAST, USA



Photo Credit: Friedmutter Group

## 4/9/2014

# Senior Thesis Spring 2014

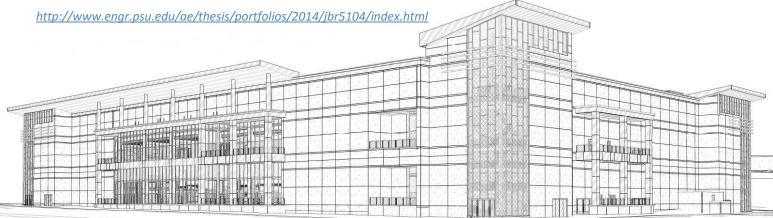
## **Brad Robertson**

Penn State Architectural Engineering – Lighting/Electrical Option Faculty Advisor – Shawn Good

# ABSTRACT

# Casino Gold | East Coast, USA

# Brad Robertson | Lighting + Electrical



## The Team

Executive Architect: ka Design/Interiors Architect: Friedmutter Group Construction Manager: Whiting-Turner Structural Engineer: Carroll Engineering, Inc. MEPT Engineer: JBA Consulting Engineers Lighting Design: The Lighting Practice

## The Building

Occupancy Type: A2 Assembly, B, S1 Type of Construction: Type 1B sprinklered, Noncombustible Size: 309,450 GSF Levels Above Grade/Total Levels: 3/3 Approximate Cost: \$400 Million Dates of Construction: June 2013-September 2014



Casino Entrance at Night



Active Outdoor Plaza

### **The Systems**

**Lighting:** The lighting in Casino Gold is a mix of pendant, recessed, and strip luminaires. The majority of sources are LED and there are multiple custom chandeliers.

**Mechanical:** A 15,000 sq. ft. central plant adjacent to the building houses the casino's hydronic systems. Rooftop air handling units and exhaust fans service the casino. Due to the nature of the building, special attention is paid to the smoke control system.

**Structural:** This is a steel structure with metal framed walls and architectural concrete covering the exterior. **Electrical:** 480/277V service begins in the Central Plant with Utility Owned transformers. The service is distributed throughout the casino using both 480/277V and 120/208V panels located in defined electrical rooms.

\*All images belong to Friedmutter Group and design team

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## EXECUTIVE SUMMARY

The lighting depth covers the redesign of four spaces within the main casino building: The Outdoor Plaza, Pre-function space, Poker Room, and Player's Lounge. Each space has its own description in the lighting depth for recommended illuminance recommendations, code requirements, lighting equipment schedule, lighting plan, AGi.32 calculations and a summary. The illuminance recommendations are referenced from the IES Lighting Handbook, 10<sup>th</sup> Edition. ASHRAE 90.1 is used for the code requirements.

The final lighting design for the Outdoor Plaza guides casino guests towards the entrance while creating a safe environment through the use of overhead string lights. The Pre-Function space, adjacent to the multi-purpose room, uses cove lighting in the recessed ceilings areas to create a psychological impression of spaciousness. In the poker room an environment similar to a workspace has been designed through a combination of recessed down lights and large pendants. Finally, in the Player's Lounge an intimate social setting is the result of custom pendant luminaires and unique indirect linear luminaires.

In the electrical depth, four panels were modified to contain the new loads that resulted from the lighting redesign. While most loads fit on one branch circuit, a couple of them were spread across all three phases. Each new load was added so that the current fuses could remain on the panel. The lighting loads were not large enough to change any of the feeder sizes for the panels. Also in the electrical depth is an analysis of a proposed solar array for the roof of the casino. The analysis includes monthly data for the electrical production of the array based on TMY weather data.

With the new solar array comes a new load on the roof of the casino. A structural breadth evaluates the roof decking, roof joists, joist girders, and columns of the casino's third level. The calculations show that the members of the third level are adequate for the new load, except the roof joists. The roof joists had to be increased in size from 39LH09 to 39LH11. The written calculations are included in Appendix C.

A construction breadth is included in the report that details the labor and material costs of installing the new solar array. A 10 day schedule was achieved with the RS Means 2014 release values. The installation is not expected to significantly impact the 18 month construction schedule of the casino.

## ACKNOWLEDGEMENTS

I would like to thank each and every individual who has helped me throughout this year long project.

A special thank you:

Mr. Shawn Good – Senior Thesis Advisor Ms. Leslie Beahm – Senior Thesis Electrical Advisor Dr. Kevin Houser – AE Lighting Professor Dr. Richard Mistrick – AE Lighting Professor Professor Kevin Parfitt – Director of Senior Thesis JBA Consulting Engineers – Las Vegas, NV

\*And of course a big thank you is in order for my family and fiancé. You have helped me the entire way through five years of Architectural Engineering with your love and support.

# PROJECT OVERVIEW

Casino Gold is a three level casino located in the eastern United States. The building is 309,450 sf and has three levels. The first two levels house gaming, dining, a multi-function space, a World Series of Poker Room, and even private gaming areas. The third level is mainly offices for the employees of the casino.

The project site contains three structures. They include a main casino building, a large parking garage, and a separate central services plant. The parking structure is connected to the casino with two bridges. One bridge is for the guests while the other is a smaller, service bridge. The site plan seen below shows the layout of the site.



Note: The name of the casino and the location are withheld from this report per the owner's request.

## **Project Team**

Executive Architect: ka Design/Interiors Architect: Friedmutter Group Construction Manager: Whiting-Turner Structural Engineer: Carroll Engineering, Inc. MEPT Engineer: JBA Consulting Engineers Lighting Design: The Lighting Practice

Photo Credit: Friedmutter Group

## **Construction and Cost**

Approximate cost: \$400 million Approximate dates of construction: January 2013 – July 2014 Project delivery method: Design-Bid-Build

## Codes

Major national codes: International Building Code ASHRAE 90.1 International Mechanical Code National Electric Code International Plumbing Code

## **Building**

Occupancy type: A2 Assembly, B, S1 Type of construction: Type 1B sprinklered, Noncombustible, Protected Size: 309,450 sq. ft. Levels above grade/Total levels: 3/3

#### Facade

The building façade is a mostly prefabricated architectural concrete on top of a vapor barrier, and metal studs, with batt insulation. The main entranceways of the casino have glass curtain wall systems with metal framing.

#### Roofing

The majority of the roofing for the casino is type RFA1, with the construction:

Single ply TPO roof membrane R-25 minimum rigid insulation Sheathing board 1 ½" Metal Decking on steel structure

The next largest area of roofing is type RFA2, with the construction:

Single ply TPO roof membrane Protection Board R-25 Minimum rigid insulation Vapor Retarder 3 <sup>1</sup>/<sub>4</sub>" Concrete 3" Metal decking on steel structure

## PROPOSAL OVERVIEW

The focus of my Senior Thesis Project is on the lighting and the electrical systems within the main casino. The following report will include a lighting re-design of four different spaces within the casino as well as changes to the electrical system. Breadth topics such as construction and structural will also be included. The goal of this capstone project is to provide alternative solutions to the great designs already in place, for the academic purpose of individual learning.

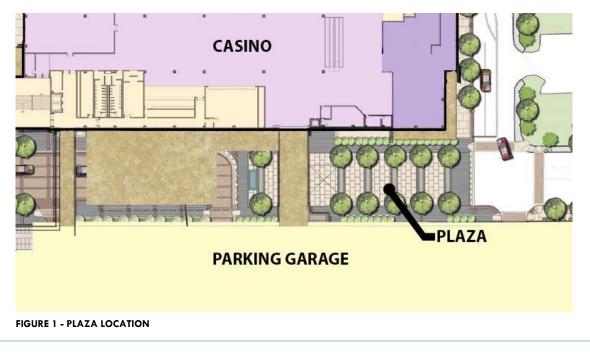
# LIGHTING DEPTH

#### Concept

The atmosphere inside of a casino is very much centered on a social experience. Whether you are enjoying a night out with your friends or you end up meeting complete strangers while playing your favorite game, people are always connecting with each other. The concept for Casino Gold's lighting design will be "Connecting with People." During our daily lives we are constantly connected to others through social media, email, and messaging. With all of this technology it can be easy to forget that face-to-face interaction with others is still important. A strong design that focuses on intimacy in certain spaces, and excitement in others, will be able to bring people together.

## **Outdoor Plaza Lighting Design**

The outdoor plaza for Casino Gold is one of the first parts of the casino that guests will encounter. It is important to create a great first impression with arriving guests. This will most likely be a meeting spot for many visitors and it will be used at all hours of the day. Due to the twenty-four hour nature of the casino, safety at night is a top priority for this space. The materials present in the Outdoor Plaza are relatively simple, as it is mostly concrete and stone work. The plaza is lined with tree planters that provide an extra element for the lighting design. The Outdoor Plaza is located between the parking garage and the casino at ground level.



#### **Recommended Illuminance Values**

The recommended illuminance values are referenced from the Illuminating Engineering Society's *The Lighting Handbook*, 10<sup>th</sup> Edition. The values for the outdoor plaza can be found in Table 34.2. For an outdoor plaza of a single commercial establishment the recommended illuminance values are taken from the low activity Plaza section.

Horizontal (E <sub>h</sub> ) Targets	Vertical (E <sub>v</sub> ) Targets	Average/Minimum Ratio
4 lux	2 lux	5:1

#### **Required Power Density**

The code requirements for power density are referenced from ASHRAE 90.1. The table pertaining to exterior lighting is Table 9.4.3B. The plaza is considered a Zone 3 and the lighting power allowance is

Building grounds					
Walkways less than 10 ft wide	No allowance	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
Walkways 10 ft wide or greater Plaza areas Special feature areas	No allowance	0.14 W/ft <sup>2</sup>	0.14 W/ft <sup>2</sup>	0.16 W/ft <sup>2</sup>	0.2 W/ft <sup>2</sup>
Stairways	No allowance	0.75 W/ft <sup>2</sup>	$1.0 \text{ W/ft}^2$	$1.0 \text{ W/ft}^2$	$1.0 \text{ W/ft}^2$
Pedestrian tunnels	No allowance	0.15 W/ft <sup>2</sup>	0.15 W/ft <sup>2</sup>	$0.2 \text{ W/ft}^2$	0.3 W/ft <sup>2</sup>
Landscaping	No allowance	$0.04 \text{ W/ft}^2$	0.05 W/ft <sup>2</sup>	0.05 W/ft <sup>2</sup>	$0.05 \text{ W/ft}^2$

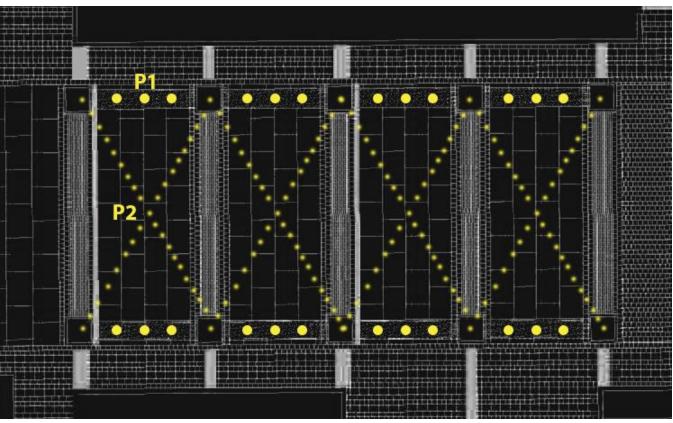
0.16 W/ft<sup>2</sup>. The approximate area of the plaza is 17,600 ft<sup>2</sup>.

### Lighting Plan and Schedule

As a result of the additional criteria for safety and guidance, the lighting design for the Outdoor Plaza makes use of overhead string lights. This overhead light not only renders the faces of guests for safety, but it also creates an inviting atmosphere for people to gather under. Attracting guests to gather and socialize is a main goal of the overall lighting design for this project and ties into the concept of bringing people together quite well. Ground mounted bollard lighting is also used to line the plaza and create a pathway to the entrance of the main casino building. Manufacturer data sheets for the selected luminaires can be found in Appendix A.

