
Question #1

Electrical One-Line Diagram
Electrical One-line diagram is very important document required for understanding and evaluating the Electrical Power Network and Interconnection of a Power Plant. Applicant to submit Electrical One-line diagram of the installation.

RESPONSE: The electrical one-line diagram submitted to PJM in the Project's interconnection application is attached hereto as Exhibit A.

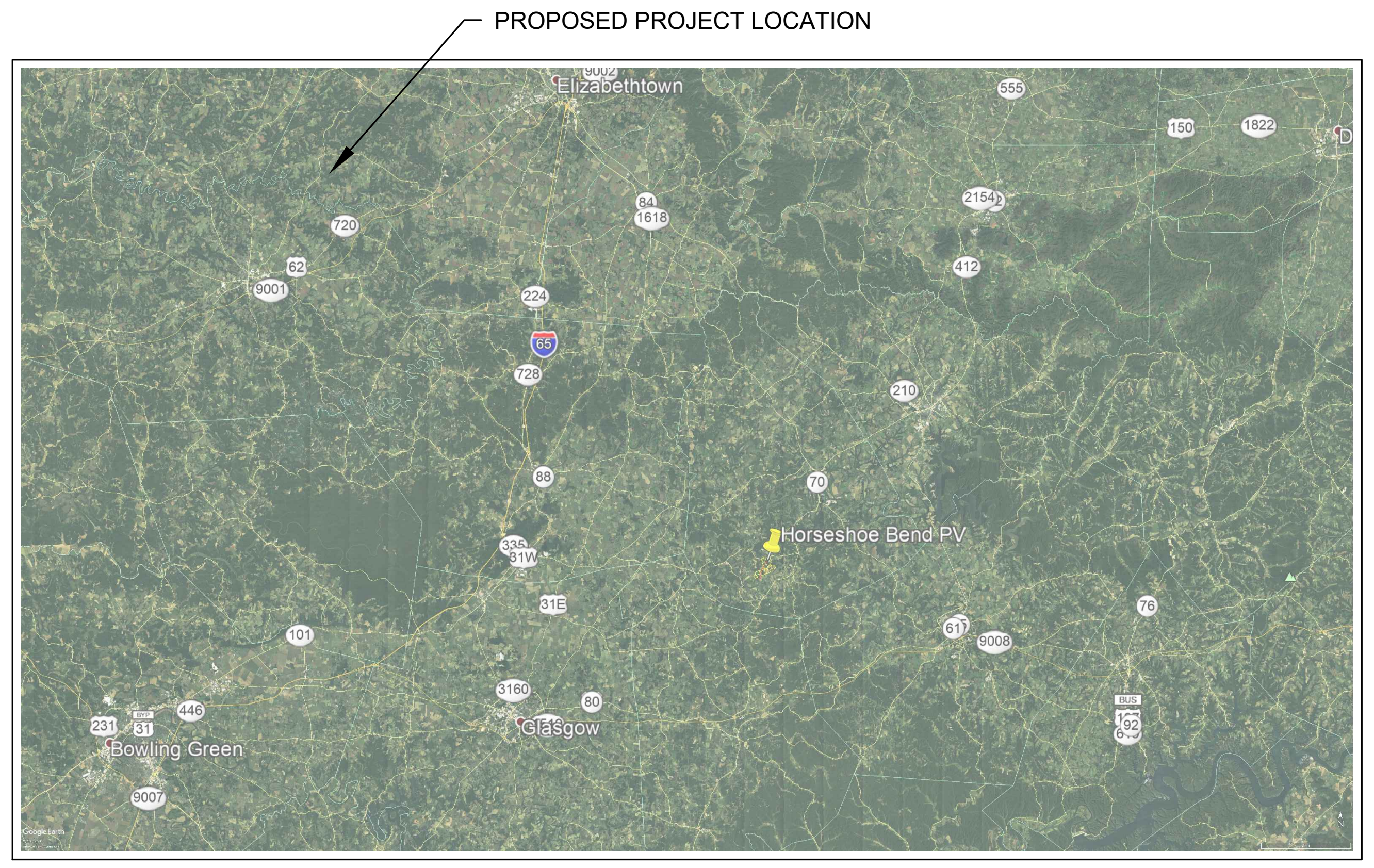
WITNESS: Carson Harkrader

EXHIBIT A

HORSESHOE BEND SOLAR

A PHOTOVOLTAIC POWER GENERATION & ENERGY STORAGE FACILITY

PRELIMINARY DESIGN & INTERCONNECTION APPLICATION PACKAGE



VICINITY PLAN

Not to Scale

PRELIMINARY PROJECT PLAN

Not to Scale

SYSTEM DATA and SUMMARY

- HIGH DESIGN TEMPERATURE (99.6%, ASHRAE): 36 degC
- MINIMUM OPERATING TEMPERATURE (ASHRAE): -16 degC
- AC PEAK OUTPUT AT POI: 60.0 MWAC
- INVERTER KVA/KW RATING: 4400 KW at UNITY POWER FACTOR
- INVERTER QUANTITY: 15
- PV MODULE TYPE: TRINA SOLAR M# TSM-385DE14H(II) or EQUAL
- PV MODULE POWER: 385 W DCp
- PV MODULE UNIT TOTAL: ~ 233,280
- TOTAL DC OUTPUT: ~84 MW DCp
- 30MW DC ENERGY STORAGE SYSTEM CHARGE / DISCHARGE CAPACITY
- 4-HOUR NOMINAL ENERGY STORAGE CAPACITY (INITIAL)

KEY NOTE / PROJECT CAPACITY: TOTAL OUTPUT TO BE LIMITED BY PLANT CONTROLLER AS INDICATED, TO 60.0MW AC PEAK POWER AT POINT OF INTERCONNECTION, AND TO A POWER FACTOR TO AGREED UPON WITH THE CONNECTED UTILITY.

ISSUED FOR
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NOT FOR CONSTRUCTION

REV No	DESCRIPTION	DATE
-	FOR INTERCONNECTION APPLICATION	7/07/2019

HORSESHOE BEND SOLAR

HIGHWAY 218
near PIERCE, KENTUCKY
Appox 37.175° N, 85.571° W

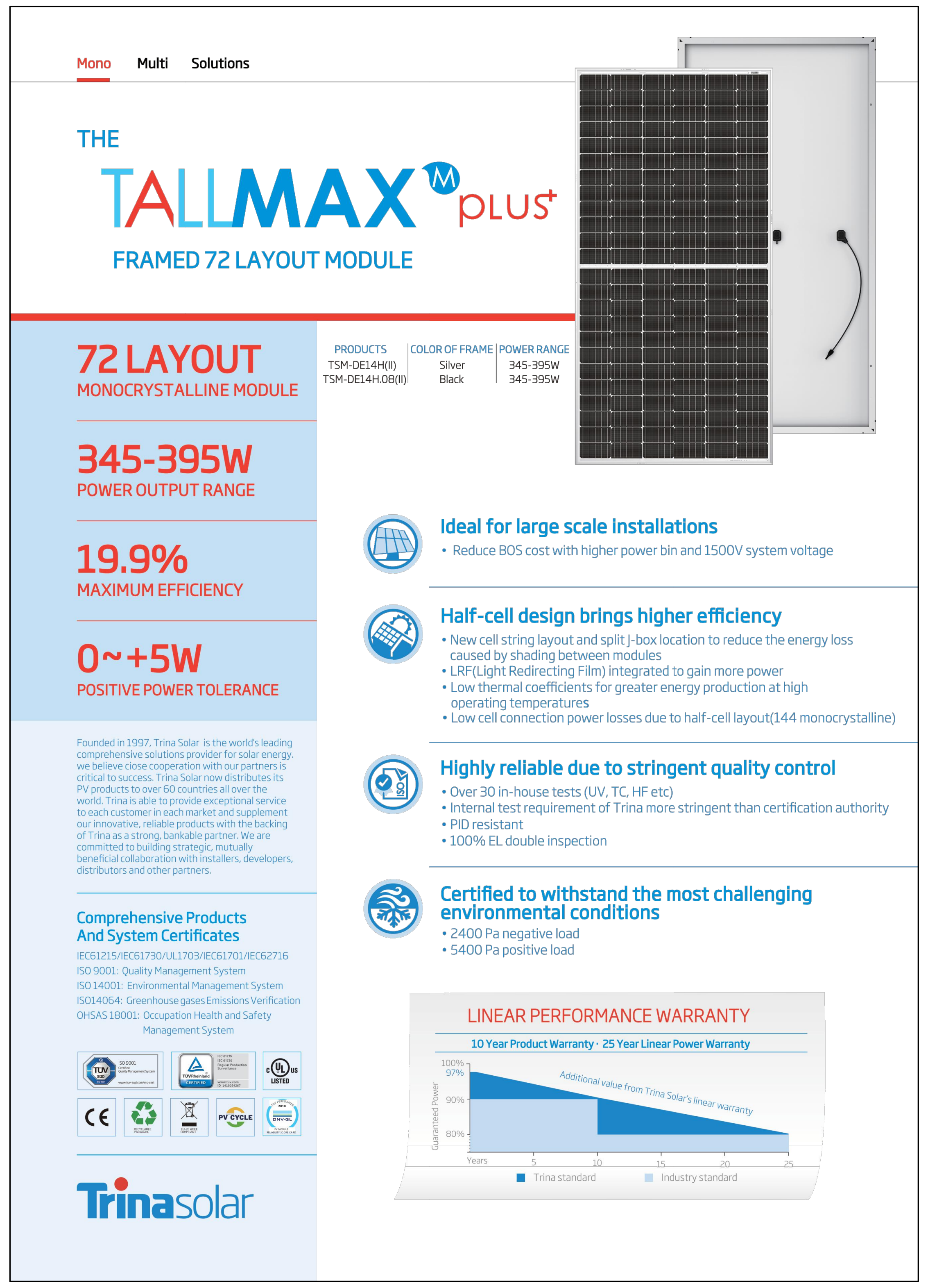
HORSESHOE BEND SOLAR, LLC
400 W. MAIN ST SUITE 503
DURHAM, NC, 27701

Enertis Solar, Inc
Madrid San Francisco
New York Raleigh

DATE JULY 7, 2019

COVER PAGE

SHEET G-000



THE

TALLMAX plus

FRAMED 72 LAYOUT MODULE

PRODUCTS	COLOR OF FRAME	POWER RANGE
TSM-DE14H(II)	Silver	345-395W
TSM-DE14H.08(II)	Black	345-395W

72 LAYOUT
MONOCRYSTALLINE MODULE

345-395W
POWER OUTPUT RANGE

19.9%
MAXIMUM EFFICIENCY

0~+5W
POSITIVE POWER TOLERANCE

Founded in 1997, Trina Solar is the world's leading comprehensive solutions provider for solar energy. we believe ciose cooperation with our partners is critical to success. Trina Solar now distributes its PV products to over 60 countries all over the world. Trina is able to provide exceptional service to each customer in each market and supplement our innovative, reliable products with the backing of Trina as a strong, bankable partner. We are committed to building strategic, mutually beneficial collaboration with installers, developers, distributors and other partners.

Comprehensive Products And System Certificates

IEC61215/IEC61730/UL1703/IEC61701/IEC62716
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse gases Emissions Verification
OHSAS 18001: Occupation Health and Safety Management System

Trinasolar

Ideal for large scale installations
- Reduce BOS cost with higher power bin and 1500V system voltage

Half-cell design brings higher efficiency
- New cell string layout and split J-box location to reduce the energy loss caused by shading between modules
- LRF(Light Redirecting Film) integrated to gain more power
- Low thermal coefficients for greater energy production at high operating temperatures
- Low cell connection power losses due to half-cell layout(144 monocrystalline)

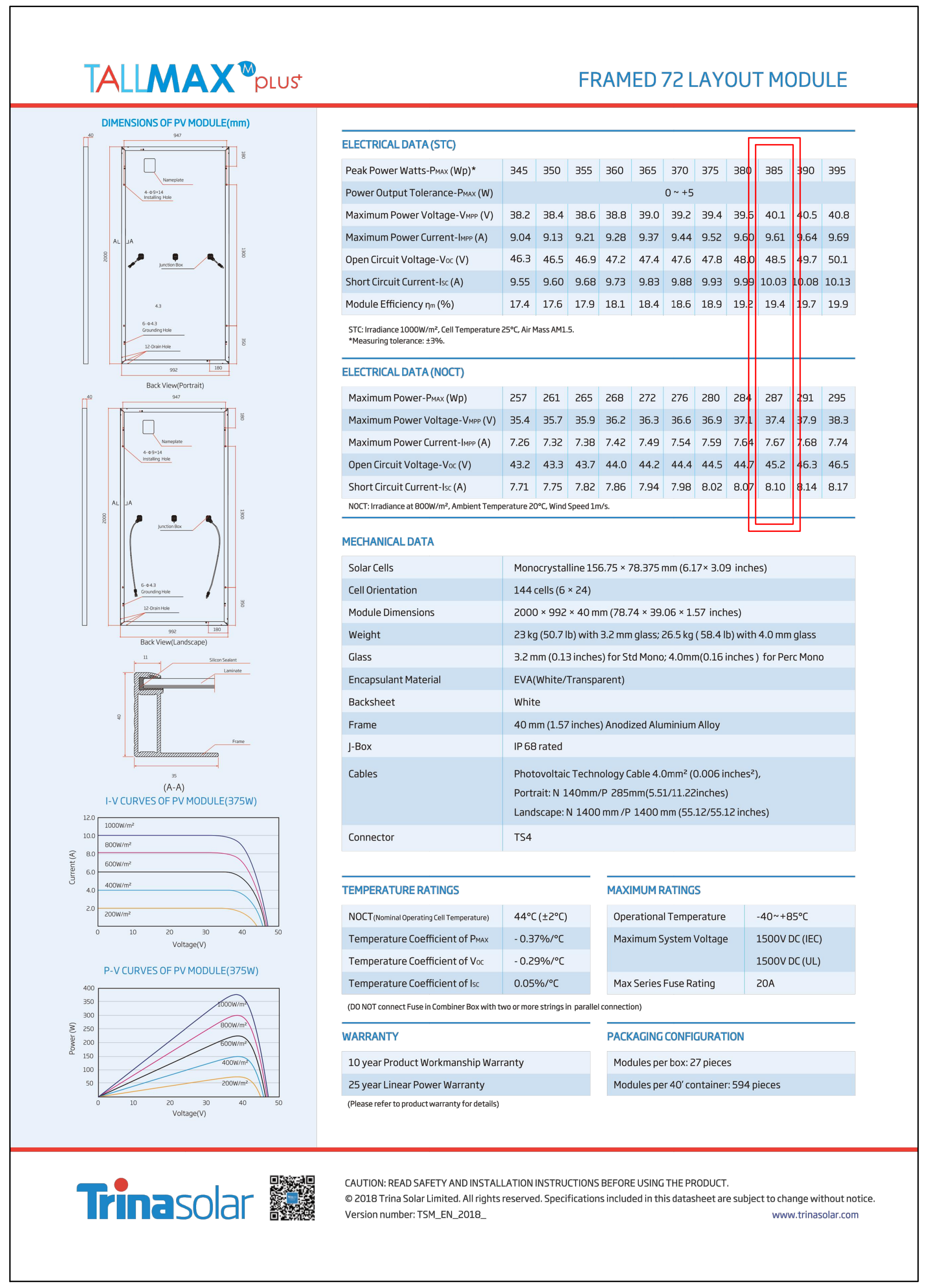
Highly reliable due to stringent quality control
- Over 30 in-house tests (UV, TC, HF etc)
- Internal test requirement of Trina more stringent than certification authority
- PID resistant
- 100% EL double inspection

Certified to withstand the most challenging environmental conditions
- 2400 Pa negative load
- 5400 Pa positive load

LINEAR PERFORMANCE WARRANTY

10 Year Product Warranty · 25 Year Linear Power Warranty

PROJECT PV MODULE



TALLMAX plus

FRAMED 72 LAYOUT MODULE

DIMENSIONS OF PV MODULE(mm)

I-V CURVES OF PV MODULE(375W)

P-V CURVES OF PV MODULE(375W)

ELECTRICAL DATA (STC)

Peak Power Watts-P_{MAX} (Wp)*	345	350	355	360	365	370	375	380	385	390	395
Power Output Tolerance-P_{MAX} (W)	0 ~ +5										
Maximum Power Voltage-V_{MPP} (V)	38.2	38.4	38.6	38.8	39.0	39.2	39.4	39.6	40.1	40.5	40.8
Maximum Power Current-I_{MPP} (A)	9.04	9.13	9.21	9.28	9.37	9.44	9.52	9.60	9.61	9.64	9.69
Open Circuit Voltage-V_{OC} (V)	46.3	46.5	46.9	47.2	47.4	47.6	47.8	48.0	48.5	49.7	50.1
Short Circuit Current-I_{SC} (A)	9.55	9.60	9.68	9.73	9.83	9.88	9.93	9.99	10.03	10.08	10.13
Module Efficiency η_m (%)	17.4	17.6	17.9	18.1	18.4	18.6	18.9	19.2	19.4	19.7	19.9

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5.
*Measuring tolerance: ±3%.

