ENERGIZE MISSOURI

RENEWABLE ENERGY STUDY SUBGRANT

Missouri Department of Natural Resources

Solar Design Study

Subgrant Award No: G11-SEP-RES-08

Prepared for -

Missouri Department of Natural Resources

12 Aug. 2011

Prepared by -

GlaxoSmithKline
St. Louis, Missouri

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The ***Energize Missouri Renewable Energy Study Subgrant*** program was created to increase the ability of businesses, governments and organizations to make informed decisions about complex renewable energy systems by understanding and solving information deficiency and technical uncertainties. Program funds are made possible through the American Recovery and Reinvestment Act and the Transform Missouri initiative and administered by the Missouri Department of Natural Resources.

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1.0 EXECUTIVE SUMMARY

The Missouri Department of Natural Resources (MDNR) selected GlaxoSmithKline to conduct a rooftop solar design study at its St. Louis manufacturing facility. This facility manufactures Tums tablets and Os-Cal vitamin supplements as part of the Consumer Healthcare division. The purpose of the study is to perform a detailed design analysis to include solar panel layout drawings, electrical one-line drawings, structural analysis, estimated energy output, and payback analysis.

GlaxoSmithKline engaged in a multi-site solar bidding project analysis. The site's included facilities in St. Louis, Aiken, SC, Memphis, TN, and Zebulon, NC. The solar vendors bidding on the projects were Southern Energy Management, Strata, and Tecta. Southern Energy Management was selected as the winning bidder for each of the manufacturing facilities.

This study was conducted in several phases starting in October 2010 and design completion in June 2011. The solar system proposed is a roof mounted, 74 KW which generates 95,700 KWh./year in year 1. Payback analysis shows 19 years. Approximate area for the solar array is 10,000 sq. ft.

2.0 INTRODUCTION

The MDNR selected GlaxoSmithKline to participate in the Energize Missouri Renewable Energy Study Subgrants program. GlaxoSmithKline is investigating the feasibility of a roof top solar array as part of the energy and climate change reduction program.

The solar panels chosen for this project area manufactured by REC Solar and were chosen due their 25 year warranty and Southern Energy Management's recommendations. The cells are multi-crystalline and are supported by the Sunlink mounting system. Considerations given during the detailed design of the solar array were for shading of the panels in order to maximize energy output. Drawing PV 5.0 (Appendix A) shows the shading involved with the proposed locations. The stringing design on drawing PV 1.1 (Appendix A) was developed to minimize the effects of shading.

This study will provide GlaxoSmithKline with the detailed design information to proceed with the installation of the design if the site determines it is economically feasible and/or aligns with the corporate sustainability objectives.

Solar PV Financial Analysis
Commercial Investment Model - 235-watt Solar PV Modules
GSK - St Louis, MO
Solar PV Project

System Size kW	74.00

10/28/2010

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Full System Cost (varies by $/watt decimal)	429,106																				
Inverter Warranty Extension	3,966																				
Estimated Utility Tie-In Expense	500																				
Fed/State Solar Grant	32,500																				
Federal Tax Credit		120,171																			
State Tax Credit	50,000	0	0	0	0	0															
Fed. Stimulus Package - Depreciation Bonus		0																			
Fed. Tax Depreciation Tax Benefit		22,862	36,579	21,948	13,169	13,169	6,584														
State Tax Depreciation Tax Benefit		3,572	5,715	3,429	2,058	2,058	1,029														
State Benefit Impact on Fed. Tax Liability			1,429	2,286	1,372	823	823	412	0	0	0	0	0	0	0	0	0	0	0	0	0
Liability Insurance Expense		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utility Meter Fees		953	981	1,011	1,041	1,072	1,104	1,138	1,172	1,207	1,243	1,280	1,319	1,358	1,399	1,441	1,484	1,529	1,575	1,622	1,671
Maintenance Expense - Reserve		250	258	265	273	281	290	299	307	317	326	336	346	356	367	378	389	401	413	426	438
O&M Contract - Annually Years 6 - 20							1,584	1,632	1,680	1,731	1,783	1,836	1,891	1,948	2,007	2,067	2,129	2,193	2,258	2,326	2,396
SREC Revenue		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utility kWh Revenue		6,222	6,438	6,662	6,894	7,134	7,382	7,639	7,905	8,180	8,465	8,759	9,064	9,379	9,706	10,044	10,393	10,755	11,129	11,516	11,917
Total Cash Flow	**351,072**	**151,625**	**46,065**	**28,477**	**19,434**	**20,183**	**11,194**	**4,160**	**4,745**	**4,926**	**5,113**	**5,307**	**5,508**	**5,717**	**5,933**	**6,158**	**6,391**	**6,632**	**6,883**	**7,143**	**7,412**
Accumulated Cash Flow	**351,072**	**199,447**	**153,382**	**124,905**	**105,471**	**85,287**	**74,094**	**69,934**	**65,188**	**60,263**	**55,150**	**49,843**	**44,335**	**38,619**	**32,686**	**26,528**	**20,137**	**13,505**	**6,622**	**521**	**7,933**

MODEL VARIABLES:

Federal Tax Credit	30%	*All in Yr 1*	*Cost of Solar PV System*	$407,061
State Tax Credit	0%	*Over 10 years*	*Approximate Sales or Use Tax*	$26,010
State Tax Credit Cap	$ -		*Ttl Cost/Watt installed*	5.85
			Size of System in kW	74.00
Federal Corp Income Tax Rate	40.0%		*Estimated # of Panels*	315
State Corporate Income Tax Rate	6.25%		*Watt/panel*	235
State Sales Tax	9.24%		*Est. System kWh Production Yr 1*	95,717
			Annual System Degradation	0.50%
Fed. Stimulus Package Depreciation Bonus	0.0%			
Fed/State Reduction of Basis for Depr.	15%		*Utility Meter Fee/Yr*	$953
Salvage Value Year 20 - % Initial Cost	15%		*Estimated Utility Tie-In Fee*	$500
			Incremental Liability Insurance Expense	$0
Federal MACRS Depreciation Schedule	20.0%	*Period 1*	*Annual Maintenance Expense - Reserve*	$250
	32.0%	*Period 2*	*Annual O&M Contract - Years 6 - 20*	$1,584
(5 yr depreciation = 6 periods)	19.2%	*Period 3*	*Avg. Annual Inflation Rate*	3.0%
	11.5%	*Period 4*	*Discount rate / cost of capital*	8.0%
	11.5%	*Period 5*		
	5.8%	*Period 6*	*Avoided Cost - $/kWh*	$0.0650
			Utility Rate Annual Cost Escalation %	4.0%
			SREC Rate $/kWH - Period 1	$0.00
Federal/State Solar Grants - Design	$32,500		*Duration Period 1SREC Contract*	5
			SREC Rate $/kWh-Period 2	$0.00
Image Value in Year 1	$ -			
			Inverter Warranty: 20-year extension	$3,966.00

MODEL OUTPUT:

Pay back period in Yrs < =	19
IRR % =	0.5%
ROI % =	2.26%
Lbs CO2 Reduction/Yr =	133,121

Results

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Fig. 2-1 Financial Analysis

3.0 SITE PLANS

3.1 CORPORATE SOLAR ENERGY REVIEW

The facility has reviewed the solar payback analysis with GSK's corporate energy team. The payback is longer than desired, but there are other considerations for the project. Renewable energy growth is a key GSK corporate objective, which this project will support.

Recent discussions with corporate involve using the solar design to power equipment for selected brands. This has the potential to give marketing support to the brand as "Powered By The Sun". Further reviews are still needed in order to determine the project feasibility given the high costs.

As with other technologies, costs will be reduced over time. This will make this project more economically attractive in the future.

4.0 SUMMARY

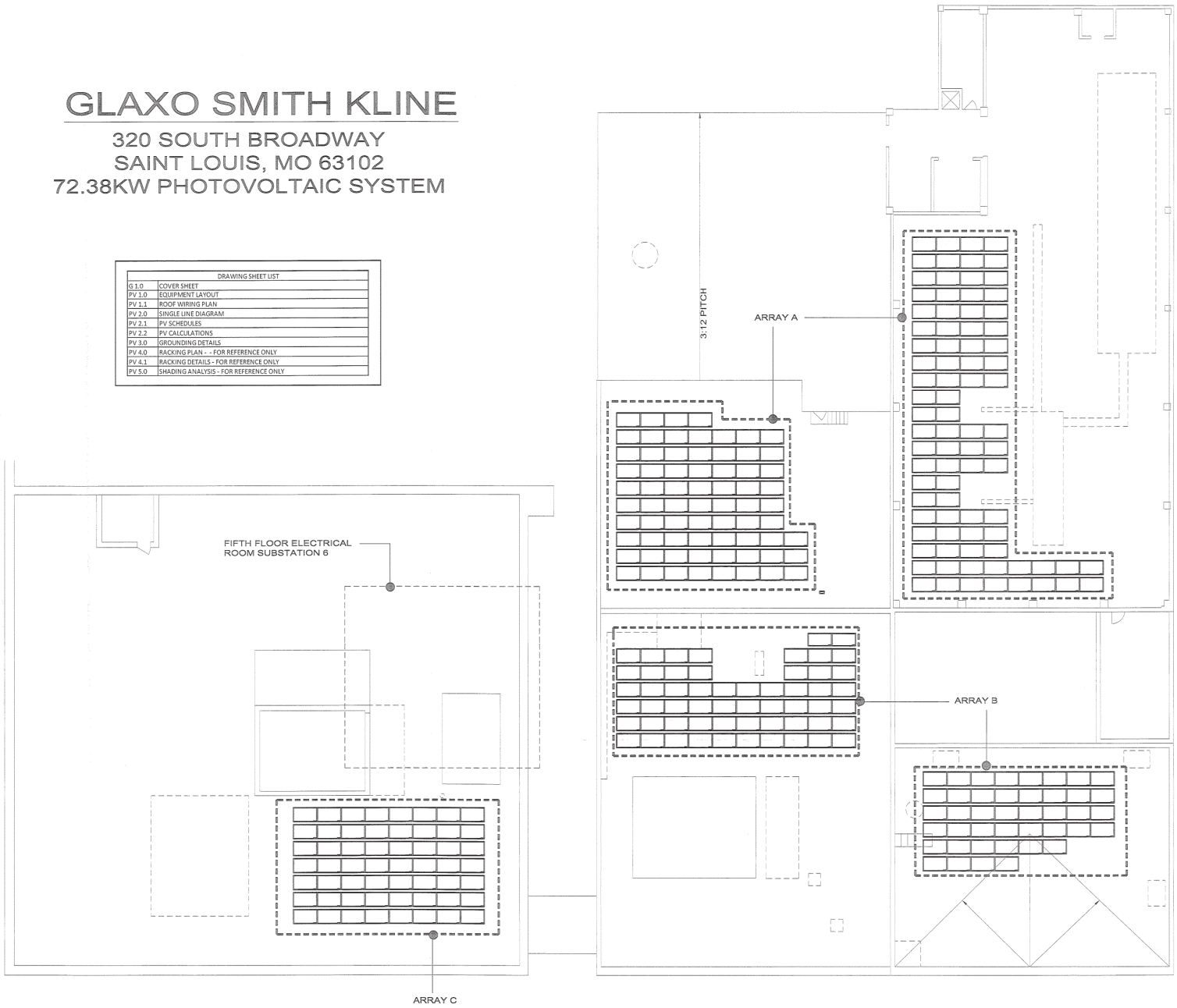
The solar panel design has several facets to consider. This technology aligns with GSK's corporate sustainability strategy for reduced carbon dioxide emissions. Given the site's relatively small array and multiple rooftops to support the solar panels, the payback was not as attractive as desired.

Reviews with the corporate energy team are being pursued in order to determine next steps. Future reviews are needed in order to agree on a plan. Considerations being reviewed are GSK corporate responsibility for renewable energy, project costs with payback to GSK, technology cost reductions in the future, product brand promotion, the St. Louis's facility community reputation, and the support of solar manufacturers.

GLAXO SMITH KLINE

320 SOUTH BROADWAY
SAINT LOUIS, MO 63102
72.38KW PHOTOVOLTAIC SYSTEM

DRAWING SHEET LIST	
G 1.0	COVER SHEET
PV 1.0	EQUIPMENT LAYOUT
PV 1.1	ROOF WIRING PLAN
PV 2.0	SINGLE LINE DIAGRAM
PV 2.1	PV SCHEDULES
PV 2.2	PV CALCULATIONS
PV 3.0	GROUNDING DETAILS
PV 4.0	RACKING PLAN - - FOR REFERENCE ONLY
PV 4.1	RACKING DETAILS - FOR REFERENCE ONLY
PV 5.0	SHADING ANALYSIS - FOR REFERENCE ONLY



STATE OF MISSOURI
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NUMBER
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PROFESSIONAL ENGINEER
6-1-2011

REVISIONS

DATE	NOTE	BY

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Morrisville, NC 27560
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GSK ST. LOUIS
320 SOUTH BROADWAY STREET
ST. LOUIS, MO 63102
5/31/11