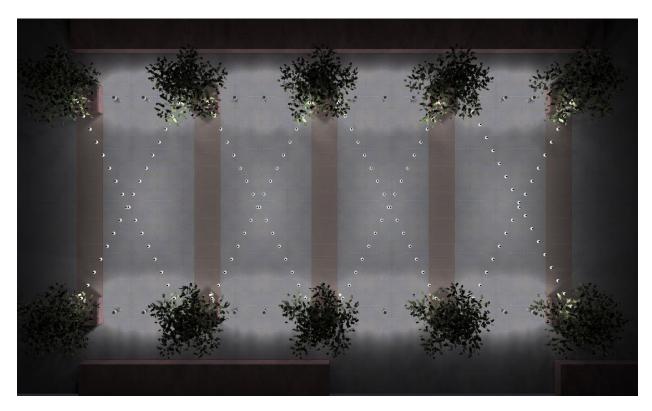
Туре	Model	Description	Manufacturer	Lamp Type	Input Volts	Input Watts	No. Used
P1	KBA8	3ft tall, 8" round, LED bollard	Lithonia	LED	120	31	24
P2	ML2000-CA	String Light	Cali	LED	120	2.5	128





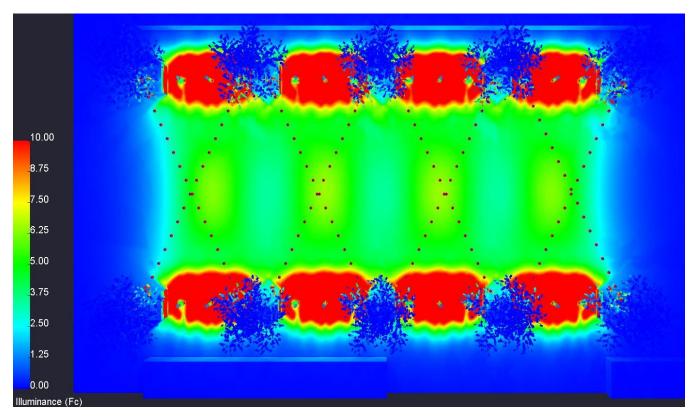
#### FIGURE 2 - PLAZA LIGHTING PLAN

The bollards have a height of 3ft and line the plaza. The string lights are stretched across the plaza from tree to tree using poles located in the planters. They are 12ft above the ground level in the plaza.



#### Calculations

AGi.32 was used to analyze the space and calculate the illuminance values of the final design. The following pseudo color rendering shows an even distribution of light across the plaza.



#### FIGURE 3 - PLAZA PLAN VIEW

Statistics	
Project 1 Calc Pts	
CalcPts Illuminance (Fc) Average=5.74 Maximum=22.6 Minimum=1.2 Avg/Min=4.78 Max/Min=18.83	

The calculated illuminance average of 5fc meets the recommendation level. The average to minimum ratio is less than 5:1, showing that the plaza is appropriately designed. The total consumption of power for the plaza is approximately 1,064W and the area is 17,600 ft<sup>2</sup>. This leads to a calculated power density of 0.06 W/ft<sup>2</sup>, well below the ASHRAE 90.1 requirement of 0.16 W/ft<sup>2</sup>.

#### AGi.32 Rendering



FIGURE 4 - PERSPECTIVE



FIGURE 5 - GUEST VIEW

#### Summary

The final design for the outdoor plaza includes LED bollards as well as string lights. The lighting achieves the main criteria of safety and guidance. With the architectural lighting overhead, guests have an inviting place to meet and socialize with friends outside of the casino. The string lights also serve a functional purpose of helping to render guests faces for safety of others, and the bollards guide guests along the plaza to the main entrance of the casino. The AGi.32 calculations show that the final design meets the IES recommendations with an average horizontal illuminance of 5fc. Finally, the 0.06 W/ft<sup>2</sup> power density of the plaza is well below the ASHRAE 90.1 code limit of 0.16 W/ft<sup>2</sup>.

## **Pre-Function Lighting Design**

Once guests have entered the first level of the casino, they may need to attend a dinner, meeting, or event in the multi-purpose room. While waiting for these events to begin it is likely that the guests will occupy the pre-function space. The Pre-Function space is located on the first level of the casino and it is adjacent to the multi-purpose room.

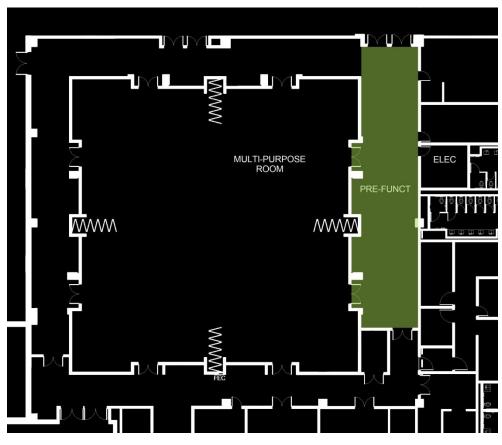


FIGURE 6 PRE-FUNCTION LOCATION

The lighting design in the Pre-Function space makes use of the architectural features present such as ceiling coves and overhangs. The materials include carpet flooring, painted GWB, and dark woodwork around the two entrances into the multipurpose room. The lighting design is meant to create an impression of spaciousness for the guests that will be gathering in the space during events.

#### **Recommended Illuminance Values**

The recommended illuminance values are referenced from the Illuminating Engineering Society's *The Lighting Handbook*, 10<sup>th</sup> Edition. The values for the Pre-Function space can be found in Table 28.2. The recommended values for the space range from 50 lux with general circulation to 200 lux for registration tables. For this particular design the desired illuminance target is for times of high activity before and after functions in the multi-purpose room.

Horizontal (E <sub>h</sub> ) Targets	Vertical (E <sub>v</sub> ) Targets	Average/Minimum Ratio
300 lux (max)	2 lux	4:1

#### **Required Power Density**

The code requirements for power density are referenced from ASHRAE 90.1. The table pertaining to space-by-space method interior lighting is Table 9.6.1. The Pre-Function space is assumed to be a common space type of Corridor/Transition for this analysis which results in a lighting power allowance of  $0.66 \text{ W/ft}^2$ . The approximate area of the Pre-Function space is 1,980 ft<sup>2</sup>.

#### TABLE 9.6.1 Lighting Power Densities Using the Space-by-Space Method

Common Space Types <sup>a</sup>	LPD, W/ft <sup>2</sup>	RCR Threshold
Corridor/Transition	0.66	Width<8 ft

#### Lighting Plan and Schedule

The lighting design for the Pre-Function space makes use of the given architectural features such as the overhangs above the doorways and the coves surrounding the recessed ceilings. Wall washing luminaires are used to highlight the areas of wall that will contain artwork. Recessed downlights are located above the entrances to the multi-purpose room to create a visual point of interest. Custom pendant luminaires line the middle of the Pre-Function space and add to the overall illumination level in the space without adding glare or significant shadows. Cove luminaires are used in the areas of recessed ceiling surfaces to create a psychological impression of spaciousness for the guests.

Туре	Model	Description	Manufacturer	Lamp Type	Input Volts	Input Watts	No. Used
F1	SQHZW	6" square lensed wallwash	Gotham	HID	120	86.6	4
F2	DoM6	6" round recessed downlight	Lithonia	LED	120	15.6	4
F3	107-P	Fabric covered pendant, square cylinder	Shaper	T5	120	93	4
F4	iW Cove MX	4ft cove accent with intelligent white light controls	Philips	LED	120	20.7	22

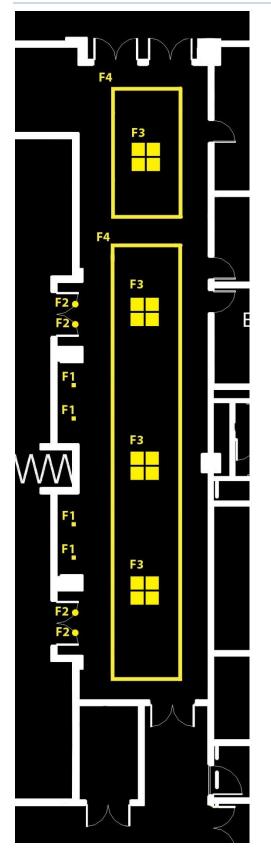


FIGURE 7 PRE-FUNCTION LIGHTING PLAN

#### Calculations

AGi.32 was used to analyze and calculate the illuminance values of the final design. The following pseudo color rendering shows an even distribution of light across the Pre-Function space.

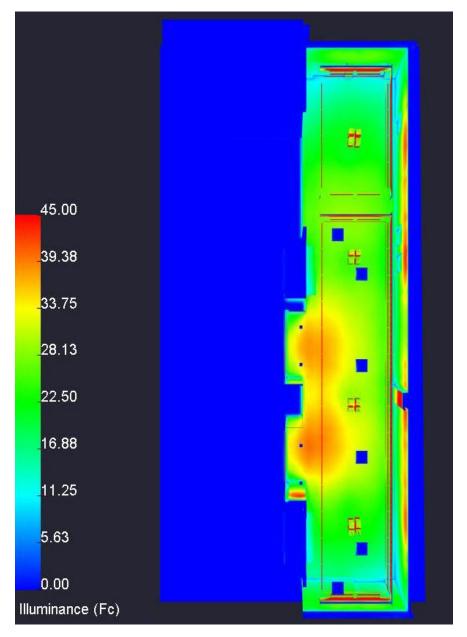


FIGURE 8 PRE-FUNCTION PLAN VIEW



The calculated illuminance average of 30fc meets the selected design criteria for the Pre-Function space. The average to minimum ratio is only 1.95, much less than the recommended 4:1 ratio. The total consumption of power for the Pre-Function space is approximately 1,236W and the area is 1,980ft<sup>2</sup>. This leads to a calculated power density of 0.62 W/ft<sup>2</sup>, which is just below the ASHRAE 90.1 requirement of 0.66 W/ft<sup>2</sup>.

#### AGi.32 Rendering



FIGURE 9 PRE-FUNCTION PLAN VIEW



FIGURE 10 PRE-FUNCTION GUEST VIEW

#### Summary

The final design for the Pre-Function space meets the design goals and criteria. This is a flexible space that can be used for many different functions taking place inside of the adjacent multi-purpose room. The cove lighting for the recessed ceiling creates the feeling of a more spacious area for guests to enjoy their social interaction before events. The pendant luminaires are a great addition to the space with their unique fabric covers and alternating suspension lengths from the ceiling. The AGi.32 calculations show that the final design meets the IES recommendations with an average horizontal illuminance of 30fc. Finally, the 0.62 W/ft<sup>2</sup> power density of the Pre-Function space is below the ASHRAE 90.1 code limit of 0.66 W/ft<sup>2</sup>.

## Poker Room Lighting Design

A poker room is about as close to a workspace as a casino will have. Players grind away at these tables for hours on end, often without leaving their seats. A space this heavily used must be visually comfortable so occupants will stick around for the long haul.

The World Series of Poker Room is located in the southeast quadrant of the second level in the casino. The floor space in the Poker Room is approximately 8,100 sq. ft. and is split into two areas. One area is for general poker games, while the other smaller area is for high-limit games or special events. The high-limit area is raised two steps above the main area and is bordered by a railing as well as an accessible ramp. The bar in the lower right corner of the plan view is not included in this design.

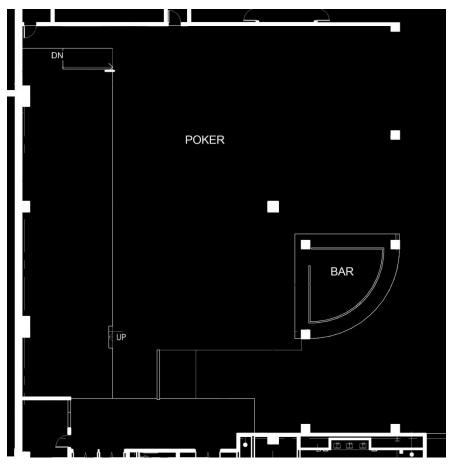


FIGURE 11 - POKER PLAN VIEW

The walls in the poker room use dark colored wood to border painted areas of GWB as well as artwork and televisions. Ceilings in the Poker Room are 15' tall with 16' recessed squares that are bordered with more dark wood trim.