ELECTRICAL DATA (NOCT)

Maximum Power-P_{MAX} (Wp)	257	261	265	268	272	276	280	284	287	291	295
Maximum Power Voltage-V_{MPP} (V)	35.4	35.7	35.9	36.2	36.3	36.6	36.9	37.1	37.4	37.9	38.3
Maximum Power Current-I_{MPP} (A)	7.26	7.32	7.38	7.42	7.49	7.54	7.59	7.64	7.67	7.68	7.74
Open Circuit Voltage-V_{OC} (V)	43.2	43.3	43.7	44.0	44.2	44.4	44.5	44.7	45.2	46.3	46.5
Short Circuit Current-I_{SC} (A)	7.71	7.75	7.82	7.86	7.94	7.98	8.02	8.07	8.10	8.14	8.17

NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

MECHANICAL DATA

Solar Cells	Monocrystalline 156.75 × 78.375 mm (6.17× 3.09 inches)
Cell Orientation	144 cells (6 × 24)
Module Dimensions	2000 × 992 × 40 mm (78.74 × 39.06 × 1.57 inches)
Weight	23 kg (50.7 lb) with 3.2 mm glass; 26.5 kg (58.4 lb) with 4.0 mm glass
Glass	3.2 mm (0.13 inches) for Std Mono; 4.0mm(0.16 inches) for Perc Mono
Encapsulant Material	EVA(White/Transparent)
Backsheet	White
Frame	40 mm (1.57 inches) Anodized Aluminium Alloy
J-Box	IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm² (0.006 inches²), Portrait: N 140mm/P 285mm(5.51/11.22inches) Landscape: N 1400 mm /P 1400 mm (55.12/55.12 inches)
Connector	TS4

TEMPERATURE RATINGS

NOCT(Nominal Operating Cell Temperature)	44°C (±2°C)
Temperature Coefficient of P_{MAX}	- 0.37%/°C
Temperature Coefficient of V_{OC}	- 0.29%/°C
Temperature Coefficient of I_{SC}	0.05%/°C

MAXIMUM RATINGS

Operational Temperature	-40~+85°C
Maximum System Voltage	1500V DC (IEC) 1500V DC (UL)
Max Series Fuse Rating	20A

(DO NOT connect Fuse in Combiner Box with two or more strings in parallel connection)

WARRANTY

10 year Product Workmanship Warranty
25 year Linear Power Warranty

(Please refer to product warranty for details)

PACKAGING CONFIGURATION

Modules per box: 27 pieces
Modules per 40' container: 594 pieces

Trinasolar

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

Version number: TSM_EN_2018_
www.trinasolar.com

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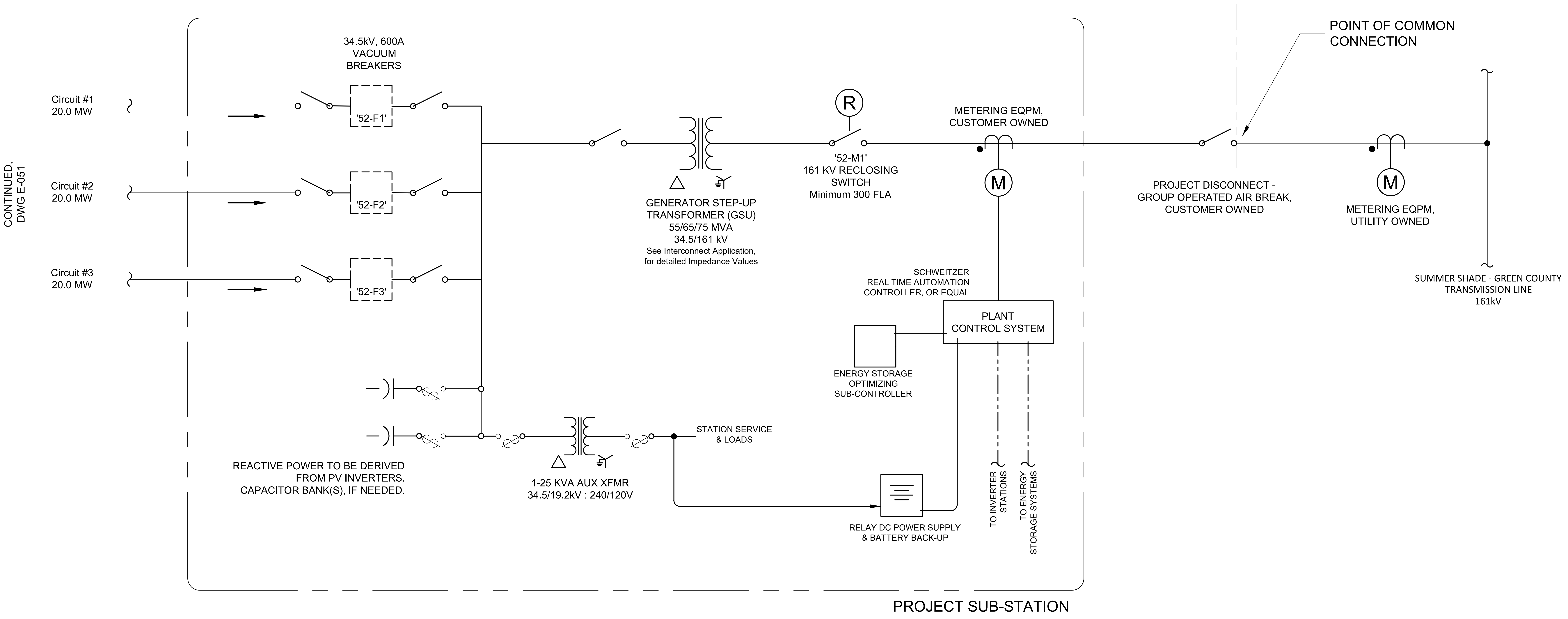
PRELIMINARY
EQUIPMENT
SPECIFICATIONS

SHEET
G-010



GENERAL NOTES

ALL CONDUCTORS AND OCP SIZES TO BE CONFIRMED IN DETAILED DESIGN, BASED ON SPECIFIC SITE CONDITIONS AND EQUIPMENT.

1. SYSTEM GROUNDING DETAILS NOT YET SHOWN.
2. UTILITY SUPPLIED EQUIPMENT IS REPRESENTATIONAL ONLY. FINAL EQUIPMENT SPECIFICATIONS TO BE DETERMINED BY UTILITY AND INTERCONNECTION STUDIES.
3. UTILITY TO SPECIFY THE TYPE, QUANTITY, AND SIZE OF ALL PT AND CT DEVICES AND TO SPECIFY THE USE AND PLACEMENT OF ALL MANUAL AND REMOTE OPERATING DEVICES CONNECTED TO THE PLANT FEEDER CIRCUIT.
4. ALL PV MODULES, INVERTERS, COMBINER BOXES, AND DISCONNECTS SUPPLIED BY THE CUSTOMER TO BE LISTED BY RECOGNIZED TESTING AND CERTIFICATION AGENCIES.
5. SYSTEM DESIGN AND INSTALLATION WILL COMPLY WITH NFPA-70 NATIONAL ELECTRICAL CODE (NEC) ARTICLES 250, 690, & 705, AND OTHERS AS APPLICABLE. VERSION AS CURRENTLY ADOPTED BY LOCAL AUTHORITY HAVING JURISDICTION.

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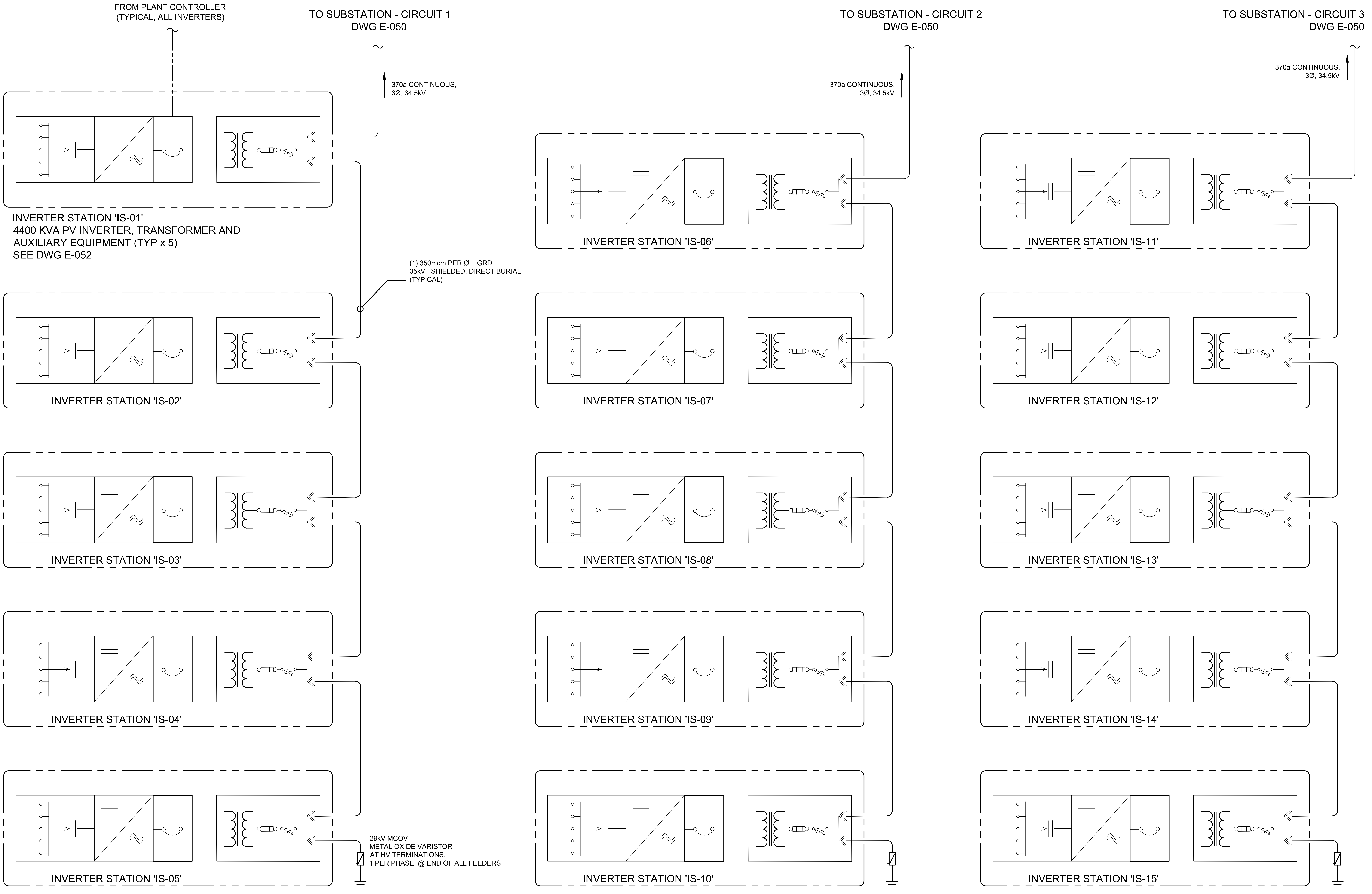
SINGLE LINE DIAGRAM - SUBSTATION

SHEET G-050



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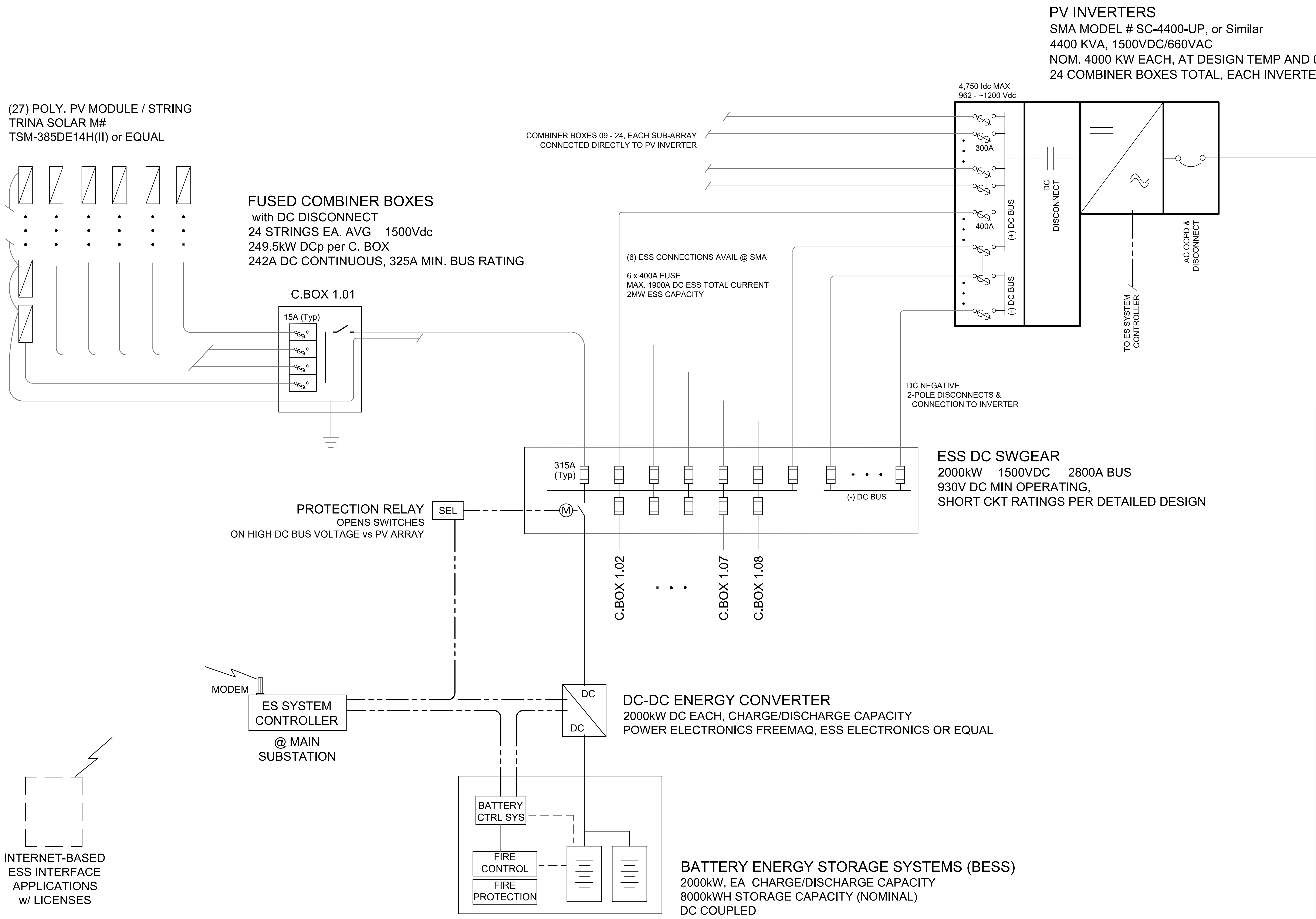
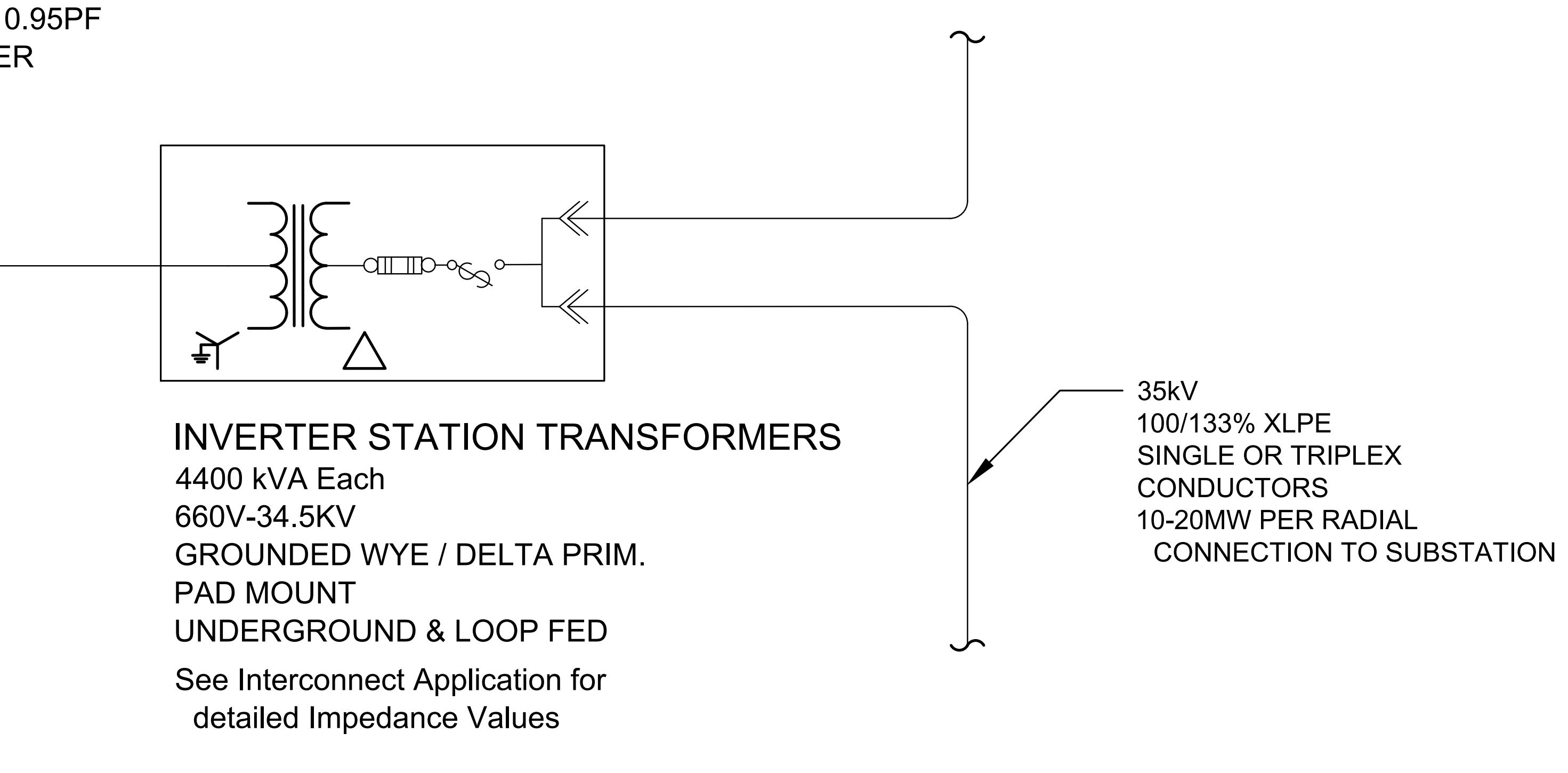
SINGLE LINE
DIAGRAM - AC
MV FEEDERS