SOLAR PHOTOVOLTAIC SYSTEM
DRAWN BY: KYRA MOORE
SCALE: NONE

G-1.0

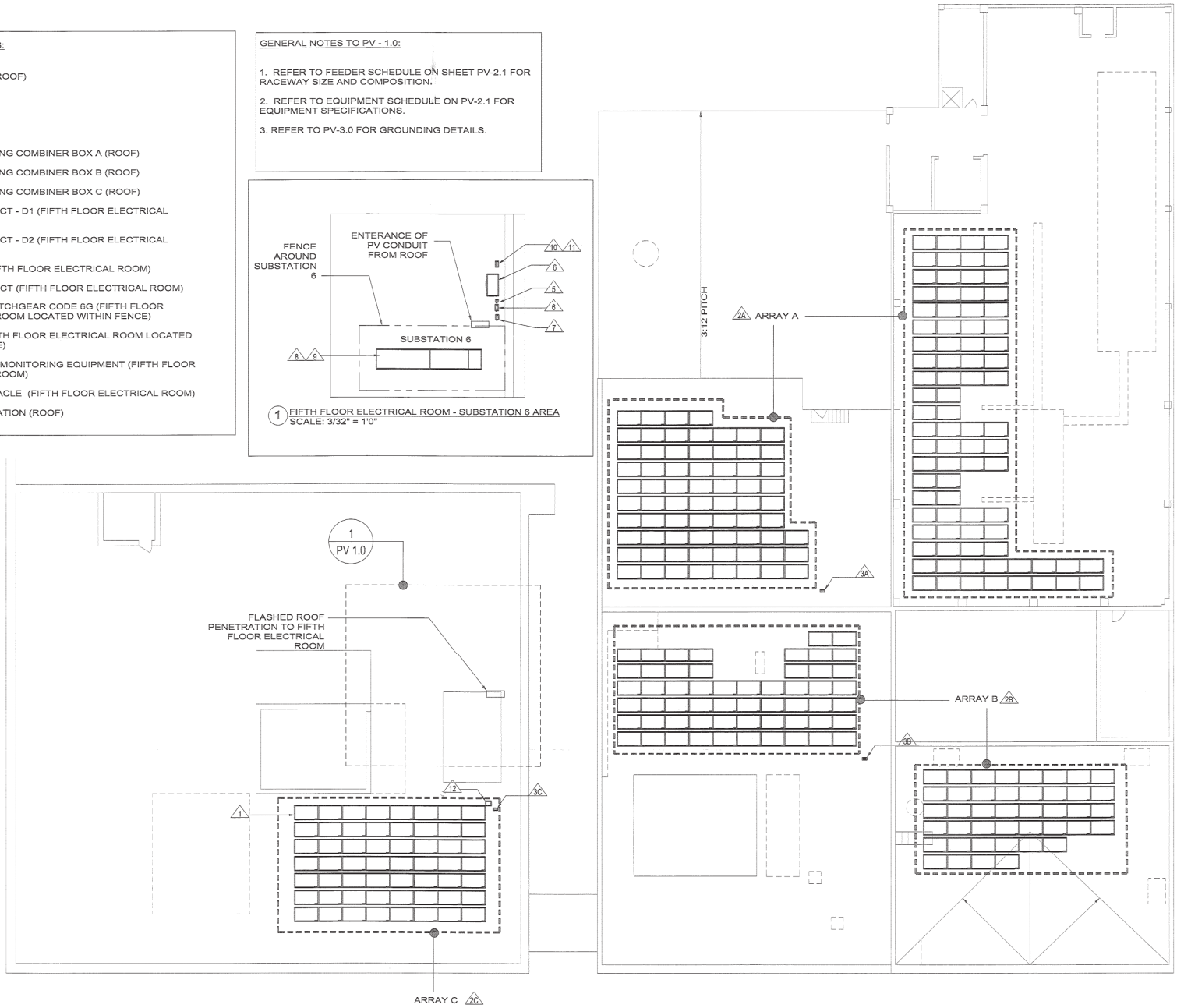
EQUIPMENT NOTES:

- 1 PV MODULE (ROOF)
- 2A PV ARRAY A
- 2B PV ARRAY B
- 2C PV ARRAY C
- 3A DISCONNECTING COMBINER BOX A (ROOF)
- 3B DISCONNECTING COMBINER BOX B (ROOF)
- 3C DISCONNECTING COMBINER BOX C (ROOF)
- 4 DC DISCONNECT - D1 (FIFTH FLOOR ELECTRICAL ROOM)
- 5 DC DISCONNECT - D2 (FIFTH FLOOR ELECTRICAL ROOM)
- 6 INVERTER (FIFTH FLOOR ELECTRICAL ROOM)
- 7 AC DISCONNECT (FIFTH FLOOR ELECTRICAL ROOM)
- 8 EXISTING SWITCHGEAR CODE 6G (FIFTH FLOOR ELECTRICAL ROOM LOCATED WITHIN FENCE)
- 9 PV FUSE (FIFTH FLOOR ELECTRICAL ROOM LOCATED WITHIN FENCE)
- 10 PRODUCTION MONITORING EQUIPMENT (FIFTH FLOOR ELECTRICAL ROOM)
- 11 120V RECEPTACLE (FIFTH FLOOR ELECTRICAL ROOM)
- 12 WEATHER STATION (ROOF)

GENERAL NOTES TO PV - 1.0:

1. REFER TO FEEDER SCHEDULE ON SHEET PV-2.1 FOR RACEWAY SIZE AND COMPOSITION.
2. REFER TO EQUIPMENT SCHEDULE ON PV-2.1 FOR EQUIPMENT SPECIFICATIONS.
3. REFER TO PV-3.0 FOR GROUNDING DETAILS.

1 FIFTH FLOOR ELECTRICAL ROOM - SUBSTATION 6 AREA
SCALE: 3/32" = 1'0"



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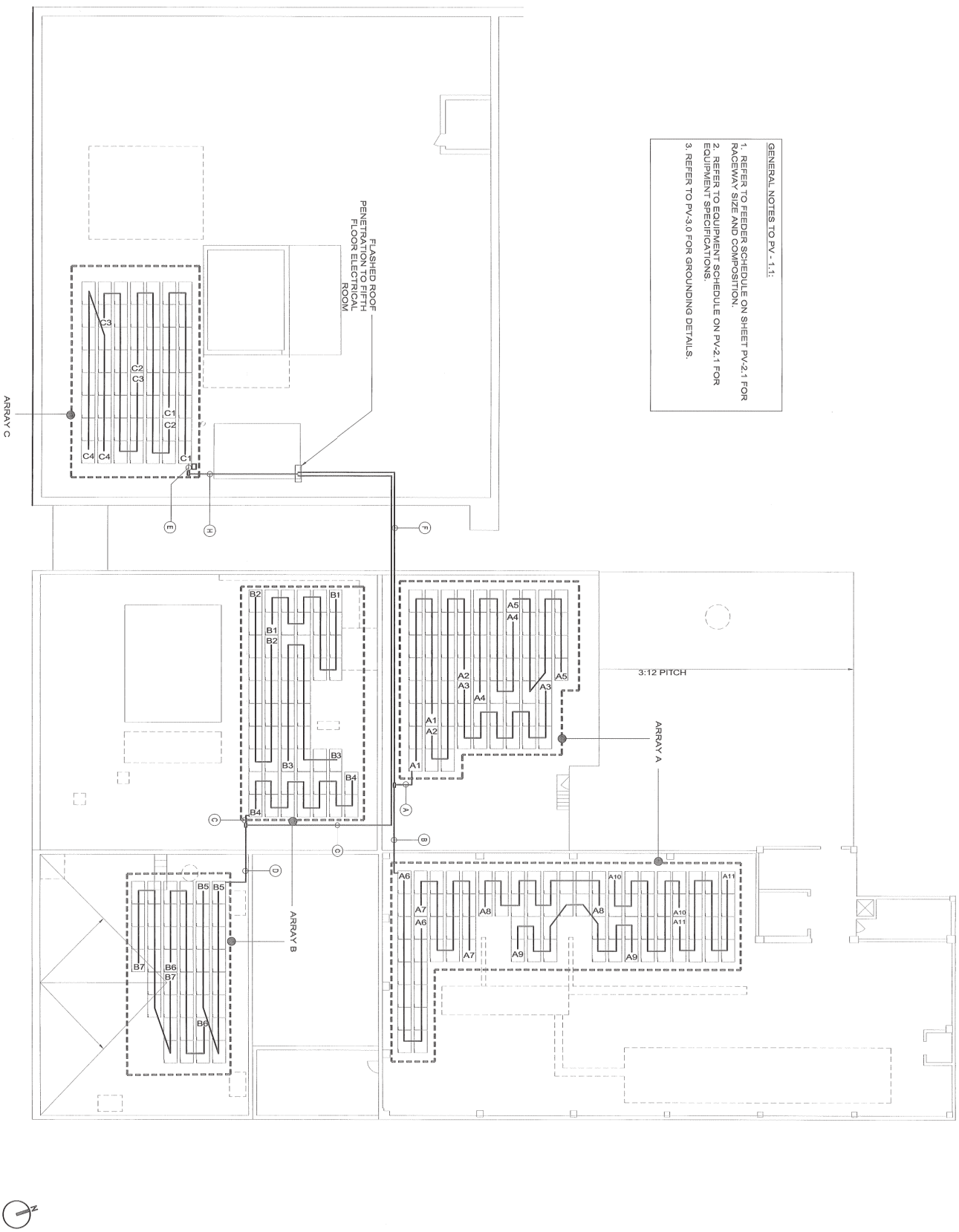
SOLAR PHOTOVOLTAIC SYSTEM
EQUIPMENT LAYOUT
DRAWN BY: TYRA MOORE
SCALE: 3/32" = 1'-0"

PV-1.0



GENERAL NOTES TO PV - 1.1:

1. REFER TO FEEDER SCHEDULE ON SHEET PV-2.1 FOR RACEWAY SIZE AND COMPOSITION.
2. REFER TO EQUIPMENT SCHEDULE ON PV-2.1 FOR EQUIPMENT SPECIFICATIONS.
3. REFER TO PV-3.0 FOR GROUNDING DETAILS.

PV-1.1

GSK ST. LOUIS
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SOLAR PHOTOVOLTAIC SYSTEM
ROOF WIRING PLAN
DRAWN BY: KYRA MOORE
SCALE: 3/32" = 1'-0"

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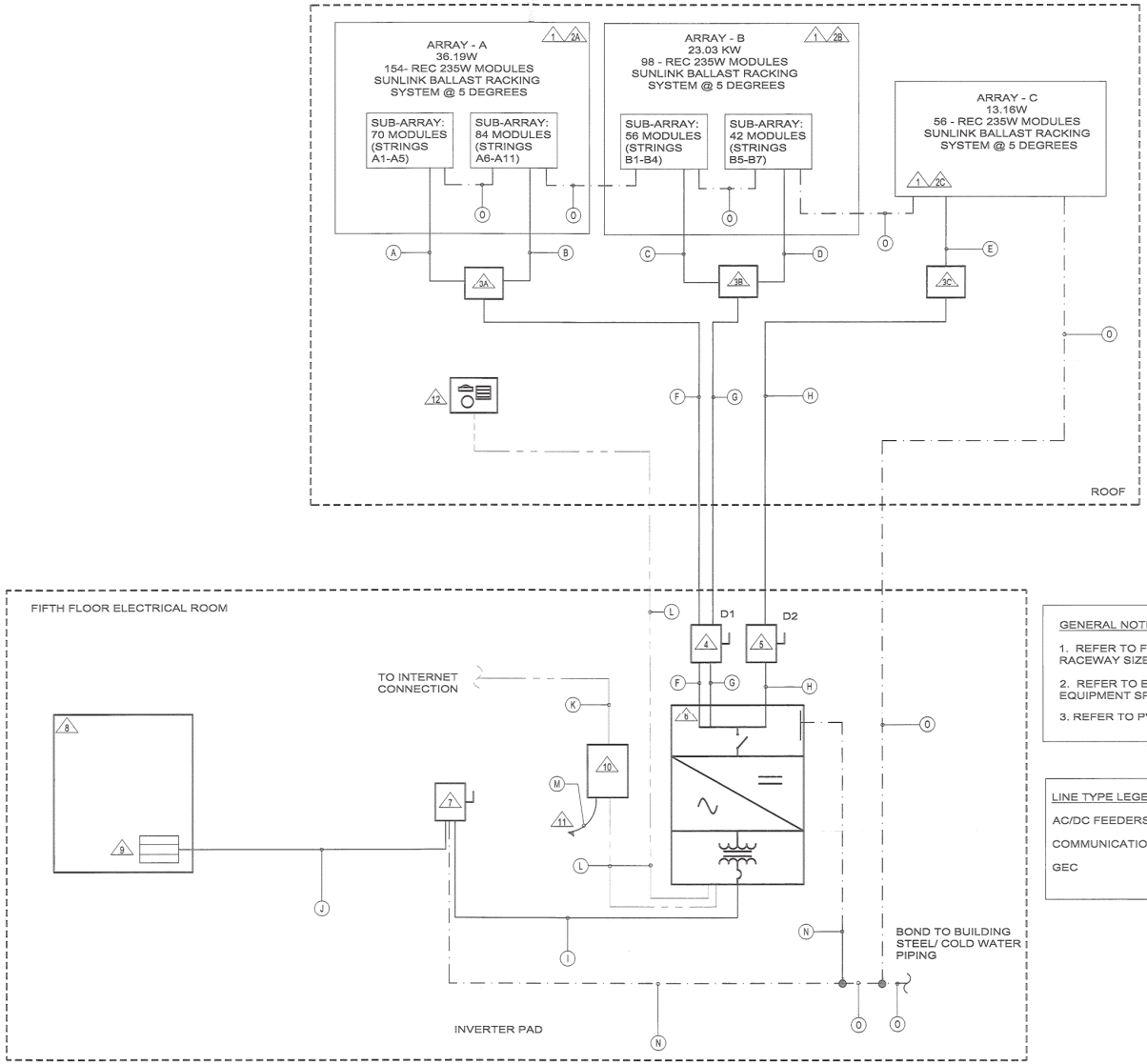

GENERAL NOTES TO PV-2.0:

1. REFER TO FEEDER SCHEDULE ON SHEET PV-2.1 FOR RACEWAY SIZE AND COMPOSITION.
2. REFER TO EQUIPMENT SCHEDULE ON PV-2.1 FOR EQUIPMENT SPECIFICATIONS.
3. REFER TO PV-3.0 FOR GROUNDING DETAIL.