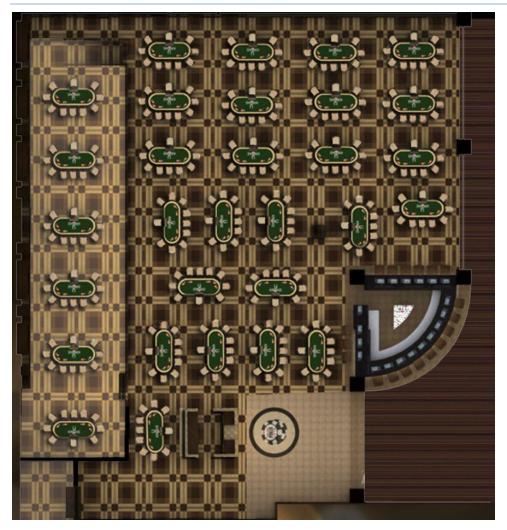


FIGURE 12 - POKER FURNITURE LAYOUT \*IMAGE COURTESY OF FRIEDMUTTER GROUP AND DESIGN TEAM

The goal of the lighting design for the Poker Room is to provide a comfortable environment for the players, especially because many players can be there for hours on end. Discipline coordination is important for the construction of this space because the proposed lighting design cannot interfere with the view of security cameras. Mechanical devices such as diffusers have to be accounted for when designing the layout of the downlights and pendants in the space.

#### **Recommended Illuminance Values**

The recommended illuminance values are referenced from the Illuminating Engineering Society's *The Lighting Handbook*, 10<sup>th</sup> Edition. The values for the Poker Room can be found in Table 28.2. The exact recommended values depend on the individual casino and their security specialist. With that in mind, the assumption is made that the Poker Room will follow the recommended illuminance values of lounges containing table games in Table 28.2. The average to minimum ratio is found in Table 12.6.

Horizontal (E <sub>h</sub> ) Targets	Vertical (E <sub>v</sub> ) Targets	Average/Minimum Ratio
300 lux	50 lux	5:1

#### **Required Power Density**

The code requirements for power density are referenced from ASHRAE 90.1. The table pertaining to space-by-space method interior lighting is Table 9.6.1. A poker room is not a very typical space so it is not listed specifically in the table. For this design it is that the Poker Room has the same power density requirements of a classroom, which results in a lighting power allowance of  $1.24 \text{ W/ft}^2$ . The reason why the classroom/lecture/training designation is assumed is because the tasks for the space are similar. Players need appropriate levels of light to read the faces of cards just the same as a student needs to read a book in class. The approximate area of the Poker Room is 8,100 ft<sup>2</sup>.

<b>TABLE 9.6.1</b>	Lighting Power Densities Using the
S	pace-by-Space Method

Common Space Types <sup>a</sup>	LPD, W/ft <sup>2</sup>	RCR Threshold	
Classroom/Lecture/Training	1.24	4	

#### Lighting Plan and Schedule

The lighting design for the Poker Room aims to create a workspace for players. Wall washing luminaires are used to highlight the areas of wall that will contain artwork. Compact fluorescent wall washing luminaires have been chosen for their color rendering qualities of the artwork and woodwork throughout the room. Recessed downlights are located throughout the entire poker room to avoid shadowing or pools of light as best as possible. Pendant luminaires are located in each of the recessed ceiling bays and provide indirect/direct light to the poker tables. Decorative wall drum luminaires are also included on the columns in the high-limits area of the lighting design.

Туре	Model	Description	Manufacturer	Lamp Type	Input Volts	Input Watts	No. Used
PK1	SQFW	6" Square Lensed Wallwash	Gotham	CFL	120	32.5	12
PK2	Ortwin	Decorative wall drum	Winona	CFL	120	32.2	3
PK3	DoM8	8" recessed round downlight	Lithonia	LED	120	27.5	123
PK4	Apollo	43" diameter bowl pendant	Winona	CFL	120	186	14



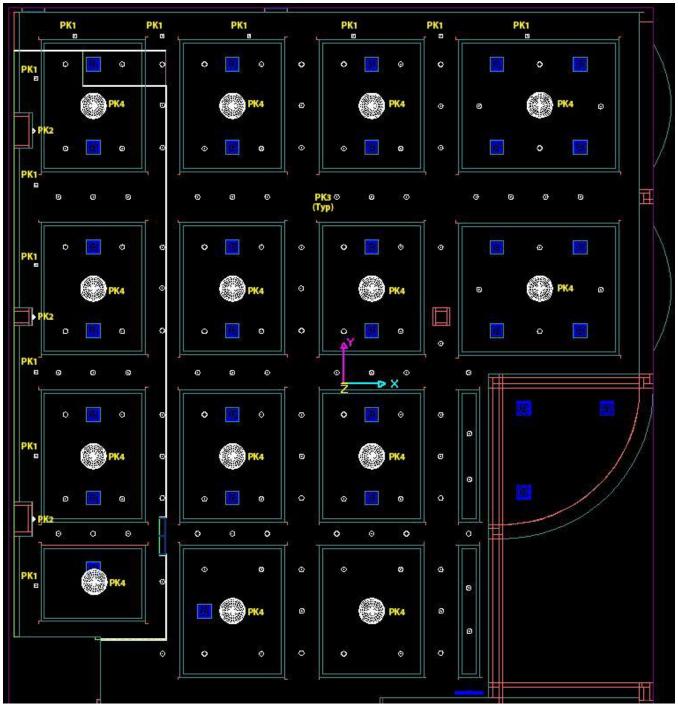


FIGURE 13 - POKER ROOM LIGHTING PLAN

#### Calculations

AGi.32 was used to analyze and calculate the illuminance values of the final design. The following pseudo color rendering shows an even distribution of light across the Poker Room.

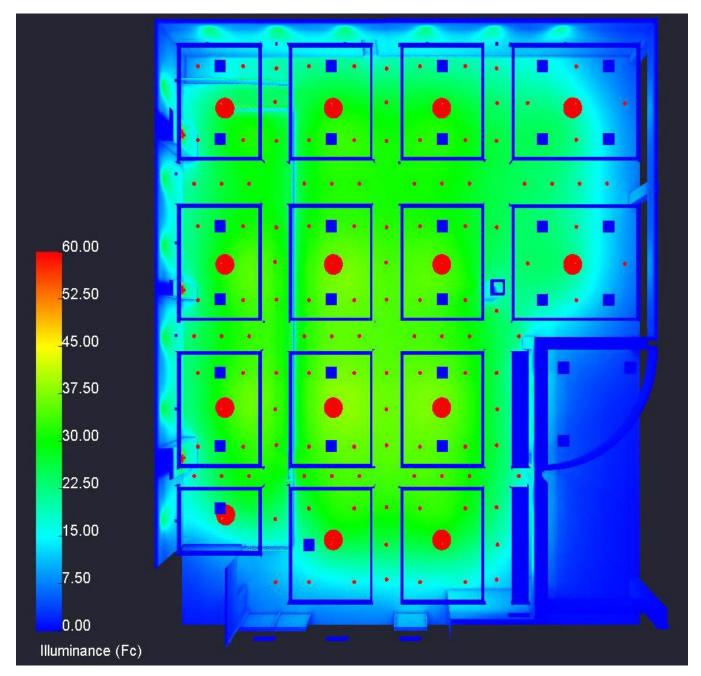
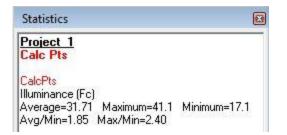


FIGURE 14 - POKER ROOM PLAN VIEW



The calculated illuminance average of 32fc meets the selected design value for the Poker Room. Also, the average to minimum ratio is only 1.85, which is much less than the recommended 5:1 ratio. The total consumption of power for the Poker Room is approximately 6,473W and with an area of 8,100ft<sup>2</sup> for this design. This leads to a calculated power density of  $0.80 W/ft^2$ , which is below the ASHRAE 90.1 requirement of  $1.24 W/ft^2$ .

#### AGi.32 Rendering



FIGURE 15 - POKER GUEST VIEW

#### Summary

The final lighting design for the Poker Room creates a workspace for the players. This is a room that will be used constantly by guests and the lighting will hold up to the task. With all of the wood finishes located throughout the Poker Room it was important to include fluorescent luminaires close to those surfaces to best render the wood color and texture. The LED downlights located across the entire ceiling ensure an even distribution of light to minimize shadows on the tables. This lighting design achieved that goal with a low average to minimum illuminance ratio of 1.85. The AGi.32 calculations show that the final design meets the IES recommendations with an average horizontal illuminance of 32fc. Finally, the 0.80

 $W/ft^2$  power density of the Poker Room is well below the assumed ASHRAE 90.1 code limit of 1.24  $W/ft^2$ .

## Player's Lounge Lighting Design

The Player's Lounge brings the "Connecting with People" concept full circle by creating an intimate setting for the guests to visit and interact with each other. This is one of the few places in the casino that the owner can make a profit from beverage sales, so the lighting design of the bar within the Player's Lounge is used to attract guests from outside of the lounge. It is located in the southwest quadrant of the casino's second level.



FIGURE 16 - PLAYER'S LOUNGE LOCATION

The goal of the lighting design for the Player's Lounge is to provide an inviting setting that draws guests into the space and keeps them there. The bar is the main focus from outside of the space and so is the wall surrounding the entrance. It gives guests a glimpse of the interior and tempts them to enter.

#### **Recommended Illuminance Values**

The recommended illuminance values are referenced from the Illuminating Engineering Society's *The Lighting Handbook*, 10<sup>th</sup> Edition. The values for the Player's Lounge can be found in Table 22.2. A lounge can be found under the section of Food Service for Common Applications.

Horizontal (E <sub>h</sub> ) Targets	Vertical (E <sub>v</sub> ) Targets	Average/Minimum Ratio
100 lux (lounge area)	50 lux	3:1
50 lux (back bar)	20 lux	3:1

#### **Required Power Density**

The code requirements for power density are referenced from ASHRAE 90.1. The table pertaining to space-by-space method interior lighting is Table 9.6.1. A lounge can be found under Dining Area, which results in a lighting power allowance of  $1.31 \text{ W/ft}^2$ . The approximate area of the Player's Lounge is  $1,556 \text{ ft}^2$ .

#### TABLE 9.6.1 Lighting Power Densities Using the Space-by-Space Method

Common Space Types <sup>a</sup>	LPD, W/ft <sup>2</sup>	RCR Threshold
Dining Area	0.65	4
For Bar Lounge/Leisure Dining	1.31	4

#### Lighting Plan and Schedule

The lighting design for the Player's lounge is centered on the guest experience and social interaction. This connection with people is based directly off the casino's lighting concept. Pendant luminaires create intimate seating areas for small groups of guests in the lounge area. Cove lighting provides a soft glow while highlighting the unique architectural features of the ceiling above the guests. Suspended linear luminaires provide an indirect light about the space between the seating and the bar so that glare is not an issue. Behind the bar the coves are illuminated to draw attention to it from people just outside looking in.

Туре	Model	Description	Manufacturer	Lamp Type	Input Volts	Input Watts	No. Used
L1	Ortwin	36" drum with custom finish	Winona	CF	120	94	2
L2	iW Cove MX	4ft linear cove with intelligent white light	Philips	LED	120	20.7	8
L3	LL1MA	Indirect/direct linear suspended	Peerless	Т8	120	30.5	28

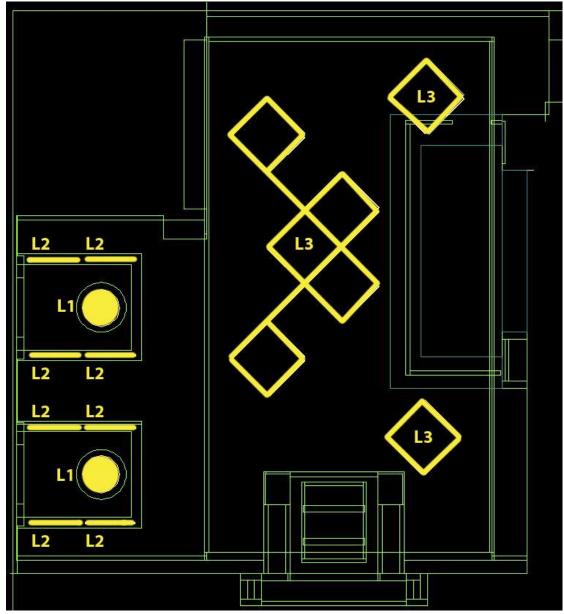


FIGURE 17 - LIGHTING PLAN

#### Calculations

AGi.32 was used to analyze and calculate the illuminance values of the final design. The following pseudo color rendering shows an even distribution of light across the Player's Lounge.