SHEET
G-051





TYPICAL SUBARRAY

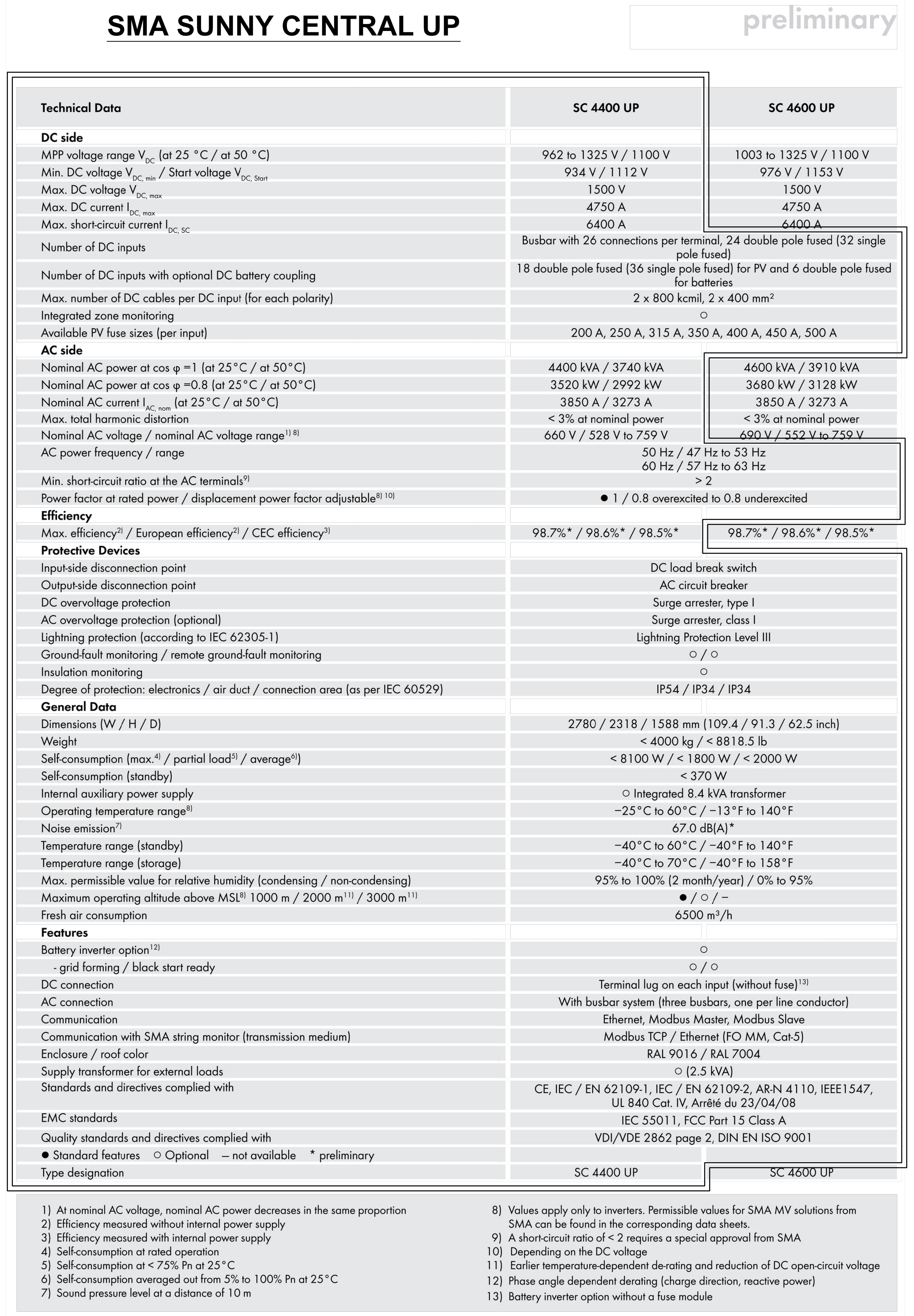
PV INVERTER
- SMA SUNNY CENTRAL 4400 UP (or EQUAL)
- OPERATING VOLTAGE: 660 VAC, 934-1350 VDC
- 4,400 kWac (NOMINAL)
- 1.40:1.0 DC:AC RATIO
- DC AFCI PROTECTION

SINGLE AXIS TRACKERS
- +/- 52-60 DEG ROTATION
- S.A. TRACKER (ROW-to-ROW) SPACING: 5.00m
- PV MDLE IN PORTRAIT: 2.02m ea

PV SOURCE CIRCUITS ("STRINGS")
- 10.08A / STRING Isc.
- AVG 24 STRINGS (648 MDLES) PER C.BOX
- 325A MIN PER C. BOX & FEEDER
- 249.5kW DCp PER C. BOX

DC-CONNECTED DISTRIBUTED ENERGY STORAGE SYSTEM (ESS)
2000kW DC CHARGE / DISCHARGE CAPACITY
4 HOURS / 8000kWH STORAGE CAPACITY
LITHIUM ION "LFP" CELL TYPE OR SIMILAR

- NEMA 3R/4 ENCLOSURES WITH HVAC
- BATTERY CONTROL & FIRE PROTECTION SYSTEMS
- INTEGRATION WITH INVERTER OPERATION AND MPPT CTRL
- SUPERVISORY CONTROL, DISPATCH AND MONITORING BY PROJECT SCADA SYSTEM
- PV INVERTER UNITS ARE STANDARD PV INVERTERS, WITH POWER FLOW ONLY FROM DC TO AC GRID, ONLY. ESS SYSTEM WILL BE UNABLE TO CHARGE FROM GRID.



SMA SUNNY CENTRAL UP

preliminary

Technical Data	SC 4400 UP	SC 4600 UP
DC side		
MPP voltage range V_{DC} (at 25 °C / at 50 °C)	962 to 1325 V / 1100 V	1003 to 1325 V / 1100 V
Min. DC voltage $V_{DC, min}$ / Start voltage $V_{DC, Start}$	934 V / 1112 V	976 V / 1153 V
Max. DC voltage $V_{DC, max}$	1500 V	1500 V
Max. DC current $I_{DC, max}$	4750 A	4750 A
Max. short-circuit current $I_{DC, SC}$	6400 A	6400 A
Number of DC inputs	Busbar with 26 connections per terminal, 24 double pole fused (32 single pole fused)	
Number of DC inputs with optional DC battery coupling	18 double pole fused (36 single pole fused) for PV and 6 double pole fused for batteries	
Max. number of DC cables per DC input (for each polarity)	2 x 800 kcmil, 2 x 400 mm²	
Integrated zone monitoring	○	
Available PV fuse sizes (per input)	200 A, 250 A, 315 A, 350 A, 400 A, 450 A, 500 A	
AC side		
Nominal AC power at cos φ =1 (at 25°C / at 50°C)	4400 kVA / 3740 kVA	4600 kVA / 3910 kVA
Nominal AC power at cos φ =0.8 (at 25°C / at 50°C)	3520 kW / 2992 kW	3680 kW / 3128 kW
Nominal AC current $I_{AC, nom}$ (at 25°C / at 50°C)	3850 A / 3273 A	3850 A / 3273 A
Max. total harmonic distortion	< 3% at nominal power	< 3% at nominal power
Nominal AC voltage / nominal AC voltage range1) 8)	660 V / 528 V to 759 V	690 V / 552 V to 759 V
AC power frequency / range	50 Hz / 47 Hz to 53 Hz 60 Hz / 57 Hz to 63 Hz	
Min. short-circuit ratio at the AC terminals9)	> 2	
Power factor at rated power / displacement power factor adjustable8) 10)	● 1 / 0.8 overexcited to 0.8 underexcited	
Efficiency		
Max. efficiency2) / European efficiency2) / CEC efficiency3)	98.7%* / 98.6%* / 98.5%*	98.7%* / 98.6%* / 98.5%*
Protective Devices		
Input-side disconnection point	DC load break switch	
Output-side disconnection point	AC circuit breaker	
DC overvoltage protection	Surge arrester, type I	
AC overvoltage protection (optional)	Surge arrester, class I	
Lightning protection (according to IEC 62305-1)	Lightning Protection Level III	
Ground-fault monitoring / remote ground-fault monitoring	○ / ○	
Insulation monitoring	○	
Degree of protection: electronics / air duct / connection area (as per IEC 60529)	IP54 / IP34 / IP34	
General Data		
Dimensions (W / H / D)	2780 / 2318 / 1588 mm (109.4 / 91.3 / 62.5 inch)	
Weight	< 4000 kg / < 8818.5 lb	
Self-consumption (max.4) / partial load5) / average6))	< 8100 W / < 1800 W / < 2000 W	
Self-consumption (standby)	< 370 W	
Internal auxiliary power supply	○ Integrated 8.4 kVA transformer	
Operating temperature range8)	−25°C to 60°C / −13°F to 140°F	
Noise emission7)	67.0 dB(A)*	
Temperature range (standby)	−40°C to 60°C / −40°F to 140°F	
Temperature range (storage)	−40°C to 70°C / −40°F to 158°F	
Max. permissible value for relative humidity (condensing / non-condensing)	95% to 100% (2 month/year) / 0% to 95%	
Maximum operating altitude above MSL8) 1000 m / 2000 m11) / 3000 m11)	● / ○ / –	
Fresh air consumption	6500 m³/h	
Features		
Battery inverter option12)	○	
- grid forming / black start ready	○ / ○	
DC connection	Terminal lug on each input (without fuse)13)	
AC connection	With busbar system (three busbars, one per line conductor)	
Communication	Ethernet, Modbus Master, Modbus Slave	
Communication with SMA string monitor (transmission medium)	Modbus TCP / Ethernet (FO MM, Cat-5)	
Enclosure / roof color	RAL 9016 / RAL 7004	
Supply transformer for external loads	○ (2.5 kVA)	
Standards and directives complied with	CE, IEC / EN 62109-1, IEC / EN 62109-2, AR-N 4110, IEEE1547, UL 840 Cat. IV, Arrêté du 23/04/08	
EMC standards	IEC 55011, FCC Part 15 Class A	
Quality standards and directives complied with	VDI/VDE 2862 page 2, DIN EN ISO 9001	
● Standard features ○ Optional – not available * preliminary		
Type designation	SC 4400 UP	SC 4600 UP

1) At nominal AC voltage, nominal AC power decreases in the same proportion
2) Efficiency measured without internal power supply
3) Efficiency measured with internal power supply
4) Self-consumption at rated operation
5) Self-consumption at < 75% Pn at 25°C
6) Self-consumption averaged out from 5% to 100% Pn at 25°C
7) Sound pressure level at a distance of 10 m
8) Values apply only to inverters. Permissible values for SMA MV solutions from SMA can be found in the corresponding data sheets.
9) A short-circuit ratio of < 2 requires a special approval from SMA
10) Depending on the DC voltage
11) Earlier temperature-dependent de-rating and reduction of DC open-circuit voltage
12) Phase angle dependent derating (charge direction, reactive power)
13) Battery inverter option without a fuse module

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SINGLE LINE DIAGRAM - DC & STATIONS

SHEET
G-052

Question #2

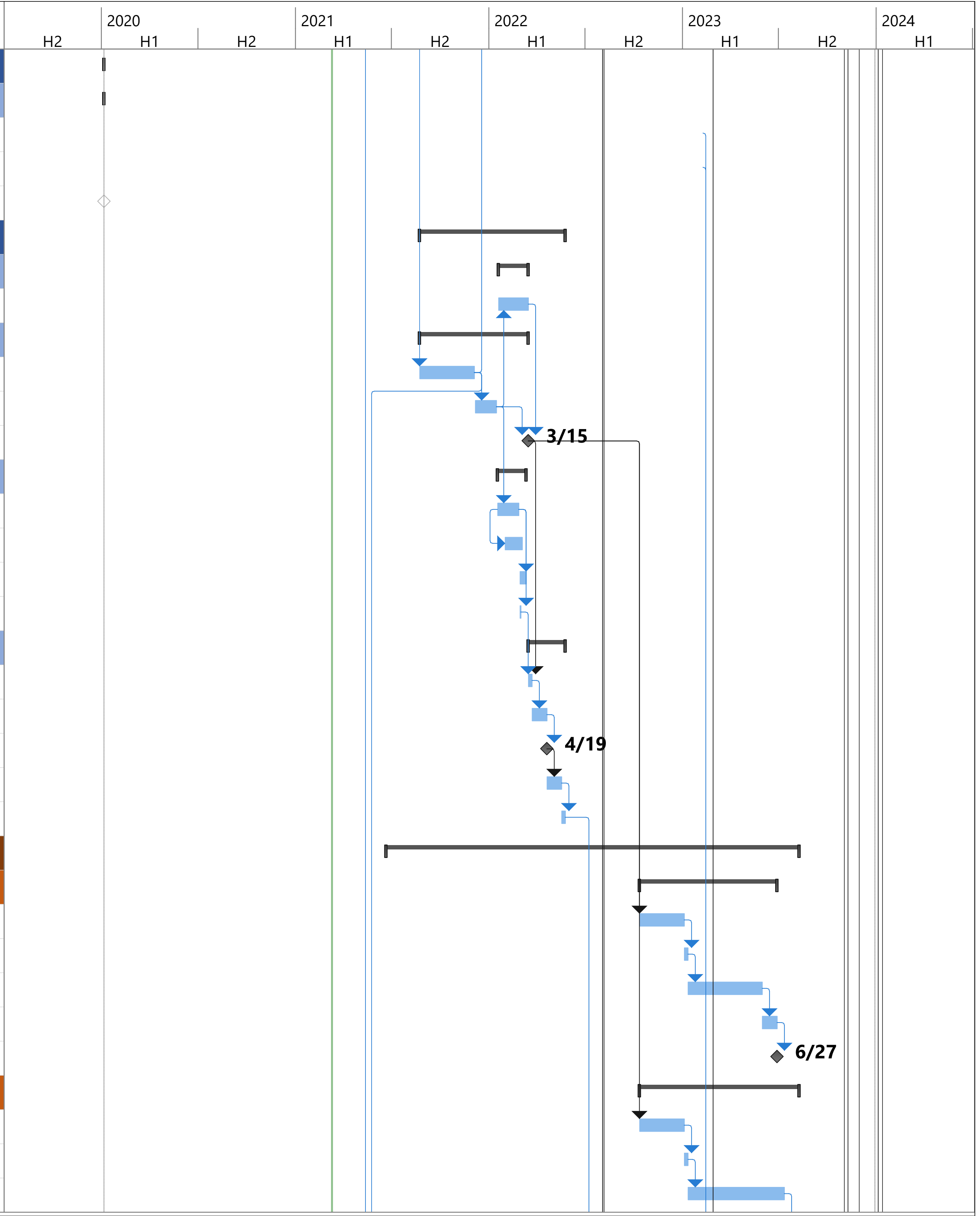
Project Schedule
Applicant to submit an over-all tentative schedule of the project, starting from the receival of the certificate for construction to the completion of the project. This document helps in understanding the total time required and the major milestones involved.

RESPONSE: An indicative construction schedule for Horseshoe Bend is attached hereto as Exhibit B. This schedule is a generic schedule for a solar project of this size, and has not yet been customized to the Project.