LINE TYPE LEGEND:

AC/DC FEEDERS

COMMUNICATION

GEC

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SOLAR PHOTOVOLTAIC SYSTEM
SINGLE LINE
DRAWN BY: KYRA MOORE
SCALE: NONE

PV-2.0

PV MODULE @ STC	
MAKE	REC
MODEL	REC235PE
MAX POWER-POINT CURRENT (I_{MP})	7.90 A
MAX POWER-POINT VOLTAGE (V_{MP})	29.8 V
OPEN CIRCUIT VOLTAGE (V_{OC})	37.4 V
SHORT CIRCUIT CURRENT (I_{SC})	8.30 A
MAX SERIES FUSE (OCPD)	15.0 A
MAX POWER (P_{MAX})	235 W
MAX VOLTAGE (V_{DC})	600 V
V_{OC} TEMP COEFF	-0.32 %/°C

INVERTER	
MAKE	PVPOWERED
MODEL	PVP-75KW
MAX DC VOLTAGE RATING	600 V
MAX POWER @ 40°C	75 W
NOMINAL AC VOLTAGE	480 V
MAX AC OUTPUT CURRENT	90 A
MAX OCPD	125 A
MAX DC INPUT CURRENT	267 A

EQUIPMENT SCHEDULE

**EQUIPMENT IS NOTED BY #

TAG	DESCRIPTION	MANUFACTURER	PART NUMBER	NOTES
1	SOLAR PV MODULE	REC	REC235PE	235 WATT MODULE, QUANTITY 308 (REFER TO DRAWINGS FOR QUANTITY AND LOCATION). MODULES SHALL BE LABELED PER NEC 690 VI.
2A	PV SUB-ARRAY - A			ARRAY IS 11 STRINGS WITH 14 MODULES EACH
2B	PV SUB-ARRAY -B			ARRAY IS 7 STRINGS WITH 14 MODULES EACH
2C	PV SUB-ARRAY-C			ARRAY IS 4 STRINGS WITH 14 MODULES EACH
3A	COMBINER BOX	SOLARBOS	CS200C-11-15-N3	12 STRING DISCONNECTING CONONTACTOR COMBINER RATED AT 200A WITH (11) 15A FUSES, 600 VDC, RATED FOR CONTINUOUS DUTY, NEMA 3R ENCLOSURE
3B	COMBINER BOX	SOLARBOS	CS200C-7-15-N3	8 STRING DISCONNECTING COMBINER RATED AT 200A WITH (7) 15A FUSES, 600 VDC, RATED FOR CONTINUOUS DUTY, NEMA 3R ENCLOSURE
3C	COMBINER BOX	SOLARBOS	CS200C-4-15-N3	4 STRING DISCONNECTING COMBINER RATED AT 200A WITH (4) 15A FUSES, 600 VDC, RATED FOR CONTINUOUS DUTY, NEMA 3R ENCLOSURE
4	DC DISCONNECT	SQUARE-D	H464AWK	200 AMP 4 POLE FUSED DISCONNECT WITH (2) 150 AMP FUSES AND (2) 100 AMP FUSES, NEMA 12 WITHOUT KNOCKOUTS. FUSES SHALL BE DC RATED.
5	DC DISCONNECT	SQUARE-D	H362AWK	60AMP 3 POLE FUSED DISCONNECT WITH (2) 60 AMP FUSES, NEMA 12 WITHOUT KNOCKOUTS. FUSES SHALL BE DC RATED.
6	INVERTER	PV POWERED	PVP-75	75 KWATT, THREE PHASE 480 VOLT(REFER TO INVERTER RATING SCHEDULE FOR ADDITIONAL INFORMATION)
7	AC DISCONNECT	SQUARE-D	H364AWK	200 AMP 3 POLE FUSED DISCONNECT WITH (3) 125 AMP FUSES, NEMA 12 WITHOUT KNOCKOUTS, PROVIDE NEMA 3R FOR MANUFACTURES OTHER THAN SQUARE D
8	EXISTING SUBSTATION 6 (CODE 6G)			400A SWITCHGEAR (CODE 6) ,
9	(3) 125 AMP FUSES			REPLACE 250 AMP EXISTING FUSES WITH (3) 125 AMP FUSES SUITABLE FOR BACK FEEDING.
10	MONITORING EQUIPMENT	LOCUS		MONITORING DATA ACQUISITION UNIT
11	120V RECEPTICAL			PROVIDE 20A RECEPTACLE
12	WEATHER STATION	LOCUS		WEATHER STATION TO MONITOR: CELL AND AMBIENT TEMPERATURES, WIND SPEED, AND IRRADIANCE. SENSORS TO BE LOCATED ON ROOF NEAR ARRAY

FEEDER SCHEDULE

**FEEDER IS NOTED BY α

TAG	CONDUCTOR SIZE	INSULATION TYPE	GROUND SIZE	GROUND INSULATION TYPE	CONDUIT SIZE	CONDUIT TYPE
A	(10) #10	XLPE	#6	BARE COPPER	(1) 1-1/2"	IMC
B	(12) #10	XLPE	#6	BARE COPPER	(1) 1-1/2"	IMC
C	(8) #10	XLPE	#6	BARE COPPER	(1) 1-1/2"	IMC
D	(6) #10	XLPE	#6	BARE COPPER	(1) 1-1/2"	IMC
E	(8) #10	XLPE	#6	BARE COPPER	(1) 1-1/2"	IMC
F	(2) #1/0	THWN-2	(1) #6	THWN-2	(1) 1-1/2"	IMC
G	(2) #3	THWN-2	(1) #6	THWN-2	(1) 1-1/4"	IMC
H	(2) #6	THWN-2	(1) #6	THWN-2	(1) 1"	IMC
I	(4) #2	THWN-2	(1) #6	THWN-2	(1) 1-1/2""	EMT
J	(4) #2	THWN-2			(1) 1-1/2""	EMT
K	(1) CAT 5E COMMUNICATIONS WIRE				(1) 1"	IMC
L	(1) RS-485 WIRE (+/-/G)				(1) 1"	IMC
M	(2) #12	THWN-2	(1) #12	THWN-2	(1) 3/4"	EMT
N			(1) #6	BARE COPPER		
O			(1) #1/0	BARE COPPER		

NOTES:

1. (#) - DENOTES QUANTITY TO BE PROVIDED
2. WHERE MULITPLE CONDUITS ARE NOTED, THE RACEWAYS SHALL BE PROVIDED IN PARALLEL AND THE CONDUCTOR QUANTITES NOTED SHALL BE PROVIDED PER CONDUIT.
3. GROUNDS SHALL BE INSULATED UNLESS NOTED OTHERWISE
4. ALL RACEWAYS SHALL TRANSITION TO PVC AT POINT OF EARTH PENITRATION WHERE CONDUITS SHALL BE BURIED AND RUN UNDERGROUND.
5. ALL CONDUCTORS SHALL BE COPPER.
6. ROUTE IN WIRE MANAGEMENT INTEGRAL WITH THE RACKING SYSTEM.

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SOLAR PHOTOVOLTAIC SYSTEM
EQUIPMENT SCHEDULES
DRAWN BY: KYRA MOORE
SCALE: NONE

PV-2.1

DC FEEDER CALCULATIONS

*NOTE - WIRE SIZE SHALL BE DETERMINED BY THE LARGER WIRE REQUIRED BY 690.8(B)(2)(c) OR 690.8(B)(a)

CALCULATED PER NEC 690.8(B)(2)(c)

91° F AMBIENT TEMPERATURE
6 (INCHES) DISTANCE CONDUITS MOUNTED ABOVE ROOF
90° C TEMPERATURE RATING OF CONDUCTOR
75° C TEMPERATURE RATING OF FUSE TERMINALS

FEEDER TAG	QTY	WIRE SIZE		NEC REFERENCE
A	10	#10		
	1.	50%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	30° F	AMBIENT TEMPERATURE ADJUSTMENT FOR ROOFTOP RACEWAYS	T310.15(B)(3)(c)
	3.	121° F	AMBIENT TEMPERATURE + ADJUSTMENT FOR ROOFTOP RACEWAYS	
	4.	0.82	AMBIENT TEMPERATURE CORRECTION FACTORS	T310.15(B)(2)(a)
	5.	40.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	6.	20.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	7.	16.40 A	APPLY ADJUSTMENT FACTOR STEP 4	
	8.	1	QUANTITY OF STRINGS IN SERIES	
	9.	10.38 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	10.	35.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES - FUSE TERMINALS SHALL BE RATED FOR LOAD	
B	12	#10		
	1.	50%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	30° F	AMBIENT TEMPERATURE ADJUSTMENT FOR ROOFTOP RACEWAYS	T310.15(B)(3)(c)
	3.	121° F	AMBIENT TEMPERATURE + ADJUSTMENT FOR ROOFTOP RACEWAYS	
	4.	0.82	AMBIENT TEMPERATURE CORRECTION FACTORS	T310.15(B)(2)(a)
	5.	40.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	6.	20.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	7.	16.40 A	APPLY ADJUSTMENT FACTOR STEP 4	
	8.	1	QUANTITY OF STRINGS IN SERIES	
	9.	10.38 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	10.	35.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES - FUSE TERMINALS SHALL BE RATED FOR LOAD	
C & E	8	#10		
	1.	70%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	30° F	AMBIENT TEMPERATURE ADJUSTMENT FOR ROOFTOP RACEWAYS	T310.15(B)(3)(c)
	3.	121° F	AMBIENT TEMPERATURE + ADJUSTMENT FOR ROOFTOP RACEWAYS	
	4.	0.82	AMBIENT TEMPERATURE CORRECTION FACTORS	T310.15(B)(2)(a)
	5.	40.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	6.	28.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	7.	22.96 A	APPLY ADJUSTMENT FACTOR STEP 4	
	8.	1	QUANTITY OF STRINGS IN SERIES	
	9.	10.38 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	10.	35.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES - FUSE TERMINALS SHALL BE RATED FOR LOAD	
D	6	#10		
	1.	80%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	30° F	AMBIENT TEMPERATURE ADJUSTMENT FOR ROOFTOP RACEWAYS	T310.15(B)(3)(c)
	3.	121° F	AMBIENT TEMPERATURE + ADJUSTMENT FOR ROOFTOP RACEWAYS	
	4.	0.82	AMBIENT TEMPERATURE CORRECTION FACTORS	T310.15(B)(2)(a)
	5.	40.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	6.	32.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	7.	26.24 A	APPLY ADJUSTMENT FACTOR STEP 4	
	8.	1	QUANTITY OF STRINGS IN SERIES	
	9.	10.38 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	10.	35.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES - FUSE TERMINALS SHALL BE RATED FOR LOAD	
F	2	#1/0		
	1.	100%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	30° F	AMBIENT TEMPERATURE ADJUSTMENT FOR ROOFTOP RACEWAYS	T310.15(B)(3)(c)
	3.	121° F	AMBIENT TEMPERATURE + ADJUSTMENT FOR ROOFTOP RACEWAYS	
	4.	0.82	AMBIENT TEMPERATURE CORRECTION FACTORS	T310.15(B)(2)(a)
	5.	170.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	6.	170.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	7.	139.40 A	APPLY ADJUSTMENT FACTOR STEP 4	
	8.	11	QUANTITY OF STRINGS IN SERIES	
	9.	114.13 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	10.	150.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES - FUSE TERMINALS SHALL BE RATED FOR LOAD	
G	2	#3		
	1.	100%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	30° F	AMBIENT TEMPERATURE ADJUSTMENT FOR ROOFTOP RACEWAYS	T310.15(B)(3)(c)
	3.	121° F	AMBIENT TEMPERATURE + ADJUSTMENT FOR ROOFTOP RACEWAYS	
	4.	0.82	AMBIENT TEMPERATURE CORRECTION FACTORS	T310.15(B)(2)(a)
	5.	115.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	6.	115.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	7.	94.30 A	APPLY ADJUSTMENT FACTOR STEP 4	
	8.	7	QUANTITY OF STRINGS IN SERIES	
	9.	72.63 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	10.	100.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES - FUSE TERMINALS SHALL BE RATED FOR LOAD	
H	2	#6		
	1.	100%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	30° F	AMBIENT TEMPERATURE ADJUSTMENT FOR ROOFTOP RACEWAYS	T310.15(B)(3)(c)
	3.	121° F	AMBIENT TEMPERATURE + ADJUSTMENT FOR ROOFTOP RACEWAYS	
	4.	0.82	AMBIENT TEMPERATURE CORRECTION FACTORS	T310.15(B)(2)(a)
	5.	75.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	6.	75.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	7.	61.50 A	APPLY ADJUSTMENT FACTOR STEP 4	
	8.	4	QUANTITY OF STRINGS IN SERIES	
	9.	41.50 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	10.	65.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES - FUSE TERMINALS SHALL BE RATED FOR LOAD	

CALCULATED PER NEC 690.8(B)(a)

90° C TEMPERATURE RATING OF CONDUCTOR
75° C TEMPERATURE RATING OF FUSE TERMINALS

FEEDER TAG	QTY	WIRE SIZE		NEC REFERENCE
A	10	#10		
	1.	50%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	40.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	3.	20.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	4.	1	QUANTITY OF STRINGS IN SERIES	
	5.	10.38 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	6.	12.97 A	APPLY NEC FACTOR FOR CONTINUOUS DUTY (MODULE ISC * # STRINGS * 1.25)	
	7.	35.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES	
B	12	#10		
	1.	50%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	40.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	3.	20.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	4.	1	QUANTITY OF STRINGS IN SERIES	
	5.	10.38 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	6.	12.97 A	APPLY NEC FACTOR FOR CONTINUOUS DUTY (MODULE ISC * # STRINGS * 1.25)	
	7.	35.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES	
C & E	8	#10		
	1.	70%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	40.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	3.	28.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	4.	1	QUANTITY OF STRINGS IN SERIES	
	5.	10.38 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	6.	12.97 A	APPLY NEC FACTOR FOR CONTINUOUS DUTY (MODULE ISC * # STRINGS * 1.25)	
	7.	35.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES	
D	6	#10		
	1.	80%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	40.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	3.	32.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	4.	1	QUANTITY OF STRINGS IN SERIES	
	5.	10.38 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	6.	12.97 A	APPLY NEC FACTOR FOR CONTINUOUS DUTY (MODULE ISC * # STRINGS * 1.25)	
	7.	35.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES	
F	2	#1/0		
	1.	100%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	170.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	3.	170.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	4.	11	QUANTITY OF STRINGS IN SERIES	
	5.	114.13 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	6.	142.66 A	APPLY NEC FACTOR FOR CONTINUOUS DUTY (MODULE ISC * # STRINGS * 1.25)	
	7.	150.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES	
G	2	#3		
	1.	100%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	115.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	3.	115.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	4.	7	QUANTITY OF STRINGS IN SERIES	
	5.	72.63 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	6.	90.78 A	APPLY NEC FACTOR FOR CONTINUOUS DUTY (MODULE ISC * # STRINGS * 1.25)	
	7.	100.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES	
H	2	#6		
	1.	100%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	75.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	3.	75.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	4.	4	QUANTITY OF STRINGS IN SERIES	
	5.	41.50 A	LOAD ON CONDUCTOR (MODULE I_{SC} * # STRINGS*1.25(IRR))	
	6.	51.88 A	APPLY NEC FACTOR FOR CONTINUOUS DUTY (MODULE ISC * # STRINGS * 1.25)	
	7.	65.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES	

AC FEEDER CALCULATIONS

*NOTE - WIRE SIZE SHALL BE DETERMINED BY THE LARGER WIRE REQUIRED BY 690.8(B)(2)(c) OR 690.8(B)(a)

CALCULATED PER NEC 690.8(B)(2)(c)

91° F AMBIENT TEMPERATURE
6° F (INCHES) DISTANCE CONDUITS MOUNTED ABOVE ROOF
90° F TEMPERATURE RATING OF CONDUCTOR
75° F TEMPERATURE RATING OF FUSE TERMINALS