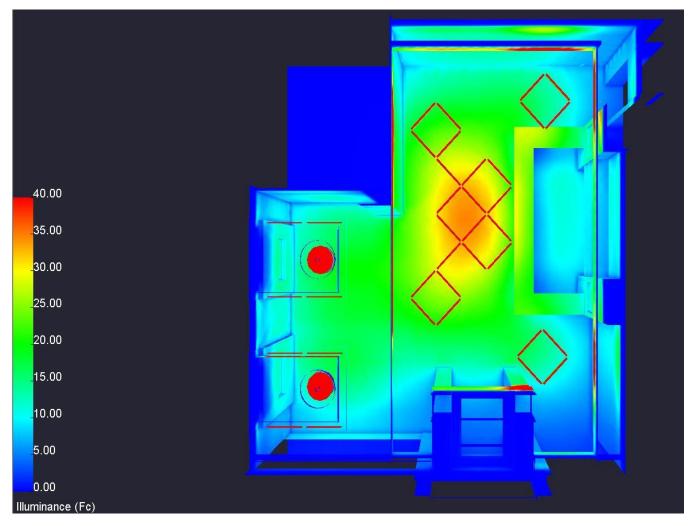
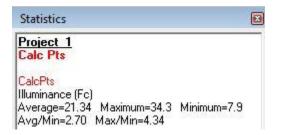


FIGURE 18 - LOUNGE PLAN VIEW



The calculated illuminance average of 21fc exceeds the selected recommended value for the Player's Lounge. The average to minimum ratio is only 2.70 which is just under the ASHRAE 90.1 requirement of 3:1. The total consumption of power for the lounge is approximately 1,208W with an area of 1,556ft<sup>2</sup>. This leads to a calculated power density of 0.78 W/ft<sup>2</sup>, which is below the ASHRAE 90.1 requirement of 1.31 W/ft<sup>2</sup>.

### AGi.32 Rendering



FIGURE 19 - PLAN VIEW

#### Robertson



FIGURE 20 - FRONT VIEW

#### Summary

The final lighting design for the Player's Lounge creates a space for guests to interact without gambling. With all of the wood and stone finishes located throughout the lounge it was important to include fluorescent luminaires close to those surfaces to best render the wood color and stone textures. The LED cove lights used have an intelligent white control so that the color temperature can be adjusted by the user on site. The AGi.32 calculations show that the final design meets the IES recommendations with an average horizontal illuminance of 21fc. Finally, the 0.78 W/ft<sup>2</sup> power density of the Player's Lounge is below the ASHRAE 90.1 code requirement of 1.31 W/ft<sup>2</sup>.

# ELECTRICAL DEPTH

The electrical depth for Casino Gold focuses on the redesign of existing panels to meet the new lighting demands that have resulted from the Lighting Depth. The lighting loads were not a large enough change to require the resizing of any feeders.

Also included in the electrical depth is a photovoltaic array that has been added to the main roof of the casino. The evaluation of the solar resource was conducted in a software system known as SAM. SAM is a shortened version of System for Advisor Model. Monthly outputs of electricity produced by the array were calculated and a cost study is included in the Construction Breadth. The structural impacts are also evaluated in the Structural Breadth of this report.

Manufacturer's data sheets for the specified solar module and inverter are located in Appendix B.

## **Existing Electrical Information**

#### **Connected Building Loads**

There are numerous distribution boards and panelboards throughout the casino. The distribution system can be somewhat simplified by tracing all of these connected loads back to the five main switchboards that service them. The main switchboards for Casino Gold are: MSA, MSB, MSC, MSD, and GMS1 (the generator switchboard. The loads for each of these are:

- MSA 723 kVA
- MSB 2226 kVA
- MSC 1749 kVA
- MSD 2482 kVA
- GMS1 318 kVA
- Total Building Load 7498 kVA

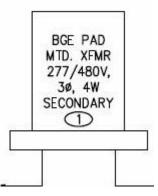
#### **Power Company Rate Schedule**

Schedule GL – General Service Large-Electric, 480V Service Voltage

#### **Building Utilization Voltages**

The Power Distribution for Casino Gold begins in the Central Plant building located just outside the casino. Service from Baltimore Gas and Electric enters the Central Plant into multiple 480/277V Secondary transformers. These transformers are owned by Baltimore Gas and Electric even though they are inside of casino property. Adjacent to each transformer is a switchboard that begins a branch of the distribution system. Distributions panels are separated for emergency loads, lighting loads, high voltage loads, and low voltage loads.

- Building Utilization Voltage 480/277 V
- Lighting 120 volt, plus low voltage LED lighting
- Receptacle 120 volt
- Mechanical 480 volt 3 phase



- Special Equipment
  - IT Equipment 120 volt
  - Fire Pumps 208 volt
  - Elevators 480 volt

#### Emergency Power Distribution System

The emergency power for Casino Gold originates at a diesel generator. This 500kVA generator has the capability to produce 400kw of power and operates on 277/480V. Loads connected to the emergency system include:

- Fire Pump (103kVA load)
- Switchboard GMS1 (318kVA load)
  - Distribution Board 'EDBHA'
  - Distribution Board 'EDBHCP'
  - Distribution Board 'ELEV1'

Each of the distribution boards listed above has a 4-pole automatic transfer switch connected to it that operates in the event of a power loss.

## **Changes to Existing Panels**

Four electrical panels have been changed due to the new lighting loads. There is one modified panelboard for the Plaza, Pre-Function space, Poker Room, and Player's lounge. The lighting loads were not significant enough to change fuse size or feeder size on the panels and branch circuits.

#### **Outdoor Plaza**

JOB: X000000					VOLTAGE: BU\$: MAIN\$: AIC RATING:				20/208 W 225A L.O. 10,000			3Ø, 4W LOCATION: MOUNTING:		COR		2131	6		IT CODE: blank or N: NON-CONTINU L: LONG-CONTINU R: DEMANDABLE I K: KITCHEN N	JOUS RECEPT	DUS ECEPTACLES		
скт	CODE	TRIP	POLE	LOAD DESCRIPTION	м	R	L	NOTE	A	в	l c	A	в	с	NOTE	L.	R	м	LOAD DESCRIPTION	POLE	TRIP	CODE	
1	R	20	1	RECEPTS		2	-	More	360	-		100			HOTE	-		1	DDC	1	20	N	2
3	N	20	1	UH-2	1	-	8	8 8		100		100	100	0 0				1	AHU-1 DDC	1	20	N	
5	N	20	1	UH-1	1		51			100	100		100	1176				1	EF-1 (1/2HP)	1	20	N	
7	N	20	1	MOTORIZED DAMPER	1	8	2		100	9. <u>2</u>	100	0		1110	1000	9		-	SPARE	1	20	-	
9	R	20	1	RECEPT	-	4	4-	4 - 2	100	720		-	50	4 (4		-	-	1	TERRACE HEATER	1	20	N	
11	N	20	1	VAV	6	-	<i>.</i>	<del>1. 1</del> 7			300	1 - H		150				3	TERRACE HEATER	1	20	N	
13	R	20	1	RECEPTS - POLE	-	1	÷.	<del>8</del> 8	180	-		540		100			3	-	REC - TERRACE	1	20	R	
19				RECEPT - POLE	-		-	-		-		-		2 2		-	4	- 1	RECEPTS	_	1000		1
	R	20	1		_	1	-	-	180	100		720	-	-		-	-		RECEPTS	1	20	R	-
21	R	20	1	RECEPT - POLE RECEPT - POLE	_	1				180	180		720	100			4	_	METERS	1	20	R	2
23 25	R	20	1	RECEPT - POLE	-	1			180		iou	100		100			-	-	METERS	1	20 20	N	
20	R	20	1	RECEPT - POLE	-	1			100	180		100	100					-	METERS	1	20	N	
27	R	20	1	RECEPT - POLE SIGN	-	1	1			100	500	-	100	744			-	-	101 SA 6866			-	1
29 31	-	20	1	SIGN	-		1	5	500		500	320		744	-	-			PLAZA BOLLARD LTG	1	20	-	
31	L	20			-		1		500	500		320				-	1			_			
2.4	L		1	SIGN	-		1	-		500	200	-	0		-	-	-	-	SPARE	1	20	-	-
35	L	20	1	SIGN SIGN	-		1	0	500	2	500			0	-	-	-	-	SPARE	1	20	-	
37 39	L	20 20	1	SPARE	-		-	-	500	-		0			-	-	-	-	SPARE	1	20	-	
3¥ 41		20		SPARE	-	-	-			0			0	0	-	-	-	-	SPARE	1	20	-	-
	-	20	1	SPARE	-	-	-	-		8	0			0	-	-	-	-	SPARE	1	20	-	1
43	-	20		SPARE	-	-	-	-	0			0		2	-	-	-	-	SPARE		20	-	1
45	-		1		-	-	-	-		0	-	-	0	-	-	-	-	-	SPARE	1	-	-	4
		20	1	SPARE	-	-	-				0			0		-	-	-		1	20	-	-
49	-	20	1	SPARE SPARE	-	-	-	-	0			0			-		-	-	SPARE SPARE	1	20	-	
51 53	-	20	1	SPARE	-	-	-			0	0		0	0	-	-	-	-	SPARE	1	20 20	-	1
55		20		SPARE	-	-	-	-	0	5		0		v	-	-	-	-	SPARE	-	20	-	1
57	-	20	1	SPARE	-	-	-	-	0	0			0	-	-	-	-	-	SPARE	1	20	-	
59	-	-		SPARE	-	-	-	-		0			0		_	-	-	-	SPARE	-	_		6
		20	1	SPARE	-	-	-	-			0			0	-	-	-	-	SPARE	1	20	-	-
61 63	-	20	1	C + 2011 0 F 2011	-	-	-	-	0			0	-	-	-	-	-	-		1	20	-	6
1000	-	20	1	SPARE SPARE	-	-	-	-		0			0	-	-	-	-	-	SPARE SPARE	1	20	-	-
65	-	20		1000	-	-	-	-			0			0	-	-	-	-	SPARE	1	20		1
67 69	_	20	1	SPARE SPARE	-	-	-		0	0		0	0	8 8	-	-	-		SPARE	1	20	-	-
69 71	-	20	1	SPARE	-	-		-		0	0	-	0	-	-	-	-		SPARE	1	20	-	
71		20		SPARE	-	-	-	_		-	0			0		-	-	-	SPARE	1		-	-
73	-		1		-	-	-	-	0	-		0	-	-	-	-	-	-		1	20	-	
1.5.1.1	125	20	1	SPARE	-	-	-	1000		0		-	0		0.000	-	-	-	SPARE	1	20	0.000	1
77	-	20	1	SPARE	-	-	-	-		-	0			0	-	-	-	-	SPARE	1	20	-	7
79 81	-	20	1	SPARE SPARE	-	-	-	-	0	0		0	0	<u> </u>	-	-	-	-	SPARE SPARE	1	20	-	1 2
83		20		SPARE	-	-	-	-		0	0	-	0		-	-	-	-	SPARE		20	-	8
65	-	20	1	SPARE	-	-	-	-		-	-			0	-	-	-	_		1		-	1
NEL	NOTES				1	PHAS	SETO	DTALS	3780	DVA.	409	OVA	4650	AV					TOTAL CONNECTED VA CONNECTED VA (CODE N)		3,83	20 VA	
															-	_	_	_	CONNECTED VA (CODE L)	<u> </u>		O VA	_
															-	-	-	-	CONNECTED VA (CODE R)	<u> </u>		AVO	
															-				CONNECTED VA (CODE K)	<u> </u>		VA	
															-				PANEL CONNECTED KVA			5 KVA	
																			PANEL CONNECTED KVA	1	14.4	AVA	

The plaza lighting was added to branch circuits 30 and 32 of Panel LCCB. Using the power consumption data from the luminaire spreadsheets, and the quantity of luminaires from the light depth, a load for each circuit was calculated. The perimeter lighting is calculated to have a load of 733VA, while the string lights have a smaller load of 320VA. This lighting is considered to be a non-continuous load and each branch circuit will keep its 20A fuse.