WITNESS: Carson Harkrader

EXHIBIT B

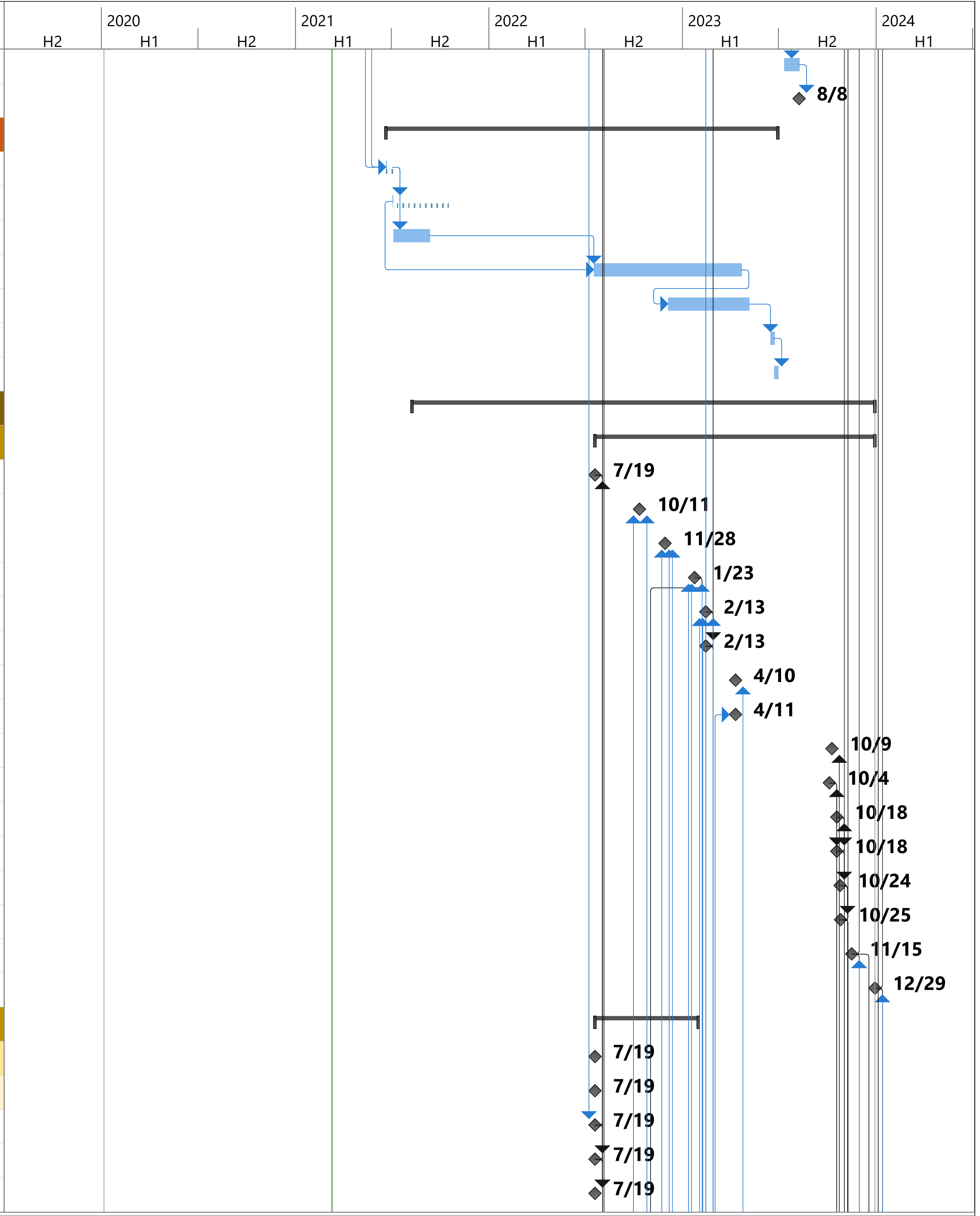
ID	WBS	Task Name	Duration	Start	Finish
35		**Horseshoe Bend Solar - Indicative Construction Schedule**			
36					
37					
38					
39					
40	**1.2.5**	**Pre-Construction**	**197 days**	**Mon 8/23/21**	**Tue 5/24/22**
41	**1.2.5.1**	**Estimating**	**40 days**	**Wed 1/19/22**	**Tue 3/15/22**
42	1.2.5.1.1	Indicative Estimate	8 wks	Wed 1/19/22	Tue 3/15/22
43	**1.2.5.2**	**Preliminary Engineering**	**147 days**	**Mon 8/23/21**	**Tue 3/15/22**
44	1.2.5.2.1	Conceptual Design	15 wks	Mon 8/23/21	Fri 12/3/21
45	1.2.5.2.2	10% Engineering Design	6 wks	Mon 12/6/21	Fri 1/14/22
46	1.2.5.2.3	10% Engineering Design & Estimate Complete	0 wks	Tue 3/15/22	Tue 3/15/22
47	**1.2.5.3**	**Preliminary Geotech**	**40 days**	**Mon 1/17/22**	**Fri 3/11/22**
48	1.2.5.3.1	Preliminary Geotech Onsite Investigation	6 wks	Mon 1/17/22	Fri 2/25/22
49	1.2.5.3.2	Pile Load Testing	4.9 wks	Mon 1/31/22	Fri 3/4/22
50	1.2.5.3.3	Preliminary Structural Design	2 wks	Mon 2/28/22	Fri 3/11/22
51	1.2.5.3.4	Geotech Report	2 days	Mon 2/28/22	Tue 3/1/22
52	**1.2.5.4**	**BOP EPC RFP**	**50 days**	**Wed 3/16/22**	**Tue 5/24/22**
53	1.2.5.4.1	Issue Bid Invitation	5 days	Wed 3/16/22	Tue 3/22/22
54	1.2.5.4.2	BOP EPC Review and Compile Bid	20 days	Wed 3/23/22	Tue 4/19/22
55	1.2.5.4.3	Bid Due	0 days	Tue 4/19/22	Tue 4/19/22
56	1.2.5.4.4	Bid Evaluation	20 days	Wed 4/20/22	Tue 5/17/22
57	1.2.5.4.5	BOP EPC Bid Award	5 days	Wed 5/18/22	Tue 5/24/22
58	**1.3**	**Project Material Procurement**	**557 days**	**Mon 6/21/21**	**Tue 8/8/23**
59	**1.3.1**	**Racking System**	**185 days**	**Wed 10/12/22**	**Tue 6/27/23**
60	1.3.1.1	PO Negotiations	60 days	Wed 10/12/22	Tue 1/3/23
61	1.3.1.2	Place Order	5 days	Wed 1/4/23	Tue 1/10/23
62	1.3.1.3	Manufacturing	100 days	Wed 1/11/23	Tue 5/30/23
63	1.3.1.4	Delivery to Site	20 days	Wed 5/31/23	Tue 6/27/23
64	1.3.1.5	Racking Deliveries Complete	0 days	Tue 6/27/23	Tue 6/27/23
65	**1.3.2**	**Modules**	**215 days**	**Wed 10/12/22**	**Tue 8/8/23**
66	1.3.2.1	PO Negotiations	60 days	Wed 10/12/22	Tue 1/3/23
67	1.3.2.2	Place Order	5 days	Wed 1/4/23	Tue 1/10/23
68	1.3.2.3	Manufacturing	130 days	Wed 1/11/23	Tue 7/11/23



Project: Horseshoe Bend_60MW
Date: Thu 3/11/21

Task	▬	Project Summary	┌─┐	Manual Task	▬	Start-only	[	Deadline	⬇
Split	┈	Inactive Task	▭	Duration-only	▬	Finish-only	]	Progress	─
Milestone	◆	Inactive Milestone	◇	Manual Summary Rollup	▬	External Tasks	▬	Manual Progress	─
Summary	┌─┐	Inactive Summary	┌─┐	Manual Summary	┌─┐	External Milestone	◆		

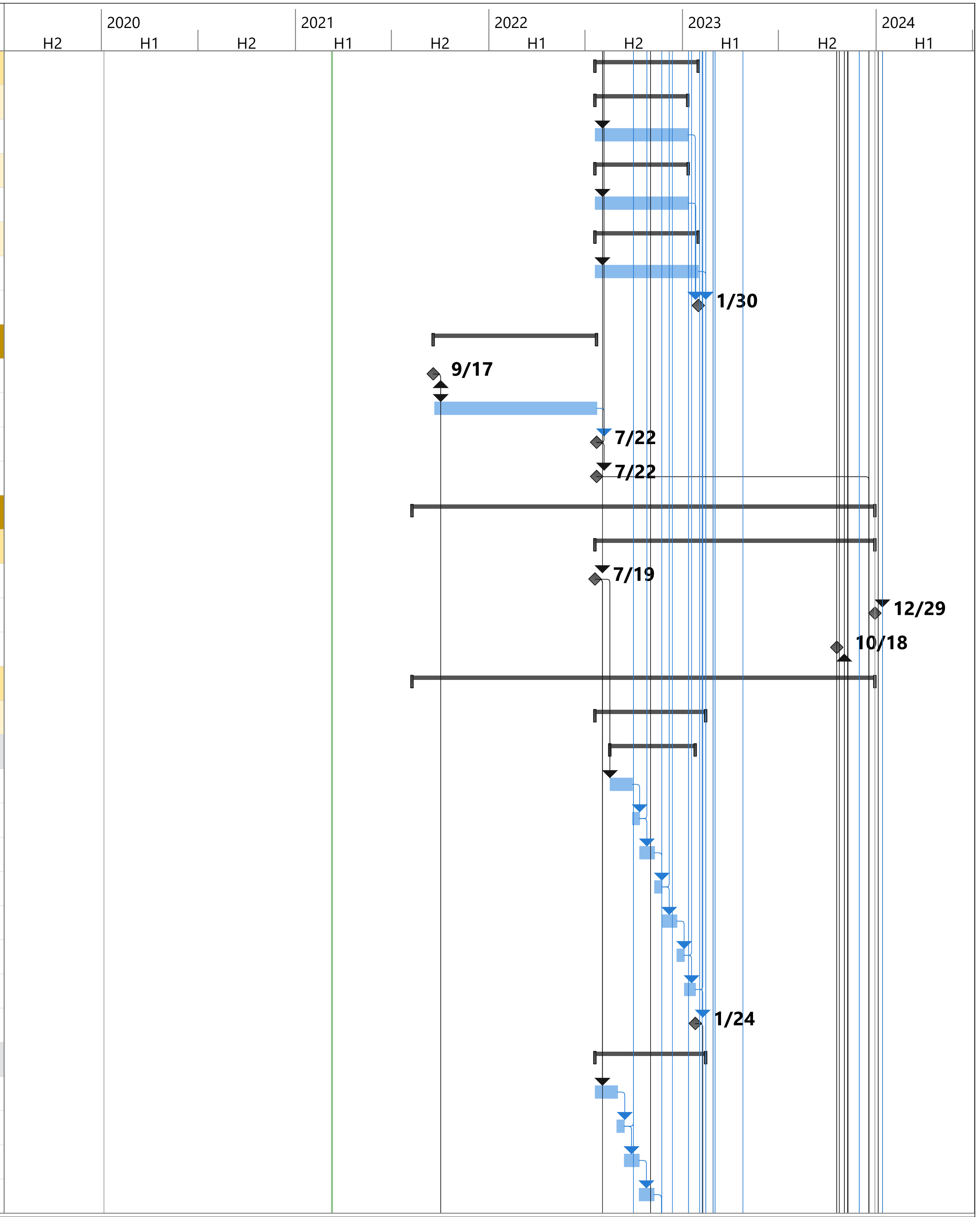
ID	WBS	Task Name	Duration	Start	Finish
69	1.3.2.4	Delivery to Site	20 days	Wed 7/12/23	Tue 8/8/23
70	1.3.2.5	Modules Deliveries Complete	0 days	Tue 8/8/23	Tue 8/8/23
71	**1.3.3**	**Main Power Transformer**	**529 days**	**Mon 6/21/21**	**Thu 6/29/23**
72	1.3.3.1	MPT Contractually Secured	2 wks	Mon 6/21/21	Fri 7/2/21
73	1.3.3.2	Procurement (ITC Materials)	15 wks	Fri 7/2/21	Fri 10/15/21
74	1.3.3.3	MPT Assignment	10 wks	Mon 7/5/21	Fri 9/10/21
75	1.3.3.4	Engineering	10 mons	Mon 7/18/22	Fri 4/21/23
76	1.3.3.5	Manufacturing	22 wks	Mon 12/5/22	Fri 5/5/23
77	1.3.3.6	Final Tests (FAT)	1 wk	Fri 6/16/23	Thu 6/22/23
78	1.3.3.7	Delivery	1 wk	Fri 6/23/23	Thu 6/29/23
79	**1.4**	**Project Delivery**	**625 days**	**Mon 8/9/21**	**Fri 12/29/23**
80	**1.4.1**	**Delivery Milestones**	**378 days**	**Tue 7/19/22**	**Fri 12/29/23**
81	1.4.1.1	BOP-EPC NTP	0 wks	Tue 7/19/22	Tue 7/19/22
82	1.4.1.2	BOP Engineering Drawings (30%) Complete	0 wks	Tue 10/11/22	Tue 10/11/22
83	1.4.1.3	BOP Engineering Drawings (60%) Complete	0 wks	Mon 11/28/22	Mon 11/28/22
84	1.4.1.4	BOP Engineering Drawings (90%) Complete	0 wks	Mon 1/23/23	Mon 1/23/23
85	1.4.1.5	BOP Engineering Drawings IFC	0 wks	Mon 2/13/23	Mon 2/13/23
86	1.4.1.6	BOP Mobilization	0 wks	Mon 2/13/23	Mon 2/13/23
87	1.4.1.7	Start Substation Construction	0 wks	Mon 4/10/23	Mon 4/10/23
88	1.4.1.8	n/a	0 days	Tue 4/11/23	Tue 4/11/23
89	1.4.1.9	n/a	0 wks	Mon 10/9/23	Mon 10/9/23
90	1.4.1.10	Collection System Construction Complete	0 wks	Wed 10/4/23	Wed 10/4/23
91	1.4.1.11	Substation Construction Complete	0 wks	Wed 10/18/23	Wed 10/18/23
92	1.4.1.12	Mechanical Completion(Ready for Backfeed Power)	0 days	Wed 10/18/23	Wed 10/18/23
93	1.4.1.13	MC Funding	0 days	Tue 10/24/23	Tue 10/24/23
94	1.4.1.14	Energize Project Substation (Backfeed Power)	0 wks	Wed 10/25/23	Wed 10/25/23
95	1.4.1.15	IRS Placed-In-Service Date	0 wks	Wed 11/15/23	Wed 11/15/23
96	1.4.1.16	Substantial Completion/ECCA (Tax Equity) COD	0 wks	Fri 12/29/23	Fri 12/29/23
97	**1.4.2**	**Owner's SOW**	**139 days**	**Tue 7/19/22**	**Mon 1/30/23**
98	**1.4.2.1**	**Agreements**	**0 days**	**Tue 7/19/22**	**Tue 7/19/22**
99	**1.4.2.1.1**	**BOP-EPC Agreement**	**0 days**	**Tue 7/19/22**	**Tue 7/19/22**
100	1.4.2.1.1.1	BOP-EPC Executed	0 wks	Tue 7/19/22	Tue 7/19/22
101	1.4.2.1.1.2	BOP-EPC NTP (Full)	0 wks	Tue 7/19/22	Tue 7/19/22
102	1.4.2.1.1.3	BOP-EPC Agreement Milestones Complete	0 wks	Tue 7/19/22	Tue 7/19/22



Project: Horseshoe Bend_60MW
Date: Thu 3/11/21

Task	▬	Project Summary	⊓	Manual Task	▬	Start-only	[	Deadline	⇩
Split	┈	Inactive Task	▭	Duration-only	▬	Finish-only	]	Progress	─
Milestone	◆	Inactive Milestone	◇	Manual Summary Rollup	▬	External Tasks	▬	Manual Progress	─
Summary	⊓	Inactive Summary	⊓	Manual Summary	⊓	External Milestone	◆		

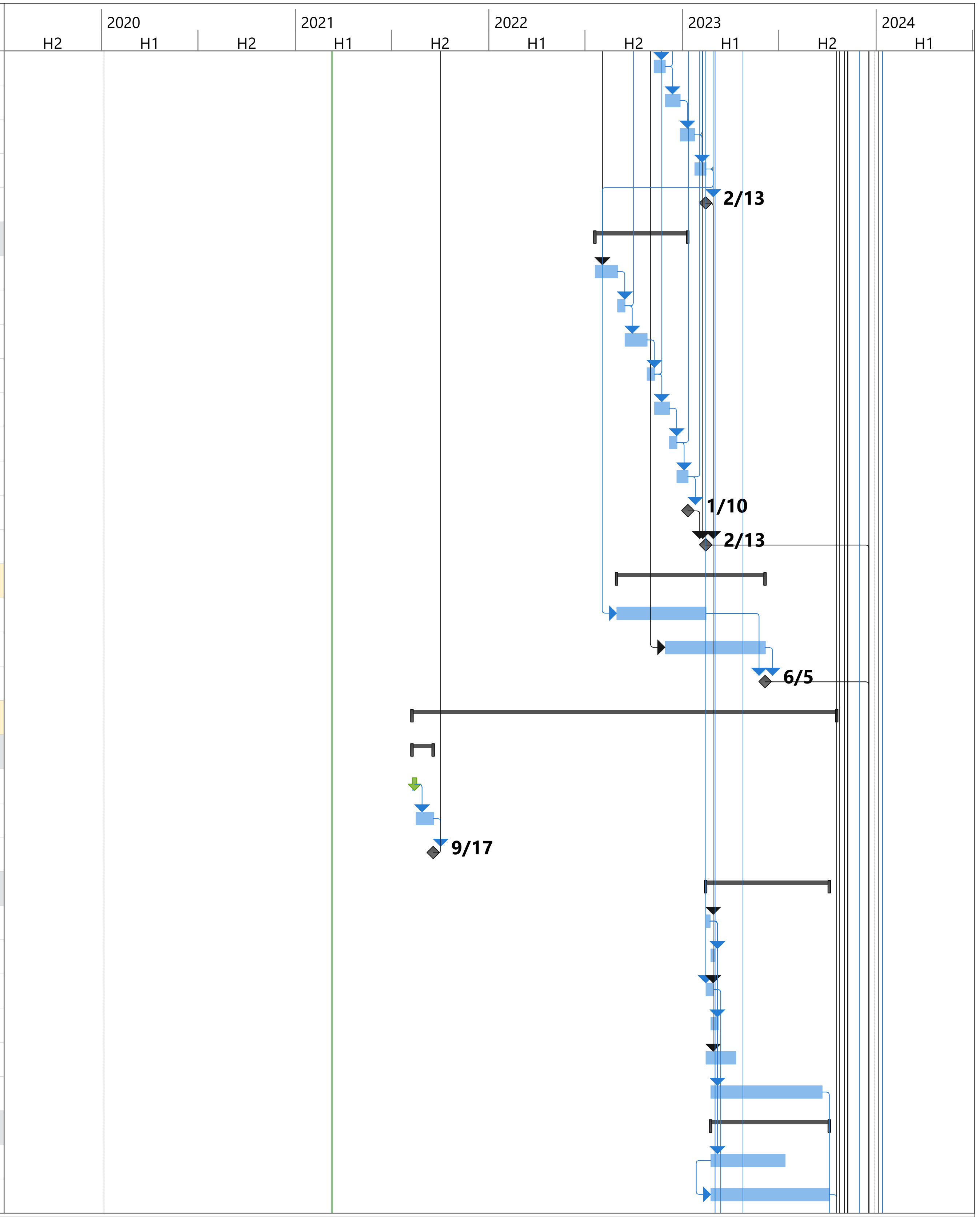
ID	WBS	Task Name	Duration	Start	Finish
103	**1.4.2.2**	**Construction Permits**	**139 days**	**Wed 7/20/22**	**Mon 1/30/23**
104	**1.4.2.2.1**	**Federal**	**125 days**	**Wed 7/20/22**	**Tue 1/10/23**
105	1.4.2.2.1.1	DOT Permits	25 wks	Wed 7/20/22	Tue 1/10/23
106	**1.4.2.2.2**	**State**	**126 days**	**Wed 7/20/22**	**Wed 1/11/23**
107	1.4.2.2.2.1	State Permits	25.2 wks	Wed 7/20/22	Wed 1/11/23
108	**1.4.2.2.3**	**Local / County**	**139 days**	**Wed 7/20/22**	**Mon 1/30/23**
109	1.4.2.2.3.1	County Permits	27.8 wks	Wed 7/20/22	Mon 1/30/23
110	1.4.2.2.4	Pre-Con Permits & Agreements Complete	0 wks	Mon 1/30/23	Mon 1/30/23
111	**1.4.3**	**TIF EPC SOW**	**220 days**	**Fri 9/17/21**	**Fri 7/22/22**
112	1.4.3.1	TIF Switchyard Pad Complete(BOP EPC)	0 days	Fri 9/17/21	Fri 9/17/21
113	1.4.3.2	Switchyard Construction	11 mons	Mon 9/20/21	Fri 7/22/22
114	1.4.3.3	TIF In Service Date	0 days	Fri 7/22/22	Fri 7/22/22
115	1.4.3.4	TIFEPC SOW Complete	0 wks	Fri 7/22/22	Fri 7/22/22
116	**1.4.4**	**Solar Plant EPC Contractor SOW**	**625 days**	**Mon 8/9/21**	**Fri 12/29/23**
117	**1.4.4.1**	**BOP-EPC Milestones**	**378 days**	**Tue 7/19/22**	**Fri 12/29/23**
118	1.4.4.1.1	Notice to Proceed	0 wks	Tue 7/19/22	Tue 7/19/22
119	1.4.4.1.2	Guaranteed Project Substantial Completion	0 wks	Wed 10/18/23	Wed 10/18/23
120	1.4.4.1.3	Guaranteed Project Final Completion	0 wks	Fri 12/29/23	Fri 12/29/23
121	**1.4.4.2**	**BOP-EPC (General) SOW**	**625 days**	**Mon 8/9/21**	**Fri 12/29/23**
122	**1.4.4.2.1**	**Engineering**	**149 days**	**Wed 7/20/22**	**Mon 2/13/23**
123	**1.4.4.2.1.1**	**Civil Design**	**115 days**	**Wed 8/17/22**	**Tue 1/24/23**
124	1.4.4.2.1.1.1	Civil Engineering 30%	30 days	Wed 8/17/22	Tue 9/27/22
125	1.4.4.2.1.1.2	Civil Engineering 30% Review	10 days	Wed 9/28/22	Tue 10/11/22
126	1.4.4.2.1.1.3	Civil Engineering 60%	20 days	Wed 10/12/22	Tue 11/8/22
127	1.4.4.2.1.1.4	Civil Engineering 60% Review	10 days	Wed 11/9/22	Tue 11/22/22
128	1.4.4.2.1.1.5	Civil Engineering 90%	20 days	Wed 11/23/22	Tue 12/20/22
129	1.4.4.2.1.1.6	Civil Engineering 90% Review	10 days	Wed 12/21/22	Tue 1/3/23
130	1.4.4.2.1.1.7	Civil Engineering IFC	15 days	Wed 1/4/23	Tue 1/24/23
131	1.4.4.2.1.1.8	Civil Engineering Complete	0 wks	Tue 1/24/23	Tue 1/24/23
132	**1.4.4.2.1.2**	**Collection System Design**	**149 days**	**Wed 7/20/22**	**Mon 2/13/23**
133	1.4.4.2.1.2.1	30% Collection Design	30 days	Wed 7/20/22	Tue 8/30/22
134	1.4.4.2.1.2.2	30% Collection Design R&C	10 days	Tue 8/30/22	Mon 9/12/22
135	1.4.4.2.1.2.3	30% Collection System Studies	20 days	Tue 9/13/22	Mon 10/10/22
136	1.4.4.2.1.2.4	60% Collection Design	20 days	Tue 10/11/22	Mon 11/7/22