FEEDER TAG	QTY	WIRE SIZE		NEC REFERENCE
I	4	#2		
	1.	80%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	30° F	AMBIENT TEMPERATURE ADJUSTMENT FOR ROOFTOP RACEWAYS	T310.15(B)(3)(c)
	3.	121° F	AMBIENT TEMPERATURE + ADJUSTMENT FOR ROOFTOP RACEWAYS	
	4.	0.82	AMBIENT TEMPERATURE CORRECTION FACTORS	T310.15(B)(2)(a)
	5.	130.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	6.	1	PARALLELED SETS	
	7.	130.0 A	APPLY FACTOR FOR PARALLELED SET	
	8.	104.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	9.	85.28 A	APPLY ADJUSTMENT FACTOR STEP 4	
	10.	90.0 A	LOAD ON CONDUCTOR (INVERTER MAXIMUM CURRENT OUTPUT)	
	11.	115.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES - FUSE TERMINALS SHALL BE RATED FOR LOAD	
J	4	#2		
	1.	80%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	30° F	AMBIENT TEMPERATURE ADJUSTMENT FOR ROOFTOP RACEWAYS	T310.15(B)(3)(c)
	3.	121° F	AMBIENT TEMPERATURE + ADJUSTMENT FOR ROOFTOP RACEWAYS	
	4.	0.82	AMBIENT TEMPERATURE CORRECTION FACTORS	T310.15(B)(2)(a)
	5.	130.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	6.	1	PARALLELED SETS	
	7.	130.0 A	APPLY FACTOR FOR PARALLELED SET	
	8.	104.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	9.	85.28 A	APPLY ADJUSTMENT FACTOR STEP 4	
	10.	90.0 A	LOAD ON CONDUCTOR (INVERTER MAXIMUM CURRENT OUTPUT)	
	11.	115.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES - FUSE TERMINALS SHALL BE RATED FOR LOAD	

CALCULATED PER NEC 690.8(B)(a)

90° C TEMPERATURE RATING OF CONDUCTOR
75° C TEMPERATURE RATING OF FUSE TERMINALS

FEEDER TAG	QTY	WIRE SIZE		NEC REFERENCE
I	4	#2		
	1.	80%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	130.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	3.	1	PARALLELLED SETS	
	4.	130.0 A	APPLY FACTOR FOR PARALLELED SET	
	5.	104.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	6.	90.0 A	LOAD ON CONDUCTOR (INVERTER MAXIMUM CURRENT OUTPUT)	
	7	112.50 A	APPLY NEC FACTOR FOR CONTINUOUS DUTY (INVERTER MAXIMUM CURRENT OUTPUT * 1.25)	
	8.	115.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES	
J	4	#2		
	1.	80%	ADJUSTMENT FACTOR FOR MORE THAN 3 CURRENT CARRYING CONDUCTORS IN A RACEWAY	T310.15(B)(3)(a)
	2.	130.0 A	CONDUCTOR AMPACITY @ 90° C	T310.15(B)(16)
	3.	1	PARALLELLED SETS	
	4.	130.0 A	APPLY FACTOR FOR PARALLELED SET	
	5.	104.0 A	APPLY ADJUSTMENT FACTOR STEP 1	
	6.	90.0 A	LOAD ON CONDUCTOR (INVERTER MAXIMUM CURRENT OUTPUT)	
	7	112.50 A	APPLY NEC FACTOR FOR CONTINUOUS DUTY (INVERTER MAXIMUM CURRENT OUTPUT * 1.25)	
	8.	115.0 A	CONDUCTOR AMPACITY @ 75° C - VERIFICATION PURPOSES	

SOLAR ARRAY CALCULATIONS FOR DC DISCONNECT - D1

INITIAL EVALUATION - PARALLELED SETS OF 11 STRINGS AND 7 STRINGS OF 14 REC 235 WATT MODULES EACH (TOTAL 18 STRINGS)

RATED MPP CURRENT	11 * 7.9A =	86.90 A
RATED MPP VOLTAGE	14 * 29.8V =	417.2 V
MAX SYSTEM VOLTAGE	14 * (37.4V) * [(1 + (-20°C - 25°C)) * (-0.0032/°C)] =	599. V
MAX CIRCUIT CURRENT	11 * 8.3A * 1.25 =	114.13 A
MAX POWER	18 * 14 * 235W =	59220 W

SOLAR ARRAY CALCULATIONS FOR DC DISCONNECT - D2

INITIAL EVALUATION OF 4 STRINGS OF 14 REC 235 WATT MODULES EACH (TOTAL 4 STRINGS)

RATED MPP CURRENT	4 * 7.9A =	31.60 A
RATED MPP VOLTAGE	14 * 29.8V =	417.2 V
MAX SYSTEM VOLTAGE	14 * (37.4V) * [(1 + (-20°C - 25°C)) * (-0.0032/°C)] =	599. V
MAX CIRCUIT CURRENT	4 * 8.3A * 1.25 =	41.50 A
MAX POWER	4 * 14 * 235W =	13160 W

CALCULATION VARIABLES

RATED MPP CURRENT	= # OF STRINGS * I_{MP}
RATED MPP VOLTAGE	= # OF MODULES PER STRING * I_{MP}
MAX SYSTEM VOLTAGE	= # OF MODULES PER STRING * (V_{OC}) * [(1 +(RECORD LOW TEMP$_{LOCATION}$ - RECORD LOW TEMP$_{STC}$)) * (TEMP COEFFICIENT$_{MODULE}$)]
MAX CIRCUIT CURRENT	= # OF STRINGS * I_{SC} * IRRADIANCE FACTOR
MAX POWER	= # OF STRINGS * # OF MODULES PER STRING * WATTAGE OF MODULE

PHENOLIC LABEL REQUIRED FOR THE DC DISCONNECT

PHOTOVOLTAIC POWER SOURCE DISCONNECT D1

RATED MPP CURRENT	86.90 A
RATED MPP VOLTAGE	417.2 V
MAX SYSTEM VOLTAGE	599. V
MAX CIRCUIT CURRENT	114.13 A

WARNING: ELECTRICAL SHOCK HAZARD - DO NOT TOUCH TERMINALS. TERMINALS ON BOTH LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION

PHENOLIC LABEL REQUIRED FOR THE DC DISCONNECT

PHOTOVOLTAIC POWER SOURCE DISCONNECT D2

RATED MPP CURRENT	31.60 A
RATED MPP VOLTAGE	417.2 V
MAX SYSTEM VOLTAGE	599. V
MAX CIRCUIT CURRENT	41.50 A

WARNING: ELECTRICAL SHOCK HAZARD - DO NOT TOUCH TERMINALS. TERMINALS ON BOTH LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION

PHENOLIC LABEL/SIGN REQUIRED FOR THE INVERTER OCPD AND AC DISCONNECT

SOLAR PV SYSTEM AC POINT OF CONNECTION

AC OUTPUT CURRENT	90
NOMINAL AC VOLTAGE	480 V

THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)

STATE OF MISSOURI
CHARLES R. LADD JR.
NUMBER
PE-2007005022
PROFESSIONAL ENGINEER
6-1-2011

REVISIONS

DATE	NOTE	BY

SOUTHERNENERGY MANAGEMENT
ENERGY EFFICIENCY & SOLAR POWER

101 Kitty Hawk Drive
Morrisville, NC 27560
(919) 836-0330

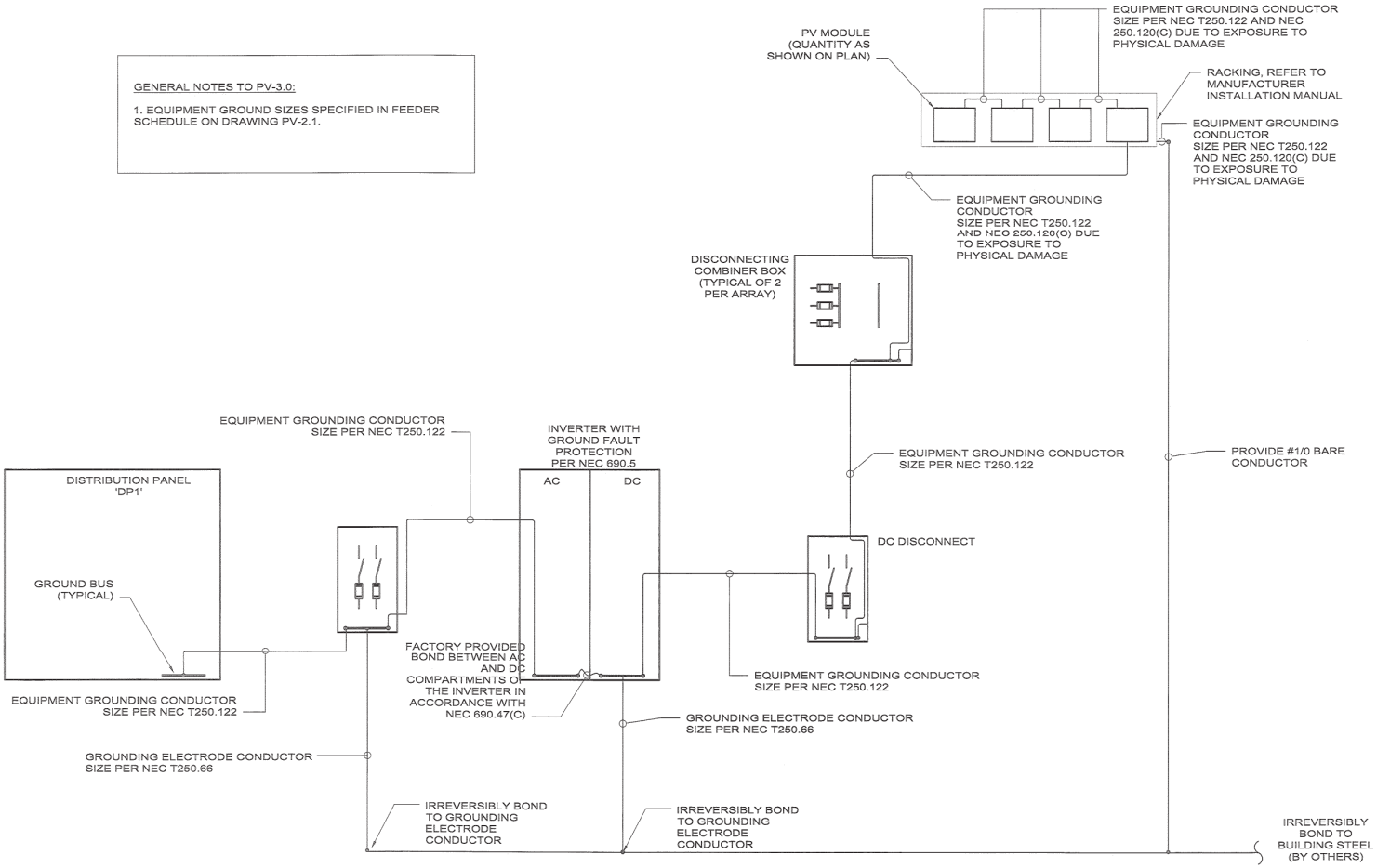
GSK ST. LOUIS
320 SOUTH BROADWAY STREET
ST. LOUIS, MO 63102
5/31/11

SOLAR PHOTOVOLTAIC SYSTEM
PV CALCULATIONS
DRAWN BY: KYRA MOORE
SCALE: NONE

PV-2.2

GENERAL NOTES TO PV-3.0:

1. EQUIPMENT GROUND SIZES SPECIFIED IN FEEDER SCHEDULE ON DRAWING PV-2.1.



1 TYPICAL ELECTRICAL GROUNDING DETAIL

STATE OF MISSOURI
CHARLES R. LADD JR.
NUMBER PE-2007000022
PROFESSIONAL ENGINEER
6-1-2011

REVISIONS

DATE	NOTE	BY

SOUTHERN ENERGY MANAGEMENT
ENERGY EFFICIENCY & SOLAR POWER

101 Kitty Hawk Drive
Morrisville, NC 27560
(919) 836-0330

GSK ST. LOUIS
320 SOUTH BROADWAY STREET
ST. LOUIS, MO 63102
5/31/11

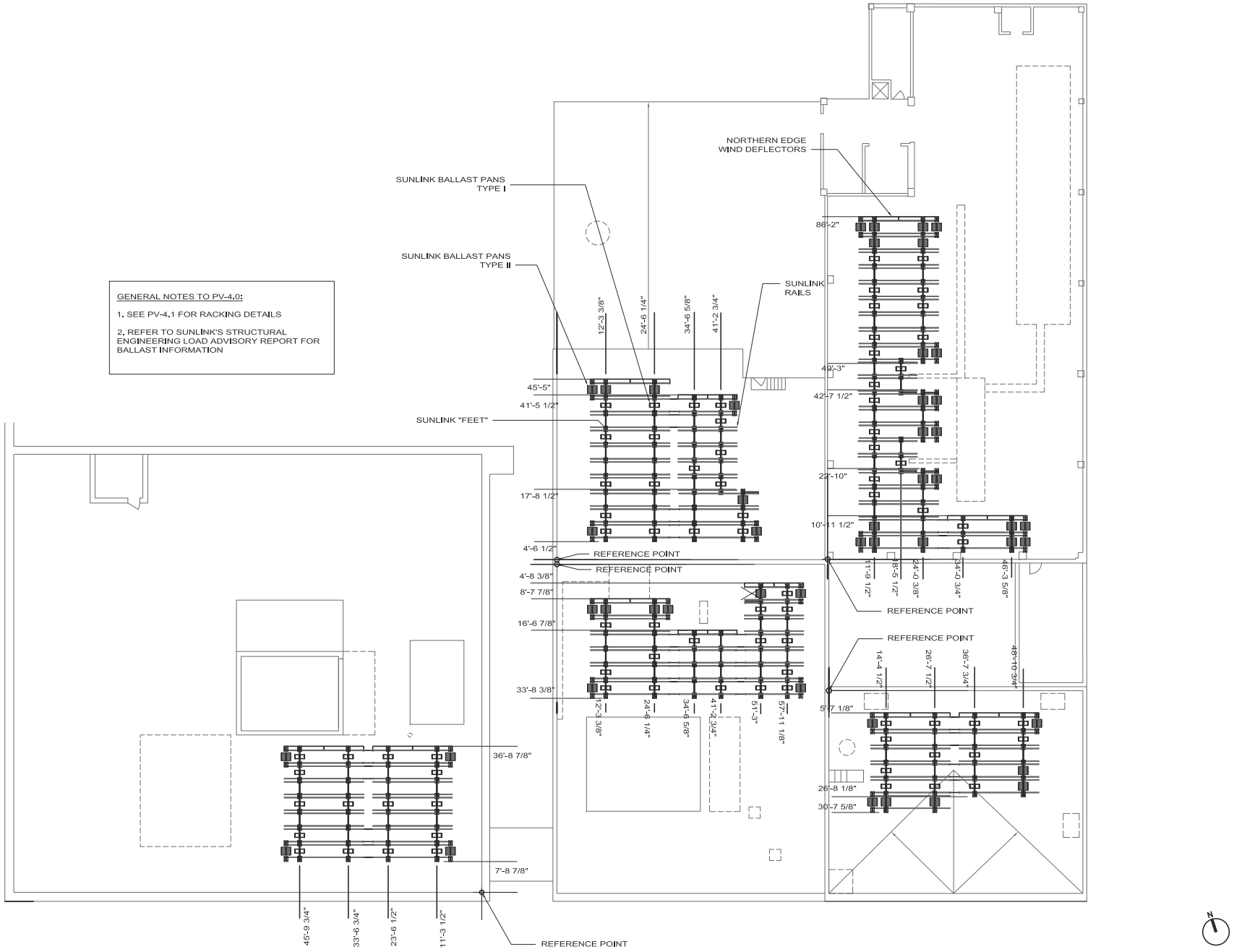
SOLAR PHOTOVOLTAIC SYSTEM
GROUNDING DETAIL
DRAWN BY: KYRA MOORE
SCALE: NONE

PV-3.0

GENERAL NOTES TO PV-4.0:

1. SEE PV-4.1 FOR RACKING DETAILS

2. REFER TO SUNLINK'S STRUCTURAL ENGINEERING LOAD ADVISORY REPORT FOR BALLAST INFORMATION



FOR REFERENCE ONLY

REVISIONS

DATE	NOTE	BY

SOUTHERN ENERGY MANAGEMENT
ENERGY EFFICIENCY & SOLAR POWER

101 Kitty Hawk Drive
Morrisville, NC 27560
(919) 836-0330

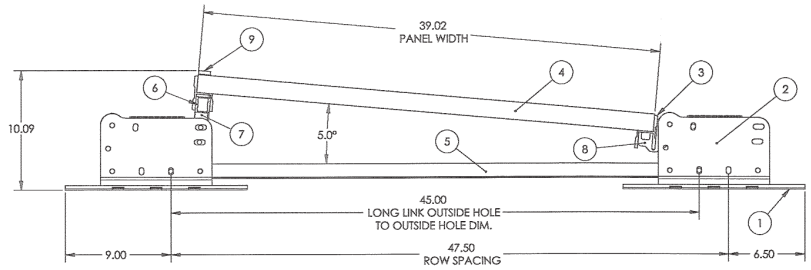
GSK ST. LOUIS
320 SOUTH BROADWAY STREET
ST. LOUIS, MO 63102
5/31/11

SOLAR PHOTOVOLTAIC SYSTEM
RACKING PLAN
DRAWN BY: KYRA MOORE
SCALE: 3/32" =1'-0"

PV-4.0

REC 230PE 5° 4X1 ASSEMBLY

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
X01	INITIAL DESIGN RELEASE	7/16/10	JHM



ITEM NO.	PART NUMBER	Description	QTY.
1	201-TBB-05-U	TILT BRACKET BASE 5° UNIVERSAL	4
2	211-TBC-05-W	TILT BRACKET COVER, 5° WIDE MODULES	4
3	1119-240-02-1	SPAR, REC 230PE, 4X1, DEFLECTOR HOLES	2
4	REC230PE	REC 230PE PANEL ASSEMBLY	4
5	301-470-00-1	LONG LINK, 47.0" LONG	2
6	302-118-33-1	LATERAL LINK 33" LONG, HS 31.45"	-
7	401-000-05-U	UNIVERSAL 5 DEGREE ANCHOR BLOCK	2
8	402-000-00-0	PIVOT BLOCK	2
9	403-000-00-2	UNIVERSAL CLAMP BLOCK, 0.500IN HOLE SPACING	6
	201-TBB-05-U	TILT BRACKET BASE 5° UNIVERSAL	-
	211-TBC-05-W-ER	TILT BRACKET COVER, 5° MODULES, WIDE, NORTH END ROW	-
	500-WD-CLIP-1	DEFLECTOR TB CLIP	-
	500-0055	5° 4X1 EAST DEFLECTOR, WIDE 1	-
	500-0056	5° 4X1 WEST DEFLECTOR, WIDE 1	-

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/8"
ANGULAR: MACH ± .2° BEND ± 1°
ONE PLACE DECIMAL ± .1"
TWO PLACE DECIMAL ± .01"
THREE PLACE DECIMAL ± .005"
INTERPRET GEOMETRIC TOLERANCING PER: ANSI Y14.5
MATERIAL: REF PARTS
FINISH: REF PARTS

	NAME	DATE
DRAWN	RJC	7/16/10
ENG APPR.	JHM	7/16/10

PROPRIETARY AND CONFIDENTIAL
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SUNLINK CORP, SAN RAFAEL, CA

SUNLINK
SUNLINK CORPORATION
1010 B STREET, SUITE 400
SAN RAFAEL, CALIFORNIA
94901 USA
t: 415.925.9650 - f: 415.925.9636

TITLE: REC 230PE 5° ASSEMBLY, NORTH ROW

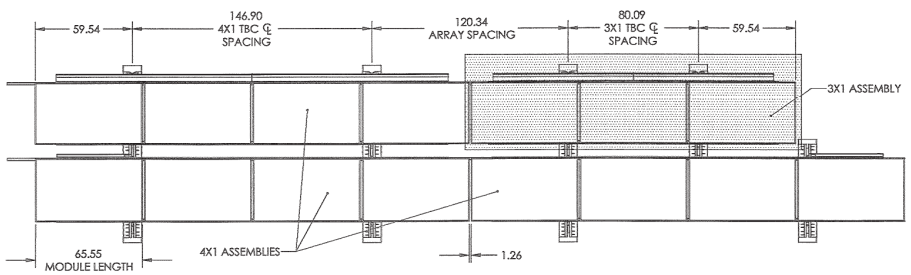
SIZE	DWG. NO.	REV
B	1001-119-02-05	X01
SCALE: 1:5	DO NOT SCALE	SHEET 1 OF 3

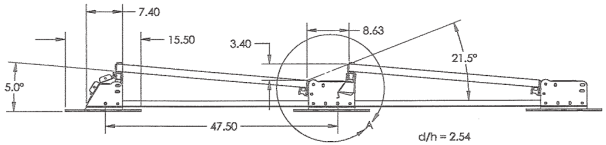
REC 230PE 5° ARRAY SPACING

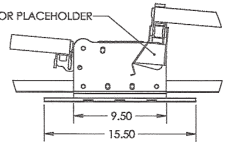
REV.	DESCRIPTION	DATE	APPROVED
-	See Sheet1	-	-

NOTE:

1. SECOND ROW DEFLECTORS ARE PLACEHOLDERS







DETAIL A
SCALE 1 : 6

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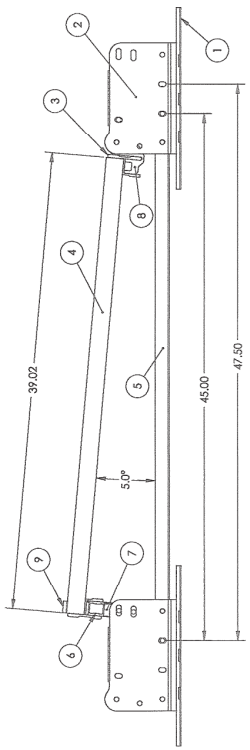
SUNLINK CORP, SAN RAFAEL, CALIFORNIA

SIZE	DWG. NO.	REV
B	1001-119-02-05	X01
SCALE: 1:26	DO NOT SCALE	SHEET 3 OF 3

REC 230PE 5° 3X1 ASSEMBLY

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
-	See Sheet1	-	-



ITEM NO.	PART NUMBER	Description	QTY.
1	201-TBB-05-U	TILT BRACKET BASE 5° UNIVERSAL	4
2	211-TBC-05-W	TILT BRACKET COVER, 5° WIDE MODULES	4
3	1119-178-02-2	SPAR, REC 230PE, 3X1, DEFLECTOR HOLES	2
4	REC230PE	REC 230PE PANEL ASSEMBLY	3
5	301-470-00-1	LONG LINK, 47.0" LONG	2
6	302-118-33-1	LATERAL LINK 33" LONG, HS 31.45"	-
7	401-000-05-U	UNIVERSAL 5 DEGREE ANCHOR BLOCK	2
8	402-000-00-0	PIVOT BLOCK	2
9	403-000-00-2	UNIVERSAL CLAMP BLOCK, 0.500IN HOLE SPACING	4
	201-TBB-05-U	TILT BRACKET BASE 5° UNIVERSAL	-
	211-TBC-05-W-ER	TILT BRACKET COVER, 5° MODULES, WIDE, NORTH END ROW	-
	500-WD-CLIP-1	DEFLECTOR TB CLIP	-
	500-0057	5° 3X1 EAST DEFLECTOR, WIDE 1	-
	500-0058	5° 3X1 WEST DEFLECTOR, WIDE 1	-

PROPRIETARY AND CONFIDENTIAL
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SUNLINK CORP, SAN RAFAEL, CALIFORNIA

SIZE	DWG. NO.	REV
B	1001-119-02-05	X01
SCALE: 1:5	DO NOT SCALE	SHEET 2 OF 3

FOR REFERENCE ONLY

REVISIONS

DATE	NOTE	BY

SOUTHERNENERGY MANAGEMENT
ENERGY EFFICIENCY & SOLAR POWER
101 Kitty Hawk Drive
Morrisville, NC 27560
(919) 836-0330

GSK ST. LOUIS
320 SOUTH BROADWAY STREET
ST. LOUIS, MO 63102
5/31/11

SOLAR PHOTOVOLTAIC SYSTEM
SUNLINK RACKING DETAIL
DRAWN BY: KYRA MOORE
SCALE: NONE

PV-4.1

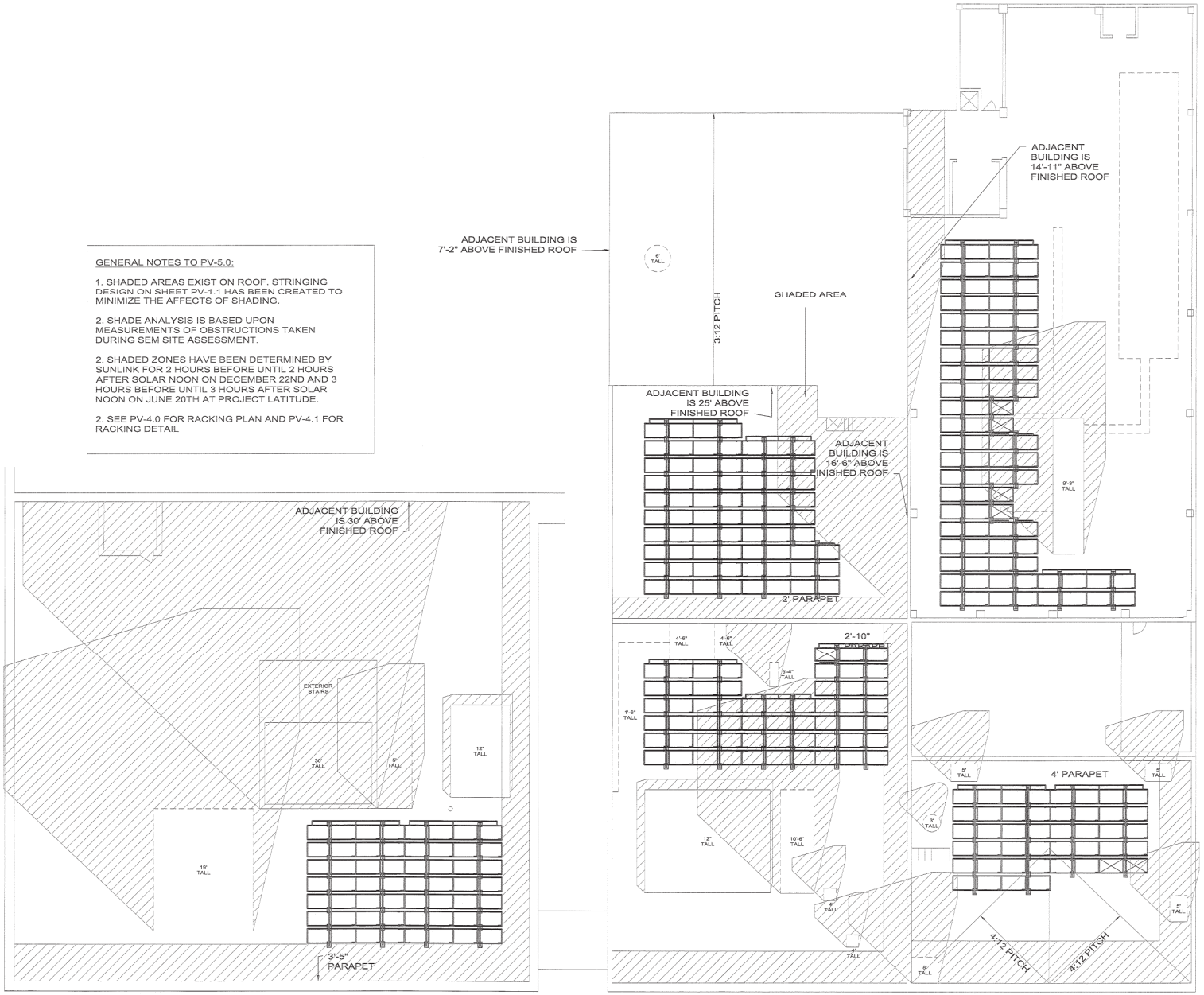
GENERAL NOTES TO PV-5.0:

1. SHADED AREAS EXIST ON ROOF. STRINGING DESIGN ON SHEET PV-1.1 HAS BEEN CREATED TO MINIMIZE THE AFFECTS OF SHADING.

2. SHADE ANALYSIS IS BASED UPON MEASUREMENTS OF OBSTRUCTIONS TAKEN DURING SEM SITE ASSESSMENT.

2. SHADED ZONES HAVE BEEN DETERMINED BY SUNLINK FOR 2 HOURS BEFORE UNTIL 2 HOURS AFTER SOLAR NOON ON DECEMBER 22ND AND 3 HOURS BEFORE UNTIL 3 HOURS AFTER SOLAR NOON ON JUNE 20TH AT PROJECT LATITUDE.