#### **Pre-Function**

PANEL: LCAC					VOLTAGE: BUS: MAINS: AIC RATING:			1.	20/208 W 225A L.O. 22,000	ye		LOC	3Ø, 4VV LOCATION: NOUNTING:			105	Cir	100	IT CODE: blank or N: NON-CONTINU L: LONG-CONTINU R: DEMANDABLE F K: KITCHEN NO	IOUS RECEPT			
СКТ	CODE	TRIP	POLE	LOAD DESCRIPTION	м	-	L	NOTE	А	В	С	A	В	С	NOTE	L	R	M		POLE	1.000	CODE	20.00
া	R	20	1	RECEPTS - IDF		5	a	. — »	900			409				-	-	-	PREFUNCTION PERIMETER	া	20	199	. 3
3	R	20	1	RECEPTS	_	2	J.			360			455			-	-	-	PREFUNCTION COVE	1	20	-	-
5	R	20	1	RECEPT - PREFUNCTION	0	1					180			372	1	-	-	Ξ	PREFUNCTION PENDANTS	1	20	-	
7	R	20	1	RECEPT - PREFUNCTION		1	Ĩ.	ĺ.	180			U		d		-	-	-	SPARE	1.1	20	-	
9	R	20	1	RECEPT - PREFUNCTION		1	ĵ.			180			0	i i	37/8	17	$\overline{a}$	-	SPARE	1	20	375	
11	R	20	1	RECEPT - PREFUNCTION	1	1	1	1			180	3 2		0	230	E.	<u>s</u> ,	ίΞ,	SPARE	1	20	020	
13	R	20	1	RECEPT - PREFUNCTION	22	1	3		180	1 1		0			120	-	-	-	SPARE	1	20	-0.2003	
15	R	20	9	RECEPT - PREFUNCTION	14	1				180			0		223	3	10	1	SPARE	Э,	20	122	
17	R	20	1	RECEPT - PREFUNCTION		1	1				180			0		-	-	-	SPARE	1	20		
19	R	20	1	RECEPT - JANUS		2	1		360	[ ]		0		) )		E.	-	-	SPARE	1	20	-	
21	R	20	6.816	RECEPT - ARTWORK	Č.	1	Ĩ.			180		1	0		-	-	-	-	SPARE	1	20	-	
23	R	20	1	RECEPT - ARTWORK		1		1. Th			180			0	-	-	-	-	SPARE	1	20	278	
25	R	20	1	RECEPT - ARTWORK	10	1	1		180	-		0		-	1.00	-	1	-	SPARE	1	20	र जन्म	
27	R	20	1	RECEPT - ARTWORK	1	1	9	9 3		180			0		570	-	-	-	SPARE	1	20	0.510	1
29	( 2 )	20	1	SPARE	2	-	-	-			0	8 8		0	1.20	-	-	-	SPARE	1	20	0.270	3
31	12	20	1	SPARE	-	-	-	223	0	<u> </u>		0			2233	1		-	SPARE	1	20	3223	t
33	12	20	1	SPARE	-	-		-		0			0		- 20	-	-	-	SPARE	1	20	522	t
35		20	1	SPARE	-	-	-	-			0	2 X	-	0		-	-	-	SPARE	1	20	-	t
37		20	1	SPARE				-	0	<del>( )</del>	~	0			-	-	-	-	SPARE	1	20	-	+
39		20	1	SPARE	1000			-		0	_		0	-		-	-	-	SPARE	1	20	- 1990. 	+
41	 	20		SPARE	0,550		-	-			0			0		-	-	2	SPARE	100	20	- 67%) - 11	+
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45		20	1	SPARE	-	-	-	-		0		8 9	0	8 1	-	-	-	-	SPARE	1	20		
47	<u> </u>	20	1	SPARE	-	-	-	1			0	3		0		-	-	-	SPARE	1	20	1941	
49	~	20	_1	SPARE	-	-	-	100	0			0		4		-	1	-	SPARE	া	20	243	
51	. ÷.,	20	ુલ્લર	SPARE	-	-	-	18 A.		0			0		1.000	-	-	-	SPARE	1	20	-	-
53	, R	20	1	SPARE	100	-	-	1			0			0	1	-	-	.=	SPARE	1	20	-	
55	177	20	1	SPARE	550	-	-	1778	0			0		1 1	100	-	-	=	SPARE	1	20	278	
57	177	20	1	SPARE	1	-	-	125		0			0	í	37/8	7	$\overline{a}$	-	SPARE	1	20	375	
59	S 1	20	1	SPARE	55	-	-	100			0			0	530	1	्य	-	SPARE	1	20	(30)	
61	(-2)	20	1	SPARE	-	-	-	-	0	( ))		0			- 20	-	-	-	SPARE	1	20	-0209	
63	_ <del>```</del>	20	1	SPARE		-	-	2		0			0		- 22/3	-	-	-	SPARE	A.,	20	144	-
65	-	20	1	SPARE	-	-	1	1			0			0	1440	-	-	-	SPARE	া	20		
67	×.	20	(1)	SPARE	-	-	-	1	0			0			-	E.	-	-	SPARE	1	20	-	
69	-	20	1	SPARE	-	-	-	1		0		1	0	1	1	-	-	Ξ	SPARE	1	20	-	
71	1	20	1	SPARE	-	-		1			0			0	178	-	-	1	SPARE	1	20	- 275	-
73	177	20	1	SPARE	-	-	-	3	0			0		1	100	-	$\overline{a}$	-	SPARE	1	20	3751	
75		20	1	SPARE	5.00	-	-	3		0		a) (19	0		1770	1	1	1	SPARE	1	20	6570	
77	- 2 - 3	20	1	SPARE	12	-	-	14		5 3	0	8 18		0	1020	-	-	-	SPARE	1	20	-0.2003	
79	12	20	1	SPARE		-	-	220	0			0			3213	13	1	-	SPARE	9	20	1223	T
81	-	20	1	SPARE		-	-	-		0			0		140	-	-	-	SPARE	1	20	342	t
83		20	1	SPARE	1	-	-	-		1	0			0	- 540	-	-	-	SPARE	1	20	-	+
-			2				E TO	TALS	2209	1/4	153	5 VA	720	1/A				-	TOTAL CONNECTED VA		115	4 VA	<u> </u>
NEL	NOTES	5													100					1			
																			CONNECTED VA (CODE N)		0	VA	
																			CONNECTED VA (CODE L)		0	VA	_
															The second se				CONNECTED VA (CODE R)		360	AVIO	_
															-				CONNECTED VA (CODE K)			VA	
																			PANEL CONNECTED KVA			KVA	
															1				PANEL DEMAND KVA	<u> </u>	52.00	KVA	_
															-				PANEL DEMAND AMPS	<b>—</b>		4A	_

Three branch circuits were used on Panel LCAC for the lighting in the Pre-Function space. Existing receptacles in the Pre-Function space are already located on the left side of this panel. The perimeter lighting on branch circuit 2 includes the wallwash luminaires as well as the 6" LED downlights, both from the lighting depth report. The new cove lighting in the Pre-Function space is located on branch circuit 4 of this panel and is the largest of the three new loads at 455VA. Finally, the 4 pre-function pendants were

added to branch circuit 6 with a load of 372VA. All three of these loads are under 1920VA, meaning that they are able to stay on the current 20A circuits.

### Poker Room

F/	ANE,	L. L 06: X		5		MAI	US: NS:	12	100A 100A L.O. 10,000			LOC	30, 4VV ATION: NTING:	SEC	JRTTY E	213	CIF	RCU	IT CODE: blank or N: NON-CONTINU L: LONG-CONTINU R: DEMANDABLE I K: KITCHEN N	uous			
СКТ	CODE	TRIP	POLE	LOAD DESCRIPTION	M	R	L	NOTE	Α	в	с	A	в	с	NOTE	L	R	M	LOAD DESCRIPTION	POLE	TRIP	CODE	СКТ
1	R	20	1	RECEPTS - CORRIDOR		4			720			720							RECEPTS - CORRIDOR	1	20	R	2
3	R	20	1	RECEPTS - OFFICE		3				540	Ĵ.		180				1		RECEPTS - ELEV EQ	1	20	R	-4
5	R	20	1	RECEPTS - OFFICES		3					540			180	1		1		RECEPTS - COND	1	20	R	6
7	R	20	1.7	RECEPTS - OFFICES		4			720		5	0			-	-	-	-	SPARE	1	20	-	8
9	S <del></del>	20	1	Poker Room Perimeter Ltg	-	-	-	35 <b>5</b> 5		487			720		Ĩ.		4		RECEPTS - SECURITY	1	20	R	10
11		20	1	Poker Room Down Ltg	-	-	-	375	G. (1		1128		a 10	200				2	DDC	1	20	N	12
13	0770	20	1	5	100	-	-	0000	1128		8	300	S - 5	-		- 7		3	DDC	1	20	N	14
15	- 0.277	20	1	2	-	-	-	2022	3	1128	8		100		3 8	3		1	DDC	1	20	N	16
17	3 <u>4</u> 3	20	12.	Poker Room Pendants	-	-	12	842			868			0	22	-	-		SPARE	1	20	1040	18
19	- 24	20	1	-	2	-	-	5-	868			0			-	-	-	-	SPARE	1	20		20
21	-	20	1		-	-	4	34		868			0		-	-	-	-	SPARE	1	20		22
23	100	20	1	SPARE	-	-	-	23 <del></del> 5			0		ii i	0	8 <del>4</del> 8	-	-	÷	SPARE	1	20		24
25	378	20	1	SPARE	1	1	1	200	0			0			19-58	-	-	-	SPARE	1	20	1. A. C.	26
27	175	20	1	SPARE	-	-	-	9 <del>7</del> 8	() ·	0	S. 5		0		1000	-	-	-	SPARE	1	20	19 <del></del>	28
29	6.56	20	1	SPARE	-	-	2	3000	S - 2	-	0		3	0	-	07	-	-	SPARE	1	20	1000	30
31	-02053	20	1	SPARE	-	-	-	100	0	1		0				22	1	4	SPARE	1	20		32
33	1943), 1	20	1	SPARE	-	-	12	34		0			0		2	-	2	1	SPARE	1	20		34
35	242	20	1	SPARE	2	-	-	5.44			0		14 14	0		-	-	-	SPARE	1	20	-	36
37	-	20	1	SPARE	-	-	-	100-	0			0			243	-	-	1	SPARE	61	20	() 	38
39	1	20	1	SPARE	-	-	-	20 <del>00</del>	Î. Î	0			0		-	-	-	F	SPARE	1	20		40
41	278	20	1	SPARE	1	1	-	2000			0			0	8 <del></del> 8	-	-	-	SPARE	1	20	1	42
PANEL	NOTES		e - 68		1.5	PHA	SE T	OTALS	445	5 VA	402	3 VA	2916	5 VA	6 6 6	A 80	- 28	5 - 53	TOTAL CONNECTED VA		1139	95 VA	£
															- T				CONNECTED VA (CODE N)		600	AVO	
															1				CONNECTED VA (CODE L)	-	0	VA	
															8				CONNECTED VA (CODE R)	iš.	432	0 VA	
																			CONNECTED VA (CODE K)	0	0	VA	
															1				PANEL CONNECTED KVA		11.4	KVA.	
																			PANEL DEMAND KVA	6	11.4	KVA	
																_	_		PANEL DEMAND AMPS		31	6 A	

The additions to Panel LAAC for the Poker Room are different from the previous two panels because some of the loads were spread across 3 phases. The first load that was added to the panel was the Poker Room perimeter lighting, which includes the wallwash luminaires and the wall drum luminaires from the lighting depth. The perimeter lighting has a total load of 457VA. The next load is the 8" LED downlights that are arrayed across the space. These downlights totaled a load of 3383VA so the load was spread across the 3 phases evenly with 1128VA loads. This allows the downlights to be grouped together and stay on the current fuse of 20A. Finally, the Poker Room pendants were added to the panel in the same fashion. The pendants have their load spread across the 3 phases with 868VA on each phase.