Project: Horseshoe Bend_60MW
Date: Thu 3/11/21

Task	▬	Project Summary	┌─┐	Manual Task	▬	Start-only	[	Deadline	⬇
Split	┈	Inactive Task	▭	Duration-only	▬	Finish-only	]	Progress	─
Milestone	◆	Inactive Milestone	◇	Manual Summary Rollup	▬	External Tasks	▬	Manual Progress	─
Summary	┌─┐	Inactive Summary	┌─┐	Manual Summary	┌─┐	External Milestone	◇		

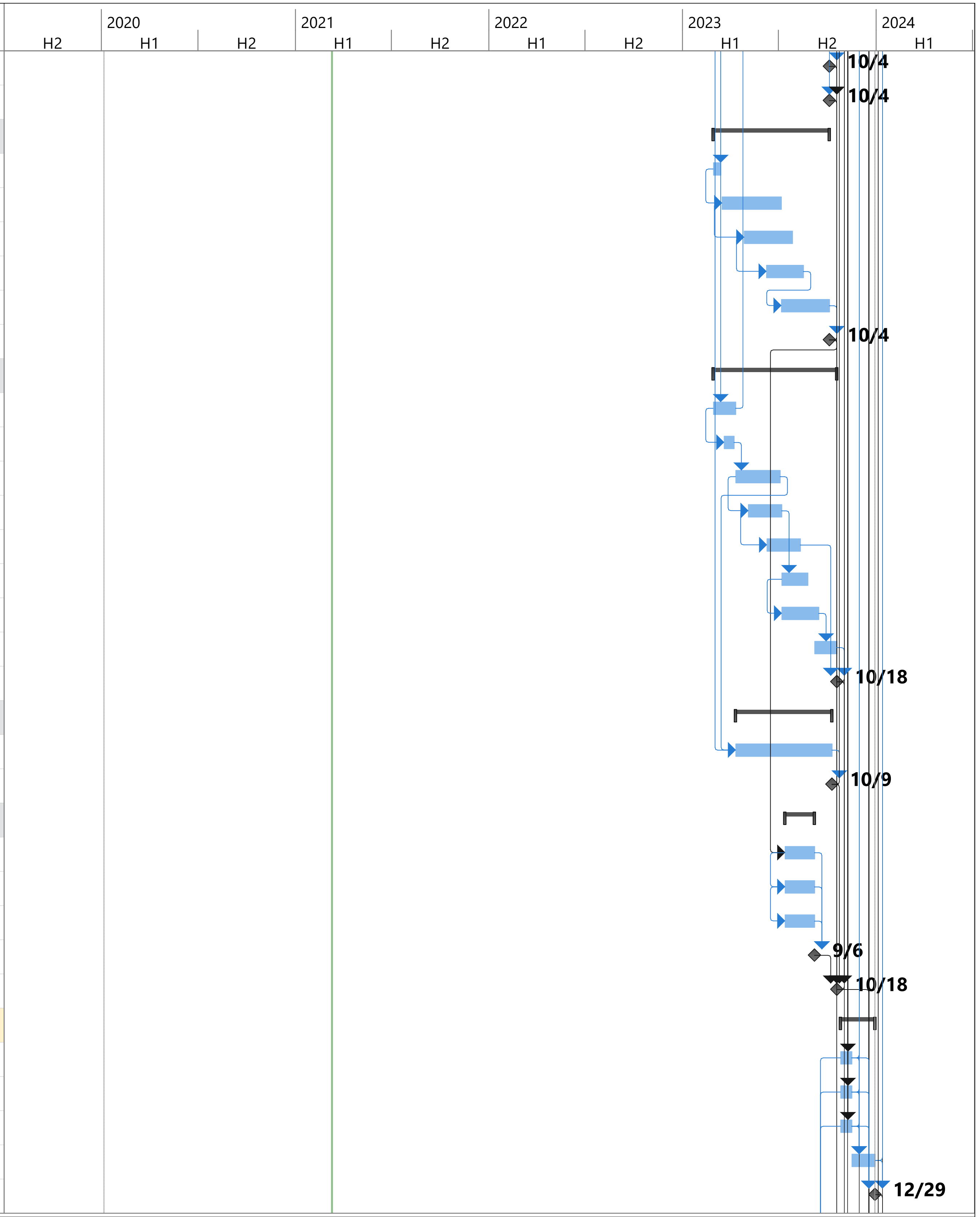
ID	WBS	Task Name	Duration	Start	Finish
137	1.4.4.2.1.2.5	60% Collection Design R&C	15 days	Tue 11/8/22	Mon 11/28/22
138	1.4.4.2.1.2.6	90% Collection Design	20 days	Tue 11/29/22	Mon 12/26/22
139	1.4.4.2.1.2.7	90% Collection Design R&C	20 days	Tue 12/27/22	Mon 1/23/23
140	1.4.4.2.1.2.8	IFC Collection Design	15 days	Tue 1/24/23	Mon 2/13/23
141	1.4.4.2.1.2.9	Collection System Engineering Complete	0 wks	Mon 2/13/23	Mon 2/13/23
142	**1.4.4.2.1.3**	**High Voltage (HV) Engineering**	**125 days**	**Wed 7/20/22**	**Tue 1/10/23**
143	1.4.4.2.1.3.1	30% HV Engineering	30 days	Wed 7/20/22	Tue 8/30/22
144	1.4.4.2.1.3.2	30% HV Engineering Review	10 days	Wed 8/31/22	Tue 9/13/22
145	1.4.4.2.1.3.3	60% HV Engineering	30 days	Wed 9/14/22	Tue 10/25/22
146	1.4.4.2.1.3.4	60% HV Engineering Review	10 days	Wed 10/26/22	Tue 11/8/22
147	1.4.4.2.1.3.5	90% HV Engineering	20 days	Wed 11/9/22	Tue 12/6/22
148	1.4.4.2.1.3.6	90% HV Engineering Review	10 days	Wed 12/7/22	Tue 12/20/22
149	1.4.4.2.1.3.7	HV Engineering IFC	15 days	Wed 12/21/22	Tue 1/10/23
150	1.4.4.2.1.3.8	HV Engineering Complete	0 wks	Tue 1/10/23	Tue 1/10/23
151	1.4.4.2.1.4	BOP-EPC Engineering Complete	0 wks	Mon 2/13/23	Mon 2/13/23
152	**1.4.4.2.2**	**Procurement**	**200 days**	**Tue 8/30/22**	**Mon 6/5/23**
153	1.4.4.2.2.1	Long Lead Items	120 days	Tue 8/30/22	Mon 2/13/23
154	1.4.4.2.2.2	Control Building	135 days	Tue 11/29/22	Mon 6/5/23
155	1.4.4.2.2.3	BOP-EPC Procurement Complete	0 wks	Mon 6/5/23	Mon 6/5/23
156	**1.4.4.2.3**	**Construction**	**573 days**	**Mon 8/9/21**	**Wed 10/18/23**
157	**1.4.4.2.3.1**	**Switchyard Pad**	**30 days**	**Mon 8/9/21**	**Fri 9/17/21**
158	1.4.4.2.3.1.1	Switchyard Pad Mobilization	1 wk	Mon 8/9/21	Fri 8/13/21
159	1.4.4.2.3.1.2	Switchyard Pad Construction	5 wks	Mon 8/16/21	Fri 9/17/21
160	1.4.4.2.3.1.3	Switchyard Pad Complete	0 days	Fri 9/17/21	Fri 9/17/21
161	**1.4.4.2.3.2**	**Sitework**	**167 days**	**Tue 2/14/23**	**Wed 10/4/23**
162	1.4.4.2.3.2.1	Training & Planning	6 days	Tue 2/14/23	Tue 2/21/23
163	1.4.4.2.3.2.2	Grade Office Trailer / Laydown Area	6 days	Thu 2/23/23	Thu 3/2/23
164	1.4.4.2.3.2.3	Mobilization	10 days	Tue 2/14/23	Mon 2/27/23
165	1.4.4.2.3.2.4	Grade Substation Area	10 days	Thu 2/23/23	Wed 3/8/23
166	1.4.4.2.3.2.5	Survey & Layout	40 days	Tue 2/14/23	Mon 4/10/23
167	1.4.4.2.3.2.6	Install / Maintain Erosion Control	150 days	Thu 2/23/23	Wed 9/20/23
168	**1.4.4.2.3.2.7**	**Roads**	**160 days**	**Thu 2/23/23**	**Wed 10/4/23**
169	1.4.4.2.3.2.7.1	Access Roads	100 days	Thu 2/23/23	Wed 7/12/23
170	1.4.4.2.3.2.7.2	Road Maintenance & Dust Control	160 days	Thu 2/23/23	Wed 10/4/23



Project: Horseshoe Bend_60MW
Date: Thu 3/11/21

Task		Project Summary		Manual Task		Start-only	[	Deadline	⇩
Split		Inactive Task		Duration-only		Finish-only	]	Progress	
Milestone	◆	Inactive Milestone	◇	Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone	◆		

ID	WBS	Task Name	Duration	Start	Finish
171	1.4.4.2.3.2.7.3	Roads Complete	0 wks	Wed 10/4/23	Wed 10/4/23
172	1.4.4.2.3.2.8	Sitework Construction Complete	0 wks	Wed 10/4/23	Wed 10/4/23
173	**1.4.4.2.3.3**	**Collection System**	**157 days**	**Tue 2/28/23**	**Wed 10/4/23**
174	1.4.4.2.3.3.1	Mobilization & Training	10 days	Tue 2/28/23	Mon 3/13/23
175	1.4.4.2.3.3.2	Trench/Place Cable/Backfill Circuits	80 days	Thu 3/16/23	Wed 7/5/23
176	1.4.4.2.3.3.3	Install Racking & Modules	65 days	Thu 4/27/23	Wed 7/26/23
177	1.4.4.2.3.3.4	Wire Management/Above Ground Electrical	50 days	Thu 6/8/23	Wed 8/16/23
178	1.4.4.2.3.3.5	Circuit Testing	65 days	Thu 7/6/23	Wed 10/4/23
179	1.4.4.2.3.3.6	Collection System Construction Complete	0 wks	Wed 10/4/23	Wed 10/4/23
180	**1.4.4.2.3.4**	**Substation**	**167 days**	**Tue 2/28/23**	**Wed 10/18/23**
181	1.4.4.2.3.4.1	Control Building	30 days	Tue 2/28/23	Mon 4/10/23
182	1.4.4.2.3.4.2	Mobilization & Training	15 days	Mon 3/20/23	Fri 4/7/23
183	1.4.4.2.3.4.3	Install Foundations & Grounding	60 days	Tue 4/11/23	Mon 7/3/23
184	1.4.4.2.3.4.4	Install Support Steel	45 days	Fri 5/5/23	Thu 7/6/23
185	1.4.4.2.3.4.5	Buswork	45 days	Fri 6/9/23	Thu 8/10/23
186	1.4.4.2.3.4.6	Receive & Terminate Main Power Transformers	35 days	Fri 7/7/23	Thu 8/24/23
187	1.4.4.2.3.4.7	Install & Terminate Equipment	50 days	Fri 7/7/23	Thu 9/14/23
188	1.4.4.2.3.4.8	Test / Commission Substation	30 days	Thu 9/7/23	Wed 10/18/23
189	1.4.4.2.3.4.9	Substation Construction Complete	0 wks	Wed 10/18/23	Wed 10/18/23
190	**1.4.4.2.3.5**	**O&M Trailer**	**130 days**	**Tue 4/11/23**	**Mon 10/9/23**
191	1.4.4.2.3.5.1				
192	1.4.4.2.3.5.2	O&M Trailer Installation	0 wks	Mon 10/9/23	Mon 10/9/23
193	**1.4.4.2.3.6**	**Restoration**	**40 days**	**Thu 7/13/23**	**Wed 9/6/23**
194	1.4.4.2.3.6.1	Reclaim Roads	40 days	Thu 7/13/23	Wed 9/6/23
195	1.4.4.2.3.6.2	Cleanup & Demobilization	40 days	Thu 7/13/23	Wed 9/6/23
196	1.4.4.2.3.6.3	Seed Reclamation Areas	40 days	Thu 7/13/23	Wed 9/6/23
197	1.4.4.2.3.6.4	Restoration Complete	0 wks	Wed 9/6/23	Wed 9/6/23
198	1.4.4.2.3.7	BOP-EPC Construction Complete	0 wks	Wed 10/18/23	Wed 10/18/23
199	**1.4.4.2.4**	**Commissioning**	**47 days**	**Thu 10/26/23**	**Fri 12/29/23**
200	1.4.4.2.4.1	Inverter Hot Commissioning	15 days	Thu 10/26/23	Wed 11/15/23
201	1.4.4.2.4.2	Trackers Hot Commissioning	15 days	Thu 10/26/23	Wed 11/15/23
202	1.4.4.2.4.3	SCADA Control	15 days	Thu 10/26/23	Wed 11/15/23
203	1.4.4.2.4.4	Performance Testing	32 days	Thu 11/16/23	Fri 12/29/23
204	1.4.4.2.4.5	Commissioning Complete	0 days	Fri 12/29/23	Fri 12/29/23



Project: Horseshoe Bend_60MW
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Task
Split
Milestone ◆
Summary
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Inactive Task
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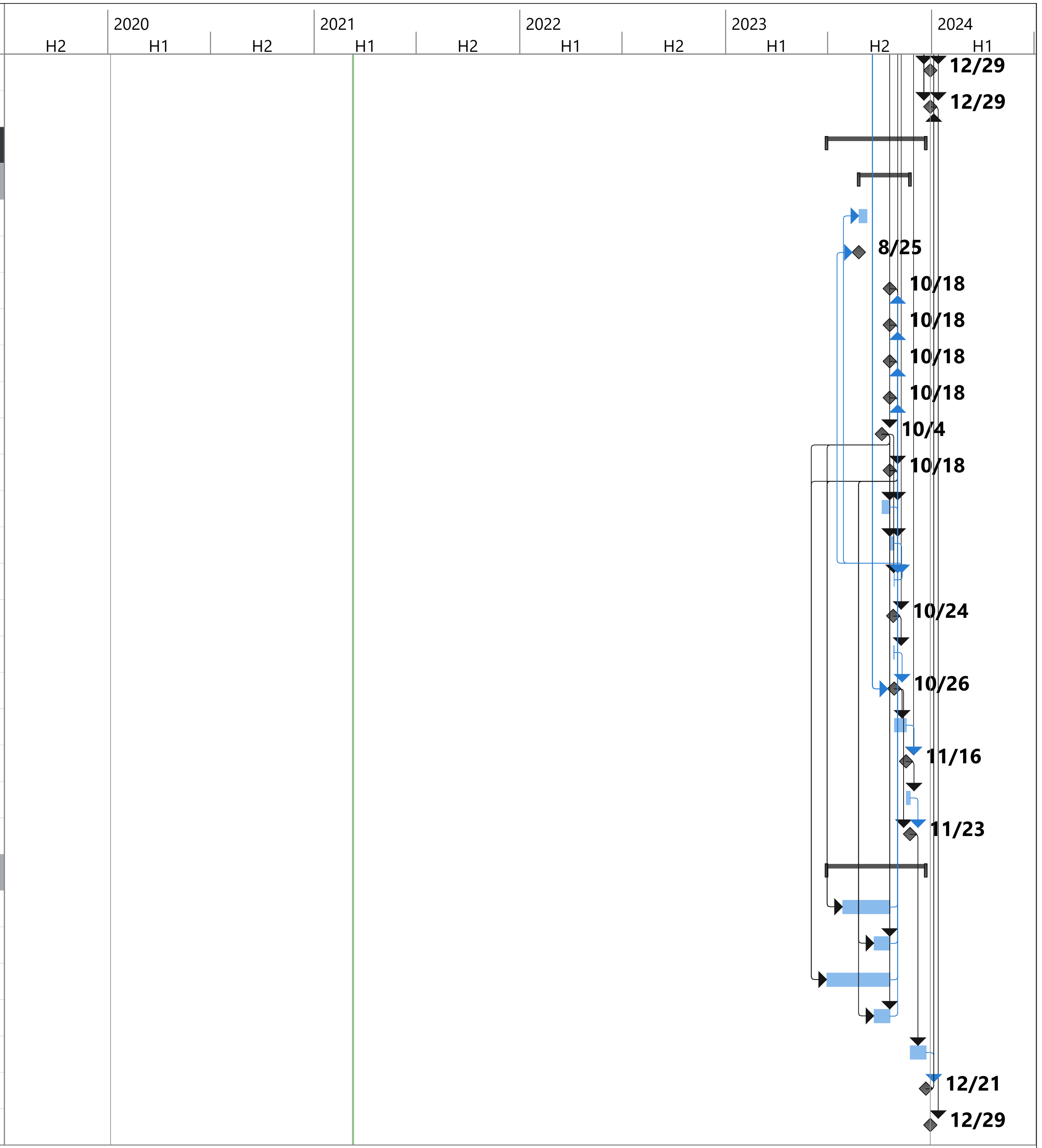
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only [
Finish-only]
External Tasks
External Milestone ◆
Deadline ⇩
Progress
Manual Progress