2. SEE PV-4.0 FOR RACKING PLAN AND PV-4.1 FOR RACKING DETAIL



FOR REFERENCE ONLY

REVISIONS

DATE	NOTE	BY

SOUTHERN ENERGY MANAGEMENT
ENERGY EFFICIENCY & SOLAR POWER

101 Kitty Hawk Drive
Morrisville, NC 27560
(919) 836-0330

GSK ST. LOUIS
320 SOUTH BROADWAY STREET
ST. LOUIS, MO 63102
5/31/11

SOLAR PHOTOVOLTAIC SYSTEM
SHADING ANALYSIS
DRAWN BY: KYRA MOORE
SCALE: 3/32" =1'-0"

PV-5.0

KCI TECHNOLOGIES, INC.
WORK AUTHORIZATION
12-16-2010

KCI Technologies, Inc. is pleased to provide the services described below. The purpose of this form is to obtain your authorization for the work verbally requested and to confirm the terms under which these services will be provided.

Project Name: *GlaxoSmithKline Bldg 7 Roof Loading Analysis*
Project Location: *St. Louis, MO*

Invoices to: *Southern Energy Management*
Attention: *Kyra Moore*
101 Kitty Hawk Dr
Morrisville, North Carolina 27560

Scope of Work: *Structural analysis of existing roof with additional new equipment*

Basic Fee Option D: Lump Sum
Base Bid Fee: Lump sum of $ *1320.00* .
Alternate #1 Fee: Lump sum of $ *2400.00* .

General Provisions: It is agreed that the attached General Provisions are accepted and are made part of this contract.

Prepared by:_____ **Approved by:**_____
Chris Aycock — *Jim Gellenthin*
Project Manager — *Chief Engineer*

Guarantee: In consideration of the execution of this contract and extension of credits, the signator does hereby unconditionally and personally guarantee the payment of all fees and expenses arriving out of said contract.

Work Authorized by:

Southern Energy Management
(Name of Firm)

Kyra Moore — Solar Designer
(Print or Type Name) — (Title)

(Signature)

Ver. July 2008

SunLink Roof Mount System
Structural Engineering Load Advisory

The following information pertains to the proposed SunLink Roof Mount System (RMS) for the subject project only. It is intended for use by the Engineer of Record (EOR) for structural adequacy evaluation of the building supporting the array.

1.0 GENERAL PROJECT INFORMATION

1.1	Customer	SOUTHERN ENERGY MANAGEMENT
1.2	Building / Array Owner	GLAXO SMITH KLINE
1.3	Array Location	320 SOUTH BROADWAY, SAINT LOUIS, MO 63012
1.4	Quote Number	1003181
1.5	Sales Order Number	n/a

2.0 SITE & BUILDING INFORMATION

Note:
The following parameter values are provided to SunLink by the Customer. It remains the responsibility of the Customer to verify with the Engineer of Record and with the Building Official that these values are appropriate for this project, and to notify SunLink immediately if these parameters require adjustment.

					Notes / Reference:
2.1	Building Occupancy Category		II		
2.2	Building Roof Height		50	ft	
2.3	Roofing Surface		TPO		
2.4	Maximum Roof Slope		8	%	
2.5	Basic Wind Speed (3 sec gust)		90	mph	
2.6	Wind Exposure Category		B		
2.7	Wind Site Topographic Effects		None		
2.8	Ground Snow Load	p_g =	20	psf	
2.9	Site Latitude | Longitude (deg)		38.622	| -90.191	
2.10	Soil Site Class		D		

3.0 ARRAY CONFIGURATION & WEIGHT (EXCLUDING BALLAST)

					Notes / Reference:
3.1	Array Layout Drawing		1003181-GSKSAINTLOUIS-053111-ENG-R3		
3.2	Sub-array(s)		1, 2, 3 & 5		
3.3	Module Manufacturer		REC Solar		Per Customer (spec. sheet attached)
3.4	Module		REC235PE		
3.5	Module Tilt Angle		5	°	Per Customer & layout drawing
3.6	Row Spacing Type		Standard		
3.7	Row Repeat Spacing		47.5	in	
3.8	Number of Modules		224		Per Customer & layout drawing
3.9	Array Planform Area (pfa)		5002	ft^2	Roof area covered by array

			Per Module	Array Total	
3.10	Module Area	ft^2	17.76	3,979	Per attached module spec. sheet
3.11	Module Weight	lb	39.60	8,870	
3.12	SunLink RMS Weight	lb	18.65	4,178	
3.13	Array Weight (Modules + RMS)	lb	58.25	13,048	

3.14	Array Weight / Planform Area	2.61	psf	= w_{RMS}

4.0 DESIGN PARAMETERS

					Notes / Reference:
4.1	**Wind**				
4.1.1	Air Mass Density Constant		0.00256		
4.1.2	Velocity Press. Exp. Coefficient	K_z =	0.81		ASCE 7-05 Table 6-3
4.1.3	Topographic Factor	K_{zt} =	1		See Line 2.3 above
4.1.4	Importance Factor	I =	1.00		ASCE 7-05 Table 6-1 based on Line 2.1
4.1.5	Directionality Factor	K_d =	0.85		ASCE 7-05 Table 6-4
4.1.6	Basic Velocity Pressure, q_h	q_h =	14.3	psf	ASCE 7-05 Equation 6.15

Note:
Wind pressures on the SunLink RMS are determined per the ASCE 7-05 Method 2 approach: $p = q_h G C_p$ Gust effect factors and pressure coefficients have been determined from boundary layer wind tunnel testing specific to the SunLink RMS. The testing is proprietary to SunLink, and the resulting coefficients are not reported here. The testing conforms to ASCE 7-05 Method 3 (Section 6.6).

4.2	**Snow**				
4.2.1	Exposure Factor	C_e =	1.0		ASCE 7-05 Table 7-2
4.2.2	Thermal Factor	C_t =	1.2		ASCE 7-05 Table 7-3 (unheated)
4.2.3	Importance Factor	I =	1.0		ASCE 7-05 Table 7-4
4.2.4	Flat Roof Snow Load	p_f =	20.0	psf = $0.7 \cdot C_e \cdot C_t \cdot I \cdot p_g > I \cdot (p_g \leq 20$ psf)	ASCE 7-05 Eq. 7-1
4.2.5	Roof Slope Factor	C_s =	1.0		ASCE 7-05 Fig. 7-2 (obstructed)
4.2.6	Sloped Roof Snow Load	p_s =	20.0	psf = $C_s \cdot p_f$	ASCE 7-05 Eq. 7-2

5.0 TILT BRACKET BEARING LOADS ON ROOF (NO UPLIFT RESISTANCE)

					Notes / Reference:
5.1.1	Tilt Bracket (TB) Bearing Width		11.00	in	
5.1.2	Tilt Bracket (TB) Length		15.50	in	
5.1.3	Tilt Bracket (TB) Bearing Area		1.18	ft^2	
	Dead Load				
			3x1 panels	4x1 panels	
5.2.1	Interior TB Reaction	lb	88	114	D
5.2.2	Bearing Pressure on Roof	psf	74	96	Assuming uniform bearing under TB
5.2.3	Factored Interior TB Reaction	lb	123	160	ASCE 7 Section 2.3.2 Eq. 1: 1.4·D
5.2.4	Bearing Pressure on Roof	psf	104	135	Assuming uniform bearing under TB
	Wind				
	Maximum Tilt Bracket Reactions				
	Wind Load Only		3x1 panels	4x1 panels	
5.3.1	Wind Downward Force	lb	273	318	W_{max}
	Combined Wind & Dead Loads				
5.3.2	Interior TB Reaction	lb	542	646	ASCE 7 Section 2.3.2 Eq. 4: $1.2 \cdot D + 1.6 \cdot W_{max}$
5.3.3	Bearing Pressure on Roof	psf	458	546	Assuming uniform bearing under TB
	Average Tilt Bracket Reactions				
5.3.4	No. of Adjacent TB's Required:		7	5	If the number of adjacent TB's is less than this, use linear interpolation between Lines 5.3.2 and 5.3.6.
	Wind Load Only:				
5.3.5	Wind Downward Force	lb	68	91	W
	Combined Wind & Dead Loads				
5.3.6	Interior TB Reaction	lb	214	282	ASCE 7 Section 2.3.2 Eq. 4: 1.2·D + 1.6·W
5.3.7	Bearing Pressure on Roof	psf	181	238	Assuming uniform bearing under TB

Note:
Design wind pressure acting on the modules decreases as the amount of module area that the wind is acting on increases.

If a structural roof element is supporting just one tilt bracket (such as decking, perhaps), it should be checked for the wind downward load in Line 5.3.1 acting at the tilt bracket location.

If a structural roof element is supporting at least the number of tilt brackets shown in Line 5.3.4 (such as a roof joist, beam, or girder) it should be checked for the wind downward load in Line 5.3.5 acting at each of the tilt bracket locations.

If a structural roof element is supporting more than one tilt bracket, but less than the number of tilt brackets shown in Line 5.3.4, linear interpolation can be used to determine the downward load at each tilt bracket, as stated in the notes on Line 5.3.4.

Once the wind load has been determined by the above method, the structural roof element should be checked for combined wind & dead loads.

			3x1 panels	4x1 panels	
	Snow				
	Snow Load Only				
5.4.1	Snow Load	lb	531	708	S
	Combined Snow, Wind, Dead Loads				
	Maximum Tilt Bracket Reactions				
5.4.2	Interior TB Reaction	lb	1173	1524	ASCE 7 Section 2.3.2 Eq. 3: $1.2 \cdot D + 1.6 \cdot S + 0.8 \cdot W_{max}$
5.4.3	Bearing Pressure on Roof	psf	991	1287	Assuming uniform bearing under TB
5.4.4	Interior TB Reaction	lb	808	1000	ASCE 7 Section 2.3.2 Eq. 4: $1.2 \cdot D + 1.6 \cdot W_{max} + 0.5 \cdot S$
5.4.5	Bearing Pressure on Roof	psf	682	845	Assuming uniform bearing under TB
	Average Tilt Bracket Reactions				
5.4.6	Interior TB Reaction	lb	1009	1342	ASCE 7 Section 2.3.2 Eq. 3: $1.2 \cdot D + 1.6 \cdot S + 0.8 \cdot W$
5.4.7	Bearing Pressure on Roof	psf	852	1133	Assuming uniform bearing under TB
5.4.8	Interior TB Reaction	lb	479	636	ASCE 7 Section 2.3.2 Eq. 4: $1.2 \cdot D + 1.6 \cdot W + 0.5 \cdot S$
5.4.9	Bearing Pressure on Roof	psf	405	537	Assuming uniform bearing under TB

6.0 BALLAST PAN CONFIGURATION

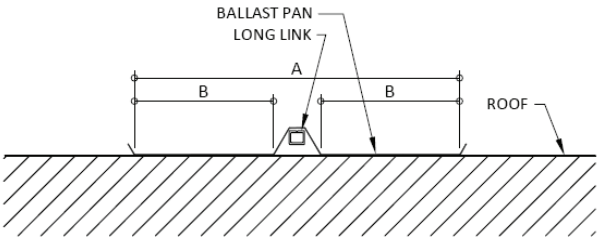
					Notes / Reference:
6.1	Ballast block weight		24	lbs	See Note 1 below
6.2	Coefficient of friction	μ =	0.47		See Note 2 below

	Ballast Pan Type		Type I	Type II	Type III
6.3	Ballast pan self-weight		2.6	5.2	0
6.4	No. of ballast blocks / pan		6	10	0
6.5	Total weight / pan W_{BP} =	lbs	146.6	245.2	0
6.6	Ballast pan dimension 'A'	in	27.3	27.3	n/a
6.7	Ballast pan dimension 'B'	in	12	12	n/a
6.8	Ballast pan dimension 'C'	in	12	24	n/a
6.9	Bearing pressure under ballast (assuming uniform ballast block stacking)	psf	73.3	61.3	n/a

Notes:

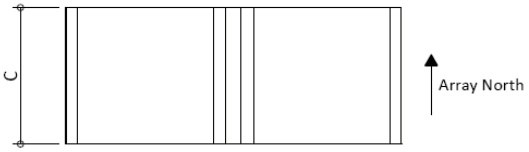
1. Ballast assumed to be 12 x 12 nominal blocks (pavers) equally distributed on both sides of ballast pan. Cross tie wires are required unless blocks are adhered to the pan and to each other with a suitable waterproof adhesive. If blocks used are a different nominal size or are a different weight than assumed here, notify SunLink.

2. Customer / EOR to notify SunLink if a different friction coefficient should be used.



BALLAST PAN ELEVATION

NOTE: PAVERS NOT SHOWN



BALLAST PAN PLAN

7.0 SUB-ARRAY TABLE

ITEM	units	EQUATION	SUB-ARRAY				Totals
Sub-array			1	2	3	5	
Number of modules			56	70	56	42	224
Planform area	sf	pfa	1234	1542	1256	970	5002
Unballasted weight	lb	$D = w_{RMS} \cdot pfa$	3219	4024	3276	2529	13048
Module area	sf		995	1243	995	746	3979
South slope angle	deg	Θ	4.74	4.74	4.74	4.74	
Wind load :							
Wind load	lb	W	2554	3192	2554	1915	
Total lift	lb	$W_L = W \cdot \cos(tilt)$	2544	3180	2544	1908	
Total drag	lb	$W_D = W \cdot \sin(tilt)$	223	278	223	167	
Array weight:							
Slope Factor	lb	$K = \cos(\Theta) - \sin(\Theta) / \mu$	0.82	0.82	0.82	0.82	
Weight required for lift	lb	$D_L = W_L / (0.6 \cos(\Theta))$	4256	5320	4256	3192	
Weight required for drag	lb	$D_D = D_{MIN} - D_L$	1873	2341	1873	1404	
Minimum weight required	lb	$D_{MIN} = W_D / (0.6 \cdot \mu \cdot K) + W_L / (0.6 \cdot K)$	6129	7661	6129	4596	
Ballast:							
Minimum ballast required	lb	$B_{MIN} = D_{MIN} - D$	2910	3637	2852	2067	
Number of Type I ballast pans		N_I	16	18	16	12	62
Number of Type II ballast pans		N_{II}	4	7	8	7	26
Number of Type III ballast pans		N_{III}					
Total number of ballast pans		$N = \Sigma N_i$	20	25	24	19	88
Ballast weight	lb	$B_T = \Sigma Ni \cdot W_{BPi}$	3326	4355	4307	3476	15464
Total weight	lb	$D_T = D + B_T$	6545	8379	7584	6005	28513
Dist. Weight / pfa	psf	$w_{sa} = D_T / pfa$	5.30	5.43	6.04	6.19	5.70

SunLink Roof Mount System
Structural Engineering Load Advisory

The following information pertains to the proposed SunLink Roof Mount System (RMS) for the subject project only. It is intended for use by the Engineer of Record (EOR) for structural adequacy evaluation of the building supporting the array.