### Player's Lounge

F	ANE ,	08: X				BU MAIN	IS: IS:	13	20/208 W 225A L.O. 10,000	ye		LOC	3Ø, 4VV ATION: NTING:	SER		R C26		RCU	IT CODE: blank or N: NON-CONTINU L: LONG-CONTINU R: DEMANDABLE K: KITCHEN N	UOUS RECEPT		NT:	
СКТ	CODE	TRIP	POLE	LOAD DESCRIPTION	м	R	L	NOTE	A	в	С	A	в	С	NOTE	L	R	M	LOAD DESCRIPTION	POLE	TRIP	CODE	CK
1	к	20	1	E23-002 DISPLAY CASE		1			1440			180					1		CONV OUTLET	1	20	R	2
3	К	20	1	E23-018 COFFEE GRINDER		1		1		1128			180	6			1	-	CONV OUTLET	1	20	R	4
5	K	20	1.0	E23-012 BEV CTR	1	2	8	§ §		1 6	840	6 8		1920			1		E23-023 BOD UNIT	1	20	R	6
7	К	20	1	E23-084 LIQOUR GUN					1200			1800					1		E23-078 POS	1	20	R	8
9	K	20	1	E23-067 BLENDER	1	1				1920			1920				1		E23-087 CPU	1	20	R	10
11	К	20	1	E23-007 CARBONATOR		1				1	1800			1200			1		E23-083 CASH REGISTER	1	20	R	12
13	К	20	1	E23-091/041 CABINET/BAR TOP	2	8	6	1	1200			1800		· · · ·			1		E23-078 POS	1	20	R	14
15	K	20	1	E23-078 CARBONATOR		1		÷		1800			1800				1		E23-083 CASH REGISTER	1	20	R	16
17	K	20	1	E23-070 REACH-IN COOLER		1		<u> </u>		1	1020			1920			1		E23-043 PRINTER	1	20	R	18
19	К	20	1	E23-089 SS CABINET WITH STEPS	1			0	600	1		1920					3		E23-086 CPU	1	20	R	20
21	K	20	1	E23-081 REACH IN COOLER		1		3 8	1	1020		1 2	1800	1			1		E23-083 CASH REGISTER	1	20	R	22
23	К	20	1	E23-107/108/109 BCKBR STOR/CLR	5			1			941		10000	3016			1		E23-015 COFFEE BREWER	2	40	K	24
25	K	20	1	E23-095 BAR TOP AND DIE	1000	1	-	-	1200	-		3016			122	-	-	-	-				26
27	К	20	1	E23-064 LIQUOR STEPS	-	1	-			1200	-		3600		-	-		1	E23-034 ICE MAKER	3	40	K	28
29	K	20	1	E23-007 CARBONATOR	100	1		5 (A) (5 (S)		1200	1800	1		3600	1207	-	-	-		-	-	-	30
31	K	25	1	E23-100 BLENDER STATION	1	1		1	2400		1000	3600	-	0000	-	-	-	-	-	-	-	-	32
33	ĸ	20	1	E23-084 SOLENOIDS	3.5	1	-		2400	1200	-	3000	1560	2 3	0776	-	1	-	E23-063 FROZEN DRINK MACH	2	20		34
10000	30.00				-				-	1200	100	-	1300	4550		-	-		E23-063 PROZEN DRINK MACH		1.000	K	36
35	K	20	1	E23-007 CARBONATOR	-	1			4000		180	4550		1560	-	-	2.5	-	E23-063 FROZEN DRINK MACH	-	-	-	1.0
37	K	20	1	E23-095 BAR TOP AND DIE	1	8		5 - G	1200	<u> </u>		1560		9 9			1		E23-063 PROZEN DRINK MACH	2	20	K	38
39	К	40	1	E23-101 GLASSWASHER	1		-		-	3228		1	1560	-	-	-	-	-	-	-	-	-	40
41	R	20	1	RECEPTS - SERVICE BAR C260	-	3	-		700	<u>,  </u>	540	-		1560			1		E23-088 GLASSWASHER	2	20	K	42
10	-	- 22	-			-	-	2 - X	-		_	1560			-	-	-	-	-	-	-	-	44
45	-	20	1	BAR COVE LTG	-	-	-	-		166			180				1		CONV OUTLET	1	20	R	46
47	3)	20	1	BAR PENDANT	-	-	-	-			188			180			1		CONV OUTLET	1	20	R	48
49		20	1	BAR OVERHEAD LTG	-	-	-	1000	854			180					1		CONV OUTLET	1	20	R	50
91	5.	20	1	SPARE	1		-	-		v			180				1		CONV OUTLET	1	20	R	52
53	-	20	1	SPARE	-	-	-				0	1 - B		180			1		CONV OUTLET	1	20	R	54
55	-30	20	1	SPARE	-	-	-		0			180			-	-	1		E23-103 CASH REGISTER	1	20	K	56
57	->	20	1	SPARE	-	-	-	-		0			180				1		E23-103 CASH REGISTER	1	20	R	58
59	-	20	1	SPARE	-	-	-	-			0			0	-	-	-	-	SPARE	1	20	-	60
61	-	20	1	SPARE	-	-	-	-	0			0			-	-	-	-	SPARE	1	20	-	62
63	-	20	1	SPARE	-	-	-	-		0			0		-	-	-	-	SPARE	1	20	-	64
65		20	1	SPARE	-	-	-	1000			0			0		-	-	-	SPARE	1	20	8 <b>-</b> 9	66
67	-	20	1	SPARE	-	-	-		0			0			-	-	-	-	SPARE	1	20	-	68
69	-	20	1	SPARE	-	-	-	-	3	0		1 8	0		-	-	-	-	SPARE	1	20	-	70
71		20	1	SPARE	-	-	-	-		. 3	0			0	-	-	-	-	SPARE	1	20	-	72
73	-3	20	1	SPARE	-	-	-	-	0			0			-	-	-	-	SPARE	1	20	-	74
75	-	20	1	SPARE	-	-	-	-		0			0		-	-	-	-	SPARE	1	20	-	76
77	-	20	1	SPARE	-	-	-	-			0			0	-	-	-	-	SPARE	1	20	-	78
79	-	20	1	SPARE	-	-	-	-	0	1		0		-	-	-	-	-	SPARE	1	20	-	80
81		20	1	SPARE	-	-	-			0			0	0	-	-	-	-	SPARE	1	20		82
83	-	20	1	SPARE	-	-	-	-		-	0	1	- 17	0	-	-	-	-	SPARE	1	20	-	84
	2333			71107	1.00			TALS	2661	0.1/4	26	22 VA	224	IS VA	3.80	- 3	1003		TOTAL CONNECTED VA	30	-	77 VA	
ANE	NOTES							TAL .			-		-		- 2					1			
															E.				CONNECTED VA (CODE N)	10) 	0	VA	
																			CONNECTED VA (CODE L)	1	0	VA	
																			CONNECTED VA (CODE R)		187	BO VA	
															1				CONNECTED VA (CODE K)	2.22	- 64.4	89 VA	
																			PANEL CONNECTED KVA	2 iv		KVA	
															- E					0155	100		
																			PANEL DEMAND KVA	916	50 5	5 KVA	

The final panel that was modified due to the new lighting loads is Panel KLDBC. Three branch circuits were used for the new lighting in the Player's lounge. The first load, the Bar Cove Lighting on circuit 45, has a small total of 166VA. Next, a branch circuit was used for the two pendants located in the seating area of the lounge. The pendants were placed on branch circuit 47 with a load of 168VA. Finally, the third load that has been created is on branch circuit 49. This load is the Peerless overhead lighting in the

Player's lounge and is the largest of the three loads at 854VA. All three of these new circuits have loads that will adequately fit on the current 20A branch circuits.

# **Photovoltaic Array**

The proposed photovoltaic array for this project was designed using System Advisor Model, or SAM. SAM is solar design software from the National Renewable Energy Laboratory. The program takes various inputs from the user to determine weather data, size of the array, and financial details. For this electrical depth, a solar module and invertor are chosen based on a balance of cost and . Their manufacturer's data sheets can be found in Appendix B. The monthly energy produced by the array has also been calculated.

The following analysis will go through the beginning steps of setting up a simulation in SAM. This process leads to the chosen equipment and calculates the production data for the array.

#### 😴 SAM 2014.1.14: C:\Users\Brad\Desktop\\_Thesis\Solar\solar.zsam File Case Analysis Tools Script Help My project $\times$ Select Technology and Market... Flat Plate PV, Commercial Choose Weather Data File Location and Resource Location: BALTIMORE, MD Type a few letters of the location name: Download weather file... Lat: 39.2 Long: -76.7 Elev: 47.0 m SAM/KY Covington.tm2 .... Module SAM/KY Lexington.tm2 SAM/KY Louisville.tm2 1 Suntech Power STP250-20-Wd SAM/LA Baton Rouge.tm2 Folder settings... Output: 250.2 Wdc SAM/LA Lake Charles.tm2 SAM/LA New Orleans.tm2 Refresh list Inverter Growatt New Energy Technology: GROWATT 20000 TL3-U SAM/LA Shreveport.tm2 SAM/MA Boston.tm2 Copy to project SAM/MA Worcester.tm2 Capacity: 20194 Wac Remove from project CAM/ME Caribou tm? Array -Create TMY3 file Power: 99.8318 kWdd Click a file in the list to choose a file from the NREL NSRDB TMY2 dataset, or dick Download Weather File to enter an address and downlo Area: 649.2 m2 the NREL Solar Prospector database. A blue highlight indicates the weather file SAM uses for simulations. SA M lists files in the **PV** Subarrays default weather folder and in any folders you specify in Folder Settings. The prefix "SAM/" indicates a file from the default folder. To emb weather data in your. zsam file for sharing with other people, click Copy to Project: SAM indicates the embedded weather file in the list with the prefix "USER/". See Help for details. Number of subarrays: 1 Performance Adjustment 09 Percent of annual output: 100 % Year-to-year decline: 0.5 % per year **PV System Costs** S Total: \$ 255,680,46 Location Information Per Capacity: \$ 2.56 per Wdc GMT -5 39. 1833 deg City BALTIMORE Time Zone Latitude Financing 47 m Longitude -76.6667 dea Elevation State MD Analysis: 25 years Debt Fraction: 100.0% percent Weather Data Information (Annual) Incentives Direct Normal 1429.7 kWh/m2 Dry-bulb Temp 12.6 'C Fed, ITC View hourly data... Global Horizontal 1482.1 kWh/m2 Wind Speed 4.1 m/s No cash incentives Depreciation Web Links 5-yr MACRS (Federal) SAM reads weather files in the TMY3, TMY2, EPW, and SMW file formats, The default weather folder contains copies of the complete NREL NSRDB TMY2 dataset. You can use the links below to visit websites with other weather files. If you download files from the web, dick Folder Settings to choose folders where SAM can find your downloaded weather files. See Help for details. 5-yr MACRS (State) **Utility Rate** . Net Metering? Yes 111:5 Electric Load Annual Energy: 7.6463e+006 kWh Best weather data for the U.S. (1200 + locations in TMY3 format) Annual Peak: 1687.62 kW Best weather data for international locations (in EPW format) **Exchange Variables** U.S. satellite-derived weather data (10 km grid cells in TMY2 format) (For Excel Exchange and custom TRNSYS only.)