ID	WBS	Task Name	Duration	Start	Finish
205	1.4.4.2.5	BOP-EPC SOW Complete	0 wks	Fri 12/29/23	Fri 12/29/23
206	1.4.5	Project Delivery Complete	0 wks	Fri 12/29/23	Fri 12/29/23
207	**1.5**	**Market Readiness Grid (PJM) Compliance**	**126 days**	**Thu 6/29/23**	**Thu 12/21/23**
208	**1.5.1**	**Site Synchronization**	**65 days**	**Fri 8/25/23**	**Thu 11/23/23**
209	1.5.1.1	Complete Commissioning Plan - 45 days prior to Back feed (Owr	2 wks	Fri 8/25/23	Thu 9/7/23
210	1.5.1.2	Complete FIS Stability Study - 45 days prior to back feed (Owner	0 days	Fri 8/25/23	Fri 8/25/23
211	1.5.1.3	PJM Operations Checklist Complete	0 wks	Wed 10/18/23	Wed 10/18/23
212	1.5.1.4	PJM Market Checklist Complete	0 wks	Wed 10/18/23	Wed 10/18/23
213	1.5.1.5	PJM Administrative Checklist Complete	0 wks	Wed 10/18/23	Wed 10/18/23
214	1.5.1.6	PJM Systems Communications Checklist Complete	0 wks	Wed 10/18/23	Wed 10/18/23
215	1.5.1.7	PV Park Mechanical Completion	0 days	Wed 10/4/23	Wed 10/4/23
216	1.5.1.8	Substation Mechanical Completion	0 wks	Wed 10/18/23	Wed 10/18/23
217	1.5.1.9	Complete Pre-Energization Engie Checklist	10 days	Thu 10/5/23	Wed 10/18/23
218	1.5.1.10	Tax Equity MC Funding (Funding #1)	5 days	Thu 10/19/23	Wed 10/25/23
219	1.5.1.11	Energize Project Substation	1 day	Thu 10/26/23	Thu 10/26/23
220	1.5.1.12	Mechanical Completion (Backfeed) Milestone 2	0 wks	Tue 10/24/23	Tue 10/24/23
221	1.5.1.13	Complete Pre-Synchronization Checklist (Owner)	2 days	Wed 10/25/23	Thu 10/26/23
222	1.5.1.14	Final Hot Commissioning Start	0 days	Thu 10/26/23	Thu 10/26/23
223	1.5.1.15	Review of Plant Controls	15 days	Fri 10/27/23	Thu 11/16/23
224	1.5.1.16	Final Hot Commissioning Complete	0 days	Thu 11/16/23	Thu 11/16/23
225	1.5.1.17	Fine Tune, Commission and Test All plant controllers	5 days	Fri 11/17/23	Thu 11/23/23
226	1.5.1.18	Substation Completion (Plant Substantial Completion) COD Achi	0 days	Thu 11/23/23	Thu 11/23/23
227	**1.5.2**	**PJM Activities**	**126 days**	**Thu 6/29/23**	**Thu 12/21/23**
228	1.5.2.1	Operations Checklist	3 mons	Thu 7/27/23	Wed 10/18/23
229	1.5.2.2	Market Checklist	1 mon	Thu 9/21/23	Wed 10/18/23
230	1.5.2.3	Administrative Checklist	4 mons	Thu 6/29/23	Wed 10/18/23
231	1.5.2.4	Systems Communications Checklist	1 mon	Thu 9/21/23	Wed 10/18/23
232	1.5.2.5	Training Checklist	4 wks	Fri 11/24/23	Thu 12/21/23
233	1.5.3	Market Readiness SOW Complete	0 wks	Thu 12/21/23	Thu 12/21/23
234	1.6	Project Complete	0 wks	Fri 12/29/23	Fri 12/29/23



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Task	▬	Project Summary	⊓	Manual Task	▬	Start-only	[	Deadline	⬇
Split	┈	Inactive Task	▭	Duration-only	▬	Finish-only	]	Progress	—
Milestone	◆	Inactive Milestone	◇	Manual Summary Rollup	▬	External Tasks	▬	Manual Progress	—
Summary	⊓	Inactive Summary	⊓	Manual Summary	⊓	External Milestone	◆		

Question #3

Overall Project Layout
Please provide the information on the utilities like Water, Sewer, etc, to be provided to any of the buildings, warehouses, Project offices and Power Stations as applicable to site. This is required for assessing the capability of the proposed utilities.

RESPONSE: There will not be any water or sewer servicing the Project site. There is likely to be no permanent project office building on site because there will not be permanent workers at the Project site after construction. If there is a building on site, it will likely be a trailer or container to store operations and maintenance equipment and parts. This trailer or container will not require water or sewer service.

Communications fiber and distribution power will be provided from local service providers. During Project operation, electricity generated by the Project can be used to supply power needs at the site. Electricity may be purchased from the local utility prior to Project commissioning, or during operation during times when the Project is not generating electricity.

During construction, water may be required initially for irrigating the vegetative buffer until it is established. This water would be trucked onto site. During operation solar sites have very little water usage, as it is unlikely that the solar panels will need to be washed and there are no other water needs within the plant. Rainfall is generally efficient at cleaning the panels. If panel washing is needed (potentially once every few years), water would likely be trucked in. An onsite well might be used if it is suitable, and the use of an on-site well would be subject to any required state or local permits, if applicable.

WITNESS: Carson Harkrader

Question #4

Applicant to provide pertinent information for,
At end of life when the system is decommissioned will the area be restored? Will the soil be useful for farming after the demolition of the solar plant after 30 years? If not, will the companies do something to bring the soil back to normal?

RESPONSE: Yes, at the end of life when the system is decommissioned the area will be restored. Horseshoe Bend's proposed decommissioning process has been copied into the response to the Siting Board's question number 2.

Regarding anticipated soil quality after the decommissioning of the solar plant in 30-40 years, please refer to section 2.2 of the white paper titled Balancing Agricultural Productivity with Ground-Based Solar Photovoltaic (PV) Development, attached hereto as Exhibit C. This white paper from NC State University, one of two land-grant universities in North Carolina, reviews the impacts to the soil from solar project installation.

The paper states on page 9 that the addition of fertilizer or lime may be required during facility operation in order to maintain healthy groundcover, and also after a solar project is removed in order to return it to useful production. According to the paper, the amounts fertilizer or lime required can be measured by a routine soil test. The solar decommissioning process does not include the addition of fertilizer or lime, which may be added after Project decommissioning by the landowner, and determined by the next use the landowner chooses for their property.

Vegetation maintenance during the Project lifetime is typically provided by mowing, limited use of herbicides, and sometimes grazing of farm animals (typically sheep). Mowing and grazing can improve soil quality over time, and the white paper states "Herbicide use at solar facilities is typically similar to that in agriculture, and the types of herbicides used are similar between the two uses. As such, the impact of herbicides used at solar facilities on neighboring land and the environment is likely to be no more than that of conventional agriculture." Herbicide is sometimes used around racking posts where it is difficult to mow, but is typically not used on large areas during solar project operation because vegetation needs to be maintained across the solar site for erosion control.

WITNESS: Carson Harkrader

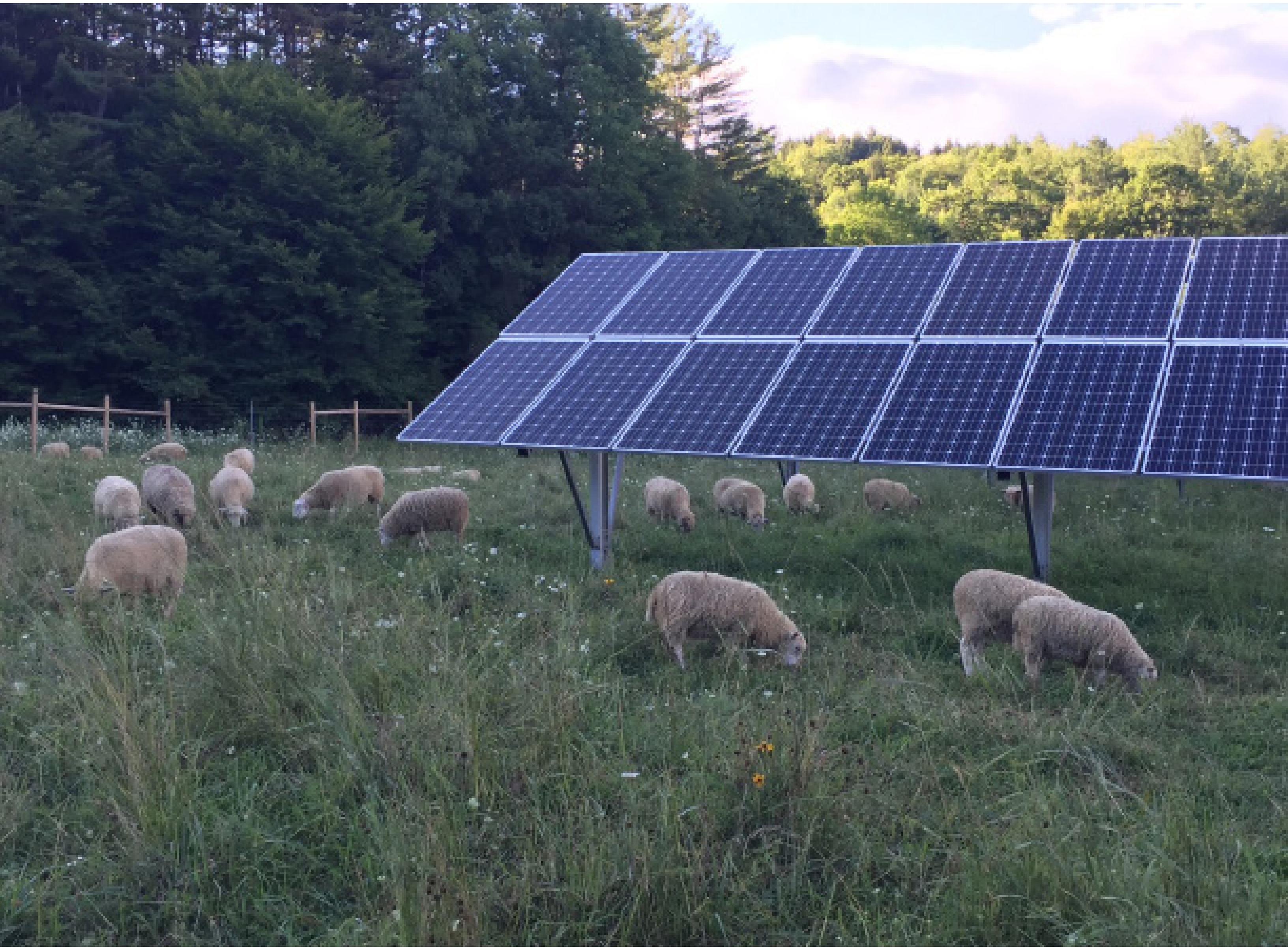
EXHIBIT C

WHITE PAPER

Balancing Agricultural Productivity with Ground-Based Solar Photovoltaic (PV) Development

Tommy Cleveland and David Sarkisian

May 2019



NC CLEAN ENERGY TECHNOLOGY CENTER

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Contents

Balancing Agricultural Productivity with Ground-Based Solar Photovoltaic (PV) Development

Introduction

For centuries North Carolina farmers have made a major contribution to the state's economy by working the land and providing billions of pounds of agricultural and forestry products to meet demands for food and fiber. This resource serves as a foundational economic building block for the state. North Carolina's farming and forestry community provides North Carolinians and people across the world with food and fiber. That said, the demands of our growing, modern society require renewable forms of energy to begin to replace finite non-renewable energy resources that have traditionally provided the means for transportation, electricity, and much more.

Given that land and climatic conditions suitable for agriculture are finite, solar development may compete with agricultural land use. One use converts sunlight and fertilizer into food and fiber, while the other converts sunlight into electricity. The purpose of this paper is to explore the extent to which solar photovoltaic facilities and agricultural production compete for land use, as well as the extent to which agricultural production is affected by solar development. The paper is divided into two sections:

(1) Understanding the Context of Solar Development and Agriculture in North Carolina.
    (1.1) Developing Renewable Energy,
    (1.2) Landowner Land Use Choice,
    (1.3) Solar Facility Construction,
    (1.4) Duration of Solar Use,

(2) Weighing the Impact of PV Development on Agriculture
    (2.1) Solar PV Land Use
    (2.2) Impact on Agricultural Productivity

1. Understanding the Context of Solar Development and Agriculture in NC

This section provides some background on solar development in North Carolina. By illustrating the existing demand for renewable energy (1.1), touching on the state's political climate towards private land use (1.2), and highlighting two important considerations of PV development (1.3 and 1.4), the context surrounding the two competing land uses of solar development and agriculture can be better understood. As agriculture is and has been a dominant, established land use in this state for generations, discussion in this section will primarily focus on the increasing demands of land to be used for solar development.

1.1 Developing Renewable Energy

Currently, almost all of North Carolina's electricity is generated from fuels, such as coal, natural gas, and uranium, which are produced outside the state. Some coal plants in North Carolina are reaching the end of their useful lives and being retired.[1,2] Alternative sources of energy, such as solar and wind, have become much more economically attractive in the last several years, making it possible to economically replace some nuclear, coal, and gas electricity generation with these sources.[3]

More than three hundred privately financed utility-scale solar facilities operate in North Carolina under current electricity prices, regulations, and policies, with more planned for the future. As with any new technology, price drops and performance improvements may be expected over time as production volumes increase and experience is gained. Since 2009, the total cost to develop and build a utility-scale solar facility in North Carolina has dropped from over $5 per watt to about $1 per watt. This rapid cost reduction in utility-scale solar facilities has greatly improved the financial viability of solar projects; many solar projects are now being planned even without the North Carolina renewable energy tax credit that expired at the end of 2015.[4,5]

In addition to the increasingly attractive economics, some of the shift towards solar energy has been driven by policy choices. Solar and other types of renewable energy have many benefits that have motivated support from policymakers. For instance, they do not use imported fuel, reducing our exposure to fuel price volatility. Solar energy also does not produce the air pollution and greenhouse gases emitted by fossil fuel-powered electricity generation, and it avoids some other environmental risks associated with fossil and nuclear fuels such as coal ash and radioactive waste disposal. Reduction of air pollution has been part of state and national policy for decades, and the U.S. has seen steadily improving air quality as a result[6] Solar and other clean energy sources assist in this ongoing reduction in air pollution.

Solar energy offers many benefits to North Carolina. However, while solar development provides a source of clean in-state energy, it requires land to do so. This means that solar energy projects will sometimes compete with other potential land uses.

1.2 Landowner Land Use Choice

North Carolina policy generally leaves land use decisions in the hands of landowners. That said, the state, local, and federal governments can encourage or discourage specific landowner choices through the incentives or disincentives that they provide for particular uses, as well as through various forms of regulation, such as zoning rules and environmental restrictions. The balance of state-provided incentives for agricultural or solar energy production can, in some cases, be the determining factor in the decision to invest in solar or agriculture development. Also, the current grid infrastructure limits the sites feasible for solar development; it is only feasible to connect solar to certain locations in the grid and only to a limited density.

North Carolina has granted local governments the power to regulate land use in their jurisdictions, although state and federal rules apply in many circumstances. This means that local governments can manage land development with the needs of the community in mind, while also safeguarding natural resources. These land-use regulations can put limits on the allowed uses for some land and thus limit landowners' options, in some cases affecting the viability of solar development. Some agricultural land has been exempted from certain regulations due to "grandfathering," and changing the land use to solar may remove these exemptions, which can affect the ability to return the land to agricultural use in the future.[7]

Land use regulations that may be relevant to solar development, depending on the location, can include (but are not limited to):[8]

- Local zoning and land use rules (fencing, buffer zones between buildings and roads, border shrubs/trees, etc.)
- Floodplain development rules

- Erosion and sedimentation rules
- Permitting regarding military and air traffic impact
- Water quality rules (i.e. Neuse nutrient strategy rules, Coastal Area Management Act rules)
- USDA wetlands impact rules

To determine whether these and other rules are relevant for a potential solar development, landowners and solar developers should consult their local government planning departments, the Soil and Water Conservation Division of the N.C. Department of Agriculture and Consumer Services, the USDA Natural Resources Conservation Service office, and the USDA Farm Services Agency.

1.3 Solar Facility Construction

Solar panels are supported by steel or aluminum racks. The racks are attached to galvanized steel posts driven 6-8 feet into the ground without concrete, although very occasionally, site conditions require the use of cement grout in the pile hole. The only concrete is generally at the inverter/transformer pads which are typically about 10' by 20' each. There is usually no more than one such pad per MW of AC capacity. At some sites these pads are precast concrete or steel skids that sit above grade on helical steel piers. Much of the wiring at the site is above-ground attached to the racking under the rows of panels. The rest of the wiring is 2 to 3 feet underground either as direct-bury cables or in 2"-6" PVC conduit. Most sites involve minimal grading of the land.