1.0 GENERAL PROJECT INFORMATION

1.1	Customer	SOUTHERN ENERGY MANAGEMENT
1.2	Building / Array Owner	GLAXO SMITH KLINE
1.3	Array Location	320 SOUTH BROADWAY, SAINT LOUIS, MO 63012
1.4	Quote Number	1003181
1.5	Sales Order Number	n/a

2.0 SITE & BUILDING INFORMATION

Note:
The following parameter values are provided to SunLink by the Customer. It remains the responsibility of the Customer to verify with the Engineer of Record and with the Building Official that these values are appropriate for this project, and to notify SunLink immediately if these parameters require adjustment.

					Notes / Reference:
2.1	Building Occupancy Category		II		
2.2	Building Roof Height		80	ft	
2.3	Roofing Surface		TPO		
2.4	Maximum Roof Slope		8	%	
2.5	Basic Wind Speed (3 sec gust)		90	mph	
2.6	Wind Exposure Category		B		
2.7	Wind Site Topographic Effects		None		
2.8	Ground Snow Load	p_g =	20	psf	
2.9	Site Latitude | Longitude (deg)		38.622	| -90.191	
2.10	Soil Site Class		D		

3.0 ARRAY CONFIGURATION & WEIGHT (EXCLUDING BALLAST)

					Notes / Reference:
3.1	Array Layout Drawing		1003181-GSKSAINTLOUIS-053111-ENG-R3		
3.2	Sub-array(s)		4		
3.3	Module Manufacturer		REC Solar		Per Customer (spec. sheet attached)
3.4	Module		REC235PE		
3.5	Module Tilt Angle		5	°	Per Customer & layout drawing
3.6	Row Spacing Type		Standard		
3.7	Row Repeat Spacing		47.5	in	
3.8	Number of Modules		84		Per Customer & layout drawing
3.9	Array Planform Area (pfa)		1939	ft^2	Roof area covered by array

			Per Module	Array Total	
3.10	Module Area	ft^2	17.76	1,492	Per attached module spec. sheet
3.11	Module Weight	lb	39.60	3,326	
3.12	SunLink RMS Weight	lb	18.81	1,580	
3.13	Array Weight (Modules + RMS)	lb	58.41	4,906	

3.14	Array Weight / Planform Area	2.53	psf	= w_{RMS}

4.0 DESIGN PARAMETERS

					Notes / Reference:
4.1	**Wind**				
4.1.1	Air Mass Density Constant		0.00256		
4.1.2	Velocity Press. Exp. Coefficient	K_z =	0.93		ASCE 7-05 Table 6-3
4.1.3	Topographic Factor	K_{zt} =	1		See Line 2.3 above
4.1.4	Importance Factor	I =	1.00		ASCE 7-05 Table 6-1 based on Line 2.1
4.1.5	Directionality Factor	K_d =	0.85		ASCE 7-05 Table 6-4
4.1.6	Basic Velocity Pressure, q_h	q_h =	16.3	psf	ASCE 7-05 Equation 6.15

Note:
Wind pressures on the SunLink RMS are determined per the ASCE 7-05 Method 2 approach: $p = q_h G C_p$ Gust effect factors and pressure coefficients have been determined from boundary layer wind tunnel testing specific to the SunLink RMS. The testing is proprietary to SunLink, and the resulting coefficients are not reported here. The testing conforms to ASCE 7-05 Method 3 (Section 6.6).

4.2	**Snow**				
4.2.1	Exposure Factor	C_e =	1.0		ASCE 7-05 Table 7-2
4.2.2	Thermal Factor	C_t =	1.2		ASCE 7-05 Table 7-3 (unheated)
4.2.3	Importance Factor	I =	1.0		ASCE 7-05 Table 7-4
4.2.4	Flat Roof Snow Load	p_f =	20.0	psf = $0.7 \cdot C_e \cdot C_t \cdot I \cdot p_g > I \cdot (p_g \leq 20$ psf)	ASCE 7-05 Eq. 7-1
4.2.5	Roof Slope Factor	C_s =	1.0		ASCE 7-05 Fig. 7-2 (obstructed)
4.2.6	Sloped Roof Snow Load	p_s =	20.0	psf = $C_s \cdot p_f$	ASCE 7-05 Eq. 7-2

5.0 TILT BRACKET BEARING LOADS ON ROOF (NO UPLIFT RESISTANCE)

					Notes / Reference:
5.1.1	Tilt Bracket (TB) Bearing Width		11.00	in	
5.1.2	Tilt Bracket (TB) Length		15.50	in	
5.1.3	Tilt Bracket (TB) Bearing Area		1.18	ft^2	
	Dead Load				
			3x1 panels	4x1 panels	
5.2.1	Interior TB Reaction	lb	88	114	D
5.2.2	Bearing Pressure on Roof	psf	74	96	Assuming uniform bearing under TB
5.2.3	Factored Interior TB Reaction	lb	123	160	ASCE 7 Section 2.3.2 Eq. 1: 1.4·D
5.2.4	Bearing Pressure on Roof	psf	104	135	Assuming uniform bearing under TB
	Wind				
	Maximum Tilt Bracket Reactions				
	Wind Load Only		3x1 panels	4x1 panels	
5.3.1	Wind Downward Force	lb	313	364	W_{max}
	Combined Wind & Dead Loads				
5.3.2	Interior TB Reaction	lb	605	719	ASCE 7 Section 2.3.2 Eq. 4: $1.2 \cdot D + 1.6 \cdot W_{max}$
5.3.3	Bearing Pressure on Roof	psf	511	607	Assuming uniform bearing under TB
	Average Tilt Bracket Reactions				
5.3.4	No. of Adjacent TB's Required:		7	5	If the number of adjacent TB's is less than this, use linear interpolation between Lines 5.3.2 and 5.3.6.
	Wind Load Only:				
5.3.5	Wind Downward Force	lb	78	104	W
	Combined Wind & Dead Loads				
5.3.6	Interior TB Reaction	lb	230	303	ASCE 7 Section 2.3.2 Eq. 4: 1.2·D + 1.6·W
5.3.7	Bearing Pressure on Roof	psf	194	256	Assuming uniform bearing under TB

Note:
Design wind pressure acting on the modules decreases as the amount of module area that the wind is acting on increases.

If a structural roof element is supporting just one tilt bracket (such as decking, perhaps), it should be checked for the wind downward load in Line 5.3.1 acting at the tilt bracket location.

If a structural roof element is supporting at least the number of tilt brackets shown in Line 5.3.4 (such as a roof joist, beam, or girder) it should be checked for the wind downward load in Line 5.3.5 acting at each of the tilt bracket locations.

If a structural roof element is supporting more than one tilt bracket, but less than the number of tilt brackets shown in Line 5.3.4, linear interpolation can be used to determine the downward load at each tilt bracket, as stated in the notes on Line 5.3.4.

Once the wind load has been determined by the above method, the structural roof element should be checked for combined wind & dead loads.

			3x1 panels	4x1 panels	
	Snow				
	Snow Load Only				
5.4.1	Snow Load	lb	531	708	S
	Combined Snow, Wind, Dead Loads				
	Maximum Tilt Bracket Reactions				
5.4.2	Interior TB Reaction	lb	1204	1561	ASCE 7 Section 2.3.2 Eq. 3: $1.2 \cdot D + 1.6 \cdot S + 0.8 \cdot W_{max}$
5.4.3	Bearing Pressure on Roof	psf	1017	1318	Assuming uniform bearing under TB
5.4.4	Interior TB Reaction	lb	871	1073	ASCE 7 Section 2.3.2 Eq. 4: $1.2 \cdot D + 1.6 \cdot W_{max} + 0.5 \cdot S$
5.4.5	Bearing Pressure on Roof	psf	735	906	Assuming uniform bearing under TB
	Average Tilt Bracket Reactions				
5.4.6	Interior TB Reaction	lb	1017	1352	ASCE 7 Section 2.3.2 Eq. 3: $1.2 \cdot D + 1.6 \cdot S + 0.8 \cdot W$
5.4.7	Bearing Pressure on Roof	psf	859	1142	Assuming uniform bearing under TB
5.4.8	Interior TB Reaction	lb	495	657	ASCE 7 Section 2.3.2 Eq. 4: $1.2 \cdot D + 1.6 \cdot W + 0.5 \cdot S$
5.4.9	Bearing Pressure on Roof	psf	418	555	Assuming uniform bearing under TB

6.0 BALLAST PAN CONFIGURATION

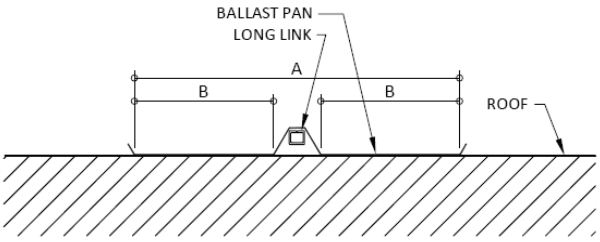
					Notes / Reference:
6.1	Ballast block weight		24	lbs	See Note 1 below
6.2	Coefficient of friction	μ =	0.47		See Note 2 below

	Ballast Pan Type		Type I	Type II	Type III
6.3	Ballast pan self-weight		2.6	5.2	0
6.4	No. of ballast blocks / pan		6	10	0
6.5	Total weight / pan W_{BP} =	lbs	146.6	245.2	0
6.6	Ballast pan dimension 'A'	in	27.3	27.3	n/a
6.7	Ballast pan dimension 'B'	in	12	12	n/a
6.8	Ballast pan dimension 'C'	in	12	24	n/a
6.9	Bearing pressure under ballast (assuming uniform ballast block stacking)	psf	73.3	61.3	n/a

Notes:

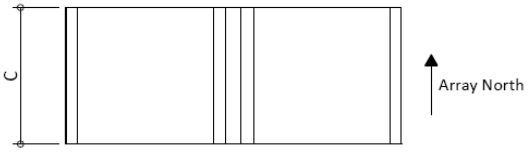
1. Ballast assumed to be 12 x 12 nominal blocks (pavers) equally distributed on both sides of ballast pan. Cross tie wires are required unless blocks are adhered to the pan and to each other with a suitable waterproof adhesive. If blocks used are a different nominal size or are a different weight than assumed here, notify SunLink.

2. Customer / EOR to notify SunLink if a different friction coefficient should be used.



BALLAST PAN ELEVATION

NOTE: PAVERS NOT SHOWN



BALLAST PAN PLAN

7.0 SUB-ARRAY TABLE				
ITEM	**units**	**EQUATION**	**SUB-ARRAY**	
Sub-array			4	**Totals**
Number of modules			84	84
Planform area	sf	pfa	1939	1939
Unballasted weight	lb	$D = w_{RMS} \cdot pfa$	4906	4906
Module area	sf		1492	1492
South slope angle	deg	Θ	4.74	
Wind load :				
Wind load	lb	W	4381	
Total lift	lb	$W_L = W \cdot \cos(tilt)$	4364	
Total drag	lb	$W_D = W \cdot \sin(tilt)$	382	
Array weight:				
Slope Factor	lb	$K = \cos(\Theta) - \sin(\Theta) / \mu$	0.82	
Weight required for lift	lb	$D_L = W_L / (0.6 \cos(\Theta))$	7301	
Weight required for drag	lb	$D_D = D_{MIN} - D_L$	3213	
Minimum weight required	lb	$D_{MIN} = W_D / (0.6 \cdot \mu \cdot K) + W_L / (0.6 \cdot K)$	10514	
Ballast:				
Minimum ballast required	lb	$B_{MIN} = D_{MIN} - D$	5608	
Number of Type I ballast pans		N_I	20	20
Number of Type II ballast pans		N_{II}	22	22
Number of Type III ballast pans		N_{III}		
Total number of ballast pans		$N = \Sigma N_i$	42	42
Ballast weight	lb	$B_T = \Sigma Ni \cdot W_{BPi}$	8326	8326
Total weight	lb	$D_T = D + B_T$	13233	13233
Dist. Weight / pfa	psf	$w_{sa} = D_T / pfa$	6.82	6.82

HIGH PERFORMANCE SOLAR MODULES

REC PEAK ENERGY (BLK) SERIES

REC Peak Energy (PE)-Series modules are the perfect choice for building solar systems that combine long lasting product quality with reliable power output.

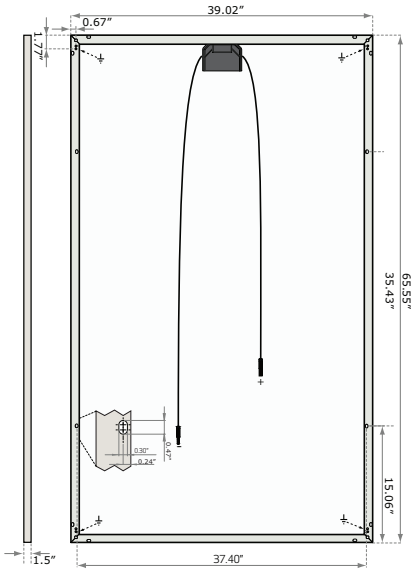
MORE POWER PER FT²

ROBUST AND DURABLE DESIGN

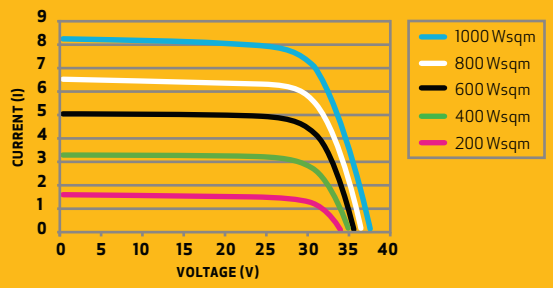
ENERGY PAYBACK TIME OF ONE YEAR

US-PRODUCED SILICON

REC PEAK ENERGY (BLK) SERIES



IV CHARACTERISTICS 235W MODULE



14.2 EFFICIENCY

63 MONTHS WORKMANSHIP WARRANTY

25 YEAR POWER OUTPUT WARRANTY

ELECTRICAL DATA @ STC	REC215PE (BLK)	REC220PE (BLK)	REC225PE (BLK)	REC230PE (BLK)	REC235PE (BLK)	REC240PE (BLK)
Peak Power Watts - P_{MAX} (Wp)	215	220	225	230	235	240
Watt Class Tolerance - P_{TOL} (W)	0/+5	0/+5	0/+5	0/+5	0/+5	0/+5
Watt Class Tolerance - P_{TOL} (%)	0/+2	0/+2	0/+2	0/+2	0/+2	0/+2
Maximum Power Voltage - V_{MPP} (V)	28.3	28.7	29.1	29.4	29.8	30.4
Maximum Power Current - I_{MPP} (A)	7.6	7.7	7.7	7.8	7.9	7.9
Open Circuit Voltage - V_{OC} (V)	36.3	36.6	36.8	37.1	37.4	37.7
Short Circuit Current - I_{SC} (A)	8.1	8.2	8.2	8.3	8.3	8.4
Module Efficiency (%)	13.0	13.3	13.6	13.9	14.2	14.5

Values at Standard Test Conditions STC (Air Mass AM 1.5, Irradiance 1000 W/m², Cell temperature 25 °C)

GENERAL DATA

Cell Type	60 REC PE multi-crystalline cells 3 strings of 20 cells - 3 by-pass diodes
Glass	High-transparency solar glass with antireflection surface treatment by Sunarc Technology
Back sheet	Double layer high performance polyester
Frame	Black anodized aluminium
Cable	Radox 4 mm² solar cables 35 in +47 in
Connector	Radox 4mm² twist locking connector

TEMPERATURE RATINGS (235 W RATED MODULE)

Nominal Operating Cell Temperature (NOCT)	47.9 °C (±2°C)
Temperature Coefficient of P_{MPP}	-0.46 %/°C
Temperature Coefficient of V_{OC}	-0.32 %/°C
Temperature Coefficient of I_{SC}	0.011 %/°C

WARRANTY

10 years limited warranty of 90% power output
25 years limited warranty of 80% power output
63 months workmanship warranty

CERTIFICATION

Certified according to UL1703, IEC 61215 and IEC 61730

MECHANICAL DATA

Dimensions	65.55 x 39.02 x 1.5 in
Area	17.76 ft²
Weight	39.6 lbs

MAXIMUM RATINGS

Operational Temperature	-40 ... +80°C
Maximum System Voltage	600V
Design Load (UL1703)	75.2 lbs/ft² (3600Pa)
Maximum Load (IEC 61215)	551 kg/m² (5400 Pa)
Maximum Wind Speed	122 mph (safety factor 3)
Max Series Fuse Rating	15A
Max Reverse Current	15A

Note! Specifications subject to change without notice.