### **Specify a Location**

FIGURE 21 - SAM LOCATION AND RESOURCE PAGE

# Selecting a Solar Module

File Case Analysis Tools Script Help					
My project 🗙					
Select Technology and Market Flat Plate P	V, Commercial				
ocation and Resource	CEC Performance Model with Module Database Change				
ocation: BALTIMORE, MD at: 39.2 Long: -76.7 Elev: 47.0 m	Search for modules by manufacturer or model name:				
lodule					
untech Power STP250-20-Wd Nutput: 250.2 Wdc	SAM/CEC Modules/Suntech Power PLUT0245-Wde SAM/CEC Modules/Suntech Power PLUT0245-Wdm SAM/CEC Modules/Suntech Power STP245-20-Wd				
i <b>nverter</b> irowatt New Energy Technology: GROWATT 20000 TL3-L Capacity: 20194 Wac	SAM/CEC Modules/Suntech Power STP2455-20-Wdb SAM/CEC Modules/Suntech Power STP2455-20-Wde				
Array Iower: 99.8318 kWdc rea: 649.2 m2	SAM/CEC Modules/Suntech Power PLUTO250-Wdb SAM/CEC Modules/Suntech Power PLUTO250-Wde SAM/CEC Modules/Suntech Power PLUTO250-Wdm SAM/CEC Modules/Suntech Power STP250-20-Wd				
<b>W Subarrays</b> Number of subarrays: 1	SAM/CEC Modules/Suntech Power STP250-20-Wdb				
Performance Adjustment	Reference conditions: Total Irradiance = 1000 W/m2, Cell temp = 2	5 C			
ercent or annual output: 100 % ear-to-year decline: 0.5 % per year	Suntech Power STP250-20-Wd	Efficiency	15.38 %	Temperature Coefficients	
V System Costs	8	Maximum Power (Pmp)	250.205 Wdc	-4.500e-001 %/C	-1.126e+000 W/C
otal: \$ 255,680.46 er Capacity: \$ 2.56 per Wdc		Max Power Voltage (Vmp)	30.7 Vdc	7.00001001 76/C	1.1200 TUOU W/C
inancing	- P CTLett	Max Power Current (Imp)	8.15 Adc		
nalysis: 25 years lebt Fraction: 100.0% percent		Open Circuit Voltage (Voc) Short Circuit Current (Isc)	37.4 Vdc 8.63 Adc	-3.400e-001 %/C	-1.272e-001 V/C 4.876e-003 A/C
ncentives ed. ITC o cash incentives Pepreciation					
-vr MACRS (Federal)	Temperature Correction				
yr MACRS (State)	NOCT cell temp model	-Nominal operating	cell temperature (NOC	T) parameters	
tility Rate	Mounting specific cell temp model			round or rack mounted	•
let Metering? Yes	Refer to Help for more information about CEC cell temperature models.			ne story building height or low	er 🔻
lectric Load			6		
Annual Energy: 7.6463e+006 kWh Annual Peak: 1687.62 kW	Mounting configuration heat transfer cell temperature model	~	Rows of modu	lee in array	1
xchange Variables	Heat Transfer Dimensions Module Dimensions	*	Columns of modu		10
For Excel Exchange and custom TRNSYS only.)	Mounting Structure Orientation Structures do not impede flow und		Temperature behind		20 C
	Module Width         1         m           Module Length         1.627         m			ap Spacing 0.0	05 m
	Physical Characteristics				
	Material Multi-c-Si Module	e Area 1.627 m2	Nu	mber of Cells	60

FIGURE 22 - SAM CHOOSING A SOLAR MODULE

A Suntech STP250 – 20/Wd was chosen as the solar module for the casino. This is a 250Watt, polycrystalline solar module. It has an open circuit voltage of 37.4A and an efficiency of 15.4%. The full specifications for the panel can be found in Appendix B.

### Selecting an Inverter

My project × Select Technology and Market Flat Plate F						
Select Technology and Market Flat Plate						
	PV, Commercial					
ocation and Resource ocation: BALTIMORE, MD at: 39.2 Long: -76.7 Elev: 47.0 m	Sinverter CEC Database Change					
Module Suntech Power STP250-20-Wd Jutput: 250.2 Wdc Inverter	Search for inverters by manufacturer or model name: SAM/Sandia Inverters/Growatt New Energy: GROWATT 5000MT-US (208V) 208V [CEC: SAM/Sandia Inverters/Growatt New Energy: GROWATT 5000MT-US (240V) 240V [CEC: SAM/Sandia Inverters/Growatt New Energy: GROWATT 5000MT-US (277V) 277V [CEC: SAM/Sandia Inverters/Growatt New Energy: GROWATT 5000MT-US (277V) 277V [CEC: SAM/Sandia Inverters/Growatt New Energy: GROWATT 5000MT-US (277V) 277V [CEC: SAM/Sandia Inverters/Growatt New Energy: GROWATT 5000MT-US (278V) SAM/Sandia Inverters/Growatt New Energy Technology: GROWATT 10000T-US (288V)	2011] 2011] [CEC 2012]				
krowatt New Energy Technology: GROWATT 20000 TL3- Capacity: 20194 Wac		240V [CEC 2013] [CEC 2012]				
irray	SAM/Sandia Inverters/Growatt New Energy Technology: GROWATT 20000 TL3-US 277V SAM/Sandia Inverters/Growatt New Energy Technology: GROWATT 8000TL-LIS (208V) 2	[GEC 2012] NRV [CEC 2013]				
lower: 99.8318 kWdc irea: 649.2 m2	*					4
V Subarrays	Efficiency Curve and Characteristics Growatt New Energy Technology: GROWATT 20000 TL3-US 277V	CEC weighted efficiency	96	5274 %		
umber of subarrays: 1	Growatt New Energy Technology: GROWATT 20000 TL3-US 277V	European weighted efficiency		1344 %		
erformance Adjustment ercent of annual output: 100 %	95-	Maximum AC power	20194 Wac	CO	-4.20679e-007	1/Wad
ar-to-year decline: 0.5 % per year		Maximum DC power	20882 Wdc	C1	-6.4611e-005	
/ System Costs	2 <sup>90</sup>	Power consumption during operation 9	1.5823 Wdc	C2	0.0010009	1/Vdc
tal: \$ 255,680.46 r Capacity: \$ 2.56 per Wdc	- 28 C	Power consumption at night	0.2 Wac	C3	0.000720304	1/Vdc
nancing	1 80	Nominal AC voltage	277 Vac			
nalysis: 25 years ebt Fraction: 100.0% percent	MPPT-low	Maximum DC voltage	1000 Vdc			
Icentives	75 MPPT-hi	Maximum DC current	25 Adc			
ed. ITC	70 10 20 30 40 50 60 70 80 90 100	Minimum MPPT DC voltage Nominal DC voltage 4	400 Vdc 18,491 Vdc			
o cash incentives	% of Rated Output Power	Maximum MPPT DC voltage	800 Vdc			
Depreciation -yr MACRS (Federal) -yr MACRS (State)		( Lauran a ) - CC ( Crage	and fue			
	8					
Jtility Rate Net Metering? Yes Electric Load	4					
let Metering? Yes						

FIGURE 23 - SAM INVERTER SELECTION

The SAM software has a very large database of DC to AC inverters to choose from. When an inverter is selected the software will notify the user of any conflicts that may arise. It will often take a few tries to find an inverter that matches with the chosen solar module and the characteristics of the array. A Growatt inverter was selected for this study and a corresponding cut sheet is located in Appendix B.

# **Calculate Array Size**

File Case Analysis Tools Script Help						
My project ×						
Select Technology and Market Flat Plate PV,	Commercial					
ocation and Resource	Layout Specify System Size		Actual Layout			
at: 39.2 Long: -76.7 Elev: 47.0 m	The second se	and the second barrants	Modul	les	Inverters	
1odule .		pecify modules and inverters	Nameplate capacity	99.8318 kWdc	Total capacity	100.97 kWac
untech Power STP250-20-Wd	Desired array size 100 kWdc	Modules per string	Number of modules	399	Total capacity	104.41 kWdc
utput: 250.2 Wdc	DC to AC ratio 1.1	Strings in parallel	5 Modules per string	19	Number of inverters	5
iverter		Number of inverters	0 Strings in parallel	21	Maximum DC voltage	1000 Vdc
rowatt New Energy Technology: GROWATT 20000 TL3-US apacity: 20194 Wac	Sizing messages (see Help for details):		Total module area	649.173 m2	Minimum MPPT voltage	400 Vdc
	Actual DC to AC Ratio is 0.99. Check for more sizi	no messages after running		710.6 V	Maximum MPPT voltage	800 Vdc
Irray ower: 99.8318 kWdc	simulations.	· · · · · · · · · · · · · · · · · · ·		583.3 V	Maximum MPPT Voltage	000 VGC
rea: 649.2 m2			String Vmp	565.5 V		
V Subarrays			Nameplate capacity and string incident irradiance and 25 'C or		ference conditions. String Voc is at	1000 W/m2
umber of subarrays: 1		12		er temperature,		
erformance Adjustment	Interconnection Derates (AC)		Ground Reflectance			
ercent of annual output: 100 %	AC wiring losses	0.99 (01)	Ilise albedo	in weather file if it is sp	pecified	
aar-to-year decline: 0.5 % per year	Step-up transformer losses	1 (01)		ground reflectance (al		
V System Costs	Total interconnection derate	0.99 (01)				
otal: \$ 255,680.46 er Capacity: \$ 2.56 per Wdc		0.55 (01)	Tilted Surface Radiation M	odel (Advanced)		
inancing	Land Area		Sotropic		-Radiation Components	50
nalysis: 25 years	Packing factor	2.5	O HDKR		Beam and diffuse	
ebt Fraction: 100.0% percent	Total land area 0.	.401027 acres	Perez		Total and beam	
ncentives						
Fed. ITC	Self Shading Calculator for Fixed Tilt Arrays					
lo cash incentives	Enable Self-Shading Calculator					
epreciation	Module					9
yr MACRS (Federal)	Orientation	Landscape		Portrait	Landscape	
-	Length	2.418 m		1 0000		
et Metering? Yes	Width	0.673 m				
lectric Load	Number of Cells along Length	10	Leng®		Width	
nnual Energy: 7.6463e+006 kWh	Number of Cells along Width	6		5555 1		
nnual Peak: 1687.62 kW	Number of Bypass Diodes	3		-	Length >	
xchange Variables	Characteristics from Module Page	1994 (A)	-	✓ Width ★		
xchange variables	characteristics nonin noune rage					

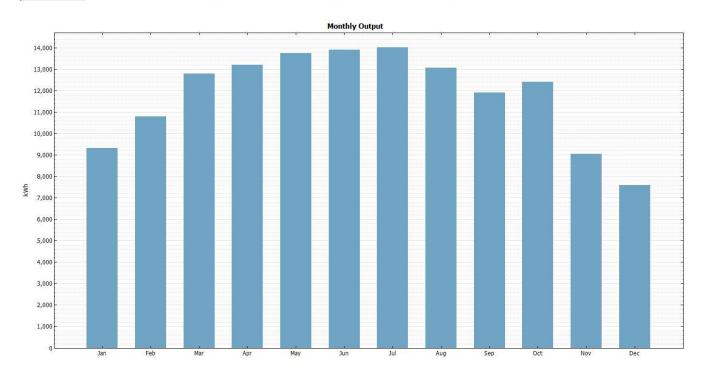
FIGURE 24 - SAM ARRAY SIZE

The section of SAM that works with the size of the array is the most interesting. For this study, an array of 400 panels was chosen based on the dimensions of the main casino roof. A 20 row array, with 20 panels in each row, will fit on the main casino roof. This is also taking into consideration inter-array shading and row spacing across the array. With 400 panels, five inverters will be needed.

### Data Output

After loading the meteorological data for the project's location, specifying a solar module, and specifying an AC to DC inverter, SAM will run an annual simulation. The simulation ran for Casino Gold produced the following values. The numbers 1-12 represent the month of the calendar year.

	Monthly Energy (kWh)	Net ac output (kWh)	Net dc output (kWh)
1	9324.69	9324.69	9681.71
2	10785.1	10785.1	11175.7
3	12786	12786	13274.6
4	13206.1	13206.1	13724.6
5	13743.2	13743.2	14303.9
6	13895.6	13895.6	14481.4
7	14008.3	14008.3	14601.6
8	13070	13070	13626.9
9	11916.1	11916.1	12411.9
10	12397.3	12397.3	12885.2
11	9056.27	9056.27	9416.5
12	7594.67	7594.67	7912.91



### Summary

The solar resource was analyzed at the location of the project, a solar module and inverter have been selected, and the array has been sized. The specified solar module is a Suntech STP250 – 20/Wd. The specified AC to DC inverter is a Growatt 20000TL3-US. The proposed array will contain a total of 400 panels and produce a peak load of about 14,000kWh in the month of June.

# CONSTRUCTION BREADTH

Adding a solar array to the roof of the casino will result in an added cost for the project as well as extra work for the crew. The following analysis provides information related to the cost and schedule impacts of the new array.

# Cost

The 2014 release of RS Means was used to find the following values. The Master Format 2010 section used for Photovoltaic Collectors is 263113500. The first table shows the values directly from RS Means, the second table shows the quantities estimated for this project.

Description	Crew	Daily Output	Labor Hours	Bare Materials	Bare Labor	Bare Total	Total O&P
150W, 33V, PV Panel	1 Elec	8	1	645.00	53.50	698.50	790.00
48V, 5500W DC to AC inverter	1 Elec	2	4	3750.00	213.00	3963.00	4445.00
PV components, combiner box	1 Elec	4	2	189.00	107.00	296.00	368.00
Fuse, 15A for combiner box	1 Elec	40	0.2	16.40	10.65	27.05	34.00
PV Rack system, on steel framing, with standoff	R1A	11.00	1.455	55.00	64.00	119.00	1 <i>57</i> .50

# **RS** Means Values

# **Costs Specific to Casino Array**

The following table uses RS Means values for pricing of materials and labor, except for the Suntech 250W panels. The Suntech STP250 – 20/Wd panel was priced at an average of \$375 from multiple retailers. The data sheet for the Suntech panel can be found in the Appendix B. The number of crew members and corresponding daily output has been modified to finish the installation in 10 days. The breakdown of the construction time is found in the next section titled "Schedule."