Every site provides access for vehicles, which requires roads, or "access aisles," to be constructed. These roads are sometimes improved with gravel, but they do not require application of concrete or asphalt. Many sites only use gravel close to the entry to the public Right of Way, as required by NCDOT regulation, with the rest of the access aisles as simply compacted native soil. Some developers use reusable wooden logging mats to provide temporary stabilization during construction to avoid the need for the addition of gravel. A best practice when building a gravel access aisle is to strip the organic topsoil, place a geotextile fabric under the aggregate and redistribute the topsoil on site to assist in soil stabilization. This will provide stability for the aggregate, allow for more efficient removal of the gravel at the end of the project's life cycle by providing separation between aggregate and subgrade, while preserving the valuable topsoil on site for future agricultural use. Well-drafted leases will specify allowable construction techniques and locations of roads and other infrastructure. The NC Department of Environmental Quality (DEQ) requires soil erosion and sedimentation control plans and permits and inspects implemented measures on the site until vegetative groundcover is established.

1.4 Duration of Solar Use

Currently in North Carolina most utility-scale solar projects have a 15-year Power Purchase Agreement (PPA) with the local electric utility. Some developers prefer to purchase the land, while others prefer to lease, depending on the project's business model and financing arrangements. Typical land leases have a term of 15 to 30 years, often with several optional 5-year extensions.[10] While specific lease rates are generally undisclosed, in our understanding lease rates often range between $500 and $1,000 per acre per year. Most solar PV panel manufacturers include a 25-year power warranty on their panels, which cover the panels to produce at least 80% of their original power output at the expiration of the warranty period.

Modern solar facilities may be considered a temporary, albeit long-term, use of the land, in the sense that the systems can be readily removed from the site at the end of their productive life. At this point, the site can be returned to agricultural use, albeit with a potential for some short-term reduction in productivity due to loss of topsoil, compaction, change in pH, and change in available nutrients. Leasing farmland for solar PV use, particularly land that is not actively being farmed today, is a viable way to preserve land for potential future agricultural use. PV use is particularly valuable in this regard when compared to commercial or residential development, which require changes to the land that are very difficult to reverse. For landowners struggling to retain ownership of their land due to financial strains, solar leasing may provide a vital, stable income solution. It may also serve as a more appealing alternative to selling their land to buyers intending to use the land for other, more permanent non-agricultural uses.

While it is very difficult to predict the state of electricity, agriculture, and real estate markets 25 or more years into the future, existing circumstances can provide some insight into the likelihood of today's solar facilities continuing as solar facilities at the end of the initial PV modules' useful lifetime. The he economics of existing solar facilities are such that many of the projects built today are likely to update some of their equipment after 20 or more years and continue to operate as a solar electricity facility for many more years. The ability to facilitate interconnection to the electric grid provides great value to a landowner. A parcel of land featuring this capability in today's market will likely also appeal to solar developers in the future due to the infrastructure cost savings.

2. Weighing the Impact of PV Development on Agriculture

The purpose of this section is to explore how the competing land uses of solar development and agriculture interact and can coexist with each other. Subsection 2.1 provides analysis of data and metrics that quantify the current and potential amount of solar development on agricultural land in North Carolina. Subsection 2.2 explores the impacts that solar development could have on future agricultural production on the developed site and neighboring properties. Taken together, Section 2 of this factsheet provides several factors to consider when weighing the impact of PV development on agriculture.

2.1 Solar PV Land-Use

The NC Sustainable Energy Association (NCSEA) with the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) used GIS software to quantify the amount of solar land use. As of December 2016, solar installations occupied 0.2 percent (9,074 acres) of North Carolina's 4.75 million acres of cropland.[11] NCDA&CS has provided an updated estimate; they estimate that 14,864 acres of cropland, or 0.31 percent of the total, were occupied by solar development at the end of the first quarter of 2017.[12] NCSEA and NCDA&CS were able to locate and quantify solar use for 318 of 341 currently-installed utility-scale facilities in North Carolina. A map of the solar installations in the state prepared by NCSEA is available at: http://energyncmaps.org/gis/solar/index.html.[13] The researchers extrapolated the per-MW findings of the 318 sites found in aerial photos to generate an estimate for the remaining 23 projects not yet visible in the latest aerial photography. Across all projects, 79% of solar project area was formerly farmland, defined as land identified from aerial photography to have been used for crops, hay, or pasture before solar development. On average, the solar projects occupied 5.78 acres per MW_{AC}.

N.C. has been losing farmland to various forms of development for many years. Over the last decade, North Carolina has lost about one million acres of cropland to development and housing.

Since 1940, total cropland in N.C. has fallen from 8.42 million acres to 4.75 million acres (as of 2012). The North Carolina Department of Agriculture has identified farmland preservation as one of its top priorities since 2005.

As of the end of 2016, solar PV installations added 2,300 MWAC of solar generating capacity to North Carolina's electricity grid, making NC second in the nation for installed solar PV capacity. These installations generate enough electricity to power approximately 256,000 average N.C. homes, equaling 6.2% of all households in the state.[14] NCSEA and NCDA&CS published the summary of their land-use analysis in February of 2017 and NCSEA released a report on this research in April of this year.[15]

If the current siting and production trends were to continue until ground-mounted solar produced, on average, an amount of electricity equal to *100%* of N.C.'s current electricity use, solar facilities would cover about 8% of current N.C. cropland.[16] This is an unrealistic extreme to illustrate the limited possible magnitude of land usage for solar even at very high solar generation levels, yet even this scenario would occupy only about half of the N.C. cropland acreage lost to development in the last 10 years. Even if solar were to provide all of our electricity, ground-mounted utility-scale solar will almost certainly not be the only source of electricity. As PV prices continue to decline it is likely that North Carolina will see more and more rooftop and parking lot canopies, reducing the need for green field development. A recent Department of Energy study found that rooftop systems have the technical capability to meet 23.5% of North Carolina's electricity demand.[17]

A more likely scenario, even assuming that fossil fuel and nuclear based electricity is entirely phased out, is that other sources of renewable electricity and technologies will meet a large portion of our electricity needs. A Stanford University study of the optimal mix of renewable energy sources for each state to achieve 100% renewable energy found that North Carolina would get only 26.5% of its electricity from utility-scale solar plants.[18] At this still highly expanded level of solar development, based off of the 8.3% land use for 100% solar figure calculated earlier, the amount of NC cropland used for solar would be around 2.2%.

More realistically, in the next decade or two, solar electricity may grow to provide around 5 – 20% of North Carolina's electricity, which would allow solar to meet, or nearly meet, the full requirements of the North Carolina Renewable Energy and Energy Efficiency Portfolio Standard. At the 12.5% REPS requirement, this is about 13 GW_{AC} of PV, which will require about 75,000 acres of land at the average historic density found in the NCCETC/NCDA study. This is not an insignificant amount of land, but if split between agricultural and non-agricultural land at the same ratio as the first 2.3 GW installed in NC this represents about 1.1% of cropland in the state. NCSEA projects that by 2030, utility-scale solar will provide 5.03% of North Carolina's electricity and use 0.57% of available cropland.[19]

Solar energy's land use requirements are comparable to those of existing energy sources. According to an MIT study, supplying 100% of U.S. electricity demand in 2050 with solar would require us of about 0.4% of the country's land area; this is only half the amount of land currently used to grow corn for ethanol fuel production, and about the same amount of land as has been disturbed by surface coal mining.[20]

For landowners interested in solar development, it is important to understand the agricultural value of the land before entering into a solar lease agreement. Careful due diligence in the siting phase can help mitigate the use of the most valuable farmland. Landowners can contact their county tax office for property value information. The following online resources can assist landowners and developers in assessing the agricultural value of land before selecting the final footprint for solar development:

- www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/dma/ The USDA Natural Resources Conservation Service provides several tools in this link to identify soil types on property.
- www.ncmhtd.com/rye/ The North Carolina Realistic Yields Database provides landowners with a useful mapping and soil analysis tool that produces realistic productivity yields for expected crops given the landowner's property location and soil type.

2.2 Impact on Agricultural Productivity

This subsection provides an overview of impacts that solar development may have on agricultural land. The discussion of these impacts is divided into the following subtopics: construction grading and soil preservation, compaction, erosion, weed control, toxicity, and pollinators, followed by a brief discussion of decommissioning. The subtopic discussions illustrate that solar development, with proper planning and implementation, results in a small but manageable impact on the future agricultural productivity of the land on which it is sited. Further, these discussions also illustrate that solar development is unlikely to significantly affect the agricultural productivity of neighboring properties now or in the future.

Construction Grading and Soil Preservation

The amount of grading necessary to prepare a parcel for a utility-scale solar facility is dependent on the slope of land and the type of solar mounting used. In much of N.C., fixed-tilt mounting of PV requires little to no grading for installation of the PV system. Single-axis tracking systems that slowly rotate each row of panels to track the sun's path across the sky generally require flatter land (typically less than 8% grading) and thus more often require grading of the site, particularly for projects in the Piedmont region or farther west.[21] Typical construction practices require that topsoil be stripped and stockpiled prior to cut/fill operations. The stockpiled topsoil will be redistributed across graded areas, to assist in growing adequate ground cover as quickly as possible to provide ground stabilization. The stripping, stockpiling and redistribution of topsoil in this manner will have some impact on the amount of organics and nutrients that remain in the soil immediately after placement. However, proper ground stabilization practices include soil testing to determine the appropriate levels of lime, fertilizer and seed to be applied to establish ground cover. Proper installation practices require these additives to be tilled into the soil, which effectively reduces the compaction of the upper soil stratum, typically to a depth of 8”-12”. Typical solar projects will not remove any topsoil from the project site, partly due to financial implications, but more importantly due to its value in establishing ground cover as quickly as possible[22] (removing soil also requires a mining permit).[23] Most landowners steer solar projects to their least productive soils on a given piece of property to the extent practical.[24]

Soil Quality

Modern agriculture relies on regular additions of lime and fertilizer to maintain soil pH and fertility. Solar facilities maintain vegetative ground covers that can help build soil quality over time, which may require lime and fertilizer to be applied. When the vegetation is cut, the organic matter is left in place to decompose which adds valuable organic matter to the soil. A facility operation and maintenance schedule should include a plan for maintenance of sufficient plant groundcover to protect soil from erosion. Maintaining healthy plant cover will require monitoring of soil fertility and may call for the addition of fertilizer or lime to ensure sufficient nutrients are available for plant growth and that soil pH is adequate. Vegetation mixes may help balance soil nutrient needs, but will need to be managed. Species composition will change over time.[25] NREL and others are researching and using vegetation mixes that include many native grasses with deep root systems; many include some nitrogen fixing plants as well. According to a study published in July 2016 that measured soil and air microclimate, vegetation and greenhouse gas emissions for twelve months under photovoltaic (PV) arrays, in gaps between PV arrays and in control areas at a UK solar sited on species-rich grassland, UK scientists found no change in soil properties among the three locations. After a solar project is removed, a routine soil test (available from the North Carolina Department of Agriculture) should be obtained to determine fertility requirements, including lime, for optimum crop production.

Compaction

Soil compaction can negatively impact soil productivity and will occur to some degree on every solar site. Soil compaction can also limit water infiltration into the soil environment, and lead to greater surface water runoff during rain events.[27] In addition to the roads built in and around solar project sites, the construction of the facility itself as well as regular use of lawn mowers compacts the soil, decreasing the ability of plant roots to grow. However, use of land as a solar site will avoid agriculture-related activities that can induce compaction, such as tillage. There are no data available on the degree of compaction common at solar facilities, but it is possible that some sites could experience heavy compaction in frequently used areas. In cases of heavy compaction, hard pans in the soil will form that can take decades to naturally free up; however, tractor implements such as chisels and vibrators designed to break up hard pan can often remove enough compaction to restore productivity. To prevent damage to soil due to compaction, landowners can negotiate for practices that will result in the least amount of compaction and for roads to be constructed on less productive land. Additionally, maintaining healthy groundcover, especially varieties with deep root systems, can serve to keep the soil arable for potential future agricultural use. The appropriate use of alternative vegetative maintenance strategies, such as grazing with sheep, can reduce the use of mowing equipment onsite and therefore the compaction that may result from using this equipment.[28] Furthermore, livestock grazing works to cycle nutrients in the pasture ecosystem onsite and improve the soil.

Erosion

According to its current Stormwater Design Manual, the N.C. Department of Environmental Quality allows solar panels associated with ground-mounted solar farms to be considered pervious if configured such that they promote sheet flow of stormwater from the panels and allow natural infiltration of stormwater into the ground beneath the panels.[29] For solar development, an erosion control and sedimentation permit is required, which involves on-site inspections and approval by the North Carolina Department of Environmental Quality. The permit requires establishment of permanent vegetative ground cover sufficient to restrain erosion; according to DEQ staff, the site must be "completely stabilized," although this does not require a specific percentage of ground cover.[30] In-depth information on erosion control and sedimentation laws, rules, principles, and practices is available at the NC DEQ's website, at http://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permit-guidance/erosion-sediment-control-planning-design-manual. Once permanent vegetation is established it will be necessary to maintain soil pH and fertility as mentioned above in order to ensure sufficient, healthy, and continuous ground cover for erosion control.

Weed and Vegetation Control

Maintenance of vegetation on site can be accom-

-plished using several options, including but not limited to the following: mowing, weed eaters, herbicides, and sheep. Reductions in fertilizer use on the site will slow growth of vegetation and weeds. Mowing allows the landowner to have the option of laying cut grass or vegetation on grounds of site to decompose and improve long-term soil fertility. In some cases, landowners have used grazing animals, normally sheep, to frequent the solar site grounds and control the vegetation and weeds, which also returns organic matter to the soil on site.

Like most lawns and parks, many utility-scale solar facilities in N.C. use a combination of mowing and herbicides to maintain the vegetation. When using herbicides, applicators are advised to be mindful of label instructions and local conditions. Herbicide persistence is affected by the organic matter content and moisture level of the soil. The importance of complying with legal responsibilities in using the treatments cannot be stressed enough, especially for land located near surface water, land where the surface is near the water table, or where application might carry over to other neighboring lands.

Herbicide use at solar facilities is typically similar to that in agriculture, and the types of herbicides used are similar between the two uses. As such, the impact of herbicides used at solar facilities on neighboring land and the environment is likely to be no more than that of conventional agriculture. Herbicide use differs widely among different crops and farming techniques, so the change in herbicide appliance between agricultural and solar use will vary in individual cases, but in the aggregate, there is no reason to believe that solar facilities will result in more herbicide impacts on neighboring lands than do current agricultural uses.[31] Herbicide use can be discontinued 1-2 years before decommissioning of a site, minimizing any residual impact on crop production at former solar sites.[32]

A number of sites use sheep at low densities to maintain vegetation during the growing season, although the sheep do not fully replace the need for mowing and/or herbicide use. The sheep are leased from sheep farmers, and the demand for sheep at solar facilities has been beneficial for North Carolina's sheep industry.[33] The grazing of sheep at solar facilities incorporates local farmers into the management of the sites, engaging the local community with solar development. The growth of solar farms represents a huge opportunity for the North Carolina sheep industry, with thousands of acres that are fenced well for sheep, and allow North Carolina farmers to diversify into new agricultural products for which there is increasing demand.[34]

Toxicity

There is no significant cause for concern about leaking and leaching of toxic materials from solar site infrastructure.[35] Naturally occurring rain is adequate to generally keep the panels clean enough for good electricity production. If panels do need to be washed, the washing process requires nothing more than soap and water. Additionally, the materials used to build each panel provide negligible risk of toxic exposure to the soil, environment, or people in the community. Details about toxicity for aluminum and zinc are described below, and more information on the potential for human toxicity can be found in the NCSU Health and Safety Impacts of Solar Photovoltaics white paper.

Aluminum

Aluminum is very common in soils around the world, including those common in North Carolina. In fact, the earth's crust is about 7% aluminum, and most soils are over 1% aluminum![36] The aluminum is generally unavailable to plants as long as the soil pH is above about 5.5. In acidic soils many forms of aluminum become more bio-available to plants; this can be toxic to many plant species.[37] This effect is one of the major reason many plants do not tolerate very acidic soils. The use of aluminum building materials releases negligible amounts of aluminum during their useful life because the material is so corrosion resistant.[38] The aluminum frames of PV modules are anodized which adds a very thin hard coating of aluminum oxide to the exterior of the aluminum that greatly improves aluminum's already-high resistance to corrosion. Therefore, any minute amount of aluminum that could be released by corrosion from aluminum construction materials during the life of a solar project will not materially add to the thousands or millions of pounds of aluminum naturally present in the soil of a typical N.C. solar facility. The common practice of liming soils to maintain appropriate soil pH for crop systems alleviates most, if not all, concerns about aluminum impacting crop growth in the future.