REC is a leading vertically integrated player in the solar energy industry. REC is among the world's largest producers of polysilicon and wafers for solar applications, and a rapidly growing manufacturer of solar cells and modules. REC is also engaged in project development activities in selected PV segments. Founded in Norway, REC is an international solar company, employing more than 4,000 people worldwide. REC had revenues in excess of NOK 9 billion in 2009, approximately EUR 1 billion and approximately USD 1.4 billion.

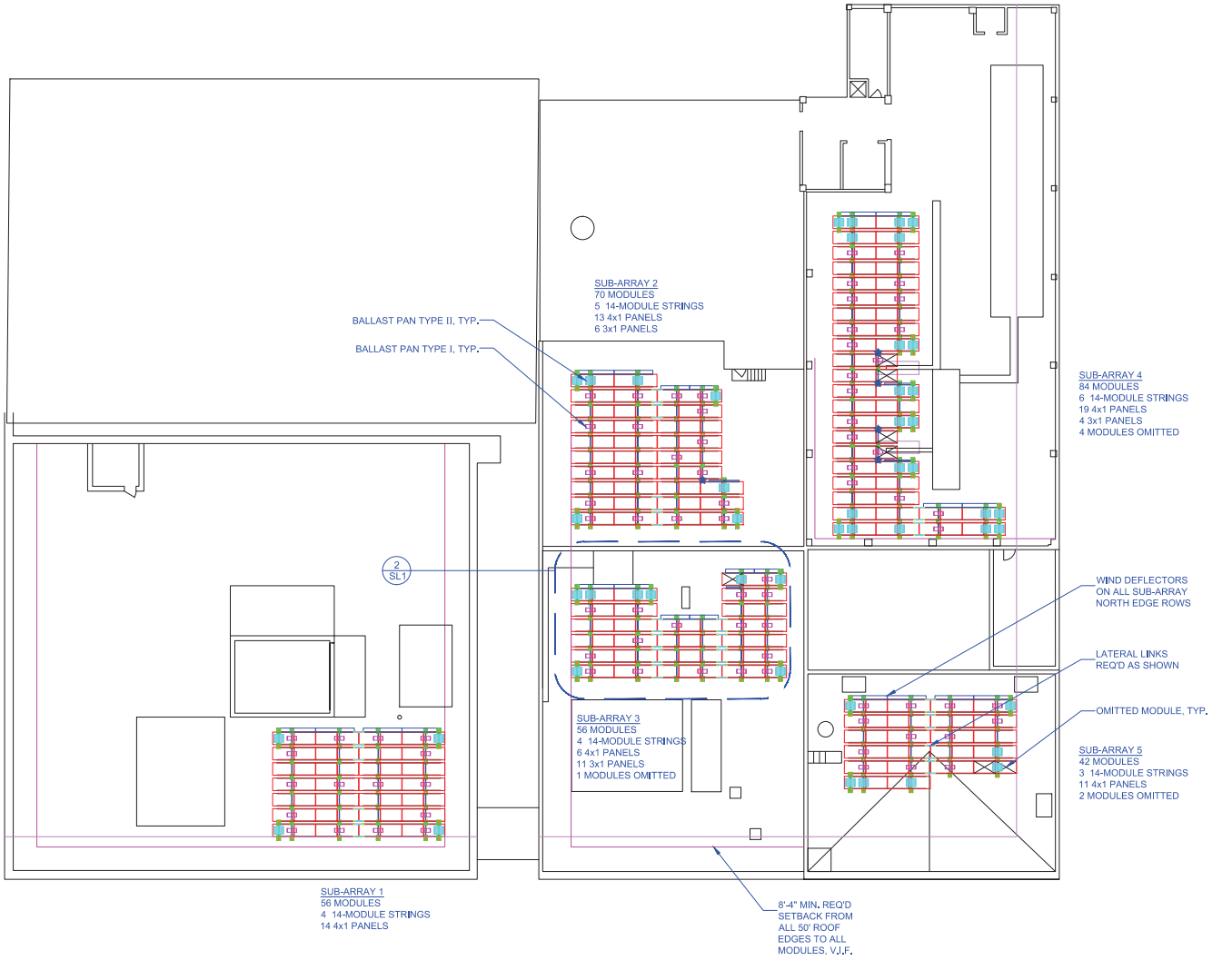
Please visit **www.recgroup.com**

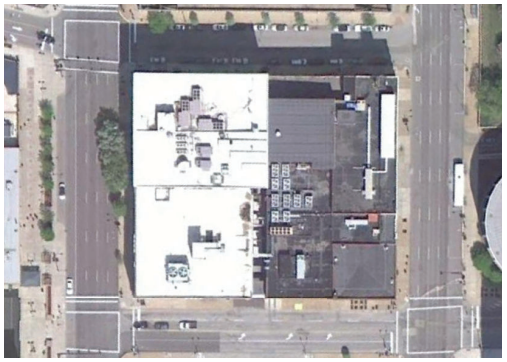
REC

REC Solar US LLC
PO Box 3416
San Luis Obispo, CA 93403
USA

www.recgroup.com

July 2010, version E





ARRAY INFORMATION

Sub-Arrays	1 thru 5	Quantities:	
No. of Modules	308	4x1 Panels	63
Module Wattage	235	3x1 Panels	21
DC String Length	14	2x1 Panels	0
No. of Strings	22	Omitted Modules	7
Roof Height (ft)	50 & 80	Tilt Brackets	198
Roof Area (ft^2)	-	End-Row Tilt Brackets	46
Project Latitude	38° 37' 21.2" N	Lateral Links	44
Tilt Angle (degrees)	5	Long Links	193
Inter-Row Spacing (in)	47.5	Field Drills	5
Planform Area (ft^2)	6,941	Tilt Brackets Base Size	15.5" x 11.25"

HOLD DOWNS

Ballast Pan Type	Type I	Type II
Ballast Pan Size	12	24
Number of Ballast Pans	82	48
Pavers Per Ballast Pan	6	10
Number of Pavers Required	972	
Req'd Ballast Paver Wt. (lbs)	24	
Number of ZCA Connectors	-	
Number of WRAC Connectors	-	

NOTES

1. The purpose of this drawing is to show the location of the array on the building roof and the required location of SunLink Mounting System components for this project.

2. Rooftop information and other project information has been provided by the Customer and has not been verified by SunLink. Confirm key dimensions in the field before beginning installation.

3. Notify SunLink before modifying the layout shown, relocating, omitting or modifying any SunLink component. Install all SunLink components per the SunLink Assembly Instructions.

4. All additional installation requirements, such as roofing protection, electrical components, waterproofing, and connector attachment, are not by SunLink. Refer to appropriate third party's project documents.

5. Shade affected zones shown have been determined by SunLink for 2 hours before until 2 hours after solar noon on December 22nd and 3 hours before until 3 hours after solar noon on June 20th at project latitude.

6. For array weight and loading information, refer to the Array Design Wind Load Support Letter for which this layout is referenced.

Issue	Date	Description
R0	05-18-11	CR - LAYOUT DEFINITION WITH REC 235PE AT 10 DEGREES
R1	05-19-11	CR - REVISED PER CUSTOMER COMMENTS
R2	05-24-11	CR - (4) 4X1s CHANGED TO 3X1s PER EQUIPMENT INTERFERENCE
R3	05-31-11	DEFINED BALLAST PANS LOCATION; ADDED ARRAY NOTES

File: 1003181-GSKSAINTLOUIS-053111-ENG-R3

Drawn: AL — Date: 25 May 11

Checked: JAL — Date: 31 May 11

Project ID Number: 1003181

SUNLINK CORPORATION
1010 B ST STE 400 SAN RAFAEL CA 94901 www.sunlink.com
v: 415.925.9650 f: 415.925.9636

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Customer: SOUTHERN ENERGY MANAGEMENT

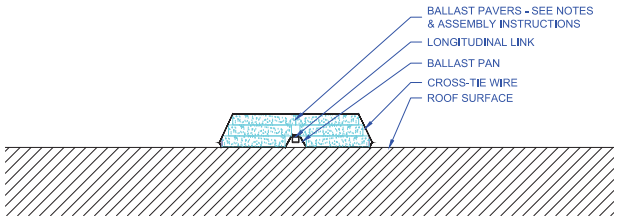
Project: GLAXO SMITH KLINE

Location: 320 SOUTH BROADWAY, SAINT LOUIS, MO 63012

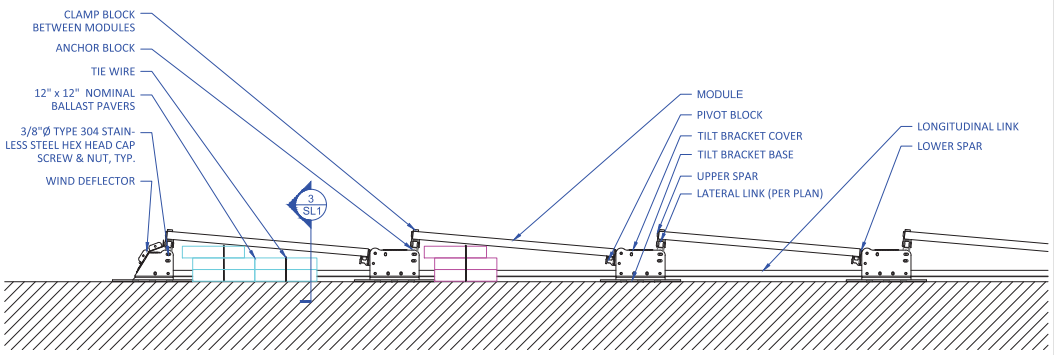
Module	Tilt Angle	No. of Modules	Power Output (DC)
REC Solar PE 235	5°	308	72.4 kW

Sheet Number: SL0

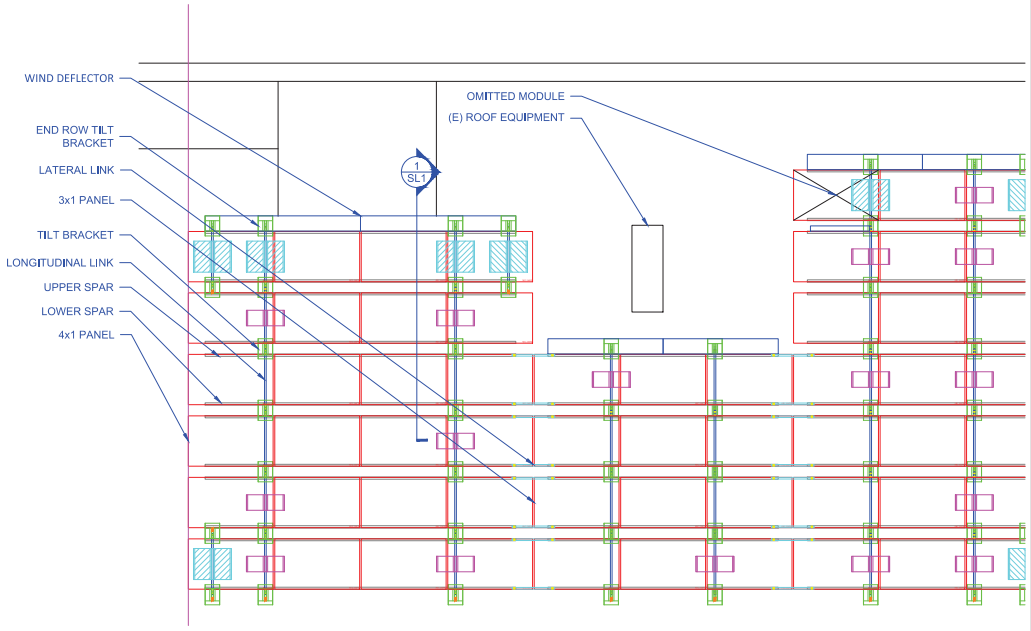
Issue: R3



3 Section - Ballast Scale: 1" = 1'-0"



1 Section - Panel Assembly Scale: 1" = 1'-0"



2 Plan - Partial Array Layout Scale: 1/4" = 1'-0"

Issue	Date	Description
R0	05-18-11	CR - LAYOUT DEFINITION WITH REC 235PE AT 10 DEGREES
R1	05-19-11	CR - REVISED PER CUSTOMER COMMENTS
R2	05-24-11	CR - (4) 4X1s CHANGED TO 3X1s PER EQUIPMENT INTERFERENCE
R3	05-31-11	DEFINED BALLAST PANS LOCATION; ADDED ARRAY NOTES

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Drawn: AL Date: 25 May 11
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Customer: SOUTHERN ENERGY MANAGEMENT
Project: GLAXO SMITH KLINE
Location: 320 SOUTH BROADWAY, SAINT LOUIS, MO 63012

Module	Tilt Angle	No. of Modules	Power Output (DC)
REC Solar PE 235	5°	308	72.4 kW

Sheet Number: SL1
Issue: R3