Description	No.	Crew	Daily Output	Labor Hours	Bare Materials	Bare Labor	Bare Total
250W, 37V, Suntech PV Panel	400	6 Elec	48	1	150,000	21,400	171,400
Growatt DC to AC inverter	5	5 Elec	10	4	18,750	1,065	19,815
PV components, combiner box	1	1 Elec	4	2	189.00	107.00	296.00
Fuse, 15A for combiner box	21	1 Elec	40	0.2	344.40	223.65	568.05
PV Rack system, on steel framing, with standoff	400	4 R1A	44	1.455	22,000	25,600	47,600

# Schedule

Using the labor information gathered from the 2014 release of RS Means, an estimate for the length of time needed to install the new solar array can be calculated. The table below takes labor hours and daily output directly from the Photovoltaic Collectors section 263113500 in RS Means.

Description	No.	Crew	Daily Output	Labor Hours	Total Hours	Days
250W, 37V, Suntech PV Panel	400	1 Elec	8	1	400	50
Growatt DC to AC inverter	5	1 Elec	2	4	20	2.5
PV components, combiner box	1	1 Elec	4	2	2	0.25
Fuse, 15A for combiner box	21	1 Elec	40	0.2	4.2	0.5
PV Rack system, on steel framing, with standoff	400	R1A	11.00	1.455	582	37

The length of installation for each component calculated in the table above would have a significant impact on the schedule of the project. Assuming that the Suntech panels and the racks can be installed simultaneously, an installation of 8 to 10 days would be desirable. This much shorter installation time would not have a significant impact on the overall 18 month construction of the casino.

To achieve an 8-10 installation time for the array, the amount of workers needs to be increased. A 6 man crew, working in teams of two, will be able to handle the installation of the panels. An R1A crew consists of two workers already, so the project will need 4 of these crews totaling 8 workers. The total amount of workers assigned to the installation of the solar array will be 14.

Description	No.	Crew	Daily Output	Labor Hours	Days
250W, 37V, Suntech PV Panel	400	6 Elec	48	1	8.3
Growatt DC to AC inverter	5	5 Elec	10	4	0.5
PV components, combiner box	1	1 Elec	4	2	0.25
Fuse, 15A for combiner box	21	1 Elec	40	0.2	0.5
PV Rack system, on steel framing, with standoff	400	4 R1A	44	1.455	9.1

# Estimated Construction Times

The number of days calculated from the Estimated Construction Times table shows that the solar array installation can be completed in less than 10 days. All 6 of the electricians will begin by installing the Suntech panels and that will take just over 8 days. The 9<sup>th</sup> day of installation will be for the electricians to

finish installing the panels and install the inverters. While the electricians are working, the 4 R1A crews will also be working on the installation of the PV rack system. The PV rack system will take about 9 days for the crew to install.

# Conclusion

The total cost estimate for the materials of the proposed solar array is \$191,283. The total cost of labor is estimated to be \$48,396. Adding materials and labor together results in \$239,680 estimated for the entire installation. This estimation does not include profit. The installation will take a total period of 10 days and will not significantly impact the 18 month construction schedule for Casino Gold.

# STRUCTURAL BREADTH

The proposed solar array on the casino roof creates a new load and it requires an evaluation of the structural members supporting it. The main roof for the casino is the top of the third level. This roof has a width of 168 feet and a length of 300 feet. The chosen Suntech 250 watt polycrystalline solar module has a width of 3.25 feet and a length of 5.4 feet. With a weight of 40 pounds, the panel exerts a load of 3lbs/ft<sup>2</sup>. The dimensions of both the roof and panel can be found in Appendix C.

The calculations for the following structural analysis can also be found in Appendix C. The structural calculations analyze the roof decking, a roof joist, joist girder, and the supporting column. All of the joists, joist girders, and columns for the roof structure are consistent throughout the third level.

# **Dead Loads**

- 3psf Suntech panel self-weight
- 1psf 3-ply ready roofing (AISC Table 17-13, 14<sup>th</sup> Edition)
- 1.5psf Rigid insulation, R-25 (AISC Table 17-13, 14th Edition)
- 3psf 3/4" wood sheathing (AISC Table 17-13, 14th Edition)
- 10psf Superimposed dead load
- 1.78psf Vulcraft 1.5B x 22 gauge roof decking (Vulcraft Roof Decking Table)

# Live Loads

• 30psf – Snow Load

# **Roof Deck**

The roof deck meets the requirements for a 3-span, unshored condition, determined form the Vulcraft Roof Deck table.

# **Current Roof Joist**

- 21 plf 32LH09 Roof Joist (Steel Joist Institute Joist Catalog, LRFD Table)
- Span of 60ft, spacing of 5' 8"
- An LRFD load combination of [1.2D+1.6S] was used in evaluating the current roof joist.
- W<sub>utl</sub> = 445plf
- W<sub>tl</sub> = 310plf

# **Evaluation of the Roof Joist**

- Use Steel Joist Institute Long Span Steel Joist LRFD Table
- 32LH09 joist designation and a clear span of 60ft
  - $\circ$  W<sub>utl</sub> = 534plf (from table) > 445plf (from calculations), OK
  - $\circ$  W for L/360 = 180plf (from table)
  - W for L/240 = 270 plf < 310 plf (from calculations), current roof joist is not big enough for the new load of the solar array

### Choosing a New Roof Joist

- Increase size of joist to satisfy the deflection criteria that was not met in the previous section
  - Choose a new joist of 32LH11
    - $W_{utl} = 643$  plf (from table) > 445 plf (from calculations), OK
    - W for L/360 = 216plf (from table)
    - W for L/240 = 324plf > 313plf (from calculations), OK
- New 32LH11 joist is adequate
  - Self-weight of 5psf

# **Evaluation of Joist Girder**

The current joist girder for the roof is a 60G10N20K. This notation shows that the joist girder is 60 inches deep, has 10 panels, and has an unfactored point load of 20 kips. The evaluation conducted in the attached calculations shows an actual point load of less than 20 kips, proving that the joist girder is adequate. The girder has a self-weight of 93plf, or 2psf, found in the Steel Joist Institute LRFD joist girder table.

# **Evaluation of a Column**

The casino is designed with W8X48 columns on the third level, supporting the roof structure. The columns have a height of 13 feet. When evaluating the  $P_u$  on the column a tributary area of 3,360ft<sup>2</sup> is used. This leads to a  $P_u$  of 275 kips for the column. Using Table 4-1 in the AISC 14<sup>th</sup> Edition, a value of  $\emptyset P_u = 421k$  for a W8X48 column is much larger than the calculated 275k. This proves that the columns in the current design are able to support the new loading condition.

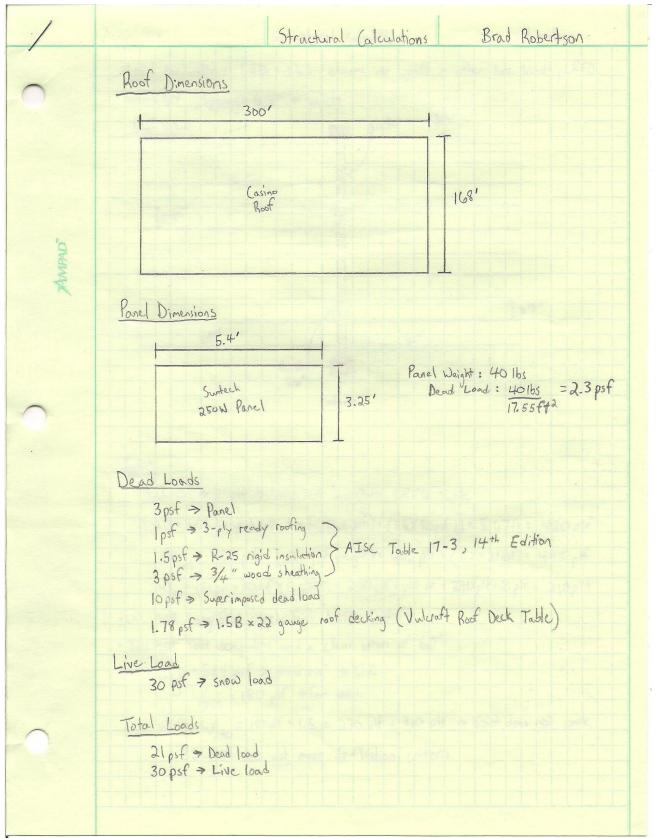
# Conclusion

After evaluating the structural members of the third level, the calculations determine that the current roof joists must increase in size. The roof joists must increase from 32LH09 to 32LH11. The current roof decking, joist girders and columns of the third level are adequately designed to support the new load of the solar array.

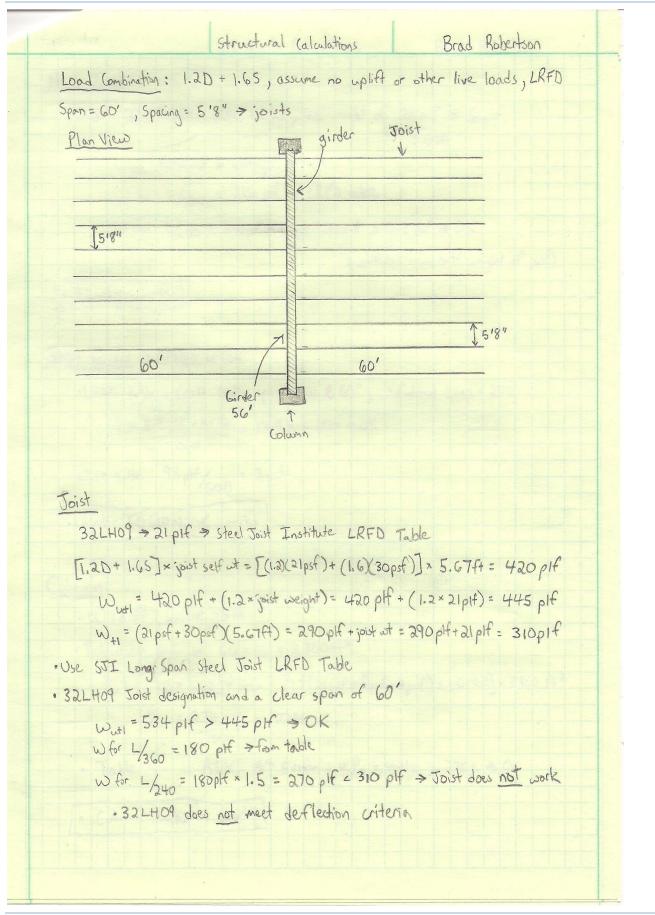
# APPENDIX A – LUMINAIRE DATA SHEETS

APPENDIX B – SOLAR EQUIPMENT DATA SHEETS

# APPENDIX C – STRUCTURAL CALCULATIONS



#### Robertson



#### Robertson

Gradual (alculations)Brad RebertonNew Jobst• Choose 32LtH from Leto table, self weight of 24 pH 
$$\Rightarrow$$
 5 psf  
5.67AWar = 643 plf > 445 plf  $\Rightarrow 0K$   
W for  $1/360 = 216 plf  $\Rightarrow 1.8 = 324 plf > 313 plf  $\Rightarrow 0K$   
(includes new self weight of jost)• Jack is a constrained of the self is the self is the self weight of jost)• Jack Golder : 600 GION 30K  
• LAFD Table : 93 plf  $\Rightarrow 56A$   
(includes new self weight of jost)• Jack Golder : 600 GION 30K  
• LAFD Table : 60A Seder span, 10N & 60°, Wardend Lead = 20K  
 $P_{1000} = 313 plf + 56A = (1.5 K < 20 k  $\Rightarrow 0K$   
• LAFD Table : 93 plf for  $= 2psf$   
• Golder Table : 93 plf for  $= 2psf$   
• Golder MarksColumn  
• W8X48 , height 13A  
• Tributory Ares of 60'x 50' = 3,360 Ala  
 $P_{10} = 2,74,176 = 275K$   
• Table 4 -1 in AISC, 14th Edithn : 87 Pn = 431 K > 215 K  $\Rightarrow 0K$ • Column W8X48 works$$$