Zinc

Zinc from galvanized components, including support posts for solar panels, can move into the soil.[39] Zinc from building material stockpiles has been previously noted as a localized problem for peanut production in some North Carolina fields.[40] While it is difficult to predict in advance the degree to which this will occur, it is relatively simple to collect soil samples and monitor this situation in existing installations. Analysis of zinc is included in routine soil testing procedures used by the NC Department of Agriculture & Consumer Services Agronomic Services Division Laboratory. Awareness of zinc concentrations in the soil, and any spatial patterns noted with depth and distance from structures, should allow producers to determine if the field is adequate for desired crops as is. If zinc limitations exist, awareness of concentrations and spatial distribution patterns may indicate the potential for deep tillage, liming, or crop selection alternatives required for successful agricultural use. Of the agronomic crops grown in NC, peanuts are the most sensitive crop to zinc toxicity. Based on information from the N.C. Department of Agriculture and Consumer Services, there is risk of toxicity to peanuts when the zinc availability index (Zn-AI) is 250 or higher, particularly in low-pH situations. Risk increases with increasing soil test levels, especially if pH management through a liming program is not followed. For most other crops, zinc toxicity does not become problematic until the Zn-AI index reaches 2,000-3,000.[41]

Pollinators

Solar projects with appropriate vegetation can provide habitat for pollinators, as well as other wildlife.[42] Rather than planting common turf grasses, some solar facilities are starting to use seed mixes of native grasses and pollinator-friendly flowering plants as ground cover in solar facilities.[43,44] This provides habitat for pollinators, which can be beneficial to neighboring farms. Minnesota passed the country's first statewide standards for "pollinator friendly solar" in 2016. According to Fresh Energy, a clean energy nonprofit in St. Paul, more than 2,300 acres of these plants took root near solar panels last year, according to Fresh Energy.[45] Solar facilities can also cooperate with commercial beekeepers to facilitate honey production, although this may conflict with providing habitat for wild pollinators.[46,47] Pollinators provide benefits for agricultural production at nearby farms where insect-pollinated crops are grown.[48]

Temperature Effects

Solar PV facilities can cause changes in the air and surface temperature of the space in which they are located. The effect of solar PV facilities on surface and air temperatures is different. Solar panels shade the ground on which they are located, reducing the surface (ground) temperature from what it would be without solar panels present.[49] However, solar panels absorb solar radiation more effectively than do typical agricultural land surfaces due to their darker color, leading to an increase in air temperature directly above the solar panels as the absorbed radiation is released as heat. The decrease or increase for surface and air temperatures, respectively, is around 2-4 degrees Celsius (3.6-7.2 degrees Fahrenheit), depending on the type of land cover in the area.[50, 51]

Temperature effects on land outside the solar facility are much smaller. One study found that an air temperature increase of 1.9 degrees Celsius directly over a solar farm dissipated to 0.5 degrees Celsius at 100 meters in horizontal distance from the solar farm, and less than a 0.3 degree increase at 300 meters.[52] Another study found that a temperature difference of 3-4 degrees Celsius directly above a solar farm was dissipated to the point that it could not be measured at a distance of 100 feet from the solar farm's edge.[53] Meteorological factors can affect the range and size of any temperature effect on land nearby a solar facility, but even under very conducive circumstances the possible temperature increase for nearby land would be on the order of tenths of degrees. Studies have varied on the time at which temperature differences are most pronounced; one study noted as taking place in a desert landscape found that temperature differences were larger at night,[54] while another study found larger temperature differences during midday;[55] differences in weather and landscape between the study locations may be responsible for the different results.

Decommissioning

If land used for a solar facility is to be returned to agricultural use in the future, it will be necessary to remove the solar equipment from the land. This process is known as decommissioning. Decommissioning is basically the construction process in reverse; it involves removal of the solar panels, breakup of support pads, removal of access roads, replacement of any displaced soil, and revegetation.

Solar development often takes place on leased land, although it also occurs on land owned by solar companies. When leased land is involved, it must be determined whether the landowner or the solar developer bears responsibility for decommissioning. Responsibilities for decommissioning are lease-specific in North Carolina. It is important for landowners to consider decommissioning when setting lease terms, although landowners may choose in some cases to accept decommissioning responsibility themselves. Although state rules on solar decommissioning do not currently exist in North Carolina, local jurisdictions can choose to adopt regulations pertaining to decommissioning.

The materials recovered in the decommissioning process have significant economic value, which can help pay for the costs of decommissioning. Some engineering analyses have indicated that the salvage value of recovered materials is more than enough to pay for the removal of all the materials and to return the site to its pre-construction state.[56,57,58,59]

NCSU has produced several resources that provide more information on decommissioning. They include:

- Health and Safety Impacts of Solar Photovoltaics[60]
- Template Ordinance for Solar Energy Development in North Carolina[61]
- Working Paper: State Regulation of Solar Decommissioning[62]
- Landowner Solar Leasing: Contract Terms Explained[63]

Summary

The purpose of this paper is to explore the extent to which competition exists between solar development and agriculture and the extent to which the agricultural productivity of land is affected by solar development. Discussion on this topic was divided into two sections: (1) Understanding the Context of Solar Development and Agriculture in North Carolina and (2) Weighing the Impact of PV Development on Agriculture. In these sections, information and tools were provided to aid in understanding the impact of solar development on agricultural land. Equipped with the information and tools provided by this paper, landowners may be able to better evaluate the viability of solar development on their land.

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TECHNOLOGY CENTER

Question #5

Storage Battery Potential Hazards
Applicant to provide information on the potential hazards associated with the storage batteries if installed and what are the safety precautions taken?

RESPONSE: The battery storage system will be installed and maintained by ENGIE North America ("ENGIE"), who will be the owner/operator of Horseshoe Bend. ENGIE's Safety FAQ for Battery Energy Storage Systems ("BESS") is attached as Exhibit D, and provides information on the potential hazards associated with the storage batteries, and the safety precautions taken.

As detailed at the end of Exhibit D, all ENGIE BESS projects will have a project-specific Emergency Response Plan ("ERP") developed in conjunction with BESS safety experts. These plans are made available to the local fire department and will clearly detail the hazards on site and recommended protocol for first responders in the unlikely event of a safety event on site. Contact information is also provided for on-call support from an ENGIE-representative.

ENGIE also offers local first responders and relevant stakeholders a safety training class conducted by BESS safety subject matter experts. This training is project-specific to allow participants to familiarize themselves with the project, its potential hazards, and response protocol. An example third party training provided by the National Fire Protection Association ("NFPA"), can be seen at the following link: https://catalog.nfpa.org/Energy-Storage-and-Solar-Systems-Safety-Online-Training-P20882.aspx. The training offered will be similar or equal to this NFPA training, with additional project-specific information.

Energy storage systems, if installed at Horseshoe Bend, will additionally comply with National Fire Protection Association NFPA 855, Standards for the Installation of Stationary

Energy Storage Systems. This is the national best practice for the safe installation and operation of utility scale battery storage systems.

WITNESS: Carson Harkrader

EXHIBIT D

GridSynergy
by ENGIE Storage

Safety FAQ
ENGIE Battery Energy Storage Systems

V2021.03

Contents

INTRODUCTION

ENGIE deploys and operates battery-based energy storage systems (BESS) to help power the world sustainably and efficiently. ENGIE Storage adheres to all applicable UL, Electrical Permits and National Electrical Code (NEC) standards and our battery system installations are designed and engineered by licensed electrical engineers in accordance with NEC/National Fire Protection Association regulations.

WHAT IS A BATTERY ENERGY STORAGE SYSTEM?

A BESS consists of three major sub-systems; power conversion system (PCS), battery system, and balance of system (BoS). These are specifically engineered for inter-operability and packaged into a 'turn-key' BESS. Some common variations between different BESS providers include:

- PCS original equipment manufacturer
- Battery system chemistry
- Battery system OEM
- Balance of System integrator
- PCS power capacity
- Battery system energy capacity
- Indoor or outdoor rating

Power Conversion System

The PCS, also called a bi-directional inverter, handles the conversion of DC power from the battery system into AC power. During battery discharge, the DC power is converted to AC power and supplied to the grid and/or load. During battery charge, AC grid power is consumed and converter to DC power.

Battery System

The battery system is an array of battery cells that converts electrical energy into chemical energy for storage. BESS most often use lithium-ion (Li-ion) battery cells as the building block for the battery system.

Balance of System (BoS)

The BoS is a collection of components that tie the PCS and battery system together. Typical components include:

- Enclosure
- HVAC
- Power and communication cables
- Fuses, contactors, disconnects, and other power flow control components
- Sensors
- Control system
- Fire suppression system
- Human machine interface

WHAT SAFETY TOPICS ARE RELEVANT TO A BESS?

All BESS carry safety considerations inherent to a device designed to store large amounts of energy, in a compact space, while interconnected with live utility power. Key safety considerations can be categorized as electrical safety, fire safety, and chemical safety.

Electrical Safety

BESS operate at higher voltages. For systems sited behind-the-meter, 208V and 480V AC power are most common. For systems interconnected at primary distribution or transmission voltages, those values may exceed 10,000V. Most battery systems are based on DC bus voltages that are several hundred volts.

Protective equipment and a robust set of electrical code, equipment certifications, and licensing requirements have been established to address electrical safety. More details are provided in the following sections.

Fire Safety

Batteries store large quantities of energy in a small space using reversible chemical reactions. In rare instances, thermal events can trigger reactions that release large quantities of energy, which in turn can trigger fires, generation of flammable gases, and explosion.

Established fire code, equipment certifications, protective equipment, and licensing requirements are in place to address fire safety. More details are provided in the following sections.

Chemical Safety

The chemical hazards of BESS vary, depending on the battery chemistry in use.

Li-ion batteries used in most BESS are exclusively produced in hermitically sealed packaging, which prevent contact of the internal chemical compounds with the outside environment. More detail is provided in the following sections.

ENSURING THE ELECTRICAL SAFETY OF THE BESS

ENGIE understands that many customers will choose to install systems in close proximity to inhabited spaces. As such, there are multiple levels of controls and equipment certifications in place to ensure the electrical safety of BESS installations.

Electrical Permits and National Electrical Code (NEC)

All BESS installations are designed and engineered by licensed electrical engineers in accordance with code. Electrical equipment installed as part of the BESS, inclusive of the BESS itself, carry UL listings. All installation work for a BESS is completed by licensed general and/or electrical building contractors.

As part of the permitting process, all installations are submitted to the Authority Having Jurisdiction (AHJ) for a review of compliance with active building and electrical codes. Additionally, proposed systems are submitted to the local utility for approval to install and interconnect. Prior to receiving Permission to Operate (PTO) from the interconnecting utility provider, each BESS installation must undergo final inspection by the AHJ electrical inspector.

Arc Flash Assessments

All BESS installations have arc flash studies performed in order to identify electrical hazards and appropriate signage and PPE requirements for personnel on site.

UL 9540 Listing for Energy Storage Systems and Equipment

The BESS are UL 9540 certified by a Nationally Recognized Testing Laboratory (NRTL). UL 9540 is a system-level listing that holistically considers the PCS, battery system and BoS to ensure the safety of the BESS. This listing checks that the electrical system of the BESS is designed and constructed to NEC compliance. Examples of items covered by the listing include:

- Proper conductor and fuse ratings for the application
- Proper insulation ratings
- Proper grounding

- Proper overcurrent / overvoltage handling

UL 1741-SA Listing for Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources – Supplement A

The BESS include a PCS certified to the latest UL 1741-SA Listing. This listing includes specifications and tests for utility safety, such as anti-islanding protection and synchronous grid interoperability. It also has a section dedicated to "Protection Against Risks of Injury to Persons". This section ensures the safe design of enclosures, guards, and human-interactive components such as switches and disconnects.

ENSURING THE FIRE SAFETY OF THE BESS

ENGIE understands that many customers will choose to install systems in close proximity to inhabited spaces. As such, there are multiple levels of controls and equipment certifications in place to ensure the fire safety of ENGIE BESS installations.

Building Permits and Code

All BESS installations are designed and engineered by licensed engineers in accordance with established codes and listings including but not limited to NEC, NFPA, IFC, IBC, and UL. Prior to receiving Permission To Operate, each BESS installation must receive a building permit sign-off by the local AHJ. Typically, the local building department reviewing a plan set will circulate the submitted project to the local fire official for review and approval.

UL 9540 Listing for Energy Storage Systems and Equipment

All ENGIE BESS tested to conformance with UL 9540 by a qualified NRTL. UL 9540 is a system-level listing that holistically considers the PCS, battery system and BoP to ensure the safety of the BESS. This listing confirms that the thermal controls (HVAC) of a BESS are adequately designed to keep the batteries in their nominal operating range. It also references UL 1973, described below, which specifically addresses battery system fire safety. A manufacturer "Failure Mode and Effects Analysis" are required to ensure proper consideration of relevant component failure modes and to ensure controls are in place for a safe shutdown of the BESS. ENGIE BESS are designed to automatically shut down power transfers and signal a fault or alarm condition to their Network Operations Center in the event of anomalous currents, voltages, and temperatures in the PCS, battery system, or BoS.

UL 9540A Testing for Energy Storage Systems and Equipment

All ENGIE BESS utilize batteries that have been fire-tested to the UL 954A standard by a qualified NRTL. The UL 9540A testing standard specifies conditions by which battery cells, modules, racks, and when necessary entire units, are intentionally subjected to a fire initiating at the battery cell. The resulting report characterizes the propagation behavior of a fire event so that engineers may design the project to appropriately mitigate the risk and impact of a battery fire event.

UL 1642 Listing for Lithium Batteries

All ENGIE BESS carry the UL 1642 Listing. This listing tests battery cells to ensure they handle all normal operating conditions and the following abnormal conditions safely:

- Short circuits
- Abnormal charging
- Heating
- Crush
- Impact
- Shock
- Vibration

UL 1973 Listing for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications

All ENGIE BESS carry the UL 1973 listing. This builds on the cell level UL 1642 listing to additionally test the battery module, which is a collection of battery cells. Module mechanical and thermal designs are tested in addition to module-level safety monitoring and control electronics. The design of thermal management, safety circuits and controls, and overall system safety are evaluated. Tests included specific determinations of fire hazards, and the ability of the battery module to withstand a fault on any component. Abuse testing includes the following tests to ensure battery module integrity and fire safety under extreme conditions:

- Overcharge
- Short circuit
- Overdischarge
- Failure of the cooling system
- Impact and drop impact
- Single cell thermal event propagation

ENSURING THE CHEMICAL SAFETY OF THE BESS

The BESS are based on the Li-ion family of battery chemistries. As such, the chemical safety risk profile is low. The chemical contents of the battery cells can pose a contact, ingestion, and inhalation hazard, but these chemicals are stable across the range of ambient temperatures and are contained in hermetically sealed cells. These cells are then further factory-packaged in rigid casings at the battery module level. The integrity of the battery cell is tested and certified to the UL 1642 listing.

UL 1642 Listing for Lithium Batteries

All ENGIE BESS carry the UL 1642 listing. This listing covers the battery cell casing construction and includes mechanical crush, impact, shock, and vibration tests to ensure the integrity of the cell.

UL 1973 Listing for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications

UL 1973 listing for batteries for use in stationary, vehicle auxiliary power, and light electric rail applications.

ENSURING THE GENERAL SAFETY OF THE BESS

In addition to the measures described above, ENGIE provides takes further steps to ensure the general safety of its BESS installations.

Emergency Response Plans for First Responders

All ENGIE BESS projects will have a project-specific Emergency Response Plan (ERP) developed in conjunction with BESS safety experts. These plans are made available to the local fire department and will clearly detail the hazards on site and recommended protocol for first responders in the unlikely event of a safety event on site. Contact information is also provided for on-call support from an ENGIE-representative familiar with the project.

On-Site Training for First Responders and Stakeholders

ENGIE offers local first responders and relevant stakeholders a in-person safety training class hosted at or near the project site, and is conducted by BESS safety subject matter experts. This training is project-specific to allow participants to familiarize themselves with the project, its potential hazards, and response protocol.

Question #6

Storage Battery Environmental Impact
Applicant to provide information on the environmental impact these batteries impose if the project is installed with storage batteries.

RESPONSE: The battery energy storage systems are hermetically sealed and protected within rigid battery modules installed on racks and then contained within an outdoor-rated and fire-rated enclosure. The batteries have their temperature regulated by a closed-loop HVAC system. As such, during operations, there is no generation of gas, exhaust, or waste byproduct from the energy storage system.

Over the past few years, large battery energy storage systems are increasingly being installed in stand-alone installations in both rural and high-density urban locations across the country, and as AC-connected or DC-connected systems connecting to the grid at the same point of interconnection as renewable energy or other power generation plants. In various high-density city environments, batteries have been chosen partially because they can provide reliable power and grid support while significantly improving local air quality versus other forms of power generation.

The Project will decommission the battery system at the end of life, removing all equipment and sending the batteries to recycling or disposal facilities specifically qualified to handle large-format batteries.

WITNESS: Carson Harkrader

Question #7

Cell Phone Towers
Applicant to provide information on any cell phone tower that may be required/constructed for the project.

RESPONSE: There are no cell phone towers that will be required or constructed for the Project.

WITNESS: Carson Harkrader.

Question #8

Fiber Optic Communication & Associated excavation
Applicant to provide information on any fiber optic or any kind of communication network installed as part of the project?
Applicant to provide information on excavation that may be required for the above.

RESPONSE: Communications fiber will be contracted with a local service provider. The fiber lines are usually plowed in with a ditch-witch or similar and do not require extensive excavation, however that might vary with location and provider approach.

If connection to an existing fiber network is too far away or cost prohibitive, regular cell phone service might be used for communication (using existing cell phone towers servicing the area).

WITNESS: Carson Harkrader

Question #9

PV Cell/Solar Panel Manufacturing
Applicant to provide indicative information on where the PV cells/Solar Panels are manufactured and what will be the % of import & % indigenous for the project.

RESPONSE:

Solar modules represent approximately one quarter of total Project construction costs. A manufacturer has not yet been selected for the solar modules to be used for this project, but solar modules installed in the United States are typically imported from Asia.

Other components with domestic content include:

- Trackers (racking system) represent about 10% of total construction costs. The amount of domestic content varies and depends on manufacturer, commodities, and market conditions.
- Tracker foundations (piles) represent about 3% of total construction costs. They are usually sourced domestically.
- Fencing and Electrical Balance of System (“BOS”) components represent about 5-7% of total construction costs. They are usually sourced domestically.

WITNESS: Carson Harkrader

Question #10

DOE Compliant Transformer
Applicant to provide information on the DOE Compliant transformers used at site.

RESPONSE: We are aware of the Executive Order “Securing the United States Bulk-Power System,” and the Biden administration’s ongoing review.

Any equipment selected will be compliant with DOE requirements and regulations. ENGIE’s policy and legal teams are constantly monitoring and ensuring compliance.

WITNESS: Carson Harkrader

Question#11

Pollinator Maintenance
Applicant to provide compliance on maintaining the pollinators, as long as the plant is in operation.

RESPONSE: Horseshoe Bend will enter in a long-term agreement with a service provider to maintain the pollinator plantings. It is likely that an external service provider will be used for the initial years, with a transition to an in-house service provider in later years once the pollinators are well established.

ENGIE has experience with pollinators on solar project sites in the mid-Western United States and will install numerous acres of pollinators on two solar project sites in Virginia in 2021-2022, providing experience that will benefit the pollinators plantings at Horseshoe Bend.

WITNESS: Carson Harkrader

Question #12

Cemetery Access and Maintenance
Applicant to provide compliance on providing permanent public access and maintain the Cemeteries as long as the plant is in operation.

RESPONSE: The Project will not block public access to either cemetery, and will not provide maintenance to the cemeteries.

WITNESS: Carson Harkrader